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Review

Progress in Endovascular Management of Type A Dissection CME

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WHAT THIS PAPER ADDS?

- The surgical management of acute type A aortic dissection is evolving. This paper describes how endovascular solutions are likely to improve outcomes in this challenging pathology. It reports the world experience to date and the specific challenges that remain to the pioneers of endovascular therapy in the proximal aorta.

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ABSTRACT

Proximal acute aortic dissection [type A] remains a disease with a poor prognosis. High peri-operative open surgical mortality [up to 30%] and a significant turn-down rate [up to 40%] substantiate the bleak prospects for patients with this disease. Thoracic endovascular stent grafting has revolutionized the treatment of distal [type B] acute aortic dissection. Endovascular surgeons are now looking to improve the treatment of type A dissection by offering endovascular techniques to supplement conventional surgical therapy. Less invasive endovascular therapy, obviates the need for sternotomy and cardiopulmonary bypass, may reduce perioperative morbidity and offers a solution for those patients declined conventional intervention due to co-morbidity or severe complications of the disease. Thoracic stent grafting in the ascending aorta presents specific challenges due to proximity to the aortic valve, navigation over the steep aortic arch and pulsatile aortic movement. Endovascular surgeons have treated type A dissection off-license using aortic cuffs and stents designed for infra-renal aortic surgery. Now grafts specifically designed for treating type A dissection are being developed and deployed under trial [compassionate license] in patients deemed unfit for open surgery. This paper explores how endovascular solutions may fit into the future care of patients with acute type A dissection.

Introduction

Type A acute aortic dissection [TAAD] is a catastrophic arterial insult, which requires emergency cardiac surgical intervention. Although surgical results have improved with superior grafts and compatible suture materials, enhanced cardiopulmonary bypass, cerebral protection, biologic glue and tailored postoperative surveillance, overall in-hospital mortality remains as high as 30%.[1] This statistic also fails to account for the considerable proportion of patients (up to 40%) turned-down for operative intervention due to co-morbidity or haemodynamic instability.[2] The in-hospital mortality for patients managed medically is also dismal (59% die without leaving hospital).[3]

Endovascular solutions have become the preferred management of many complex aortic diseases involving the aortic arch and descending thoracic aorta. Thoracic endografting has an established role in acute complicated type B aortic dissection superseding primary open surgery. The ascending aorta represents the new endovascular frontier,[4] and clearly there is a requirement for improved outcomes in TAAD. In this paper the possible role of endovascular solutions to TAAD is explored.

Epidemiology

The reported estimates of thoracic aortic dissection [TAD] are 2.9–4.3 cases per 100,000 persons per year. Approximately two-thirds of TADs involve the ascending aorta [Stanford type A].[5] The incidence appears to be rising, although this may simply be a function of improved diagnostic imaging. TAAD is more common in men, with an average age at onset of 63 years.[2] The principle risk factors are hypertension, aortic dilatation, congenital

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cardiovascular defects and hereditary connective tissue disorders [e.g. Marfan's]. It appears likely that the incidence of TAAD will increase as emergency departments utilise more cross sectional imaging and patients are more rigorously investigated.

Current Gold Standard

Open surgical repair remains the gold standard treatment TAAD. Surgery necessitates replacement of the ascending aorta sometimes requiring hypothermic circulatory arrest. The goals of repair are to resect the primary intimal tear, resect and repair the ascending aorta, achieve occlusion of the false lumen, restore aortic valve competence and limit dissection downstream. Most patients do not require aortic valve replacement or coronary re-implantation, although this is required in 10–20% of cases.[6] If the tear has extended into the arch, the replacement of the arch and great vessel re-implantation is required. Risk models have explored factors associated with outcome. Independent preoperative predictors of mortality include advancing age, prior cardiac surgery, hypotension on presentation, neurological deficit, and myocardial ischaemia.[7] Patients continue to be turned-down for life-saving surgery when the risks of surgery outweigh the benefits.

The natural history of the dissected aorta distal to the replaced ascending can be one towards progressive enlargement despite hemiarch replacement. This can lead to the need for re-operation in up to one third of cases. Rigorous anti-hypertensive therapy and life-long imaging is mandated in all cases following surgery.[8] When re-operation is indicated it often necessitates complex hybrid endovascular solutions or high-risk thoracoabdominal surgery.

The Need for an Endovascular Solution?

Thoracic endovascular repair [TEVR] of complicated type B aortic dissections [TBAD] has revolutionised the management of this disease.[9–11] The reduced physiological insult associated with this technique has transformed the perioperative outcomes for TBAD.[12] Experience gained from TEVR for TBAD and the ever increasing complexity of aortic disease treated endovascularly has led a natural progression around the aortic arch. This is driven by the poor outcomes associated with patients who cannot be treated surgically and advances in understanding of endovascular solutions.

The principle behind endovascular treatment of TAAD, as with TBAD, is closure of the primary entry tear in the aorta. This preserves true luminal blood flow, encourages false lumen thrombosis and allows the vessel to remodel.[13] The rules of applicability are the same as for all endovascular procedures; it is the challenges that increase as endovascular surgeons migrate around the arch, with greater potential for neurological and procedural complications, proximity to the aortic valve and coronary ostia and increased mobility of the aorta adjacent to the left ventricle.

Morphological Suitability

Endovascular suitability is dependent on adequate access vessels, an appropriate location and length of the proximal and distal landing zones, and luminal diameter compatible with available stent-grafts. In acute dissection additional exclusions to endovascular repair include disturbed aortic valve function and prior coronary revascularisation. The principle determinant of suitability is the location of the primary proximal entry tear. This must lie a minimum of 20 mm distal to the sinotubular junction to allow stent coverage of the flap whilst maintaining coronary blood flow. [Fig. 1] The mean distance, representing the safe landing zone, from sinotubular junction to innominate artery ostia is reported to be 63.4 ± 10.2 mm.[14]

Two studies have explored the feasibility of endovascular repair of TAAD based purely on cross-sectional imaging. They report that, based on current device designs 32–50% of patients currently undergoing open repair for TAAD could potentially be candidates for endovascular repair.[15,16] [Table 1]

Specific Challenges and Solutions

The anatomical and physiological challenges to endovascular therapy of the ascending aorta remain formidable. They include proximal graft fixation close to the aortic valve and coronary ostia and a distal landing zone that may impinge on the innominate artery. The steep curvature of the distal ascending aorta and the sizing discrepancies found in acute pathology highlight the requirement for pathology-specific grafts. The haemodynamic forces in the ascending aorta resist accurate graft deployment, whilst the distal cone of current grafts prohibits deployment close to the aortic valve. Accurate device control and deployment is hindered by loss of torque control through tortuous iliac vessels into the 270° aortic arch.

None of these challenges is insurmountable. Short large diameter stents have been developed to fit the ascending aortic anatomy. Precise deployment in the tortuous and gothic-arched aorta can be facilitated using stiff buddy wires or externalised transeptal guidewire.[17] Devices designed for ascending arch pathology are longer than standard thoracic stents due to the distance from the groin access site. They incorporate a shorter nose cone to limit cardiac trauma at deployment.

As with all endovascular procedures endoleaks are the Achilles heal. The short coverage means only proximal and distal type 1 leaks are relevant and represent treatment failure. This highlights the advantages of devices made-for-purpose; designed to sit in the ascending aorta, and appose the aortic wall.

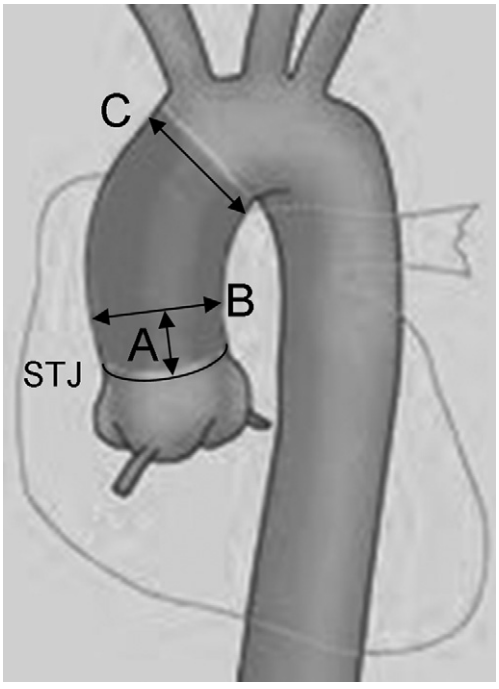

Figure 1. Proposed suitability for a wholly endovascular solution to TAAD [STJ = Sinotubular junction, A > 20 mm, B < 38 mm, C < 42 mm].

Table 1
Proposed anatomical suitability criteria for endovascular treatment of TAAD.

Entry tear distal to sinotubular junction
Proximal and distal landing zone length >20 mm
Proximal landing zone diameter <38 mm
No aortic valve involvement
Absence of coronary grafts originating from ascending aorta
Adequate iliofemoral access vessels [24Fr]

Technique

Meticulous planning is essential. ECG-gated contrast enhanced CT images, to minimise motion artefact, should be examined on dedicated vascular workstations. All measurements should be based on centreline-of-flow reconstructions. Preoperative trans-oesophageal echocardiography [TOE] is essential to detect aortic valve insufficiency or regurgitation. This investigation may also allow accurate measurement of distance between dissection entry tear and coronary ostia. TOE is used to evidence the presence of pericardial effusions and cardiac tamponade which would further exclude the patient from an endovascular solution.[18] Grafts are over-sized 5–10% relative to the native true lumen at the site of the proximal seal zone to minimise aortic trauma. Endovascular surgery should be performed under general anaesthesia. Accurate deployment requires complete cardiac standstill, this should be induced by overdrive pacing using a temporary cardiac pacing wire. Serial angiography is performed to ensure accurate deployment and patency of the coronary arteries and supra-aortic trunks. Ballooning of the endograft is not recommended.

Particular Risks

There are additive risks when operating further round the aortic arch, particularly with the increased instrumentation, requirement for reduced systemic blood pressure at deployment and proximity to the aortic valve.[19] Lessons have been learned from the trans-catheter aortic valve implantation [TAVI] experience. Stroke is perhaps the most worrisome complication and is generally procedure-related and embolic. The risks increase as the procedure progresses around the aortic arch.[20] Stroke may occur as a consequence of instrumentation around the diseased aortic arch or extension of the dissection into the supra-aortic branches. In the TAVI population trials of embolic-protection devices (Embrella embolic deflector system®, Edwards Lifesciences, Irvine, CA, USA) are being considered;[21,22] it is likely these results will translate to endovascular strategies for TAAD. The benefits of these will have to be weighed against the risks associated with additional instrumentation and manipulation.

The fragility of the aortic wall exposes patients to potentially fatal retrograde dissection [RTAD] into the coronary vessels or rupturing into the pericardium. RTAD may also be related to proximal bare springs of the endografts and overall stiffness of the endoprosthesis relative to the mobile pulsating ascending aorta.[23] These factors are relevant when designing future ascending aortic devices; making them compliant and flexible to interact with the aortic wall with atraumatic proximal fixation. Operating so close to the heart exposes the patient to wire and/or device trauma to the aortic valve or left ventricle. At deployment the tip of the device must cross the aortic valve and sit in the left ventricle, with attendant risk of ventricular perforation. Cardiac trauma can be minimised by delivery systems with enhanced trackability and conformation, and accurate wire control throughout the procedure. This issue further highlights the requirement for custom ascending aortic devices without the long nosecones of traditional thoracic endoprostheses. Extra stiff wires with atraumatic floppy tips, capable of sitting in the left ventricle, will enhance safety at deployment.

Current Series/Case Reports [Table 2]

The first case report of complete endovascular treatment of TAAD was published in 2004. Infra-renal aortic endovascular cuffs have generally been used as they are short enough not to cover the innominate artery, although they are limited by relatively short delivery systems. This represents an off-licence use, and therefore should only be used when all alternative options have been exhausted. Hybrid revascularisation involving supra-aortic debranching and deployment of a bifurcate device from the right common carotid artery has also been reported.[24] Although innovative and another example of off-license use, this approach is limited by endograft diameters, conformation, and morphology.

The first report utilising a made-for-purpose Zenith ascending dissection device was published in 2011.[25] These devices, specific to the ascending aorta, are undergoing proof of concept studies and offer the first glimpse of a robust endovascular solution with broad applicability [Fig. 2]. All the case reports of endovascular management of TAAD describe successful outcome beyond 30-days; none report any significant perioperative morbidity. A more realistic description of the likely risks of this procedure is described in the Chinese series of Ye et al. In their series of mixed acute and chronic ascending dissections they experienced a 20% stroke rate and 10% 30-day mortality.[26] This series should however be interpreted understanding that 2/10 cases required a hybrid, open and endovascular approach, to create safe landing zones.

Future Developments

It is becoming apparent that different aortic pathologies require diverse stent-graft solutions. Off-licence techniques such as using aortic cuffs for TAAD are likely to compromise outcomes and are unlikely to offer a robust solution. Experience with specific

Table 2
Reported cases of endovascular stenting for type A dissection [stent deployed between sinotubular junction and innominate artery] [ND = Not described, Acute: defined as treatment within 14 days].

Author	Country	Year	*N*=	30-day mortality [%]	Acute or Chronic	Conditions for deployment	Stent details
Case reports							
Ihnken et al.[27]	USA	2004	1	0	Acute	ND	40 × 10 mm Excluder Cuff [WL Gore, USA]
Zhang et al.[28]	China	2004	1	0	Chronic	ND	38 × 70 mm Gianturco Z-stent
Zimpfer et al.[29]	Austria	2006	1	0	Chronic	Overdrive pacing	46 × 85 mm custom stent [Jotec, Germany]
Senay et al.[30]	Turkey	2007	1	0	Acute	ND	46 mm Talent cuff [Medtronic, USA]
Palma et al.[31]	Brazil	2007	1	0	Chronic	Overdrive pacing	38 × 155 mm custom partially covered stent
Metcalfe et al.[25]	UK	2011	1	0	Acute	Overdrive pacing	34 mm Zenith ascending dissection device
Series							
Ye et al.[26]	China	2011	10	10	6 Acute 4 Chronic	ND	Assorted aortic cuffs 32–42 × 50–80 mm [2 hybrid procedures]

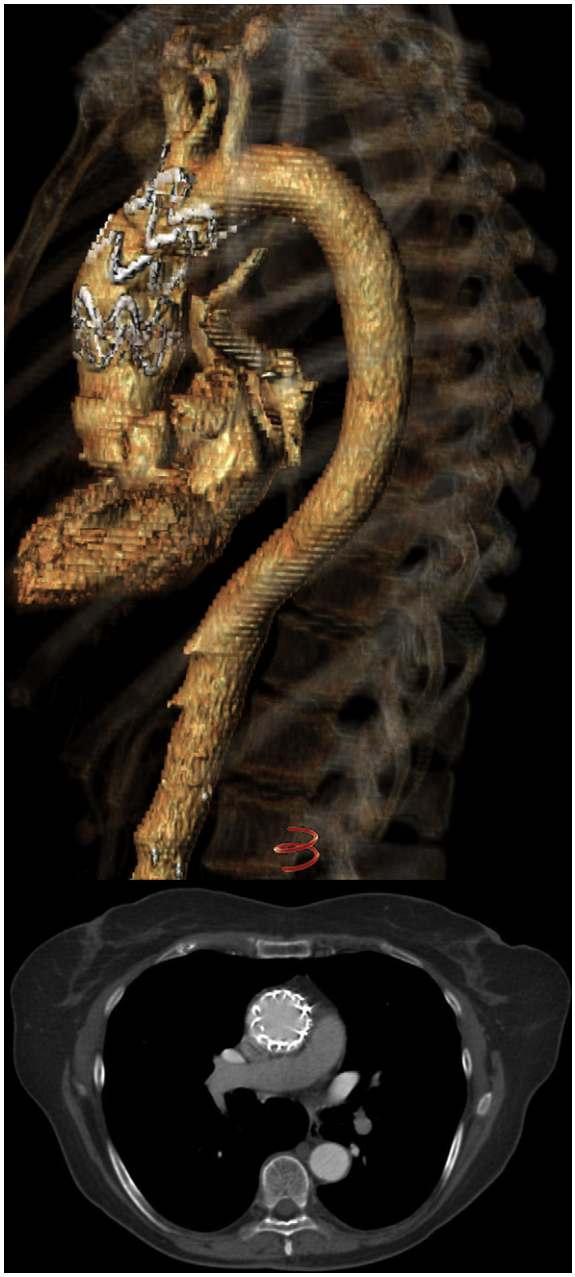

Figure 2. Images demonstrating custom ascending aortic stent in-situ landing proximal to innominate artery [3 month follow-up scan]. Volume rendered 3D reconstruction and axial contrast-enhanced CT image.

ascending aortic devices will clarify understanding of the behaviour of these devices in the ascending aorta, and through entering cases into registries, document their durability and applicability. Equally, registries should gather data on all cases turned down for surgical treatment. This would further clarify the demand for an endovascular solution.

A new generation of lower profile thoracic devices, 16 Fr [Zenith TX2 low profile, Cook Medical, USA] are set to be launched. This would permit a left subclavian artery approach to be taken, reducing the distance between access and disease and facilitating more precise deployment. Devices need to be more flexible to negotiate the arch without trauma, but maintain torque control and allow millimetre perfect deployment. The TAVI experience will help to advance endovascular solutions in the ascending aorta.

Conclusions

Endovascular development may offer a therapeutic modality for cases of surgically untreatable type A dissection. Proof of concept studies are in progress using stent-grafts designed specifically for the ascending aorta. Vascular surgeons, cardiologists and cardiothoracic surgeons should be encouraged to refer patients that are ineligible for open surgery to endovascular units offering this technology. It is inevitable that in the future thoracic endovascular surgeons will become integral to the multidisciplinary team caring for patients with TAAD as they have for type B dissection.

Funding

None.

Conflict of Interest

None.

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