Thoracic endovascular aortic repair (TEVAR) in proximal (type A) aortic dissection: Ready for a broader application?

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ABSTRACT

Objective: Thoracic endovascular aortic repair (TEVAR) has demonstrated encouraging results and is gaining increasing acceptance as a treatment option for aortic aneurysms and dissections. Yet, its role in managing proximal aortic pathologies is unknown—this is important because in proximal (Stanford type A) aortic dissections, 10% to 30% are not accepted for surgery and 30% to 50% are technically amenable for TEVAR. We describe our case series of type A aortic dissections treated by using TEVAR.

Methods: Between year 2009 and 2016, 12 patients with acute, subacute, or chronic type A aortic dissection with the proximal entry tear located between the coronaries and brachiocephalic artery were treated with TEVAR at 3 centers. Various stent-graft configurations were used to seal the proximal entry tear in the ascending aorta under rapid pacing.

Results: A total of 12 patients (9 male, 3 female), mean age 81 ± 7 years, EuroSCORE II 9.1 ± 4.5 , underwent TEVAR for the treatment of type A aortic dissection. Procedural success was achieved in 11 of 12 patients (91.7%). There was 1 minor stroke and 1 intraprocedural death. No additional deaths were reported at 30 days. At 36 months, there were 4 further deaths (all from nonaortic causes). The mean survival of these 4 deceased was 23 months (range 15–36 months). Follow-up computed tomography demonstrated favorable aortic remodeling.

Conclusions: TEVAR is feasible and reveals promising early results in selected patients with type A aortic dissection who are poor candidates for surgical repair. The current iteration of stent-graft technology, however, needs to be adapted to features specific to the ascending aorta. (J Thorac Cardiovasc Surg 2017;153:S3–11)

Successful treatment of a type A aortic dissection by using thoracic endovascular aortic repair.

Central Message

Thoracic endovascular aortic repair in type A aortic dissection is feasible in selected patients. Favorable aortic remodeling occurs in type A (and B) dissections. Thus, thoracic endovascular aortic repair may be an option in patients at high risk for surgery.

Perspective

Thoracic endovascular aortic repair offers a potential treatment option in a subset of patients with type A aortic dissection at high surgical risk but with suitable anatomy. With thoracic endovascular aortic repair, 30-day survival is >90% in these high surgical risk patients. With this proof-of-concept study, broader application may be possible with further specific technological advances.

See Editorial Commentary page S12.

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Surgical mortality and morbidity remain high for proximal (Stanford type A) aortic dissections, particularly in elderly patients with significant comorbidities, despite recent strides to improve its surgical technique and

Scanning this QR code will take you to the videos for the article.

Abbreviations and Acronyms

CT	= computed tomography
SD	= standard deviation
TEVAR	= thoracic endovascular aortic repair

management.^{1,2} Considering the Western demographics with increasing aging population and variety of comorbidities that portend inherent increased surgical risks, the concept of endovascular stent-grafting, also known as thoracic endovascular aortic repair (TEVAR, a catheter-based nonsurgical technique), in patients with thoracic aortic disease is increasingly attractive, propelled by the desire to minimize surgical risks. TEVAR has been shown to initiate healing and remodeling of the dissected aorta by excluding and depressurizing the false lumen.³⁻⁵ To date, TEVAR strategies appear encouraging in the treatment of various aortic pathologies.⁶⁻¹⁰ The technology has been embraced without level I evidence for the treatment of distal (Stanford type B) aortic dissections and even used to treat acute proximal (Stanford type A) aortic dissections¹¹; however, the complexity of the anatomy in the ascending aorta continues to be a major obstacle for the use of endovascular technologies.

Acute type A aortic dissection usually requires very urgent surgical repair of the ascending aorta¹²⁻¹⁴; selected cases, however, may qualify for TEVAR as an option in scenarios of unacceptably high surgical risk. According to the International Registry of Acute Aortic Dissections, 86% patients qualify for surgical replacement of the ascending aorta, and 23% or 12% require additional partial or total arch replacement, respectively.¹⁵ Overall, in aggregate 91% of patients in this registry underwent surgical repair under cardiopulmonary bypass with 25% in-hospital mortality.^{15,16} A less-traumatic repair of type A aortic dissection by using TEVAR, where applicable, may potentially lower the procedural/in-hospital mortality risk, particularly as the technology improves.

Surgical repair leaves a patent false lumen in both the aortic arch and descending aorta in 75% of patients; those who survive often require distal reintervention(s).^{15,16} One solution may be a 2-stage hybrid procedure, whereby initially surgery is performed to replace the ascending aorta together with aortobrachiocephalic artery bypass without hypothermic circulatory arrest. This is followed on a second occasion by surgery for left carotid artery bypass and TEVAR to retrogradely place an endovascular stent-graft in the thoracic aorta transfemorally in the same setting. The stent-graft excludes the retrogradely perfused distal false lumen.¹⁷ The objective of such an approach is to avoid surgery on the arch and to complete the repair with an aortic stent-graft in a minimally invasive way. Such an approach

not only minimizes the procedural risks but also enables careful evaluation of the distal false lumen before stent-graft placement. Alternatively, 1-stage hybrid procedures combining open (surgical) insertion of an tube-graft in the ascending aorta with head vessel transposition and antegradely placing an endovascular stent-graft in the arch and descending aorta are feasible¹⁸ but require the skills of both a cardiac and endovascular specialist and lack the precision of the 2-stage hybrid procedure.¹⁹ Moreover, there is some resistance to apply such 1-stage hybrid procedures in acute type A aortic dissections, because experts are aware that the fragile outer aortic wall and friable dissecting lamella are prone to injury or perforation by antegrade positioning of the stent-graft under conditions of circulatory arrest. At present, there are no dedicated stent-grafts for the ascending aorta, in particular for the repair of aortic dissections; such challenges will certainly be addressed by customized stent-graft technology in the near future. Nevertheless, the concept of a 1-stage hybrid repair with antegrade stent-graft placement may become part of a therapeutic armamentarium for complex type A dissections with distal malperfusion; while a multistage hybrid repair incorporating retrograde stent-graft placement may become a preferred option in stable situations.

From an anatomical perspective, 30% to 50% patients with type A aortic dissection are amenable to TEVAR.^{20,21} Thus, in the future more patients may be considered suitable for TEVAR with life-long follow-up. The ultimate goal is a fully catheter-based approach to repair the ascending aorta that minimizes procedural risk and initiates healing (as documented in type B dissections in which interventional entry closure is associated with thrombosis of the false lumen and favorable aortic remodeling).^{3,4,6,7} Such approach is feasible with current technology.²²⁻²⁵ Here, we describe our 12-case series of type A aortic dissections treated using TEVAR.

METHODS**Patient Selection**

Between year 2009 and 2016, 12 patients with type A aortic dissection consisting of an isolated dissection entry in the ascending aorta, referred to the University Hospital Rostock (Rostock, Germany), CHU (Liege, Belgium), and Royal Brompton Hospital (London, United Kingdom) were selected and subjected to TEVAR. These patients were selected for TEVAR because of high comorbidities and anatomic suitability, for instance, aortic dimensions suitable to accommodate a ready-made commercial stent-graft. All had elevated anesthetic risk score (American Society of Anesthesiologists classification IV or greater), New York Heart Association class III or IV, chronic lung disease, and/or renal impairment. Decisions regarding treatment required consensus between cardiac surgeons and cardiologists, with the patients providing informed written consent. TEVAR in this setting was approved by the internal review board of each center. All patients had electrocardiogram-gated computed tomography (CT) (Figure 1) and echocardiography for the diagnosis and assessment of aortic dissection. Echocardiography allowed assessment of

the aortic valve, left ventricular function, presence/absence of tamponade, and interrogation of the supra-aortic vessels.

TEVAR Procedure

Procedural planning was based on contrast-enhanced, electrocardiogram-gated CT (**Figure 1**), which was evaluated with standard software (TeraRecon [Foster City, Calif] or 3Mensio [PIE Medical Imaging, Maastricht, The Netherlands]) to select the appropriate stent-graft size; the diameter of the stent-graft was chosen according to an estimate of the previous (before dissection) aortic dimension to avoid oversizing. The stent-grafts used were usually ZENITH TX2 (Cook, Bloomington, Ind), GORE C-Tag (Gore Ltd, London, United Kingdom), or Relay NBS (Bolton, Barcelona, Spain). They are made of a self-expanding nitinol stent platform covered with polyester fabric. They are packed and mounted onto a catheter-based delivery system.

Figure 2 and **Videos 1-3** show a typical TEVAR procedure. With the patient under general anesthesia, a temporary pacing wire was placed in the right ventricle and vascular access for the TEVAR device (22-24 F) obtained via femoral arterial cut-down. The true lumen of the aorto-ilio-femoral arterial route was navigated using a soft long hydrophilic guide wire (Terumo Medical Corp, Somerset, NJ) protruding ahead of a pigtail catheter to reach the left ventricle under fluoroscopy and ultrasound guidance (transesophageal echocardiography).²⁶ Once the pigtail is in the left ventricle, the soft hydrophilic guide wire was exchanged to a stiff 270 cm length guide wire through the pigtail catheter. The stiff guide wire has a soft coiled tip that sits within the left ventricular cavity. The stent-graft was then delivered along the stiff guide wire to its intended position, where its distal landing zone is between distal to the coronary ostia and proximal to the brachiocephalic artery in the ascending aorta. In this position, the distal tip of the delivery system may cross the aortic valve. For stent-graft deployment, rapid right ventricular pacing at 180 bpm was used to reduce the systolic blood pressure to ≤ 50 mm Hg to avoid displacement (windsock effect) of the stent-graft during its deployment, thus enabling its precise placement. At the end of the procedure, the temporary pacing wire was removed, the femoral artery access site closed, and the patient extubated and transferred to the coronary care unit. Procedural success was defined as successful placement of the stent-graft in its intended position with sealing of the entry tear.

Follow-up

Overall aortic and true lumen diameters were assessed at the level of sinotubular junction, ostium of the brachiocephalic artery, and left subclavian artery. Follow-up CT scans were performed approximately at 6 months and then annually post-TEVAR.

Statistical Analysis

Descriptive statistic was used to characterize patients, procedural data and individual survival.

RESULTS

A total of 12 patients with proximal (type A) aortic dissection were selected for TEVAR (**Table 1**). There were 10 DeBakey type II and 2 DeBakey type I dissections. The mean age $\pm$ standard deviation (SD) was 81 ± 7 years; male/female ratio was 9:3. All patients were of advanced age with chronic lung disease, coronary artery disease, and/or renal impairment. The mean EuroSCORE II was 9.1 ± 4.5 (SD). The median time from onset of symptoms/diagnosis to TEVAR was 24 days. There were 6 cases of acute (≤ 14 days after symptom onset) and 6 cases of subacute (15 days to 3 months) or chronic (>3 months)

FIGURE 1. From top to bottom: 2-dimensional transverse and coronal section of a localized proximal aortic dissection (type A) with a large entry between the aortic valve and brachiocephalic artery; 3-dimensional reconstruction prior to treatment.

FIGURE 2. TEVAR procedural sequence for placing a covered stent-graft to treat a type A aortic dissection. A, Aortogram and set-up showing a right ventricular pacing wire and transesophageal echo probe. B, Stent-graft deployment during rapid pacing. C, Completed deployment of the stent-graft. D, Aortogram demonstrating procedural success.

aortic dissections. The false lumen of the dissection expanded significantly causing various complications, including dyspnea, hoarseness, or laryngeal nerve dysfunction. There was a history of chest and back pain in all cases. There were no significant aortic insufficiency, no clinically apparent distal malperfusion syndromes and no distal interventions required.

Procedural success was 91.7% (11/12) (Table 1). There was 1 death attributable to cardiac tamponade from wire-induced perforation of the left ventricle. All remaining 11 patients were discharged alive within 2 weeks of TEVAR. The mean procedural time was 86 ± 33 (SD) minutes. Stent-grafts were deployed under rapid right ventricular pacing, which achieved a mean systolic pressure of 34 ± 15 (SD) mm Hg. The mean follow-up time was 21.1 ± 11.8 (SD) months (range 0-36 months) post-TEVAR. There were 4 deaths, one each at 15, 19, 23,

and 36 months (Table 1). All appeared to have died from natural causes. The mean survival in those who died during follow-up was 23 months.

Follow-up CT scans revealed thrombosis or remodeling of the stent-graft excluded false lumen. The diameter of the aorta at the sinotubular junction was not enlarged and remained similar to the normal aorta post-TEVAR (Figure 3).

DISCUSSION

There is general consensus that proximal aortic dissection or any major pathology involving the ascending aorta should be subjected to surgical repair; however, 10% to 30% of patients with acute type A aortic dissection are considered too high risk for surgical repair and would therefore receive only medical therapy with associated high mortality of $\approx 60\%$ in the intermediate

VIDEO 1. Before thoracic endovascular aortic repair. Digital subtraction angiogram showing a large tear in the ascending aorta and a marker pigtail, pacing wire, and transesophageal echocardiography probe in place. Video available at: [http://www.jtcvsonline.org/article/S0022-5223\(16\)31049-2/addons](http://www.jtcvsonline.org/article/S0022-5223(16)31049-2/addons).

VIDEO 3. After thoracic endovascular aortic repair. Completion angiogram after placement of the Viabahn stent-graft in the brachiocephalic artery and C-Tag stent-graft in the ascending aorta; the entry to the dissection is sealed and flow is preserved to the brachiocephalic and coronary arteries. Video available at: [http://www.jtcvsonline.org/article/S0022-5223\(16\)31049-2/addons](http://www.jtcvsonline.org/article/S0022-5223(16)31049-2/addons).

term.^{13,15,27,28} Surgical mortality is 10% to 25%^{16,27} depending on the complexity of the operation and the clinical status of the patient. In our hands, the procedural mortality of TEVAR was 8%, which compares favorably with the published early endovascular mortality of 11%.^{18,19} Interestingly, the most anticipated complications such as major stroke did not occur. One minor stroke (transient) and one death from guide wire perforation of the left ventricle leading to fatal tamponade occurred.

We estimate the number of TEVAR procedures performed in this study relative to all emergency surgeries for type A aortic dissection in our 3 centers to be $\approx 2\%$, or 6% to 17% of inoperable type A cases (assuming the incidence of type A dissection ≈ 40 cases/year for a typical aortic center; therefore across 3 centers spanning the study period of 6 years, the total number of cases = 40 cases $\times$ 6 years $\times$ 3 centers = 720 cases; generally 10% to 30% of type A dissections are inoperable¹⁵).

Successful sealing of the false lumen entry with no development of proximal type I endoleak were achieved. During follow-up, no cases of endoleak were identified

which is encouraging and different to $\approx 10\%$ incidence reported elsewhere.²⁹ In selecting the appropriate size of stent-grafts, we chose the diameter of the stent-grafts according to an estimate of the previous (before dissection) aortic dimension to avoid oversizing. The goal was to reshape the dissected ascending aorta, cover the entry tear, and depressurize the false lumen^{30,31}; there is a fine balance between fixation to the aortic wall and the degree of intimal injury caused by the self-expanding stent-graft. Once precisely deployed, however, the process of remodeling of the false lumen appears similar between the proximal and distal dissection and takes place usually within 1 year, similar to that reported elsewhere.^{32,33} Most of our cases were DeBakey type II dissections, and even in the 2 cases of type I dissection (patients 2 and 3 in Table 1), favorable aortic remodeling of the descending aorta were observed. It seems that the therapeutic concept of closing the entry and depressurizing the false lumen in type B (distal) aortic dissection holds true also in type A (ascending) aortic dissection.^{3,4} As long as the false lumen is thrombosed and depressurized, survival even with type A aortic dissection can be improved by TEVAR.³⁴ In addition, the patients' exposure to unacceptable risk of surgery is minimized.

Current literature (mostly single or small case series) underlines the feasibility of proximal endovascular procedures over more than 10 years, performed by surgeons and interventionalists (Table 2).^{22-25,30,31,33} Our series over 6 years with a mean follow-up of >20 months (range up to 3 years) underlines the fact that in the setting of significant comorbidities representing high surgical risk but with suitable anatomy, TEVAR can be a viable alternative to surgical repair. In other words, it is feasible to avoid high-risk/complex surgery and apply a less-traumatic intervention to obtain a similar or better short-term outcome in a subset of elderly patients with significant comorbidities. The advantages of TEVAR includes the avoidance of thoracotomy, cardiopulmonary bypass,

VIDEO 2. During thoracic endovascular aortic repair. Fluoroscopic display of the launch of a self-expanding Viabahn stent-graft in the brachiocephalic artery followed by a self-expanding C-Tag stent-graft covering the ascending aorta under rapid pacing. Video available at: [http://www.jtcvsonline.org/article/S0022-5223\(16\)31049-2/addons](http://www.jtcvsonline.org/article/S0022-5223(16)31049-2/addons).

TABLE 1. Patient details

Patient	Age (y), sex	Diagnosis	EuroSCORE II	SG	SG size D × L (mm)	Procedure duration (min)	Procedural complications	Follow-up (mo)
1	74 M	cTAAD (DeBakey II)	6.9	Cook	34 × 77	90	None	32
2	75 M	aTAAD (DeBakey I)	8.1	Bolton NBS	34 × 60	140	None	29
3	87 M	aTAAD (DeBakey I)	13.4	Bolton NBS	34 × 60	79	None	35
4	89 M	cTAAD (DeBakey II)	15.0	Cook	36 × 77	149	None	15*
5	90 M	cTAAD (DeBakey II)	19.3	Cook	36 × 77	70	Ventricular rupture, tamponade	0*
6	69 M	aTAAD (DeBakey II)	3.9	Cook	34 × 77	61	None	36*
7	75 M	cTAAD (DeBakey II)	4.9	Bolton NBS	34 × 60	70	None	24
8	87 M	cTAAD (DeBakey II)	9.4	Cook	36 × 77	49	Minor Stroke	15
9	87 F	aTAAD (DeBakey II, post-TAVR)	7	Optimed	32 × 50	120	None	23*
10	83 M	cTAAD (DeBakey II)	6.9	Cook	34 × 77	89	None	19*
11	75 F	aTAAD (DeBakey II)	5.9	Cook	34 × 77	60	None	5
12	75 F	aTAAD (DeBakey II)	8.9	Gore + Viabahn in innominate artery	34 × 100	60	None	0

SG, Stent-graft; D, diameter; L, length; M, male; cTAAD, subacute or chronic type A aortic dissection; aTAAD, acute type A aortic dissection; NBS, nonbare stent; F, female; TAVR, transcatheter aortic valve replacement. *Deceased.

selective head perfusion, and associated surgical risks in an elderly population, often in a critical condition.³⁵ If the high initial $\approx 60\%$ mortality of type A aortic dissection can be successfully lowered by TEVAR, such less traumatic strategy may potentially become an option in a broader spectrum of patients.²⁷ As TEVAR is a fairly expensive procedure, its associated lower risks/complications and shorter lengths of hospital stay compared with surgery may potentially demonstrate its advantages in terms of cost and clinical outcome over surgery.

TEVAR will not be feasible in every patient; the most suitable anatomy is where the entry tear of the dissection is located in the middle portion of the ascending aorta. Entry tears close to the coronaries or aortic valve lack a suitable length of landing zone. Entry tears close to the brachiocephalic artery would require complex branching/fenestration strategies. Currently, only a limited number of choices are available regarding the type of stent-graft and delivery system because relatively large diameter and short length stent-grafts are required. Existing delivery systems need to be modified for ascending aorta intervention: a long nosecone can either damage the aortic valve or increase the chance of left ventricular perforation by the stiff guide wire, as occurred in one of our patients.

On a technical note, with the use of rapid ventricular pacing no misplacement of these short stent-grafts was seen. Pacing is probably the most efficient method to avoid windsock effect of the left ventricle, enabling precise stent-graft placement. Transoesophageal echocardiography

is also useful in guiding stent-graft positioning and assessing sealing of the entry tear.²⁶

It should be emphasized that a multidisciplinary team, consisting of cardiac and vascular surgeons and cardiologists, should select suitable patients for the procedure, similar to transcatheter aortic valve replacement. Looking forward, we believe TEVAR in the ascending aorta is a definitive solution for patients not accepted for surgery, or a bridging solution in case of unclear neurological diagnosis (eg, major stroke) to buy time for reconstructive surgery. The selection process in patients not suitable for surgical valve replacement may even be conceivable for combined transcatheter aortic valve replacement-TEVAR technology, in an attempt to treat variants of aortic dissection including those with compromised aortic valve function. It also should be emphasized that in the acute setting there is a need to identify and transfer type A aortic dissection patients to a specialized unit as quickly as possible; once the dissection has produced coronary obstruction (usually the right coronary artery) with ensuing (right) ventricular infarction and heart failure, it is a difficult situation to retrieve by any intervention.

Study Limitations

Although we could demonstrate proof of concept and feasibility of TEVAR in the ascending aorta with encouraging results, we did not examine possible detrimental effects such as stiffening of the ascending aorta by the stent, lowered vascular compliance, negative

FIGURE 3. From top to bottom: 2-dimensional transverse and coronal sections of a proximal (type A) aortic dissection before (*left*) and after stent-grafting (*right*), demonstrating thoracic endovascular aortic repair reconstruction and remodeling of the aorta. The *bottom panels* demonstrate the successful intervention in 3-dimensional reconstruction.

TABLE 2. Current literature (mostly single or small case series) on proximal endovascular procedures over more than 10 years

Author	Year	n	Acute, n (%)	Stent-graft	Access route	Follow-up, mo	Early mortality, n (%)	Cause of death	Complications	Re-intervention
Dorros et al	2000	1	1 (100)	Lecteba	RFV Trans-septal	1	1 (100)	Cardiac arrest	—	—
Wang et al ²³	2003	1	1 (100)	Covered Z-stent	Aorta	12	0	—	—	—
Ihnken et al ²²	2004	1	1 (100)	Gore	—	None	0	—	—	—
Zhang et al ²⁴	2004	1	0	Gianturco Z-stent	TF	21	0	—	Aortic regurgitation	Open surgery
Zimpfer et al ²⁵	2006	1	1 (100)	Jotec	TF	1	0	—	—	—
Senay et al	2007	1	1 (100)	Medtronic	TF	None	0	—	Endoleak	—
Palma et al	2007	1	0	Braile Biomed	TF	None	1 (100)	Cardiac arrest stent migration	—	—
Ye et al ³⁰	2011	10	6 (60)	Various	2 LCCA, 8 TF	35.5	1 (10)	Gastrointestinal bleeding	—	Balloon dilatation for endoleak
Metcalfe et al ³¹	2012	1	1 (100)	Medtronic	TF	None	0	—	—	—
Gustavo et al	2012	1	1 (100)	Cook	Aorta	32	0	—	Tachycardia	—
Ronchey et al ³³	2013	4	4 (100)	Cook	TF	15 (4-39)	0	—	—	—
Bahaeddin et al	2013	1	0	Cook	TA	1	0	—	Aortic regurgitation	—
Eric et al	2013	1	1 (100)	Cook	TA	None	0	—	—	—
Kölbel et al	2013	1	1 (100)	Cook	TA	6	0	—	—	—
Frederic et al	2013	1	1 (100)	Jotec	TA	None	0	—	—	—
Lu et al	2013	15	5 (33)	Cook	—	22 (12-31)	0	—	Arrhythmia	Angioplasty and stenting of left renal artery
Yuuya et al	2014	1	1 (100)	Gore	RCA	None	0	—	—	—
Kimberly et al	2014	1	1 (100)	Medtronic	TF	None	0	—	—	—
Vallabhajosyula et al	2015	6	3 (50)	Cook Amplatzer	4 TA, 1 TF, 1 LCCA	33 (3-57)	0	—	Endoleak Stroke	Re-stenting for endoleak
Roselli et al	2015	18	9 (50)	Cook, Gore, Medtronic	5 TA, 4 TAx, 9 TF	12 median	3 (17)	Coronary obstruction, aortic rupture, tamponade	Contained aortic rupture, endoleak, stent migration, apical PA	Stent extension, open surgery

RFV, Right femoral vein; TF, transfemoral; LCCA, left common carotid artery; TA, transapical; RCA, right carotid artery; TAx, transaxillary; PA, pseudoaneurysm.

effects on the aortic valve function, or hypertension in this observational study. Our sample size is relatively small, but it represents one of the biggest case-series in the field and supports the feasibility of TEVAR in practical terms. We have no control group (medically treated or surgery) for comparison, but historical data suggests that surgery confers 25% perioperative mortality, and medical treatment is associated with 60% mortality.^{13,15,27,28} A propensity-matched comparison prior to any randomized study would probably be the next step to strengthen the data on TEVAR in the proximal aorta; current technology is unlikely to allow a broader application yet.

CONCLUSIONS

TEVAR is feasible and reveals promising early results in selected patients with proximal (type A) aortic dissection who are poor candidates for surgical repair. The current

iteration of stent-graft technology however needs to be adapted to the specific features of the ascending aorta before TEVAR as a concept emerges for broader applications in the proximal aorta.

Conflict of Interest Statement

Authors have nothing to disclose with regard to commercial support.

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