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Mid-Term Results of Fenestrated/Branched Stent Grafting to Treat Post-dissection Thoraco-abdominal Aneurysms

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WHAT THIS PAPER ADDS

This is the largest report with mid-term follow up on fenestrated/branched stent grafting for patients with post-dissection thoraco-abdominal aortic aneurysm (TAAA), following a previous report from 2014. It now includes 71 patients from two institutions experienced in advanced endovascular techniques and demonstrates that fenestrated/branched stent grafting is feasible and a promising alternative for the treatment of this complex type of pathology.

Objectives: Patients surviving acute aortic dissection are at risk of developing a post-dissection thoraco-abdominal aortic aneurysm (PD-TAAA) during follow up, regardless of the type of treatment in the acute setting. Fenestrated and branched stent grafting (F/B-TEVAR) has been used with success to treat PD-TAAA, albeit reported only with short-term results. The aim of this study was to report mid-term results in a cohort of 71 patients.

Methods: This was a retrospective analysis of a prospectively maintained database including all patients with PD-TAAAs who underwent F/B-TEVAR within the period January 2010 - April 2017 at two vascular institutions experienced in endovascular techniques.

Results: A total of 71 consecutive patients (56 male, mean age 63.8 $\pm$ 10.6 years) were treated. Technical success was achieved in 68/71 (95.8%) patients. In hospital mortality was four (5.6%) patients. Peri-operative morbidity was 19.6%. Three (4.2%) patients developed severe spinal cord ischaemia, one of these patients 12 months post-operatively. Mean follow up was 25.3 months (1—77 months). Cumulative survival rates at 12, 24, and 36 months were 84.7 $\pm$ 4.5%, 80.7 $\pm$ 5.1%, and 70.0 $\pm$ 6.7%, respectively. Estimated freedom from re-intervention at 12, 24, and 36 months was 80.7 $\pm$ 5.3%, 63.0 $\pm$ 6.9%, and 52.6 $\pm$ 8.0%, respectively. The main reasons for re-intervention were endoleak from visceral/renal arteries and iliac endoleak requiring extension. Target vessel occlusion occurred in 8/261 (3.1%) vessels (renal artery $n = 4$; superior mesenteric artery $n = 2$; coeliac artery $n = 2$). Mean aneurysm sac regression during follow up was 9.2 $\pm$ 8.8 mm, with a false lumen thrombosis rate of 85.4% for patients with a follow up longer than 12 months. No ruptures occurred during follow up.

Conclusion: F/B-TEVAR for post-dissection TAAA is feasible and associated with low peri-operative mortality and peri-operative morbidity. Mid-term results demonstrate a high rate of aneurysm sac regression. Rigorous follow up is required because of the significant re-intervention rate. Longer bridging covered stents for target vessels are advised.

Keywords: Fenestrated, Branched, Chronic dissection, Thoraco-abdominal aneurysm
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INTRODUCTION

Current guidelines recommend that Stanford type A dissections should be treated surgically, whereas uncomplicated type B dissections should be treated medically, and complicated type B dissection by thoracic endovascular repair (TEVAR).[1—3] As a result of improved management of acute aortic dissection with increased survival, the number of patients presenting with post-dissection aneurysms of the descending thoracic (PD-TAA) and the thoraco-abdominal aorta (PD-TAAA) is increasing. Aortic expansion remains the crucial factor determining long-term survival in these patients.

Until recently, PD-TAAA was addressed by open surgery. This is without doubt a demanding procedure with considerable mortality and morbidity despite current

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technical advances.[4–7] The young age of patients in studies of open PD-TAAA repair indicates careful patient selection and a significant turn down rate for this potentially fatal condition.[7]

Literature on fenestrated and branched endografting (F/B-TEVAR) for PD-TAAA is limited.[8,9] The present study group previously reported promising results in a group of 31 patients with limited follow up.[10,11] This study presents mid-term outcomes of the technique in 71 consecutive patients treated at two centres experienced in advanced endovascular techniques.

MATERIALS AND METHODS

Patient population

Prospectively maintained databases from two vascular institutions were analysed for patients who underwent elective F/B-TEVAR for TAAA between January 2010 and April 2017. Patients with thoraco-abdominal aneurysms following Type A or Type B dissection extending through the visceral segment were included in the study. Indication for treatment was the presence of thoraco-adominal aneurysmal degeneration $\geq$55 mm. Informed consent was obtained from all patients. In view of the retrospective and anonymised nature of the study, the internal review board (IRB) waived the need for medical ethical committee approval.

Planning

Pre-operative planning has been described in detail previously.[11] Patients were treated with either a custom made branched/fenestrated Cook stent graft based on the Zenith system (William A. Cook Australia, Ltd., Brisbane, Australia) or with the off the shelf Zenith t-branch thoraco-abdominal stent graft (William A. Cook Australia, Ltd., Brisbane, Australia).

Preservation of the left subclavian artery and pelvic circulation was always targetted, to reduce the risk of spinal cord ischaemia (SCI). This was achieved by the use of carotid-subclavian debranching or an additional fenestration/branch for the left subclavian artery and the use of an iliac bifurcation device (IBD) for common iliac artery involvement. In several cases, landing in a dissected common iliac artery with an oversized limb was attempted with the aim of pushing the dissection flap against the wall and achieve false lumen thrombosis in the mid-term.

Gradually, staging strategies were applied in both institutions to reduce the risk of SCI. With fenestrated grafts, staging was carried out either by deployment of the thoracic tube graft(s) as a first step and subsequent deployment of the fenestrated component as well as all bridging stent grafts 4–6 weeks after the initial procedure, or by delayed deployment of the contralateral iliac limb. For branched grafts, staging was carried out by means of temporary sac perfusion (TASP)[12] through an open branch for the coeliac artery (CA), which was secured 2–4 weeks following the initial procedure.

The protocol of the endovascular procedure was described in detail in a previous paper.[11] Intra-operative monitoring of motor evoked potentials (MEPs) was increasingly applied in the latter part of the series in Regensburg.

A spinal catheter was applied in all cases and spinal fluid was drained at the start of the procedure until 48–72 h after the procedure. Systolic blood pressure was kept normotensive to hypertensive to increase perfusion of the spine through collateral circulation.

Primary technical success was defined as a procedure completed endovascularly with absence of type I or III endoleak and patent target vessels. Assisted technical success included patients in whom an additional retroperitoneal approach was required to facilitate renal artery catheterisation via retrograde puncture. Planned laparotomy for the sake of CA debranching was not considered technical failure.

Follow up and data analysis

The follow up protocol has been described previously.[11] Data analysis was performed with SPSS for Windows (version 20.0; SPSS Inc, Chicago, IL, USA). Variables are presented as mean $\pm$ standard deviation (SD) in case of normal distribution, and median plus range if data had a skewed distribution. Statistical significance was set at $p < .05$. Patient survival, target vessel patency, and freedom from re-intervention were analysed using Kaplan–Meier methodology. To ensure complete follow up, all patients or relatives were phoned by the investigators if needed.

RESULTS

Patient characteristics

A total of 71 consecutive patients (56 male, mean age 63.8 $\pm$ 10.6 years) underwent elective F/B-TEVAR for PD-TAAA. ASA classification, patient demographics, and comorbidity are presented in Table 1.

The median interval from the primary acute dissection to treatment of the PD-TAAA was 45 months (range 1–192 months). Table 2 lists the number and type of aortic procedures prior to F/B-TEVAR, as well as the length of aorta covered during the initial procedure. The mean maximum aneurysm diameter at the time of F/B-TEVAR was 65.9 $\pm$ 9.1 mm. The origins of target vessels from the true or false lumen are presented in Table 3.

Operative planning and details

All patients were treated with proximal thoracic tube grafts followed by the fenestrated/branched component. In seven patients (9.8%) with an inadequate proximal landing zone at the level of the left subclavian artery (LSA), a carotid-subclavian bypass ($n = 6$) or an additional fenestration for the LSA ($n = 1$) was applied. Custom made devices were used in 69 (97.2%) patients, in two (2.8%) patients the off the shelf Zenith t-branch endograft was used. Distal landing took place at the level of the infrarenal aorta in 22 (31%) patients and in the common iliac arteries in 44 (62%)

Table 1. **Patient comorbidities and ASA classification in 71 consecutive patients undergoing elective F/B-TEVAR**

Comorbidity risk factor	Patients *n* (%)
CAD	42 (59.2)
Congestive heart failure	18 (25.3)
Hypertension	62 (87.3)
COPD	33 (46.5)
Smoking (current or past)	48 (67.6)
Diabetes mellitus	7 (9.8)
Hypercholesterolemia	60 (84.5)
Serum Cr >100 μmol/L	(32.3)
Previous stroke/TIA	3 (4.2)
Marfan syndrome	2 (2.8)
Loeys-Dietz syndrome	1 (1.4)
ASA II	26 (36.6)
ASA III	39 (54.9)
ASA IV	6 (8.5)
Acute event	
Type A dissection	15 (21.1)
Type B dissection	56 (78.9)

CAD = coronary artery disease; COPD = chronic obstructive pulmonary disease; F/B-TEVAR = Fenestrated and branched stent grafting; TIA = transient ischaemic attack.

patients. In 14 of these patients the dissection extended up to or below the orifice of the internal iliac artery. In the remaining five (7%) patients, sealing took place in the external iliac artery by use of an IBD unilaterally ($n = 4$) or bilaterally ($n = 1$).

In total, 261 visceral vessels (renal artery $n = 130$; accessory renal artery $n = 2$; superior mesenteric artery (SMA) $n = 71$; CA $n = 58$) were targetted. One hundred and ninety three target vessels were targetted with fenestrations, and 68 with downward branches (Table 3). Two CAs were surgically reimplanted in the SMA via laparotomy as planned, in one case three weeks prior to and in one case during F/Br-TEVAR. In the case of two severely stenosed CAs, no fenestration/branch was planned and the CA was overstented.

Table 2. **Previous aortic procedures with length of aortic coverage distal to the left subclavian artery**

Previous aortic procedures	Patients ($n = 71$) *n* (%)
No procedure	18 (25.3)
One procedure	30 (42.3)
Two procedures	20 (28.2)
Three procedures	3 (4.2)
Type of previous procedure	
Open thoracic aortic repair	23 (29.1)
TEVAR	45 (57.0)
Open abdominal aortic repair	3 (3.8)
EVAR	8 (10.1)
Length of coverage from LSA	
No coverage	22 (31)
5–10 cm	4 (5.6)
11–15 cm	13 (18.3)
16–20 cm	23 (32.4)
>20 cm	9 (12.7)

TEVAR = thoracic endovascular aneurysm repair; EVAR = endovascular aneurysm repair; LSA = left subclavian artery.

A staged approach was employed in 29 (40.8%) patients. In 14 patients staging was carried out with the TASP technique through an open branch for the CA, in 10 patients by deployment of the thoracic tube grafts and subsequent deployment of the fenestrated/branched component 4–6 weeks later, and in five patients by delayed deployment of the iliac limb 2–4 weeks after the main procedure.

Implantation of the fenestrated/branched graft was carried out under general anaesthesia in all patients. The median operation time for the main procedure was 260 min (range 90–690 min), with a median fluoroscopy time of 61.5 min (range 19–130 min), and a mean iodinated contrast volume use of 249 ± 94.9 mL.

Technical success and operative outcome

Primary technical success was achieved in 67/71 patients (94.4%) and assisted technical success in 68/71 (95.8%) patients. One patient underwent conversion because of deployment of the fenestrated tube graft into the false lumen. In the second patient, catheterisation of the left renal artery was not feasible and a second stage transbrachial approach was also unsuccessful. In the third patient, catheterisation of both SMA and CA was not successful. Intra-operative angiography showed no endoleak and the vessels were left unstented. At 30 months, a type IB endoleak was diagnosed and the SMA stented with success, while the severely stenosed CA was overstented. Finally, in one patient with a severely tortuous renal artery, antegrade catheterisation was not feasible and a retrograde catheterisation was carried out via a retroperitoneal approach to the distal segment of the renal artery.

Four early deaths occurred, accounting for an in hospital mortality of 5.6%. The first patient died from multiple organ failure following intestinal micro-infarction. The second patient suffered a deterioration of his cardiac function following a technically successful procedure, resulting in cardiac failure and death. The third case involved the patient with the unsuccessful renal artery catheterisation. During the second procedure via a transbrachial approach he suffered a perforation of the left subclavian artery, resulting in mediastinal bleeding and death. The fourth patient became dialysis dependent following a collapse of the proximal thoracic tube graft on the fourth post-

Table 3. **Origin of visceral vessels targetted with fenestrations and branches**

Target vessel	TL		FL		Total
	Fen	Branch	Fen	Branch	*n*
RRA	51[a]	10	4	2	67
LRA	48[b]	10	5	2	65
SMA	52	18	0	1	71
CA	33	25	0	0	58
All	184	63	9	5	261

TL = true lumen; FL = false lumen; Fen = fenestration; RRA = right renal artery; LRA = left renal artery; SMA = superior mesenteric artery; CA = coeliac artery.

[a] Includes one accessory right renal artery.

[b] Includes one accessory left renal artery.

operative day. Inadvertent puncture of the aorta during placement of a dialysis catheter 30 days following the procedure resulted in haemorrhagic shock and death.

Major complications occurred in 13 (18.3%) patients, in two (2.8%) related to renal function deterioration and in 11 (15.5%) to SCI. Both patients with renal complications had pre-existing renal insufficiency and became dialysis dependent following deterioration of their renal function despite having patent renal arteries. Eleven patients suffered symptoms of spinal cord ischaemia (SCI) peri-operatively. In nine (12.7%) patients, SCI was temporary with paresis of one (n = 2) or both (n = 7) lower extremities, with complete recovery at the time of discharge. Two (2.8%) patients suffered severe SCI with paraplegia that partly recovered to paraparesis at discharge. Both patients had patent subclavian and internal iliac arteries. In one case the procedure was carried out without staging, in the second patient severe SCI occurred despite temporary aneurysm perfusion via an open CA branch. A comparison between the staged and non-staged groups showed a lower rate of SCI for the staged group (13.8% vs. 17.5%). This difference was not significant statistically ($p = .75$).

Median hospital stay was 11 days (range 6—48 days). Median intensive care and intermediate care unit stay was three days (range 1—47) days.

Follow up

During a mean follow up of 25.3 months (1—77 months) all cause mortality was 14 patients, 13 of them aneurysm unrelated. One patient presented in an external hospital 450 km away at 41 months, 4 days following radical open prostatectomy and pelvic lymphadenectomy, with disconnection of the thoracic and fenestrated/branched tube grafts as well as occlusion of the CA and SMA. The stent grafts were relined with an additional thoracic tube graft and both visceral vessels were recanalised. The patient died from complications of bowel ischaemia, despite laparotomy and partial colectomy. This patient had not attended scheduled follow up since the procedure. Estimated overall survival rates at 12, 24, and 36 months were 84.7 $\pm$ 4.5%, 80.7 $\pm$ 5.1%, and 70.0 $\pm$ 6.7%, respectively. Fig. 1A demonstrates the cumulative survival curve as estimated by Kaplan—Meier analysis.

One patient developed late onset permanent paraparesis. This patient underwent an uneventful procedure. Initial and six month CTAs showed a type II endoleak. At 12 months the patient presented in the outpatient clinic for follow up with existing two week history of paraparesis and incontinence. CTA showed spontaneous occlusion of the endoleak.

Target vessel patency. Occlusions occurred in 8/261 (3.1%) target vessels (renal artery $n = 4$; SMA $n = 2$; CA $n = 2$). In six cases vessels had been originally targetted with branches and in two cases with fenestrations. In one case, occlusion of the right renal artery 6 months post-operatively was successfully treated with an iliac-renal bypass. In a second patient with pre-existing occlusion of the left renal artery, occlusion of the right renal artery occurred 21 months post-operatively following a colonoscopy. Thrombosuction was carried out and the renal artery was partially recanalised; however, the patient became dialysis dependent. In one patient described previously, the CA and SMA occluded following disconnection of the thoracic and fenestrated/branched tube grafts. In the remaining four cases, occlusions were asymptomatic and noted during follow up CTA. Cumulative target vessel patency at 12, 24, and 36 months was 98.6 $\pm$ 0.8%, 97.2 $\pm$ 1.3%, and 96.3 $\pm$ 1.6%, respectively (Fig. 1B). There was a higher occlusion rate for vessels targetted with branches in comparison with vessels targetted with fenestrations ($p = .001$), as well as for vessels originating from the false lumen ($p = .009$).

Endoleaks and re-interventions. Endoleaks were detected in 29 (32.4%) patients. Ten (14.1%) patients had a type Ib endoleak from the distal sealing zone of target vessels. Four (5.6%) patients had a type Ib endoleak from the common iliac artery. Three (4.2%) patients had a combination of both target vessel and iliac artery Ib endoleaks. Two (2.8%) patients had a type III endoleak, one involving renal artery stent graft dislocation from the fenestration of the main aortic graft and the second involving the patient with the disconnection of thoracic and fenestrated/branched components following pelvic lymphadenectomy. Ten (14.1%) patients presented with type II endoleaks.

Reasons for re-interventions, as well as re-intervention type and time are presented in Table 4. All type Ib endoleaks from target vessels were treated by stent graft extension into the respective vessel. Type III endoleaks were treated by relining of the renal artery stent grafts in one case and relining of the thoracic tube graft with the fenestrated/branched tube in the second case. Five iliac type Ib endoleaks were treated by unilateral ($n = 5$) or bilateral ($n = 1$) IBDs. In one patient an additional re-intervention was required because of a persisting endoleak from a dissected internal iliac artery. The IBD was occluded and a bypass from the external to the internal iliac artery was carried out. Two distal type Ib endoleaks were treated by occlusion of the internal iliac artery and iliac limb extension to the external iliac artery. In two cases, type II endoleaks were treated by lumbar embolisation. A persistent type II IMA endoleak after preoperative coiling was treated by laparoscopic clipping. In one case, a renal artery stenosis was treated by balloon angioplasty. Finally, two renal artery occlusions were treated by thrombosuction in one patient, and by iliac renal bypass in the second patient. Estimated freedom from re-intervention at 12, 24, and 36 months was 80.7 $\pm$ 5.3%, 63.0 $\pm$ 6.9%, and 52.6 $\pm$ 8.0%, respectively (Fig. 1C).

Aneurysm sac behavior. Mean aneurysm sac regression during follow up was 9.2 $\pm$ 8.8 mm. Of the 48 patients that completed a one year follow up, complete false lumen thrombosis was noted in 41 (85.4%) patients. In seven cases residual perfusion of the false lumen was noted. The reason was a type II endoleak in four patients, and a type Ib endoleak in three patients. Type II endoleaks were not

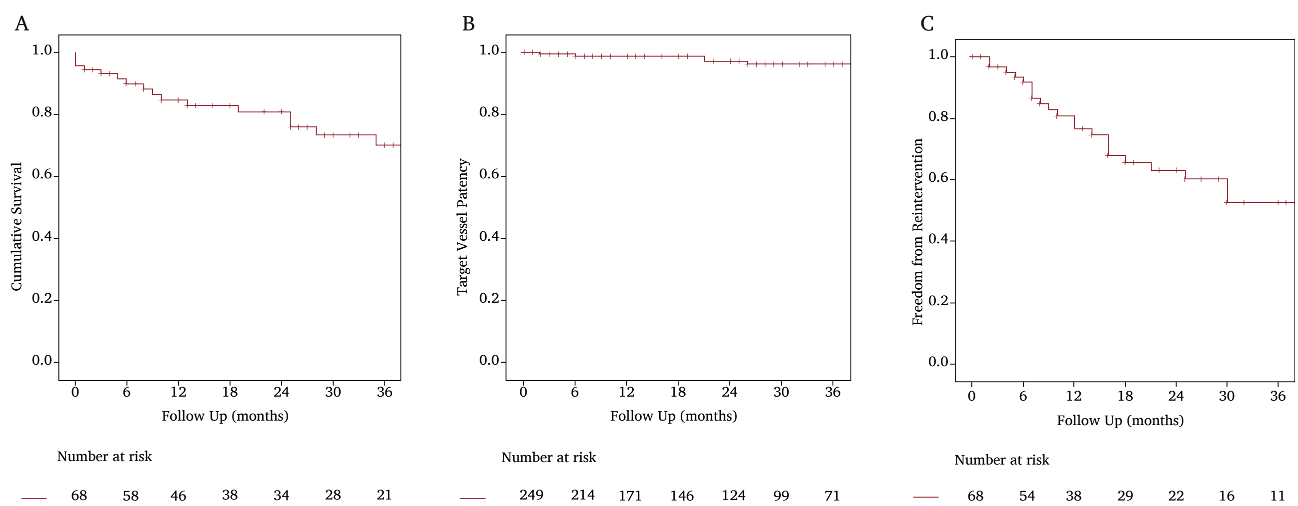

Figure 1. Kaplan–Meier estimates of (A) cumulative overall patient survival for all cause mortality, (B) target vessel patency, and (C) freedom from re-intervention during follow up.

Table 4. Reason for re-intervention, time and type of re-intervention, main graft configuration for the respective vessel, and bridging stent graft(s) originally applied

Reason for Re-int	Re-int. type	Re-int. time, months	Fen/Br	Stent graft
Type Ib RRA/SMA	Relining RRA/SMA	4	Fen/Fen	BESG/BESG
Type Ib LCIA	IBD LCIA	51		
Type Ib LCIA	IBD LCIA	5		
	Bypass LEIA to LIIA and extension to LEIA	12		
Type Ib RRA/LRA	Relining RRA/LRA;	2	Fen/Fen	BESG/BESG
Type Ib RCIA	Extension to REIA	50		
Type Ib LRA	Relining LRA	30	Fen	BESG + SEMS
Type II	Lumbar embolisation	6		
Type Ib LCIA	IBD LCIA	48	Fen	BESG
Type Ib LRA	Relining LRA	55		
Type Ib SMA/CA	Stent SMA + overstenting CA	30	Fen/Fen	Not stented
Type Ib unclear origin	Relining SMA/RRA/LRA	36	Fen/Fen/Fen	BESG/BESG/BESG
Type Ib CA	Stent CA	12	Fen	BESG
Type II	Lap clipping IMA	2		
Stenosis LRA	PTA LRA	8	Fen	BESG
Type Ib CA	Relining CA	7	Br	SESG
Type Ib LRA	Relining LRA	7	Fen	BESG + SEMS
Type Ib LRA	Relining LRA	14	Fen	BESG + SEMS
Type Ib LRA	Relining LRA	9	Fen	BESG
Type II	Lumbar embolisation	10		
Type III (disconnection)	TEVAR + relining CA/SMA	41		
RRA occlusion	Thrombosuction RRA	21	Br	BESG
Type Ib RCIA/LCIA	Bilateral IBD	16		
Type Ib LCIA	IBD LCIA	18		
Type Ib SMA/LRA	Relining SMA/LRA	25	Fen/Fen	BESG/BESG
Type III LRA	Relining LRA	16	Fen	BESG
Type Ib RRA	PTA RRA	12	Fen	BESG + SEMS
Type Ib RCIA	Extension to REIA	16		
Occlusion RRA	Iliac-renal bypass RRA	7	Fen	BESG + SEMS

Re-int. = re-intervention; Fen = fenestration; Br = branch; RRA = right renal artery; SMA = superior mesenteric artery; BESG = balloon expandable stent graft; SESG = self expandable stent graft; SEMS = self expandable metallic stent; LCIA = left common iliac artery; IBD = iliac branched device; LEIA = left external iliac artery; LIIA = left internal iliac artery; LRA = left renal artery; CA = coeliac artery; IMA = inferior mesenteric artery; PTA = percutaneous transluminal angioplasty; TEVAR = thoracic endovascular aneurysm repair; RCIA = right common iliac artery.

associated with aneurysm growth and were treated conservatively. One patient had a small type Ib endoleak from a dissected SMA, which has not been treated because of stable aneurysm size. Two patients had a type Ib endoleak from the CA. One of these patients suffered a temporary paraparesis following the initial procedure and refused further treatment. This patient died from aneurysm unrelated causes two years following the procedure. The second patient with connective tissue disease (Loeys-Dietz syndrome) was treated by overstenting of the stenotic CA, extension of the SMA stent and relining of the RRA and LRA stents. The patient still has a persisting endoleak at the level of the CA but currently declines further treatment. Aneurysm sac behavior in patients who completed a 12 month follow up is detailed in Table 5.

DISCUSSION

Patients who develop a PD-TAAA represent a serious challenge for treatment. Historically, open surgical repair has been associated with high mortality and morbidity rates.[4,13] According to a recent review, in contemporary studies mortality is 7.5%, while the incidence of stroke is 5.9%, paraplegia/paralysis 4.1%, and renal ischaemia complications 8.1%.[7] Notably, all of these studies pool thoracic and thoraco-abdominal aneurysms together, while median patient age is low at 58.6 years. Results solely for TAAA in chronic dissection reveal high peri-operative morbidity and major peri-operative adverse outcome rates ranging from 25.2% to 45.2%.[6,14,15] TEVAR alone is associated with improved peri-operative results but fails to address the issue of continuing aortic expansion and false lumen patency below the level of stent graft, and is not a treatment option for TAAA in chronic dissection.[16,17] Recently, TEVAR combined with false lumen embolisation techniques has been reported in a small number of patients. This is a promising technique for aneurysms limited to the thoracic aorta; however, currently patient numbers as well as follow up have been very limited.[18]

The present study group has previously reported early results for F/B-TEVAR in PD-TAAA patients.[11] The current study demonstrates result consistency in an extended patient group with longer follow up.

Table 5. Aneurysm sac behavior in relation to thrombosis of the false lumen in 48 patients with a 12 month follow up

	False lumen thrombosis		Total
	Yes	No	
Decrease (<−5 mm)	33[a] (68.7%)	0	33 (68.7%)
Stable (−5 mm to 5 mm)	8[b] (16.7%)	7[c] (14.6%)	15 (31.3%)
Increase (>5 mm)	0	0	0
Total	41 (85.4%)	7 (14.6%)	48 (100%)

[a] Includes 12 patients with false lumen thrombosis following re-intervention.
[b] Includes seven patients with false lumen thrombosis following re-intervention.
[c] Includes one patient with persisting type Ib endoleak despite re-intervention.

Technical success remains high despite the technical difficulties in planning and execution of the procedure that have previously been discussed extensively.[11]

Peri-operative mortality is low considering the complexity of the pathology. Notably, peri-operative mortality as well as estimated survival rates have somewhat improved in comparison with the previous report. This can partly be attributed to ASA IV patients being over represented in the previous study, and that the treatment rationale is currently more conservative in significantly comorbid patients. In addition, a learning curve has to be accepted.

Whereas renal and cardiac peri-operative morbidity is fairly low, the rate of SCI remains significant. In the vast majority of cases, SCI was temporary, with only two patients developing permanent paraparesis. Recent studies have underlined the importance of staging to prevent SCI in thoraco-abdominal aneurysm repair.[11,19] Following these new insights, staging protocols have been introduced in both institutions for all patients undergoing TAAA repair. Results show a tendency for lower SCI in the staged group, although this difference did not reach statistical significance. A further point to consider is the type of staging protocol that is best suited for TAAAs in chronic dissection. TASP can be applied in the case of branched endografts. In fenestrated endografts with apposition to the aortic wall, delayed deployment of the bifurcated graft or iliac limb could prove helpful, or a two stage approach with TEVAR first while waiting for the custom made graft to be delivered. As one patient developed very late onset paraparesis 12 months after the procedure, this indicates that patients with extensive stenting of the thoraco-abdominal aorta are probably still at risk of spinal cord ischaemia following any change of spinal perfusion.

To further reduce the risk of severe SCI, a combination of peri-operative measures has been reported in recent literature.[19–21] These include cerebrospinal fluid (CSF) drainage for all extensive repairs, aggressive correction of intravascular volume, haemoglobin, and arterial blood pressure, rapid reperfusion of hypogastric arteries and lower limbs and the shortest possible visceral artery ischaemic times.

The high endoleak rate and number of re-interventions during follow up is a serious concern, with almost half of the patients having undergone a re-intervention after 36 months. The most common reason for re-intervention in PD-TAAA is type Ib endoleaks from target vessels. In F/B-TEVAR for atherosclerotic TAAA, bridging stent grafts are oversized roughly one mm and, in the case of fenestrated grafts, flared with a larger PTA Balloon. A sealing length of 15–20 mm inside the target vessels is advised. In PD-TAAA this sealing length is associated with an increased rate of type Ib endoleaks in the mid-term. It seems therefore advisable to use longer bridging stent grafts to seal deeper into the target vessel, compared with standard TAAA. The second most frequent reason for re-interventions was distal type Ib endoleaks from dissected iliac arteries. In 14 patients distal sealing took place in dissected common iliac arteries. Seven of these patients required additional measures because of ongoing retrograde false lumen perfusion.

These procedures are obviously listed as re-interventions in the manuscript, but the present authors prefer to see them as an additional option of a staged approach and seal off distally with an IBD if the endoleak persists.[22] With one exception, all type Ib endoleaks were successfully addressed by minimally invasive means. Target vessel patency, as reported with fenestrated/branched grafts is very good in the mid-term, also in this pathology, with only three patients requiring re-intervention because of vessel stenosis/occlusion. The tendency for a higher branch occlusion rate in TAAA repair has been reported in the literature.[23] It is unclear whether the differences seen between the two configurations is attributable to branch versus fenestration design or aneurysm morphology, as branches are generally used when the distance to target vessels is longer and when a switch must be made between true and false lumen. Furthermore, in two of six cases, branch occlusions occurred after separation of stent graft components following open pelvic lymphadenectomy and were not directly attributable to branch design.

Notably, these series include three patients with connective tissue disorders (CTD) who were unfit for open surgery and were treated by F/B-EVAR. In one of these patients, it was not possible to completely seal a type Ib endoleak, despite relining of three target vessels and overstenting of the fourth. The durability of an endovascular repair in patients with CTD is questionable, and, therefore, open repair remains the treatment of choice for this patient subgroup. Ultimately, F/B-TEVAR led to a high rate of assisted complete false lumen thrombosis and significant aneurysm regression in patients who completed a 12 month follow up. Contrary to TEVAR, treatment with fenestrated and branched endografts can lead to complete exclusion of the TAAA in chronic dissection and may constitute a more durable solution for this type of pathology.

The limitations of this study are those of an observational study. The number of patients is small, and duration of follow up still limited. This is also a selected patient population and a certain referral bias must be acknowledged. The outcomes in this study may not be generalisable as the operations were performed in two tertiary care high volume centres with accumulated expertise in F/B-TEVAR.

CONCLUSION

F/B-TEVAR for TAAA in chronic aortic dissection is feasible and associated with low peri-operative mortality and acceptable peri-operative morbidity. Mid-term results demonstrate a high rate of complete false lumen thrombosis and aneurysm regression. Rigorous follow up is required because of the significant re-intervention rate. Whereas some distal re-interventions could be explained by a staging strategy, it is advisable to use longer bridging covered stents in PD-TAAA.

CONFLICT OF INTEREST

Eric L.G. Verhoeven received educational grants and is a consultant for Cook Inc., W.L. Gore & Associates, Siemens, Atrium-Maquet, and Medtronic. Piotr Kasprzak received educational grants and is a consultant for Cook Inc., W.L. Gore & Associates, Bard, Atrium-Maquet, Medtronic and Vascutek.

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COUP D'OEIL

'If You Fall Down, You Have to Climb up Again'

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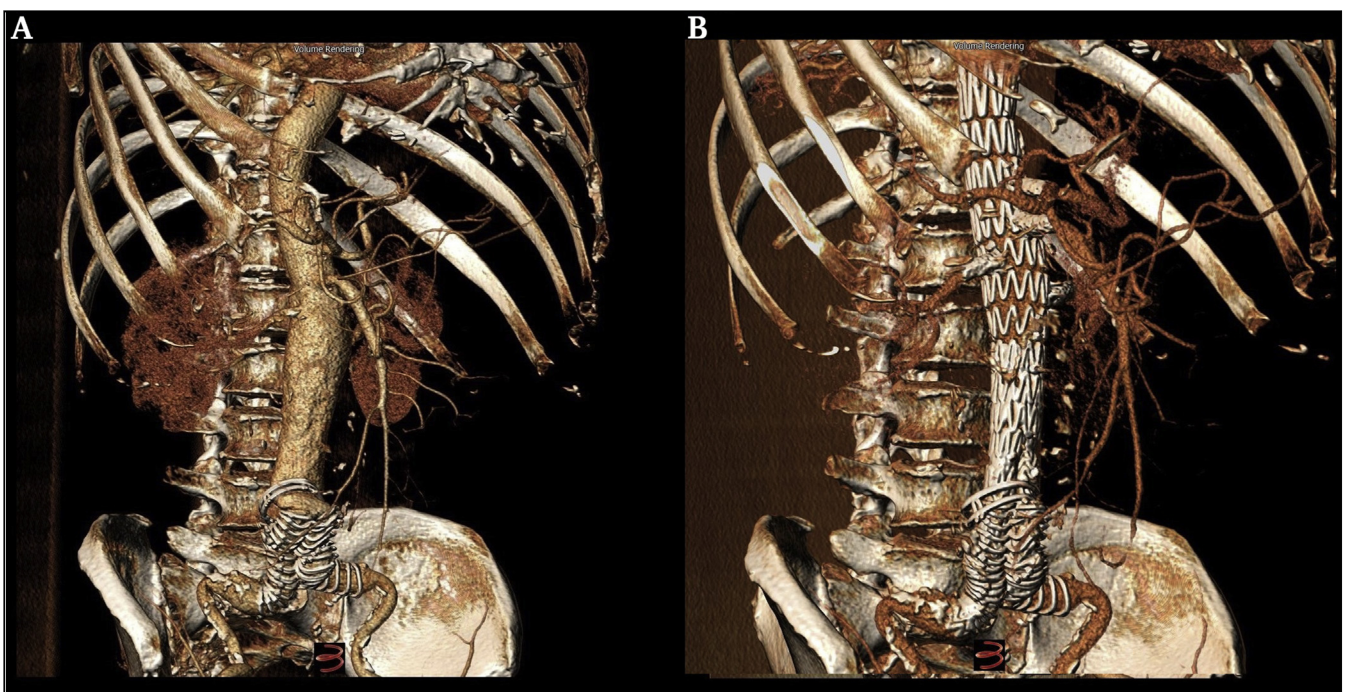

A 69 year old male presented at the outpatient clinic concerned about being able to palpate his aneurysmal pulsation. He had had endovascular repair five years previously with a 34 mm Anaconda stent graft (Terumo Aortic, Inchinnan, UK) at another vascular centre, but failed to attend follow up appointments for personal reasons. Computed tomography angiography (CTA) revealed caudal migration of the stent graft towards the iliac bifurcation (panel A). Redo aneurysm exclusion was successfully achieved with a four fenestration stent graft (Zenith, Cook Aortic Intervention, Bloomington, IN, USA) with all splanchnic vessels patent with good fixation of the stent graft and no endoleak on follow up (panel B).

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