Avoidance of Proximal Endoleak Using a Hybrid Stent Graft in Arch Replacement and Descending Aorta Stenting

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Background. **In complex thoracic aortic procedures, proximal repair and antegrade stent grafting of the descending aorta is an emerging technique to achieve one-stage treatment of the thoracic aorta. To overcome problems of proximal endoleak, a hybrid stent graft was designed and used. This study assessed technical feasibility and early results.**

Methods. **From Jan 2005 to May 2008, 41 patients (age, 60 ± 13 years) comprising 35 aortic dissections (AD) and 6 aortic aneurysms underwent arch replacement and antegrade stent grafting of the descending aorta using the hybrid stent graft. Endoleaks were evaluated by computed tomography (CT) scans. In AD cases, the false lumen (FL) was evaluated with CT volume measurements.**

Results. **Combined arch replacement and antegrade stent grafting was technically successful. One proximal endoleak was observed, which was not related to the hybrid prosthesis (40 of 41, 98%). Three patients died (7%). No paraplegia occurred. Incidence of immediate FL thrombosis was 97% at the proximal and 80% at the distal stent graft level. During follow-up (17 ± 11 months), complete thrombosis of the perigraft space was 91%. FL volume shrinkage was documented ($p < 0.01$). No perfusion of the perigraft space was observed in aneurysm cases. Intermediate survival was 33 of 38 (87%).**

Conclusions. **One-stage repair of complex thoracic aortic disease using a hybrid stent graft can be reliably performed with low hospital mortality. Proximal endoleak can be definitely avoided; in AD, exclusion and ongoing significant shrinkage of the FL can be achieved.**

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In aortic dissection (AD) or aortic aneurysm resulting in aortic arch and descending aortic disease, arch replacement and open antegrade stent grafting of the descending aorta in an elephant trunk like fashion represents an emerging surgical technique to achieve extensive thoracic aortic repair through a median sternotomy. This method was first reported in the 1990s using hand-made stent grafts, and we as others, adopted this technique using specially designed self-expandable aortic stent grafts [1–5]. However, the experience with endovascular thoracic aortic repair indicated that the use of an aortic stent graft may not be a definitive aortic treatment [6, 7]. Potential problems such as proximal endoleak or aneurysm development at the site of the untreated distal aorta can occur and require secondary interventions [8, 9].

To overcome a proximal endoleak, a novel hybrid stent graft prosthesis was designed and serially used for aortic arch replacement and antegrade stent grafting of the descending aorta. In the present study, the characteristics of the aortic pathology around the stent grafted and distal aortic site were documented postoperatively and reevaluated in the follow-up period.

Patients and Methods

Between Jan 2005 and May 2008, 41 of 314 consecutive thoracic aortic patients underwent proximal aortic replacement and antegrade stent grafting of the descending aorta using the E-vita open (JOTEC GmbH, Hechingen, Germany) hybrid stent graft prosthesis. Patients were a mean ± SD age of 60 ± 13 (range, 34 to 78) years, and 31 were men (76%). Owing to the retrospective character of the study the chairman of the Ethics Committee waived the need for patient consent.

Dr Jakob discloses that he has a financial relationship with JOTECH GmbH.

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Table 1. Patient Characteristics According to Aortic Disease

Aortic disease Mean ± SD, or No. (%)	Acute AD (n = 22)	Chronic AD (n = 13)	TAA (n = 6)
Age, y	61 ± 12	54 ± 14	69 ± 5
Male	15 (68)	13 (100)	3 (50)
Emergency	21 (95)	1 (8)	1 (17)
Adrenergic drugs, pre-op	9 (41)	1 (8)	1 (17)
Prior cardiovascular operation	1 (5)	7 (54)	0
Prior endovascular aortic repair	1 (5)	1 (8)	0
Aortic valve regurgitation ≥ 2	12 (55)	2 (15)	0
Coronary artery disease	6 (27)	1 (8)	2 (33)
Hypertension medication	15 (68)	13 (100)	5 (83)
Peripheral vascular disease	2 (9)	2 (15)	3 (50)
COPD	4 (18)	3 (23)	3 (50)
Diabetes mellitus	2 (9)	0	2 (33)
Chronic renal failure	7 (32)	2 (15)	3 (50)
History of stroke	4 (18)	0	1 (17)

AD = aortic dissection; COPD = chronic obstructive pulmonary disease; SD = standard deviation; TAA = thoracic aortic aneurysm.

Acute aortic dissection (AD) was the indication for operation in 22 of the 41 patients (54%), comprising 21 with acute type A and 1 with complicated acute type B AD); 13 (31%) had chronic AD, consisting of 8 chronic type A, 5 complicated chronic type B; and 6 (15%) had for extensive thoracic aortic aneurysm (TAA). Operations were emergencies in 23 (56%); of these, 21 had acute type A AD, 2 had contained aortic rupture after chronic type B and TAA, respectively. Treatment was urgent in 3 hemodynamically stable patients (7%) due to progressive aortic symptoms after acute type B AD in 1 and chronic type A AD in 2. Redo procedures were required in 7 patients (54%) with contained AD 7 ± 3 years after ascending aortic replacement for acute type AD (Table 1).

In 32 of 35 (92%) patients with AD, the false lumen (FL) extended into the abdominal aorta. All acute type A patients were operated on for DeBakey type I AD. The indications for extended aortic repair in AD by antegrade stent grafting are listed in Table 2. In the TAA patients, the operation was performed for TAA complicated by penetrating atherosclerotic ulcer in the distal aortic arch in 4 and for a progressive arch and descending aortic aneurysm in 2 (aortic diameter, 6.4 ± 0.5 cm).

All patients were diagnosed preoperatively by computed tomography (CT) and transesophageal echocardiography (TEE). The diagnosis was supplemented by angiography in all elective procedures as well as in 17 of 23 (74%) emergency procedures with suspected malperfusion or unknown coronary artery status. Six patients underwent endovascular abdominal aortic repair in our hybrid operating room before the aortic operation.

Hybrid Stent Graft Prosthesis, Application, and Sizing

The E-vita open stent graft prosthesis consists of a 15-cm-long and nitinol stented polyester prosthesis with diameters between 24 and 40 mm for descending stent grafting and an integrated unstretched 7-cm-long nonstented woven graft for arch replacement. The detailed characteristics and development of the E-vita open were reported previously [10]. Care had been taken in the design of the prosthesis to ensure an uninterrupted continuity between the grafts.

The stent graft was introduced into the descending aorta over a stiff guidewire in antegrade fashion. The wire was placed in the proximal descending aorta through a 6F sheath in the femoral artery, guided by TEE. The size of the stent graft was determined by CT measurements of the descending aorta and intraoperatively using highly bendable nitinol obturators (Fehling Instruments GmbH & Co. KG, Karlstein, Germany). In patients with AD, the size of the stent graft was adjusted to the diameter of the true lumen (TL), and oversizing beyond 10% was avoided. Therefore, in one elective patient with chronic AD, a custom-made stent graft with a diameter of 22 mm was used. Care had been taken to avoid distal landing beyond Th9. Thus, in 1 TAA patient (150-cm body height) a custom-made stent graft 10 cm in length was used.

Extended Hybrid Aortic Operation

The surgical technique has been reported previously [11]. In brief, after proximal aortic repair and resection of the aortic arch, antegrade stent grafting of the descending aorta was performed during a short period of hypothermic circulatory arrest at 25°C under selective bilateral cerebral perfusion (18°C, 10 to 15 mL/kg/min.). After stent graft deployment, a continuous suture line between the slightly retracted woven graft and the descending aortic stump was performed. The anastomosis was stabilized externally with Teflon felt (Impra Inc, subsidiary of L.R. Bard, Tempe, Arizona). Thereafter, the inverted

Table 2. Primary Entry and Reentry Sites and Indication for Antegrade Stent Grafting in Aortic Dissection

Aortic disease No. (%)	Acute AD (n = 22)	Chronic AD (n = 13)
Primary entry		
Ascending aorta	11 (50)	1 (8)
Aortic arch	10 (45)	7 (54)
Left subclavian artery	0	2 (15)
Descending aorta	1 (5)	3 (23)
Descending aorta pathology indicating stent grafting		
Reentry	12 (55)	0
Full circular dissection	5 (23)	0
Reentry + circular dissection	2 (9)	0
Aortic rupture	2 (9)	2 (15)
Severe atherosclerosis	1 (5)	0
Growing of false lumen	0	11 (85)

AD = Aortic dissection.

Table 3. Intraoperative Data and Operative Procedures in Addition to Antegrade Stent Grafting of the Descending Aorta

Variable	Value (N = 41)
Continuous	Mean ± SD
CPB time, min	248 ± 56
Cross-clamp time, min	138 ± 33
SACP time, min	65 ± 17
HCA time, min	11 ± 8
Categoric	No. (%)
Ascending aortic replacement	40 (98)
Total arch replacement	41 (100)
AV repair/replacement	17 (41)
CABG	11 (27)
Mitral valve repair	1 (2)

AV = aortic valve; CABG = coronary artery bypass grafting; CPB = cardiopulmonary bypass; HCA = hypothermic circulatory arrest; SACP = selective antegrade cerebral perfusion; SD = standard deviation.

woven graft was pulled back into the aortic arch position for conventional total arch replacement. The operative procedures are listed in Table 3. After rewarming and administration of protamine, TEE was performed to evaluate the expansion of the stent graft and in AD cases the thrombosing process of the FL.

Aortic Imaging and Serial CT Volume Measurements

Endoleak was evaluated by CT examinations of the entire aorta routinely during the hospital stay. Control CT or magnetic resonance tomography was performed for follow-up after 3, 6, and 12 months, and annually thereafter. The CT examinations were performed on a multislice CT (Siemens Sensation 16, Siemens Medical Solution, Erlangen, Germany) using intravenous contrast material. For intravenous contrast 120 mL of an iodinated contrast agent (Xenetix 300, Guerbet, Sulzbach, Germany) were administered according to a standardized protocol using an automated injector (Liebel Flarsheim, Medical Supplies, Kerpen, Germany). In AD patients, volume measurements (cm^3) of the TL, the FL, and the patent part of the FL were analyzed by integration of the serial finite volume elements using an institutional computed 3-dimensional aortic simulation model (Institute of Mechatronics and System Dynamics of University of Duisburg-Essen, Essen, Germany).

Thrombus was defined as the area of absence of contrast opacification on the late-phase CT slice. Total FL volume was calculated as volume of perfused FL plus volume of thrombosed FL. To evaluate the behavior of the aortic lumina and the extension of FL thrombosis or perfusion, the aorta was subdivided in four segments: segment A, between left subclavian artery and pulmonary bifurcation; segment B, between pulmonary artery and distal stent graft end; segment C, between the distal stent graft end and the coeliac trunk; and segment D, between coeliac trunk and infrarenal aorta (Fig 1).

Definitions

Endoleak was classified according to reporting standards [12]. Inadequate seal at the proximal or distal stent graft end was defined as endoleak type Ia or type Ib, respectively. Retrograde blood flow from aortic side branches was defined as type II endoleak and from a junctional leak between stent grafts was defined as type III endoleak. New appearance of endoleak after postoperative day 30 was classified as secondary endoleak.

Data Analysis

Data were collected prospectively supported by our database for thoracic aortic surgery and studied retrospectively. Analysis was done with SPSS 15.0 software (SPSS Inc, Chicago, IL). Categoric and continuous variables of both groups were compared by the Fisher exact test and the paired or unpaired *t* test, respectively. The changes of volume of the aortic lumen during follow-up were evaluated by measuring the difference of volume between the CT examinations. The last follow-up data always served as the baseline for the next evaluation.

Results

The procedural success rate was 100%. The mean diameter of the stent grafts was 28 ± 5 mm (range, 22 to 40 mm). In patients with AD, the stent graft diameter was 27 ± 4 vs 32 ± 6 for patients with TAA ($p = 0.01$). The intraoperative procedures are listed in Table 3. The intraoperative TEE demonstrated complete deployment of the stent graft in all patients and initiation of thrombosis of the FL in all AD patients.

No intraoperative deaths occurred. The in-hospital

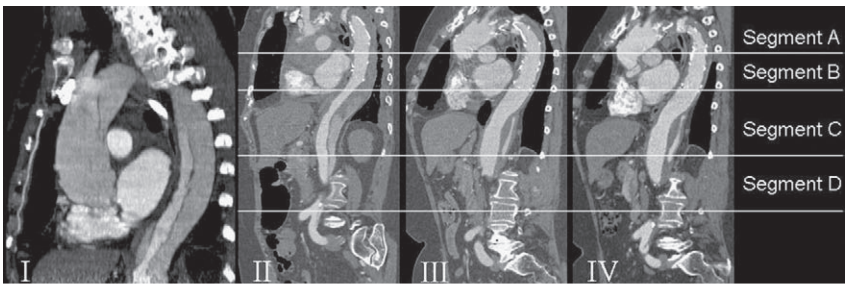

Fig 1. Aortic segments for the evaluation of the true and false lumen are shown in panels I to IV. (I) A 65-year-old woman underwent proximal aortic replacement and antegrade stent grafting of the descending aorta for acute type A AD. Computed tomography (II) postoperatively, (III) after 6 months, and (IV) 24 months demonstrated durable exclusion of the false lumen in the stent grafted aortic portion. The volume of the true lumen increased and the volume of the false lumen decreased.

Table 4. Postoperative Characteristics and Secondary Aortic Interventions

Characteristic	No. (%)
Patients	41 (100)
In-hospital mortality	3 (7)
Intubation time > 72 h	22 (54)
Reexploration for bleeding	7 (17)
Stroke	
Permanent	3 (7)
Temporary	2 (5)
Renal insufficiency, n (%)	
Permanent	1 (2)
Temporary	16 (39)
Secondary aortic interventions, n (%)	
Surgical	1 (2)
Endovascular	3 (7)

mortality rate was 7%. One patient with acute AD and visceral malperfusion died of malperfusion sequelae 2 days postoperatively despite restoration of visceral perfusion in a preoperative endovascular procedure. Two patients with TAA died 30 and 31 days after the operation of sepsis. No in-hospital deaths occurred within the chronic AD patients. No paraplegia was documented. Postoperative details are listed in Table 4.

During a mean follow-up of 17 ± 11 (SD) months, the overall survival rate was 87% (33 of 38). Causes of death were stroke in 2, mesenteric ischemia after an abdominal operation in 1, pneumonia in 1, and myocardial infarction in 1. These patients died within 9 ± 8 months (range, 2 to 21 months), and 4 had been previously operated for acute AD and 1 for chronic AD.

Endoleak and Secondary Stent Graft-Related Interventions

The proximal entry tears were excluded in 34 of 45 AD patients (97%). One proximal endoleak originating from the left subclavian artery was observed after an emergency operation for chronic AD complicated by aortic rupture and massive hemothorax. An entry tear at the inner curve of the arch was identified during the operation. The aortic diameter distally to the left subclavian artery was 7 cm, and 2 FLs were detected with an intact left subclavian artery origin out of the TL. Thus, a tissue bridge between the left subclavian artery and the posterior aortic wall was left in place. After antegrade stent grafting of the TL, the visible FLs were transected and a 2/3 end-to-side anastomosis with the retracted prosthesis was performed. The tissue bridge at the subclavian artery origin was connected side to side to the prosthesis. However, the postoperative CT angiography control after 6 days identified an undetected third FL, originating 1.5 cm beyond the subclavian artery origin, feeding a large persisting FL. This finally had to be eliminated by secondary open descending aortic replacement after failed interventional coil repositioning.

At the distal stent graft end, two type III junctional endoleaks occurred (6%) in 1 acute AD and 1 chronic AD patient after the E-vita open graft was landed within a previously implanted endograft (uncovered stent in 1, covered stent in 1). A secondary type II endoleak was also documented at the distal stent graft side 16 months after the procedure for acute AD (3%). In all 3 patients, the endoleak was excluded by secondary endovascular stent grafting.

In TAA patients, no endoleak was observed. Thus, the total incidence of proximal endoleak was 2% (1 of 41) and of distal endoleak was 7% (3 of 41).

Evolution of the FL in AD

In the 35 AD patients, the rate of immediate thrombosis of the FL was 97% (n = 34) in segment A and 80% (n = 28) in segment B (Table 5). However, partial thrombosis was observed in 5 of the 7 patients with a patent FL. Patency of the FL was observed more frequently in patients with chronic AD (n = 5) than in patients with acute AD (n = 2; $p = 0.05$) and was not related to stent graft size (patent, 25 ± 2 mm vs thrombosed, 27 ± 5 mm; $p = 0.28$) or to the aortic diameter in the distal landing zone of the stent graft (patent, 41 ± 10 mm vs thrombosed, 36 ± 8 mm; $p = 0.14$). In 33 of 35 (21 acute AD; 12 chronic AD patients), the FL extended to the segments C. The rate of FL thrombosis in this segment was 15% (5 of 33). Partial thrombosis was observed in an additional 5 patients (15%). A FL was identified in aortic segment D in 30 of 35 patients. The FL remained patent in 90% (27 of 30), and a complete thrombosis occurred only in acute AD cases (3 of 30, 10%; Figure 2).

Evolution of the FL was evaluated in 33 patients at follow-up. Two patients had to be excluded because of in-hospital death in 1, and secondary descending aorta

Table 5. Status of the False Lumen Postoperatively and in Follow-up

Variable	Pre-discharge CT Segment A	Segment B	Segment C	Segment D
No. (%)	N = 35	N = 35	N = 33	N = 30
Complete thrombosis	34 (97)	28 (80)	5 (15)	3 (10)
Partial thrombosis	0	5 (14)	5 (15)	0
Patent	1 (3)	2 (6)	23 (70)	27 (90)
	Last follow-up CT Segment A	Segment B	Segment C	Segment D
	N = 33	N = 33	N = 31	N = 28
Complete thrombosis	33 (100)	30 (91)	5 (16)	3 (11)
Partial thrombosis	0	2 (6)	8 (26)	2 (7)
Patent	0	1 (3)	18 (58)	23 (82)

CT = computed tomography.

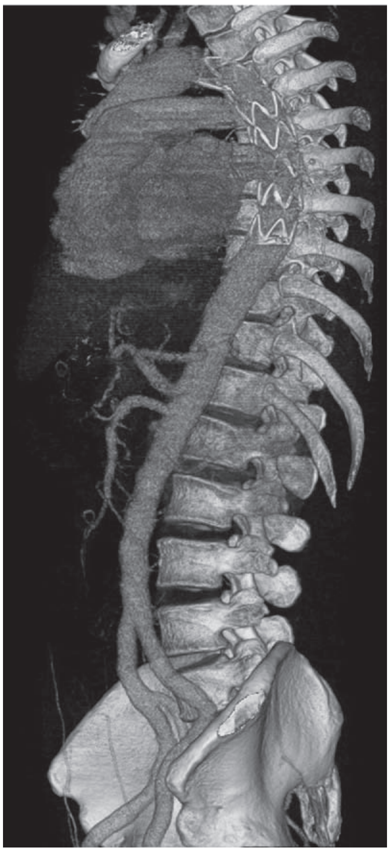

Fig 2. Complete aortic remodelling in acute type I aortic dissection (AD) is shown in a computed tomography angiography 6 months after extended thoracic aortic repair for acute AD. The false lumen is completely obliterated along the entire aorta.

replacement in 1; in both of them, the intimal flap extended throughout the entire abdominal aorta. A control CT was done in 33 patients (100%) within the first 6 months, 21 (64%) had CT examination at 12 months, and 12 (36%) at 24 months. After 6 months, a complete thrombosis of the FL was demonstrated in all patients (100%) in aortic segment A, and it remained thrombosed during the follow-up. The thrombosis rate of the FL in aortic segment B was 94% (31 of 33). During the follow-up, and concerning mentioned secondary type II endoleak in 1 patient, a durable FL thrombosis in segment B occurred in 30 of 33 patients (91%). In segment C and D, the incidence of complete FL thrombosis was 16% (5 of 31) and 11% (3 of 28), respectively. In segment C, however, partial thrombosis was documented in 8 of 31 patients (26%), comprising acute AD in 7 and chronic AD in 1, and in segment D in 2 of 28 (7%), both acute ADs. Complete or partial thrombosis of the FL distally to the stent graft end occurred more frequently in acute AD patients (12 of 20, 60%) than in chronic AD patients (1 of 11, 9%; $p = 0.007$).

A total of 5650 axial CT-scan volume measurements in 33 AD patients (171 ± 67 measurements/patient) were used for the evaluation of TL and FL behavior (Table 6). The statistical analysis demonstrated a significant growth of the TL in segments A, B, and C within the first 6 months postoperatively ($p < 0.01$). Thereafter, the volume of the TL remained stable ($p > 0.05$). On the contrary, the FL shrank in segments A and B within the first 6 months ($p < 0.01$) and remained stable thereafter ($p > 0.05$). No changes of the FL volume were documented in segments C and D, ($p > 0.05$), and no significant volume reduction was observed within the patent FL ($p > 0.05$).

Table 6. Volume Changes of the Lumen

	Post-op[a]	Post-op vs 1st FU[b]		1st vs 2nd FU[c]		2nd vs 3rd FU[d]	
Segment	cm³	cm³	p Value	cm³	p Value	cm³	p Value
Segment A							
TL	187 ± 91	+22 ± 20	<0.01	+6 ± 18	0.26	−1 ± 15	0.64
FL	224 ± 153	−72 ± 85	<0.01	−18 ± 43	0.06	−3 ± 6	0.07
PFL	...	...	...	...	...	...	...
Segment B							
TL	363 ± 174	+37 ± 32	<0.01	+8 ± 25	0.23	−3 ± 12	0.28
FL	410 ± 305	−140 ± 174	<0.01	−13 ± 100	0.52	−10 ± 26	0.18
PFL	35 ± 93	−17 ± 78	0.2	−5 ± 41	0.54	−2 ± 7	0.17
Segment C							
TL	295 ± 170	+38 ± 58	<0.01	−4 ± 108	0.33	−9 ± 20	0.11
FL	363 ± 270	−5 ± 130	0.81	+1 ± 54	0.99	−20 ± 96	0.47
PFL	242 ± 243	+4 ± 120	0.88	−4 ± 23	0.84	−45 ± 99	0.13
Segment D							
TL	195 ± 171	+11 ± 26	0.06	−6 ± 23	0.21	−3 ± 8	0.08
FL	293 ± 269	+5 ± 44	0.61	+8 ± 22	0.18	−1 ± 15	0.59
PFL	279 ± 273	−2 ± 53	0.75	−6 ± 26	0.29	−3 ± 15	0.37

[a] Postoperative CT within 30 days. [b] First follow-up within 6 months. [c] Second follow-up after 1 year. [d] Third follow-up after 2 years.

CT = computed tomography; FL = false lumen; FU = follow up; PFL = patent part of the false lumen; TL = true lumen.

Comment

The surgical strategy to deal with combined aortic arch and descending aortic disease is a matter of ongoing debate. The one-stage technique using a bilateral clamshell incision offers perfect exposition to the surgeon but represents major surgical trauma, probably not amenable to every patient [13]. The two-stage approach, greatly facilitated by the Borst elephant trunk technique and perfected by Safi and colleagues is a well-evaluated method [14, 15]. However, the cumulative mortality of this surgical strategy remains substantial despite shortening of the interim time between both surgical procedures.

In the present study, we performed aortic arch replacement and antegrade stent grafting of the descending aorta through a median sternotomy, recently called “frozen elephant trunk,” aiming at one-stage repair and splinting of the descending aorta. Thus, the aortic pathology of the descending aorta can be excluded, and in case of AD, obliteration of the FL can be propagated by the stent graft reducing aortic wall stress. However, our initial experience with the antegrade stent grafting using a separate stent graft that is fixed surgically to the arch prosthesis demonstrated proximal endoleak in 3 of 14 cases from June 2001 until October 2004, requiring two surgical and one endovascular reintervention [16]. Similar complications were also reported from other groups [17].

To avoid proximal endoleak, a novel hybrid stent graft with an uninterrupted continuity between stent graft and vascular prosthesis for the arch replacement was developed and serially used. The only proximal endoleak observed in this study (2%) was unrelated to the stent graft. In this case, a tissue bridge was left in place due to hardened exposure of the leftward-displaced subclavian artery. However, an unidentified third FL originating from the proximal subclavian artery was neglected, finally leading to conventional replacement of the descending aorta after failed coil obliteration attempts. We conclude from this singular experience that radical surgical removal of pathologic tissue, at least in AD cases, is preferable to partial arch resection [18].

The in-hospital mortality rate in our study was low, and the procedure was 100% successful, both in aneurysm and AD cases. In AD, the FL was excluded and shrunk significantly in the stent grafted aortic part. Durable thrombosis and obliteration of the FL was achieved in all but 1 patient, indicating feasibility of this one-stage aortic repair in acute and chronic AD through sternotomy. Similar results have been reported by Kato and colleagues [19] and Uchida and colleagues [20] using self-made, shorter stent grafts. The rate of immediate complete FL thrombosis was 91% in acute AD vs 62% in chronic AD.

Thus, the morphology of chronic aortic disease with a more stable, endothelialized surface and the characteristics of blood-flow into the FL may negatively affect thrombus formation. Whether our policy to rely on direct sizing of the TL and not to oversize beyond 10% influences thrombus formation is unknown; however, our results demonstrate that a patent FL in segment B around the distal stent graft was not related to the stent graft diameter or the aortic diameter at the distal landing zone. An increase of radial forces by even more oversizing may enhance the process of thrombosing, but on the other hand, aortic wall stress and the risk for aortic injury, such as erosion into neighboring structures, might be increased as well.

Growth of the TL diameter in the stent grafted segment over 6 months demonstrates the adaptation of the aortic lumen to the expanded stent graft size. The increasing diameter of the TL distally to the stent graft end indicates the improved perfusion of the TL as well as flow and pressure reduction in the FL. No significant change of lumina was observed after 6 months, although longer follow-up is required to determine the fate of the disease in the abdominal aorta. Furthermore, the effect of the documented progression of the FL thrombosis distally to the stent graft in regards to secondary malperfusion and paraplegia remains unclear. The risk of paraplegia is reported and an association with atherosclerotic aneurysm is suggested and related to the stent graft length [21]. The landing zone in the present study was proximately to Th9 using a 15-cm-long stent graft, and no paraplegia occurred; however, modifications on the stent graft size may be necessary in elective cases.

Pichlmaier and colleagues [9] previously reported results in 6 of 39 patients, in whom 4 underwent surgical and 2 underwent endovascular distal aortic reinterventions after antegrade stent grafting. These authors stated that the distal reoperation was simplified due to the already excluded proximal aortic pathology by the stent graft. This can be confirmed by our results demonstrating that in cases of a distal endoleak, the placed stent graft represents a safe landing zone for a secondary endovascular treatment.

Because of the rare incidence of this complex aortic disease, the single-center design of the study represents a limitation with small patient numbers. In addition, a separate evaluation of the acute and chronic AD would be preferable to study the specific aortic changes after combined arch and descending aortic repair. Thus, a multicenter study should be encouraged.

The knowledge about antegrade stent grafting of the descending aorta in acute and chronic AD is still limited, and controversy about the necessity of extended surgical repair, especially in acute AD, does exist [22]. In the present study, we demonstrated that antegrade stent grafting of the descending aorta was successful in acute and chronic AD as well as in complex aneurysmal disease. Proximal endoleak can be avoided, and a durable exclusion of the aortic pathology in the stent grafted descending aorta seems to be warranted. We believe that progressive FL thrombosis after operations for acute AD may improve the late outcome and probably will reduce the frequency of secondary aortic interventions. However, a surgical learning curve that includes experience with endovascular techniques is necessary to improve results.

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INVITED COMMENTARY

This article presents further experience with the "frozen elephant trunk" technique for ascending aortic dissection [1]. The authors are to be commended for their development of this technique and the pertinent specialized hybrid endograft–conventional graft. (We should note that one of the authors has disclosed a financial interest regarding the manufacturer of this device.) The authors are to be congratulated for their excellent clinical results.

There are several weaknesses of this study. The analyses of these patients really should have been confined only to those with acute type A aortic dissection. The contamination with chronic cases, degenerative aneurysms, descending pathology, and penetrating ulcers makes interpretation difficult. The follow-up is short, as is obligatory with the new technology. Also, it is unclear how this technology can be applied without a total arch replacement, which the authors indicated was the case in nearly half their patients.

We must also keep in mind several other important points as follows:

1. Is there truly a need for adjunctive descending stenting? The incidence of significant dilatation of the descending aorta in the long term after conventional ascending aortic replacement for type A dissection appears to be relatively low. At our institution, we have needed to reoperate late for descending aortic enlargement in only a very small proportion of our patients [2]. In another recent report, only 12 of 221 patients required late reoperation for thoracoabdominal aneurysm [3]. Thus, it is unclear that any additional measures need to be taken at the time of initial repair.
2. Does adjunctive descending aortic stenting really improve long-term survival after type A repair? Follow-up, understandably, is short at this stage in the technologic development. Surgeons experienced in aortic repair will recognize that the intimal flap has no strength. It can not hold sutures. So, it is difficult to envision how applying an endograft against this layer can produce any substantive, durable anatomical impact.
3. There is a good surgical alternative: extended resection at the time of original type A repair. If it is believed that there is a need to do more at the time of initial repair of type A dissection, then a resection and conventional elephant trunk placement should be

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