Deployment of proximal thoracic endograft in zone 0 of the ascending aorta: treatment options and early outcomes for aortic arch aneurysms in a high-risk population

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OBJECTIVES: Open repair of aortic arch aneurysms can be technically challenging. Hybrid approaches have been developed to facilitate arch repairs and improve their clinical outcomes in high-risk patients. We examined treatment options and early outcomes in patients whose thoracic endografts were deployed to include Zone 0.

METHODS: Between 2005 and 2011, a hybrid approach in which the endograft was deployed in the ascending aorta was used in 29 patients (median age 67 years, range 32–85 years). The indication for surgery was saccular arch aneurysm in 11 patients (37.9%), fusiform arch aneurysm with or without involvement of the proximal descending aorta in 10 (34.5%), proximal Type I endoleak after endovascular repair of the descending aorta in 5 (17.2%), chronic Type III (Type B) aortic dissection with aneurysmal arch formation in 2 (6.9%) and acute Type I (Type A) dissection with prior repair of an extent I thoracoabdominal aneurysm in 1 (3.4%). Six patients (20.7%) had previously undergone a sternotomy. One-, two- or three-branch aortobrachiocephalic de-branching, with or without concomitant heart surgery, was performed in 28 patients and extra-anatomic bypass in 1.

RESULTS: Two patients (6.9%) died during postoperative hospitalization. Overall survival during the follow-up period (median 411 days) was 79.3%. Five neurological events occurred: one extensive stroke, two minor strokes (10.3%) and two episodes of paraparesis (6.9%), one with partial recovery and one with full recovery.

CONCLUSIONS: The hybrid approach enables the treatment of aortic arch disease in high-risk individuals. Long-term follow-up data are needed.

Keywords: Aorta • Thoracic • Aortic arch aneurysm • Hybrid procedures • Zone 0

INTRODUCTION

The choice of repair technique for various thoracic aortic pathologies involving the arch is influenced by patients’ comorbidities and age. Traditionally, the use of cardiopulmonary bypass and hypothermic circulatory arrest, with or without antegrade or retrograde cerebral perfusion, was routine for any patient with an acceptable level of risk who undergoes intervention for aortic arch disease, even though using these measures was associated with significant mortality and morbidity. Elderly and high-risk individuals were referred to high-volume centres. Recent advancements in endovascular technology have created different treatment options and allow the treatment of patients for whom open approaches would otherwise pose a prohibitive risk. Hybrid approaches, as alternative surgical treatments, are currently under debate and evaluation. A decade ago, few data were available regarding perioperative morbidity and mortality after hybrid repair of the aortic arch when the thoracic endovascular aortic repair involves the ascending aorta, also called the Zone 0 landing zone [1]. More recent studies found that these hybrid procedures produce acceptable mid- and long-term results [2]. We performed a retrospective study to examine these outcomes.

MATERIALS AND METHODS

From 2005 to 2011, 29 consecutive patients (median age 67 years, range 32–85 years; 72.4% female; Table 1) who presented with thoracic aortic disease involving the aortic arch were treated in our institution with hybrid procedures in which the endograft was deployed in Zone 0. Treated pathologies included the following: saccular arch aneurysm (n = 11), fusiform aneurysm...
with or without involvement of the descending thoracic aorta (n = 10), proximal Type I endoleak after endovascular repair of the descending aorta (n = 5), chronic Type III (Type B) aortic dissection with aneurysmal arch formation (n = 2) and acute Type I (Type A) dissection with prior repair of an extent I thoracoabdominal aneurysm (n = 1). Institutional Review Board approval was obtained.

The current STS scoring system and the EuroSCORE are not used in this report. None of the current systems is ideal for risk-stratifying patients with thoracic aortic pathologies. All of the included patients were evaluated by an experienced aortic surgery team and were considered too high risk to undergo conventional open arch aneurysm repair.

Preoperative evaluation

Multislice computed tomography (CT) or magnetic resonance (MR) imaging was performed in all the patients to assess the entire aorta and its proximity to the sternum in patients with prior sternotomy and iliac access. Preoperative duplex ultrasound of the carotid arteries was performed to evaluate anatomy and occlusive disease. Preoperative echocardiography was performed routinely.

Intraoperative procedure: endovascular exclusion of the arch

The stent graft for the endovascular exclusion of the arch was deployed antegrade or retrograde. The choice of site was based on the surgeon’s preference and on the size and quality of the iliofemoral arteries in the preoperative CT. In 10 patients, the iliofemoral vessels were considered acceptable, and the endograft was delivered retrograde. Radio-opaque markers (large surgical clips or pacing wires) were used at the proximal anastomosis site to mark the proximal landing zone during the retrograde endovascular stent delivery. In the remaining cases of antegrade delivery, a 10-mm Dacron graft was sutured to the aortic arch and was anastomosed end to side to the left common carotid artery. In 3 patients, the origin of the left subclavian artery was ligated, we proceeded with left subclavian artery revascularization (end-to-end anastomosis with the limb of the bifurcated or trifurcated graft with 6.0 Prolene). If the left subclavian artery was not easily accessed, it was deferred, and we proceeded with revascularization of the left common carotid artery and then the innominate artery. After the de-branching, a left carotid-to-subclavian bypass was performed if necessary via a left supraclavicular incision. In all cases, it is our practice to try to revascularize the left subclavian artery via median sternotomy or left supraclavicular incision unless specific circumstances prevent it, such as chronic occlusion, haemodynamic instability, emergency presentation, a prolonged procedure or particular exposure challenges.

In no case was a shunt employed. The mean blood pressure during the anastomosis of the head vessels was kept at 90–100 mmHg. If the NIRS dropped by 20%, then the blood pressure was pharmacologically adjusted to a higher level. In 3 patients, the left vertebral artery originated from the aortic arch and was anastomosed end to side to the left common carotid artery. In 3 patients with significant concomitant coronary artery disease, off- or on-pump coronary artery bypass was performed before the de-branching procedure. In 2 patients, the ascending aorta—and in one of these patients, the aortic root—required replacement. Cardiopulmonary bypass was used during the repair, and the de-branching procedure followed. Operative variables are listed in Table 2.

### Table 1: Preoperative characteristics (n = 29)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median age (years)</td>
<td>67 (58–72)</td>
</tr>
<tr>
<td>Female gender</td>
<td>21 (72.4)</td>
</tr>
<tr>
<td>Smoking</td>
<td>21 (72.4)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>28 (96.5)</td>
</tr>
<tr>
<td>Non-obstructive coronary artery disease</td>
<td>8 (27.6)</td>
</tr>
<tr>
<td>Myocardial infarction with or without coronary artery stenting</td>
<td>3 (10.3)</td>
</tr>
<tr>
<td>Previous open heart surgery</td>
<td>5 (17.2)</td>
</tr>
<tr>
<td>Previous sternotomy</td>
<td>6 (20.7)</td>
</tr>
<tr>
<td>Previous open or endovascular repair of the descending thoracic and/or abdominal aorta</td>
<td>10 (34.9)</td>
</tr>
<tr>
<td>Emergency repair</td>
<td>6 (20.7)</td>
</tr>
<tr>
<td>Genetically triggered thoracic aortic disease</td>
<td>2 (6.9)</td>
</tr>
<tr>
<td>Pulmonary disease</td>
<td>10 (34.9)</td>
</tr>
<tr>
<td>Renal dysfunction with creatinine ≥ 1.5</td>
<td>5 (17.2)</td>
</tr>
<tr>
<td>Previous stroke</td>
<td>3 (10.3)</td>
</tr>
</tbody>
</table>

Data are reported as median [interquartile range (IQR) 25–75%] for continuous variables and number (percentage) for categorical variables.

*Marfan syndrome (n = 1); Loeys–Dietz syndrome (n = 1).
Protection of the spinal cord

In cases in which >15 cm of the descending thoracic aorta was covered, we protected the spinal cord with cerebrospinal fluid (CSF) drainage and by increasing the blood pressure to a mean arterial pressure (MAP) of 90–100 mmHg or a systolic pressure of 150–160 mmHg. Keeping the spinal cord perfusion pressure (SCPP, computed as MAP – CSF pressure (CSFP)) at ~12 mmHg during and after surgery is critical to averting spinal cord injury. To this end, the SCPP may be increased by decreasing the CSFP or by increasing the aortic pressure. In 3 patients, the left subclavian artery was not revascularized via the median sternotomy for technical reasons, and a carotid-subclavian bypass was performed as an extra step to protect the spinal cord. Seven patients in our series had CSF drainage.

Postoperative monitoring and follow-up

A CT scan of the chest with intravenous contrast was performed before discharge in all patients but one. Seventeen patients were discharged home, 3 to an inpatient rehabilitation facility and 7 to an extended care facility. Planned follow-up evaluation included CT scans performed 6 and 12 months postoperatively and then yearly unless there was special concern regarding endoleak identified on the postoperative study, in which case we would request a CT scan 1 month postoperatively.

Statistics

Data are reported as median with interquartile range (IQR 25–75%) for continuous variables and number (percentage) for categorical variables. A Kaplan–Meier curve was generated to examine survival. Statistical analysis was performed with the SAS/STAT software version 9.1.3, SAS system for Windows (SAS Institute, Inc., Cary, NC, USA). Contact via a phone call or via the Social Security Death Index (http://ssdi.rootsweb.ancestry.com/) was used to verify late deaths.

RESULTS

In-hospital and overall mortality

Thirty-day and in-hospital mortality was 6.9% (2 of 29). Six patients had emergent operations. One of these patients suffered an extensive ischaemic stroke, and at the family’s request, support was withdrawn on postoperative day 6. The other patient who died became very hypertensive on postoperative day 1; the proximal anastomosis ruptured, and the patient died immediately despite emergency bedside mediastinal exploration. Overall survival was 79.3% during the follow-up period (median 14 months, IQR 5–22 months). Six patients died from causes unrelated to their aortic disease (Fig. 1).

Neurological events

Three patients (10.3%) had postoperative strokes: one major and two minor. The major stroke, which was fatal, occurred in a patient with contained aortic arch aneurysm rupture; the patients who had the two minor strokes had significant recovery afterwards. One minor stroke occurred in a patient who underwent CPB for replacement of the ascending aorta and the proximal arch concurrent with the de-branching procedure. The other minor stroke occurred in a patient who required concurrent off-pump coronary revascularization. None of the patients had paraplegia. Two patients (6.9%) had paraparesis, 1 with full recovery and 1 with partial recovery. In both patients, a CSF drain was placed postoperatively and immediately after they developed symptoms. All patients with neurological events were evaluated by a neurologist.

Other early outcomes

Table 3 lists all early outcomes. None of the patients had retrograde Type A aortic dissection.

Type of de-branching and concomitant procedures and mode of stent delivery

All patients but one underwent median sternotomy. One patient underwent extra-anatomic bypass. Cardiopulmonary bypass (CPB) was employed in 3 patients. Two of them required replacement of the ascending aorta, including one who required a composite valve graft. The third patient had a prior sternotomy, and CPB was initiated emergently upon sternal entry. All patients underwent a complete de-branching procedure. To prevent proximal endoleaks and possible retrograde dissection, our threshold for performing concomitant ascending aortic replacement is a diameter of 4.0–4.5 cm, unless CPB poses a prohibitive
risk for the patient. For the de-branching procedure, a bifurcated graft (inverse Y-graft) was used in 14 patients, a trifurcated graft was used in 13 and a single-branch graft was used in 1 in whom the left subclavian artery and the left common carotid artery were chronically occluded and asymptomatic. In the patients with the bifurcated graft, the left subclavian artery was ligated without revascularization (n = 5), was left alone (n = 3) or was chronically occluded (n = 1), or a carotid-to-subclavian artery bypass was performed (n = 5).

Three patients required off-pump coronary artery bypass. None of the procedures was a staged procedure. Two of the patients had a prior carotid-subclavian bypass as part of another procedure. Extra-anatomic bypass was performed in 1 patient who had a methyl methacrylate sternal plate from a prior excision of a chest fibrosarcoma, chest radiation and reconstruction of the chest wall, which made his sternal entry prohibitive (Fig. 2). In this patient, bypass was created from the descending thoracic aorta to the left subclavian artery via a left thoracotomy, followed by a left carotid-to-left subclavian bypass and a left carotid artery-to-right carotid artery bypass. The saccular aneurysm of the transverse arch was excluded with retrograde stent delivery.

Five patients had prior open heart surgery (2 had CABG, one with a patent left mammary artery; 3 had ascending aortic grafts because of prior proximal aortic dissection). In both patients with prior CABG, the left subclavian artery was revascularized. None of the cases required CPB. In the 3 patients with an ascending aortic graft, the intent was for all cases to be performed without CPB. In 1 case, emergent CPB was initiated upon sternal entry. Only in 1 of these 3 cases was the left subclavian not revascularized (because of a challenging and prolonged procedure).

Among the 28 patients with median sternotomy, antegrade stent delivery was performed in 18 (67.9%). Fifteen patients had two stents, 7 had one stent, 4 had three stents and 3 had four stents placed. The Gore TAG device (W.L. Gore & Associates Flagstaff, AZ, USA) was used in 26 patients, the Talent CAPTIVIA (Medtronic, Inc., Santa Rosa, CA, USA) in 2 patients and the Cook Zenith TX2 (Cook, Bloomington, IN, USA) in 1 patient. The two Talent CAPTIVIA devices were delivered retrograde for repair of proximal Type I endoleak secondary to fusiform arch aneurysm in 1 patient and to Type III aortic dissection in the second patient. The Cook Zenith TX2 stent graft was delivered retrograde for repair and endovascular exclusion of an arch and proximal descending thoracic aneurysm. In the 26 other cases, we used the Gore TAG device, which was placed by retrograde delivery in 8 cases and antegrade delivery in the other 18 cases. The deployment mechanism of the Gore device was one of the reasons for the antegrade delivery of this particular endograft. Often, our decision whether to use antegrade or retrograde delivery was made intraoperatively. Our decision-making process evolved over the study period but was usually influenced by surgeon preference, the size of the iliofemoral arteries and whether there was enough anatomic space for an additional graft site in the ascending aorta. If the patient had previously undergone coronary artery bypass grafting (CABG) and had patent vein grafts in the ascending aorta or if the patient required a CABG procedure concomitant with the de-branching procedure, we chose to use retrograde delivery.

Table 3: Early outcomes (n = 29)

<table>
<thead>
<tr>
<th>Event</th>
<th>Cases (Percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30-day mortality</td>
<td>2 (6.9)</td>
</tr>
<tr>
<td>In-hospital mortality</td>
<td>2 (6.9)</td>
</tr>
<tr>
<td>Stroke</td>
<td>3 (10.3)</td>
</tr>
<tr>
<td>Extensive</td>
<td>1 (3.4)</td>
</tr>
<tr>
<td>Minor</td>
<td>2 (6.9)</td>
</tr>
<tr>
<td>Paraplegia</td>
<td>0</td>
</tr>
<tr>
<td>Paraparesis</td>
<td>0</td>
</tr>
<tr>
<td>Atrial fibrillation</td>
<td>2 (6.9)</td>
</tr>
<tr>
<td>Trachoeotomy</td>
<td>9 (31.0)</td>
</tr>
<tr>
<td>Reoperation for bleeding</td>
<td>4 (13.8)</td>
</tr>
<tr>
<td>Endoleaks*</td>
<td>2 (6.9)</td>
</tr>
<tr>
<td>Early</td>
<td>0</td>
</tr>
<tr>
<td>Late</td>
<td>2 (6.9)</td>
</tr>
<tr>
<td>Aortic reintervention</td>
<td>2 (6.9)</td>
</tr>
<tr>
<td>Acute renal insufficiency</td>
<td>0</td>
</tr>
<tr>
<td>Retrograde Type A aortic dissection</td>
<td>0</td>
</tr>
<tr>
<td>Intensive care unit stay (days)</td>
<td>6 (4–14)</td>
</tr>
</tbody>
</table>

*Type I proximal and Type III.

Data are reported as median [interquartile range (IQR) 25–75%] for continuous variables and number (percentage) for categorical variables.

Figure 1: Kaplan–Meier survival curve
In addition, 2 of our youngest patients had genetically triggered thoracic aortic disease. One patient with prior thoracoabdominal aortic aneurysm repair presented in extremis with acute Type A aortic dissection. Aortic root replacement with a composite valved graft was performed in addition to a Y-graft to the head vessels. The endograft excluded the arch and was landed inside Dacron grafts. The other patient had multiple previous sternotomies and thoracotomies, so the full de-branching procedure was added to the endovascular exclusion of the arch. In both cases, the endograft was landed inside a Dacron graft. In all cases, the rerouting procedures enabled us to achieve a proximal landing in the mid-ascending aorta without interfering with the coronary arteries.

**Need for aortic reintervention**

Two patients (6.9%) required reintervention. One patient developed a Type I endoleak and underwent percutaneous proximal stent placement 9 months after the index procedure. The other patient developed a Type III endoleak and underwent percutaneous stent placement 4 years postoperatively. None of the patients required open conversion.

**DISCUSSION**

Arch replacement continues to carry substantial risks despite the use of protective adjuncts. Hypothermic circulatory arrest and prolonged bypass are associated with increased neurological events and mortality. Although contemporary series have shown excellent results, especially in high-volume centres [4, 5], patient-specific comorbidities such as advanced age, chronic renal dysfunction, compromised cardiac function or history of stroke can greatly increase a patient’s risk of adverse outcomes [6, 7].

The first report of a hybrid arch procedure described a physically compromised patient who needed reoperation for a leaking aortic arch patch graft. A specialized trifurcated graft was prepared; two branches were used to bypass the left common carotid artery and left subclavian artery, and the third branch was used to deliver a stent graft antegrade into the arch [8]. Inspired by this concept of distal two-vessel arch de-branching, several authors have explored total arch rerouting and proximal two-vessel de-branching techniques to repair both aortic arch aneurysm and acute ascending aortic dissection [9–15]. Typically, full rerouting of the brachiocephalic vessels is accomplished through a median sternotomy, and CPB and hypothermic circulatory arrest are occasionally needed [2, 9]. Likewise, in our series, only in 2 patients was CPB part of the procedure as planned, because these patients had concomitant ascending aortic and aortic valve disease. In another patient, who had prior sternotomy, CPB was initiated emergently upon sternal entry. All of our cases were performed in a single stage under a single general anaesthesia. Czerny et al. [2], in a transcontinental registry with five participating centres, reported that among 66 patients treated with total arch rerouting (Zone 0), the revascularization was performed in two stages in 42% of patients.

In recent series, 30-day and in-hospital mortality for hybrid aortic arch de-branching in Zone 0 has varied from 0 to 29.6% [9–18] (Table 4). It can be concluded from these reports that more extensive proximal aortic repair with complete de-branching is associated with higher mortality [10, 17]. A higher incidence of cerebrovascular accident is also observed when the stent graft is deployed in Zone 0 vs Zone 1 or 2 [19–21]. It might be presumed that revascularizing the left subclavian artery on the basis of information from preoperative imaging decreased the incidence of posterior circulation strokes from 5.5 to 1.2% (P = 0.13) in a reported series [21]. In our series, the one
A patient with an extensive stroke had a posterior circulation stroke. This patient underwent an urgent procedure, and the left subclavian artery was not revascularized. In our 2 patients who had minor strokes, the left subclavian artery was also ligated without revascularization. Both patients had infarcts in the posterior circulation territory, and one had an additional, small infarct in the anterior circulation.

We did not routinely obtain preoperative intracerebral CT or MR angiograms. Carotid Doppler, as well as preoperative CT of the chest from the jaw to the diaphragm, is done routinely.

Retrograde Type A dissection, a known and devastating complication of endovascular repair for disease of the descending thoracic aorta [22], is reported in various aortic arch de-branching series [2, 17]. No retrograde Type A dissection occurred in our series. However, we are extremely cautious because this complication may be related to the procedure, the stent graft or the natural progression of disease. Sheath and wire manipulation in the aortic arch, semi-rigid grafts that cannot adapt perfectly to the aortic curve, oversizing of the stent grafts and congenital weakness of the aortic wall may cause localized intimal tears, flaps or full retrograde dissection.

No permanent spinal cord injury was noted in our series. There were two episodes of paraparesis, one with full recovery. The reported rate of permanent and transient spinal cord ischemia after hybrid arch procedures varies from 0 to 11% [9, 12, 14–16, 23]. It is our practice to use CSF drainage if the intended coverage of the descending thoracic aorta is >15 cm. In our series, 7 patients had an intraoperative CSF drain, and 1 patient with early postoperative paraparesis had a CSF drain placed immediately and made a full recovery. Only 2 patients required reintervention, one for a proximal Type I endoleak 9 months postoperatively and one for a Type III endoleak 4 years postoperatively. Reinforcement of the proximal aorta at the intended proximal landing zone of the endograft has been advocated as a means of reducing early to mid-term endoleak [24]. In our series, 2 septuagenarian patients underwent wrapping of the ascending aorta with an external Dacron tube graft that was opened longitudinally and sutured around the aorta. Both patients had multiple comorbidities and were considered high risk with regard to ascending aortic repair. We prefer to use aortic reinforcement if the ascending aorta is 4.0–4.5 cm in diameter and the patient is too high risk to undergo CPB for the repair.

Limitations and strengths of the study

The main limitation of our study is the lack of a comparison group of patients who underwent open arch repair. The small number of patients is another limitation, even though our single-centre series is one of the largest series of Zone 0 aortic arch de-branching procedures. A slight bias towards open aortic arch repair vs the hybrid approach cannot be excluded because of the long tradition of open aortic surgery at our institution. Therefore, the patients in our series represent a high-risk population in which the traditional open approach was considered prohibitive.

CONCLUSION

When performed in the traditional open manner, extensive and complex aortic arch repair involves substantial technical challenges that are associated with significant mortality in patients with multiple comorbidities. The rapid evolution of endovascular technology provides alternative options for treating these patients. Full aortic arch rerouting with anchoring of the stent graft in the ascending aorta permits the treatment of high-risk patients and produces acceptable early results. To justify the use of this hybrid procedure in more than just high-risk patients, long-term outcomes data are necessary.

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Conflict of interest: Ourania Preventza has given lectures for WL Gore & Associates. Joseph S. Coselli has given lectures for Medtronic and served on Gore’s advisory board; he has also been principal investigator of clinical research trials sponsored by Medtronic, Gore, and Cook Medical. The other authors have no disclosures to make.

REFERENCES


APPENDIX. CONFERENCE DISCUSSION

Dr M. Czerny (Berne, Switzerland): Dr Preventza and her colleagues report a series of patients undergoing a combined vascular and endovascular approach for the treatment of aortic arch disease in patients at high risk for conventional repair.

I would be interested primarily in your approach regarding the left subclavian artery. I think your liberal approach in revascularizing this important vessel is obviously one of the reasons why you did not observe any new onset of paraplegia in your setting, but it seems that in some cases, maybe due to exposure challenges, revascularization is omitted. Could you comment on that?

Dr Preventza: That is a very important question. Our strategy is the following: we try in every case to revascularize the left subclavian for different reasons, including dominant left vertebral artery, protecting the spinal cord and avoiding posterior circulation stroke. In one of the cases that I showed, the patient had contained rupture and for technical reasons we could not revascularize the subclavian artery through a median sternotomy, so we proceeded with subclavian-carotid bypass via a left supraclavicular incision. In our series we had three strokes. One major stroke occurred in a patient with a contained rupture, in whom we could not revascularize the left subclavian; the patient had a very large posterior circulation stroke and expired. The other two neurologic events were minor. In both of them, the left subclavian was not revascularized. One patient had a small posterior circulation stroke, and the other patient had a small anterior and posterior circulation stroke. This experience has reinforced our belief that revascularization of the left subclavian is very important.

Dr Czerny: In the cases where you have used cardiopulmonary bypass, could you please comment on the reasons? The case with root replacement is clear, but the two others should perhaps be described a bit more. And it would be interesting to know your threshold for ascending replacement, I would suspect in anticipating the problem of retrograde type A.

Dr Preventza: With regard to the threshold for ascending replacement, if the ascending aorta is 4.1, 4.2 cm and the arch needs to be replaced with our plan before had been to try and do it without. So if we think that it is going to be feasible, we do it, but our threshold to go on bypass if we have any issues is actually very low.
Dr Czerny: Finally, could you report the gained length of landing zone reached by the transpositions?

Dr Preventza: The length proximally?

Dr Czerny: Exactly, yes. What kind of length do you request after transposition and what effective length did you gain?

Dr Preventza: You saw some of the cases that we did. You have the aortic valve, you have the sinuses, sometimes you have coronary artery bypasses there. All of these can be constraining factors in terms of what you can do. Usually we try to find a good part of the ascending aorta where we will be able to land the graft effectively without having issues. Sometimes the ascending aorta can be calcified, especially in these kinds of patients. So it is really like hit or miss sometimes. We try to find the place where we can safely land, and, of course, with all the constraints with the aortic valve and the sinuses and the possible prior bypass that somebody can have.

Dr B. Zipfel (Berlin, Germany): I want to ask a provocative question in relation to those two presentations that we heard at the beginning of the session. Do you think that with the simple fenestrated graft you could have done these procedures much easier?

Dr Preventza: That is an excellent question. I wish I could give you an answer. In our institution, our threshold to proceed with an open arch repair is low. During the same period of time, we did more than 290 open arch repairs. The decision to do the debranching procedure is based on the frailty of the patients as well as their comorbidities. As I showed you, with the type of disease that they had, I personally think that with the currently available technology, a fenestrated graft would not be able to achieve what we were able to achieve with our procedure based on what we have now with the fenestrated grafts.

Dr E. Weigang (Mainz, Germany): I saw in your presentation that you used the bifurcated graft as well as the trifurcated graft. When you use, for example, a 16 mm to 8 mm bifurcated graft, your anastomosis will measure at least 2 cm to 2.5 cm, so you will lose a part of your landing zone. This occurs especially when you combine that with an antegrade approach for stent graft deployment; I saw in your paper that you used this antegrade approach in 67% of your patients. It is always quite challenging to deploy a stent graft antegrade without losing a part of your landing zone. Can you please comment on that.

Dr Preventza: Usually we try to go retrograde. We studied antegrade delivery for the simple reason that we have the chest open and we didn’t want to make another incision. We ended up having quite a few patients in whom the femoral access was not what we wanted it to be. In that case, we had to go antegrade. I completely agree with you that the bifurcated grafts that we usually use (a pre-made Terumo Vascutek), are usually 10/8 or 12/8 or 14/8, and you do lose about 2–2.5 cm. In some of these cases, as you saw in the patient that I showed, the antegrade portion where we put the stent graft was very, very proximal into the aorta in a way that could not interfere with the landing zone for this particular reason. One way to avoid that could be a retrograde delivery, if possible, or the other way via the subclavian. We have also done some cases like that.