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Follow-up results of aortic arch cervical debranching performed with the help of a temporary crossover external carotid artery bypass for cerebral protection followed by endovascular thoracic aortic aneurysm repair

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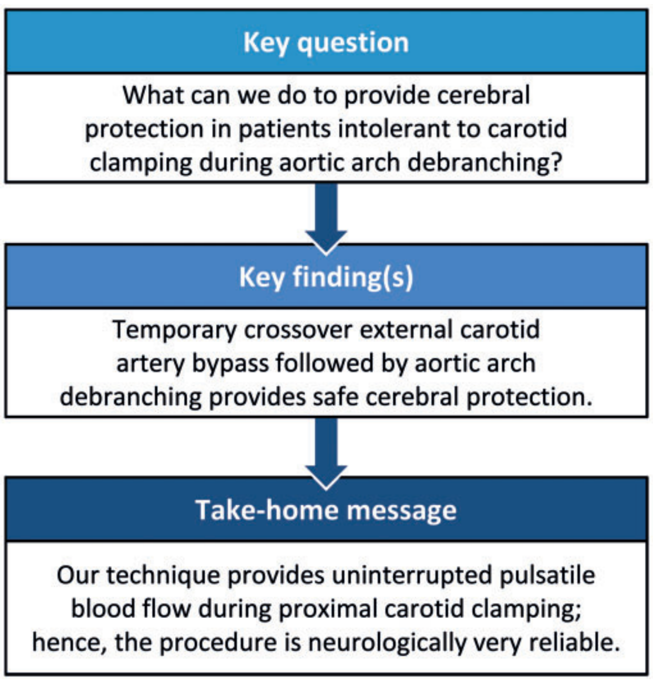

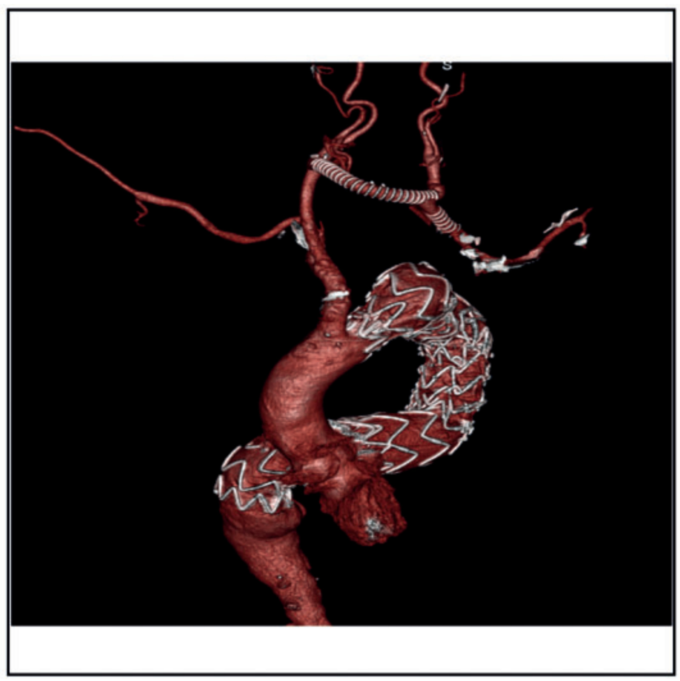

Abstract

OBJECTIVES: Treating aortic arch aneurysms with conventional open surgical and endovascular stent graft procedures is challenging due to the complex anatomy of the arch and the arteries arising from it that nourish the brain. Cerebral protection is of the utmost importance during the treatment of thoracic aneurysms involving the aortic arch.

METHODS: Between May 2014 and November 2018, 7 patients with thoracic aortic aneurysms involving the aortic arch who underwent aortic arch cervical debranching with our technique were reviewed retrospectively. Because all the patients being considered for conventional surgical aortic arch replacement had serious comorbidities, they were selected to receive hybrid therapy. The mean age of the patients was 71.2 ± 9.4 years. One patient was a woman and 6 patients were men. One patient was given general anaesthesia; the remaining 6 patients had a regional block. A crossover temporary bypass was performed between the external carotid arteries with a 6-mm polytetrafluoroethylene graft for cerebral protection in all patients. Thoracic endovascular aortic repair (TEVAR) was successfully performed in all patients except 1 following debranching.

RESULTS: Neurological complications did not occur during the procedures. Patients were followed for a mean of 18.3 ± 4.9 months. One female patient died of exacerbating chronic obstructive pulmonary disease within the first follow-up year. Three other patients died: 1 died of natural causes; 1 died of pneumonia followed by multiorgan failure; and 1 died of myocardial infarction during the mid-term follow-up period. The remaining patients are still being followed and are event free.

CONCLUSIONS: Endovascular treatment of thoracic aortic diseases involving the aortic arch is facilitated when the aortic arch is debranched. Our cerebral protection method with a temporary crossover bypass between the external carotid arteries provides continuous pulsatile blood flow to the brain; hence, neurologically, it is a reliable procedure. The follow-up results of the patients who underwent aortic arch cervical debranching followed by TEVAR depended on their comorbidities.

Keywords: Thoracic aortic arch aneurysm • Endovascular stent graft repair • Debranching • Hybrid procedure • Cerebral protection

ABBREVIATIONS

CT	Computed tomography
PTFE	Polytetrafluoroethylene
TEVAR	Thoracic endovascular aortic repair

INTRODUCTION

Thoracic aneurysms involving the aortic arch and the arch vessels are challenging. The treatment options for these aneurysms include open repair and thoracic endovascular aortic repair (TEVAR) with a stent graft. Although conventional arch replacement is still the gold standard method of treatment, the endovascular approach is increasingly considered a good alternative for patients with comorbidities [1].

Conventional open total aortic arch replacement has approximately 3.8–7.1% mortality rate and a 4.7–7% stroke rate [2]. The ratios increase in high-risk patients with comorbidities and in the elderly population. Various studies have shown that the 30-day and in-hospital mortality rates following open surgery in ascending and arch aneurysms were 3.2% and 4.8%, respectively; these results increased to 7.5–40% and 8–20% for morbidity and mortality rates, respectively, for more complex arch aneurysms extending to the descending aorta, especially in debilitated patients [2, 3]. Adding the frozen elephant trunk procedure during open surgery to the treatment of complex aneurysms including the distal aortic arch and beyond was considered promising; however, mortality rates as high as 20% for zone 2 and 16% for zone 3 aneurysms were reported in the literature [4]. There has always been a search for less invasive durable alternative options to the gold standard conventional open surgery for the treatment of the aneurysms in all zones of the aortic arch for elderly and comorbid patients. Isolated TEVAR or hybrid treatment options are among these alternative options [3, 5–7].

The unique anatomy of the aortic arch, with the arch vessels, makes TEVAR challenging. In addition, inadequate landing zones and the tight curves add more limitations to TEVAR. Chimney and fenestrated techniques have been attempted to overcome these problems [8]. Also, the literature includes reports of complete debranching, i.e. reimplantation of the 3 arch vessels to the ascending aorta, or partial debranching, i.e. reimplantation of only the left subclavian artery or both the left subclavian and left common carotid arteries followed by TEVAR [9–11]. Cerebral protection is of the utmost importance during these debranching procedures [9].

Our goal was to present the follow-up results of our hybrid treatment procedure: aortic arch cervical debranching followed by TEVAR. All the patients had thoracic aortic aneurysms including the aortic arch and underwent debranching of the left common carotid and left subclavian arteries and their reimplantation to the right common carotid artery with our cerebral protection technique with a crossover bypass between the external carotid arteries prior to TEVAR for the treatment of the aneurysm confining the aortic arch.

PATIENTS AND METHODS

Ethical statement

Ethical approval was not required due to the retrospective nature of the study. The head of the clinic as well as all the authors approved the submission and publication of this work. Informed consent was obtained from each patient and their relatives prior to the procedures after we explained the interventions, risks and benefits in detail as a policy of the healthcare system in our country.

Patients. Between May 2014 and November 2018, the technique [9] was applied to 7 patients with thoracic aortic aneurysms including the aortic arch. The cohort included only those patients who were intolerant to carotid cross-clamping and 1 patient who underwent general anaesthesia. The patients with a patent polygon of Willis, which was investigated using transcranial Doppler ultrasonography and confirmed with computed tomography (CT) angiography of the cranium, who underwent debranching with a simple clamp-and-go technique were not included in the study group. Patients were researched retrospectively. All the patients for whom we had CT angiography scans of the head, the neck and the thoraco-abdominal and iliofemoral segments of the aorta prior to the procedures and detailed information about the anatomy of the arteries were studied for procedure planning.

The mean age was 71.28 ± 10.32 years. One patient was a woman and 6 patients were men. One patient had advanced chronic obstructive pulmonary disease. All the patients had hypertension. Four patients had diabetes. One patient was 92 years old. Three patients had ischaemic heart disease with compromised ejection fractions (<30%). One patient had undergone ascending aortic replacement for acute type 1 aortic dissection 4 years earlier. Two patients with malignancies were scheduled for chemotherapy and surgical therapy after repair of the aneurysm. One patient had chronic renal failure and was on haemodialysis 3 days per week. The mean diameter of the aneurysms was 69.3 ± 2.9 mm (Fig. 1). Two patients were obese with body mass indexes >31 kg/m^2. One patient had aortoiliac occlusive disease, and femoral access was possible only for the deployment of the endovascular stent graft. The comorbidity features of the patients are summarized in Table 1.

All patients were assessed by the anaesthesiology, cardiology and re-animation teams preoperatively and were found to be more suitable for hybrid treatment due to their comorbidity factors and high American Society of Anesthesiologists physical status classification scores (grades 3 and 4). The TEVAR with a stent graft was performed following the debranching procedure in all patients. Patients are followed at the outpatient clinic. Follow-up is divided into early-, mid- and long-term periods. The early period includes the hospital stay and the first month after the procedure. The mid-term follow-up period is defined as the first year; the long-term follow-up period is regarded as being beyond the first year. The patients received 100 mg of aspirin life-long, 75 mg of clopidogrel for 3 months and 20 mg of atorvastatin for at least 1 year or longer, depending on their cholesterol levels at the end of the first year.

SURGICAL TECHNIQUE AND ENDOVASCULAR STENT GRAFT REPAIR

As a policy of our institution, all carotid interventions are performed with local-regional anaesthesia for momentary neurological monitoring and a selective shunt or other cerebral protection methods. In fully anaesthetized patients, these procedures are executed with the routine use of a carotid shunt or crossover external carotid artery bypass during debranching. Near infrared spectroscopy probes are attached to the forehead in all patients to check the cerebral oxygenation.

Aortic arch debranching was performed with Ugurlucan *et al.*'s [9] cerebral protection method, which was published previously. The bilateral common carotid artery and the internal and external carotid arteries were dissected with bilateral cervical incisions. The left subclavian artery was approached with a supraclavicular incision. Carotid arteries were clamped consecutively. Instant neurological deterioration such as loss of consciousness and inability to move the contralateral extremity occurred in all of the patients; this deterioration was temporary and reversed spontaneously in 15–20 s after the release of the clamp. In addition, the cerebral oximetry values of the corresponding side decreased significantly when the carotid arteries were clamped, and the values returned to preclamp levels after the release of the clamp. After systemic administration of 5000 units of heparin, a crossover temporary bypass was performed between the external carotid arteries with a 6-mm polytetrafluoroethylene (PTFE) graft (Fig. 2). A Y-graft was prepared with an 8-mm PTFE graft and was passed through the tunnels to the left carotid and left subclavian regions. The right carotid artery was clamped. The neurological status of the patient was assessed for 2–3 min. Deterioration did not occur, which was confirmed with cerebral oximetry values provided by the sufficient pulsatile flow through the crossover external carotid artery bypass. Then the proximal end of the 8-mm Y-graft was anastomosed end to side to the right common carotid artery. After the release of the right carotid clamp, the left carotid artery was clamped. The neurological status of the patient was again assessed: Deterioration did not occur, which was confirmed with cerebral oximetry. This result was attributed to the sufficient pulsatile flow provided by the crossover external carotid artery bypass. Then the left common carotid artery was divided and the aortic side was sutured primarily. The short leg of the Y-graft was anastomosed end to end to the left common carotid artery. The crossover external carotid artery bypass was not required after this stage and was simply clamped and separated from the external carotid arteries. The stumps of the 6-mm PTFE graft were left and oversewn. The left subclavian artery was clamped, ligated, transected and proximally sutured; the long branch of the Y-graft was anastomosed end to end to the left subclavian artery in 4 cases. In 3 cases the long branch of the Y-graft was anastomosed end to side to the left subclavian artery. Then the subclavian artery was ligated proximally to the left vertebral artery. Meticulous precautions were undertaken during de-aeration of the grafts. With the crossover bypass between the external carotid arteries, pulsatile flow in the internal carotid arteries was achieved throughout the procedure; hence, stroke or major permanent neurological sequelae were not observed. All the procedures were performed without neurological complications.

For the TEVAR procedure, the right femoral artery was surgically accessed with local or spinal anaesthesia. A longitudinal

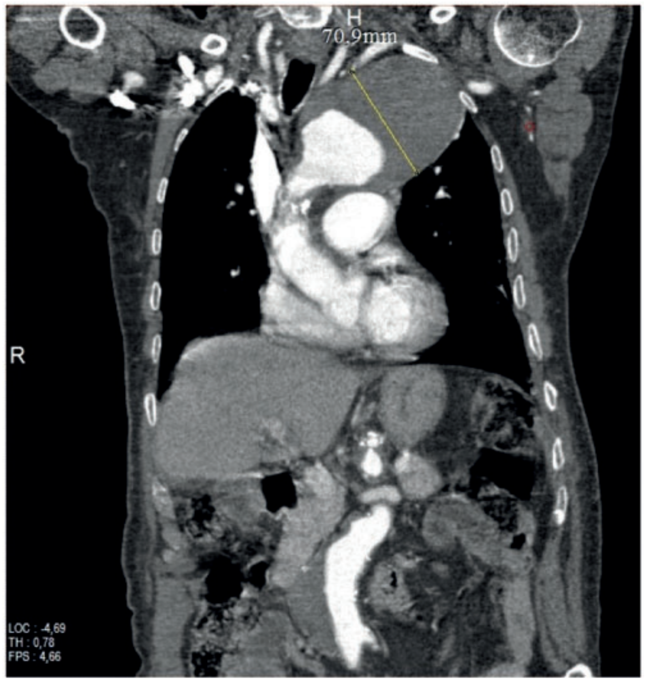

Figure 1: Preoperative computed tomography angiographic scan of 1 patient.

Table 1: Patient characteristics

Patients	Age (years)	Gender	Body mass index (kg/m^2)	Comorbidity factors	Additional cardiovascular disease	ASA score	Procedure	Outcomes	Follow-up
1	60	Male	32.2	Hypertension, diabetes mellitus, malignancy	Ischaemic heart disease	4	Debranching + TEVAR	Type 2 endoleak	Left vertebral artery coil embolization
2	65	Male	33.4	Hypertension, diabetes mellitus		4	Debranching + TEVAR	Successful	Alive, descending aorta aneurysm of 5.5 cm
3	67	Male	25.7	Hypertension, diabetes mellitus, chronic renal failure		4	Debranching + TEVAR	Successful	Type 1 endoleak—proximal stent graft implantation, died of pneumonia followed by multi-organ failure
4	68	Female	27.4	Chronic obstructive pulmonary disease, hypertension	Ischaemic heart disease, ascending aortic replacement	4	Debranching TEVAR postponed	TEVAR postponed	Died of pulmonary causes TEVAR could not be performed
5	72	Male	28.6	Hypertension, diabetes mellitus		3	Debranching + TEVAR	Successful	Alive
6	75	Male	23.2	Hypertension, malignancy	Ischaemic heart disease	4	Debranching + TEVAR	Successful	Died of congestive heart failure
7	92	Male	22.5	Hypertension, aortoiliac occlusive disease	Peripheral arterial disease	4	Debranching + TEVAR attempt failed due to iliac rupture and inability to deploy the stent graft through iliac arteries; performed after aortobifemoral reconstruction	TEVAR was successful the second attempt	Died of old age, natural causes

ASA: American Society of Anesthesiologists; TEVAR: thoracic endovascular aortic repair.

arteriotomy was performed; a Backup Meier superstiff 0.035-inch guidewire (Schneider Medizintechnik Co., Bulach, Switzerland) was positioned at the ascending aorta. A 5-Fr sheath was inserted percutaneously through the left femoral artery, through which a 5-Fr pigtail catheter was directed for angiographic monitoring of the stent graft position. After systemic administration of 5000 units of heparin, a thoracic endovascular stent graft delivery system (Endurant, Medtronic Endovascular, Santa Rosa, CA, USA) was inserted through a longitudinal incision in the right common femoral artery and positioned beyond the brachiocephalic trunk at the aortic arch. The stent was then expanded, excluding the aortic arch and descending aortic aneurysms. The femoral artery was reconstructed primarily or with a patch when needed. Thoracic endovascular stent grafting with appropriately sized stent grafts (Endurant, Medtronic Endovascular) was successfully performed at the same session in all of the patients except 1, who had peripheral arterial disease. In this patient the same procedure was performed after aortobifemoral reconstruction, and a thoracic stent graft was deployed through the aortobifemoral bypass graft.

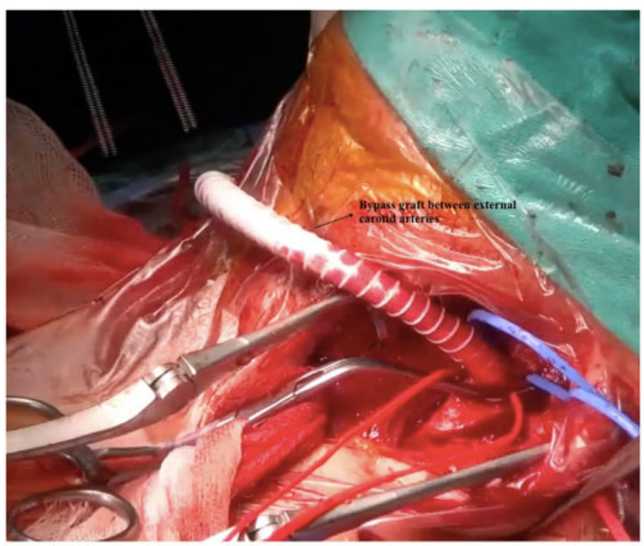

Figure 2: External crossover bypass between external carotid arteries.

RESULTS

No deaths occurred during the perioperative period. All the patients tolerated the debranching procedure well without any major neurological events. Temporary minor neurological events confined to the nerves of the platysma and the hypoglossal nerve appeared as a nasolabial sulcus drop; deviation of the tongue occurred in 2 patients due to the stretching of the nerves during exploration of the carotid artery. They reversed spontaneously in a few months. Further electromyelography studies were not performed because these conditions did not lead to clinical symptoms.

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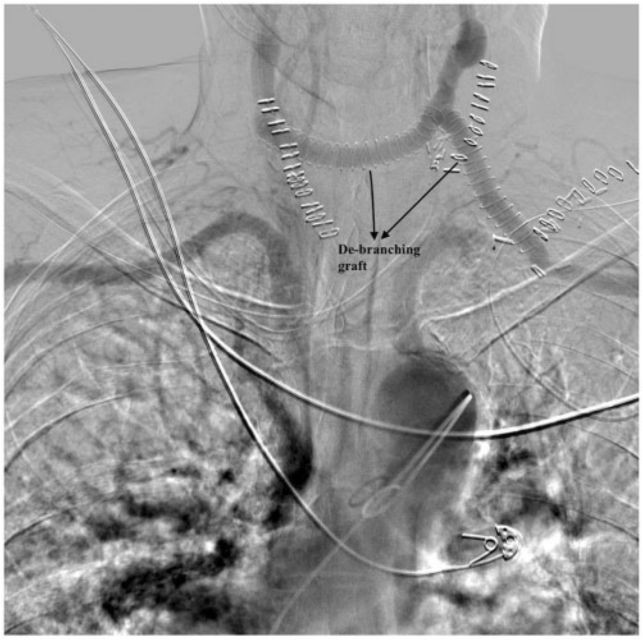

Figure 3: Control angiography of the debranching procedure during thoracic endovascular aortic repair.

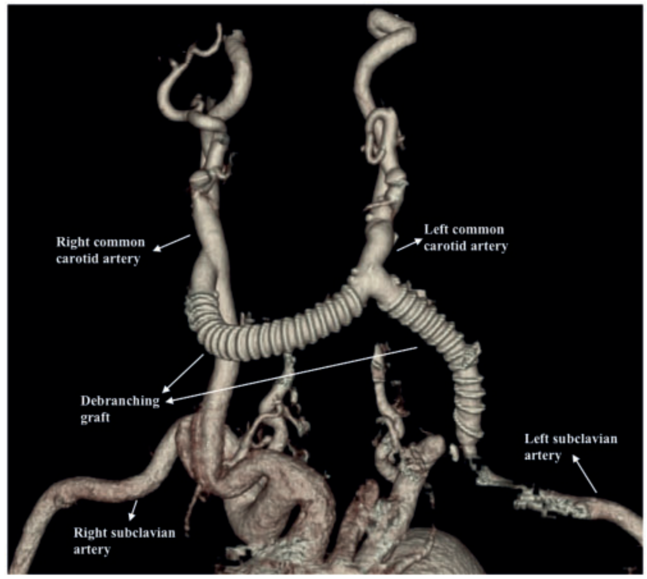

Figure 4: Mid-term follow-up computed angiography examination of the debranching procedure showing patent grafts without significant stenosis.

The TEVAR procedures were performed during the same surgical session in all patients (Fig. 3) except 2 (patients 4 and 7; Table 1). TEVAR failed in the patient (patient 7; Table 1) with peripheral artery disease. All patients were taken to the cardiovascular surgery intensive care unit after the debranching and TEVAR procedures. The patient (patient 4; Table 1) who was operated on while under general anaesthesia was extubated in 3 h. All the patients were taken to the ward the next day except 1 (patient 4; Table 1) with chronic obstructive pulmonary disease. Haematomas did not occur; secondary interventions were not required in any patients. The patient (patient 4; Table 1) who was extubated within 3 h required positive pressure air support early postoperatively because of exacerbated chronic obstructive pulmonary disease and pneumonia. She required reintubation 2 days after the procedure. She was extubated after 3 days. This patient was discharged from the hospital on postoperative day 10. TEVAR was postponed in this patient because she and her family refused further elective procedures. Except for the patient with peripheral artery disease (patient 7; Table 1), the remaining patients were discharged within 4 days following the debranching and the TEVAR procedures.

The patient (patient 4; Table 1) on whom we were not able to perform TEVAR through the femoral route had aortobi-iliac occlusive disease. The patient underwent endovascular stent grafting not at the same session but 6 days after the debranching procedure due to old age and presumably long-term radiographic intervention. Iliac balloon angioplasty was performed to dilate the calcified bilateral iliac arteries for TEVAR while the patient was in the angiography suite. TEVAR was attempted; however, iliac rupture occurred during the deployment of the endovascular stent graft. It was successfully managed with an iliac stent graft (16 mm × 16 mm × 120 mm, Endurant, Medtronic Endovascular). We tried to deploy the thoracic stent graft through the iliac stent graft; but again, it was not possible. The patient had a concomitant abdominal aortic aneurysm (infrarenal abdominal aorta, diameter 4.3 cm) and bi-iliac stenosis. Hence, we planned an aortobifemoral bypass graft operation to make thoracic endovascular repair possible. He underwent an elective aortobifemoral bypass grafting operation with a 22 mm × 11 mm Dacron graft (Vascutek, Terumo, Renfrewshire, UK) 7 days after a failed TEVAR attempt. TEVAR was performed simultaneously at this session through the aortobifemoral bypass graft. The hospital stay following this procedure for this patient was 7 days [3].

Perioperative angiographic scans of the patients resulted in the successful exclusion of the aneurysm without a type 1 endoleak. In 1 patient (patient 1; Table 1), a type 2 endoleak occurred from the vertebral artery; the anastomosis of the subclavian artery bypass graft could not be performed proximal to the vertebral artery because of anatomical difficulties. We decided to follow this patient.

At the mid-term follow-up (between 6 and 9 months), all of the patients received CT angiography of the neck and thoracoabdominal regions. In all cases, the bilateral common carotid and subclavian arteries were open, and the debranching grafts were patent without any stenosis (Fig. 4). We detected an increase in the size of the aneurysm in the patient with the type 2 endoleak (patient 1; Table 1) and decided to occlude the left vertebral artery. Coil embolization was performed, and the endoleak resolved immediately (Fig. 5).

In 1 patient (patient 3; Table 1), a type 1 endoleak was observed due to the migration of the stent graft from the proximal sealing zone, which was presumed to occur during the remodelling of the aorta. Coil embolization was attempted at first to occlude the leak region, but it was not successful. An additional thoracic stent graft was implanted proximal to the previous stent graft and was ballooned. Control angiography showed no further endoleak.

The woman (patient 4; Table 1) with severe chronic obstructive pulmonary disease died during postoperative month 6 of pulmonary causes before we were able to perform TEVAR.

During the long-term follow-up period, 3 patients (patients 3, 5 and 6; Table 1) died. Patient 3 (Table 1) died of pneumonia and multiorgan failure 12 months after the debranching and TEVAR

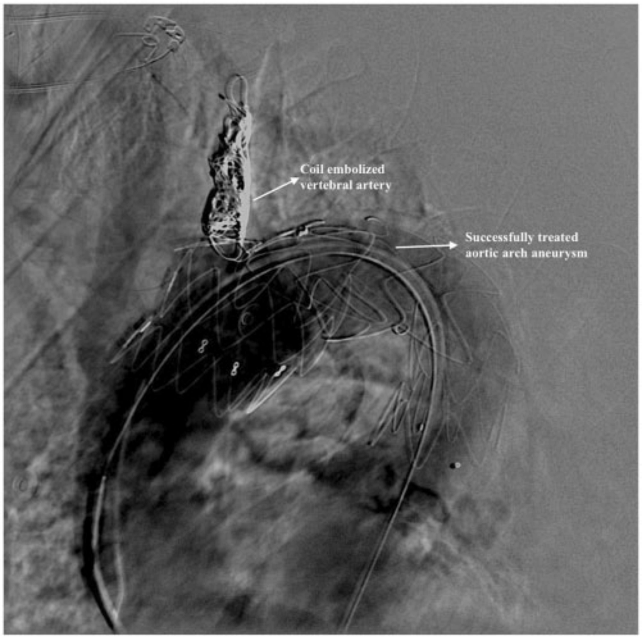

Figure 5: Coil embolization in a patient with type 2 endoleak.

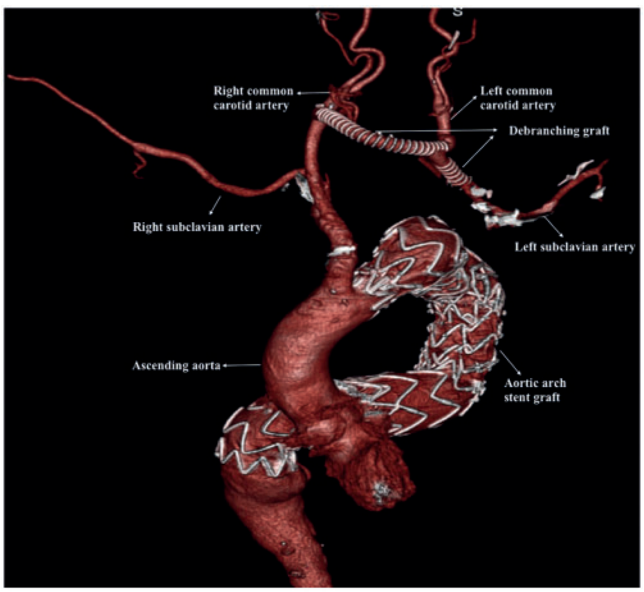

Figure 6: Follow-up computed tomography angiographic scan of the debranching procedure showing patent grafts without significant stenosis and a successfully treated aortic arch aneurysm.

procedures. Another patient (patient 6; Table 1) died during the 15th month of congestive heart failure and myocardial infarction. The patient who was 92 years old (patient 7; Table 1) died of natural causes within 2 years after his operations. The remaining 3 patients are still followed for free at the outpatient clinic. Their latest CT angiography scans revealed patent grafts and successful exclusion of the aortic arch aneurysms (Fig. 6).Follow-up CT angiograms are only performed if the patients report back pain or discomfort; otherwise, periodic ultrasonographies were performed to control the aneurysms. One patient (patient 2; Table 1) has a descending aortic aneurysm that is 5.5 cm at its largest diameter; no intervention is planned at the current stage (Fig. 7).

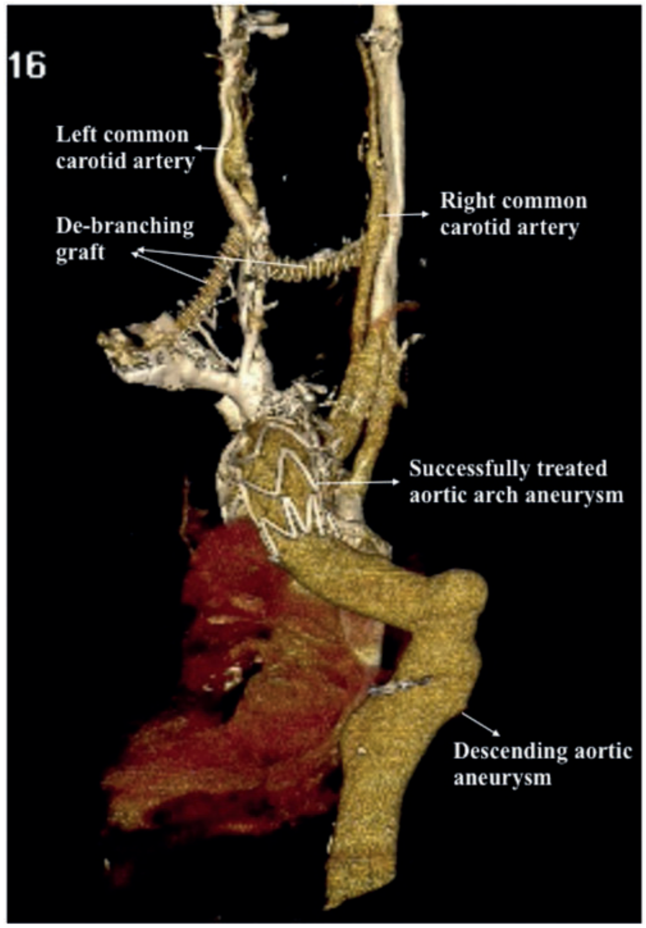

Figure 7: Computed angiography showing a descending aortic aneurysm that was 5.5 cm at the largest diameter.

DISCUSSION

Thoracic aortic aneurysms are rare. They are seen with an incidence of 4.5/100 000 [12]. Patients are usually asymptomatic or may complain of chest or back pain, dyspnoea, dysphagia and/or symptoms due to the compression of the recurrent laryngeal nerve [5]. Diagnosis of the condition relies heavily on suspicion followed by tomography imaging studies of the chest or sometimes incidentally with increased healthcare screening programmes. The disease is serious and may lead to severe complications including dissection, rupture and death [5].

Conventional open surgery is still the gold standard for the treatment of thoracic aortic aneurysms. In brief, conventional open surgery comprises resection of the aneurysm and replacement with a graft [1]. The procedure is not simple and carries certain mortality- and morbidity-related risks including stroke, prolonged ventilatory therapy, renal or visceral organ dysfunction, paraplegia and long-term physical rehabilitation. The risks are even higher in elderly patients and patients with additional comorbidities. The operation usually lasts long and requires cardiopulmonary bypass, hypothermia, cardiac arrest and even sometimes total circulatory arrest [13].

There has always been a search for alternative treatment options that are easier than conventional high-risk open surgical procedures for the replacement of the diseased enlarged segments of the thoracic aorta and the aortic arch; however, none

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of the methods is superior to open surgery. Since the beginning of endovascular stent grafting, stent graft technology has evolved tremendously with the goal of offering percutaneous treatment options for the aneurysms of the entire arterial tree [3, 5–7, 14]. Hence, endovascular aortic aneurysm repair is a less invasive procedure and usually preferred as an alternative to surgery, especially in high-risk, unfit patients [1, 6, 15, 16].

Thoracic aneurysms, including the aortic arch, are challenging due to the anatomy of the arch itself as well as the cerebral vessels. Risk of open aortic arch and descending aortic replacement is higher in patients with serious comorbidities [17]. Because all of our patients had certain risks for an open aortic arch and replacement of the descending aorta, we searched for less invasive alternatives. There are custom branched or fenestrated stent graft options provided by different companies in accordance with the anatomical considerations of the patients' ascending aorta, aortic arch and descending aorta; however, their wide distribution and routine implantation seem far from reality due to the high-level requirements for implantation skills, the ready availability of the materials and cost issues [18]. Moreover, manipulations of the aortic arch and thoracic aorta during the chimney technique or implantation of the fenestrated or branched grafts carry a risk of stroke due to embolization of the atheromatous plaques [1]. Hence, hybrid treatment techniques that combine lower risk surgery and the use of readily available marketed stent grafts may be a more realistic option in this high-risk patient population [8, 19, 20].

In our cohort, all the patients had aneurysms of the aortic arch and descending aorta. The proximal landing zone of the endovascular stent graft had to be between the left and right common carotid arteries for safe and successful exclusion of the aneurysm. Such patients were accepted as high-risk candidates for full or partial sternotomy for conventional arch replacement or even for debranching; i.e. reimplantation of the arch vessels to the proximal ascending aorta. Hence, debranching of the left carotid and subclavian arteries and reimplantation of them to the right carotid artery with cervical and supraclavicular incisions were considered an alternative that could be performed with regional and/or local anaesthesia. Such debranching is a straightforward procedure in patients with a patent polygon of Willis without the need for additional cerebral protection measures; therefore, those patients were excluded from this cohort.

In patients devoid of sufficient collateral supply from the contralateral side (as the cohort presented in this paper), carotid clamping may lead to stroke. Additional measures are necessary during carotid interventions in these patients. Sufficiency of the contralateral carotid flow was tested with a temporary carotid clamp test in our patients. It resulted in instant loss of consciousness and the inability to move upper and lower extremities on the contralateral side, responses that were also confirmed with the decrease in cerebral oximetry values. The neurological status of the patients as well as the cerebral oximetry levels reversed to baseline values with the release of the carotid clamp. Accordingly, the operations in the carotid clamp-intolerant cases were performed uneventfully with Ugurlucan's cerebral protection method fashioned by a crossover bypass between the external carotid arteries, which provides continuous pulsatile cerebral flow even in the presence of a proximal carotid clamp. The neurological instability was instantaneous, temporary and merely clinical in all cases with the clamping of the carotid artery. It did not continue after the release of the clamp or throughout the procedure when it included the flow from the crossover external carotid artery bypass. Because the neurological disturbances were not permanent in any of our cases, we did not perform additional radiographic investigations to investigate the cerebral vasculature in detail. An additional trick of the technique is related to the debranching of the left subclavian artery, which has to be proximal to the left vertebral artery; otherwise a type 2 endoleak might occur if it is not occluded during the endovascular stent grafting, which occurred in 1 of our patients; the leak was treated with coil embolization.

After the debranching procedures, TEVAR was performed through the femoral route except in 1 patient with aortoiliac occlusive disease. Aneurysms and arterial occlusive disease share atherosclerosis as the common aetiology [21]. We needed to perform aortobifemoral bypass in order to convey the stent graft after failing the initial stent grafting attempt due to iliac rupture, which was treated with endovascular means in this patient. We regularly follow another patient at the outpatient clinic who has a stable 5.5 cm in diameter type 5 aortic aneurysm. In 1 patient, we observed proximal dislocation of the stent graft and ended up with a type 1 aneurysm. She was treated with an additional stent graft positioned 1 cm proximal to the initially implanted stent graft. Other patients are followed regularly; 4 of them were lost to follow-up due to various causes unrelated to the debranching or the TEVAR procedures. We did not observe neurological consequences related to the debranching grafts in any of the patients. All the grafts were patent; there was no significant stenosis in any patient.

Limitations

This study has some limitations. One major limitation is the small size of the cohort. The second major limitation is the relatively short follow-up period, which was a maximum of 34 months. The retrospective nature of the study may be regarded as an additional limitation.

CONCLUSION

Aortic arch debranching performed with cervical and supraclavicular incisions with local or regional anaesthesia, thereby avoiding sternotomy, with a cerebral protection technique provided by a temporary crossover bypass between the external carotid arteries in patients with non-patent polygon of Willis is safe and durable. TEVAR and positioning of the stent graft beyond the brachiocephalic trunk followed by debranching is straightforward, does not require additional skills and may be performed with acceptable outcomes. Survival of such high-risk patients is strongly related to their comorbidity features rather than to debranching and/or TEVAR. Multicentre studies with higher numbers of patients and longer follow-up results are warranted because the experience is limited.

Conflict of interest: none declared.

Author contributions

Didem Melis Oztas: Conceptualization; Data curation; Investigation; Methodology; Writing—original draft; Writing—review & editing. **Murat Ugurlucan:** Conceptualization; Data curation; Formal analysis; Investigation;

Methodology; Supervision; Writing—original draft; Writing—review & editing. **Metin Onur Beyaz:** Conceptualization; Investigation; Methodology; Supervision; Writing—review & editing. **Mustafa Ozer Ulukan:** Conceptualization; Data curation; Investigation; Methodology; Writing—review & editing. **Orcun Unal:** Conceptualization; Data curation; Formal analysis; Writing—review & editing. **Yilmaz Onal:** Conceptualization; Data curation; Formal analysis; Investigation; Writing—review & editing. **Muzaffer Umutlu:** Data curation; Investigation; Methodology; Writing—review & editing. **Bulent Acunas:** Data curation; Investigation; Methodology; Writing—review & editing. **Ufuk Alpagut:** Conceptualization; Data curation; Investigation; Methodology; Writing—review & editing.

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