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Endovascular repair of type-V thoracoabdominal aortic aneurysms using parallel graft techniques

Paralel greft teknikleri kullanılarak tip-V torakoabdominal aort anevrizmalarının endovasküler tamiri

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ABSTRACT

Background: This study aims to present mid-term outcomes of endovascular aortic repair of type-V thoracoabdominal aortic aneurysms using parallel grafts to maintain blood flow to renovisceral arteries.

Methods: Between March 2013 and March 2014, four consecutive patients (3 males, 1 female; mean age 66.8 years; range 63 to 73 years) with type-V thoracoabdominal aortic aneurysms underwent endovascular aortic repair with parallel grafts. Chimney and sandwich grafts were inserted from an axillobrachial access, while periscope grafts and aortic endografts were delivered via transfemoral access.

Results: The mean follow-up was 16.25 (range 9 to 22) months. All aortic stent-grafts and parallel grafts were implanted with 100% procedural success. The aortic aneurysms were excluded with thoracic endografts (n=11) and a bifurcated stent-graft. A total of 16 parallel grafts (8 sandwich grafts, 2 chimney grafts, and 6 periscope grafts) using 26 Viabahn®-coated stents were placed to maintain blood flow to eight renal and eight visceral arteries. Temporary worsening of kidney function was seen in a patient. During follow-up, three of the four patients were uneventful and a subdural hematoma developed in a patient in the first postoperative month. No postoperative mortality was seen in any patient. No aneurysmal growth was seen. All parallel grafts were patent. Minimal type-I and type-III endoleaks were observed in two patients with short-term follow-up.

Conclusion: The parallel graft technique to treat type-V thoracoabdominal aortic aneurysms is a feasible and less invasive alternative method with extremely low mortality rates.

Keywords: Chimney graft; coated stent; endovascular aortic repair; parallel graft; thoracoabdominal aortic aneurysm.

ÖZ

Amaç: Bu çalışmada renoviseral arterlerin kan akımının devamını sağlamak için tip-V torakoabdominal aort anevrizmalarının paralel greftler kullanılarak endovasküler aort tamirinin orta dönem sonuçları sunuldu.

Çalışma planı: Mart 2013 - Mart 2014 tarihleri arasında tip-V torakoabdominal aort anevrizması olan ardışık dört hastaya (3 erkek, 1 kadın; ort. yaş 66.8 yıl, dağılım 63-73 yıl) paralel greftler kullanılarak endovasküler aort tamiri yapıldı. Baca ve sandviç greftler aksillobrakiyal erişim ile yerleştirilirken, periskop greftler ve aortik endogreftler transfemoral erişim ile yerleştirildi.

Bulgular: Ortalama takip süresi 16.25 (dağılım 9-22) ay idi. Tüm aortik stent-greftler ve paralel greftler %100 işlem başarısıyla yerleştirildi. Aort anevrizmaları torasik endogreftler (n=11) ve bir bifurke stent-greft kullanılarak dışarıda bırakıldı. Sekiz renal ve sekiz viseral arterin kan akımını sağlamak için toplam 16 paralel greft (8 sandviç greft, 2 baca greft, ve 6 periskop greft) 26 Viabahn® kaplı stent kullanılarak yerleştirildi. Bir hastanın böbrek fonksiyonunda geçici kötüleşme görüldü. Takip sırasında dört hastanın üçünde sorun görülmedi ve bir hastada ameliyat sonrası birinci ayda subdural hematom gelişti. Hastaların hiçbirinde ameliyat sonrası mortalite gözlenmedi. Anevrizmada büyüme saptanmadı. Tüm paralel greftler açıktı. Kısa dönem takipte iki hastada minimal tip I ve tip III endo kaçaklar gözlendi.

Sonuç: Paralel greft tekniği, tip-V torakoabdominal aort anevrizmalarının tedavisinde çok düşük mortalite oranları ile kullanışlı ve daha az invaziv alternatif bir yöntemdir.

Anahtar sözcükler: Baca greft; kaplı stent; endovasküler aort tamiri; paralel greft; torakoabdominal aort anevrizması.

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Thoracoabdominal aortic aneurysms (TAAAs) are relatively uncommon in the spectrum of aneurysmal disease, accounting for only 3% of diagnosed aneurysms.[1] The initial classification for TAAAs was first described by Crawford.[2] It included four subtypes of varying extent of the thoracic and abdominal aorta. In 1999, Safi and Miller[3] modified the Crawford classification by adding a fifth subtype, which extends from the distal thoracic aorta including the celiac artery (CA) and superior mesenteric artery (SMA) origins, but not the renal arteries (RAs).

The five-year survival and repair-free survival rates of non-operable >6 cm TAAAs are 39% and 17%, respectively.[4] The annual rupture rate in this setting is estimated as 14%, indicating that TAAAs represent a considerable risk for life.[5]

Traditionally, type-V TAAAs have been treated with open surgery. The first published reports of open TAAA repair were in 1955.[6] Open repair of TAAA, particularly in patients with pre-existing co-morbidities, is fraught with complications. A recent meta-analysis reported a 30-day mortality rate of 7%, in-hospital mortality rate of 10%, spinal cord ischemia rate of 7.5%, renal failure rate of 19%, and pulmonary dysfunction rate of 36% following open repair.[7]

Due to these high morbidity and mortality rates, several treatment alternatives using endovascular therapy in combination with open surgery or alone have been developed to repair these complex aneurysms. Since the first endovascular exclusion reported in 1994,[8] the trend is likely to be toward a less invasive approach, which improves outcomes, recovery time, and quality of life.

Current endovascular techniques include hybrid procedures creating landing zones by the construction of extra-anatomical bypass to either visceral or arch vessels.[9,10] Another common approach is the utilization of parallel grafts (PG) to preserve flow to the side branches of the vessels.[9,10] Thanks to the recent availability of fenestrated (FG) and branched grafts (BG),[11] and multi-layer flow modulators (MFM),[12] total endovascular TAAA repair has regained its former splendour. However, endovascular treatment of type-V TAAAs is still a considerable challenge for surgeons.

In this article, we aimed to present our experience with mid-term outcomes of endovascular aortic repair (EVAR) of type-V TAAAs using PG technique.

PATIENTS AND METHODS

Four consecutive patients who underwent EVAR for type-V TAAA with PG techniques between March 2013 and March 2014 were retrospectively analyzed. Before operation, all patients were informed about the details of endovascular procedures. The pre-, peri- and postoperative data and data of the patients with all radiologic images recorded in the hospital database were recorded. A written informed consent was obtained from each patient. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Endovascular aortic repair with PG techniques was performed in four patients (3 males, 1 female; mean age 66.8 years, range 63 to 73 years) who were considered eligible for endovascular treatment by the Council of Interventional Radiology and Cardiovascular Surgery. All patients were asymptomatic and the diagnoses were made incidentally by various radiologic studies. All patients in this series underwent first time elective repair of TAAA.

Degenerative fusiform type-V TAAA (mean diameter 66.5 mm, range 55 to 100 mm) existed in all patients. In one patient, there was an accompanying abdominal aortic aneurysm (AAA) with a diameter of 57 mm. The patients were classified according to the American Society of Anesthesiologists (ASA) by an anesthesiologist. All patients were smokers and they had at least one comorbid condition. These included patients with poorly compensated congestive heart failure, ejection fraction ≤35%, recent myocardial infarction, chronic obstructive pulmonary disease (forced expiratory volume in 1 second of ≤1 L), morbid obesity, and those with a hostile abdomen as a result of multiple prior abdominal surgeries.

All patients underwent thoracoabdominal computed tomography (CT) angiography and images were carefully analyzed on a workstation. Thoracic images were evaluated for arch and subclavian anatomy for the delivery of chimney (CGs) or periscope (PeGs) grafts. All anatomic features were documented and stent-graft and coated stent sizing were based on the CT angiographic findings.

Endovascular repair technique

A vascular team consisting of interventional radiologists and cardiovascular surgeons performed all endovascular treatments in the angiography suit. All patients underwent general anesthesia. Systemic heparin sodium was given and activated clotting time was kept at 300 to 350 sec. In all patients, both common femoral arteries were surgically exposed and all aortic stent-grafts were advanced via femoral artery. Zenith® TX2® thoracic grafts (Cook Medical Inc.; Bloomington, IN, U.S.A) were used in all four

patients. A Gore Excluder® endoprosthesis (W.L. Gore and Associates; Newark, DE) was used in one patient with AAA in addition to TAAA. To constitute the PGs, self-expandable Viabahn®-coated stents (W.L. Gore and Associates, Flagstaff, AZ) were used in all patients.

Chimney (CG) and sandwich (SG) grafts were introduced and deployed from a supraaortic access site, the brachial artery, or the axillary artery. They cranially originated from the proximal landing zone of the aortic stent-graft and received antegrade flow. Conversely, PeGs were introduced transfemorally, originating distally from the distal aortic landing zone, and received retrograde blood flow. The PeG configuration allowed an extension of the distal landing zone. The CGs and PeGs were positioned between the stent-graft and aortic wall, while the SGs were positioned between the two aortic stent-grafts (inside one and outside the other). The length of a PG was chosen at least 1 cm of the PG extending beyond the coated part of the aortic stent-graft.

For SGs, a thoracic stent-graft was firstly inserted via femoral artery and deployed approximately 2 cm proximal to CA before a SG was deployed. This first thoracic stent-graft deployment stage was not applied for the CGs. Subsequent steps were the same for both the SG and CG. A 10Fr 80 cm sheath (Flexor Introducer; Cook Medical Inc.; Bloomington, IN) was inserted percutaneously and carried down the distal thoracic aorta via axillary arteries. Through the guiding sheath, various 5Fr diagnostic catheters including Headhunter, Bern, and Multipurpose were advanced to cannulate the CA or SMA. Then, the other visceral artery was cannulated from the contralateral axillary artery. Over a 0.035-inch 260 cm Amplatz super-stiff wire-coated stents (Boston Scientific, Global Park, Heredia, Costa Rica) were delivered into the CA and SMA and released. Afterwards, second coated stents were inserted into the previous ones without releasing them. Then, a thoracic stent-graft (second for the SG procedure and first for the CG procedure) was introduced via femoral artery. After deployment of the stent-graft to position the distal end approximately at the inferior border of SMA, coated stents were released.

In case of PeG for RA, a 20Fr extra-large introducer sheath (Check-Flo® Performer; Cook Medical Inc.; Bloomington, IN) was inserted from the contralateral femoral artery. Through the introducer sheath, two 7Fr 80 cm sheaths (Flexor Introducer; Cook Medical Inc.; Bloomington, IN) for PeG placement and a short 6Fr sheath for diagnostic angiography were inserted. Renal arteries were cannulated by using 7Fr sheaths, 5Fr Cobra-2 catheter (Glidecath; Terumo Europe, Leuven, Belgium) and Rosen wires (Cook Medical Inc.; Bloomington, IN). After cannulation, coated stents were placed in RAs without releasing them. Then, a thoracic stent-graft (third for the SG procedure and second for the CG procedure) was introduced and deployed, and coated stents were released. Finally, kissing balloon technique was applied to achieve full expansion of the stents.

If the SGs were placed for RAs, kissing balloon technique was first applied to the visceral arteries and aorta. Then, RAs were cannulated via axillary introducer sheaths by 5Fr Headhunter catheters (Boston Scientific, Global Park, Heredia, Costa Rica) and Amplatz wires. After cannulation, coated stents were placed in the RAs without completely releasing them. Thereafter, a thoracic stent-graft (third for the SG procedure and second for the CG procedure) was introduced and deployed, and then, coated stents were finally released. Finally, kissing balloon technique was applied to the RAs and aorta. Angiography was performed to assess the position and the patency of the grafts and any possible endoleaks were evaluated. Balloon dilatations were repeated, if required.

Postoperative management

Dual antiplatelet drug therapy (clopidogrel and acetylsalicylic acid) were given immediately after the operation and continued for at least six months followed by lifelong single antiplatelet regimen. Also, low molecular weight heparin was administered subcutaneously for five days after the procedure.

Computed tomography angiography was performed before discharge, and at 3, 6 and 12 months postoperatively and yearly thereafter (Figure 1a-d). Non contrast-CT and Duplex scan were performed in patients with renal insufficiency. Clinical follow-up consisted of physical and laboratory examinations including serum creatinine and urea at one month, three months, six months, and yearly thereafter, if no complications were observed.

All clinical, anatomical, and operative data were performed prospectively collected in our institutional database and retrieved for the analysis. Primary endpoints were technical success (defined as successfully completed procedure with endograft patency, preserved target vessels, and no evidence of high flow type I or III endoleaks at the postprocedural imaging scans), 30-day morbidity (defined as paraplegia and access complications), and mortality. Follow-up

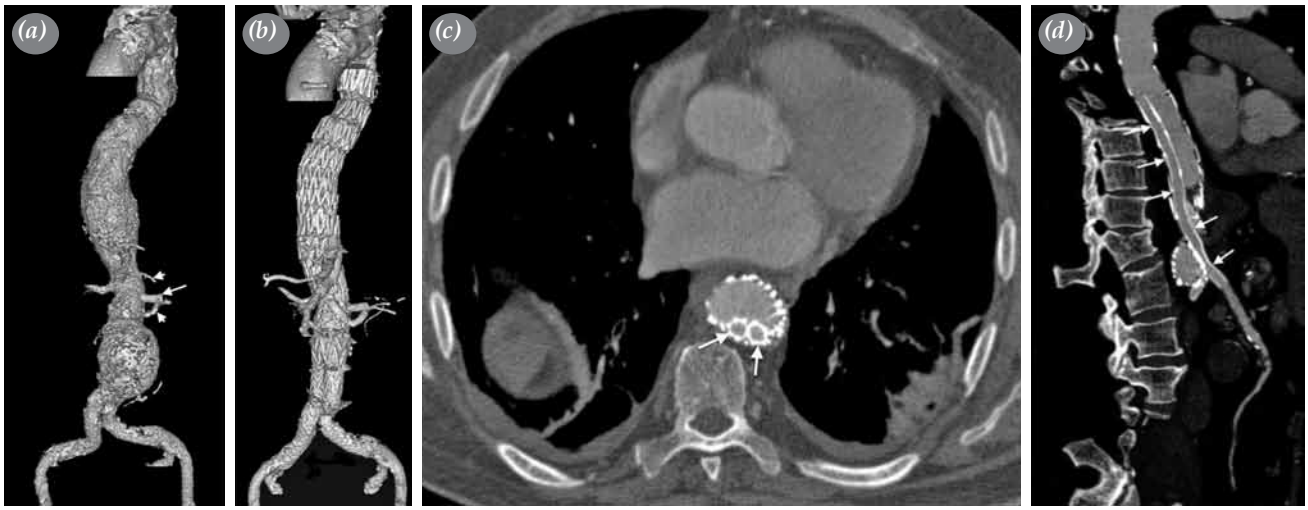

Figure 1. A preoperative volume-rendered three-dimensional reconstruction image **(a)** showing type-V thoracoabdominal aortic aneurysm including celiac and superior mesenteric arteries and infrarenal abdominal aortic aneurysm. While occlusion of the left main renal artery placed previously stent (arrow) is observed, two left accessory renal arteries (arrowheads) and the right renal artery are patent. A volume-rendered three-dimensional reconstruction image obtained one year after the procedure **(b)** showing that all implanted stents including aortic endografts and parallel stents are patent. An axial computed tomography angiography image **(c)** showing patent sandwich grafts (arrows) of celiac and superior mesenteric arteries at the descending thoracic aorta level. A curved multi-planar reformat image **(d)** showing lengthwise patency of the sandwich graft (arrows) and its continuity with superior mesenteric artery.

was mainly based on all-cause mortality, branch vessel patency, renal impairment, and secondary interventions. Due to the small sample size, no control groups were selected for the study and data were analyzed using a descriptive method.

Statistical analysis

Statistical analysis was performed using IBM SPSS for windows version 20.0 software (IBM Corporation, Armonk, NY, USA). Categorical variables are expressed in frequencies and percentages, while continuous variables are presented in the mean and range.

RESULTS

The mean follow-up was 16.25 (range 9 to 22) months. The mean ASA score was 3.75 (range 3 to 4) in the preoperative period. All aortic stent-grafts and PGs were implanted with 100% procedural success in all patients. As a technical complication, a limited hepatic artery dissection was developed during the procedure and resolved immediately by implanting a coated stent. Contrast material volumes and, to a greater extent, fluoroscopy times varied significantly, primarily on the basis of patient's anatomy. The median procedural time, amount of blood loss, contrast agent volume and X-ray exposure time were 217 min (range 120 to 300 min), 60 mL (range 35 to 150 mL), 280 mL (range 220 to 350 mL), and 47 min (range 35 to 60 min), respectively.

The aortic aneurysms were excluded with thoracic endografts (n=11) and a bifurcated stent-graft. A total of 16 PGs (8 SGs, 2 CGs, and 6 PeGs) using 26 coated stents were implanted to maintain blood flow to eight renal and eight visceral arteries. A splenic artery originating as a common trunk with the hepatic artery was occluded by a coated stent. Another splenic artery originating from the aorta as a distinct trunk was not cannulated. Two accessory RAs were occluded in two patients. In a patient with occluded left main RA stent, a SG was placed into the accessory RA. In this patient, temporary worsening of renal functions (preoperative creatinine level: 1.32 mg/dL, postoperative third day and third month creatinine levels: 1.90 mg/dL and 1.21 mg/dL respectively) was observed.

No postoperative mortality was seen during 30-day period. All patients except one were uneventful; an acute subdural hematoma was developed in a patient in the second postoperative month. Subdural hematoma was surgically evacuated and the patient was discharged without any neurological deficit. Intraoperative digital subtraction angiography and predischarge CT angiography showed low-flow type and type-III endoleaks in two patients. There was no late postoperative rupture or sac growth in any patient.

DISCUSSION

Type-V TAAAs are challenging to treat. While conventional surgery is effective and durable, it is associated with considerable morbidity and mortality, particularly among high-risk patients for surgery.[7] Therefore, alternative approaches have been sought with two approaches currently. In the first, the 'hybrid approach', visceral perfusion is safe guarded by means of an extra-anatomic bypass followed by endovascular exclusion of the entire aneurysm.[9,10] This approach has the advantage of limiting the exposure required to a laparotomy while avoiding thoracotomy, although in ineligible patients, it remains a considerable undertaking.[9] Unfortunately, recent data are less favorable with morbidity and mortality rates comparable to those of the standard open surgical technique.[13,14] Currently, the hybrid technique is restricted to a small number of patients with no other reasonable options. In addition, the second approach is totally endovascular approach utilizing different devices and techniques.[13,14] Currently, endovascular techniques have gradually become routine in the daily practice.

Since the first description of the PG technique as a bailout procedure in 2003 by Greenberg et al.,[15] this off-label technique has been successively expanded and improved by other authors[16-18] to restore the flow in the aortic branches intentionally or accidentally coated and to obtain an adequate sealing for patients with TAAA as well as in urgent cases when off-the-shelf devices are needed to be deployed. Many papers have been published on PG techniques with relatively good perioperative and short-term results. A meta-analysis evaluating the results of 15 reports on PG technique has been published recently by Moulakakis et al.[19] The 30-day mortality was 4.3% in the reported meta-analysis. In the same meta-analysis, Moulakakis described ischemic stroke in 3.2% of patients.

Furthermore, the major merit of this technique is possibly that PGs can be applied in most anatomies using conventional EVAR devices which are universally available. As a consequence, these techniques can even be employed in emergent or urgent settings in most centers performing EVAR. Another advantage is that the branch vessels are cannulated prior to the deployment of the aortic endoprosthesis. It can be quite important in case of tortuous anatomy, in small lumens, and when there is a significant thrombus in the paravisceral aorta.

However, it poses some logistical issues in terms of access. While Lobato and Camacho-Lobato[20] described using bilateral axillobrachial access to accommodate the four-renovisceral sheaths, we prefer using retrograde approach for PeGs and antegrade approach via axillobrachial access for the CGs and SGs.

On the other hand, one of the major disadvantages of the PGs is the imperfect seal inherent to the technique. The side-by-side configuration leads to gutters along the PGs, which may result in endoleaks and continued pressurization of the sac. The gutters may be eliminated by oversizing the aortic stent-graft to wrap around the branch stent. In addition, *in vitro* studies showed that 40% oversizing of the aortic stent could optimally minimize the gutters along a single parallel branch stent.[21] However, as this approach also led to a significant unfolding in published reports,[21] we prefer an approximately 30% oversizing. In consistent with the suggestion of Lobato and Camacho-Lobato,[20] we prefer overlap lengths of 5 cm to induce thrombosis of the gutters. Longer overlap lengths may affect patency rates and sometimes necessitate sacrifice of additional lumbar or intercostal vessels.[20,21] In our experience, PGs have been constructed using self-expanding stent grafts and to eliminate the gutters, we mold the PGs slightly into an eye-shape as opposed to leave it a perfect round shape. Therefore, the aortic graft can more easily conform to its exposed perimeter. When more than two visceral vessels require revascularization, however, the summative displacement of the main body endograft theoretically increases the gutter formation with subsequent endoleaks. Therefore, we prefer the "terrace" or "sandwich" strategy, which stacks the grafts into the separate layers, and instead of having four grafts at the same level, we have two upper CGs with antegrade flow and two lower periscope grafts with retrograde flow to decrease the gutter formation. Low-flow endoleaks appearing late after the injection of a contrast agent which do not fill the aneurysm sac, particularly gutter endoleaks limited to the proximal or distal neck, can be treated conservatively. In our limited experience, if there is sufficient PG aortic graft overlap, these gutter endoleaks have a tendency to seal spontaneously in a short time. In any case, meticulous follow-up is mandatory in all patients, particularly for the ones with endoleaks. Screening for endoleaks, aneurysm enlargement, or graft migration should be achieved using combined CT scanning and Duplex ultrasound.

Many patients, particularly elderly, are considered ineligible for open surgical repair of TAAAs and this patient population has been studied to date with the

growing experience of endovascular repair of these lesions. Intuitively, one would expect particularly poor outcomes of such procedure in these patients; however, interestingly this does not appear to be the case in our series. All four patients were successfully treated with this total endovascular approach to achieve a 30-day and six-month survival rate of 100%. Although in some of the larger series in high-volume centers, the mortality rate can be improved to between 5% and 12%, the mortality rates in eligible patients undergoing open TAAA repair approach is 20% based on regional or national registries.[22,23]

All patients in our series were able to return to their social environment directly after their hospital stay. Aneurysm exclusion and patent grafts were achieved in all patients. Fortunately, we observed excellent patency rates in the renal arteries as well as in the CAs and SMAs.

None of the patients experienced paraplegia. The largest series of endovascular repair of TAAA by Roselli[24] reported a 2.7% paraplegia rate with both patients who died subsequently. Chuter et al.[25] reported zero incidence of spinal cord ischemia in his series of 22 patients, while Verhoeven et al.[26] reported spinal cord ischemia with an incidence of 16.7%. We believe that appropriate protective measures against cord ischemia should always be taken for these types of repairs. In our practice, we monitor and maintain lower spinal pressure below 10 mmHg after complete exclusion of the aneurysm and try to keep the mean arterial pressure around 85 mmHg. In hemodynamically stable patients, we remove the spinal drain and continue to monitor for possible symptoms. In our case, one patient developed a subdural hematoma after 30 days which was drained uneventfully.

Renal complications were uncommon in our series with only one patient demonstrating a temporary elevation serum creatinine over baseline in the early postoperative period. None of the patients required transient dialysis perioperatively. These figures are favorably comparable with those for open TAAA repair where up to 15% patients require dialysis.[27]

Moreover, stent-grafts which have been manufactured to fit a population with typical visceral vessel anatomy and thus are not patient-tailored (custom-made) are referred to as standardized grafts.[28] Currently, patients with complex aortic aneurysms often wait up to 8 to 12 weeks for their devices to be manufactured and delivered. A standardized stent-graft would probably prevent ruptures from occurring during this waiting period and allow treatment of patients presenting with ruptures or symptoms which require urgent or emergent treatment. Currently, available off-the-shelf devices are aimed at juxtarenal and suprarenal aneurysms (fenestrated design), as well as TAAAs (branched design). While these current designs can theoretically treat up to 80% of these pathologies, the remaining 20% remain outside the current design limits and need custom devices.[28] Due to the limited way these devices are implanted, they are also usually less suitable for treating ruptured aneurysms, particularly in unstable patients. More recently, a new concept in treatment of aneurysms was introduced with multi-layered uncoated self-expanding stents. The main goal of using this type of stent is to re-direct blood flow in such a manner to remove pressure from within the aneurysm sac, thereby, preventing it from rupturing.[29] Clinical results in the form of thrombosis of the aneurysm, reduction of the aneurysm, and patency of visceral branches were achieved only in around 40% of aneurysms involving the visceral arteries and there are reports of re-intervention in around 13.7% of cases, including intestinal resection and thrombosis in 8.3% of cases, and even rupture of the aneurysm.[30] Another major factor which limits using this material is its extremely high cost compared to conventional endoprostheses.

While PG technique is currently the most durable and promising endovascular solution to treat such patients, the introduction of off-the-shelf standardized devices is expected to bring a new push in the field of fenestrated/branched endovascular aneurysm repair. However, standardization should not be allowed to suppress principles such as preservation of all aortic branches with perfectly aligned fenestrations or branches. To date, published data is not of sufficient volume to support the use of any one of these three approaches over another. The challenge to find the balance between PG, standardized branched grafts, and customized stent-grafts will be decisive in the further years.

It is worth bearing in mind that these four patients included our 'learning curve' and that it is likely that, as further experience is gained, outcomes will improve further. Also this series, in consistent with the other published series, included only patients considered ineligible for open surgery and compared outcomes with the open procedure in low-risk patients who were inherently healthier. Our current practice for patients with TAAA is to evaluate both the patient's physiology and the morphology of the aorta and its branches. We believe that it should not be

the first choice at this stage to treat a fit patient by an endovascular approach, even if the anatomy is favorable for such a treatment, although our position may probably change, when long-term data become available. Whereas long-term durability has not been proved for this technique, we think that these options for high-risk patients are still limited such that they clearly benefit from the less invasive procedure. Until industry develops a standardized, off-the-shelf, multi-branched stent-graft which can be used in urgent and emergency situations, a PG is currently the only option we have for high-risk patients. In addition, we included only elective patients in our series, we were unable to draw any conclusions on outcomes for emergency or ruptured patients.

However, there are some limitations to this study including its retrospective design, relatively short follow-up, and lack of a control group. Also, the small sample size made any statistical conclusion impossible to reach. Therefore, the results should be interpreted cautiously.

In conclusion, the parallel graft technique should not be seen as a miraculous solution for all complex aortic pathologies and criteria-based use should be encouraged. Although the present study does not offer grounds for any type of recommendation, these results might be important to accomplish an effective treatment of such patients. Of note, the parallel graft technique is still being studied and further large-scale and multi-center randomized clinical trials are required to technically optimize this treatment option and precisely define its indications. This study carried out in an inherently high-risk patient group suggests that the technique is safe compared to published data for open approaches in healthier patients. Parallel grafts may present a convenient off-label approach in this uncommon aneurysm presentation, when standard endovascular aortic repairs contraindicated. The endovascular approach appears to be durable in the short to mid-term with extremely encouraging morbidity and mortality rates.

Declaration of conflicting interests

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