Single center experience with fenestrated and branched endovascular repair (F/BEVAR) for pararenal and thoracoabdominal aortic aneurysms

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Abstract:

Objectives: To report preliminary outcomes of fenestrated and branched endovascular repair (F/BEVAR) for pararenal aortic aneurysms (PAA) and thoracoabdominal aortic aneurysms (TAAA) in a single center.

Materials and Methods: Consecutive patients treated with F/BEVAR for PAA or TAAA within the period July 2021 - March 2023 were included. Perioperative and early follow-up outcomes were analyzed.

Results: During the study period, 35 patients (33 male, mean age 72.6 ± 7.8 years) were treated. Twenty-one (60.0%) patients were treated for a TAAA and 14 (40.0%) for a PAA. Fourteen (40.0%) patients had previously undergone one or more open/endovascular aortic procedures. Five (14.3%) patients had an acute aneurysm. Mean operative time was 240 ± 65min. Technical success was achieved in 33 (94.3%) patients. Thirty-day operative mortality was 2.9% (1/35). One patient (2.9%) developed postoperatively spinal cord ischemia with permanent paraplegia. During follow-up three patients died. All target vessels remained patent excpet for one renal artery. Two patients had a type Ic endoleak and have been planned for a bridging stent-graft extension.

Conclusions: Early outcomes of this preliminary F/BEVAR single center experience seem to be comparable to published outcomes of high-volume centers. A frequent performance of these procedures under a routine protocol may have contributed to these outcomes. Further follow-up is warranted.

Key words: aortic aneurysm; pararenal, thoracoabdominal, endovascular repair; fenestrated, branched.

INTRODUCTION

Fenestrated endovascular aneurysm repair (FEVAR) was first reported in 1999 for the treatment of a juxtarenal aortic aneurysm.[1] Since then the technique has evolved and the number of the included target vessels/fenestrations has been increasing in expert centers aiming to treat more complex pararenal pathologies and to create a longer proximal sealing zone.[2] Following the invention of fenestrations, directional branches were later on introduced to address target vessels with a downward take-off angulation, especially in anatomies where the distance between the aortic stent-graft and the target vessel orifice is longer. Fenestrations and branches can be used in combination to address appropriately target vessels in more extensive thoracoabdominal pathologies. F/BEVAR is increasingly being used to address complex pararenal aortic aneurysms (PAA) and thoracoabdominal aortic aneurysms (TAAA) and real life data show that these techniques have become the first line treatment in many institutions worldwide.[3]

F/BEVAR had been sporadically applied in our institution since 2012 for some selected cases. Since July 2021, a complex endovascular aortic program was initiated aiming to offer systematically F/BEVAR in patients unfit for open repair with unfavorable anatomy for standard EVAR or TEVAR.

This report presents perioperative and early follow-up outcomes of F/BEVAR for PAA and TAAA in a single center.

MATERIALS AND METHODS

All consecutive patients treated with F/BEVAR for PAA or TAAA within the period July 2021 - March 2023, were analysed for this study. Patients with previous failed endovascular or open aortic surgery were also included. All patients signed an informed consent for collection, processing and review of clinical and morphological data.

Main indication for FEVAR included a proximal neck too short for standard EVAR, but otherwise suitable anatomy for EVAR in an AAA of at least 55 mm in diameter. Indication for F/BEVAR in TAAAs, was an aneurysm of at least 60mm in diameter. Details of device design, and procedure execution have been previously described.[3]

Follow-up

Patients were followed with clinical and laboratory examina-

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tion. Computed Tomography Angiography (CTA) controls were usually performed at 1 month, and 1 year, and thereafter, depending on each patient's characteristics. Upon suspicion of endoleak or branch vessel malperfusion, additional DSA for further evaluation and possible reintervention was carried out.

Data analysis

Statistical analysis was performed using SPSS, version 26.0 (IBM Corp, Armonk, NY). Variables are presented as mean ± standard deviation (SD). Early analyzed outcomes included technical success and 30-day operative mortality. Technical success was defined as successful deployment of the planned stent-grafts with patent stented target vessels and absence of type I or III endoleak at the first postoperative CTA. Early follow-up outcomes included survival, target vessel stent patency, and reintervention rates.

RESULTS

Patient & aneurysm characteristics

During the study period, 35 patients (33 male, mean age 72.6± 7.8 years) were treated. Twenty- one (60.0%) patients were treated for a TAAA and 14 (40.0%) for a PAA. Types of TAAA according to modified Crawford classification were: type II, n=6 (28.6%), type III, n=7 (33.3%) and type IV, n=6 (28.6%). Two patients (9.5%) received F/BEVAR for post-type B dissection TAAA. Patients' co-morbidities and risk factors are listed in Table 1. Fourteen (40.0%) patients had previously undergone one or more open/endovascular aortic procedures. Five (14.3%) patients had an acute aneurysm (2 contained rupture, 3 symptomatic). In four of these patients, an "off-the shelf" 4-branched graft was used (T-Branch, Cook Medical). The fifth patient (symptomatic) was treated with a customised graft as an urgent order. Mean aneurysm diameter was 73.9 ± 9.8 mm.

Table 1. Preoperative patient characteristics

Variable	Patients N (%)
Smoking (current or past)	17 (48.7)
Hypertension	30 (85.7)
Diabetes Mellitus	7 (20.0)
Hypercholesterolemia	13 (37.1)
CAD	18 (51.4)
COPD	18 (51.4)
Serum Cr>100μmol/l	14 (40.0)
PAD	10 (28.6)
Previous aortic surgery	14 (40.0)

CAD; Coronary Artery Disease, PAD; Peripheral Arterial Disease, COPD; Chronic Obstructive Pulmonary Disease.

Stent-graft configuration

All Customised and off-the-shelf grafts used were produced by Cook Medical (William A. Cook Australia, Ltd. Brisbane, Australia). A stent-graft with fenestrations was used in 7 (20%) patients, a stent-graft with branches in 25 (71.4%) patients and a stent-graft with a combination of fenestrations and branches in 3 (8.6%) patients. In two patients an inner branch design (Figure 1) was used

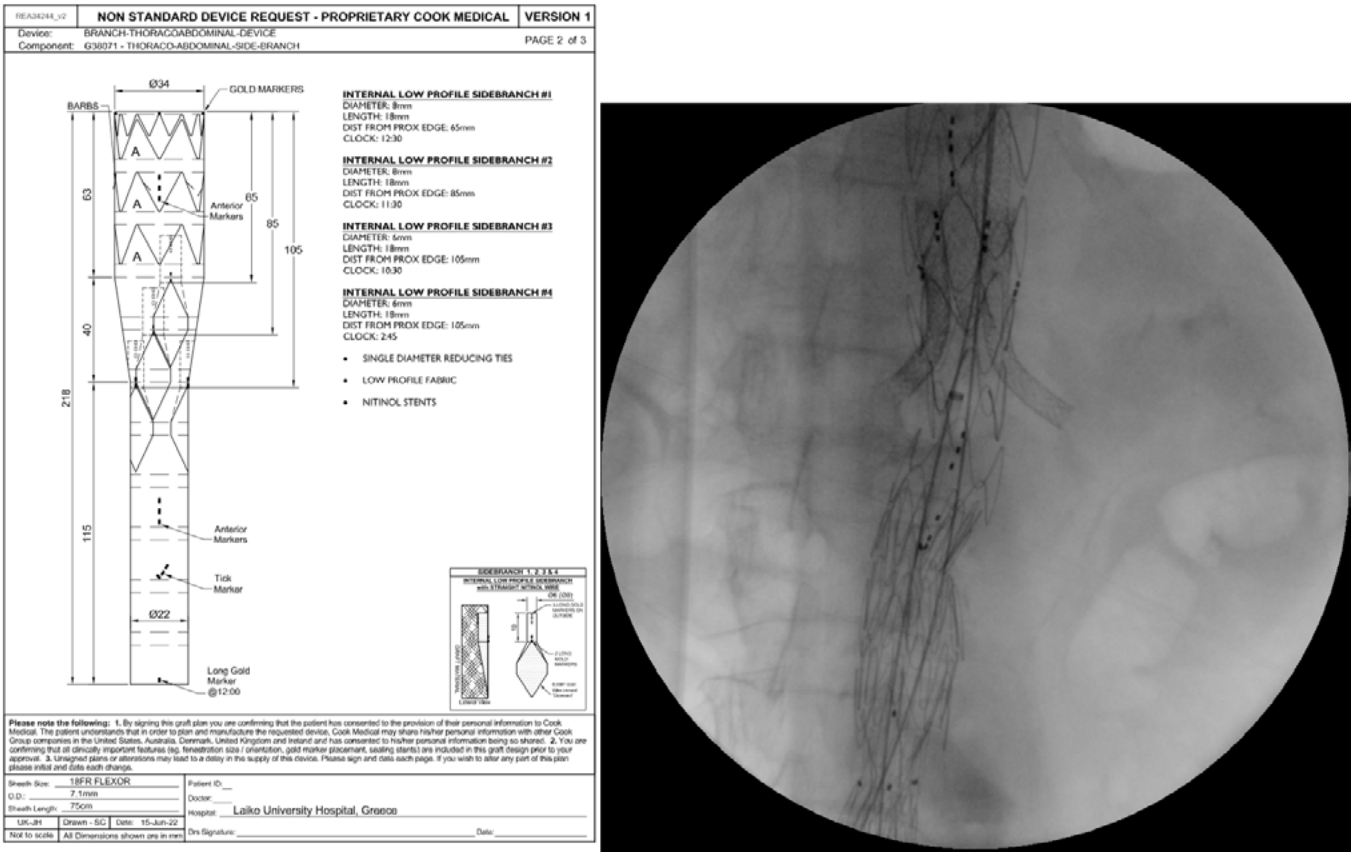

Figure 1: Inner branch configuration to address the limited space between the aortic stent-graft and the aortic wall

instead of the standard directional branches due to limited space between the aortic stent-graft and the aortic wall.[4] A total of 133 vessels were targeted, including 66 renal arteries, 35 superior mesenteric arteries (SMAs) and 32 celiac arteries.

Operative data

Mean operative time was 240 ± 65min with a median estimated blood loss of 200 ml (range, 100-2000 ml). Mean fluoroscopy time was 55 ± 22 min and mean contrast volume used 240 ± 83 ml.

Technical success

Technical success was achieved in 33 (94.3%) patients. Technical failure occurred in 2 patients (5.7%) patients. In one patient with a TAAA one renal artery could not be catheterized and was left unstented. In a second patient with a post-dissection TAAA, one renal artery was dissected and ruptured during catheterization leading to early postoperative death.

Perioperative mortality and morbidity

Thirty-day operative mortality was 2.9% (1/35). One patient suffered intraoperatively a renal artery rupture as mentioned above, which led to severe blood loss requiring acute nephrectomy and died one day after the procedure. One patient (2.9%) suffered massive embolization with buttock necrosis and spinal cord ischemia with permanent paraplegia.

Follow-up outcomes

During follow-up three patients died. One patient had undergone an emergency BEVAR procedure for a contained rupture after failed EVAR, but died of a second rupture 18 months after the BEVAR procedure due to a distal type Ib endoleak from the old EVAR iliac limb. The second patient had a prolonged postoperative course with paraplegia (mentioned above) and died finally of lung infection complications. The third patient died 5 weeks after discharge from the hospital due to COVID infection.

There was one renal artery occlusion during follow-up. Two patients had a type Ic endoleak, both from the celiac artery branch and have been planned for a bridging stent-graft extension.

DISCUSSION

F/BEVAR is being increasingly used to treat complex pararenal and thoracoabdominal aortic aneurysms. Initially FEVAR was introduced for high-risk patients, but later on was offered as a first line treatment also for low-surgical risk patients in specialised centers.[3,5] The latest ESVS AAA guidelines of 2019 stated that in juxtarenal AAA, FEVAR should be considered the preferred treatment option when feasible.[6] Moreover, real life registry data show that F/BEVAR represents also the most commonly used treatment for most TAAAs.[7]

The preliminary F/BEVAR outcomes reported in this series compare well with outcomes published by high-volume European or US expert centers. Technical success rates are in line with other published literature, even though a large proportion (40%) of the included cases were redo procedures after previous endovascular or open aortic repair. Operative mortality was below 3%. Paraplegia rates were also acceptable, given the extensive coverage of the aorta in a large proportion of the patients. Nevertheless a word of caution is required here, given that the patient that developped paraplegia did not have a very extensive aortic coverage (coverage from the mid-to distal part of the thoracic aorta to the common iliac arteries). This patient had a “shaggy aorta” that probalby led to severe embolisation during catheter and wire manipulations that may have resulted to paraplegia. “Shaggy aorta” has been indeed recognised recently as an important risk factor for spinal cord ischemia development after BEVAR.[8]

One patient died 18 months after the BEVAR procedure after suffering a second rupture due to distal type Ib endoleak. This patient had initially an EVAR procedure in another institution that failed proximally after 10 years and led to a type Ia endoleak and rupture. The BEVAR procedure addressed the proximal problem sufficienlty, but the patient finally died due to failure of the distal part of the intial EVAR graft, highlighting the need for a complete repair (relining) in these cases whenever possible in order to avoid distal failures as seen in this patient.

Despite their minimal invasive nature, F/BEVAR procedures are still major undertakings, that can be associated with significant perioperative mortality and morbidity. A multicenter french study reported very high mortality rates of >9% after FEVAR showing that these procedures may not be so benign.[9] The high mortality rates after FEVAR in this study were worrying and suggested that there may be concerns about generalizability within less experienced centres. Indeed, in this study a total of 59 FEVAR procedures were performed over a 10 year period leading to an annual case load of <6 cases per year. Similalry another french multicenter Registry (WINDOWS) reported outcomes in 268 patients who received FEVAR or BEVAR for juxtarenal AAA (group 1), suprarenal AAA and TAAA Type IV (group 2), and TAAA Type I, II, III (group 3). In-hospital mortality was 6.5% for group 1 patients, 14.3% for group 2, and 21.4% for group 3. These increased mortality rates were again associated with participation of less experienced centers in the study.[10]

The results reported in the present series should be interpreted with caution and they may not be reproducible by other centers in their early experience. In our center, all procedures were perfomed with participation of a surgeon with dedicated training in F/BEVAR over a 10-year period. Moreover, since the beginning of the complex endovascular program in our instiution, there has been a continous flow of complex endovascular cases, contributing to the development of a “routine” workflow for the whole personel that is invloved in these procedures with important implications for patient safety.

CONCLUSIONS

Preliminary outcomes of F/BEVAR in this single center series are in line with published outcomes of high-volume expert centers. Perfomance of these procedures by surgeons with

dedicated training in F/BEVAR, along with frequent execution of these procedures appear to contribute to safe patient outcomes, calling for centralisation of these operations.

CONFLICT OF INTEREST STATEMENT

Athanasios Katsargyris has received speaker fees from Cook Inc., & W.L. Gore & Associates, and is a consultant for Bentley Innomed.

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