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Editor's Choice — Ten-year Experience with Endovascular Repair of Thoracoabdominal Aortic Aneurysms: Results from 166 Consecutive Patients

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WHAT THIS PAPER ADDS
This is the largest series in Europe to report longer-term outcomes of endovascular thoracoabdominal aortic aneurysm (TAAA) repair using fenestrated and branched stent grafts. Although endovascular TAAA repair in expert hands is associated with high technical success rate, and remains safe and effective in the mid-term, complications are not rare. Correct patient selection, careful planning, team effort, and technical success are needed to provide the best possible outcome for the patients. The re-intervention rate is not low, but most re-interventions can be performed by endovascular means.

Objective: To present a 10 year experience with endovascular thoracoabdominal aortic aneurysm (TAAA) repair using fenestrated and branched stent grafts.
Materials and methods: Consecutive patients with TAAA treated with fenestrated and branched stent grafts within the period January 2004—December 2013. Data were collected prospectively.
Results: 166 patients (125 male, 41 female, mean age 68.8 ± 7.6 years) were treated. The mean TAAA diameter was 71 ± 9.3 mm. Types of TAAA were: type I, $n = 12$ (7.2%), type II, $n = 50$ (30.1%), type III, $n = 53$ (31.9%), type IV, $n = 41$ (24.8%), and type V, $n = 10$ (6%). Fifteen (9%) patients had an acute TAAA (11 contained rupture, 4 symptomatic). One hundred and eight (65%) patients were refused for open surgery earlier. Seventy eight (47%) patients had previously undergone one or more open/endovascular aortic procedures. Technical success was 95% (157/166). Thirty day operative mortality was 7.8% (13/166), with an in hospital mortality of 9% (15/166). Peri-operative spinal cord ischemia (SCI) was observed in 15 patients (9%), including permanent paraplegia in two (1.2%). Mean follow up was 29.2 ± 21 months. During follow up 40 patients died, two of them probably from aneurysm related cause. Re-intervention, mostly by endovascular means, was needed in 40 (24%) patients. Estimated survival at 1, 2, and 5 years was 83% ± 3%, 78% ± 3.5%, and 66.6% ± 6.1%, respectively. Estimated target vessel stent patency at 1, 2, and 5 years was 98% ± 0.6%, 97% ± 0.8%, and 94.2% ± 1.5%, respectively. Estimated freedom from re-intervention at 1 and 3 years was 88.3% ± 2.7%, and 78.4% ± 4.5%, respectively.
Conclusions: Endovascular repair of TAAA with fenestrated and branched stent grafts in high volume centers appears safe and effective in the mid-term in a high risk patient cohort. A considerable reintervention rate should be acknowledged, however.

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INTRODUCTION

Thoracoabdominal aortic aneurysms (TAAA) represent a challenge for vascular surgeons. Conventional open repair continues to be associated with remarkable mortality and morbidity, despite improvements in intra- and post-operative care.[1] In 2003, a nationwide database from the USA including 1542 patients reported in hospital post-operative mortality of 22.3% following elective TAAA open repair. Even higher rates were observed for low volume surgeons and hospitals.[2] Post-operative morbidity is also significant, including respiratory insufficiency with prolonged ventilation, cardiac complications, and acute renal failure.[2] In addition, there is an inherent risk for paraplegia depending on the extent of the aneurysm and its repair. In

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recent years, few selected high volume centers have achieved operative mortality rates of less than 10% with open repair.[3,4] Nevertheless, the composite adverse outcome, defined as operative death, renal failure requiring dialysis, stroke, or paraplegia/paraparesis, remains high at 15.9%.[3,4]

Endovascular techniques have demonstrated short-term advantages in abdominal aortic aneurysm (AAA) repair, and have gradually evolved to address more complex AAA and TAAA, using fenestrated and branched stent grafts.[5–9] Early results of endovascular repair of TAAA in the first 50 patients from the present study group have been published previously.[10] The present report discusses the 10 year experience in 166 consecutive TAAA patients treated with fenestrated and branched stent grafts.

MATERIALS AND METHODS

All consecutive patients with TAAA treated with fenestrated or branched stent grafts under the guidance of the senior author within the period January 2004—October 2009 at one institution, and within the period November 2009—December 2013 at a second institution, were included in this study. Patients with post-dissection TAAA were also included. Patients with suprarenal AAA treated with fenestrated/branched grafts, even if including all four visceral vessels, were excluded. Data were prospectively collected. Endovascular repair as a technique was approved by the institution's ethical committee and all patients provided their informed consent.

Aneurysm morphology was assessed by thin cut ($\leq$1.5 mm) spiral computerized tomography angiography (CTA) with axial and coronal reconstructions. The physical status of all patients was assessed preoperatively with the American Society of Anesthesiologists (ASA) score. The indication for treatment was maximum aortic diameter $\geq$60 mm, except in the case of localized disease. Symptomatic or ruptured TAAA were not excluded.

Stent grafts

Stent grafts were customized based on the Cook Zenith system (William A. Cook Australia, Ltd., Brisbane, Australia), fitting fenestrations and/or branches for the visceral vessels according to pre-operative CTA measurements. Three types of stent grafts were used depending on the aortic anatomy and aneurysm morphology: stent grafts with (A) fenestrations only, (B) branches only, or (C) branches and fenestrations. The planning of fenestrations and branches was based on the anatomy of the target vessels. Fenestrations were preferred for right angle take off visceral arteries (more common in renal arteries), and when the stent graft body was against the aortic wall. Branches were preferentially planned in larger aortic diameters, when the graft was not against the aortic wall, and when the target vessels had a downward path (often in the celiac artery).

The stent grafts had either a distal tube configuration when sealing could be achieved in the abdominal aorta (or within the body of a pre-existing stent graft or surgical graft), or a bifurcated configuration, when landing in the iliac arteries. A proximal and distal sealing zone of at least 20 mm in length was always planned.

Procedure

The procedures were routinely performed either in an angio suite with a fixed imaging system (Artis Zee, Siemens, Erlangen, Germany), or in a hybrid operating room with a fixed imaging system (Artis Zeego, Siemens, Erlangen, Germany). The operation was always done under general anesthesia. Peri-operative cerebrospinal fluid (CSF) drainage was selectively used to reduce the risk of paraplegia. Patients with TAAA type I, II, or III, and patients with previous abdominal aortic surgery were routinely subjected to CSF drainage.

Surgical access was performed via bilateral femoral cut downs in case of stent grafts with fenestrations only, and with an additional access from above (most commonly left axillary artery cut down) in case of stent grafts with fenestrations and branches or branches only. The stent graft deployment technique for fenestrated stent grafts has been previously described in detail.[11,12]

For branched stent grafts, the branched component was introduced through the femoral artery and positioned with the distal edges of the branches 10—20 mm above the ostia of the respective target vessels. After deployment of the branched component, the large femoral sheath was removed, and the arteriotomies temporarily closed (over the stiff guidewire), using snuggers fitted in purse string sutures as previously described.[12] This allowed for the prompt restoration of blood flow to the pelvis and lower limbs. Subsequently, a 45 cm 12F sheath and a coaxial 70 cm 8F or 55 cm 7F sheath were both advanced into the stent graft via the access from above. Each branch and its corresponding target vessel were sequentially catheterized, wired, and stented with a balloon expandable or self expanding covered bridging stent. For fenestrations, balloon expandable Atrium Advanta V12 (Maquet Getinge Group, Hudson, NH, USA) of 22 or 38 mm length were routinely used. For branches, Atrium Advanta V12 of 59 mm were used whenever possible. When a longer covered bridging stent was required, the Fluency (Bard, Murray Hill, NJ, USA) 80 mm stent was used. In branches, both Atrium Advanta V12 and Fluency covered bridging stents were relined with a self expandable stent if there was kinking.

For stent grafts with branches and fenestrations, the fenestrations were usually completed first and followed by the branches as described above.

Technical success was defined as successful deployment of the stent grafts with absence of type I or III endoleak, and patent target vessels. Secondary technical endpoints were reported according to the reporting standards for thoracic endovascular aortic repair (TEVAR) and included procedure time, estimated blood loss, fluoroscopy time, contrast load, and hospital and intensive care unit (ICU) length of stay.[13] Aneurysm sac morphology changes during follow up were classified as follows: aneurysm sac shrinkage