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Endovascular Repair of Acute Thoraco-abdominal Aortic Aneurysms

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WHAT THIS PAPER ADDS

This paper represents the largest single centre series of total endovascular repair of acute TAAA. Three different endovascular techniques were used based on individual patient aortic morphology and achieved acceptable early and medium-term outcomes. This study is the first to assess the suitability of the off the shelf t-Branch device in the non-elective setting and, despite considering it as the first line option, only one third of patients were suitable.

Objectives: The outcome of endovascular repair (EVAR) for acute TAAA is reported and the applicability of the t-Branch off the shelf (OTS) device is determined.

Methods: Interrogation of a prospectively maintained database identified all patients who underwent EVAR for acute TAAA between September 2012 (when the first non-elective t-Branch case was performed) and November 2015. Early and medium-term outcomes were analysed. Survival and re-intervention-free survival were calculated by Kaplan–Meier analysis.

Results: A total of 39 patients (27 men; mean ± SD age, 72 ± 8 years) were treated for acute symptomatic ($n = 29$) or ruptured ($n = 10$) TAAA (20 anatomical extent I–III, 19 extent IV). Fourteen patients had mycotic aneurysms. The mean aneurysm diameter was 80 ± 20 mm. The mean ± SD follow-up was 21.4 ± 15.4 months. Surgeon modified fenestrated EVAR was used in 24 patients, chimney/periscope EVAR in two, and t-Branch in 13 (33%) patients. Aortic coverage was greater than 40 mm above the coeliac axis in all patients. A total of 127 target vessels (TVs) were preserved (mean 3.3 per patient) and two occluded within 30 days. The 30 day mortality was 26%. Four (10%) patients developed spinal cord ischaemia (SCI): two with paraplegia died within 30 days, and two with paraparesis recovered completely with blood pressure manipulation and cerebrospinal fluid drainage. Estimated overall survival (±SD) at 12 and 24 months was 71.8 ± 7.2% and 63.2 ± 7.9%, respectively. Estimated freedom from re-intervention at 12 and 24 months was 93 ± 4.8% and 85.3 ± 6.8%, respectively.

Conclusions: EVAR for acute TAAA is associated with acceptable early and mid-term results in patients who have no other treatment options. Only one third of these patients were suitable for the t-Branch device, indicating that further advances in device design are required to treat the majority of acute TAAA patients with commercially available OTS technology.

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INTRODUCTION

The management of patients presenting acutely with symptomatic or ruptured thoracoabdominal aortic aneurysms (TAAAs) is one of the biggest challenges for cardiovascular surgeons. In patients with degenerative TAAA (as opposed to connective tissue disorders), the turndown rate for open repair (OR) is high and, in those selected patients who undergo repair, the morbidity and mortality is significant even in specialist aortic centres.[1,2]

Endovascular repair (EVAR) of TAAA with custom made fenestrated (FEVAR) and branched (BEVAR) endografts is effective in treating patients at high risk or those turned down for OR,[3] but planning and manufacturing delays have limited the technology's applicability to the elective situation. An off the shelf (OTS) endograft with a four branch design (t-Branch; Cook Medical, Bloomington, IN, USA) has become available in recent years and has been shown to be an option in 49–69% of TAAA patients who are suitable for a custom made branch device.[4–6] The device's applicability in patients presenting with symptomatic or ruptured TAAA is unknown. Surgeon-modified fenestrated devices (SM-

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FEVAR) and chimney/periscope EVAR (CHIMPS) have also been proposed as OTS solutions for acute complex aneurysms, but the outcomes in acute TAAA are unclear with the majority of published series describing the management of a heterogeneous group of acute aortic pathologies.[7–12]

This study reports the early and medium-term outcome of consecutive patients undergoing endovascular TAAA repair for symptomatic and ruptured TAAA using OTS, SM-FEVAR, and CHIMPS, and determines the applicability of the t-Branch OTS device for this group of patients.

MATERIAL AND METHODS

Study cohort

Interrogation of a prospective database identified 39 consecutive patients with acute TAAA who underwent urgent/emergency complex EVAR in a single institution (Heart of England NHS Foundation Trust, Birmingham, UK) between September 2012 and November 2015. These data were submitted to the UK National Vascular Registry. September 2012 was used as the start date of the study as this was when the t-Branch device was first used in the institution for an acute TAAA. Four patients who underwent complex EVAR for acute juxtarenal and suprarenal aneurysms during the study period, and seven patients with acute TAAA treated with SM-FEVAR ($n = 4$) and CHIMPS ($n = 3$) before the introduction of t-Branch were excluded from the analysis.

During the 38 month study period, 132 patients underwent elective endovascular thoraco-abdominal aortic repair using commercially available FEVAR and BEVAR devices, and 10 patients underwent open thoraco-abdominal aortic repair (8 elective, 2 urgent) using cardiopulmonary bypass and hypothermic circulatory arrest.

TAAA were categorised using the Crawford classification for anatomical extent. All patients were considered high risk or turned down for OR. Acute TAAA was defined by symptomatic presentation and/or radiographic evidence of contained rupture or a mycotic aneurysm. The diagnosis of mycotic aneurysm[13] was based on combinations of clinical presentation (pain, fever, sepsis, or infection), laboratory markers (elevated white cell count, C-reactive protein, positive venous blood cultures), and computed tomography (CT) findings (rapid aneurysm expansion, saccular morphology, peri-aortic soft tissue involvement) after discussion with infectious disease (ID) physicians and microbiologists. The finding of positive venous blood cultures was not mandatory. Symptomatic presentation in the non-mycotic group consisted of new onset back and/or abdominal pain associated with an aneurysm of diameter greater than 6 cm and/or rapid sac enlargement.

Pre-operative imaging and treatment algorithm

Aneurysm morphology was assessed by computed tomography angiography (CTA) of the entire aorta from arch vessels to femoral heads with 1 mm slices. Post-processing evaluations (multiplanar, three dimensional, centre lumen line reconstructions) were performed using dedicated software for vessel analysis (Aquarius 3D; Terarecon, Foster City, CA, USA) and the endovascular treatment was planned accordingly.

The t-Branch device (Cook Medical) was considered as the first choice of treatment based on certain anatomical criteria, some of which are included in the device instructions for use (IFU). Patients were excluded from treatment with the t-Branch for the following reasons: unsuitable proximal access; upward orientated target vessels; target vessel diameter <4 mm; aortic lumen diameter <25 mm at the level of target vessels or where the side branches would open; unsuitable circumferential orientation of target vessels (as per IFU); and extreme aortic angulation $> 90^{\circ}$ above the target vessels. If the aneurysm was not suitable for repair with t-Branch, then SM-FEVAR was considered as the second choice and if the aneurysm was unsuitable for this approach then CHIMPS was considered as the last resort. The “off label” nature of SM-FEVAR was disclosed in all cases, and institutional approval was granted for the use of this technique in patients considered unsuitable for other treatments.

Endovascular technique

Procedures were performed in an operating theatre equipped with a mobile C-arm (OEC 9900 Plus, General Electric, Salt Lake City, UT, USA) in the first part of the experience, and subsequently in a hybrid operating theatre (Discovery IGS 730; GE Healthcare, Chalfont St Giles, UK). All procedures were performed by one or both of two experienced endovascular surgeons (D.A., M.C.) assisted by senior clinical endovascular fellows.

All procedures were performed under general anaesthesia with antibiotic prophylaxis. In acute non-ruptured cases, a bolus of 5000 IU of intravenous heparin was given prior to introduction of the endograft and further boluses of 1000 IU were given every hour if the procedure was prolonged for more than 2 h. In four patients with ruptured aneurysm, a bolus of 3000 IU of intravenous heparin was given prior to introduction of the endograft, while the remaining six patients received no heparin. The activated clotting time (ACT) was not measured during the procedure.

With the use of t-Branch, the endografts were deployed, the delivery systems retrieved, and the femoral arteries closed prior to cannulation of the side branches and target vessels to optimise lower limb and spinal cord perfusion. For SM-FEVAR, a TX2 Zenith (Cook Medical) thoracic device (often double tapered) was used and reinforced fenestrations were created as previously described.[14] Permanent diameter reducing ties were created in the fenestration bearing segment in four cases and no patients had temporary ties. The approximate time required to create a four vessel fenestrated device was 60 min.

Post-operative details and follow-up

All patients were admitted to a high dependency or intensive care unit for a minimum of 36 h. A standardised spinal cord

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