

Outcomes of thoracic endovascular aortic repair using aortic arch chimney stents in high-risk patients



Igor Voskresensky, MD, Salvatore T. Scali, MD, Robert J. Feezor, MD, Javairiah Fatima, MD, Kristina A. Giles, MD, Rosamaria Tricarico, MS, Scott A. Berceli, MD, PhD, and Adam W. Beck, MD, Gainesville, Fla

ABSTRACT

Background: Aortic arch disease is a challenging clinical problem, especially in high-risk patients, in whom open repair can have morbidity and mortality rates of 30% to 40% and 2% to 20%, respectively. Aortic arch chimney (AAC) stents used during thoracic endovascular aortic repair (TEVAR) are a less invasive treatment strategy than open repair, but the current literature is inconclusive about the role of this technology. The focus of this analysis is on our experience with TEVAR and AAC stents.

Methods: All TEVAR procedures performed from 2002 to 2015 were reviewed to identify those with AAC stents. Primary end points were technical success and 30-day and 1-year mortality. Secondary end points included complications, reintervention, and endoleak. Technical success was defined as a patient's surviving the index operation with deployment of the AAC stent at the intended treatment zone with no evidence of type I or type III endoleak on initial postoperative imaging. The Kaplan-Meier method was used to estimate survival.

Results: Twenty-seven patients (age, 69 ± 12 years; male, 70%) were identified, and all were described as being at prohibitive risk for open repair by the treating team. Relevant comorbidity rates were as follows: coronary artery disease/myocardial infarction, 59%; oxygen-dependent emphysema, 30%; preoperative creatinine concentration >1.8 mg/dL, 19%; and congestive heart failure, 15%. Presentations included elective (67%; $n = 18$), symptomatic (26%; $n = 7$), and ruptured (7%; $n = 2$). Eleven patients (41%) had prior endovascular or open arch/descending thoracic repair. Indications were degenerative aneurysm (49%), chronic residual type A dissection with aneurysm (15%), type Ia endoleak after TEVAR (11%), postsurgical pseudoaneurysm (11%), penetrating ulcer (7%), and acute type B dissection (7%). Thirty-two brachiocephalic vessels were treated: innominate ($n = 7$), left common carotid artery (LCCA; $n = 24$), and left subclavian artery ($n = 1$). Five patients (19%) had simultaneous innominate-LCCA chimneys. Brachiocephalic chimney stents were planned in 75% ($n = 24$), with the remainder placed for either LCCA or innominate artery encroachment ($n = 8$). Overall technical success was 89% (one intraoperative death, two persistent type Ia endoleaks in follow-up). The 30-day mortality was 4% ($n = 1$; intraoperative death of a patient with a ruptured arch aneurysm), and median length of stay was 6 (interquartile range, 4-9) days. Seven (26%) patients experienced a major complication (stroke, three [all with unplanned brachiocephalic chimney]; respiratory failure, three; and death, one). Nine (33%) patients underwent aorta-related reintervention, and no chimney occlusion events occurred during follow-up (median follow-up, 9 [interquartile range, 1-23] months). The 1-year and 3-year survival is estimated to be $88\% \pm 6\%$ and $69\% \pm 9\%$, respectively.

Conclusions: TEVAR with AAC can be performed with high technical success and acceptable morbidity and mortality in high-risk patients. Unplanned AAC placement during TEVAR results in an elevated stroke risk, which may be related to the branch vessel coverage necessitating AAC placement. Acceptable midterm survival can be anticipated, but aorta-related reintervention is not uncommon, and diligent follow-up is needed. (J Vasc Surg 2017;66:9-20.)

Open surgical repair of proximal descending and aortic arch disease has historically been reported to have high morbidity (30%-40%) and mortality (2%-20%) rates,

depending on the patient's comorbidities, the indication for repair, and the acuity of the presentation.¹ Staged or hybrid approaches are often used to mitigate the risk

From the Division of Vascular Surgery and Endovascular Therapy, University of Florida College of Medicine.

This work was supported in part by funding from the National Institutes of Health (NIH-NHLBI 5K23HL115673-02) and the Society for Vascular Surgery Foundation Mentored Patient-Oriented Research Award. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Heart, Lung, and Blood Institute, the National Institutes of Health, or the Society for Vascular Surgery Foundation.

Author conflict of interest: R.J.F. has received consulting fees from Cook Medical, Inc, and educational/research grant support from Cook Medical, Inc, and Medtronic.

Presented at the Forty-fourth Annual Symposium of the Society for Clinical Vascular Surgery, Las Vegas, Nev, March 12-16, 2016.

Additional material for this article may be found online at www.jvascsurg.org.

Correspondence: Salvatore T. Scali, MD, Assistant Professor of Surgery, Division of Vascular Surgery and Endovascular Therapy, University of Florida College of Medicine, PO Box 100128, 1600 SW Archer Rd, Ste NG-45, Gainesville, FL 32610 (e-mail: salvatore.scali@surgery.ufl.edu).

The editors and reviewers of this article have no relevant financial relationships to disclose per the JVS policy that requires reviewers to decline review of any manuscript for which they may have a conflict of interest.

0741-5214

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of repair, including arch vessel debranching and extra-anatomic bypass with simultaneous or staged thoracic endovascular aortic repair (TEVAR).²⁻⁴ Outcomes of these techniques have mixed results, with morbidity and mortality rates of 30% to 40% and 10% to 15%, respectively.^{5,6} Although branched/fenestrated arch devices are less invasive, they are not widely available, are not designed to treat the full gamut of arch pathologic processes, and have ill-defined durability.⁷

An alternative approach to proximal aortic disease management is use of aortic arch chimney (AAC) stents as adjuncts to TEVAR.⁸⁻¹⁰ The concept of parallel chimney stents was first described as a “bailout” maneuver after inadvertent visceral vessel coverage during endovascular abdominal aortic repair.¹¹ Since the initial description, there has been rapid proliferation and application of chimney techniques in the management of paravisceral aortic disease.^{9,11-13} Not surprisingly, this technique is now being increasingly applied to more proximal aortic/arch disease treated during TEVAR.¹⁴⁻¹⁷ The allure of this approach is that it provides a nearly total endovascular solution and can be completed with readily available technologies using implantation techniques familiar to most operators performing TEVAR. In addition, this is a versatile technique that is applicable to elective and nonelective presentations for a variety of aortic diseases.

However, AAC use during TEVAR is still an unproven strategy, and concerns about selection of patients, device choice, operative technique, durability, and long-term outcomes remain unresolved. Thus, we sought to review our experience with AAC techniques used during TEVAR.

METHODS

The study was approved by the University of Florida Institutional Review Board (#838-2014). The need for informed consent was waived because of the retrospective nature of the analysis.

Study cohort. A prospectively collected database was queried for TEVAR procedures performed with AAC stents between January 2002 and June 2015. AAC procedures were first attempted in our practice after 2009 because of our experience with visceral aortic chimney procedures. During this time, 968 patients underwent TEVAR at our institution, of whom 115 (12%) had Ishimaru¹⁸ zone 0 and zone 1 deployments. Of this subset, 27 (23%) were deemed unfit for direct open repair or extra-anatomic arch debranching and underwent AAC stent placement. Planned or unplanned AAC procedures were included in the study, and patients who underwent simultaneous sternotomy, thoracotomy, or placement of a fenestrated/branched arch device (n = 4) were excluded.

ARTICLE HIGHLIGHTS

- **Type of Research:** Retrospective single-center cohort study
- **Take Home Message:** In 27 high-risk patients, thoracic endovascular aortic repair with aortic arch chimney grafts was performed with a technical success of 89%, early mortality of 4%, and stroke rate of 10%. No chimney graft occluded during a median follow-up of 9 months, but the reintervention rate was 33%.
- **Recommendation:** The authors suggest that thoracic endovascular aortic repair with aortic arch chimney grafts can be completed with acceptable short-term morbidity and mortality, but reintervention and stroke remain significant concerns.

Patient demographics, comorbidities, and operative variables were extracted from the database and electronic medical record. The definitions and severity of comorbidities were described per the Society for Vascular Surgery guidelines.¹⁹ All additional concurrent adjunctive procedures were described per reporting standards.¹⁹ Postoperative computed tomography angiography (CTA) images were reviewed to verify chimney patency and to determine presence of endoleak. Reintervention was defined as any unplanned return to the operating room and was dichotomized into aorta-related and non-aorta-related indications.

Selection of patients and clinical practice. All patients were considered to be at prohibitively high risk for open surgical repair²⁰ because of the unique constellation of medical and anatomic factors that characterized each patient's presentation. Consensus opinion was obtained regarding risk for open repair in each case among members of the vascular surgery and thoracic/cardiovascular surgery groups as previously reported.²¹ For planned AAC procedures, patients and their families were thoroughly informed of the “off-label” nature of the procedure.

Preoperatively, all patients underwent CTA with center-line, three-dimensional reconstruction (TeraRecon Inc, San Mateo, Calif) for planning. The treating surgeon was responsible for device selection and implantation technique. During the study period, our practice evolved from selective to routine, pre-emptive revascularization of the left subclavian artery (LSA) in cases of anticipated long-segment aortic coverage (>200 mm) in an effort to reduce spinal cord ischemia and stroke risk.^{22,23} Similarly, pre-emptive spinal drainage was increasingly used in extensive aortic coverage cases if the patient's clinical presentation allowed.

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