# Outcomes for supra-aortic branch vessel stenting in the treatment of thoracic aortic disease

**Adrian O'Callaghan, MB, Tara M. Mastracci, MD, Roy K. Greenberg, MD, Matthew J. Eagleton, MD, James Bena, MS,** and **Yuki Kuramochi, RN,** *Cleveland, Ohio*

***Objective:*** **Endovascular options for the treatment of proximal thoracic and arch disease have evolved over the years. In this manuscript, we review the midterm results of fenestrated compared with chimney configurations for proximal aortic aneurysm disease.**

***Methods:*** **We performed an analysis of all patients with chimney grafts or custom fenestrated endografts used for treatment of proximal thoracic aneurysm disease (involving the supra-aortic trunk vessels) presenting to our institution between 2004 and 2013. Patients were identified by retrospective chart review and through the prospective database (National Institutes of Health study number NCT00583050). Details of devices placed, intraoperative details, and measurements from postoperative imaging were included in the analysis. The primary outcomes of interest were long-term freedom from branch stent complications and freedom from proximal endoleak, but we also included perioperative events, in-hospital mortality, and requirement for secondary interventions in our review. The log-rank test (Mantel-Cox) was used to compare survival data. Student *t*-test (two tailed) and Fisher exact test (two tailed) were used for continuous and categorical data, respectively.**

***Results:*** **Of 767 patients who underwent thoracic endovascular repair from January 2004 to February 2013, 33 satisfied the inclusion criteria (4%): 18 of 33 noncustom and 15 of 33 custom graft designs. Overall, the rate of technical success was 97%. There were four branch stent-related problems in the follow-up period, one of 15 (7%) in the custom group and three of 18 (17%) in the noncustom group. There were three proximal sealing failures in the immediate postoperative and follow-up period, one of 15 (7%) in the custom group and two of 18 (11%) in the noncustom group. Overall, 10 patients underwent secondary procedures, four of 15 (27%) in the custom group and six of 18 (33%) in the noncustom group.**

***Conclusions:*** **Although they are technically feasible, both custom fenestrated endografts and chimney repairs for proximal thoracic disease involving the supra-aortic trunk vessels suffer from failures in intermediate follow-up, with a trend toward better long-term outcomes for custom devices. More work is needed to develop durable devices for this anatomic territory in the future. (J Vasc Surg 2014;60:914-20.)**

The endovascular treatment of thoracic aneurysm disease is superior to open repair with respect to mortality and time to recovery.[1] In some aneurysms and dissections, proximity of supra-aortic branch vessels to the intended sealing zone complicates stent graft use. Strategies for dealing with such anatomic configurations include an open or hybrid approach, use of chimney or snorkel stents, and incorporation of branches and fenestrations or scallops in the thoracic device to maintain branch vessel perfusion.[2] A pure endovascular solution remains the goal so that the invasiveness of open surgery may be minimized, without compromising the durability of repair.

From the Department of Vascular and Endovascular Surgery, Cleveland Clinic Foundation.

Author conflict of interest: T.M.M. has consultation and proctor agreements with Cook Medical Inc. M.J.E. has proctor agreements with Cook Medical Inc. R.K.G. has intellectual property and research support with Cook Medical Inc.

Reprint requests: Tara M. Mastracci, MD, Cleveland Clinic, Desk F30, 9500 Euclid Ave, Cleveland OH 44195 (e-mail: mastrat@ccf.org).

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/$36.00



http://dx.doi.org/10.1016/j.jvs.2013.12.053

Methods of endovascular incorporation of the supra-aortic branch vessels are variable and poorly studied, except for small case series proving feasibility.[3-13] Branched grafts for the arch have recently been developed, and although they are not commercially available in the United States, they are in the early stages of use and so no long-term data are available. Both custom fenestrated devices and snorkel or chimney configurations have been described for years, but the fate of the stented branches and the durability of either type of repair are unknown (Fig 1). Consequently, we have scant evidence with which to formulate management options. We sought to address this need by evaluating our experience to determine the intermediate outcomes with fenestrated/scallop and chimney configurations.

## METHODS

**Patients.** All endovascular repairs involving the thoracic aorta, irrespective of the indication, performed between January 2004 and February 2013 were reviewed. To be included in this report, an endovascular seal within the aortic arch along with concomitant stenting of a supra-aortic branch vessel was present. In each case, the requisite rationale for branch stenting was the maintenance of perfusion when a branch vessel was to be included in the sealing/landing zone. It is our routine practice to perform left carotid–subclavian bypasses at our institution when

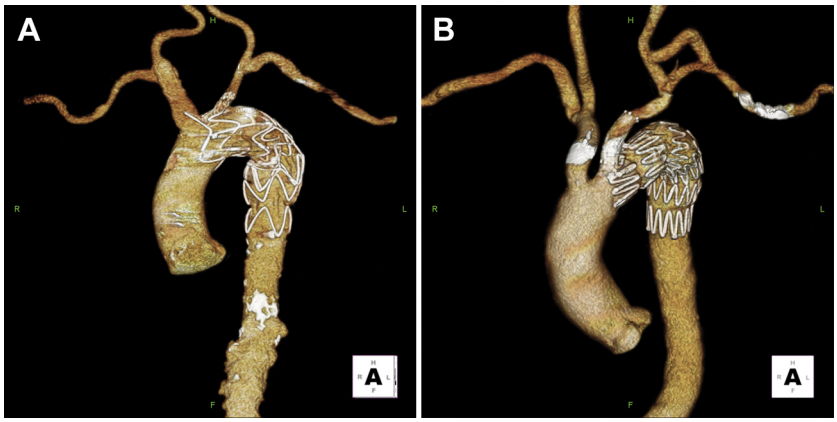


**Fig 1.** Demonstration of chimney stent **(A)** and custom fenestrated graft **(B)** for use in proximal aortic disease.

possible if the subclavian will be occluded by the proximal landing zone. For custom devices, patient information was collected in a prospectively maintained database as part of a physician-sponsored investigational device exemption study, and written permission for the use of anonymized data in a research setting was obtained at the time of surgery (National Institutes of Health study number NCT00583050). For patients with noncustom configurations, the data were retrieved retrospectively from the electronic medical record. This study was approved by the Institutional Review Board at the Cleveland Clinic.

**Repair.** Branch stenting cases were considered custom or noncustom, depending on the repair configuration. Custom repairs were those in which preoperative recognition of a suboptimal proximal sealing zone allowed the design of a manufactured custom device (Cook Medical Inc, Perth, Australia), which incorporated a scallop or fenestration for one or more supra-aortic trunks. Because of the manufacturing delay, such devices are not an option for emergent patient care. Noncustom repairs included those in which a branch vessel was incorporated with a commercially available stent placed parallel to a standard thoracic device, by a "chimney" or "snorkel" technique, but for which the acuity of the clinical presentation did not allow time for design of a fenestrated device.

The intraoperative protocol, including use of heparin, instillation of preoperative spinal drains, choice of stents, and decision to perform adjunct procedures, as well as postoperative care and follow-up was at the discretion of the treating surgeon.

**Device.** All fenestrated/scallop stent designs (customs stent grafts) were based on the Zenith platform (Cook Medical Inc, Bloomington, Ind) and manufactured by the same company. Chimney or snorkel (noncustom) repairs were performed with thoracic stents from a variety of manufacturers on the basis of the surgeon's preference. Stents used in the branch vessels were standard "off- the-shelf" devices and were considered covered or uncovered, depending on the presence or absence of a fabric cover over the metal skeleton. For noncustom configurations, choice of stent for the branch vessel was at the discretion of the treating surgeon. All fenestrated devices used balloon-expandable stents for mating with branch vessels.

**Data collection.** Demographics, risk factors, and acuity of treatment (elective or emergency) were collected in each case. The outcomes of interest included late freedom from branch stent complications and freedom from proximal endoleak. We also collected data describing perioperative events, in-hospital mortality, and any subsequent procedures or interventions.

**Data analysis.** Preoperative and postoperative computed tomography (CT) scans were re-reviewed, and data for imaging analysis were collected by one of the authors (A.O.C.) for the purposes of this study. All CT imaging was imported onto a three-dimensional workstation (TeraRecon, San Mateo, Calif) and a semiautomated centerline of flow created (adequacy of which was confirmed manually). The preoperative CT image was used to calculate the length of the proximal landing zone, defined as the distance from the target vessel (to be stented) to the aneurysm/pathologic process, and the classification of proximal landing zone (as defined by Ishimaru).[14] The target vessel in the majority of cases was the left carotid artery but also included the innominate and left subclavian. Postoperative imaging was used to determine the endovascular seal (absence of type Ia endoleak) and freedom from stented branch vessel complications (occlusion, stenosis, or migration).

The log-rank test (Mantel-Cox) was used to compare survival data. Student *t*-test (two tailed) and Fisher exact test (two tailed) were used for continuous and categorical data, respectively.

## RESULTS

Of 767 patients who underwent any form of thoracic endovascular repair from January 2004 to February 2013 at our institution, only 33 patients met the inclusion criteria (4%): 18 of 33 noncustom and 15 of 33 custom graft designs. Mean follow-up in the custom and noncustom groups was 13.5 (min-max, 1-50) and 22.2 (min-max, 1-85) months,