

Fenestrated Thoracic Endograft

Left subclavian artery revascularization in the management of thoracic aortic aneurysms.

BY FRANK R. ARKO, MD

Thoracic aortic stent grafts require proximal and distal landing zones of adequate length to effectively exclude thoracic aortic lesions. The origins of the left subclavian artery and other aortic arch branch vessels often impose limitations on the proximal landing zone, thereby disallowing endovascular repair of more proximal thoracic lesions. Coverage of the left subclavian artery has been reported to be well tolerated in the majority of cases. However, recent reports suggest that there is an increasing number of patients who are symptomatic after coverage of the left subclavian artery.^{1,2}

The number of thoracic aortic lesions that are now treated by endoluminal exclusion by using stent grafts is rapidly increasing. The typical recommendations for subclavian revascularization include when the aortic lesion is within 15 mm of the left subclavian orifice to prevent type II endoleak or perfusion of a dissected false lumen when the ipsilateral vertebral artery is patent and dominant,

when coronary revascularization using an ipsilateral internal mammary artery is anticipated, and in cases that necessitate extensive coverage of intercostals that contribute to spinal cord perfusion. Subclavian revascularization procedures can be performed with relatively low risk but have the potential of vocal cord paralysis, thoracic duct injury, brachial plexus injury, and injury to the phrenic nerve.

In this article, left subclavian artery revascularization with a fenestrated thoracic endograft and the challenges involved will be discussed.

CASE REPORT

An 81-year-old woman with a medical history significant for coronary artery disease, hypertension, and hyperlipidemia presented to an outside clinic with shortness of breath. During the work-up, a chest roentgenography was performed that demonstrated a widened mediastinum. A



Figure 1. CTA with demonstration of the aortic arch vessels allowing for measurements for creation of the left subclavian artery fenestration.



Figure 2. CTA showing the extent of the thoracic aneurysm with extension to just above the celiac artery.



Figure 3. The stent graft is partially deployed opening the bare spring (FreeFlo), which is wrapped with an umbilical tape while it is opened to allow for ease of resheathing the device. A 10-mm Goose Neck snare is used to mark the fenestration that was created with eye cautery.

computed tomography (CT) scan of the chest was then performed with evidence of a 62-mm thoracic aneurysm beginning just distal from the left subclavian artery and extending to just above the celiac artery. The proximal landing zone measured 40 mm in diameter when extending to the left common carotid artery. The landing zone measured 30 mm in diameter distally. Due to the extensive coverage of the thoracic aorta, left subclavian artery revascularization was believed to be important. Furthermore, the left vertebral artery was large and dominant. Revascularization was performed to minimize the risk of paralysis and stroke.

Three-dimensional reconstructions allow for precise measurements for creating the fenestration for the left subclavian artery. The distance from the orifice of the left carotid to the left subclavian artery is 10 mm (Figure 1). The orifice of the left subclavian artery measured 10 mm at its greatest diameter. A Talent 46-mm proximal main thoracic stent graft (Medtronic, Inc., Minneapolis, MN) was chosen as the initial device because the fabric material allows for fenestration of the graft using eye cautery and because of the slow and accurate deployment of the graft, which aids in aligning the fenestration. The external iliac arteries measured 7 mm in diameter. Because of these small access vessels, a conduit was used to allow for greater stent graft torqueability in aligning the fenestration. Once the measurements were made off of the CTA (Figure 2), the Talent stent graft was partially deployed, opening the first two covered stent rings on the back table to create the fenestration. An umbilical tape was wrapped around the uncovered stent to allow for easy resheathing of the device. The connecting bar of the stent graft was used for

360° orientation and was to be aligned along the greater curvature. The fenestration was placed just anterior to the connecting bar. Using eye cautery, a 10-mm fenestration was made. An Amplatz Goose Neck snare (ev3 Inc., Plymouth, MN) was then sewn around the fenestration with a running locking 5-0 Ethibond suture (Ethicon, Inc., Somerville, NJ) to visualize the fenestration under fluoroscopy (Figure 3). The Talent stent graft was then resheathed and delivered through the left common iliac artery conduit (Figure 4).

Access of the left brachial artery was achieved, and a 7-F 45-cm Pinnacle Destination sheath (Terumo Interventional Systems, Somerset, NJ) was placed to the level of the left subclavian artery. Using esmolol to lower the heart rate and mean arterial pressure to 50 beats per minute and 60 mm Hg pressure, respectively, the Talent stent graft was deployed aligning the fenestration with the left subclavian artery (Figures 5 and 6). The fenestration was then cannulated from the left subclavian artery. An 8- X 38-mm Atrium iCast stent (Atrium Medical Corporation, Hudson, NH) was then placed from within the stent graft and landing just proximal to the left vertebral artery (Figure 7). The proximal portion of the Atrium stent was flared to 12 mm. Approximately 1 cm of the Atrium stent was placed within the thoracic aorta to gain an adequate seal and to ensure overlap when the proximal stent was flared. The stent was flared within the thoracic stent graft with a 12- X 2-cm Atlas balloon (Bard Peripheral Vascular, Inc., Tempe, AZ). Thoracic endovascu-



Figure 4. A conduit was used to advance the delivery system secondary to small access vessels.



Figure 5. Arteriogram with delivery system in place. Distal to the left subclavian artery, there is only a 1-cm-long neck in a sharply angled thoracic aorta. With coverage to the left carotid artery, there is nearly 3 cm of proximal landing zone. There is a large dominant left vertebral artery present.

lar aneurysm repair (TEVAR) was then completed distally using two additional Talent stent grafts to exclude the aneurysm. After completion of the procedure, the conduit was stapled off using a vascular stapling device. The retroperitoneal incision was then closed in standard fashion.

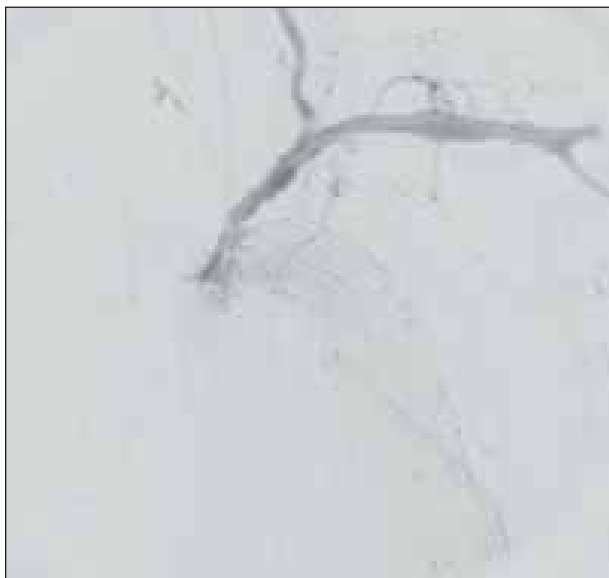


Figure 6. With the stent graft deployed, a retrograde arteriography of the left subclavian artery from the brachial access is performed. There is little filling of the aorta from this image.

The patient tolerated the procedure well without any complications. She was discharged home on the third postoperative day. The aneurysm was excluded, and the fenestrated stent was widely patent at 4-week follow-up (Figures 8 and 9). Follow-up should be continued biannually during the first year and then annually thereafter if the patient is doing well.

DISCUSSION

The mortality rate of untreated thoracic aortic aneurysms exceeds 80% at 5 years.^{3,4} Although operative repair greatly alters the natural history of this disease, these aneurysms traditionally require open surgical repair with large thoracoabdominal incisions, aortic cross-clamping, and left-heart bypass. Open surgery is therefore associated with significant morbidity (65%–80%) and mortality (10%–20%) rates.^{5–8}

Thoracic stent grafting has been associated with less blood loss, lower morbidity rates, and shorter intensive care unit and hospital stays. Further, mortality rates after TEVAR are at least comparable to that following open surgery, despite the higher prevalence of high-risk patients in the endovascular subset.^{7,8} However, this technology has been limited from widespread application by the anatomical constraints of aortic branching, which can eliminate adequate proximal and distal landing zones required for graft seal and fixation.

Experience with routine intentional left subclavian artery occlusion without revascularization has demonstrated a substantially increased risk of subsequent subcla-



Figure 7. After fenestration of the left subclavian artery, an aortogram shows excellent flow through all three aortic branches.

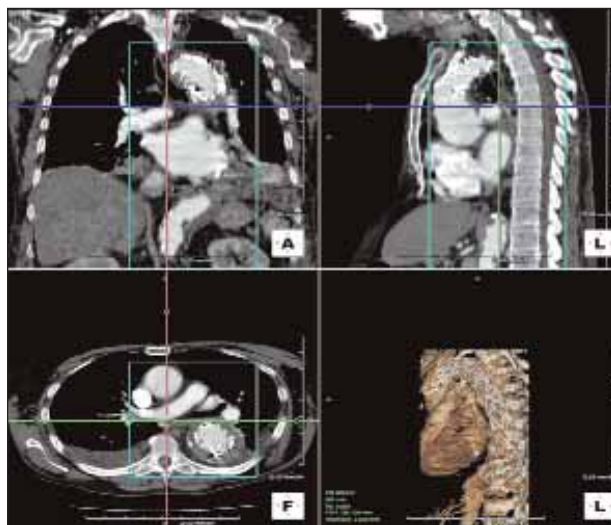


Figure 8. CTA at 4-week follow-up with the aneurysm excluded. The stent is widely patent in the left subclavian artery with no evidence of an endoleak.



Figure 9. Another view of the stent graft with the left subclavian artery stent in place.

vian steal syndrome, watershed posterior circulation cerebrovascular accidents, and an increased incidence of spinal cord ischemia by eliminating collateral blood supply to the spinal cord from the vertebral artery. In a recent study by Reece et al, 64 patients were treated with TEVAR with 27 (42%) requiring exclusion of the left subclavian artery. Seven of these patients required preoperative revascularization, and four patients required postoperative revascularization. The investigators suggested that

selective revascularization after TEVAR exclusion of the origin of the left subclavian artery may be required more frequently than previously reported.⁹

The advent of fenestrated and branched endografts has now shifted the focus of complex thoracoabdominal repair back toward the extension of endovascular technology to address these complex patients. Although reports of use in the thoracic aorta are less extensive, fenestrated endografts have been applied more frequently to pararenal and juxtarenal aneurysms with good early and midterm success.¹⁰⁻¹² With additional experience and expansion of technology, it is likely that fenestrated and branched endografts will find a place in the treatment of thoracic disease. Certainly the use of fenestrations to revascularize the left subclavian artery merits further consideration in order to avoid the potential complications of routine coverage of the left subclavian artery and to avoid the need of an operation when performing carotid subclavian artery bypass. ■

Frank R. Arko, MD, is Associate Professor of Surgery and Chief of Endovascular Surgery at UT Southwestern Medical Center in Dallas, Texas. He has disclosed that he is a paid consultant to and receives grant/research funding from Medtronic, Inc. He also disclosed that he receives grant/research funding from Terumo Interventional Systems. He further disclosed that he did not receive funding for writing this article. Dr. Arko may be reached at (214) 645-0533; frank.arko@utsouthwestern.edu.

1. Riesenman PJ, Farber MA, Mendes RR, et al. Coverage of the left subclavian artery during thoracic endovascular aortic repair. *J Vasc Surg.* 2007;45:90-94.
2. Peterson BG, Eskandari MK, Gleason TG, et al. Utility of left subclavian artery revascularization in association with endoluminal repair of acute and chronic thoracic aortic pathology. *J Vasc Surg.* 2006;43:433-439.
3. Derrow A, Seeger J, Dame D, et al. The outcome in the United States after thoracoabdominal aortic aneurysm repair, renal artery bypass and mesenteric revascularization. *J Vasc Surg.* 2001;34:54-61.
4. Cowan J, Dimick J, Henke P, et al. Surgical treatment of intact thoracoabdominal aortic aneurysms in the United States: hospital and surgeon volume-related outcomes. *J Vasc Surg.* 2003;37:1169-1174.
5. Svensson LG, Crawford ES, Hess KR, et al. Experience with 1509 patients undergoing thoracoabdominal aortic operations. *J Vasc Surg.* 1993;17:357-368.
6. Rectenwald J, Huber T, Martin T, et al. Functional outcome after thoracoabdominal aortic aneurysm repair. *J Vasc Surg.* 2002;35:640-647.
7. Bavaria JE, Appoo JJ, Makaroun MS, et al. Endovascular stent grafting versus open surgical repair of descending thoracic aortic aneurysms in low-risk patients: a multicenter comparative trial. *J Thorac Cardiovasc Surg.* 2007;133:285-288.
8. Najibi S, Terramani TT, Weiss VJ, et al. Endoluminal versus open treatment of descending thoracic aortic aneurysms. *J Vasc Surg.* 2002;36:732-737.
9. Reece TB, Gazoni LM, Cherry KJ, et al. Reevaluating the need for left subclavian artery revascularization with thoracic endovascular aortic repair. *Ann Thorac Surg.* 2007;84:1201-1205.
10. Park JH, Chung JW, Choo IW, et al. Fenestrated stent-grafts for preserving visceral arterial branches in the treatment of abdominal aortic aneurysm: preliminary experience. *J Vasc Interv Radiol.* 1996;7:819-823.
11. Faruqi RM, Chuter TA, Reilly LM, et al. Endovascular repair of abdominal aortic aneurysm using a pararenal fenestrated stent graft. *J Endovasc Surg.* 1999;6:354-358.
12. Anderson JL, Berce M, Hartley DE. Endoluminal aortic grafting with renal and superior mesenteric artery incorporation by graft fenestration. *J Endovasc Ther.* 2001;8:3-15.