The Role of Debranching in Endovascular Repair of TAAAs

Hybrid repair is an alternative in patients who are not candidates for open surgery or total endovascular approaches.

BY GUSTAVO S. ODERICH, MD

Endovascular aortic aneurysm repair (EVAR) has gained widespread acceptance and is currently considered the first treatment option for most patients with abdominal and thoracic aneurysms. Prospective trials have demonstrated several short-term advantages over open repair, including less blood loss, operative time, hospital stay, mortality, and morbidity.[1,2]

The presence of a short neck or involvement of the visceral arteries continues to limit the application of endovascular approaches. In these patients, open conventional repair remains the standard treatment, but technical complexity increases with more extensive dissection, higher clamp site, prolonged visceral ischemia, and more extensive reconstruction. It is logical to speculate that the advantages achieved with endovascular repair of infrarenal aneurysms will pale in comparison to the potential for reduction in morbidity and mortality for treatment of more complex aneurysms that involve the visceral segment.

Contemporary series have shown that open repair of thoracoabdominal aortic aneurysms (TAAAs) can be performed with satisfactory results in centers of excellence.[3-6] Mortality and spinal cord injury are the most frequently analyzed outcome measures, but other important endpoints are renal insufficiency, morbidity rates, quality of life, and functional status after the operation. Coselli and associates reported on 2,286 patients who were treated by open TAAA repair, with an operative mortality rate of 6.6% and spinal cord injury in 4%.[3] Other reports from large-volume aortic centers have shown mortality rates in the range of 4.6% to 14.6%.[4-6] However, real-world data using national and regional datasets have demonstrated more ominous results. In a study by Rigberg and associates of 797 Medicare beneficiaries who underwent elective open TAAA repair in California, the mortality rate was 19% at 30 days and 31% at 1 year.[7]

> Hybrid procedures have been introduced as a less-invasive alternative to conventional open repair, avoiding the need for a thoracotomy . . .

ENDOVASCULAR STRATEGIES

Endovascular approaches to TAAAs have evolved during the last decade. The initial experiences with fenestrated and branched endografts have shown that total endovascular repair is effective and may reduce morbidity rates in patients with arch, thoracoabdominal, and pararenal aneurysms.[8] Nonetheless, these devices are not yet widely available and still require a period of customization of 6 to 8 weeks. Although "off-the-shelf" devices are likely to allow treatment of > 60% to 80% of patients with complex aneurysms, standardized designs have not yet been clinically tested in a large number of patients with longer follow-up.[9,10]

In the absence of widely available endograft designs, a number of centers have reported creative techniques to incorporate the visceral arteries, including chimney, sandwich, octopus, and physician-modified endografts.[11,12] However, these approaches are limited by off-label indication, lack of quality control, violation of basic engineering concepts, and questionable durability.

HYBRID ENDOVASCULAR REPAIR

Hybrid procedures have been introduced as a less-invasive alternative to conventional open repair, avoiding the need for a thoracotomy and, in many patients, aortic cross-clamping. The first report was by Quinones-Baldrich and associates from UCLA in 1999.[13] The procedure aimed to reduce the anatomic and physiologic stress to the patient by avoiding several shortcomings of open surgery, namely, thoracotomy, single-lung ventilation, aortic cross-clamping, and prolonged end-organ ischemia.

Since its introduction, hybrid repair has been widely adopted as an alternative to open surgery. Its current role in the treatment of patients with complex aortic aneurysms has evolved, and most centers with easy access to fenestrated and branched endografts have relegated hybrid procedures to high-risk patients who are neither candidates for total endovascular repair or open surgery. Patient selection, case planning, and technical aspects of the procedure are key for successful outcomes.

CLINICAL RISK ASSESSMENT

A comprehensive evaluation of cardiac, pulmonary, and renal performance is crucial to optimizing patient selection. These operations are often indicated in the sickest patients, but clinical data suggest that prohibitively high-risk patients and those with limited life expectancy are not ideal candidates for hybrid procedures. The evaluation should include a noninvasive cardiac stress test (dobutamine stress echocardiography or sestamibi study), pulmonary function tests, and carotid ultrasound.

The Society for Vascular Surgery (SVS) clinical comorbidity score system can be used to stratify operative risk, but the criteria have not been validated prospectively in patients undergoing complex aortic surgery.[14] Nonetheless, most agree that factors associated with increased risk include unstable angina, symptomatic or poorly controlled ectopy, recurrent congestive heart failure, ejection fraction < 25%, myocardial infarction < 6 months, vital capacity < 1.8 L, FEV1 < 800 mL, DLCO < 30%, resting pO_2 < 60 mm Hg and pCO_2 > 50 mm Hg, and serum creatinine > 2.5 mg/dL.

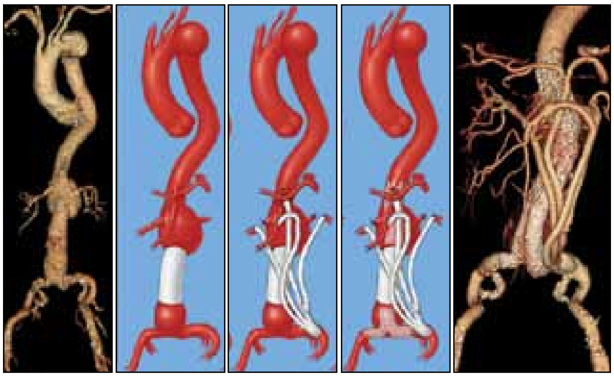

Figure 1. Type IV TAAA with prior aortic graft.

AORTIC IMAGING AND PLANNING

A basic tenet of endovascular repair is the presence of an adequate seal zone. A hybrid procedure should only be considered if the extra-anatomic bypass would provide adequate proximal and/or distal sealing zones. In most centers, computed tomographic angiography is the preferred imaging modality to plan the procedure (Figure 1); less frequently, magnetic resonance angiography can also be used.

The presence of conic, calcified, and angulated neck compromises seal. A minimum length of 2 cm of parallel aortic wall without excessive calcification or thrombus is required in the thoracic aorta, and longer seal zones may be needed in the aortic arch. Distal attachment is equally important and most often can be achieved in the common iliac arteries, infrarenal aorta, or previous aortic graft. If the common iliac arteries are aneurysmal, preservation of pelvic flow is critical to minimize the risk of spinal cord injury.[15] Similarly, proximal debranching of the subclavian artery may reduce rates of paraplegia in patients who need extensive coverage of the thoracic aorta.

Aortic side branches requiring incorporation should also be analyzed for the presence of occlusive disease, excessive calcification or thrombus, or unusual or aberrant anatomy. Small-sized, calcified, or multiple renal arteries pose a challenge and may require complex reconstruction. The quality of the inflow site, which is typically located in the distal common and proximal

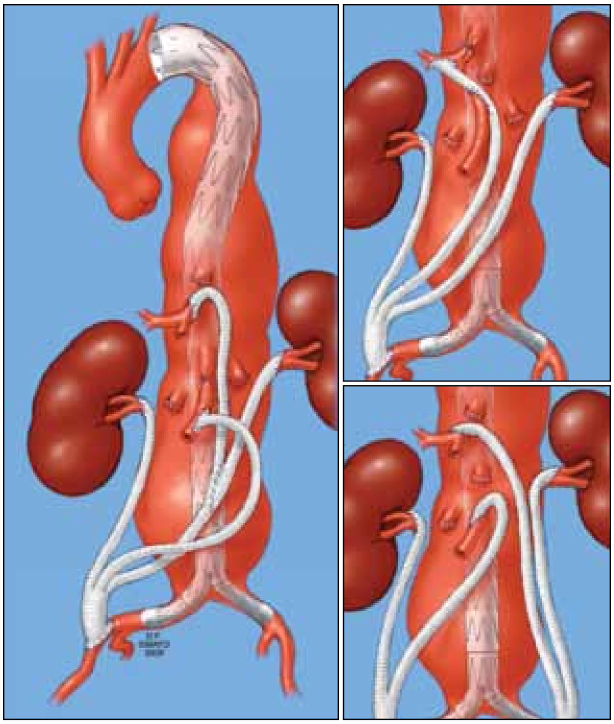

Figure 2. Debranching configurations.

external iliac artery, should be reviewed for presence of occlusive disease. It is critical to ensure optimal inflow to the visceral grafts and enough length within the common iliac artery for attachment of the endografts. The presence of any abnormal venous anatomy (eg, left-sided vena cava, retroaortic renal vein, etc.) should be noted to avoid inadvertent injury. Finally, it is critical to ensure adequate iliac access, which ideally should be planned in the opposite side. Nonetheless, ipsilateral access remains an alternative and can be achieved with a conduit, which is tied at the end and buried within the retroperitoneum in preparation for a second-stage procedure.

TECHNICAL TIPS

The debranching procedure can be performed using a midline transperitoneal or retroperitoneal incision, either in one or two stages, followed by aortic stent graft coverage. The two-stage approach may minimize morbidity and mortality rates, particularly in the higher-risk patient or in those who require difficult open surgical reconstructions. However, single-stage procedures eliminate the risk of rupture in between stages and should be considered in those patients who have uneventful debranching, excessively large aneurysms, and in those that require more limited extent of aortic coverage. The source of inflow for extra-anatomic reconstruction is usually the distal common iliac artery extending into the proximal external iliac artery.

Other alternative sites are the infrarenal aorta, previous aortic grafts, or the hepatic and splenic arteries. A variety of graft configurations have been described (Figure 2). Our preference is to use a trifurcated graft from one of the common iliac arteries, with an added limb depending on the patient's anatomy. A modification of the technique, VORTEC (Figure 3), was described by Lachat and associates and allows a sutureless anastomosis using Viabahn stent grafts (Gore & Associates, Flagstaff, AZ).[16]

RESULTS

Single-Center Experiences

Despite logical advantages over open repair and early successes, results of hybrid procedures have been tempered by high morbidity and mortality rates at several centers.[13,15-25] The UCLA and University of Michigan groups have reported two of the largest experiences, with remarkably low mortality rates of 0% and 3.4%, respectively.[17,18] Others (Cleveland Clinic, Mayo Clinic, Mass General Hospital, Methodist Hospital Houston) have shown higher mortality rates in the range of 10% to 25%.[12,19,21,25] Spinal cord injury occurs in 2% to 25% of cases and correlates with the extent of aortic coverage, preservation of flow into the subclavian and hypogastric arteries, and periprocedural hypotension.[13,15-25] Rates of type I and II endoleak have been reported in the range of 3% to 15% and 5% to 25%, respectively.

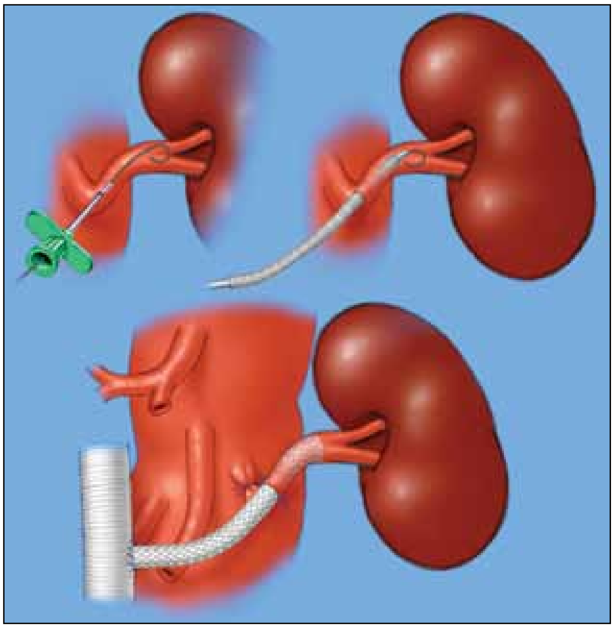

Figure 3. The VORTEC technique.

Systematic Reviews

Two systematic reviews of the available literature have been published on hybrid repair of TAAAs.[26,27] Bakoyiannis and associates reviewed the outcomes of 108 patients from 15 reports between 1999 and 2008.[26] Technical success was 92%, and 30-day mortality was 10%. In this report, 19 patients (17%) had primary endoleaks, and another three (3%) developed secondary endoleaks. Spinal cord injury occurred in three patients (3%), and renal insufficiency occurred in 12 patients (11%). After a mean follow-up of 10 months, 97% of the visceral grafts remained patent, and 24% of patients died from unrelated causes.

A more recent review by Moulakakis and associates included 507 patients and 19 reports published since 1999. There were 319 male (64%) and 188 female patients, with a mean age of 70 years. Aneurysm extent was classified as type I in 14%, type II in 27%, type III in 34%, type IV in 14%, and type V in 11%. A single-stage procedure was used in 55%, and a two-stage procedure was used in 45%, with mean period of 28 days between the two stages. Thirty-day or in-hospital mortality was 13%, and the most common causes of death were multisystem organ failure, ischemic colitis, respiratory failure, and aneurysm rupture prior to a second-stage procedure. Pooled rates of spinal cord injury were 7.5%, with irreversible paraplegia in 4.5%. After a mean follow-up of 35 months, a total of 111 patients (22%) had endoleaks, and visceral graft patency was 96%.

NACAAD Registry

The preliminary results of the North American Complex Abdominal Aortic Debranching (NACAAD) registry were presented at the 2011 Vascular Annual Meeting.[28] This study included 208 patients who were treated for complex abdominal aortic aneurysms at 14 academic centers in North America. There were 118 male (57%) and 90 female (43%) patients, with a mean age of 71 years. Cardiovascular risk factors included hypertension in 86%, cigarette smoking in 78%, hyperlipidemia in 60%, coronary artery disease in 58%, chronic pulmonary disease in 43%, previous aortic repair in 42%, and chronic kidney disease stage > 3 (eGFR < 60 mL/hr/1.73 m^2) in 28%. Aneurysm diameter averaged 6.6 ± 1.3 cm, and aneurysm extent included 163 TAAAs (type I in 6%, type II in 25%, type III in 31%, and type IV) and 45 pararenal aneurysms.

A total of 659 visceral arteries were reconstructed using single-stage debranching in 92 patients (44%) or a two-stage approach in 116 patients (56%). Arch debranching was needed in 22 patients (11%) to provide an adequate proximal landing zone. The inflow for visceral reconstruction was based on the iliac arteries in 63%, aorta or aortic graft in 29%, or a hepatic/splenic artery in 8%. The extent of visceral reconstruction included one or two vessels in 58 patients (28%) and three or four vessels in 150 patients (72%).

Thirty-day or in-hospital mortality was 14% for all patients, 16% for TAAAs, and 9% for pararenal aneurysms. Mortality rates ranged from 0% to 21% in centers with > 10 cases. In this study, mortality was associated with the severity of comorbidities as determined by SVS clinical scores: 3% for low-risk patients (SVS score < 9) and 17% for high-risk patients (score > 9). Independent predictors of early mortality included > three-vessel reconstruction, coronary artery disease, congestive heart failure, high SVS scores, and chronic kidney disease stage > 3. Any morbidity occurred in 73% of the patients, most commonly, pulmonary (22%), renal (19%), and gastrointestinal (14%) complications. Spinal cord injury occurred in 21 patients (10%), and ischemic colitis occurred in 13 patients (6%).

The mean length of hospital stay was 21 days. Patient survival at 1 and 5 years was 77% ± 3% and 61% ± 5%, respectively, and predictors of late mortality included chronic kidney disease (stage > 3), high SVS scores, and > three-vessel reconstruction. After a median follow-up of 21 months, 70% of the patients had repeat aortic imaging. Endoleaks occurred in 23 patients (13%) and were classified as type I in 3%, type II in 8%, and type III in 1%. Primary visceral graft patency and freedom from reinterventions were 90% ± 2% and 85% ± 3% at 1 year, respectively.

CONCLUSION

Hybrid procedures have several advantages over conventional open repair, including avoiding thoracotomy, single-lung ventilation, aortic cross-clamping, and minimizing end-organ ischemia. The shortcomings are the need for extensive dissection in multiple abdominal areas and prolonged procedure time. Patient selection is key for optimal results. A few centers have adopted hybrid procedures as their primary treatment option in intermediate- and high-risk patients, with good results. However, several centers with large complex aortic volume, systematic reviews, and a national registry have shown that hybrid procedures carry high mortality rates. ■

Gustavo S. Oderich, MD, is Associate Professor of Surgery, Director of Endovascular Therapy, Director of Edward Rogers Clinical Research Fellowship, Division of Vascular and Endovascular Surgery, Mayo Clinic in Rochester, Minnesota. He has disclosed that he is the National Principal Investigator of the Cook T-Branch TAAA Stent Graft Study. Dr. Oderich may be reached at (507) 284-1575; oderich.gustavo@mayo.edu.

1. EVAR trial participants. Endovascular aneurysm repair versus open repair in patients with abdominal aortic aneurysms (EVAT trial 1): randomized controlled trial. Lancet. 2005;365:2179-2186.
2. Prinssen M, Verhoeven EL, Buth J, et al. A randomized trial comparing conventional and endovascular repair of abdominal aortic aneurysms. N Eng J Med. 2004;351:1607-1618.
3. Coselli JS, Bozinovski J, LeMaire SA. Open surgical repair of 2,286 thoracoabdominal aortic aneurysms. Ann Thorac Surg. 2007;83:S862-S864.
4. Conrad MF, Crawford RS, Davison JK, Cambria RP. Thoracoabdominal aneurysm repair: a 20-year experience. Ann Thorac Surg. 2007;83:S856-S861.
5. Jacobs MJ, van Eps RG, de Jong DS, et al. Prevention of renal failure in patients undergoing thoracoabdominal aortic aneurysm repair. J Vasc Surg. 2004;40:1067-1073.
6. Safi HJ, Estrera AL, Miller CC, et al. Evolution of risk for neurologic deficit after descending and thoracoabdominal aortic repair. Ann Thorac Surg. 2005;80:2173-2179.
7. Rigberg DA, McGory ML, Zingmond DS, et al. Thirty-day mortality statistics underestimate the risk of repair of thoracoabdominal aortic aneurysms: a statewide experience. J Vasc Surg. 2006;43:217-222.
8. Greenberg RK, Eagleton M, Mastracci T. Branched endografts for thoracoabdominal aneurysms. J Thorac Cardiovasc Surg. 2010;140:S171-S178.
9. Rodd CD, Desigan S, Chesire NJ, et al. The suitability of thoracoabdominal aortic aneurysms for branched and fenestrated stent grafts and the development of a new scoring method to aid case assessment. Eur J Vasc Endovasc Surg. 2011;41:175-185.
10. Sweet MP, Hiramoto JS, Park KH, et al. A standard multi-branched thoracoabdominal stent-graft for endovascular aneurysm repair. J Endovasc Ther. 2009;16:359-364.
11. Ohrlander T, Sonesson B, Ivancev K, et al. The chimney graft: a technique for preserving or rescuing aortic branch vessels in stent-graft sealing zones. J Endovasc Ther. 2008;15:427-432.
12. Oderich GS, Ricotta JJ 2nd, Hofer J, et al. Surgeon-modified fenestrated and branched stent grafts for high risk patients with juxtarenal, paravisceral and thoracoabdominal aortic aneurysms: comparison with open abdominal debranching in a single center. J Vasc Surg. 2009;49(suppl 5):48s.
13. Quinones-Baldrich WJ, Panetta TF, Vescera CL, et al. Repair of type IV thoracoabdominal aneurysm with a combined endovascular and surgical approach. J Vasc Surg. 1999;30:555-560.
14. Chaikof EL, Fillinger MF, Matsumura JS, et al. Identifying and grading factors that modify the outcome of endovascular aortic aneurysm repair. J Vasc Surg. 2002;35:1061-1066.
15. Drinkwater SL, Goebells A, Haydar A, et al. The incidence of spinal cord ischemia following thoracic and thoracoabdominal endovascular intervention. Eur J Vasc Endovasc Surg. 2010;40:729-735.
16. Lachat M, Mayer D, Criado FJ, et al. New technique to facilitate renal revascularization with use of telescoping self-expanding stent grafts: VORTEC. Vascular. 2008;16:69-72.
17. Quinones-Baldrich W, Jimenez JC, DeRubertis B, Moore WS. Combined endovascular and surgical approach (CESA) to thoracoabdominal aortic pathology: a 10-year experience. J Vasc Surg. 2009;49:1125-1134.
18. Patel HJ, Upchurch GR, Eliason JL, et al. Hybrid debranching with endovascular repair for thoracoabdominal aneurysms: a comparison with open repair. Ann Thorac Surg. 2010;89:1475-1481.
19. Resch TA, Greenberg R, Lyden SP, et al. Combined staged procedures for the treatment of thoracoabdominal aneurysms. J Endovasc Ther. 2006;13:481-489.
20. Black SA, Wolfe JHN, Clark M, et al. Complex thoracoabdominal aortic aneurysms: endovascular exclusion with visceral revascularization. J Vasc Surg. 2006;43:1081-1089.
21. Patel R, Conrad MF, Paruchuri V, et al. Thoracoabdominal aneurysm repair: hybrid versus open repair. J Vasc Surg. 2009;50:15-22.
22. Chiesa R, Tshomba Y, Melissano G, et al. Hybrid approach to thoracoabdominal aortic aneurysms in patients with prior aortic surgery. J Vasc Surg. 2007;45:1128-1135.
23. Drinkwater SL, Bockler D, Eckstein H, et al. The visceral hybrid repair of thoraco-abdominal aortic aneurysms—a collaborative approach. Eur J Vasc Endovasc Surg. 2009;38:578-585.
24. Lee WA, Brown MP, Martin TD, et al. Early results after staged hybrid repair of thoracoabdominal aortic aneurysms. J Am Coll Surg. 2007;205:420-431.
25. Lin PH, Kougias P, Bechara CF, et al. Clinical outcome of staged versus combined treatment approach of hybrid repair of thoracoabdominal aortic aneurysm with visceral debranching and aortic endograft. Perspect Vasc Surg Endovasc Ther. In press.
26. Bakoyiannis C, Kalles V, Economopoulos K, et al. Hybrid techniques in the treatment of thoracoabdominal aortic aneurysms: systematic review. J Endovasc Ther. 2009;16:443.
27. Moulakakis KG, Mylonas SN, Avgerinos E, et al. Hybrid open endovascular technique for aortic thoracoabdominal pathology. Circulation. 2011;124:2670.
28. Oderich GS, Gloviczki P, Farber M, et al. Abdominal debranching with aortic stent grafts for complex aortic aneurysms: preliminary results of the North American Complex Abdominal Aortic Debranching (NACAAD) Registry. Society for Vascular Surgery meeting; Chicago, IL; June 15-18, 2011.