Operative Techniques in Thoracic and Cardiovascular Surgery

Endovascular Repair of Thoracoabdominal Aortic Aneurysms with Fenestrated-Branched Stent-Grafts

Edward G. Soltesz, MD, MPH, and Roy K. Greenberg, MD

The standard surgical approach to thoracoabdominal aneurysms is considerably demanding, and outcomes correlate with the number and severity of associated comorbidities.[1] Many large studies have reported mortality rates ranging from 7% to 17%. Cardiac, neurologic, respiratory, and renal complications limit the number of patients who are eligible for open surgery. Recent advances in operative technique and use of adjunctive measures for spinal cord protection have decreased, but not eliminated, the devastating complication of paraplegia. Nonetheless, other peri-procedural complications still exist due to the invasiveness of open thoracoabdominal repair. Endovascular stent-grafting has been applied to the treatment of infrarenal abdominal and descending thoracic aortic aneurysms with success.[2] A low risk of death and paraplegia after endovascular repair of descending thoracic aneurysms has been reported. Only recently have devices become available for the endovascular management of thoracoabdominal aortic aneurysms where there is extensive involvement of the visceral segment. The potential benefits from endovascular repair include avoidance of aortic cross-clamping and major incisions, minimization of blood loss, diminished postoperative pain, and limitation of visceral, renal, and spinal cord ischemia.

We have been actively involved with the development of fenestrated and branched stent-grafts to target this high-risk patient population with thoracoabdominal aortic aneurysms.[3] The branched thoracoabdominal stent-graft is a modular system based on the Zenith stent-graft (Cook Inc., Bloomington, IN). The main body component is a custom-designed straight or tapered device with reinforced fenestrations and/or standardized directional helical branches precisely chosen to correlate with the patient's target vessel anatomy based on radiographic assessment of the visceral ostial geometric relationships. Reinforced fenestrations are mated to balloon-expandable covered stents (Jomed; Abbot Labs, Abbott Park, IL), while the directional branches are mated to self-expanding covered stents (Fluency; Bard Inc., Tempe, AZ).

Candidates for endovascular thoracoabdominal aneurysm repair typically are considered to be high risk for open aneurysm repair due to their age, aneurysm morphology, or comorbid conditions. Preoperative assessment typically includes a functional cardiac stress test followed by selective coronary angiography if necessary, transthoracic echocardiography, pulmonary function testing, routine blood work, and a physical examination. A clear understanding of the aortic, iliac, and femoral anatomy is critical to patient selection and device construction. High-resolution computerized tomography (CT) scans of the entire aorta are analyzed with multiplanar reconstructions and centerline of flow measurement techniques on a workstation (TeraRecon Inc., San Francisco, CA), using 3-dimensional (3D) image analysis techniques to assess the aortic morphology. Chronic aortic dissection and severe iliac disease are potential contraindications to a pure endovascular approach, and hybrid-type repairs are considered in these patients if they are not amenable to open surgical repair.

Spinal drainage is selectively employed based on the extent of aortic coverage (type I, II, and III thoracoabdominal aneurysms) or in the setting of prior aortic surgery, internal iliac, or subclavian/vertebral disease where collateral flow to the spinal cord is potentially compromised. Regional anesthesia may be used for patients with significant pulmonary dysfunction. Patients with renal insufficiency routinely receive hydration and N-acetyl cysteine perioperatively.

The Cleveland Clinic Foundation, Heart and Vascular Institute, Cleveland, Ohio.

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Address reprint requests to Edward Soltesz, MD, MPH, Cleveland Clinic Foundation, J-4, 9500 Euclid Avenue, Cleveland, OH 44195. E-mail: soltese@ccf.org

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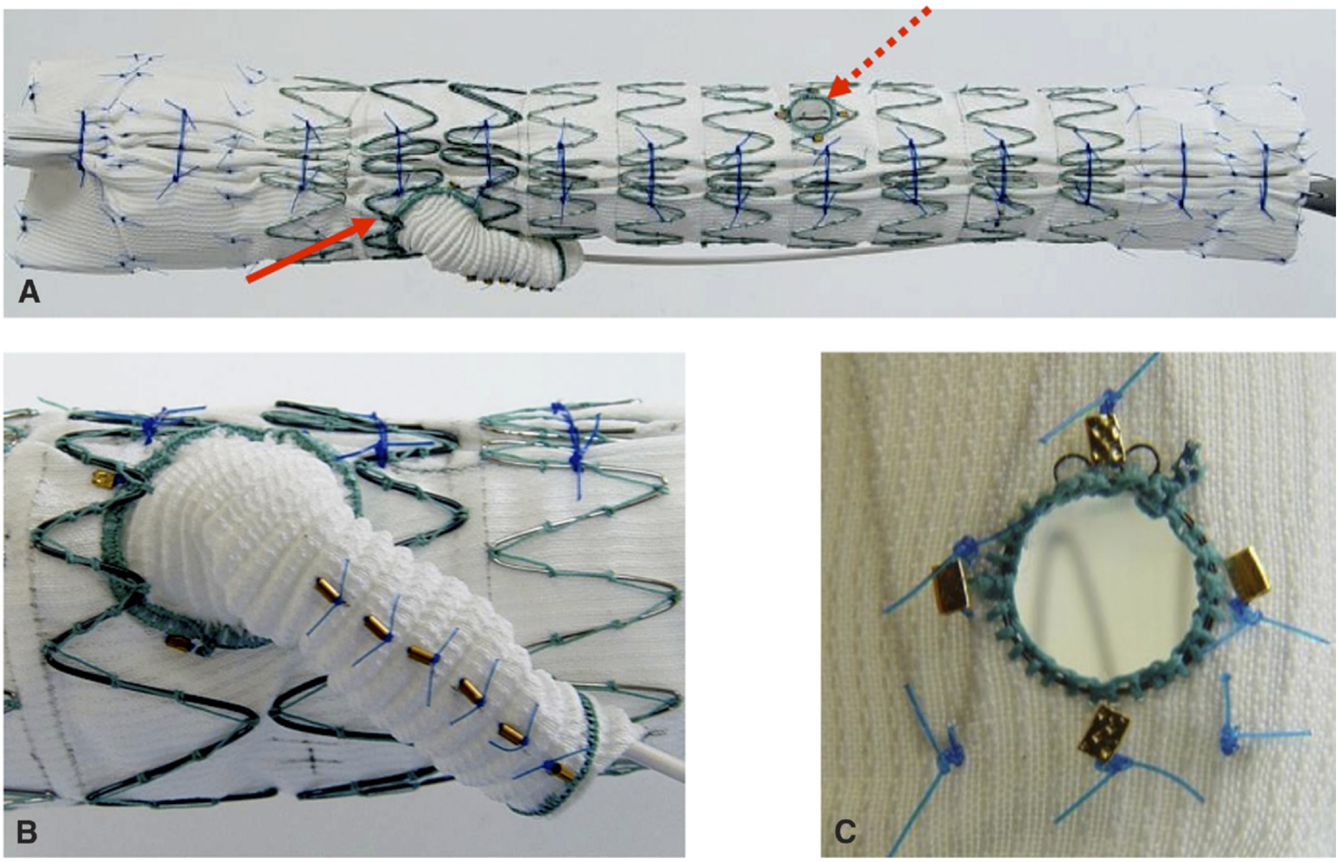

Figure 1 (A) Custom-designed main body device tethered to the delivery system demonstrating branch fenestrations for the renal arteries and a helical branch providing antegrade perfusion of the celiac artery. The helical branch for the superior mesenteric artery (SMA) and fenestration for the contralateral renal artery are out of view.

(B) The helical branch is an 8-mm polyester graft sewn to the aortic prosthesis above the target vessel. The branch is wrapped in a spiral fashion external to the aortic prosthesis, orientated in either an antegrade (as shown) or a retrograde fashion, and terminated proximal to the target vessel. These so-called directional branches provide long regions (2 cm) of overlap, allowing mating of a self-expanding stent-graft (Fluency) sized to the visceral vessel. The helical branch construct provides a more secure seal into both the mating vessel and the aortic component given the extensive potential for overlap with both sealing regions, resulting in less of a tendency to develop endoleaks or component separation. Cannulation of the helical branch from a brachial or axillary approach is made easier by a preloaded access catheter traversing the branch.

(C) The fenestrated branch is a nitinol-reinforced opening in the main body device that is sized and aligned with the target vessel ostium. This is mated with a balloon-expandable stent-graft lumen and the aortic portion is subsequently flared with a compliant balloon to achieve a seal around the fenestration. Alignment of fenestrations with target arteries is accomplished by leaving the main body device partially constrained, ensuring the ability to rotate the device to establish radial orientation, and adjusting the longitudinal position to ensure cranial/caudal alignment while selective cannulation of each artery is accomplished through the main body device.