Recommendations From a Busy Fenestrated Practice

The top 10 lessons we have learned for optimizing clinical outcomes.

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Fenestrated endovascular aneurysm repair (FEVAR) has undergone nearly 2 decades of evolution since the pioneering work of Tom Browne, Michael Lawrence-Brown, and David Hartley and the first clinical implantation procedure by John Anderson in 1998. Contemporary reports from large aortic centers worldwide have shown high technical success rates (> 95%), with mortality in the range of 1% to 5% for pararenal and 5% to 10% for thoracoabdominal aortic aneurysms.[1-5] In the United States, the Zenith Fenestrated (ZFEN) stent graft (Cook Medical) is celebrating its 5-year anniversary since commercial approval in 2012. The technique has been widely accepted in many centers, and clinical outcomes continue to improve as a reflection of increasing clinical experience.

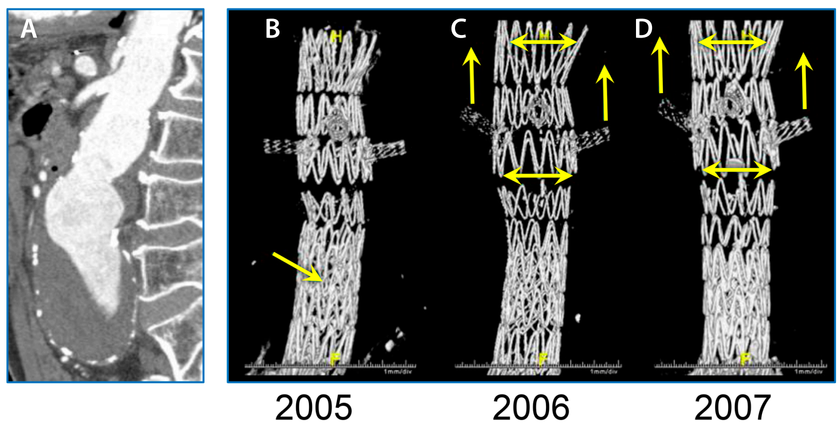

Figure 1. Sagittal view of CTA reveals a slight posterior bulge between the superior mesenteric artery (SMA) and the infrarenal aneurysm sac (A). Note the initial appearance of a three-vessel fenestrated endograft (B) with subsequent progression of aortic disease, causing flaring of the bare-metal stent, neck enlargement, and distal migration (C, D). With permission of Mayo Clinic Foundation.

LESSONS LEARNED

Branch vessel catheterization and incorporation is a critical step when dealing with complex aortic repair, regardless of which technique is used to incorporate the target vessel (ie, fenestrated, branched, or parallel grafts). Adequate planning, technical finesse, and attention to detail are of paramount importance to avoid complications. Excessive catheter and guidewire manipulation can result in a number of complications including atheroembolization, prolonged visceral ischemia, and inadvertent dissection or vessel perforation. The following sections summarize our top 10 tips and tricks for improving FEVAR results.

1. Disease Progression Can Compromise Late Results

It is critical that use of the ZFEN device follows the instructions for use for its intended indication. Although the device was approved for patients with short-necked infrarenal aneurysms (4–14 mm), it can be used more liberally in patients with aneurysms encroaching the renal arteries as long as a minimum sealing zone of 2 cm is achieved in normal aorta, which is defined by parallel aortic wall with no thrombus or calcification.[5] It is important to note that the presence of signs of aortic degeneration, such as ectasia, thoracic disease, thrombus, or posterior bulge (Figure 1), may be an indicator of disease progression. In these patients, the use of two or three fenestrations may be insufficient and lead to late neck dilatation, loss of sealing zone, migration, and displacement of target vessel stents. In most centers with access to more advanced stent graft designs, a minimum of three or four fenestrations is used and the sealing zone is placed in the supraceliac aorta.[1,5]

2. Meticulous Planning

A thorough review of patient anatomy is paramount to anticipate difficulties with side branch placement. The

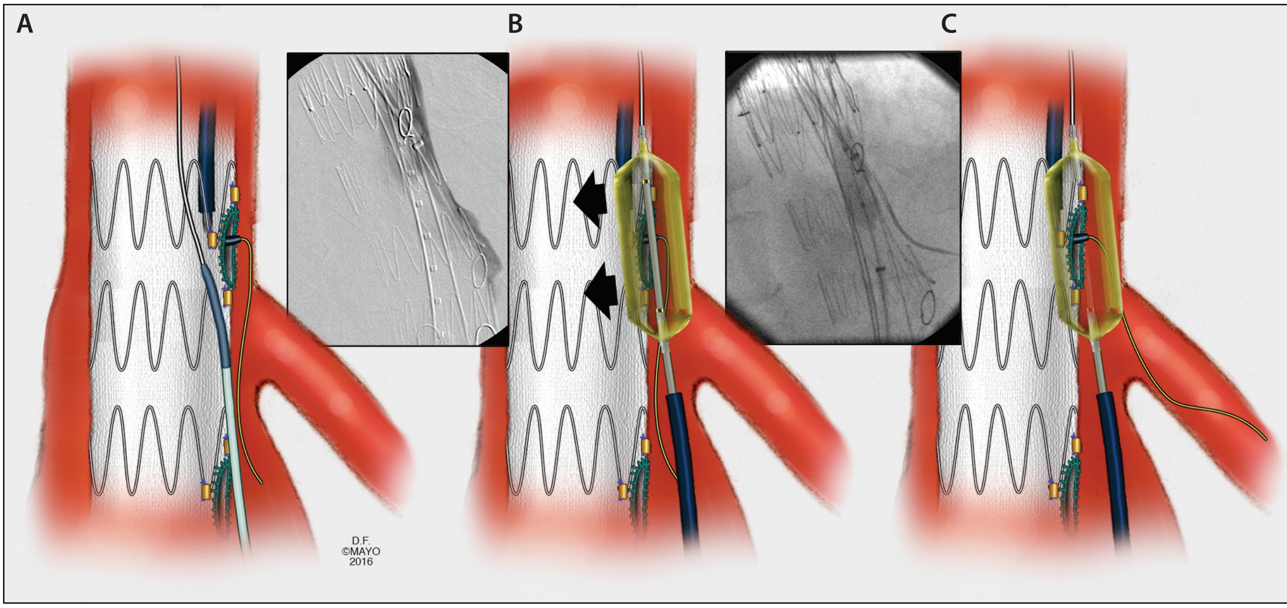

Figure 2. Misalignment between fenestration and target vessel (A) is treated by inflation of a balloon between the aortic endograft and aortic wall (B) to create space for catheter manipulation. The vessel is successfully catheterized using a "buddy" system (C). With permission of Mayo Clinic Foundation.

presence of tortuosity, ostial disease, plaque, debris, small vessel diameter, and early branch bifurcation all increase technical difficulty for placement of bridging stents. Therefore, preoperative case planning remains critical to successful execution of these procedures. Thin-slice CTA of the chest, abdomen, and pelvis determines target vessel orientation, specific stent graft design, and choice of ideal approach. Most complications, as later described, can be anticipated on the basis of careful review of preoperative imaging.

3. Optimize Imaging and Minimize Radiation Exposure

These procedures should ideally be performed in a hybrid operating room that combines optimal imaging with the ideal environment to perform complex open and endovascular operations. Although FEVAR can be performed with portable imaging, modern fixed imaging units have advantages such as stronger x-ray tube power (preventing overheating), flat panel detectors (optimizing imaging quality), and customizable protocols to regulate radiation dose levels. Several features such as CTA fusion, cone-beam CT (CBCT), larger detector panels, digital zoom, and low-dose protocols further reduce the radiation exposure to the patient and operator.

4. Minimize Contrast Use

Fenestrated repair can be technically demanding and require multiple steps. Therefore, large-volume aortography should be avoided during the initial steps of the procedure and reserved for the final assessment. Small hand injections of diluted contrast are used to identify target vessels, and CTA fusion guides device deployment and vessel catheterization. Although precatheterization of vessels is optional, this technique provides excellent means to precisely identify a target without the use of contrast.

5. Dealing With Misalignment Between Fenestration and Vessel

One of the most common difficulties during FEVAR is dealing with misalignment between the fenestration and the target vessel. Although rarely needed, leaving a stiff guidewire between the main aortic stent graft and the aortic wall can serve well in case of severe misalignment when there is not enough space to manipulate catheters. A simple maneuver is to advance and inflate a balloon between the stent graft and aortic wall, creating enough space to cannulate the vessel (Figure 2). If the fenestration can be catheterized and a wire can be advanced between the aortic wall and the stent graft, a 0.018-inch wire system should be used to maintain the tip of the sheath close to the fenestration while a buddy catheter is used to find the target vessel (Figure 3).

Excessive rotation of the device is not recommended and is usually not necessary. However, the constrained fenestrated device with top cap can be rotated to facilitate catheterization. Because the diameter-reducing ties are centered in the posterior aspect of the stent graft, the renal fenestrations are pulled posteriorly (Figure 4).

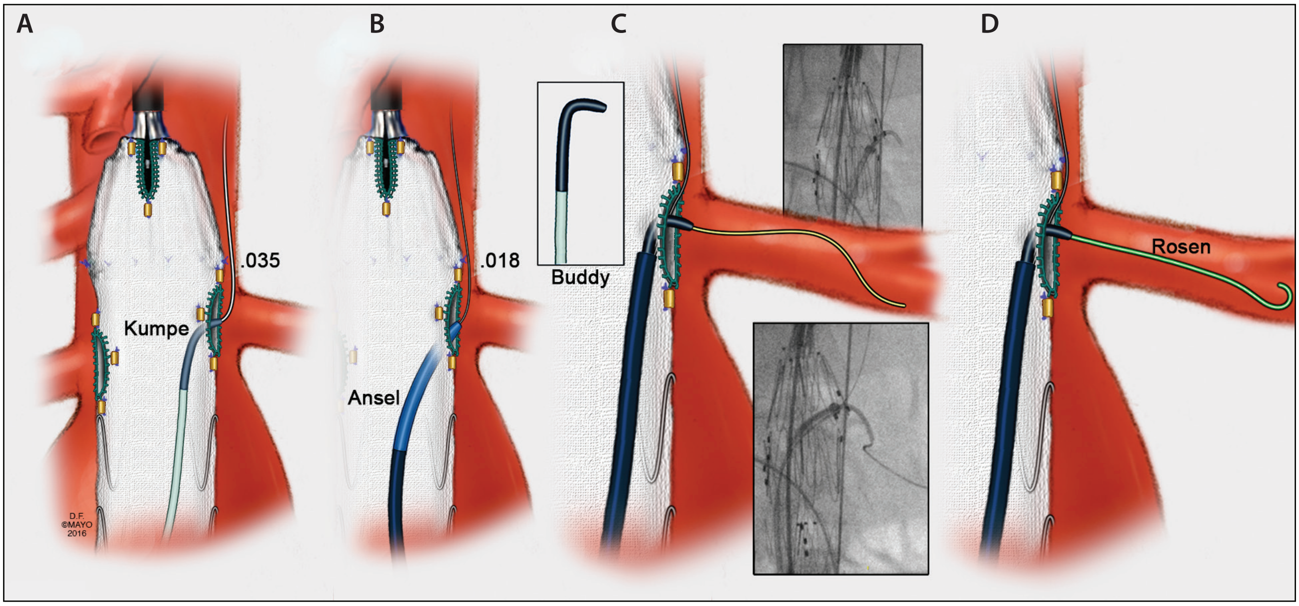

Figure 3. A renal fenestration is accessed and a 0.035-inch guidewire is advanced into the aorta (A), which is exchanged for a 0.018-inch system (B) to allow use of a buddy catheter (C), which is advanced into the target vessel (D). With permission of Mayo Clinic Foundation.

One of the first maneuvers in these cases is to rotate each fenestration more anteriorly. Once the fenestration and vessel are catheterized and a hydrophilic sheath is advanced, the graft is rotated in the opposite direction to allow catheterization of the contralateral renal artery. It is an important caveat to undo any rotation before final release of the top cap and final device deployment to avoid twisting at the distal aspect of the stent graft.

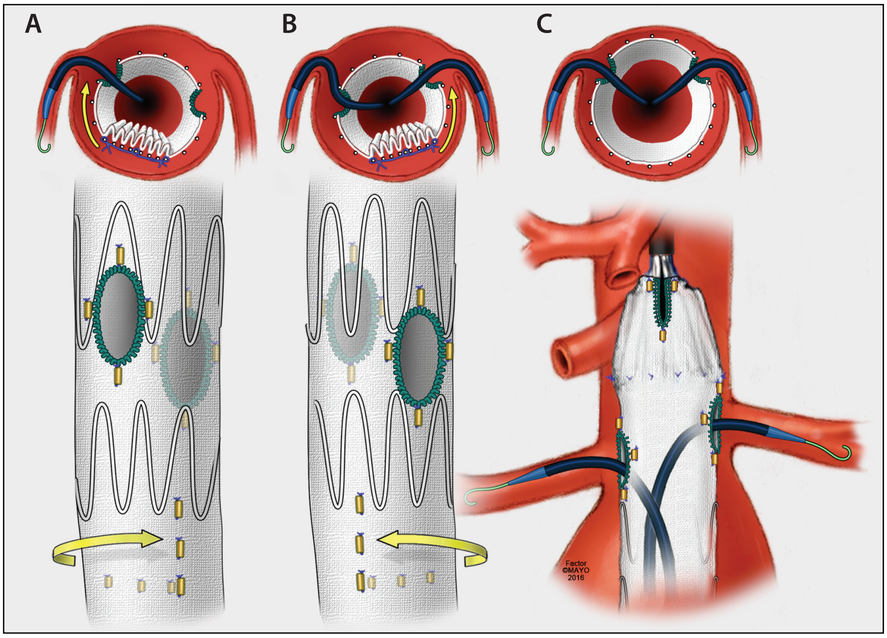

Figure 4. Natural posterior displacement of the fenestrations occurs because of posterior diameter-reducing ties. The device is rotated clockwise for access to the right renal artery (A) and counterclockwise for the left renal artery (B). Hydrophilic sheaths are advanced into both renal arteries over Rosen wires (C). With permission of Mayo Clinic Foundation.

6. Difficult Sheath Advancement

Down-going renal arteries may be difficult to access via the femoral approach. One of the first maneuvers that can be used is advancing the catheter to the top of the device and into the target vessel, allowing guidewire exchange for a Rosen wire (Cook Medical) (Figure 5). If a sheath with soft dilator cannot be advanced into the vessel, a useful maneuver is to inflate a balloon, which is used as a dilator for the sheath. The sheath is advanced into the target vessel while the balloon is deflated.

7. Selection of Bridging Stents

Alignment of fenestrations with balloon-expandable stents is recommended for all reinforced fenestrations, is optional for scallops, and is not recommended for

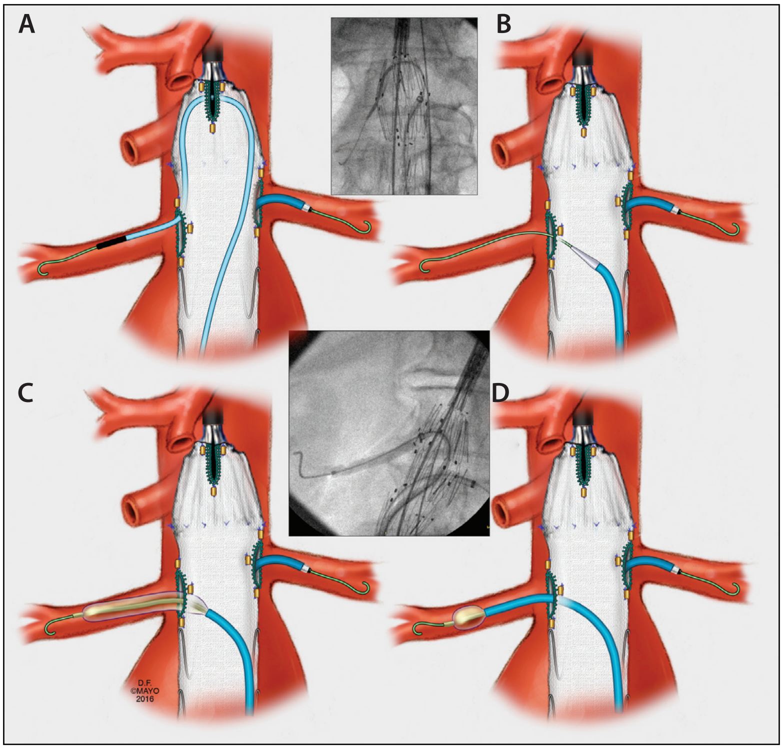

Figure 5. Sheath advancement using the top part of the fenestrated stent (A, B) and a balloon to replace the dilator of the sheath (C, D). With permission of Mayo Clinic Foundation.

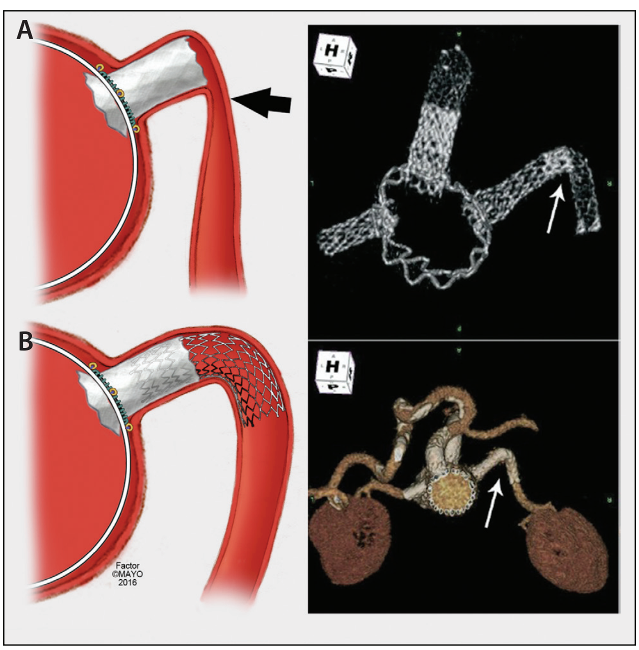

Figure 6. Renal arteries with posterior orientation are prone to kink at the distal edge of the balloon-expandable stents (A), which can be treated by placement of a self-expandable stent (B). With permission of Mayo Clinic Foundation.

large nonreinforced fenestrations. In the United States multicenter prospective study evaluating the ZFEN, a bare-metal balloon-expandable stent was used. However, most experts agree that covered balloon-expandable stents are the standard of care for vessel alignment, offering advantages of improved primary patency, lower rates of neointimal hyperplasia, and improved seal.[1-5] Kinks should immediately be recognized on selective angiography or anticipated based on vessel anatomy (Figure 6). A useful tip is to keep the length of the stents short (< 2 cm), which avoids bends and minimizes the respiratory motion. If flow-limiting kink is noted, a self-expandable stent may be needed to smooth the transition between the alignment stent and the vessel.

8. Technical Finesse

Attention to detail and careful catheter manipulation are critical for avoiding complications. With finesse, proper technique, and good patient selection, vessel perforation or dissections are infrequent. Guidewire selection is the first step. For the renal arteries, we favor using an intermediate-stiffness, J-tip guidewire such as the Rosen wire. Stiff guidewires, such as the Amplatz (Cook Medical), are avoided whenever possible in the renal arteries. It is important not to position the J-tip in small terminal branches, which are prone to perforation or dissection. In addition, the operator should maintain visualization of the tip of the guidewire during manipulations, and the guidewire should be stabilized during exchanges, avoiding forward or retrograde movement. In the unfortunate event of major renal branch perforation, a 0.035-inch balloon should be inflated in the renal stent to minimize bleeding. The 0.035-inch guidewire may be removed with the balloon inflated to allow angiography to be performed via the lumen of the balloon shaft (Figure 7). For more distal branches, access can be obtained with a 3-F microcatheter introduced via the shaft of the 0.035-inch balloon. Coils can then be delivered through the catheter. Dissections within the main renal artery can be treated by placement of an additional self-expandable stent. A devastating complication can occur if there is total disruption of the vessel beyond a short fenestrated stent. It is imperative in these cases that access is not lost. If salvage is not possible, the vessel needs to be sacrificed.

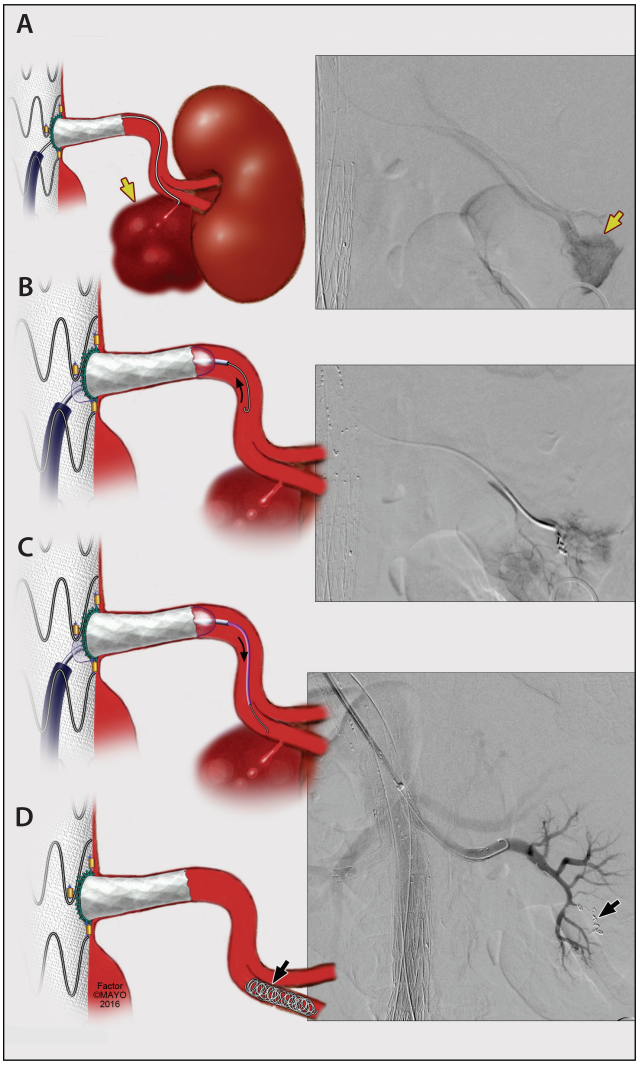

Figure 7. Inadvertent perforation of a side branch (A) should immediately be recognized by completion angiography. The balloon is reinflated in the bridging stent (B), and angiography is performed via the balloon catheter (C). A microcatheter can then be advanced over the inflated balloon, and the perforated distal vessel is coil embolized (D). With permission of Mayo Clinic Foundation.

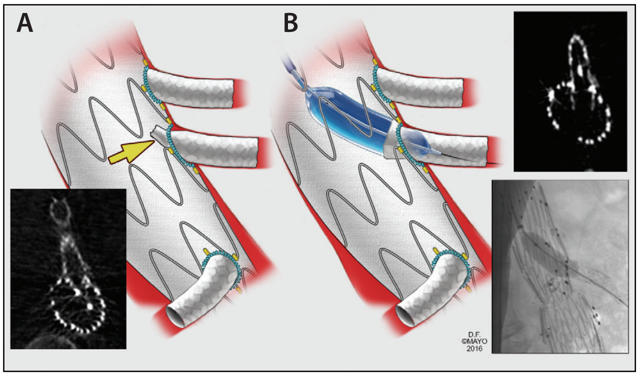

Figure 8. CBCT reveals compression of the SMA stent (A), which tends to occur during advancement of the distal bifurcated device or one of the iliac limbs. This was immediately revised by balloon inflation (B), avoiding the dreaded complication of early SMA thrombosis. With permission of Mayo Clinic Foundation.

9. Dealing With Attachment Endoleaks

The addition of more stent graft components increases the potential for failure of one of the attachment sites. The most common endoleaks are type II and IV. Type I endoleaks are uncommon with proper planning and adequately long landing zones. If noted, these should be treated by repeat balloon dilatation of the proximal neck with protection of the side stents using separate balloons. Type III endoleaks may require repeat dilatation or placement of a second covered stent.

10. Technical Assessment

It is important to immediately identify technical problems, such as endoleaks, from sealing zones or compression of side stents (Figure 8). If not recognized, these problems may lead to devastating complications such as stent occlusion or aneurysm rupture. The use of CBCT with or without contrast enhancement using high-definition imaging can be performed through three-dimensional rotation. Multiplanar reconstructions allow immediate assessment of the repair, including the location of stent grafts in relation to target vessels, configuration of side branches, patency of iliac limbs, and presence of endoleaks. These technical complications can be recognized and immediately revised.

CONCLUSION

FEVAR has increasingly been utilized to treat aortic aneurysms involving the aortic arch, thoracoabdominal aorta, and iliac bifurcation. It is important that centers performing these types of procedures are prepared to adapt to the technical demands of newer devices to treat complex anatomy and that physicians are well trained in bailout maneuvers to deal with unanticipated problems. The availability of advanced imaging tools has several advantages, notably the combination of the ideal surgical environment with optimal imaging and advanced applications to minimize radiation exposure, use of contrast media, and need for secondary interventions. ■

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Disclosures: Consultant to Gore & Associates and Cook Medical; research grants from Gore & Associates, Cook Medical, and GE Healthcare; all consulting fees and grants were paid to Mayo Clinic.

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