Chapter 10

Techniques for large sheath insertion during endovascular thoracic aortic aneurysm repair

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Despite improvements in operative technique and perioperative management, conventional open repair of descending thoracic aortic aneurysms (DTAs) continues to be associated with significant morbidity and a perioperative mortality between 4.8% and 20%, which may be even more pronounced in the acute setting.[1,2] Since the first description of the endovascular repair of a thoracic aortic aneurysm by Dake et al,[3] several studies have shown the safety of this approach, as well as possible decreases in perioperative mortality and complications, most notably paraplegia.[4-7] Because of the less invasive nature and likely improved perioperative outcomes of endovascular repair of DTA, this is rapidly becoming the favored approach for management in these patients.

Many patients, however, continue to be ineligible because of suboptimal vascular access, aortic arch angulation, and landing zone inadequacies. Although industry has been working to solve the last two issues, vascular access continues to be of major concern because delivery systems remain excessively large. In the United States, the currently available endografts for thoracic aorta aneurysms require delivery sheaths ranging from 20F to 25F, depending on the size of the graft and the manufacturer (Table). Despite these challenges, with the recent approval by the US Food and Drug Administration of the Gore Thoracic Aortic Graft endoprosthesis (W.L. Gore and Associates, Inc, Flagstaff, Ariz) and the ongoing evaluation of the Talent (Medtronic, Santa Rosa, Calif) and Zenith TX1 and TX2 (Cook Inc, Bloomington, Ind) endografts, it is clear that this technology is moving forward. With more widespread use and continued innovation, industry should be able to overcome the difficulties currently encountered with vascular access for the introduction of thoracic aortic endografts. Until that time, however, one should be knowledgeable of and comfortable with the implementation of several adjunctive maneuvers that may allow graft placement in otherwise ineligible patients. Furthermore, a thorough knowledge of these techniques will allow for better preoperative planning in difficult-access cases and may avoid potentially tragic outcomes in patients who develop severe, sometimes life-threatening, aortoiliac injury.

Problems related to vascular access for stent grafts occur in up to 28% of cases and center around three conditions that are prevalent in this patient population: iliofemoral occlusive disease, small vessel size, and excessive iliofemoral tortuosity.[8,9] In one study, these conditions were responsible for more than half of the failures to qualify for aortic stent graft placement.[10] As experience increases with the technology, several methods have been developed in an effort to overcome these difficulties, largely by attempting to modify or bypass the inadequate iliofemoral vessels.

Adequate preoperative imaging is vital to planning for access during endovascular DTA repair, thus making it possible to either deal with any problem at the outset or prepare to do so if one develops upon completion of the procedure. The use of either helical computed tomographic angiography[11] or magnetic resonance angiography[12] should allow for satisfactory examination of the iliofemoral access vessels for the purpose of measuring lumen size and determining the presence of occlusive disease and tortuosity. In addition, the use of three-dimensional reconstructions allows for direct spatial visualization of the iliofemoral vessels, thus enabling an excellent assessment of vessel tortuosity. Only rarely is conventional contrast angiography required.

ENDOVASCULAR TECHNIQUES

Balloon angioplasty. Passage of a large-caliber delivery sheath through an iliac artery that is stenotic and often highly calcified because of the presence of pre-existing occlusive disease can be challenging and dangerous. Although balloon dilation typically will not overcome difficulties due to vessel size, it is often the easiest and first maneuver one uses in this situation. In our experience, the ability of the delivery vessel to be predilated with an 8-mm angioplasty balloon is predictive of being able to pass the delivery system at the time of aortic stenting. Although device insertion may be performed after the initial angioplasty, for optimal results, balloon dilation should be performed 4 to 6 weeks before the proposed aneurysm repair, with repeat angioplasty immediately before insertion of the delivery device. This delay allows for the segment to par-

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Table. Graft and delivery sheath sizes for descending thoracic aortic stent grafts currently available in the United States

Endograft	*Graft size available (diameter) (mm)*	*Sheath size required (diameter)*
GORE TAG	26-40	20-24 F (7.6-9.2 mm)
Zenith TX1/TX2	28-42	20-22 F (7.6-8.3 mm)
Talent	22-46	22-25 F

TAG, Thoracic Aortic Graft.

tially heal, thus limiting the likelihood of dislodging debris from the freshly dilated vessel. Between dilations, patients should be maintained on antiplatelet therapy to help prevent interval thrombosis of the iliac vessels. Upon completion of the DTA stent graft, the dilated iliac vessels should be stented with a self-expanding stent to "repair" the damage produced by the dilation and stent graft delivery sheath and to maintain vessel patency. If the proximal common iliac artery required dilation, bilateral, balloon-mounted "kissing" stents may be needed to prevent compromise of the contralateral iliac artery by the ipsilateral stent.

Retrograde balloon endarterectomy. The technique of retrograde balloon endarterectomy was first described by Queral et al.[13] In their series of 36 patients, they were able to successfully treat long-segment iliofemoral stenosis through a single groin incision in a safe fashion with durable, long-term results. This technique has since been used with success to facilitate the delivery of aortic endografts.[9] The procedure involves repeated balloon inflation under fluoroscopic guidance throughout the iliofemoral system via an open femoral arteriotomy (Fig 1). The balloon disrupts the intima, which is further dissected from the vessel wall by passing a ring stripper up through the arteriotomy (Fig 2). The dissected intima is then removed through the femoral arteriotomy (Fig 3). This procedure is repeated throughout the diseased segment up to the internal iliac artery. Stent placement then proceeds as usual through the newly endarterectomized vessels. As with balloon dilation alone, stents are then placed in the treated iliac vessels to prevent restenosis and thrombosis (Fig 4).

Endoluminal conduit. The placement of aortic stent grafts in the abdominal position has been performed successfully through an endoluminal conduit, which is constructed by suturing a Palmaz stent (Cordis; Johnson & Johnson, Warren, NJ) onto a polytetrafluoroethylene graft of appropriate size.[9] This technique allows aggressive balloon dilation of long segments of iliofemoral stenosis without the risk of vessel rupture. For treatment of aneurysms in the thoracic aorta, the conduit should be constructed of grafts with diameters of at least 8 mm and preferably 10 mm. The endoluminal conduit is then back-loaded into a delivery sheath and deployed via a femoral arteriotomy into the common iliac artery, covering the origin of the internal iliac artery. By using a noncompliant balloon, the iliac artery is dilated to diameters of 8 to 10 mm from within the endoluminal conduit. The aortic endograft can then be placed through the conduit into the aorta. Upon completion, the distal end of the graft can be trimmed and sutured to the common femoral artery from within the existing arteriotomy. Although this technique has the advantage of requiring only femoral access, the increased risk of dislodging the endograft when larger delivery systems are used will likely limit its use with larger-profile thoracic stent graft systems. Furthermore, covering the internal iliac artery risks the development of colonic ischemia, especially in the presence of inferior mesenteric artery occlusion.

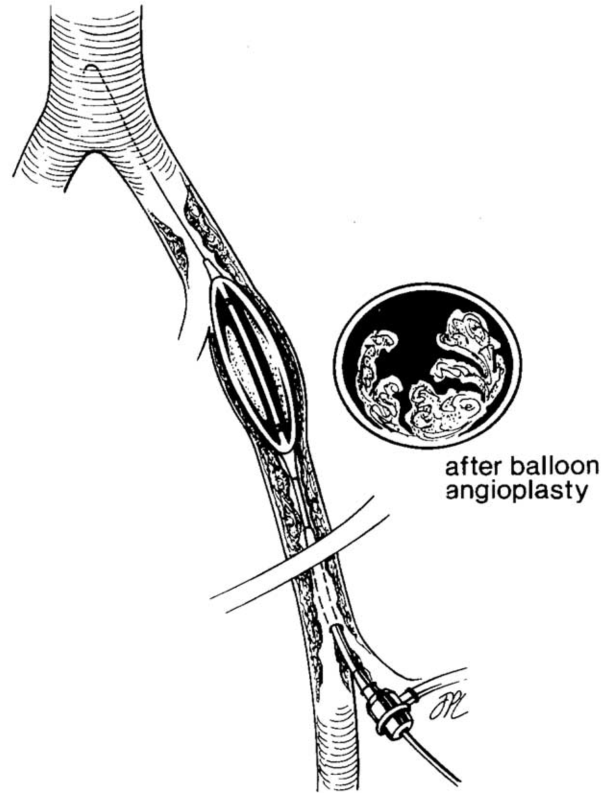

Fig 1. Balloon angioplasty of the external iliac artery is performed via a femoral arteriotomy.

OPEN "BYPASS" TECHNIQUES

With femoral or iliac vessels too small to accept the endograft delivery system or too severely diseased or occluded to allow passage via the typical femoral route, certain bypass procedures can be performed to allow insertion directly into the iliac artery or abdominal aorta.

Iliofemoral arterial conduit. The iliac artery conduit has been perhaps the most widely used bypass technique during endovascular repair of DTA, having been used in up to 22% of cases in most recent series.[5,6,8,14] This technique has the advantage of solving problems related to vessel size, disease severity, or tortuosity. Vascular exposure is obtained through a limited left or right lower retroperitoneal exposure. The common, internal, and external iliac vessels are

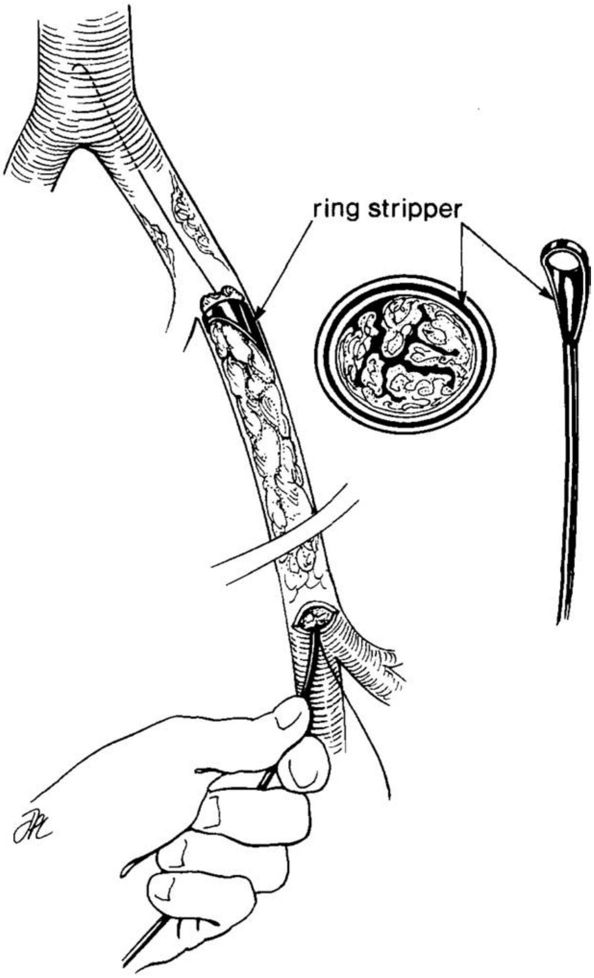

Fig 2. A ringed stripper is passed through the arteriotomy to further define the dissection plane.

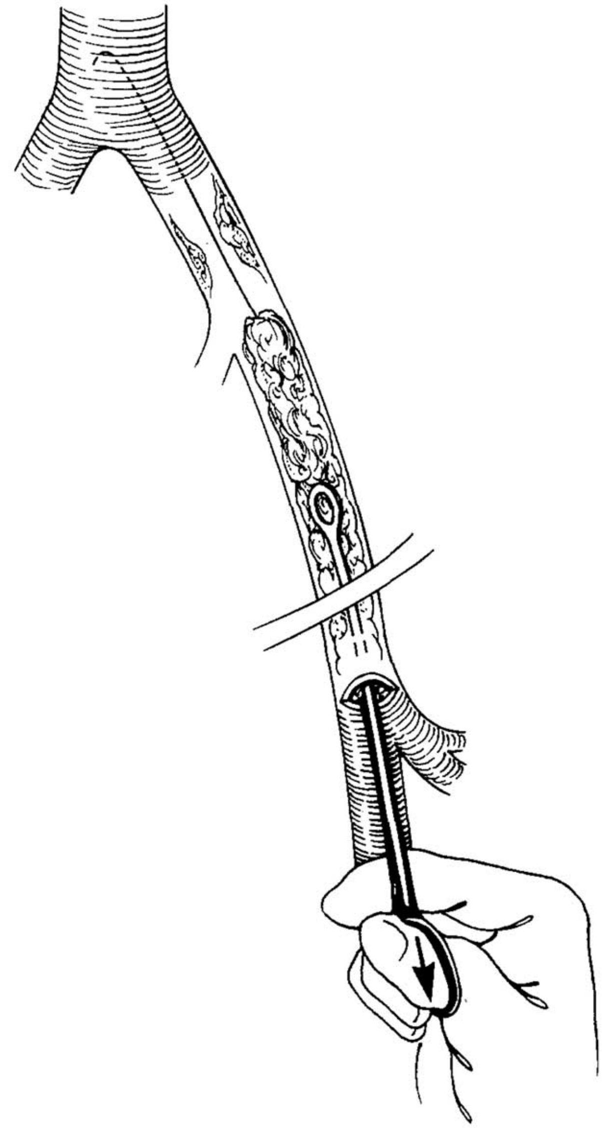

Fig 3. The dissected atheromatous plaque, including the intima and inner media, is removed with a clamp.

identified and controlled. If the proximal external iliac artery is adequate, it is used to accept the conduit; otherwise, the common iliac artery is used. A 10-mm Dacron graft (DuPont, Wilmington, Del) is then sutured in an end-to-side fashion to the desired iliac segment. Sheath insertion will occur through the Dacron graft. In obese patients, this graft can be tunneled through the abdominal wall through a separate incision to allow for optimal working angles. Care must be exercised while passing the delivery system through the anastomosis to avoid suture line disruption. Another advantage of this technique is in patients with severe iliac occlusive disease, in whom these grafts may be tunneled anatomically into a separate femoral incision for use as an iliofemoral bypass at the conclusion of the stent graft placement. Unless this conduit is to be used as a bypass, it may be oversewn and excised upon completion of the procedure.

Direct iliac artery or abdominal aorta cannulation. In patients with a history of abdominal surgery, especially aortic surgery, complete exposure and control of the iliac vessels can be difficult and hazardous. In these patients, it may be helpful to directly cannulate the proximal iliac artery or the abdominal aorta.[15] This is an excellent and easily implemented maneuver that successfully bypasses the iliofemoral system but does not require either circumferential control of the cannulated vessel or extensive retroperitoneal dissection. The technique includes performing a limited retroperitoneal exposure on the lower left abdomen (Fig 5). The right side can also be used, but access to the aorta may be limited with that approach. The common iliac artery and aorta are typically directly visualized. The internal iliac artery is identified by palpation. For thoracic endografts, either the common iliac artery or the abdominal aorta may be chosen for cannulation. Once a suitable site has been determined to be adequately free of calcification

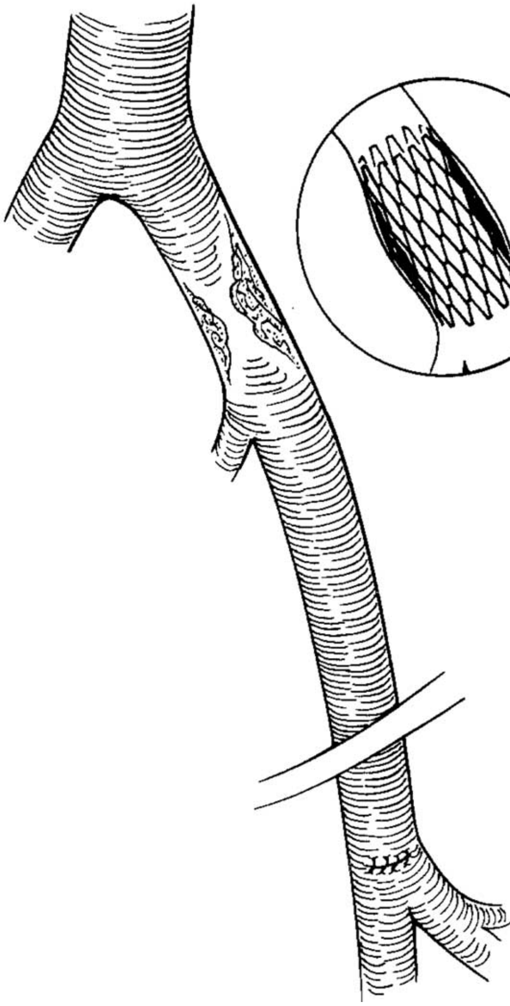

Fig 4. Upon completion of the stent graft procedure residual disease within the common iliac artery is treated with a stent and the arteriotomy is closed.

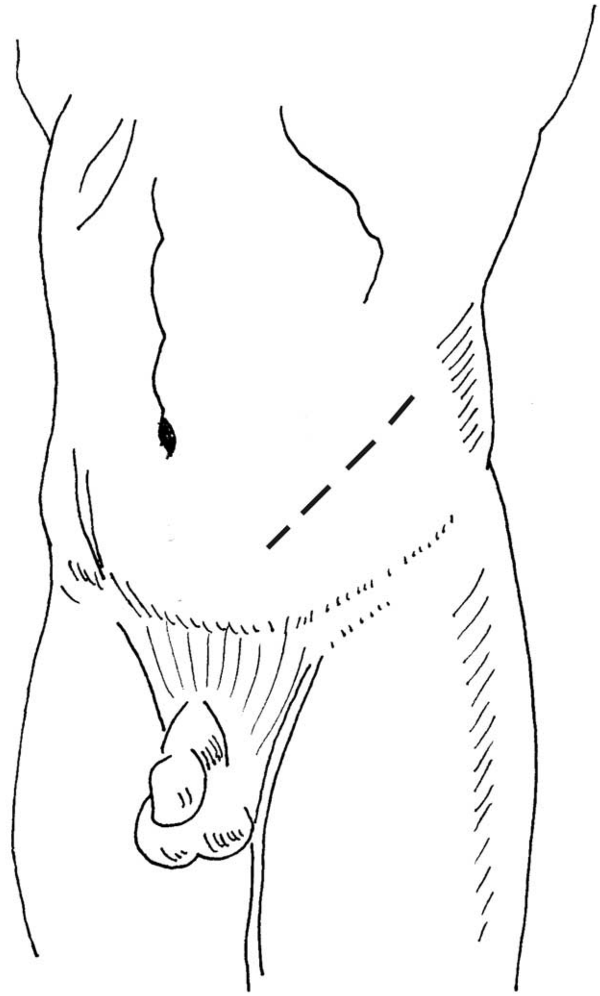

Fig 5. Incision placement for retroperitoneal exposure of the common iliac artery or distal aorta. Only the surface of the access vessel needs to be exposed.

to allow for cannulation, two concentric purse-string sutures are placed with nonabsorbable suture, preferably 4-0 polytetrafluoroethylene-impregnated polyester suture for native vessels and 2-0 polypropylene for a Dacron aortic graft. Care is taken to ensure that the sutures are placed within the adventitia and do not penetrate the full thickness of the artery into the vessel lumen. These sutures are initiated on opposite sides of the operative field to allow for optimal vessel control with the use of rubber catheter tourniquets. The iliac artery or aorta is entered with an 18-gauge needle, and a soft-tipped guidewire is passed into the aorta up to the arch (Fig 6). A stiff wire exchange is then performed through a catheter. A hemostatic sheath large enough to accommodate the endograft (Table) is directly inserted over the stiff wire into the iliac artery or aorta through the center of the purse-string sutures (Fig 7). The sheath is advanced into the abdominal aorta under fluoroscopic guidance. The tourniquets can be secured to provide hemostasis around the catheter if needed. The placement of a metallic clip at the sheath insertion site will facilitate entry site identification fluoroscopically. The endograft is then placed, and, upon completion, the sheath and guide wires are removed. The tourniquets are used for hemostasis. The defect is closed by removing the tourniquets, and, while the assistant maintains hemostasis with the outer purse string, the surgeon ties the inner. The outer purse-string suture is then tied, and the repair is reinforced with pledgeted sutures if necessary. Once hemostasis has been achieved, the retroperitoneal incision is closed in typical fashion.

We have shown that this technique can be used successfully and with minimal risk.[15] It does not risk suture line disruption, as is possible with arterial conduits, and the limited dissection performed decreases the risk of venous injury. Furthermore, in patients with previous abdominal aortic replacement, this technique works particularly well by directly cannulating the existing aortic graft. Because of

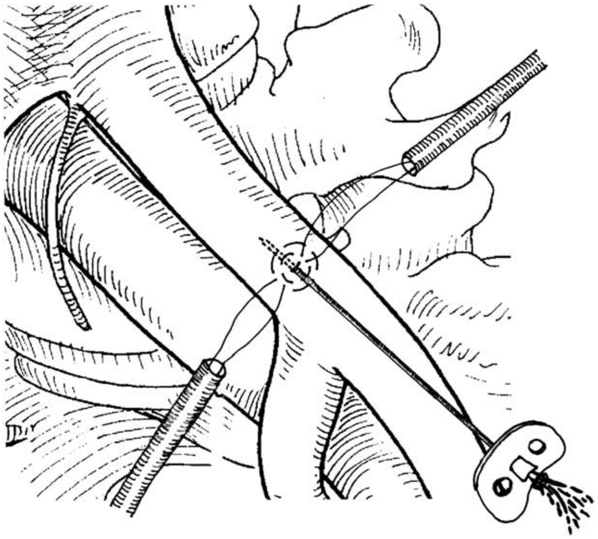

Fig 6. Placement of a double pursestring suture in the access vessel. Each of the concentric purse strings is constructed of 4-0 polytetrafluoroethylene-impregnated polyester suture for native vessels and 2-0 polypropylene sutures for Dacron graft initiated on opposite sides of the vessel and held by rubber tourniquets. The artery is punctured in the center of the purse string and a guidewire is inserted and manipulated into the proximal aorta.

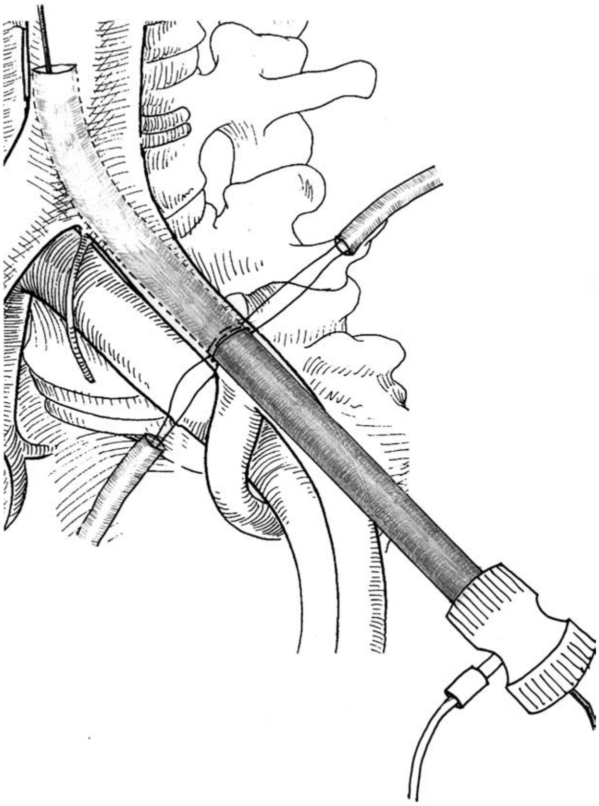

Fig 7. Sheath placement. The sheath with its tapered dilator is placed over the stiff wire and fluoroscopically guided into the common iliac artery or aorta. The tourniquets can be used to control any puncture site bleeding around the sheath. All further exchanges occur through the sheath with its hemostatic valve. Sheath removal is accomplished with simultaneous traction on both purse-string sutures to relieve tension on the puncture and maintain hemostasis while the sutures are sequentially tied.

its ease and limited risk, this has become our preferred open technique in patients with difficult or inadequate access.

TECHNIQUES FOR ILIOFEMORAL TORTUOSITY

Severe vessel tortuosity is responsible for up to 10% of failed attempts at abdominal aortic endograft placement.[10] With the even larger-profile, less flexible thoracic stent grafts, failure rates may be even higher without adjuvant techniques. Although the development of stiff guidewires has made tortuosity less of a problem, in the presence of severe iliac artery tortuosity, even the currently available stiff wires may not be sufficient to allow passage of a large-caliber delivery sheath safely. If the vessel caliber is adequate, there are several maneuvers one can use to overcome this obstacle, especially if the vessels have only limited or no calcification. However, although these relatively simple techniques can provide the edge needed to complete the procedure, they are often unsuccessful with significantly calcified vessels, and a bypass type of procedure, as described previously, may be required.

Passage of a second stiff "buddy" wire. The simplest maneuver is the placement of a second stiff "buddy" wire across the tortuous vessels. Often the extra tension of the second wire will straighten the vessels enough to allow passage of a large sheath, through which the endograft may be deployed. Once the initial stiff wire is placed within the existing 5F sheath, a second floppy wire is passed adjacent to the sheath into the proximal aorta. This wire is then exchanged for the second stiff wire through a catheter. The large delivery sheath is then advanced over the original wire into the distal aorta. With both wires in place, passage of the delivery system should proceed without much difficulty. Because of its simplicity, limited risk, and lack of any additional operative exposure, this technique should be considered first when tortuosity is the only limiting factor.

Iliac artery exposure and straightening. Another relatively simple maneuver involves surgically straightening the external iliac vessels. This is accomplished through the routine femoral exposure incision. Proximal control is achieved around the common femoral artery with a vessel loop, which is gently retracted while the external iliac artery is bluntly dissected off the surrounding tissue attachments from under the inguinal ligament. If needed, the inguinal ligament can be divided to allow greater exposure, especially in larger patients; however, it must be reconstructed with heavy absorbable sutures at the completion of the procedure to prevent the development of a femoral hernia. Once the vessels are adequately straightened, the endograft may be inserted and deployed. After deployment, signifi-

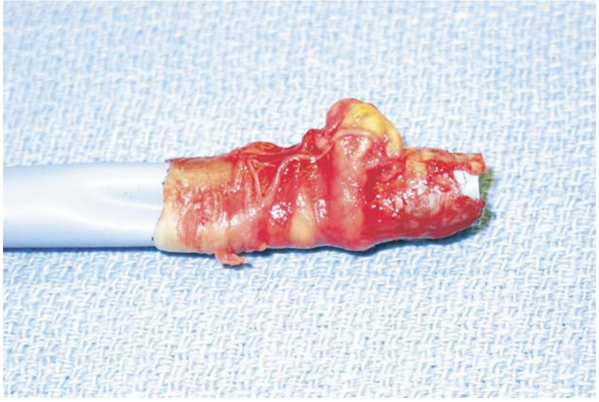

Fig 8. Avulsed external iliac artery after deployment of the endovascular stent graft.

cant redundancy of the iliac artery, if present, may be excised and an end-to-end anastomosis may be performed to the common femoral artery. Although this technique may decrease external iliac tortuosity, it has a limited effect on the common iliac artery because of the relative immobility of this segment caused by its many attachments. Furthermore, highly calcified vessels tend to be resistant to this technique and often require a bypass type of intervention.

Brachiofemoral access. Using a brachiofemoral guidewire to allow passage through tortuous iliac vessels is also relatively simple. As with the other procedures, this technique works best with vessels that have limited calcification but can help straighten even the most angulated of vessels. The left brachial artery is accessed percutaneously, and a guidewire is passed into the aortic arch down into the distal aorta with the assistance of a directional catheter. The guidewire is then either directed into the femoral artery to be used for access and grasped through a small femoral arteriotomy or captured with the use of a snare inserted through a sheath. The endograft delivery sheath is then loaded onto the brachiofemoral guidewire and passed into the aorta while constant tension is maintained to both the brachial and femoral ends of the wire. For this technique to be successful, the guidewires must be at least 250 cm long. Also, to prevent injury to the origin of the left subclavian artery, a protective catheter must be left in place over the brachial end of the wire.

ILIOFEMORAL SYSTEM INTERROGATION

Although the techniques described previously should facilitate the successful and safe placement of thoracic endografts despite small, diseased, and tortuous iliofemoral access vessels, caution should be exercised in removing a delivery sheath that required such intervention for placement. Because of the large size of the currently available sheaths, they may mask an iliac artery rupture, or the sheath may actually avulse the iliac artery upon removal (Fig 8). For this reason, the prudent surgeon will leave a guidewire well within the aorta during the removal of the delivery sheath. In addition, an aortic occlusion balloon should be in the room, if not already prepared and in the operative field. While removing the sheath, the anesthesia team should be prepared in the case of exsanguinating hemorrhage, and the blood pressure should be watched carefully for the development of sudden hypotension. Once the large sheath is removed, a smaller sheath is placed, and a quick retrograde arteriogram is performed to exclude injury to the iliofemoral vessels. If sudden hypotension occurs or a vascular injury is noted, the aortic occlusion balloon is passed and inflated, thus allowing time to expose and repair the injured vessels.

CONCLUSIONS

Endovascular repair of DTAs is becoming the favored approach of referring physicians and patients. Unfortunately, until industry makes the necessary advances to downsize the delivery systems, many patients may be ineligible for these grafts as a result of small, diseased, or tortuous access vessels. Well-trained endovascular surgeons should have available in their treatment armamentarium several ancillary techniques as described previously. Proper preparation with adequate imaging in conjunction with these techniques should allow the successful and safe endovascular repair of thoracic aortic aneurysms in patients with even the most challenging access anatomy.

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