Conduits and endoconduits, percutaneous access

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Despite technologic improvements in endovascular devices used to treat thoracic aortic diseases and rapidly growing physician familiarity with the use of these devices, access-related complications remain one of the most common sources of morbidity and mortality during thoracic endovascular aortic repair (TEVAR). Standard, remote arterial access through a femoral artery approach is often not possible during TEVAR when these patients have small-caliber or diseased iliofemoral vessels. Various methods have been developed to combat these issues and include the use of open iliac conduits or direct aortic access through retroperitoneal exposures, or more recently, endoconduits that enable treatment of remote disease processes in the thoracic aorta through a femoral approach. One of the goals of this article is to discuss the options available for addressing these access-related limitations of TEVAR—conduits and endoconduits—and provide physicians with descriptions of techniques that can become part of their armamentarium in treating these difficult patients.

The standard approach to the femoral arteries during TEVAR is through open groin exposure. This is largely because TEVAR requires delivery sheath sizes of 18F to 24F. An effort has been made to make these procedures even less invasive and to avoid the complications inherent in surgical exposure of the femoral arteries. As endovascular specialists have become more familiar with percutaneous closure devices routinely used in interventions that use smaller sheaths, the use of a totally percutaneous approach has been adopted by many physicians who perform TEVAR. This article will discuss the "Preclose" technique used in percutaneous endovascular aortic repair and review the current literature related to this approach.

CONDUITS AND ENDOCONDUITS

Besides having an adequate proximal or distal seal zone, one of the major determinants of whether a patient is a candidate for TEVAR is the status of the iliofemoral arterial system. Small-caliber vessels or the presence of occlusive disease often prevents femoral access. This, combined with the need for large-diameter delivery sheaths, makes remote femoral access difficult in a large number of patients who would otherwise be candidates for TEVAR.

Industry-sponsored TEVAR trials and an international survey of physicians performing TEVAR have demonstrated that iliac artery limitations lead to the use of conduits in 9% to 21% of patients undergoing TEVAR.[1-4] In one of the industry-sponsored trials, despite technical success in treating the thoracic aortic aneurysm, vascular complications related to the access occurred in 21% of the patients.[3] These access problems account for a large portion of the morbidity associated with TEVAR. Iliac artery disruption during TEVAR can lead to devastating outcomes; namely, uncontrolled hemorrhage and even death.

Several key access-related issues need to be considered when deciding whether a patient is a candidate for TEVAR. The first starts with predicting which patients could potentially have access limitations. The best way to determine this is with adequate preoperative imaging. Fine-cut computed tomography (CT) scans should be used in all patients being considered for TEVAR. This imaging is not limited to focusing on the thoracic aortic pathology alone, but should include complete imaging through the femoral heads to assess the distal vasculature as well. Most imaging programs contain measurement tools to accurately assess the size of the iliac vessels. Small-caliber vessels, those with a diameter <7 mm, often prevent passage of the delivery sheaths needed for TEVAR. These vessels, especially in younger patients, can be quite elastic, however, and they may be able to accommodate sheaths on the lower end of the diameter spectrum (ie, 18F to 20F).

Tortuosity and prior iliac stenting can also be a limiting factor in TEVAR, but most important is the presence of calcification. Calcification, especially in older patients, often signifies stiff, less elastic vessels that may be more prone to rupture with sheath trauma. Small-caliber vessels with areas of stenosis and calcification require adjunctive techniques for successful completion of TEVAR. This scenario highlights the second preoperative planning key to limiting access-related problems during TEVAR—prevention. Prevention refers to the liberal use of conduits when faced with unfavorable anatomy. The dictum holds true that if you contemplate using a conduit, you should do just that—use a conduit.

The most common of the various types of conduit is the open surgical conduit through a retroperitoneal exposure of the common iliac artery or distal aorta. Some of the key technical points of using iliac arterial conduits in the setting of TEVAR are addressed in a 10-year experience published by Criado.[5] A standard retroperitoneal exposure allows for control of the common iliac artery (Fig 1) or distal aorta. Next, a 10-mm polyester graft is sewn to the artery in an

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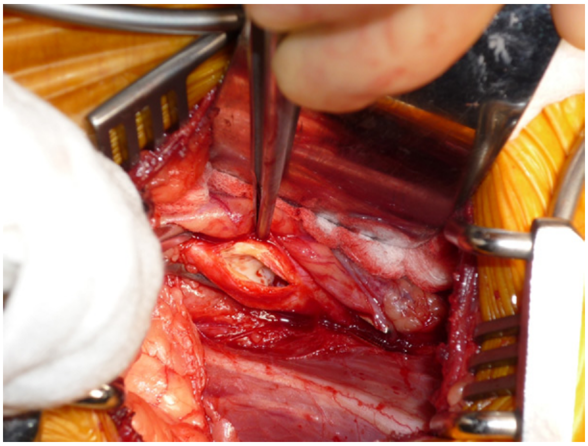

Fig 1. Retroperitoneal exposure demonstrates a longitudinal arteriotomy in the common iliac artery for placement of a conduit.

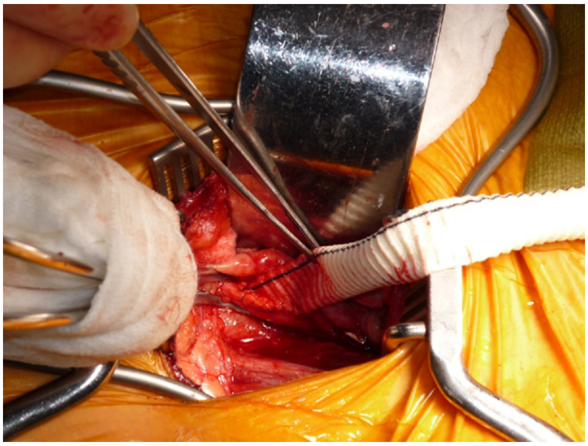

Fig 2. A 10-mm polyester graft has been anastomosed to the common iliac artery in an end-to-side fashion.

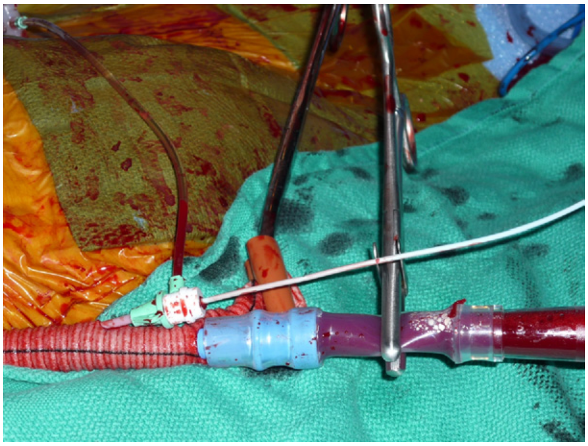

Fig 3. A conduit used during thoracic endovascular aortic repair. Notice that the end of the conduit is controlled with a clamp and that a sidewall puncture permits simultaneous passage of a 5F sheath for diagnostic purposes and a 24F sheath for device delivery.

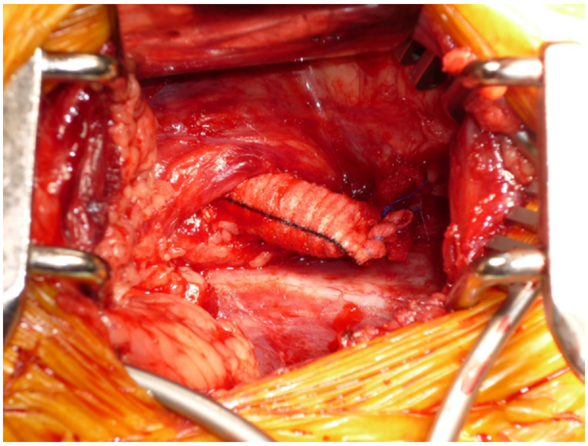

Fig 4. A transected and oversewn conduit cuff; alternatively, the conduit can be used as an iliofemoral bypass graft in the setting of symptomatic iliac occlusive disease.

end-to-side fashion (Fig 2). A 10-mm graft is chosen to facilitate unilateral access because this graft can accommodate both the large delivery sheath needed for TEVAR and a smaller sheath used for a diagnostic angiogram catheter (Fig 3). As seen in Fig 3, the end of the conduit is clamped and the sheaths are inserted through the side of the conduit. This avoids unnecessary blood loss if sheath exchanges are needed and if they are performed through the end of the conduit. The tip of the delivery sheath should be advanced through the newly created anastomosis so that disruption of the anastomosis does not occur with multiple exchanges. A surgical clip can be used to readily identify the anastomosis fluoroscopically. Others have suggested reinforcing the anastomosis with a cuff and using manual stabilization when advancing the sheath through the fresh anastomosis.[6]

Upon completion of the TEVAR, the sheaths are removed and the conduit can be oversewn, leaving a small cuff of graft on the native artery (Fig 4). Alternatively, if the patient has a history of symptomatic iliac occlusive disease, the conduit can be converted into an iliofemoral bypass by performing an anastomosis to the femoral artery. Either way, prosthetic is left behind, raising the concern for potential graft infection.

In an effort to reduce this risk, Carpenter advocated direct iliac or aortic access without the use of prosthetic.[7] This involves an arterial puncture in the middle of a purse-string suture placed directly on the artery. Upon completion, the sheath is removed and the adventitial suture is tied, closing the arteriotomy. Both of these approaches address the iliac artery limitations, but they can also add to the morbidity of TEVAR because they both require retroperitoneal exposures. In fact, Lee et al[8] demonstrated that compared with a femoral approach, this retroperitoneal approach leads to a 2.6-fold greater blood loss, 1.5-day longer length of stay, and an 82% longer procedure time.

Despite this added morbidity, elective conduits and direct aortic access help prevent potentially fatal iliac complications and overcome not only problems associated with diseased vessels but also vessel tortuosity.

Retroperitoneal exposures can be avoided and femoral access is possible using a variety of previously described endovascular techniques. The simplest of these is balloon angioplasty,[9] but retrograde endarterectomy or the sequential passage of dilators of increasing size are also options. Care must be taken to avoid overly aggressive angioplasty because vessel rupture is certainly possible in heavily calcified vessels.

A technique that Dr Matsumura and I first described[10] attempts to address the issue of iliac rupture in a more controlled fashion and involves the use of an endoconduit. A covered stent is deployed across the diseased iliac segment from a femoral approach, either percutaneously or through open femoral exposure. We have used two different devices in an off-label fashion to serve as the endoconduit. The first is a contralateral iliac limb endoprosthesis (W.L. Gore & Associates, Flagstaff, Ariz) designed for use in endovascular abdominal aortic aneurysm repair. This device has a 16-mm proximal end that is deployed in the common iliac artery and a 12-mm distal end that is extended into the proximal common femoral artery or the distal external iliac artery just under the inguinal ligament. Device oversizing and iliac tortuosity can be a problem with this device; in select cases, a commercially available Viabahn covered stent (W.L. Gore & Associates) has been used in favor over the iliac limb endoprosthesis. This device has several advantages, including a lower profile, less oversizing, and more flexibility, but both devices have been used with success.

After deployment, the endoconduit is aggressively balloon-angioplastied, creating a proximal and distal seal, as well as a controlled rupture of the diseased iliac segment (Fig 5). Angioplasty with a 10-mm balloon allows for passage of sheaths up to 22F, and a 12-mm balloon accommodates a 24F sheath (Fig 6). Ideally, the rupture occurs in the midportion of the external iliac artery and is done in a controlled manner, having first obtained a proximal and distal seal. If the narrowest or most diseased portion of the iliac artery is adjacent to a patent hypogastric artery, embolization of the hypogastric artery before deployment of the endoconduit may prevent retrograde hemorrhage analogous to a type II endoleak, but this has not been necessary in our experience.

Other potential downfalls of endoconduits include complications of decreased pelvic perfusion, namely, buttock claudication or paraplegia. Fortunately, we have not seen paraplegia in this setting, and most buttock claudication improves with cilostazol. We have learned from our experience to extend the endoconduit at least down to the inguinal ligament and, possibly, into the proximal common femoral artery. This is to prevent rupture of the intervening segment of artery between the puncture site and the end of the endoconduit. On two occasions, rupture in this segment of artery has required repair with a short interposition graft between the end of the endoconduit and the common femoral artery. Nevertheless, in our growing experience, endoconduits have made TEVAR possible using femoral access with few complications, even in the setting of unfavorable iliac artery anatomy.

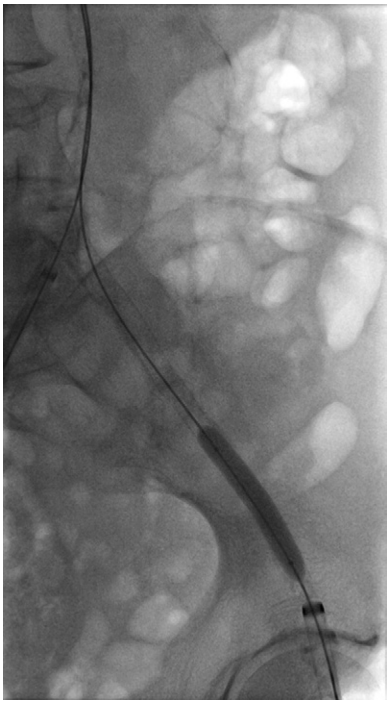

Fig 5. Balloon angioplasty within the endoconduit creates a controlled rupture of the iliac artery.

Fig 6. The endoconduit allows for the passage of a large-diameter delivery sheath.

PERCUTANEOUS ACCESS

Owing in part to the large sheath requirements of TEVAR, standard access has involved open femoral artery exposure when conduits are not used. In an effort to avoid the complications of a groin incision, namely, wound infection, hematoma, lymphocele, and paresthesias, many endovascular specialists have adopted a totally percutaneous approach to TEVAR. Percutaneous TEVAR uses the "Preclose" technique to close common femoral artery puncture sites, which most series have shown is safe and effective.

Successful percutaneous access begins with adequate imaging and patient selection. As mentioned, preoperative CT scans should extend down through the femoral heads. The location of the femoral bifurcation in relation to the femoral heads should be noted, and in the rare instance of a high femoral bifurcation at the level of the inguinal ligament, percutaneous TEVAR should not be attempted. Extensive anterior wall calcification is also considered a contraindication to the percutaneous approach. Although most physicians avoid the percutaneous approach in obese patients, these patients may actually benefit the most from percutaneous TEVAR given the higher likelihood of wound complications in this group. A recently published series of >900 percutaneous approaches during endovascular aortic repair failed to demonstrate a higher failure rate in obese patients.[11]

The most important step in performing percutaneous access safely is ensuring an anterior wall common femoral artery puncture. Ultrasound guidance using an echogenic-tipped micropuncture needle is probably the best way to facilitate common femoral artery puncture. After the micropuncture sheath is placed, a femoral angiogram in an ipsilateral oblique projection with medial deflection of the sheath should be performed in all cases to accurately determine the puncture site. If access is not clearly in the common femoral artery, defined angiographically as the artery distal to the epigastric branch and proximal to the femoral bifurcation, another common femoral puncture should be attempted. An external iliac artery puncture during a percutaneous approach to TEVAR can lead to devastating complications for several reasons. The location of the puncture superior to the femoral head does not allow for adequate hemostasis with manual compression. Also, the knots of the suture-mediated closure device can get hung up on the inguinal ligament without cinching down on the artery, leading to retroperitoneal hemorrhage. If unrecognized, patients can become dramatically unstable secondary to rapid exsanguination. Likewise, punctures of the superficial or deep femoral arteries can be difficult to control with manual compression, and these smaller-caliber vessels are more prone to thrombosis. It cannot be understated that every effort should be made to confirm common femoral artery access before proceeding with percutaneous TEVAR.

The "Preclose" technique has been described using two different suture-mediated closure devices in an off-label fashion: the Prostar XL and the Perclose ProGlide (both from Abbott Vascular, Abbott Park, Ill).[12,13] The techniques are similar. After common femoral artery access is obtained, the closure devices are deployed before upsizing to the large-diameter delivery sheath needed for TEVAR. The sutures are tied down after completion of TEVAR and removal of the delivery sheaths. Suture tying should be performed with a wire remaining in place to allow for insertion of an occlusion balloon should hemostasis not be obtained. If the closure does not seem adequate, closure can be attempted with deployment of another device, or repair can be performed by open femoral artery exposure.

The percutaneous approach to TEVAR has been shown to be safe and effective, with minimal short- and long-term complications. Rates of technical success using percutaneous access in large series have ranged from 93% to 96%.[11,14,15] In the largest series to date, predictors of conversion to open femoral repair are femoral artery calcification and operator experience.[11] Late complications of the percutaneous approach include pseudoaneurysms, thrombosis, and dissection, but these have been seen in <4% of patients.[11,15] Apart from avoiding the complications seen with open femoral artery exposure, advantages of the percutaneous approach include shorter length of stay and time to ambulation.[14,16] Experienced endovascular specialists can safely perform percutaneous TEVAR with a low incidence of early or late access-related complications in many patients.

CONCLUSIONS

Despite advances in endograft delivery system design, unfavorable iliac artery anatomy remains one of the most common difficulties of using TEVAR to treat patients with thoracic aortic problems. Various strategies can be used to overcome these obstacles, each possessing advantages and disadvantages with which endovascular specialists must be familiar. Percutaneous TEVAR can be performed safely and effectively in many patients, and the use of endoconduits can further increase the number of patients who can be treated through femoral artery access. Nevertheless, it is imperative that physicians capable of open vascular surgery techniques be involved in the treatment of these patients undergoing TEVAR.

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