Chapter

Endovascular Aortic Aneurysm Repair in Patients with Aortoiliac Occlusive Disease

Kevin D. Mangum, Arash Fereydooni and Naiem Nassiri

Abstract

Although endovascular aortic aneurysm repair (EVAR) has become an attractive, minimally invasive option for patients with abdominal aortic aneurysms (AAA), significant challenges in arterial access exist in patients with concomitant aortoiliac occlusive disease (AIOD), particularly for more advanced TASC C and D lesions. Under these circumstances, endograft delivery is possible but requires extensive preoperative planning and intraoperative techniques including but not limited to surgical conduit creation, plain balloon angioplasty, endoconduit placement, and subintimal recanalization. Newer generation aortic endografts have also shown promise in accommodating compromised access vessels. Concomitant AIOD and compromised access vessels complicate EVAR and increase operative time and complexity. Therefore, extreme caution, meticulous preoperative planning, familiarity and facility with the various surgical and endovascular options needed to circumvent these obstacles are essential for safe and effective delivery of EVAR in this high-risk subset of patients. The purpose of this chapter is to present standard approaches for access in patients undergoing EVAR; discuss how advanced AIOD precludes routine access; and present various methods to overcome difficult access in patients undergoing EVAR.

Keywords: abdominal aortic aneurysm, endovascular aortic aneurysm repair, aortoiliac occlusive disease, endograft, aorta, iliac artery, femoral artery, access, endoconduit

1. Introduction

Endovascular aortic aneurysm repair (EVAR) has expanded to more than 75% of elective abdominal aortic aneurysm (AAA) repairs due to its lower perioperative complication and high technical success rate [1, 2]. Despite its advantages, however, there are specific limitations that preclude EVAR delivery, making open AAA repair a more suitable option for select patients. In general, patient age and overall health are important considerations in deciding between EVAR versus open repair. Anatomic factors may also limit use of EVAR in select patients, and one of the single most important of these is proximal neck anatomy [3]. Unsuitable, hostile proximal neck features include angulation of ≥60°, neck length ≤ 10 mm, focal bulge in the neck >3 mm, and thrombus involving ≥50% of the aortic diameter—all common EVAR limiting factors [4]. In addition, access related issues due to atherosclerotic occlusive disease remain major barriers to EVAR as up to 36% of patients with AAA

suffer from some degree of aortoiliac occlusive disease (AIOD) [5]. Concomitant AIOD may preclude EVAR in 6–15.4% of patients [6, 7]. The current Trans-Atlantic Inter-Society Consensus (TASC) guidelines consider an aneurysm in combination with a significant iliac artery stenosis or occlusion a TASC D lesion, and open surgical repair is suggested for these patients [8]. However, open repair is still associated with an in-hospital mortality rate of approximately 4%, particularly in this high-risk subset of patients with significant comorbidities that are associated with their peripheral arterial disease [9]. This combination of factors makes patients with AAA and AIOD even higher-risk candidates for open surgery.

Within the subset of patients with AAA and concomitant AIOD, about 15% require adjunctive access-related procedures to facilitate EVAR [10]. Furthermore, previously stented iliofemoral vessels are increasingly encountered and pose significant technical challenges for endovascular access and EVAR limb durability [11]. Overall, access-related complications—such as dissection and rupture—at the time of EVAR approach 10% compared to 15% in patients with concomitant AIOD [12]. Even though there has been a general reduction in device size in recent years compared with older generation aortic endoprostheses, some of the commonly used devices and most branched and fenestrated repair endovascular systems continue to require larger-diameter sheaths and delivery conduits. There are currently no clinical guidelines delineating the optimal therapy in patients with AAA and concomitant AIOD. Thus, familiarity with various techniques that can overcome compromised access vessels is essential for the modern-day vascular surgeon. These techniques have been developed to circumvent previously prohibitive anatomy and are discussed in this chapter. The emphasis herein will be on less invasive endovascular means of facilitating access in patients with compromised aortoiliac anatomy in the setting of AAA.

2. Access

2.1 Surgical access

The common femoral artery (CFA) is the most commonly accessed site for EVAR and has traditionally been approached via surgical cutdown. Typically, an incision is made parallel to and approximately two-finger breadths inferior to the inguinal ligament at the midway point between the anterior superior iliac spine and the pubic symphysis overlying the femoral pulse if palpable [13]. The superficial femoral fascia (contiguous with Scarpa's fascia) is divided obliquely, while the deep femoral fascia is divided parallel to femoral artery.

In cases of severely diseased or occluded CFAs, focal endarterectomy with patch angioplasty may be necessary prior to or immediately after EVAR to avoid limb-threatening ischemia and to facilitate EVAR delivery. Longitudinal skin incisions extending inferiorly from the inguinal ligament distally to the femoral bifurcation are preferred under these circumstances to facilitate adequate endarterectomy with profundaplasty if necessary. The proximal superficial femoral artery (SFA)—if patent and relatively disease-free—might be another option for access in cases of compromised CFAs or hostile groins. In such cases, the SFA is accessed via direct surgical cutdown along the medial border of the sartorius muscle [14].

2.2 Percutaneous access

Percutaneous access for EVAR was initially described in 1999, when the Prostar XL device (Abbot Vascular, Abbott Park, IL) was used for suture-mediated closure

of femoral arteries [15]. The device is indicated for closure of vessels after percutaneous access of up to 10 Fr. If required, multiple devices can be used for larger caliber access closure [16].

The more popular Perclose ProGlide device (Abbot Vascular, Abbott Park, IL) is indicated for femoral access closure of up to 8 Fr for each closure device. It differs from the Prostar XL device in that it uses a single monofilament polypropylene suture instead of two braided polyester sutures. Multiple Perclose devices can be used to achieve closure for larger caliber arteriotomies up to 24 Fr inner diameter. This is achieved by deploying Perclose devices 45° clockwise and counterclockwise relative to the initially deployed device at the 12 o'clock position [17]. If needed, additional Perclose devices can be deployed for adequate hemostasis as long as wire access is maintained throughout the serial deployment process.

A recent meta-analysis of outcomes of percutaneous EVAR showed a technical success rate (defined as freedom from additional perioperative procedures) of 93%. There was an increased risk of conversion to cutdown when using sheaths ≥20 Fr [18]. Notably, both severe or anterior common femoral calcification and small access vessel diameter (<5 mm) have been associated with failed percutaneous access [18, 19]. In our own experience, we have found extreme iliac vessel tortuosity to be another predictor of unsuccessful percutaneous EVAR, given difficulty in closure device tracking and proper deployment of the footplate. To date, there has been no appropriately powered prospective, randomized study comparing percutaneous suture-mediated closure devices to open cutdown in EVAR. For now, a higher threshold for a total percutaneous approach and a readily available conversion mechanism to open surgical cutdown is advisable, particularly if one or more anatomically limiting factors are present.

3. Challenging access

3.1 Predicting access difficulty

In order to prevent inadvertent arterial injury and to avoid emergent measures, evaluation of the caliber and disease burden of all access vessels should be performed preoperatively based on adequate contrast-enhanced imaging. While computed tomography angiography (CTA) remains the preoperative imaging modality of choice, compromised access vessels may require catheter-directed angiography for pre-operative evaluation and/or treatment of access-related disease in anticipation of EVAR and for more appropriate device selection. The latter should be, in part, based on access vessel considerations such as patency, diameter, tortuosity, and severity of calcification. This is particularly important in older patients who have calcified, minimally elastic vessels and cannot tolerate excessive oversizing or stretching of the access vessels [20]. The minimum access vessel diameter requirement varies considerably based on the EVAR device manufacturer and the instructions for use (IFUs) for each particular device. A list of some of the commonly used endografts and their required iliac artery diameter has been provided in **Table 1**.

3.2 Conduit selection

Choice of conduit for EVAR delivery in the setting of AIOD is based on individual anatomy and disease severity. In general, TASC A and B disease may be amenable to simple balloon angioplasty of stenotic iliac arteries, after which the aortic endograft and/or required delivery sheath can be advanced. We caution against repeat balloon angioplasty and the use of oversized balloons due to associated life-threatening rupture that may result. In situations where simple angioplasty

Stent-graft	Graft diameter (mm)	Introducer sheath (F)	Access (outer) diameter (mm)
Abdominal aortic endograft			
Zenith Flex (Cook)	22–26	18	7.1
	28–32	20	7.7
	36	22	8.5
Excluder (Gore)	23–28	18	7.0
	31	20	7.6
Endurant II (Medtronic)	23–28	18*	7
	32–36	20*	7.6
AFX (Endologix)	22–28	17	6.5
Ovation (Endologix)	20–29	14	4.5
	34	15	4.5
Nellix (Endologix)	18–28	17	7
Thoracic aortic endograft			
Zenith Alpha (Cook)	24–30	16	6
	32–38	18	7.1
	40–44	20	7.7
TAG/C-TAG (Gore)	21	18	6.7
	26–28	20	7.5
	31–34	22	8.2
	37–45	24	8.8
Relay plus (Bolton)	22–32	22–23	8.3–8.7
	32–34	23–24	8.7–9.2
	36–40	24–25	9.2–9.3
	42	25	9.3
	44	25–26	9.3–9.5
	46	26	9.5
Valiant (Medtronic)	22–32	22*	8.3
	34–40	24*	9.2
	42–46	25*	9.3

Table 1.
*List of current abdominal and thoracic aortic endografts and their size specifications. *Represents outer diameter (OD) measurement (not sheath size) for Medtronic devices.*

does not seem to accommodate EVAR delivery, we recommend prophylactic covered stent placement prior to more aggressive angioplasty and the disruption of native vessel plaque. This technique provides a control mechanism if rupture occurs during angioplasty. For angioplasty alone, balloon diameter should not exceed the native vessel adventitia-to-adventitia diameter. Meticulous maintenance of guide wire access as well as immediately available balloon occlusion catheters and appropriately sized covered stents are strongly recommended at the time of angioplasty.

More advanced TASC C & D lesions often require a more comprehensive planning for safe and effective EVAR delivery. While open aortic surgery remains

a consideration in these patients, high risk candidates warrant consideration for creative and less invasive endovascular approaches [21].

3.3 Surgical conduits

Open surgical conduits provide the advantage of larger conduits for device delivery and surgically exposed access for repair of any inadvertent arterial injury. Most surgical conduits are created at the distal common or proximal external iliac artery (EIA) using a lower retroperitoneal incision. The ideal strategy depends on the status of the iliac arteries (e.g., calcification and patency of internal iliac arteries) and the surgical risk for each individual patient. Most patients can tolerate a retroperitoneal exposure. However, this is a less ideal option in patients with hostile anatomy, prior surgery or radiation, retroperitoneal fibrosis, or in those with extensive comorbidities [20]. Standard surgical precautions should be taken to avoid ureteral injury and sympathetic plexus injury on the left side in men. Despite their advantages, however, surgical conduits should be used judiciously, given their reported association with longer operative times, hernias, prosthetic remnant infection, and prolonged recovery [22].

Although the common iliac artery (CIA) can be directly accessed with a sheath, a conduit often simplifies the procedure and provides increased availability of the iliac landing zone for EVAR. In creating the conduit, first the iliac arteries are controlled, and then a longitudinal arteriotomy is made anteriorly extending from the distal common to the external iliac artery [20]. A 10-mm Dacron graft is spatulated and anastomosed end-to-side to the native vessel. Of note, Fogarty occlusion balloon is a useful adjunct for vessel control in cases where severe calcification of the iliac arteries precludes safe and adequate surgical clamping [20].

A stab incision can be performed in the lower abdominal wall to exteriorize the conduit [23]. If there is severe external iliac occlusive disease, the conduit can be tunneled under the inguinal ligament to a counter incision in the groin to be converted to an iliofemoral bypass at the completion of the case [14]. This maneuver is also suitable for cases with planned repeat interventions in the future. Access is established via direct graft puncture after clamping and stabilizing the externalized distal end of the graft. Upon completion of the procedure, the conduit can be ligated and oversewn near the anastomosis leaving a short stump.

In cases with anticipated prolonged lower extremity ischemia time and patients with severe aortoiliac and profunda femoral disease, a temporary femoral artery conduit can be used to minimize lower extremity ischemia—reperfusion. A 10-mm femoral conduit is anastomosed end-to-side to the CFA using a standard oblique or longitudinal groin incision. The conduit allows periodic withdrawal of occlusive sheaths with restoration of flow while maintaining guide-wire access [20].

In cases with planned staged interventions for extensive thoracoabdominal repairs, permanent iliofemoral conduits are better options to avoid redo retroperitoneal exposure. Depending on patient anatomy and the extent of iliofemoral disease, there are several possible configurations. Iliofemoral bypass can be created from the distal CIA or proximal EIA to the proximal CFA, with access established into the graft after flow is restored to lower extremity [20].

Although direct iliac exposure might allow for better control of iliac injury, it is not without complications. In a study of 15,082 patients who underwent infrarenal EVAR from 2005 to 2012, 147 (1%) required iliac conduit or direct iliac access and had a higher rate of long-term mortality. [24] Compared to standard bilateral femoral exposure, surgical conduits also have a 1.8-fold increase in perioperative complications and a 1.5-day increase in length of hospital stay, but have no statistically significant difference in early mortality [25]. Furthermore, compared to

percutaneous access, iliac exposure is associated with increased overall morbidity, operative time, intraoperative transfusion, and length of stay [14].

3.4 Alternative adjunctive techniques

Yano et al. reported that 50 of 390 patients (12%) undergoing EVAR required adjunctive maneuvers for endograft delivery [10]. Several adjunctive maneuvers have been proposed for patients with compromised and/or tortuous iliac arteries to facilitate EVAR [26]. Infrainguinal mobilization and "pull-down" of redundant external iliac arteries as well as lower abdominal manual compression during device advancement have been reported [20]. Alternatively, snared brachial-femoral wire access allows for a "body-floss" effect to stabilize the advancement of the delivery system through acutely angulated, redundant iliac arteries [27, 28]. For the brachial-femoral technique, it is useful to have an extended shaft brachial sheath to prevent the wire from transecting the subclavian-aortic junction or other angulated arterial segments [22].

Serial dilatation of the iliac artery with rigid dilators can be attempted, but application of excessive force should be avoided. Using this approach, an endovascular dilator set (Cook Medical, Bloomington, Indiana) consisting of dilators ranging from 14 to 26 Fr may be used to gradually dilate narrow, diseased iliac arteries [29]. Alternatively, a Solopath (Terumo, Somerset, NJ) balloon-expandable sheath can also be used in select cases where tortuosity and plaque is the main limiting factor [20]. The malleable design and hydrophilic coating of the sheath enable smooth tracking through narrowed vessels while the expandable balloon dilates stenosis [30].

3.5 Endoconduits

Increased morbidity with surgical conduits has led to the development of endovascular measures that facilitate EVAR in the setting of compromised access vessels [31]. Stents or stent-grafts are used to dilate atretic iliac arteries, correct any underlying occlusive disease, and/or over-dilate the artery beyond its baseline-limited caliber. First described in a series of five patients in 2001, this technique involved sewing a 6-mm expanded polytetrafluoroethylene graft to a stent and backloading the device into a 6F sheath [10]. The stent portion of the device was deployed across the internal iliac artery (IIA) and the prosthetic portion across the external iliac artery. The prosthetic portion was exteriorized through the femoral artery, and a noncompliant balloon was used to dilate the external iliac artery from within the graft.

Later in 2007, the "pave and crack" technique was introduced. Common and external iliac arteries were lined with 10-mm balloon expandable or self-expanding stents, and the stents were then dilated to 9–12 mm to create a controlled rupture [32]. In a similar technique, a 12-mm Excluder contralateral iliac limb (Gore, Flagstaff, AZ) was deployed from the common iliac extending into the proximal common femoral artery [33]. For this technique, it has been recommended to dilate the endoconduit to approximately 2 mm larger than the outer diameter of the intended endoprosthesis to allow for successful device delivery.

When planned and performed properly, endovascular conduits can be less invasive and have shorter procedural and recovery times compared to surgical conduits. Risks—such as stent dislodgement, coverage of internal iliac artery, and rupture—can be largely avoided with a measured, planned approach; appropriate device selection based on anatomic considerations; as well as familiarity with the nuances of the chosen EVAR device, its specific IFUs, and delivery apparatus. At times, a staged approach to endoconduit delivery—comprised of iliofemoral revascularization using covered stents with or without concomitant femoral endarterectomy followed by EVAR at a later date—may be necessary. The staged approach allows for stent incorporation,

minimizing the risk of stent dislodgement, and development of collateral network in cases of intentional branch vessel occlusion. Furthermore, bifurcated unibody endografts or aorto-uni-iliac stent grafts may be chosen to overcome certain anatomic configurations; the former is particularly useful in the setting of a diseased, narrow distal aortic domain and may be the best option for avoidance of iliac limb occlusion.

Our covered stent of choice for endoconduit creation is the Viabahn stent-graft (Gore, Flagstaff, AZ). This technique was first described in 2009 using a 13 mm × 10 cm Viabahn dilated to 12 mm and an 8 mm × 5 cm Viabahn dilated to 8 mm [34, 35]. If the common iliac artery is larger than 13 mm, a tapered 16–12 mm Excluder iliac limb (Gore, Flagstaff, AZ) can be used [20]. More recently, the Gore VBX balloon-expandable covered stent system has been introduced [36]. The L configuration of this stent graft allows for post-dilation of up to 16-mm diameter. It has become our stent graft of choice for more aggressive post-dilation of compromised iliac arteries. In general, balloon expandable covered stents are used proximally in less mobile ostial locations, while flexible self-expanding covered stents are better choices distally in the external iliac arteries and more tortuous vessels due to their greater flexibility (**Figures 1** and **2**).

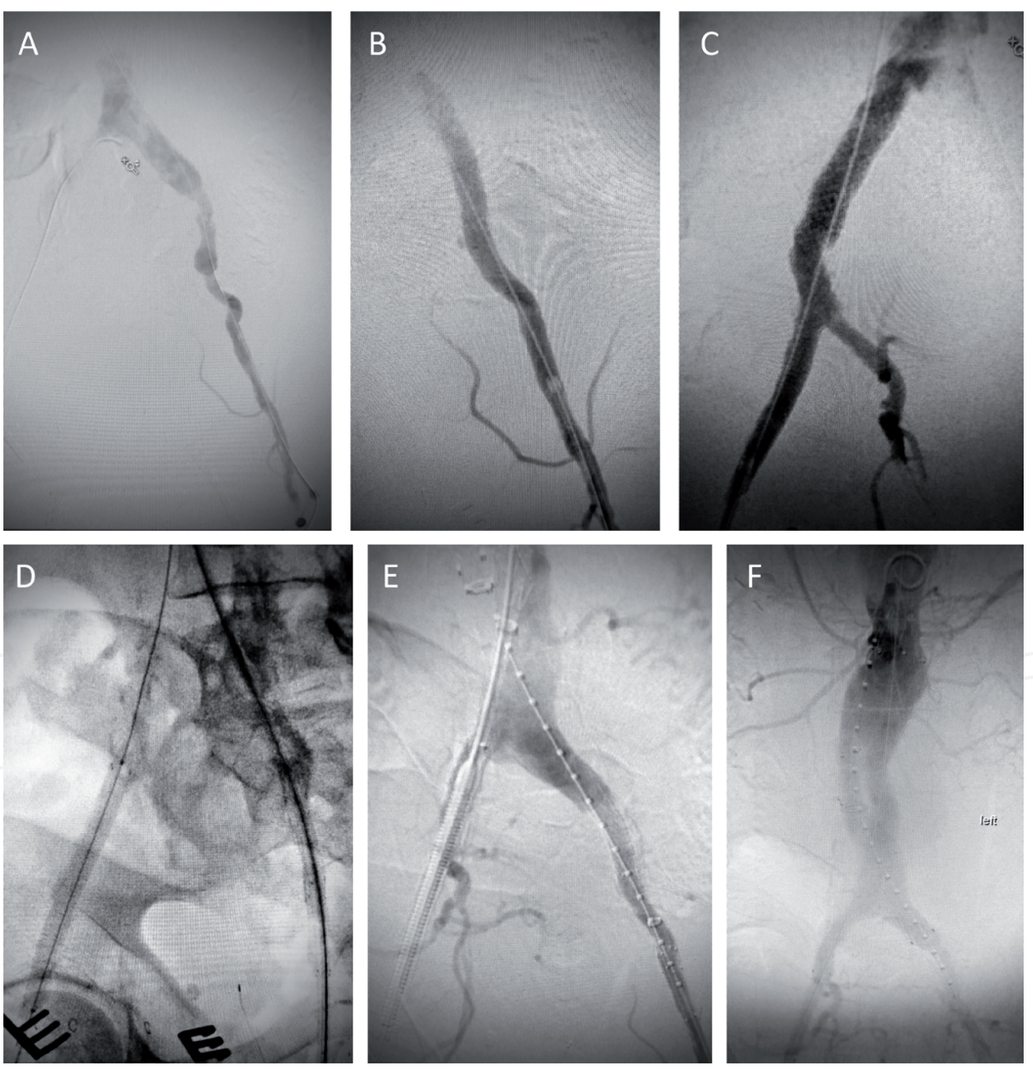

Figure 1.
(A) Diffusely diseased bilateral common and external iliac arteries precluding device advancement. (B, C) Endoconduits were created bilaterally with proximal VBX balloon expandable covered stents (Gore, Flagstaff, AZ), followed distally by self-expanding Viabahns (Gore, Flagstaff, AZ) extending into the proximal CFAs bilaterally. (C) Note the preserved patency of the right IIA. Post deployment angioplasty was performed with oversized balloons to facilitate easy (D) advancement and (E) deployment of an Endurant II aortic endograft (Medtronic, Minneapolis, Minnesota) and associated iliac limbs. (F) Completion angiogram demonstrated complete exclusion of the aneurysm sac without endoleak and unimpeded flow through the newly revascularized bilateral iliac arteries.

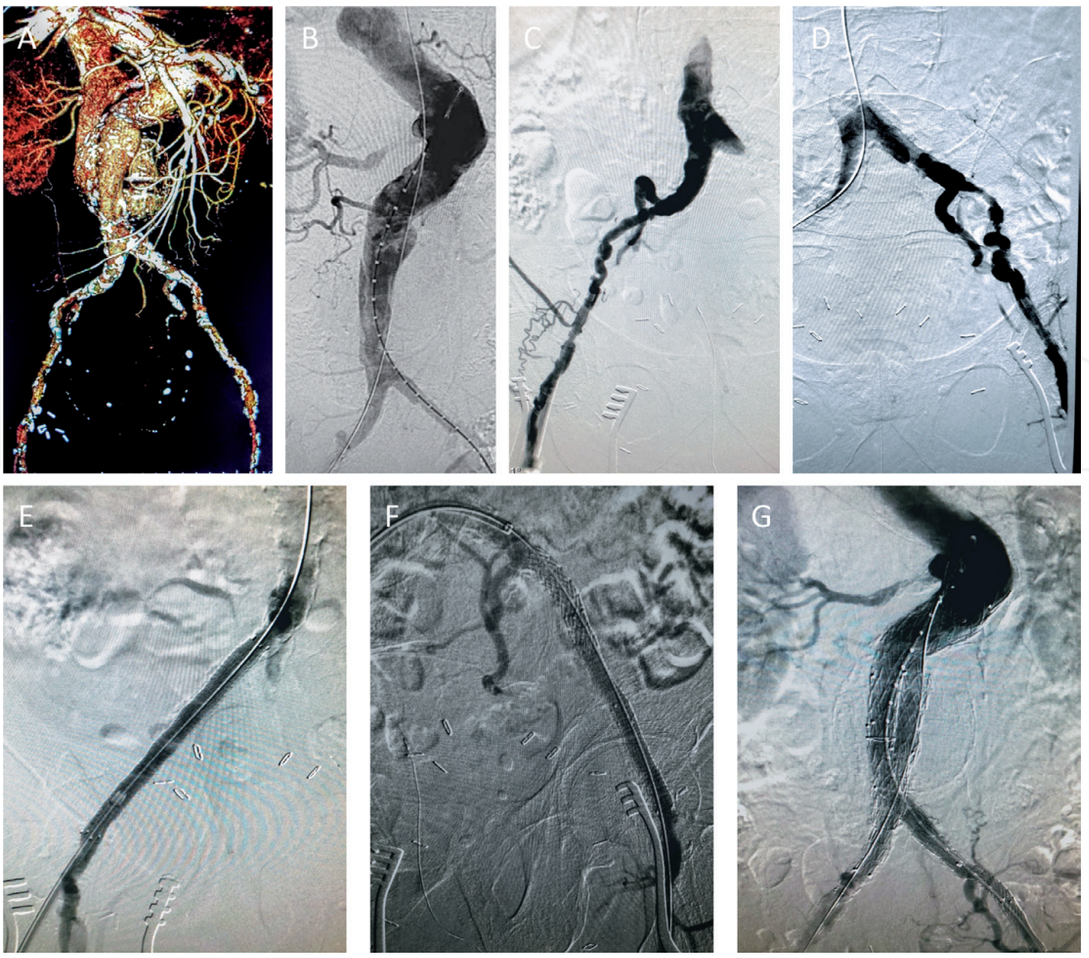

Figure 2.
(A) Three-dimensional reconstruction of the pre-operative CTA showing a juxtarenal abdominal aortic aneurysm with severe calcified stenosis of the bilateral common and external iliac arteries and occluded distal bilateral internal iliac arteries. (B) Flush abdominal aortography with bilateral iliofemoral runoff delineates shape and configuration of the aneurysm and confirms (C, D) the bilateral iliac disease burden. (E, F) Endoconduits were created using VBX balloon-expandable and Viabahn self-expanding covered stents (Gore, Flagstaff, AZ) bilaterally. The former are placed in the more proximal aspects of the diseased iliac arteries, while the latter are placed in the more mobile distal aspects of the iliac arteries to better accommodate hip flexion. Post-deployment angioplasty is an essential maneuver to ensure adequate endoconduit lumen diameter for advancing the device and to minimize risk of stent dislodgement during endograft delivery (G). Completion angiogram demonstrated complete exclusion of the AAA and a widely patent aortic endograft, CIAs, EIAs and left IIA without endoleak or kinks.

For advanced occlusive iliac lesions, covered stents are preferred over bare metal stents (BMS). The seminal COBEST study demonstrated that covered and BMS produced similar results for TASC B lesions; while for TASC C and D disease, covered stents had better long-term patency rates and lower reintervention rates [37]. Other advantages of covered stents over BMS include minimized in-stent neointimal hyperplasia and decreased risk of arterial perforation [38].

3.6 Angioplasty

Plain balloon angioplasty is favored as first-line strategy for low TASC-grade stenotic disease. We generally use 7–8-mm ultra-noncompliant balloons for passage of sheaths up to 18 Fr; 10-mm balloons for sheaths up to 22 Fr; and 12-mm balloons for 24 Fr sheaths.

When delivering devices that are not preloaded in sheaths, passage of the sheath dilator alone as the next step after ultra-noncompliant angioplasty of iliac occlusive disease is recommended [14]. The diameter of the dilator should be equal to or greater than the diameter of the anticipated endograft delivery mechanism.

Following this initial dilator passage step, the sheath and dilator are advanced together into the distal aorta. If the sheath meets obstruction, it is left in place, the dilator is removed, and the endograft is advanced "bareback" for the remaining length. Overdilating uncovered diseased or normal vessels to overcome a basic size mismatch is strongly discouraged due to risk of rupture. In such situations, endoconduits are better options, as they permit adequate angioplasty without risking iliac artery rupture in an uncontrolled fashion [10, 39]. When adequate distal and proximal seal is achieved via endoconduit creation, more aggressive angioplasty can be performed with lower risk for catastrophic hemorrhage [33].

3.7 Intraluminal or subintimal recanalization

Historically, in cases of severely diseased or occluded unilateral iliac arteries, aorto-uni-iliac stent-graft deployment with femoral-femoral bypass is performed [40, 41]. However, randomized trials have demonstrated approximately 20% lower long-term patency for femoral-femoral bypass compared to endovascular reconstruction in cases of unilateral iliac occlusive disease [42]. For EVAR, the aorto-uni-iliac configuration is also associated with inferior early and midterm outcomes as well as increased risk of graft infection [43, 44]. Therefore, in appropriately selected elective cases, intraluminal or subintimal recanalization from either brachial or femoral approach can be considered as alternative means of facilitating bifurcated EVAR device delivery [21]. Of note, successful subintimal recanalization has been described to facilitate bifurcated endograft placement in the presence of bilateral common iliac occlusive disease, making it an appropriate EVAR delivery method in select patients [14].

3.8 New generation of aortic endografts

The newest generation of ultra-low profile endografts allows for the treatment of AAAs in patients who were previously not candidates because of diseased and/or small access vessels. The Ovation Prime (Endologix, Irvine, California) stent graft system is delivered through a 14-Fr sheath. In the Ovation international pivotal trial, 40% of patients treated had access vessels smaller than 6 mm—the smallest access vessel was 4.7 mm in diameter—with a reported technical success rate of 100%; [45, 46]. Other low-profile devices currently in development or with limited approved use in the United States are the Incraft (Cordis Corp., Bridgewater, NJ) 13–15 Fr delivery system and the Zenith Low Profile (Cook Medical, Bloomington, IN) 16-Fr delivery system [47].

The AFX bifurcated unibody aortic endograft (Endologix, Irvine, California)—FDA-approved for EVAR—has also been successful in treating TASC D AIOD lesions with primary and assisted primary patency rates of 91 and 97% at 1 year, respectively (**Figure 3**) [48]. Unlike traditional modular bifurcated aortic endografts with fixation points at the infrarenal proximal aortic neck, the AFX is fixed at the aortic bifurcation [49]. Furthermore, it is delivered through a 17-Fr ipsilateral and a 9-Fr contralateral sheath facilitating advancement and deployment in heavily calcified, small-caliber iliac arteries [49]. In a recent study, the AFX unibody stent was successfully used in the treatment of TASC C/D lesions in patients with concomitant AAA [50]. At 1-year follow-up, no adverse events were reported; however, two patients required stenting of their EIAs due to worsening disease [50].

The Nellix Endovascular sealing system (Endologix, Irvine, California) is an investigational device that has a femoral access diameter requirement of at least 7-mm and involves injecting a biostable polyethylene glycol polymer into "endobags," which allow exclusion of the aneurysm and prevention of type 2 endoleaks

[51]. It has been successfully used in unilateral and bilateral common iliac artery occlusive disease ranging from 70% stenosis to complete occlusion [52]. In a study of Nellix system in five patients who had some degree of AIOD, occluded arteries were pretreated with balloon-expandable covered stents to create a patent conduit to accommodate the Nellix endograft. The aortic endograft was deployed successfully in 100% of cases without any endoleak at 9 months follow-up. Notably, this system has also been described in one case of infrarenal aortic stenosis, indicating that it has wider applicability in various degrees of AIOD [53, 54].

3.9 Common complications and management

The overall perioperative and long-term complication rates in patients with difficult EVAR access vessels have been reported to be 12 and 6%, respectively. Most commonly reported complication rates in the literature include 2.6–3.6% iliac rupture rates, 6% arterial dissections, 1.6–4% lower extremity ischemia, and 14% access site hematomas [10, 28, 41].

Iliac rupture from access is the leading cause of procedure-related mortality. If the guide wire is still in place, artery ruptures are better managed with endovascular placement of covered stents and usually do not require conversion to an open procedure. If a covered stent is not immediately available, an occlusive balloon catheter can be inserted and insufflated proximal to the rupture to achieve relative hemostasis without further damage at the rupture site until a stent graft or more definitive means of repair is delivered. In deploying covered stents for treatment of inadvertent arterial rupture, it is important to achieve long proximal and distal seal zones as the damage to the vessel is often more extensive than suggested by angiography [14]. A 10-cm self-expanding covered stent provides adequate proximal and distal seal in most cases. Iliac arteries less than 5-mm in diameter are considered to

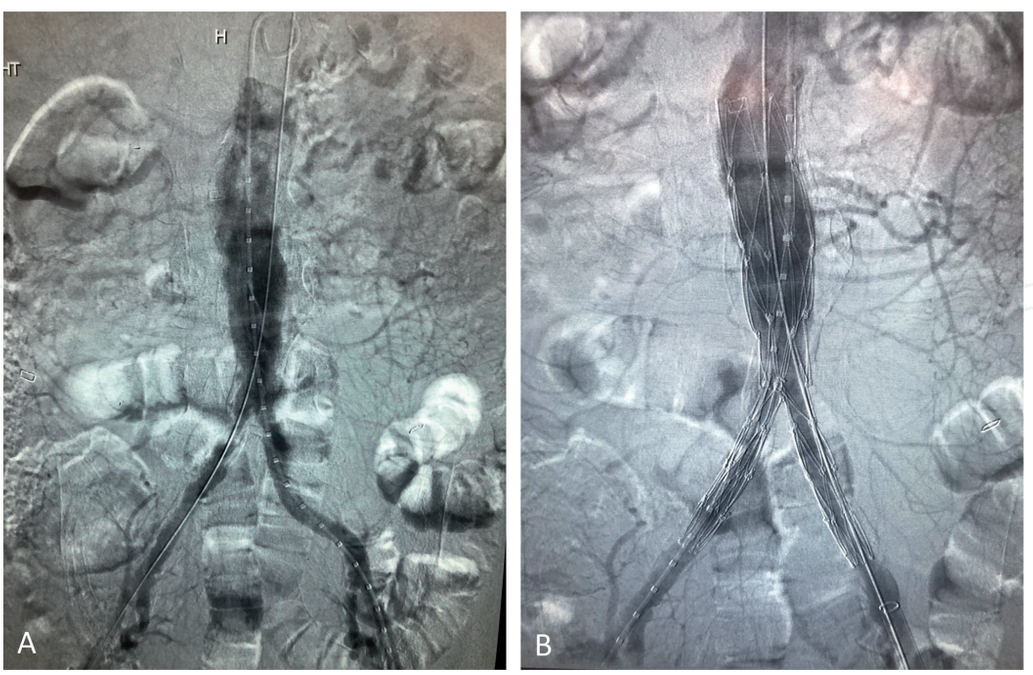

Figure 3.
(A) Intraoperative angiogram showing an infrarenal abdominal aortic aneurysm with concomitant severely symptomatic, nearly occlusive right proximal common iliac artery and high-grade stenosis of the proximal to mid-left common iliac artery. Note the diffusely diseased, narrow external iliac arteries along with a narrow distal aortic domain—all of which render deployment of a modular bifurcated device challenging and prone to complications including inadequate opening of the contralateral gate and iliac limb occlusions. (B) An AFX bifurcated unibody endograft (Endologix, Irvine, California) is preferred under these circumstances to treat both the AAA and the AIOD. Completion angiogram demonstrating complete exclusion of the AAA and a widely patent aortic endograft, CIAs, and EIAs without endoleak or kinks.

be more prone to rupture; therefore, prophylactic adjunctive procedures should be considered in these patients [41]. Almost all open iliac repairs are associated with postoperative morbidity [55].

The most feared complication is "iliac-artery-on-a-stick" or avulsion of the external iliac artery due to passage of a sheath in the setting of size mismatch. In most cases, the damage occurs initially with introduction of the sheath, but does not become obvious until the sheath is removed. This complication can be suspected when a large sheath suddenly advances easily after initial difficulty and can be avoided by proceeding with prophylactic endoconduit creation. If iliac avulsion is confirmed, an occlusion balloon may be left in place during sheath removal for immediate control. Conversion to open iliac artery exposure and endovascular reconstruction are both practical options. Proximally, the covered stent is bridged with stents to the aortic endograft. Hemorrhage from the internal iliac artery can be controlled with embolization or intentional ostial coverage. If adequate repair of rupture requires distal extension of the stent-graft well into the CFA, surgical modification and incorporation of the covered stent in to the common femoral artery is recommended.

In patients undergoing branched or fenestrated aortic endovascular repairs (FB-EVAR), hostile iliac anatomy due to calcification, stenosis, or tortuosity does not significantly affect the early outcome of FB-EVAR in terms of technical success and 30-day mortality. However, procedures performed in patients with such characteristics are technically more demanding and the adverse iliac anatomy is associated with reduced 3-year survival [56].

4. Conclusions

Patients with coexisting aortic aneurysms and aortoiliac occlusive disease represent a challenging subset at risk for higher perioperative and long-term complications rates following EVAR. Nevertheless, advancing endovascular stent graft technology and increased surgeon familiarity with prophylactic and bail-out techniques have increasingly facilitated EVAR in patients traditionally deemed unsuitable candidates given their compromised access vessels and iliac landing zones. Preoperative planning is essential for successful delivery of these multifaceted techniques that require a wide range of adjunctive equipment and preparatory maneuvers to prevent life-threatening complications. Next generation aortic stent grafts may forego the need for these adjunctive modalities via lower profile delivery means.

Conflict of interest

Nassiri: Consultant and Speakers' Bureau, W.L. Gore, INC.

Abbreviations

AAA	abdominal aortic aneurysm
AIOD	aortoiliac occlusive disease
BMS	bare metal stent
CFA	common femoral artery
CIA	common iliac artery
CTA	computed tomography angiography
EIA	external iliac artery
EVAR	endovascular aortic aneurysm repair

FB-EVAR	fenestrated-branched endovascular aortic aneurysm repair
Fr	French
IFU	instructions for use
IIA	internal iliac artery
SFA	superficial femoral artery
TASC	transatlantic inter-society consensus

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