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Strategies for managing aortoiliac occlusions: access, treatment and outcomes

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Abstract

Treatment of severe aortoiliac disease has dramatically evolved from a dependence on open aortobifemoral grafting to hybrid and endovascular only approaches. Open surgery has been the gold standard treatment of severe aortoiliac disease with excellent patency rates, but with increased length of stay and major complications. In contrast, endovascular interventions can successfully treat almost any lesion with decreased risk, compared to open surgery. Although primary patency rates remain inferior, secondary endovascular interventions are often minor procedures resulting in comparable long-term outcomes. The risks of renal insufficiency, embolization and access complications are not insignificant; however, most can be prevented or managed without significant clinical consequence. Endovascular therapies should be considered a first-line treatment option for all patients with aortoiliac disease, especially those with high-risk cardiovascular comorbidities.

Keywords

access; aortic occlusion; aortoiliac occlusion; atherosclerosis; endovascular; iliac occlusion; iliac stenosis; stent

Aortoiliac occlusion is an advanced and late manifestation of atherosclerotic vascular disease. Patients with this complicated and frequently multi-level disease can present with debilitating symptoms ranging from life-limiting claudication to limb-threatening ischemia. The goal of treatment involves re-establishment of inflow to the lower extremities and pelvis; however, the therapeutic options to achieve this end are evolving. The most recent Trans-Atlantic Inter-Society Consensus (TASC) II guidelines focus primarily on lesion morphology, defining aortoiliac occlusions as TASC B or higher lesions. Currently these guidelines emphasize open surgical reconstruction [1], with the gold standard of

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aortobifemoral bypass grafting (ABF), for treatment of TASC C and D lesions involving longer and multi-segment stenoses and occlusions. These guidelines, however, do not adequately account for the advanced patient co-morbidities that often accompany these complex lesions. The operative morbidity and mortality [2–4] of this major abdominal operation in high-risk patients is not insignificant [5], resulting in increasing interest and use of less-invasive approaches to achieve a similar therapeutic endpoint [6].

With increasing surgeon experience and comfort in endovascular treatment of aortoiliac disease combined with advances in devices and imaging, this less-invasive approach has continued to expand to more complicated lesions [7,8]. For experienced endovascular surgeons, the large majority of lesions can be successfully treated with endovascular alone or hybrid approaches, resulting in decreased length of hospital stay and major complications with comparable patency [7–10]. Ultimately, treatment decisions require a detailed understanding of the surgical and endovascular options in the context of the individual patient's underlying disease and associated comorbidities, not just the lesion classification. Treatment decisions will ultimately vary among surgeons based on their own comfort, experience and availability of advanced endovascular equipment and techniques. This review will highlight current treatment approaches with a comparison of their outcomes and discussion of strategies to avoid complications and improve outcomes.

Patient evaluation & diagnosis

Severe aortoiliac stenosis or occlusion is most often a chronic disease resulting from progressive atherosclerotic and thrombotic accumulation. While acute occlusions of the native aortoiliac system can occur, it is uncommon and a very different disease process associated with high morbidity and mortality [11,12]. The management of these often critically ill patients is separate from the chronic setting and will not be addressed in further detail in this review. Chronic occlusions, however, progressively impair direct inflow to the pelvis and lower extremities. The chronicity of this process leads to the development of extensive collateral networks involving systemic–systemic pathways via the lumbar, intercostal, epigastric and circumflex iliac vessels, as well as visceral–systemic pathways through branches of the celiac, superior and inferior mesenteric arteries [13]. The presence of these collaterals allows many patients to present with significantly less severe symptoms than what one might expect from such an advanced disease process.

Indications for intervention include life-limiting claudication, rest pain and tissue loss. Less commonly, patients may be treated following atheroembolism from aortic or iliac lesion, most often presenting with acute limb ischemia or ‘blue toe syndrome’. Approximately 45–65% of patients present with claudication of the buttocks, thighs and calves [5,7,14,15]. The classic triad of claudication of the buttock and thighs, absent femoral pulses and impotence described by Leriche [16,17] is noted in as many as 73% of men [2]. More severe symptoms of critical limb ischemia with rest pain or tissue loss are somewhat less common due to collaterals; however, when present, they often suggest extensive iliac and infrainguinal vessel involvement. Acute worsening or onset of symptoms can develop following thrombosis of chronically diseased vessels or an embolic event.

All patients presenting with symptoms related to aortoiliac disease should undergo a thorough history and physical exam. A careful surgical history should be taken, especially with regards to any prior abdominal, retroperitoneal or vascular intervention. A detailed discussion of cardiovascular and pulmonary comorbidities should be performed, and if necessary, trigger further evaluation prior to intervention. As many as 90% of these patients have a smoking history [7], and almost 60% are still smoking at the time of presentation [10,14,18]. The high rate of hypertension (65–87%), coronary artery disease (30–60%), chronic obstructive pulmonary disease (13–20%) and chronic renal insufficiency (4–13%) in these patients is, therefore, not surprising [5,7,15,18,19]. Evaluation of functional status can be difficult, as ambulation is often limited by claudication and rest pain from their aortoiliac disease. It is, therefore, our practice to refer these patients with coronary artery disease risk factors for cardiologic assessment, and further assessment of pulmonary and renal function may also be appropriate. Younger patients (<50 years old) with lower limb ischemia requiring intervention have been found to have an increased incidence of hypercoagulable states [20]. This is consistent with our experience with severe aortoiliac disease and we, therefore, recommend considering an evaluation for a hypercoagulable state in these younger patients.

A complete physical exam should be performed on all patients. Carotid arteries and the abdomen should be auscultated for bruits. Close attention should be paid to upper extremity pulse intensity and timing to evaluate for any potential upper extremity disease that may impact endovascular access or extra-anatomic surgical reconstruction. A delayed pulse compared to the contralateral extremity may indicate subclavian steal physiology, while a weak or dampened pulse may suggest a more proximal stenosis. These signs should trigger further evaluation with upper extremity PVRs and/or inclusion of the aortic arch in axial imaging, as they may impact procedural options. These patients with severe aortoiliac disease have absent or weak femoral pulses. Given the risk of tissue loss with this disease process, careful evaluation of lower extremities for wounds or ulcerations should be performed.

All patients should undergo non-invasive arterial studies including lower extremity segmental pressures and pulse volume recordings with or without toe pressure measurements, as indicated for both diagnosis and comparison postoperatively. In the absence of severe renal insufficiency, it is our practice to perform computed tomography angiography (CTA) on all patients with inclusion of the abdomen through a lower extremity runoff for procedural planning. As discussed above, the entire aorta should be included if there is concern for additional arch or upper extremity disease that may impact access. CTA allows for assessment of the extent and character of the aortoiliac disease including location of occlusion relative to renal arteries and extent of calcification of the vessels. Close attention should also be paid to large collaterals and presence of infrainguinal disease that may need to be addressed either concomitantly or in a second stage operation. This is especially true with regards to the common femoral artery (CFA) and profunda femoris artery. As the major outflow arteries and primary access vessels for endovascular repair of aortoiliac occlusion, stenosis greater than 50% and heavy calcification should be treated with a hybrid approach including a CFA endarterectomy and patch angioplasty.

Arterial duplex is another valuable imaging option for patients with renal insufficiency who cannot safely undergo CTA, as well as for assessment of femoral and lower extremity disease. Duplex, however, has its limitations, as a complete assessment of the aorta and iliac vessels can be challenging due to patient's body habitus, bowel gas and shadowing from calcification. Nonetheless, duplex remains an important tool in assessment and planning when needed [21]. MRI is an additional available imaging modality; however, it tends to overestimate the degree of stenosis in the presence of calcification. In our practice, angiography is only used in therapeutic setting and not for preoperative planning.

Open versus endovascular therapy in aortoiliac occlusions

Historically, open repair for aortoiliac disease has been the primary treatment modality with excellent patency rates as high as 72–90% at 10 years for aortobifemoral grafting [14,22,23]. This approach is currently regarded as the best management for multi-segment disease and occlusions according to current TASC guidelines [1]. However, with increasing experience, technical skill and improved endovascular equipment, this paradigm is increasingly challenged. This is reflected in a report using the National Inpatient Sample from 1996 to 2000 that noted an 850% increase in angioplasty and stenting for aortoiliac occlusive disease, with a parallel 15.5% decrease in aortobifemoral grafting [6]. Long-term primary patency rates for open bypass are superior to endovascular intervention [14,24]; however, open reconstruction comes at the cost of higher operative morbidity, mortality [2–4], longer hospitalization [5] and higher short-term costs [25]. The decision to choose open anatomic bypass is further challenged by comparable secondary patency rates between the two procedures [10,15,26]. Extra-anatomic bypass is yet another option for the treatment of aortoiliac disease. This procedure, however, is most often reserved for patients with medical or anatomic contraindications to anatomic bypass or endovascular therapy, with inferior clinical outcomes compared to either approach [27,28].

As the risks of endovascular intervention have decreased with increasing expertise, angioplasty and stenting are more favored, particularly in patients with life-limiting claudication. In those patients with critical limb ischemia and associated increased risk of future amputation, either approach is acceptable; however, these patients most likely have multilevel disease and may also require an additional outflow procedure [29]. The decision as to whether to choose endovascular or open intervention requires a balance between the extent of patient's disease, the ability for patient to withstand a significant open operation without serious complication, and the surgeon's comfort and expertise in both open and endovascular aortoiliac procedures. With appropriate tools and expertise, nearly all aortoiliac occlusions can be treated successfully with an endovascular approach.

Open approaches to aortoiliac occlusion

Open surgical options for aortoiliac occlusions most commonly include aortobiiliac or bifemoral artery bypass grafting, aortoiliac endarterectomy and extra-anatomic bypass. Unless contraindicated, ABF bypass has been the most common open reconstruction option due to its high long-term patency rates. In patients with localized aortoiliac bifurcation

disease without involvement of the CFA, aortobiiliac bypass is an option to prevent the unnecessary introduction of prosthetic graft into the groin and the potential for infection.

Currently, aortic endarterectomy is rarely utilized and most often reserved for focal stenosis of the distal aorta or proximal iliac arteries, where intervention cannot be performed. It avoids the use of prosthetic graft and has been advocated to improve sexual dysfunction when applied to those with hypogastric occlusions, as compared to bypass grafting [30,31]. However, while patency is similar to ABF when limited to local disease, extension into the external iliac arteries is associated with poor outcomes [32].

Extra-anatomic bypass has its role, particularly in the setting of patients who cannot tolerate an open abdominal operation or require remote graft placement due to infection. A review of patients receiving extra-anatomic bypass compared to aortobifemoral or aortobiiliac graft at our institution revealed that those with extra-anatomic reconstruction had significantly more advanced ischemia, renal dysfunction, severe COPD and atherosclerosis, often with prior inflow or lower extremity revascularization [27]. Outcomes in these patients are poor with high operative and late mortality, reflective more of the advanced disease and comorbidities that direct these patients toward this operation [27,28].

Aortobifemoral bypass grafting

Open aortobifemoral artery bypass grafting is performed by first exposing the femoral arteries through bilateral groin incisions. Any lymphatic structures should be suture ligated to minimize lymphatic leaks and subsequent risk of infection in the presence of prosthetic graft. Proximally, the dissection should expose the length of the inguinal ligament and the underlying distal external iliac artery. The distal exposure will depend on the extent of disease; however, it should include control of the proximal superficial femoral and profunda arteries at least. If indicated, additional distal exposure can be obtained to perform an extended endarterectomy and profundaplasty.

Exposure of the infrarenal aorta is then performed, most commonly through a transperitoneal approach. However, a retroperitoneal approach is also a reasonable option. Transperitoneal approach most often allows for faster dissection of the aorta with improved tunneling of the graft to the femoral arteries. However, in some patients, particularly those with prior open aortic or abdominal surgeries, a retroperitoneal approach may be preferable. After exploring the abdomen, a standard exposure of the infrarenal aorta should be performed. The transverse colon is retracted cephalad and the small bowel to the right abdomen. The ligament of Trietz is then identified and the third and fourth portions of the duodenum are mobilized to the right. The retroperitoneal tissues are dissected off of the anterior surface of the aorta proximally to the level of the left renal vein and inferiorly to the inferior mesenteric artery.

Retroperitoneal tunnels are then created for the femoral limbs of the graft. Blunt dissection is performed directly over the common and external iliac arteries with the index fingers from both abdominal and groin incisions. Care is taken to ensure that the ureters lie anterior to the tunnel and graft. An umbilical tape or a penrose is then passed through the tunnels.

After heparinization, aortic clamps can then be applied proximally just below the renal arteries and distally just above or below the inferior mesenteric artery. Preoperative imaging can help identify clamp location that avoids heavy calcification or thrombus. The proximal anastomosis can be performed in either an end-to-end or end-to-side fashion with a bifurcated Dacron graft. To perform an end-to-end anastomosis, a small segment of the aorta is resected, the distal aortic stump is oversewn, and the proximal aorta is anastomosed to the bifurcated graft. Some potential benefits of this technique may include elimination of competitive flow through the native system, improved hemodynamic flow through the anastomosis, and a lower profile allowing for easier coverage with retroperitoneal tissues. However, in patients with a low accessory renal artery or well-preserved perfusion to their hypogastric arteries, especially when combined with complete external iliac artery occlusion, an end-to-side technique may be preferred.

After completion of the aortic anastomosis, long clamps are passed through the retroperitoneal tunnels to pull the untwisted graft limbs into each groin. End-to-side anastomoses of the spatulated graft are then performed to the CFA with or without extension into the profunda arteries based on the extent of the disease.

Endovascular approaches to aortoiliac occlusion

Endovascular recanalization of aortoiliac occlusions plays an increasing role in the management of aortoiliac occlusions, as equipment and expertise become more readily available. Detailed preoperative planning with consideration of access options, devices and management of complications is imperative to a successful recanalization of these lesions.

Procedural setup

Endovascular interventions for aortoiliac occlusions should be performed in an endovascular suite or hybrid operating room, ideally with a fixed imaging. We find that hybrid operating rooms are not available at all institutions and these procedures are safely performed in other settings; however, these rooms are ideal for patients requiring a hybrid approach with endarterectomies, as well as in the management of complications requiring conversion to an open operation. The C-arm should approach the patient from the head, similar to a setup for carotid stenting, to allow for imaging from the aortic arch to the femoral bifurcation. To help achieve this, the patient should be centered on a radiolucent operating table with the patient's head at the top edge of the bed and the left arm abducted on an arm board. Both groins and the left arm should be included within the sterile field. At our institution, we routinely perform a surgical prep from the level of the nipples to the proximal edge of knees in the rare need for open conversion. The right arm can be tucked to the side of the patient as long as access into the aorta can be gained from the left brachial artery confidently.

The choice of sedation or anesthesia can vary depending on the patient and the extent of operation. In our series of aortic occlusions, 25 of 27 operations were performed under local anesthesia with sedation [7]. This is a reasonable approach for most patients; however, general or regional anesthesia is preferred for those who require femoral endarterectomies and should be considered for patient comfort when treating complicated lesions that may take an extended amount of time. If the procedure is to be performed by an interventional

cardiologist or a radiologist, vascular surgeon backup should be available if needed. Patients should have large-bore intravenous access as well as both non-invasive and continuous invasive blood pressure monitoring. The left arm is commonly utilized for access during these procedures; therefore, the arterial line should be placed in the right arm.

Choice of contrast media is left to the surgeon based on institutional availability and experience. We do recommend the use of low-osmolality agents to reduce the risk of contrast-induced nephropathy [33].

Access

Appropriate endovascular access is imperative to successful recanalization of aortoiliac occlusions. Based on the anatomy and the extent of disease, access options most commonly include a combination of left brachial and bilateral femoral arterial access. Left brachial access can act as a primary access site for treatment or as a supplement to groin access. In the presence of an aortic occlusion, left brachial access is recommended for initial imaging to locate the level of occlusion relative to visceral branches and act as the site for initial attempts to cross the lesion from an antegrade position. If thrombolysis is to be performed, brachial access can be subsequently used as an infusion site. In the setting of an aortoiliac occlusion, if an endovascular only procedure is planned, left brachial access should be obtained using a micropuncture technique just proximal to the antecubital fossa. Though not a requirement, we recommend that all arterial punctures be performed under ultrasound guidance to decrease the risk of access site complications [34]. With a short 5-French sheath in place, a guidewire is advanced to the level of the aortic occlusion, which is followed by a pigtail catheter for initial angiograms at the level of the occlusion. Attention should be paid to the relative location of the SMA, renal arteries, large collaterals and the location of distal reconstitution.

Femoral access can be obtained either through an open or a percutaneous approach. In patients with >50% CFA stenosis or heavy calcification that precludes safe percutaneous access, a hybrid procedure with CFA endarterectomy and patch angioplasty is recommended. Concomitant CFA endarterectomy is necessary in 24–53% of patients who underwent endovascular treatment of TASC C or D lesions [15,35]. If the superficial femoral artery is occluded, the endarterectomy and patch angioplasty can be extended distally to include a profundaplasty as needed. Femoral access can then be directly obtained by using a micropuncture technique through the patch. Position of the puncture should be away from any suture line and in a location that will not disrupt the profunda distally, yet ensure adequate working length if distal external iliac artery stenting is required. If a hybrid approach is undertaken, femoral endarterectomies should be performed prior to brachial access. Attempt should be made to cross the lesions from a retrograde approach through the femoral arteries, potentially avoiding additional access sites. In those patients without significant CFA disease, percutaneous access can be performed. Again the CFA puncture should be in a location that would allow for enough working length if external iliac stenting were required. If the treatment includes bilateral lesions or lesions close to the aortic bifurcation, bilateral femoral access should be planned.

Crossing the lesion

After obtaining appropriate angiogram images, the access system should be adjusted to optimize lesion crossing. In the setting of an aortic occlusion, brachial access should be used for initial antegrade attempts. The radial artery is not routinely used or recommended over the brachial artery due its small diameter and limitation to safely accommodate larger sheaths required for intervention. The distance from the radial artery to the aortic bifurcation also requires longer length catheters, sheaths, wires and balloons that may limit procedural options. The 5-French sheath should be exchanged for a longer, flexible 6-French sheath such as a Raabe sheath (Cook, Bloomington, IN, USA) and advanced close to the level of the occlusion. If not already in place, we recommend exchanging the wire for a 0.035" stiff, angled hydrophilic wire (Glidewire, Terumo Medical Corp., Somerset, NJ, USA), though other options can be used at the interventionalist's discretion. With continuous forward pressure on the sheath and the catheter, the wire should be rotated rapidly to 'drill' into the cap of the occlusion (FIGURES 1A & 2C). This can be one of the most challenging steps to the treatment of aortoiliac occlusions. Continue to 'drill' into the occlusion, attempting multiple locations and angles, with only a small length of the wire out of the catheter/sheath system.

Once through this cap of the occlusion, advancement through one of the iliacs is usually straightforward. The wire is then allowed to advance through the iliac artery, attempting to remain intraluminal by keeping the wire within the visible calcification. The catheter should be progressively advanced over the wire as progress is made. Creation of a subintimal plane is an option; however, it should be avoided as this can lead to an increased risk of vessel perforation and can make intraluminal re-entry very difficult. At our institution, re-entry devices are seldom utilized. If a subintimal plane has been created, it is imperative to ensure wire re-entry into the true lumen before entering the CFA. Intraluminal positions should also be assessed once across the lesion with pressure measurements or by the presence of back bleeding and confirmed with an injection of contrast. These techniques should be adequate to confirm intraluminal position; however, if there is still concern, intravascular ultrasound could be utilized. Once through the lesion, a clear release of resistance can be felt in the wire and catheter as it is advanced.

Ipsilateral femoral access should be obtained after confirming that the wire is intraluminal within the CFA. Through this access, a snare is advanced to create through-and-through brachiofemoral access (FIGURES 1B & 2D). At this point, the femoral sheath can be up-sized to a 6- or 7-French sheath. This sheath is then advanced along the wire through the occlusion with steady, firm pressure. If significant resistance is met, remove the sheath and serially advance dilators of increasing size to pre-dilate the tract, or alternatively, a balloon catheter, 4–5 mm in diameter, can be utilized. After advancing the sheath through the occlusion, retract the sheath distal to the lesion and serially inflate a small 4–5 mm angioplasty balloon to create a tract along the length of the occlusion (FIGURE 1C). The left brachial sheath and catheter can then be retracted into the thoracic aorta, sacrificing through-and-through access. A second wire is then advanced through the brachial system and this process is repeated for the contralateral side (FIGURE 1D). Again the wire, catheter and sheath are advanced to the level of the occlusion and inserting the wire and catheter into the aortic channel that has already been created, an angled catheter can be directed distally in this path toward the

contralateral iliac artery with subsequent wire advancement. An angled catheter, such as a Kumpe, or a vertebral catheter can be useful to help direct the wire into the contralateral limb. Once the contralateral lesion is crossed, again femoral access and subsequent through-and-through wire access is obtained. Again the same steps of pre-dilation with sheath and angioplasty balloon are repeated.

If a hybrid approach is performed or the occlusion is within the iliac arteries, crossing the lesion can first be attempted from a retrograde approach via the femoral arteries. The same techniques are applied as described above. If crossing the lesion through a retrograde approach is not successful, brachial access can be later obtained for an antegrade approach. The need for brachial access in iliac occlusions has been reported as 30% as compared to 4–5% with stenosis, resulting in similar technical success rates [36].

Treatment strategies

Angioplasty & stenting: Stenting has been shown to have higher patency and technical success than angioplasty, without increased complication [37]. Therefore, in the endovascular management of aortoiliac occlusions, stenting is the primary treatment modality. We recommend stenting that includes the entire length of the diseased vessel, typically proximally to distally. Proximally, if an aortic occlusion is present, a self-expanding nitinol stent is first placed. Though some groups advocate the use of larger diameter aortic stents (20–26 mm), these stents do not increase the patency rates [7,38] and theoretically increase the risk for ‘toothpasting’ possibly leading to embolization of plaque and thrombus. Therefore, we recommend 12–14 mm stents, with post-dilation to 10–12 mm. The stent length should cover the proximal end of the lesion to within a centimeter of the aortic bifurcation (FIGURE 2F). There is little evidence to support the use of stent grafts; however, consideration for their use could be in the setting of particularly friable or loose thrombus in the distal aorta.

Severe disease at or near the origin of the common iliac artery is common and is best treated with bilateral ‘kissing stents’, with or without aortic stenting. If an aortic stent has been deployed, prior to any further iliac intervention, the wire that was not used to deploy the stent will need to be retracted and readvanced through the aortic stent. This step is typically straightforward, but may influence which limb is used for aortic stent deployment. With bilateral wire access into the distal thoracic aorta, the 6–7 French femoral sheaths are both advanced into the distal aorta or aortic stent, if present (FIGURE 2E & 2F). As described above, if significant resistance is met, serial dilators or angioplasty balloon catheters can be used to pre-dilate the tract. The choice of stent, either balloon or self-expanding, is based on the length and the lesion type. Most commonly, heavy calcification is present at the aortic bifurcation and is best treated with balloon expandable stents, sized to conform to the native vessels. These stents allow for higher radial force in the presence of calcification, as well as more precise deployment both in terms of position and diameter. Intravascular ultrasound can be useful in the treatment of these lesions to help with stent sizing in the common and external iliac arteries as well as aorta, potentially leading to improved patency [39]. These stents are advanced to approximately 5 mm above the aortic bifurcation, protected within their respective sheath. After the sheaths are retracted, the stents are then synchronously

deployed. During deployment, close monitoring of arterial blood pressure and patient's symptoms is imperative. Any sudden drop in blood pressure or persistence of pain should alert the team to the potential of iliac rupture.

Additional distal intervention is based on the extent of patient's disease. More distal disease >30% stenosis involving the untreated common and external iliac artery or post-treatment dissection should also be stented. The distal common and external iliac arteries tend to be more tortuous with longer lesions. Therefore, in these locations, uncovered self-expanding stents are more commonly used due to their increased flexibility and the availability of stents of longer length. Self-expanding stents in the iliac arteries are slightly oversized and post-dilated to approximately the diameter of the native vessel (FIGURE 2G). In many patients, this can result in complete coverage of the entire iliac system. If CFA endarterectomies have been performed and the disease extends into the distal external iliac arteries, stents should cover the proximal margin of the endarterectomy, ideally without extension into the CFA.

Most commonly, uncovered stents are preferred over stent grafts to treat aortoiliac occlusive disease [7,18]. There is limited data that there is any improvement in patency using stent grafts over uncovered stents. For a potentially limited benefit, stent grafts are significantly more expensive than uncovered stents and require a larger sheath, thus increasing the risk of access site complications. It is, however, imperative to have stent grafts readily available within the operating room during any of these procedures to rapidly treat an uncommon but potentially life-threatening iliac rupture. Also, stent grafts can be used if an arterial perforation occurs or in the setting of a concomitant aortic or iliac aneurysm.

Thrombolysis & mechanical thrombectomy: Thrombolysis can be used as an adjunct to angioplasty and stenting in the treatment of aortic occlusions. Some suggest that the use of thrombolysis can increase the likelihood of crossing an aortoiliac occlusion [40]. Our use has typically been directed at patients with an aortic occlusion to decrease the amount of thrombus near the renal arteries and the risk of embolization during subsequent stenting. This is rarely utilized in patients with only iliac disease [40], except in those with evidence of distal embolization as part of their presentation. In the setting of an aortic occlusion that abuts the renal arteries, thrombolysis should be the initial treatment modality, preferably from left brachial access.(FIGURE 2A & 2B) The lesion should be crossed as described above and a channel created using a 5–6 mm angioplasty balloon through the entire segment of the diseased aortoiliac lesion. This allows for some outflow during thrombolysis, and anecdotally leads to decreased embolization to the visceral vessels and improved lysis. In our series of chronic aortic occlusions, thrombolysis was used in 29% of patients with a mean infusion time of 34.5 ± 16 h. A flow channel was achieved in all cases; however, not surprisingly, residual stenosis was present and all patients required subsequent stenting. Extended thrombolysis >48 h is associated with increased access site and other complications and should rarely, if ever, be utilized in the treatment of these patients. As discussed above, ensuring an adequate flow channel prior to initiation of lysis will help to reduce the potential for embolization from thrombotic debris at the proximal aspect of the occlusion. Mechanical thrombectomy has a limited role in the treatment of aortoiliac occlusion due to the increased risk of embolization; however, it could be considered in patients where thrombolysis is contraindicated or cannot undergo a prolonged infusion time.

Hybrid approaches: Hybrid approaches are not uncommon in the treatment of patients with severe aortoiliac disease. In patients with external iliac stenosis extending into the CFA, a hybrid approach with CFA endarterectomy can safely extend the length of treatment without the risk of stent failure at this location. In treatment of TASC C and D lesions, some series up to 24% of patients required this approach [15]. There is some evidence that this approach may improve the patency rates due to improved iliac outflow [35].

There are patients who may require additional infrainguinal interventions beyond the femoral artery, including lower extremity bypass. It is recommended that their inflow disease be treated first and later evaluated after recovery to determine if additional intervention is necessary. There is evidence that synchronous infrainguinal artery reconstruction does not improve and may potentially decrease iliac stent patency [14,24]. Also, many patients who suffer from severe claudication and even critical limb ischemia will have significant improvement of their symptoms with treatment of their inflow lesions and may no longer require additional interventions.

Outcomes

Endovascular treatment of aortoiliac occlusive disease has high technical success rates of 82–98%, even in the setting of aortic occlusion [7,10,14,38,41]. Most technical failures are associated with failure to cross the lesion, followed by early thrombosis and iliac artery injuries. Perioperative mortality for endovascular interventions remains low, with 0% in most reports, though there are some series with mortality as high as 4% (TABLE 1). The perioperative mortality for open repair is higher, ranging from 0 to 7%, with more contemporary rates closer to 1% (TABLE 2) [14,22,42,43]. Mortality is most often due to cardiac complications, and has been associated with older patients, COPD and lower hospital volume. In a comparison of open versus endovascular treatment of aortoiliac occlusive disease using the Nationwide Inpatient Sample, endovascular procedures are not only associated with decrease mortality but also with significantly decreased rates of complications (16 vs 25%), length of stay (2.5 vs 5.8 days) and hospital cost (US\$13.7k vs US\$17.2k) [25].

Postoperative ABI are not significantly different between open ABF and endovascular repair, with an increase from 0.48 to 0.84 in ABF patients and from 0.36 to 0.82 in endovascular patients [14]. Multiple studies have shown that primary patency rates are higher for patients who undergo ABF, with 5- and 10-year patency reported to be 85–90 and 75–85%, respectively [22,42–44]. In contrast, angioplasty and stenting for severe aortoiliac disease is associated with a 5-year patency of 60–86%. Though this primary patency is inferior to open bypass, secondary patency rates of 80–98% are equivalent between the two treatments [8,14,15,26,35]. Those with aortic occlusion have similar rates, from 85 to 88% at 1 year and from 66 to 98% at 3 years, with secondary patency ranging from 96 to 100% and from 90 and 92% at 1 and 3 years, respectively [7,8,10,14]. This loss of primary patency in endovascular approaches is most often due to stent thrombosis or in-stent stenosis that is most often easily treated with a repeat endovascular approach, rarely requiring open conversion. Treatment of aortoiliac disease with the endovascular approaches described in

this review does not compromise the open repair performed later if necessary. The converse, however, is often not true, especially if an end-to-end anastomosis is performed.

In comparison to open aortobiiliac/femoral bypass and endovascular approaches, extra-anatomic bypass has inferior outcomes to both approaches. Most contemporary data evaluating axillofemoral bypass notes a 3–11% operative mortality with primary 3-year patency rate of 70–85% at 3 years [27,45–47]. As described previously, choice of this procedure is biased toward patients with more advanced ischemia and comorbid conditions. This is reflected in the limited availability of longer-term data as the 3-year mortality approaches 50–57%.

In the evaluation of patency rates, it is important to note that these patients have a poor overall prognosis independent of surgery type, with 10-year survival as low as 30% [48–50]. The decreased primary patency of endovascular repair as compared to open bypass may be acceptable given the equivalent rates of secondary patency and the decreased risk of major perioperative complications and mortality associated with open surgery. Though additional procedures may be necessary to obtain equivalent long-term results, this can be achieved most often with minimally invasive approaches. Extra-anatomic bypass has inferior patency to both open bypass and endovascular approaches and should be reserved for those where endovascular intervention is unsuccessful and for the patients who are not appropriate candidates for open bypass due to anatomic or medical contraindications.

Complications

Open surgical complications

Complications of open aortobifemoral grafting are similar to those of open aortic repair, including cardiopulmonary complications, bleeding, renal insufficiency and intestinal ischemia. Specifically to ABF, injury to ureters can occur during tunneling and can be avoided by the techniques discussed above. Spinal cord ischemia is an infrequent devastating complication that can occur if hypogastric artery perfusion is impaired either by embolization or the use of an end-to-end graft.

Late complications of ABF include graft thrombosis, aortoenteric fistula and infection. Late graft thrombosis can occur in up to 30% of grafts at 10 years. Graft thrombosis typically involves one of the limbs and can often be attributed to poor outflow. Thrombectomy and endovascular techniques can be attempted within the graft. When graft thrombosis occurs, patients often require open femoral or profunda endarterectomy to maintain secondary patency. Aortoenteric fistulas are rare complications, typically caused by erosion of the proximal suture line into the duodenum. At the time of initial surgery, the graft should lay as flush as possible and tissues should be reapproximated over the graft to decrease the risk of late fistulae. Aortofemoral grafts are at increased risk of graft infection due to the presence of prosthetic in the groin. Groin complications are not uncommon, affecting up to 25% of patients due to lymphoceles, local infection or dehiscence [51,52]. These early complications can seed the prosthetic material, placing the graft at risk for late infection and sepsis. Due to presence of graft in the groin, late infections of aortofemoral grafts range from 1.3 to 6% in contrast to other intra-abdominal grafts with an infection rate of 0–1.3%

[53,54]. Management of aortoenteric fistula and other infections can be complicated often involving resection of the graft and reconstruction with either extra-anatomic bypass or *in situ* repair with deep vein or antibiotic-soaked graft. The large and often multi-stage operations are associated with very high operative mortality of 11–22% [55–58].

Access site complications—Access site issues are the most common complication when treating aortoiliac disease from an endovascular approach. As discussed above, up to 50% of patients require multiple access sites [15] and each needs to be managed carefully to prevent complications. Most complications are self-limiting hematomas that can be managed with compression, rarely leading to more significant retroperitoneal or intraperitoneal hematomas [59]. In patients undergoing thrombolysis, monitoring for the development of hematomas is critical. Pseudoaneurysms can most often be treated with thrombin injection. Arterial vessel occlusions have been reported in two cases each in a series of aortoiliac occlusion, resulting in open thrombectomy [7,10].

These complications are most common in the brachial artery, where the complication rate is up to 6.5%. When these complications do occur, up to 60% require open surgical intervention often due to the smaller vessel caliber. Female patients and the use of longer sheaths have been associated with increased complications. Both these factors are present in the treatment of aortoiliac disease, increasing the risk [60].

To minimize the risk of the complications, all percutaneous access should be performed under direct ultrasound guidance with as few attempts as possible [34]. If thrombolysis is to be performed, the number of access sites should be minimized and diligent monitoring of the infusion sites should be performed. If there is any concern for complication at an access site, it should be evaluated with duplex ultrasound.

Rupture or perforation—Iliac rupture is a rare but potentially life-threatening complication of endovascular treatment that occurs in 0.5–3% of cases [7,8,10]. Patients should have continuous hemodynamic monitoring, and any drop in blood pressure or significant pain after deployment of stent or deflation of a balloon should raise concern for rupture. Contrast should be injected into the area of concern to identify a potential injury.

Most often, iliac rupture can be rapidly addressed with covered stent placement without significant clinical impact. Patients with heavily calcified or small vessels are at most risk for this complication, and can often be identified preoperatively with CTA. In these patients, there should be increased concern for the potential for rupture during stenting and angioplasty, and in some situations, the use of covered stents will prove safer by reducing the risk of rupture. Techniques to avoid rupture include pre-dilation with small, low-profile angioplasty balloons prior to stenting, especially in heavily calcified vessels. Prophylactically, an 8-French sheath can be used in case an iliac rupture occurs, allowing for rapid deployment of a covered stent.

Embolization—Nearly all patients with aortoiliac occlusion have thrombus as a component of their disease process. Any intervention that disrupts thrombus in the aorta or iliac arteries places the patient at risk for embolization; however, clinically significant events

are rare. Heparinization should be performed early in these procedures with careful monitoring to ensure the patient remains therapeutically anticoagulated throughout the procedure. As discussed above, thrombolysis can be used even in chronic occlusions to decrease the thrombus burden, especially in the infrarenal aorta.

Care should be taken with all wire manipulation to decrease this risk. Only small angioplasty balloons should be used prior to stenting. Similarly when placing stents, large diameter stents should be avoided and they should not be overdilated. Overdilation can lead to 'toothpasting', causing the thrombus to extrude around the edges of the stent producing potential embolic debris. If embolization occurs intraoperatively, an aspiration catheter or mechanical thrombectomy can be used; however, an open embolectomy may be required if endovascular techniques are not sufficient. There are currently no distal protection devices routinely used or approved for this indication. Given their expense without any evidence to support their use beyond case reports [61,62], the use of distal protection devices in the treatment of aortoiliac occlusion is not recommended at this time.

Renal failure—Approximately 13% of patients with severe aortoiliac disease also have renal impairment at baseline. The use of contrast and risk of embolization can place patients at risk for acute renal failure. The risk of contrast-induced nephropathy is highest in patients with baseline renal insufficiency, and therefore, patients with creatinine >1.5 mg/dl (133 μ mol/l) should receive pre- and post-procedure hydration with 0.9% normal saline [63] or sodium bicarbonate [64]. The volume of contrast should also be minimized, especially in these patients. Rates of renal failure are low after iliac stenting; however, in the presence of an aortic occlusion, the rates range from 0 to 15%, with rare instances of progression to dialysis dependency [7,10,38,65]. In our series, both the patients who progressed to dialysis had normal renal function preoperatively, one with a solitary kidney and the other with known coronary disease who developed cardiogenic shock. These events are uncommon and evidence is limited to support techniques to avoid this complication; however, thrombolysis, especially in aortic occlusion, may decrease thrombus burden and, therefore, the risk of embolization.

Endovascular postoperative management

Postoperatively all patients are admitted to the hospital for close monitoring. Those undergoing thrombolysis are admitted to the intensive care unit for frequent neurovascular and access site monitoring. Unless there is a contraindication, all these patients are maintained on a statin [66] as well as dual antiplatelet therapy with aspirin and clopidogrel for at least 4–6 weeks [67,68]. Anticoagulation is rarely indicated and reserved for patients with concern for hypercoagulable state, recurrent thrombosis and those with other indications unrelated to their intervention. In patients with baseline renal insufficiency, intravenous hydration is continued post-procedure. After sheath removal, patients are initially placed on bed rest with or without an arm board if brachial access is utilized. For the remaining period of the hospital stay, access sites continue to be closely monitored and patients are encouraged to ambulate. Median length of stay ranges from 3 to 8.5 days, with prolonged stay based on anticoagulation bridging, thrombolysis and monitoring of renal function [7,10].

Patients are scheduled for an outpatient follow-up visit in 4–6 weeks with non-invasive imaging including duplex ultrasound, segmental pressures and PVRs. A follow-up CTA will also often be performed in patients with an aortic intervention. Each patient's modifiable risk factors are continually assessed and treated in collaboration with the patient at each visit.

Subsequent follow-up should occur at 6 months postoperatively and yearly thereafter.

Any change in symptoms, new loss of pulses or the development of tissue loss should trigger evaluation. On duplex imaging, a greater than 50% diameter reduction or doubling of velocities within the iliac segments is suggestive of restenosis. These changes coupled with a drop in ABI greater than 0.1 may necessitate further evaluation and potential reintervention to assure prolonged patency.

Expert commentary

Severe aortoiliac occlusive disease is increasingly being treated with endovascular and hybrid approaches over open surgical operations. These interventions have high rates of technical success with good primary and secondary patency rates. Aortobifemoral grafting has superior long-term patency over endovascular therapy for severe lesions; however, this major open operation comes at the cost of higher operative mortality, longer length of stay and increased risk of major complications. In choosing a treatment approach, it is important to consider the underlying comorbidities of these patients, beyond their aortoiliac disease. Independent of any intervention, these patients are at a high risk of 5- and 10-year mortality, often preventing them from realizing the benefit of improved long-term patency of an open operation. In the hands of a skilled endovascular surgeon with appropriate equipment, nearly all aortoiliac lesions can be treated with an endovascular approach independent of TASC classification. Open operations may still have a role in patients with renal insufficiency and in those treated in centers without the expertise and equipment to safely treat these lesions endovascularly. With either approach, a detailed understanding of the procedure with its potential complications and management is critical to successful treatment of these complex patients.

Five-year view

A speculative viewpoint on how the field will evolve in 5 years time

Endovascular interventions will continue to evolve and increasingly replace open surgery for the treatment of aortoiliac disease, independent of lesion classification. As techniques become more refined and devices evolve, patency rates may improve and the risk of severe complications including rupture, embolization and renal injury may decrease. These advancements in endovascular treatment will further tip the balance away from the risks of an open operation toward lower risk endovascular therapies. As endovascular therapies become more accessible, it remains the surgeon's responsibility to provide the right operation for the patient by ensuring they have the appropriate skill set and resources to not only appropriately treat these lesions but also manage the complications.

References

Papers of special note have been highlighted as:

- of interest
- of considerable interest

- 1••. Norgren L, Hiatt WR, Dormandy JA, et al. Inter-Society Consensus for the Management of Peripheral Arterial Disease (TASC II). *J Vasc Surg.* 2007; 45(Suppl S):S5–67. [PubMed: 17223489] [Updated international working group consensus for the management of peripheral arterial disease.]
2. Ligush J, Criado E, Burnham SJ, et al. Management and outcome of chronic atherosclerotic infrarenal aortic occlusion. *J Vasc Surg.* 1996; 24(3):394–404. discussion 404–405. [PubMed: 8808961]
3. Dimick JB, Cowan JA, Henke PK, et al. Hospital volume-related differences in aorto-bifemoral bypass operative mortality in the United States. *J Vasc Surg.* 2003; 37(5):970–5. [PubMed: 12756341]
4. García-Fernández F, Marchena Gómez J, Cabrera Morán V, et al. Chronic infrarenal aortic occlusion: predictors of surgical outcome in patients undergoing aortobifemoral bypass reconstruction. *J Cardiovasc Surg (Torino).* 2011; 52(3):371–80.
5. West CA, Johnson LW, Doucet L, et al. A contemporary experience of open aortic reconstruction in patients with chronic atherosclerotic occlusion of the abdominal aorta. *J Vasc Surg.* 2010; 52(5): 1164–72. [PubMed: 20732782]
6. Upchurch GR, Dimick JB, Wainess RM, et al. Diffusion of new technology in health care: the case of aorto-iliac occlusive disease. *Surgery.* 2004; 136(4):812–18. [PubMed: 15467666]
7. Moise MA, Alvarez-Tostado JA, Clair DG. Endovascular management of chronic infrarenal aortic occlusion in health care: the case of aorto-iliac occlusive disease. *J Endovasc Ther Off J Int Soc Endovasc Spec.* 2009; 16(1):84–92.
- 8••. Jongkind V, Akkersdijk GJM, Yeung KK, Wisselink W. A systematic review of endovascular treatment of extensive aortoiliac occlusive disease. *J Vasc Surg.* 2010; 52(5):1376–83. [PubMed: 20598474] [Systematic review of 1711 patients from 19 non-randomized cohort studies with endovascular treatment of extensive aortoiliac occlusive disease.]
9. Kim U, Hong S-J, Kim J, et al. Intermediate to long-term outcomes of endoluminal stent-graft repair in patients with chronic type B aortic dissection. *J Endovasc Ther Off J Int Soc Endovasc Spec.* 2009; 16(1):42–7.
10. Kim T-H, Ko Y-G, Kim U, et al. Outcomes of endovascular treatment of chronic total occlusion of the infrarenal aorta. *J Vasc Surg.* 2011; 53(6):1542–9. [PubMed: 21515016]
11. Crawford JD, Perrone KH, Wong VW, et al. A modern series of acute aortic occlusion. *J Vasc Surg.* 2014; 59(4):1044–50. [PubMed: 24393282]
12. Babu SC, Shah PM, Nitahara J. Acute aortic occlusion—factors that influence outcome. *J Vasc Surg.* 1995; 21(4):567–72. discussion 573–575. [PubMed: 7707562]
13. Hardman RL, Lopera JE, Cardan RA, et al. Common and rare collateral pathways in aortoiliac occlusive disease: a pictorial essay. *AJR Am J Roentgenol.* 2011; 197(3):W519–24. [PubMed: 21862782]
- 14••. Kashyap VS, Pavkov ML, Bena JF, et al. The management of severe aortoiliac occlusive disease: endovascular therapy rivals open reconstruction. *J Vasc Surg.* 2008; 48(6):1451–7. 1457, e1–3. [PubMed: 18804943] [This paper provides a comparison of open versus endovascular reconstruction of severe aortoiliac occlusive disease in similar patient cohorts; endovascular repair had lower primary patency rates compared to open, but with comparable secondary patency and limb salvage rate.]
- 15••. Leville CD, Kashyap VS, Clair DG, et al. Endovascular management of iliac artery occlusions: extending treatment to TransAtlantic Inter-Society Consensus class C and D patients. *J Vasc Surg.* 2006; 43(1):32–9. [PubMed: 16414384] [This is a series demonstrating that long iliac occlusions can be treated effectively with stenting with high success rates and comparable mid-

term patency to open repair, independent of Trans-Atlantic Inter-Society Consensus C or D classification.]

16. Leriche R. De la résection du carrefour aortico-iliaque avec double sympathectomie lombaire pour thrombose artérielle la l'aorte: le syndrome de l'oblitération termino-aortique parartérite. *Presse Med.* 1940; 48:601–7.
17. Leriche R. Des obliterations artérielles hautes (oblitération de la terminaison de l'aorte) comme causes des insuffisances circulatoires des membres inférieurs. *Bull Mem Soc Chir Paris.* 1923; 49:1404–6.
18. Sixt S, Krankenberg H, Möhrle C, et al. Endovascular treatment for extensive aortoiliac artery reconstruction: a single-center experience based on 1712 interventions. *J Endovasc Ther Off J Int Soc Endovasc Spec.* 2013; 20(1):64–73.
19. Hans SS, DeSantis D, Siddiqui R, Khoury M. Results of endovascular therapy and aortobifemoral grafting for Transatlantic Inter-Society type C and D aortoiliac occlusive disease. *Surgery.* 2008; 144(4):583–9. discussion 589–590. [PubMed: 18847642]
20. Eldrup-Jorgensen J, Flanigan DP, Brace L, et al. Hypercoagulable states and lower limb ischemia in young adults. *J Vasc Surg.* 1989; 9(2):334–41. [PubMed: 2521908]
21. Rosfors S, Eriksson M, Höglund N, Johansson G. Duplex ultrasound in patients with suspected aorto-iliac occlusive disease. *Eur J Vasc Surg.* 1993; 7(5):513–17. [PubMed: 8405494]
- 22•. De Vries SO, Hunink MG. Results of aortic bifurcation grafts for aortoiliac occlusive disease: a meta-analysis. *J Vasc Surg.* 1997; 26(4):558–69. [PubMed: 9357455] [This is a large meta-analysis of open bifurcated aortic repair of aortoiliac occlusive disease providing aggregated morbidity, mortality and patency rates of endovascular interventions for comparison.]
23. Chiesa R, Marone EM, Tshomba Y, et al. Aortobifemoral bypass grafting using expanded polytetrafluoroethylene stretch grafts in patients with occlusive atherosclerotic disease. *Ann Vasc Surg.* 2009; 23(6):764–9. [PubMed: 19540713]
24. Timaran CH, Prault TL, Stevens SL, et al. Iliac artery stenting versus surgical reconstruction for TASC (TransAtlantic Inter-Society Consensus) type B and type C iliac lesions. *J Vasc Surg.* 2003; 38(2):272–8. [PubMed: 12891108]
- 25•. Indes JE, Mandawat A, Tuggle CT, et al. Endovascular procedures for aorto-iliac occlusive disease are associated with superior short-term clinical and economic outcomes compared with open surgery in the inpatient population. *J Vasc Surg.* 2010; 52(5):1173–9. 1179, e1. [PubMed: 20691560] [An evaluation of patients from the National Inpatient Sample who underwent treatment for aortoiliac occlusive disease, noting lower complication rates, shorter length of stay and decreased hospital costs for endovascular as compared to open treatment.]
26. Chang RW, Goodney PP, Baek JH, et al. Long-term results of combined common femoral endarterectomy and iliac stenting/ stent grafting for occlusive disease. *J Vasc Surg.* 2008; 48(2): 362–7. [PubMed: 18572359]
27. Hertzner NR, Bena JF, Karafa MT. A personal experience with direct reconstruction and extra-anatomic bypass for aortoiliofemoral occlusive disease. *J Vasc Surg.* 2007; 45(3):527–35. discussion 535. [PubMed: 17321340]
28. Harrington ME, Harrington EB, Haimov M, et al. Axillofemoral bypass: compromised bypass for compromised patients. *J Vasc Surg.* 1994; 20(2):195–201. [PubMed: 8040942]
29. Brewster DC, Perler BA, Robison JG, Darling RC. Aortofemoral graft for multilevel occlusive disease. Predictors of success and need for distal bypass. *Arch Surg Chic Ill.* 1960; 117(12):1593–600.
30. Connolly JE, Price T. Aortoiliac endarterectomy: a lost art? *Ann Vasc Surg.* 2006; 20(1):56–62. [PubMed: 16378154]
31. DePalma RG, Emsellem HA, Edwards CM, et al. A screening sequence for vasculogenic impotence. *J Vasc Surg.* 1987; 5(2):228–36. [PubMed: 3820400]
32. Brewster DC, Darling RC. Optimal methods of aortoiliac reconstruction. *Surgery.* 1978; 84(6): 739–48. [PubMed: 152480]
33. Barrett BJ, Carlisle EJ. Metaanalysis of the relative nephrotoxicity of high- and low-osmolality iodinated contrast media. *Radiology.* 1993; 188(1):171–8. [PubMed: 8511292]

34. Lo RC, Fokkema MTM, Curran T, et al. Routine use of ultrasound-guided access reduces access site-related complications after lower extremity percutaneous revascularization. *J Vasc Surg.* 2015; 61(2):405–12. [PubMed: 25240244]
35. Ruzicidlo EM, Powell RJ, Zwolak RM, et al. Early results of stent-grafting to treat diffuse aortoiliac occlusive disease. *J Vasc Surg.* 2003; 37(6):1175–80. [PubMed: 12764261]
36. Pulli R, Dorigo W, Fargion A, et al. Early and long-term comparison of endovascular treatment of iliac artery occlusions and stenosis. *J Vasc Surg.* 2011; 53(1):92–8. [PubMed: 20934841]
37. Bosch JL, Hunink MG. Meta-analysis of the results of percutaneous transluminal angioplasty and stent placement for aortoiliac occlusive disease. *Radiology.* 1997; 204(1):87–96. [PubMed: 9205227]
38. Klonaris C, Katsargyris A, Tsekouras N, et al. Primary stenting for aortic lesions: from single stenoses to total aortoiliac occlusions. *J Vasc Surg.* 2008; 47(2):310–17. [PubMed: 18241754]
39. Buckley CJ, Arko FR, Lee S, et al. Intravascular ultrasound scanning improves long-term patency of iliac lesions treated with balloon angioplasty and primary stenting. *J Vasc Surg.* 2002; 35(2): 316–23. [PubMed: 11854730]
40. Motarjeme A, Gordon GI, Bodenhagen K. Thrombolysis and angioplasty of chronic iliac artery occlusions. *J Vasc Interv Radiol JVIR.* 1995; 6(6 Pt 2 Suppl):66S–72S. [PubMed: 8770845]
41. Kang JL, Patel VI, Conrad MF, et al. Common femoral artery occlusive disease: contemporary results following surgical endarterectomy. *J Vasc Surg.* 2008; 48(4):872–7. [PubMed: 18639427]
42. Chiu KWH, Davies RSM, Nightingale PG, et al. Review of direct anatomical open surgical management of atherosclerotic aorto-iliac occlusive disease. *Eur J Vasc Endovasc Surg Off J Eur Soc Vasc Surg.* 2010; 39(4):460–71.
43. Mingoli A, Sapienza P, Feldhaus RJ, et al. Comparison of femorofemoral and aortofemoral bypass for aortoiliac occlusive disease. *J Cardiovasc Surg (Torino).* 2001; 42(3):381–7.
44. Reed AB, Conte MS, Donaldson MC, et al. The impact of patient age and aortic size on the results of aortobifemoral bypass grafting. *J Vasc Surg.* 2003; 37(6):1219–25. [PubMed: 12764268]
45. Passman MA, Taylor LM, Moneta GL, et al. Comparison of axillofemoral and aortofemoral bypass for aortoiliac occlusive disease. *J Vasc Surg.* 1996; 23(2):263–9. discussion 269–271. [PubMed: 8637103]
46. Naylor AR, Ah-See AK, Engeset J. Axillofemoral bypass as a limb salvage procedure in high risk patients with aortoiliac disease. *Br J Surg.* 1990; 77(6):659–61. [PubMed: 2383734]
47. Harris EJ, Taylor LM, McConnell DB, et al. Clinical results of axillobifemoral bypass using externally supported polytetrafluoroethylene. *J Vasc Surg.* 1990; 12(4):416–20. discussion 420–421. [PubMed: 2145447]
48. Malone JM, Moore WS, Goldstone J. Life expectancy following aortofemoral arterial grafting. *Surgery.* 1977; 81(5):551–5. [PubMed: 850871]
49. Szilagyi DE, Elliott JP, Smith RF, et al. A thirty-year survey of the reconstructive surgical treatment of aortoiliac occlusive disease. *J Vasc Surg.* 1986; 3(3):421–36. [PubMed: 3951027]
50. Crawford ES, Bomberger RA, Glaeser DH, et al. Aortoiliac occlusive disease: factors influencing survival and function following reconstructive operation over a twenty-five-year period. *Surgery.* 1981; 90(6):1055–67. [PubMed: 7313940]
51. Pejkić S, Dragaš M, Ilić N, et al. Incidence and relevance of groin incisional complications following aortobifemoral bypass grafting. *Ann Vasc Surg.* 2014; 28(8):1832–9. [PubMed: 25011088]
52. Burke CR, Henke PK, Hernandez R, et al. A contemporary comparison of aortofemoral bypass and aortoiliac stenting in the treatment of aortoiliac occlusive disease. *Ann Vasc Surg.* 2010; 24(1):4–13. [PubMed: 20122461]
53. Campbell WB, Tambour LJ, Geens VR. Local complications after arterial bypass grafting. *Ann R Coll Surg Engl.* 1994; 76(2):127–31. [PubMed: 8154807]
54. Back Martin, R. Local Complications: Graft Infection. In: Cronenwett, JL., editor. *Rutherford's vascular surgery.* Elsevier Saunders; Philadelphia, PA: 2014.
55. Bandyk DF, Novotney ML, Back MR, et al. Expanded application of in situ replacement for prosthetic graft infection. *J Vasc Surg.* 2001; 34(3):411–19. discussion 419–420. [PubMed: 11533591]

56. Liekweg WG, Greenfield LJ. Vascular prosthetic infections: collected experience and results of treatment. *Surgery*. 1977; 81(3):335–42. [PubMed: 841471]
57. Yeager RA, Taylor LM, Moneta GL, et al. Improved results with conventional management of infrarenal aortic infection. *J Vasc Surg*. 1999; 30(1):76–83. [PubMed: 10394156]
58. Reilly LM, Stoney RJ, Goldstone J, Ehrenfeld WK. Improved management of aortic graft infection: the influence of operation sequence and staging. *J Vasc Surg*. 1987; 5(3):421–31. [PubMed: 3509595]
59. Tsetis D, Uberoi R. Quality improvement guidelines for endovascular treatment of iliac artery occlusive disease. *Cardiovasc Intervent Radiol*. 2008; 31(2):238–45. [PubMed: 18034277]
60. Alvarez-Tostado JA, Moise MA, Bena JF, et al. The brachial artery: a critical access for endovascular procedures. *J Vasc Surg*. 2009; 49(2):378–85. discussion 385. [PubMed: 19028057]
61. Pitta SR, Barsness GW, Lerman A, et al. Transradial iliac artery intervention with dual downstream embolic protection. *J Vasc Surg*. 2011; 53(3):808–10. [PubMed: 21095093]
62. Agle SC, Barchman MJ, Haisch CE, Stoner MC. Aortoiliac intervention with distal protection to salvage a heterotopic renal transplant. *Ren Fail*. 2009; 31(7):593–6. [PubMed: 19839857]
63. Mueller C, Buerkle G, Buettner HJ, et al. Prevention of contrast media-associated nephropathy: randomized comparison of 2 hydration regimens in 1620 patients undergoing coronary angioplasty. *Arch Intern Med*. 2002; 162(3):329–36. [PubMed: 11822926]
64. Merten GJ, Burgess WP, Gray LV, et al. Prevention of contrast-induced nephropathy with sodium bicarbonate: a randomized controlled trial. *JAMA*. 2004; 291(19):2328–34. [PubMed: 15150204]
65. Yuan L, Bao J, Zhao Z, et al. Transbrachial and femoral artery approach endovascular therapy for flush infrarenal aortic occlusion. *Eur J Vasc Endovasc Surg Off J Eur Soc Vasc Surg*. 2014; 48(1): 46–52.
66. Heart Protection Study Collaborative Group. Bulbulia R, Bowman L, et al. Effects on 11-year mortality and morbidity of lowering LDL cholesterol with simvastatin for about 5 years in 20,536 high-risk individuals: a randomised controlled trial. *Lancet*. 2011; 378(9808):2013–20. [PubMed: 22115874]
67. Mehta SR, Yusuf S, Peters RJ, et al. Effects of pretreatment with clopidogrel and aspirin followed by long-term therapy in patients undergoing percutaneous coronary intervention: the PCI-CURE study. *Lancet*. 2001; 358(9281):527–33. [PubMed: 11520521]
68. Mwipatayi BP, Thomas S, Wong J, et al. A comparison of covered vs bare expandable stents for the treatment of aortoiliac occlusive disease. *J Vasc Surg*. 2011; 54(6):1561–70. e1. [PubMed: 21906903]
69. Ye W, Liu C-W, Ricco J-B, et al. Early and late outcomes of percutaneous treatment of TransAtlantic Inter-Society Consensus class C and D aorto-iliac lesions. *J Vasc Surg*. 2011; 53(6): 1728–37. [PubMed: 21609804]

Key issues

- Endovascular therapies should be considered as first-line therapy for all patients with aortoiliac occlusive disease over open surgical approaches.
- The large majority of patients with severe aortoiliac occlusive disease have significant cardiovascular comorbidities, many of whom also have a long history of smoking, COPD and often renal insufficiency. These risk factors need to be included in decision making regarding selection of treatment.
- A thorough preoperative exam and axial imaging is strongly recommended to assess the extent and character of the aortoiliac disease, as well as to identify lesions that may alter plans for access.
- Open aortobifemoral or biiliac bypass is viewed as the 'gold standard' for treatment of advanced aortoiliac disease, with primary patency rates higher than endovascular interventions. However, secondary patency rates between the two techniques are comparable and endovascular procedures are associated with significantly decreased operative mortality and morbidity and shorter length of stay.
- Endovascular interventions for aortoiliac disease often require brachial and bifemoral access. Hybrid procedures with femoral endarterectomies and patch angioplasty are recommended if the common femoral or profunda artery stenosis is >50%.
- Stenting is recommended over angioplasty for the treatment of significant lesions, with balloon expandable stents deployed at the bifurcation in a 'kissing' configuration and the self-expanding stent through the external iliac arteries.
- Access site complications are the most common for aortoiliac interventions. Iliac rupture, dissection, embolization and renal insufficiency are serious, potential complications and understanding of causes and techniques to minimize their risk is imperative. Interventionalists should be prepared to manage or have available backup from a vascular surgeon if necessary.
- Postoperatively, patients should be maintained on antiplatelet therapy and a statin. An outpatient follow-up visit should be scheduled within 4–6 weeks with duplex ultrasound, segmental pressures and PVRs, as well as possibly computed tomography angiography if an aortic intervention was performed.

Figure 1. Representation of technique for crossing aortic occlusion and preparing for treatment (A) From the brachial approach, the sheath is advanced to the proximal edge of the occlusion and the wire is drilled through the occlusion with progressive advancement of the catheter. (B) After crossing the lesion, femoral access is obtained and the wire is snared to obtain through-and-through access. (C) A small angioplasty balloon is used to dilate the occlusion prior to sheath advancement. (D) The same technique is used on the contralateral side, followed by advancement of sheaths to the aortic bifurcation from the femoral arteries. From Current Vascular Surgery 2014; used with permission from People's Medical Publishing House-USA (PMPH-USA).

Figure 2. Endovascular intervention of patient with infrarenal aortic and iliac occlusions
(A) Initial flow channel with angioplasty balloon created after crossing lesion. **(B)** Lysis catheter in place through occlusion in aorta and left iliac artery. **(C)** Attempt at crossing right iliac occlusion by drilling wire and subsequent advancement of sheath. **(D)** Snaring the wire after crossing the lesion to obtain brachiofemoral access. **(E)** Advancement of bilateral sheaths to the bifurcation. **(F)** Placement of an aortic and bilateral 'kissing' common iliac stents. **(G)** Treatment of remaining common and external iliac artery with self-expanding stents. At completion, the aorta and bilateral iliac arteries are patent without significant stenosis.

Table 1

Outcomes of endovascular treatment of aortoiliac occlusion.

Study (year)	Patients (n)	Indication	Technical success (%)	Peri-op mortality (%)	Follow-up (years)	Patency		Ref.
						Primary (%)	Secondary (%)	
Leville <i>et al.</i> (2006)	89	TASC C, D	91	3.4	3	76	97	[15]
Chang <i>et al.</i> (2008)	171	TASC B, C, D	98	2.3	5	60	98	[26]
Hans <i>et al.</i> (2008)	40	TASC C, D	95	0	4	69	89	[19]
Kashyap <i>et al.</i> (2008)	83	TASC B, C, D	96	4	3	74	90	[14]
Moise <i>et al.</i> (2009)	31	Aortic occlusion	93	0	3	66	90	[7]
Kim <i>et al.</i> (2011)	49	Aortic occlusion	82	2	3	80	92	[10]
Ye <i>et al.</i> (2011) [†]	958	TASC C, D	94	2.9	3	77	91	[69]

TASC: Trans-Atlantic Inter-Society Consensus.

[†]TASC document on management of peripheral arterial disease.

Table 2

Outcomes of aortobifemoral/iliac bypass.

Study (year)	Patients (n)	Peri-op mortality (%)	Primary patency		Ref.
			5 years (%)	10 years (%)	
de Vries <i>et al.</i> (1997) [†]	1429	4.4	88–91%	82–87	[22]
Hertzer <i>et al.</i> (2007)	224	1.2	88%	81	[27]
Chiesa <i>et al.</i> (2009)	822	0.1	97%	90	[23]
Chiu <i>et al.</i> (2010) [†]	5738	4.1	86%	–	[42]

[†] Meta-analysis.