Abdominal Aortic Occlusive Disease

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Introduction

Atherosclerosis of the abdominal aorta or iliac arteries is one of the most common causes of lower extremity ischemia. The first implication of the disease was uncovered in the late eighteenth century by British anatomist John Hunter. However, two more centuries passed before Rene Leriche described a patient with claudication and erectile dysfunction in 1948, ultimately linking clinical symptoms with pathophysiology and anatomy [1].

Surgical revascularization of aortoiliac artery was first described by Wylie et al. in San Francisco in 1952 [2]. Since then, tremendous advances have occurred in synthetic graft conduits, tissue engineering, and, most recently, percutaneous endovascular devices which allow a wide range of treatment options based on patient morbidity and anatomic defect. This chapter will review clinical characteristics of abdominal aortic occlusive disease and contemporary management.

Epidemiology

The majority of patients with aortic occlusive disease present with diffuse disease involving multi-level peripheral vasculature including femoropopliteal or infrapopliteal vessels. This subset of patients with diffuse multi-level disease are typically older, more likely male, with a higher prevalence of diabetes and hypertension and with concomitant coronary artery disease, cerebrovascular disease, and visceral atherosclerosis [3, 4]. Such patients with multi-vessel disease often present with ischemic pain, tissue loss, or gangrene. Not surprisingly, their life expectancy is lower than their age-matched counterpart [5]. In contrast, patients with isolated aortoiliac disease are generally younger and more likely female with a high prevalence of smoking or dyslipidemia [6].

"Hypoplastic aortic syndrome" or "small aorta syndrome" is a particularly virulent form of aortic atherosclerosis often found in young, small stature women who smoke [6]. This disease particularly involves the infrarenal aorta proximal to the aortic bifurcation. Radiographic findings are typically atretic or narrowed vasculature with diffuse calcific atherosclerosis. Due to the diminutive size of the aorta and iliac vessels, durability of either endovascular intervention or local endarterectomy is generally inferior, particularly in the presence of continued cigarette use.

Pathophysiology

Aortoiliac atherosclerosis typically starts at the iliac bifurcation and extends proximally and distally. Degree of the progression may vary but ultimately could occlude aortic blood flow over time. Starrett et al. demonstrated one-third of patients experienced proximal disease progression up to the level of renal artery in the period of 6–10 years [7]. In the same study, they also demonstrated a 30–40% chance of profunda femoris or superficial femoral artery distal involvement [7].

Due to the relatively slow progression of atherosclerosis, collateral circulation often develops. The primary compensatory vessels to the lower extremity include the internal thoracic artery (mammary) to the inferior epigastric artery and the intercostal and lumbar artery to the deep circumflex artery. Additional colonic collaterals arise from the SMA to the IMA via the marginal artery of Drummond and the arc of Riolan. Pelvic collaterals from the IMA to the hypogastric include the superior rectal to the middle rectal, the iliolumbar to the lumbar, and the lateral sacral to the median sacral artery. It is important to recognize these compensatory pathways and to preserve them during reconstruction.

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Clinical Presentation

Chronic atherosclerosis of the aortoiliac segment often accompanies infrainguinal arterial disease. Thus, this disease most frequently manifests as lower extremity arterial insufficiency. Symptoms vary widely depending on location of concomitant disease and degree of collateralization.

Patients with multi-level disease can present with typical lower extremity arterial insufficiency symptoms such as leg claudication, tissue loss, or gangrene. In contrast, patients with isolated aortoiliac segment disease may present with pelvic or buttock claudication. In male aortoiliac disease patients, up to 30% experience difficulty achieving and maintaining an erection owing to decreased perfusion of the internal pudendal artery. The constellation of symptoms associated with distal aortic occlusion, including pelvic claudication, atrophy of the leg muscles, impotence, and decreased femoral pulses, is known as Leriche's syndrome [1].

Diagnosis

Patient History

Conducting a complete history and identifying cardiovascular risk factors are important in the diagnosis. Atherosclerosis is a pathologic process related with aging (Fig. 15.1). Hypertension, diabetes, dyslipidemia, chronic kidney disease, and cigarette smoking are classic risk factors that must be identified and addressed. It is critical to control these modifiable factors to slow the progression of the atherosclerosis.

Male gender and non-Hispanic black race are known unmodifiable risk factors for atherosclerosis. In patients who lack these classic risk factors, hyperhomocysteinemia, hypercoagulability, and hyperfibrinogenemia should be investigated.

Risk Factors for Atherosclerosis [8]
- Advanced age.
- Race (non-Hispanic blacks).
- Male gender.
- Hyperfibrinogenemia.
- Diabetes mellitus.
- Hyperhomocysteinemia.
- Smoking.
- Hypercoagulability.
- Hypertension.
- Elevated C-reactive protein.
- Dyslipidemia.
- Chronic renal insufficiency.

Physical Examination

Physical examination begins with inspection. Aortoiliac disease may cause ischemic changes of the pelvis/buttocks and/or the lower extremities. Visual signs of ischemia include pallor, muscular atrophy, and cyanosis or skin mottling.

Palpation and comparison of femoral pulses is the quickest and the most important way to diagnose aortoiliac occlusive disease. Grading a pulse is subjective, simply described as (1) normal, diminished, or absent and (2) symmetric versus asymmetric. If a pulse is not palpable, further assessment using Doppler should be pursued. The Doppler signal can be described as triphasic, biphasic, or monophasic. Palpation of the lower extremity is also helpful to assess the level of skin temperature and neurologic (motor and sensory) status.

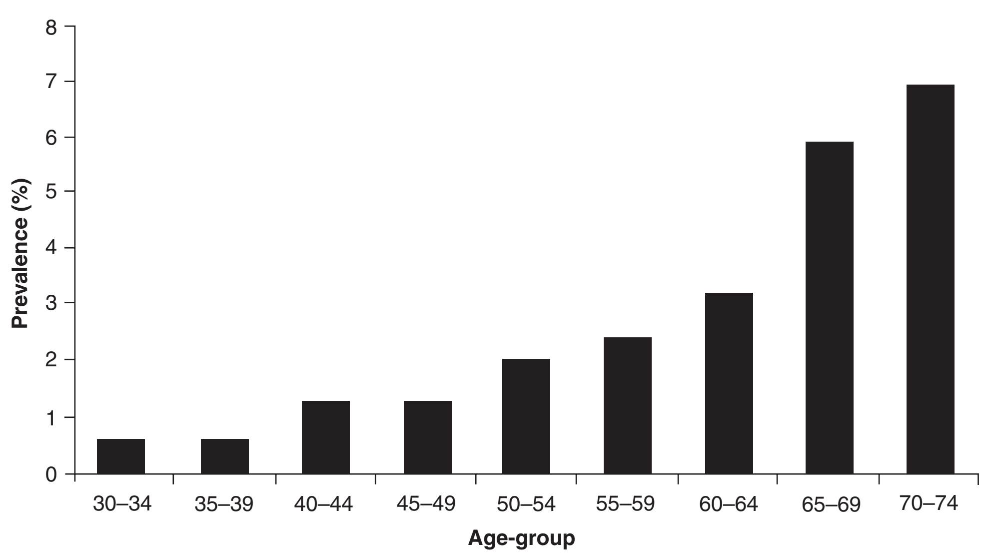


Fig. 15.1 Prevalence of symptomatic peripheral arterial disease. (From Norgren et al. [8]. Reprinted with permission from Elsevier)

Auscultation of the abdomen commonly reveals bruits when significant stenosis of the aorta or its branch is present. Middle to lower abdominal bruits may present with aortoiliac occlusive disease, whereas epigastric or paramedian bruits can indicate visceral vessel stenosis or renal artery stenosis, respectively.

Patients with aortoiliac occlusive disease and robust collateral formation may have a deceiving lack of distinct physical examination findings. In that case, an exercise trial may augment changes in pulses or bruit. Lumbar disc herniation, spinal stenosis, or arthritis of the hip or knee joint should be included in the differential diagnosis. Discomfort related with certain positions, or prolonged standing in elderly often arises from neurogenic or musculoskeletal origins.

Vascular Laboratory

Non-invasive hemodynamic vascular laboratory testing begins with ankle-brachial index (ABI). Segmental systolic blood pressure measurement and pulse volume recording (PVR) may aid in locating the area of concern. A difference of systolic blood pressure between the upper arm and proximal thigh more than 20 mmHg reflects significant stenosis in the aortoiliac or proximal femoral arteries. Further reduction of blood pressure in the distal segments or decreased PVR or ABI indicates concomitant outflow disease. The combination of a thorough history and physical examination with vascular laboratory testing often provides sufficient clinical data to decide upon the necessity of revascularization.

Duplex ultrasound (DUS) is the most commonly used diagnostic imaging study for delineating extremity vascular abnormalities. However, evaluation of aortoiliac, renal, and visceral arteries is somewhat limited mainly due to overlying bowel gas. Patient factors such as obesity or tortuosity of the vessel also complicate visualization and make it difficult to determine the precise anatomic location of the disease and its severity.

Axial Imaging

Computed tomographic angiography (CTA) is the gold standard imaging modality for aortoiliac disease in our institution. CTA is a non-invasive alternative to standard angiography and can be obtained quickly [9]. With recent advances in multi-detector CT scan, high-quality images with sub-millimeter spatial resolution are now available. Disadvantages of CT scan include radiation exposure, risk of contrast-induced nephropathy, and hypersensitivity to iodine contrast.

In some institutions, magnetic resonance angiography (MRA) has become the imaging study of choice. MRA is an excellent diagnostic study for aortoiliac occlusive disease with sensitivity and specificity near 95% [10]. MRA can even be obtained without contrast, utilizing time of flight. MRA can be a reliable guide for percutaneous or open intervention of the aortoiliac disease. However, MRA has a tendency to overestimate the degree of stenosis and has limited evaluation of the severity of calcific disease. In addition, MRI cannot be utilized for patients with certain metallic implants such as cardiac pacemaker or defibrillator.

Arteriography

Despite recent technical advances in CT or MRI with increased speed and accuracy, diagnostic catheter-based arteriography remains a valuable tool in a physician's armamentarium. Femoral approach is the preferred way in our institution; however, brachial approach may be necessary in long-segment, near-occlusive, or occlusive aortic or bi-iliac disease. Real-time angiographic imaging utilizing lateral or oblique views may delineate the contribution of accessory renal vessels (Can they be sacrificed?), IMA vs SMA perfusion (IMA reimplantation?), and lumbar vessels for spinal perfusion (risk of paralysis?) and/or clarify whether radiographic stenosis are truly hemodynamically significant. For example, the presence of superior mesenteric artery occlusion, hypogastric occlusion, or prominent inferior mesenteric artery may require preservation of the inferior mesenteric artery during aortic reconstruction to avoid bowel ischemia.

Treatment Modalities

Conservative Management

Smoking

Smoking cessation is without question desirable in aortic occlusive disease to slow down the progression of atherosclerosis. Smoking cessation is associated with reduced risks of amputation, myocardial infarction, and mortality in this patient population [11, 12].

Dyslipidemia

Use of statin has demonstrated a significant reduction of adverse cardiovascular event in patient with atherosclerosis [13–15]. Low-density lipoprotein cholesterol should be controlled under 100 mg/dL or to 70 mg/dL in very high-risk patients [16].

Diabetes

It is unclear whether aggressive diabetic control decreases adverse cardiovascular events. However, atherosclerosis tends to be more complicated, and amputation rate is higher in diabetic patient. This may be related to susceptibility to infection in this population and higher prevalence of distal sensory neuropathy from poor diabetic control.

Hypertension

Hypertension is recognized as a risk factor of atherosclerosis; however, relative risk for atherosclerosis is less for hypertension than dyslipidemia or smoking. Treatment for hypertension is associated with low cardiovascular complications, stroke, or death [17].

Antiplatelet Therapy

The American Heart Association and the Society for Vascular Surgery recommend the use of an antiplatelet agent in peripheral arterial occlusive disease [16, 18]. The same can be applied to aortoiliac atherosclerotic disease. Dual antiplatelet therapy can be applied at the physician's discretion, but there is a lack of evidence to date that combination therapy is more effective than a single-agent therapy [19].

Supervised Exercise Therapy

Exercise therapy may improve intermittent claudication. A meta-analysis of 1200 patients demonstrated overall improvement of walking distance without improvement of ankle-brachial index [20]. The precise mechanism of action is still unknown, but it is thought to be related with nitric oxide-related vasodilation and improved bioenergetics of skeletal muscle. However, severe cardiopulmonary disease or arthritis may preclude adequate exercise participation.

Medical Therapy

Medical therapy aims for symptomatic relief of claudication. There are two Food and Drug Administration (FDA)-approved medications – pentoxifylline and cilostazol – whereas the Royal College of Physicians in the UK identified naftidrofuryl as the drug of choice over those two drugs. Naftidrofuryl is widely available in the European countries but has not been FDA approved in the USA.

Pharmacodynamics of pentoxifylline includes reducing blood viscosity and enhancing peripheral perfusion and tissue oxygenation. Multicenter prospective randomized trial proved its efficacy over placebo [21]. Pentoxifylline can be begun at 400 mg three times daily with maximum dose of 1800 mg/day. Side effects of this medication include hypertension, nausea, vomiting, and headache.

Cilostazol is a phosphodiesterase inhibitor that induces vasodilation and suppresses platelet aggregation. In addition to routine antiplatelet therapy, cilostazol (100 mg twice daily) can contribute to increased overall pain-free ambulatory distance in as short as 4 weeks [22]. However, this agent can exacerbate congestive heart failure and is contraindicated in a patient with any level of heart failure.

A multicenter, randomized, double-blind, parallel-group study compared cilostazol and pentoxifylline and found that while cilostazol significantly improved walking distance, pentoxifylline was not significantly different than placebo [23].

Decision-Making to Intervention

The natural history of atherosclerosis in aortoiliac disease is a slow arterial process that impairs walking ability. With maximum medical treatment and exercise therapy, the chance of developing severe ischemic symptoms such as rest pain or tissue loss is relatively low (<5%) [8, 24]. Thus, the majority of patients need just reassurance from their physician. However, patients with advanced ischemic symptoms or claudication that significantly impacts their daily living or occupation should be under consideration for intervention.

It is important to recognize that determining the degree of functional impairment is not straightforward. Patient perception of functional impairment may vary according to their baseline activity. For example, mild to moderate claudication in an active man may have a greater impact, while severe claudication in a sedentary patient may be less significant. Patient morbidity is another important aspect to be considered. Patients with severe arthritis or spinal degenerative disease might not benefit from invasive vascular intervention, whereas patients with severe coronary artery disease or pulmonary compromise may suffer from postoperative significant morbidity or mortality.

Open revascularization has traditionally demonstrated improved patency over endovascular intervention at the expense of higher morbidity and mortality although supporting data comparing the two strategies are still poor. The TransAtlantic Inter Society Consensus (TASC) document first in 2000, then in 2007, and most recently updated in 2015, classified anatomic patterns of disease severity from types A through D for aortoiliac, femoropopliteal, and infrapopliteal segments [25] (Fig. 15.2). Initially, the TASC working group advocated endovascular intervention for TASC type A lesions and open surgical treatment for TASC type D lesions. However, the latest TASC II update in 2015 recognized that with modern advances in endovascular instruments and practitioner skill, an endovascular first approach has become the predominant modality when revascularization is decided. Moreover, hybrid open and endovascular procedures may be suitable for complex anatomy.

Endovascular Intervention

Arterial Access

Lesions at the aortic bifurcation or common iliac arteries can be treated with the usual retrograde approach from the common femoral arteries. Occlusions that cannot be crossed

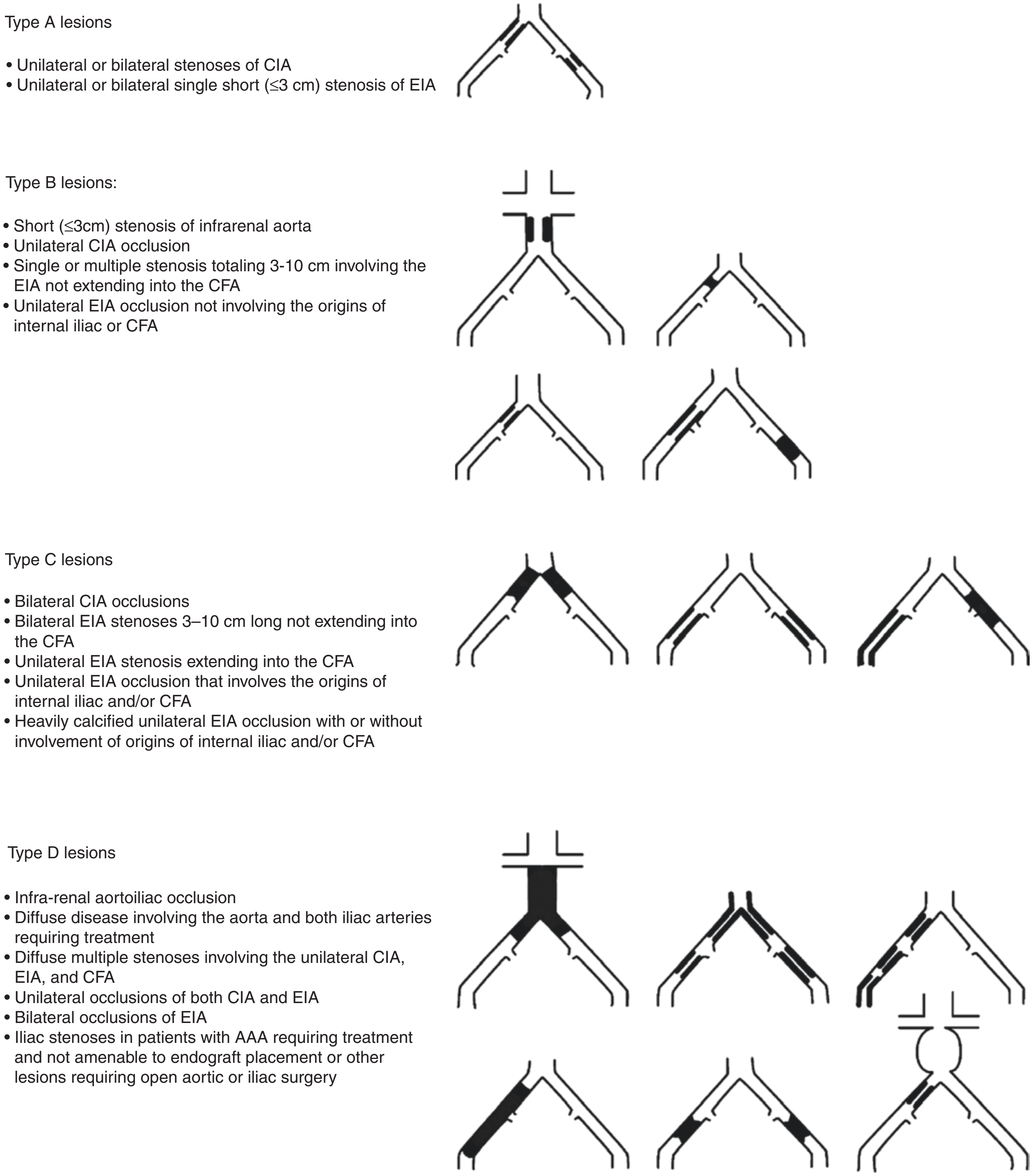


Fig. 15.2 TransAtlantic Inter-Societal Classification of aortoiliac lesions. (From Norgren et al. [8]. Reprinted with permission from Elsevier)

from the ipsilateral femoral retrograde approach may require contralateral femoral artery or brachial artery access and subsequent antegrade approach. A left brachial artery approach may also decrease the risk of an aortic dissection, but this patient population not infrequently exhibits concomitant left subclavian artery stenosis that may require pretreatment prior to aortoiliac intervention.

After access is obtained, a diagnostic angiographic evaluation should be performed prior to intervention. Aortogram and pelvic images are essential to evaluate extent of the disease. A contralateral oblique view opens the iliac bifurcation, whereas an ipsilateral oblique view helps to clarify the femoral bifurcation. Infrainguinal runoffs also should be evaluated prior to intervention in case of distal embolization during the course of intervention.

Crossing the Lesion

An angled GLIDEWIRE (Terumo Medical Corp, Somerset, NJ) and angled support catheter are the prototypical methods for crossing an iliac stenosis. Chronic total occlusions (CTO) often require a variety of wires, catheters, and sheath support. The most difficult part of the occlusion is the proximal cap. After the wire is fully crossed over, true lumen location should be confirmed with contrast injection. Blood draw as confirmation may be false. A variety of CTO devices exist, some of which allow re-entry from a subintimal plane to the true lumen (Fig. 15.3).

Aortic Bifurcation Disease

Lesions at the aortic bifurcation traditionally are treated with kissing iliac balloon and stent placement. Even in scenarios with unilateral disease, if the lesion is close to the aortic bifurcation, simultaneous bilateral intervention has been advocated to prevent contralateral iliac dissection or thrombus dislodgement and subsequent embolism. Contralateral prophylactic treatment has also been recommended in order to treat spill over plaque originating from the aorta [26, 27]. However, a retrospective of 175 patients with unilateral iliac artery lesions treated with unilateral method revealed about 1% risk of contralateral extremity complications [28].

Selection of Balloon and Stent

Plain old balloon angioplasty (POBA) is inferior in patency to balloon angioplasty and stent within the aortoiliac system [29–31]. The optimal vessel diameter is often derived from the normal equivalent segment on the contralateral side. A calibration imaging system can also be useful to facilitate measuring size and length of the lesion. Balloons and stents should be large enough to cover the diseased segment completely but small enough not to injure normal vessels and aortic branches. Five to ten percent oversize of the balloon and stent is recommended except for a heavily calcified lesion that may rupture with larger devices.

A variety of stents are commercially available which fall into two main deployment categories: balloon-expandable and self-expanding. Selection of a stent often depends on device availability and the operator's familiarity. However, it is noteworthy that a balloon-expandable stent is advantageous when precise stent placement is necessary. Such is the case in bilateral common iliac lesions which need kissing stents to be deployed precisely at the same level to allow equal opposition. In contrast, when the stent must follow a tortuous path or is to be placed from the contralateral side, a self-expanding stent provides greater flexibility. The external iliac artery often benefits from self-expanding stent placement.

A covered stent graft is a metal stent covered with Dacron or polytetrafluorethylene (PTFE) which initially was developed for exclusion of an aneurysmal segment or treatment of an iatrogenic perforation or rupture. Covered stents exclude the diseased segments from the circulation and, theoretically, may reduce in-stent restenosis. Although limited studies

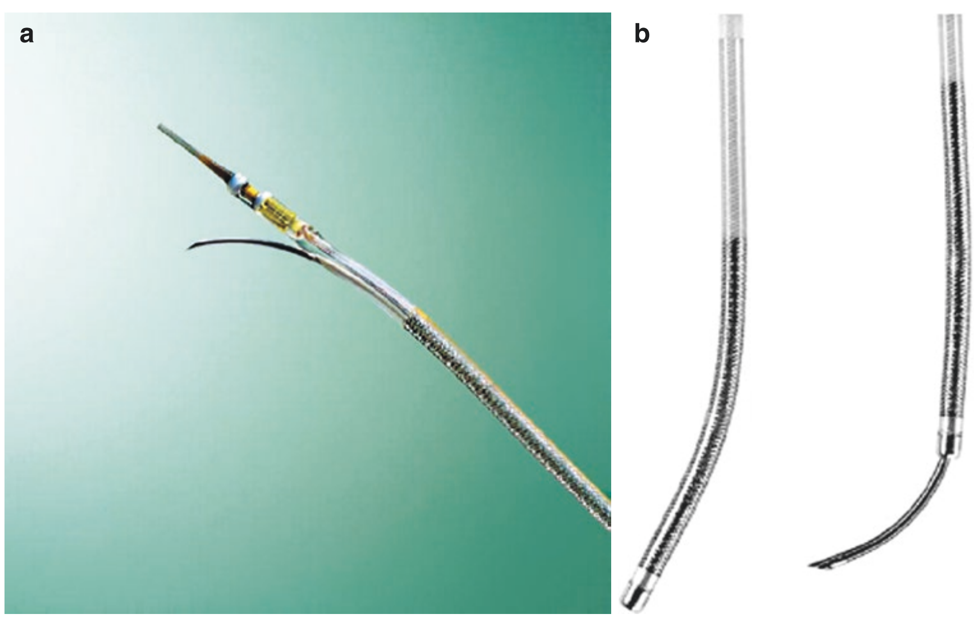


Fig. 15.3 Reentry catheters. (**a**) Pioneer catheter with needle deployed. (**b**) Outback LTD catheter. (Right: with needle retracted. Left: with needle deployed). (From Jacobs et al. [42]. Reprinted with permission from Elsevier)

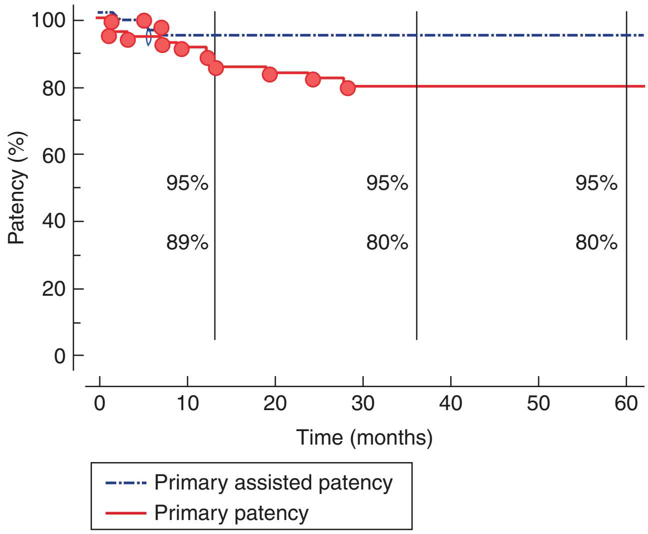


Fig. 15.4 Comparison of primary patency between stents and stent grafts. (From Chang et al. [32]. Reprinted with permission from Elsevier)

have been conducted in patients with aortoiliac atherosclerotic disease, primary and primary-assisted patency rate at 5 years are 80% and 95% which are superior to bare-metal stents [32] (Fig. 15.4).

Drug-eluting stents (DES) were initially developed for the treatment of coronary artery disease. A drug such as paclitaxel or sirolimus delivered via stent inhibits restenosis and improves long-term patency. DES and drug-coated balloons (DCB) have similarly been FDA approved for the treatment of femoropopliteal artery disease [33–35]. These newer-generation balloons and stents have been recommended over their nondrug coated counterparts but may require extended dual antiplatelet therapy [36]. Although these newer drug-coated devices have been used off label in the external iliac artery, data for the aortoiliac segment is lacking.

Concomitant Femoral Artery Disease

With coexisting severe common femoral artery disease, the artery can be accessed utilizing a hybrid femoral open cut down allowing arterial puncture under direct visualization. At the end of the intervention, proximal and distal control is obtained and the femoral artery can be endarterectomized using a longitudinal arteriotomy and closed with a patch angioplasty. This will improve inflow perfusion to the ipsilateral leg and better maintain graft patency [32].

Postoperative Care

Aspirin therapy should be initiated and continued indefinitely. Dual antiplatelet is recommended for at least 30 days. Clinical surveillance with physical exam, ABI, and duplex ultrasonography should be performed immediate postop (30 days) and every 6 months at least 1 year and annually thereafter.

Results of Endovascular Revascularization

The technical success rate of endovascular interventions in the aortoiliac segment is very high in many reports. However, maintaining long-term patency requires dedicated surveillance and may need multiple secondary interventions. Although a variety of factors can affect the outcome, the TASC classification well represents outcomes referencing disease location and severity [37]. Endovascular long-term outcomes are better in TASC A and B lesions compared to TASC C or D lesions. Cumulative primary patency of all lesions was 83% at 5 years (Fig. 15.5). Although many TASC D lesions can be treated successfully with an endovascular approach, open surgical revascularization especially in patients suitable for the procedure should be discussed.

Open Surgical Revascularization

In general, open surgical repair carries a higher perioperative morbidity and mortality compared to minimally invasive endovascular revascularization. Thus, cardiopulmonary comorbidities and renal function have to be assessed and optimized prior to operation. Coagulation profile should be checked routinely. Preoperative coronary evaluation may be necessary and is an important modifiable risk factor in patients undergoing open vascular procedures. Preoperative nuclear cardiac stress test has been used in our institution frequently given most of aortic occlusive patients cannot complete an exercise stress test and are at high risk for postoperative myocardial infarction. Full assessment of the peripheral vasculature is indicated because the condition of the distal runoffs influence the outcome of the aortoiliac intervention. Sometimes, concurrent distal bypass may be indicated.

Intraoperatively, appropriate antibiotic prophylaxis should be administered before the incision and through the perioperative period. Invasive arterial blood pressure monitoring is routine in many hospitals.

Direct Surgical Revascularization (Aorto-Bifemoral Bypass)

Initial Approach and Groin Dissection

The patient is placed in supine position. Bilateral groin incisions are made. The choices of groin incisions are predominated by preoperative findings and patient factors. Oblique

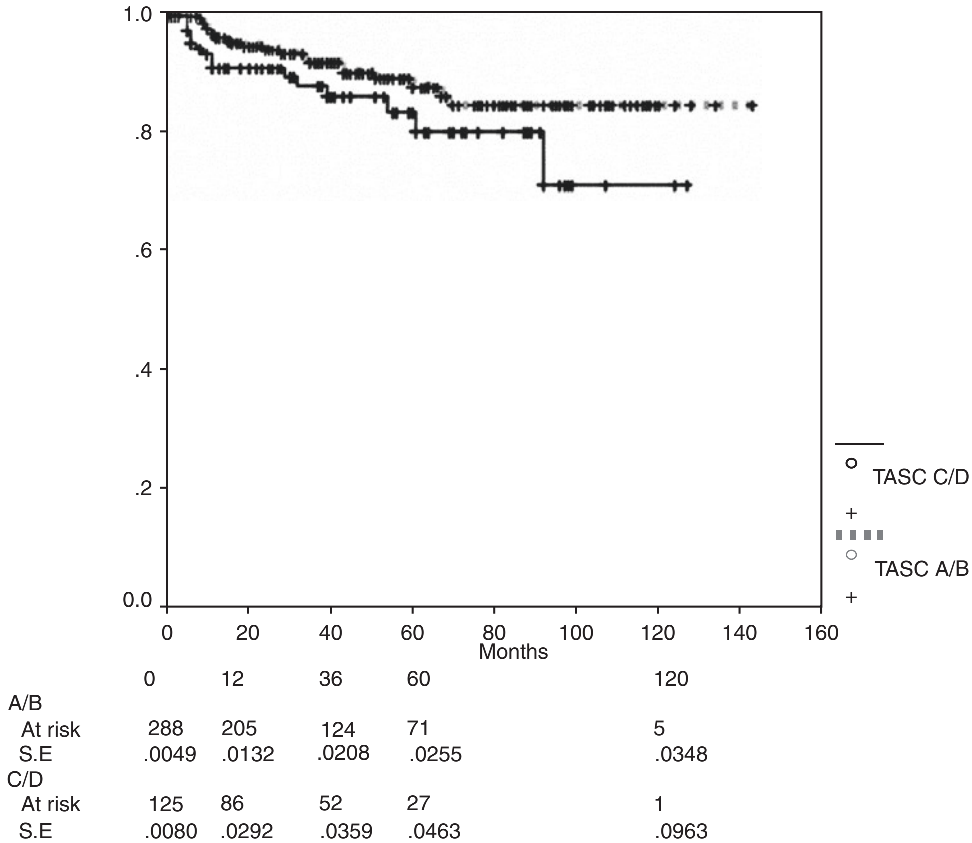


Fig. 15.5 Long-term patency of endovascular interventions. Cumulative primary patency was 83% at 5 years. (From Ichihashi et al. [37]. Reprinted with permission from Elsevier)

incisions may reduce postoperative infection and can be performed even in patients needing profunda femoral endarterectomy (Fig. 15.6). Longitudinal incision is a more traditional femoral exposure which provides technical flexibility to approach more proximal and distal femoral artery. The common, superficial, and deep (profundal) femoral arteries are dissected free and controlled with loops. The inferior border of the inguinal ligament rarely needs to be divided to create enough space for tunneling of the graft.

Abdominal Dissection

A midline abdominal incision is made from subxiphoid to a point just below the umbilicus. If the common iliac exposure is required, the incision can be extended to the suprapubic area. Multiple prior abdominal operations or history of peritonitis increases the risk of enterotomy during lysis of adhesions. In these patients, retroperitoneal or high thoracoabdominal approach may be warranted. Greater omentum and the transverse colon are retracted carefully cephalad and secured with a wet towel. An Omni wall retractor may allow for greater flexibility. Excessive traction is avoided to prevent injury to the middle colic branch of the superior mesenteric artery. The small bowel and the sigmoid colon are moved to the patient right and left, respectively. When possible, the small bowel is not eviscerated to prevent unnecessary fluid loss and bowel edema. The peritoneum between the duodenum and the inferior mesenteric vein is incised dissected along the long axis of the aorta beyond the level of the IMA. Care is taken not to injure autonomic nerve fibers on the anterolateral aspect of the aorta. The ligament of Treitz is divided, and the fourth portion of the duodenum is mobilized and dissection continued cephalad until the left renal vein is exposed (Fig. 15.7). After completion of the dissection, tunnels are made by gentle blunt dissection using fingers, simultaneously from the groin and the pelvis. The tunnel should be constructed along the iliac artery, posterior to the ureter to avoid hydroureter from mechanical obstruction from the iliac graft limb. A Penrose drain, umbilical tape, red rubber catheter, or an aortic clamp can be passed through to facilitate future passage of the graft limbs (Fig. 15.8).

After systemic heparinization, the aorta is clamped just caudal to the left renal vein and the aorta is transected. In contrast to aneurysmal aortic patients, aortic occlusive chronic disease often does not create hemodynamic changes with initial aortic cross clamp. Patent lumbar branches are ligated. The distal aortic end is oversewn with 3–0 polypropylene sutures. When possible, this is done immediately above the IMA to allow for the retrograde perfusion of the IMA after reconstruction (Fig. 15.9).

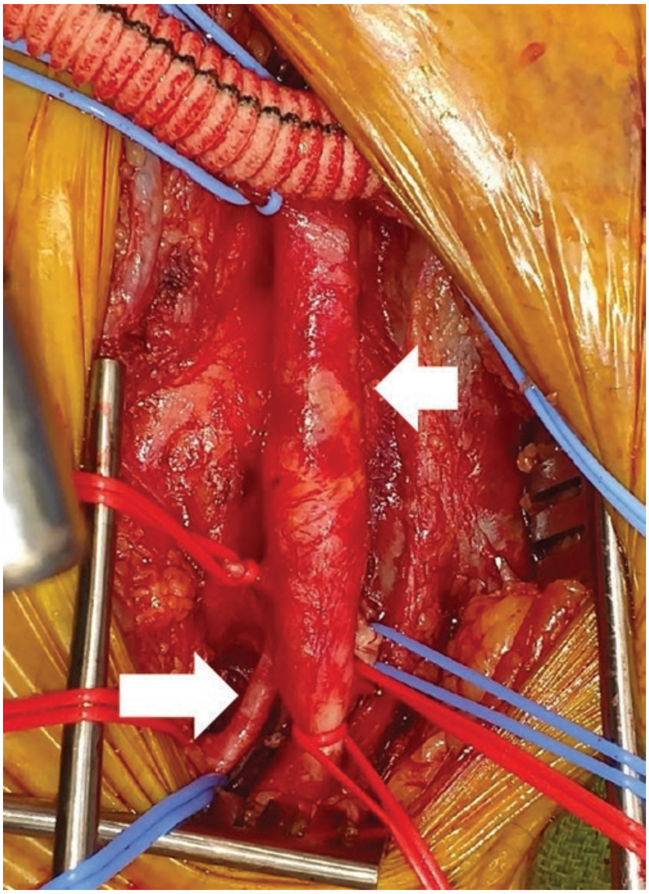


Fig. 15.6 Oblique groin incisions for femoral artery exposure (Short arrow: Common femoral artery, Long arrow: Profunda femoral artery)

Graft Anastomosis

Most surgeons prefer Dacron grafts for ease of use and hemostasis, but PTFE conduits are also available and may have decreased aortoenteric fistula complications. The standard proximal aortic anastomosis is an end-to-end anastomosis using 3–0 running sutures from the posterior aortic wall toward the anterior wall. The end-to-side anastomosis can be applied when preservation of a large accessory renal artery or a patent inferior mesenteric artery is required (Fig. 15.10). Configuration of the standard end-to-end anastomosis poses less peri-anastomotic turbulence or anastomotic aneurysm formation. Graft-enteric fistula can be more prevalent in an end-to-side anastomosis since the graft lies more prominently toward the peritoneum, although the data is lacking.

Then, the graft limbs are passed through the previously created tunnels. Longitudinal femoral arteriotomy is made and an end-to-side anastomosis is made using 5–0 or 6–0 running vascular sutures. When possible, this arteriotomy should be elongated onto the PFA (Fig. 15.11) as the natural history of prototypical PAD is that SFA disease will develop in the not too distant future. In some instances, femoral endarterectomy is required with bovine patch angioplasty

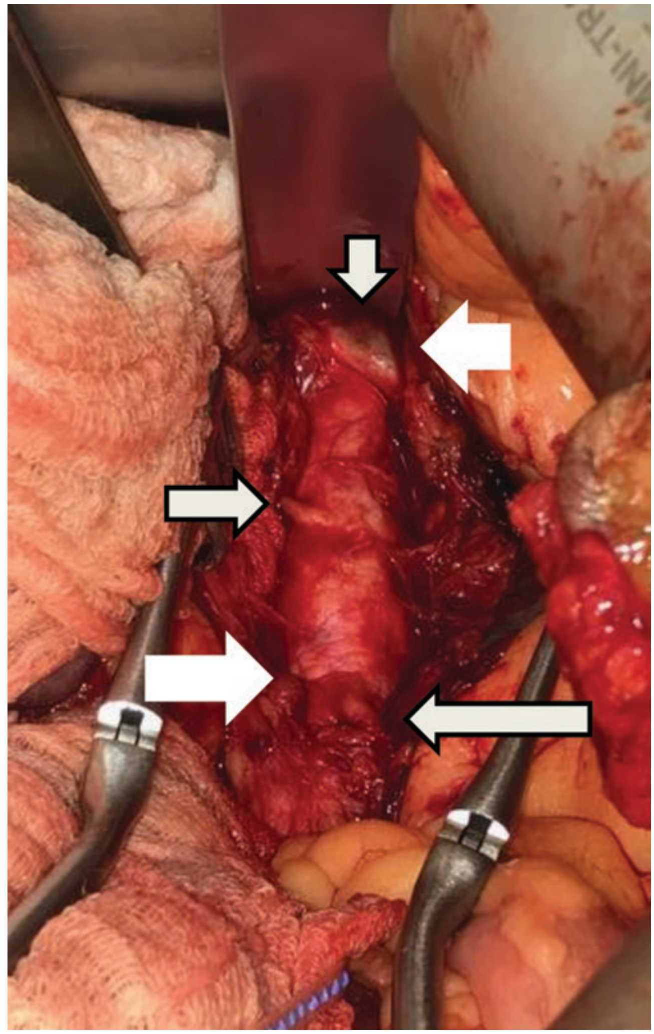


Fig. 15.7 Intraoperative exposure of the aorta (Short arrow: Renal vein, Middle arrow: Accessory right renal artery, Long arrow: Inferior mesenteric artery)

(Fig. 15.12). Upon the completion of the anastomosis, the anesthesia team has to be alerted prior to removal of vascular clamp.

Other Anatomic Revascularization

Aortoiliac Endarterectomy

Patients with limited disease in the distal aorta or proximal common iliac artery are considered for this procedure. After the dissection of the aortic wall, endarterectomy is performed using a longitudinal incision in the distal aorta and onto the common iliac arteries as needed (Fig. 15.13). Advantages of the procedure include lack of prosthetic material and exceedingly low potential for graft infection. However, this is performed very infrequently today, given the tremendous advances in endovascular angioplasty and stent procedures.

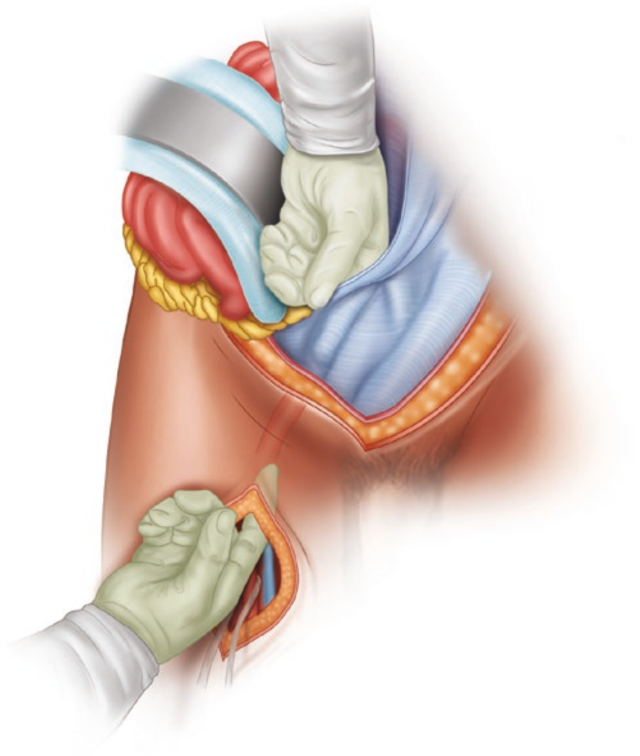


Fig. 15.8 Creation of tunnel between the aorta and the femoral artery. Tunnel should be placed underneath the ureter to avoid hydroureter

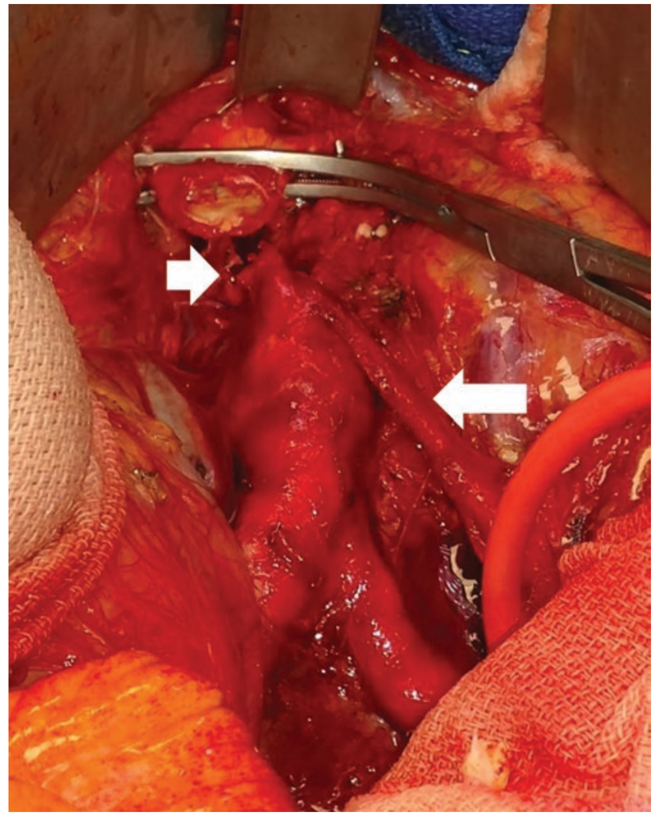
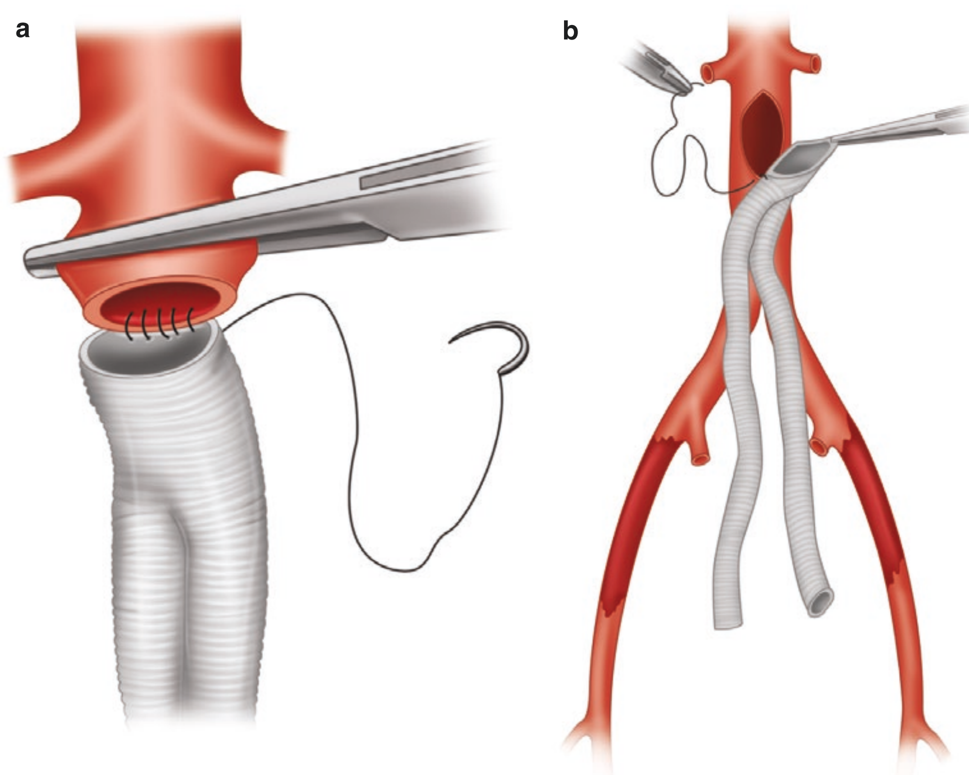


Fig. 15.9 Proximal aortic control and transected aorta. (Short arrow: Oversewn aortic stump, Long arrow: IMA)

Fig. 15.10 Aorto-femoral graft proximal anastomosis (**a**) End-to-end anastomosis, (**b**) End-to-side anastomosis)



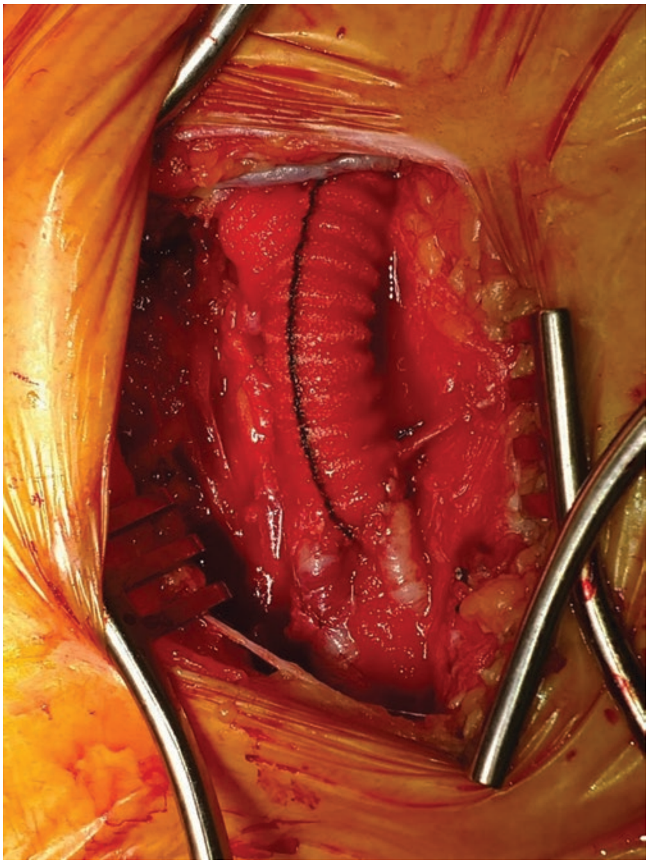


Fig. 15.11 Femoral arteriotomy onto the profundal femoris and anastomosis

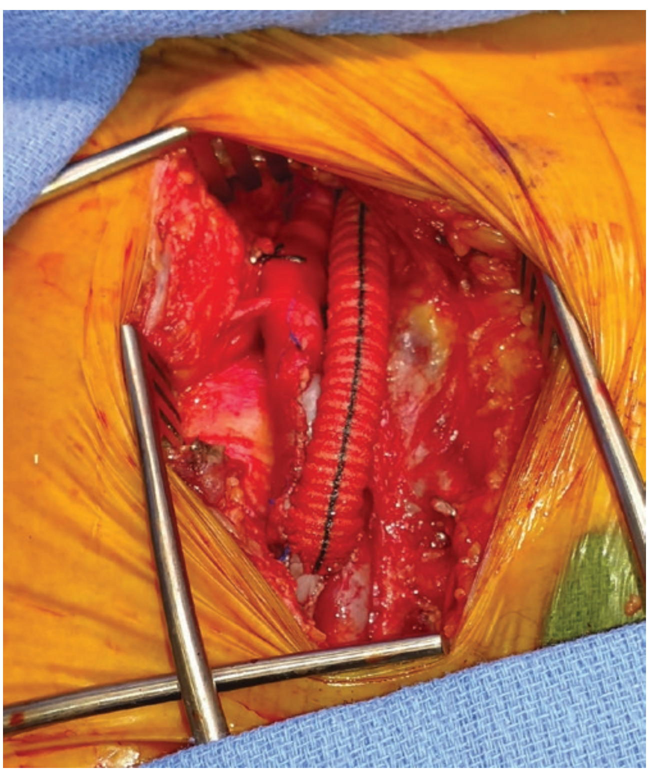


Fig. 15.12 Femoral anastomosis after bovine patch angioplasty

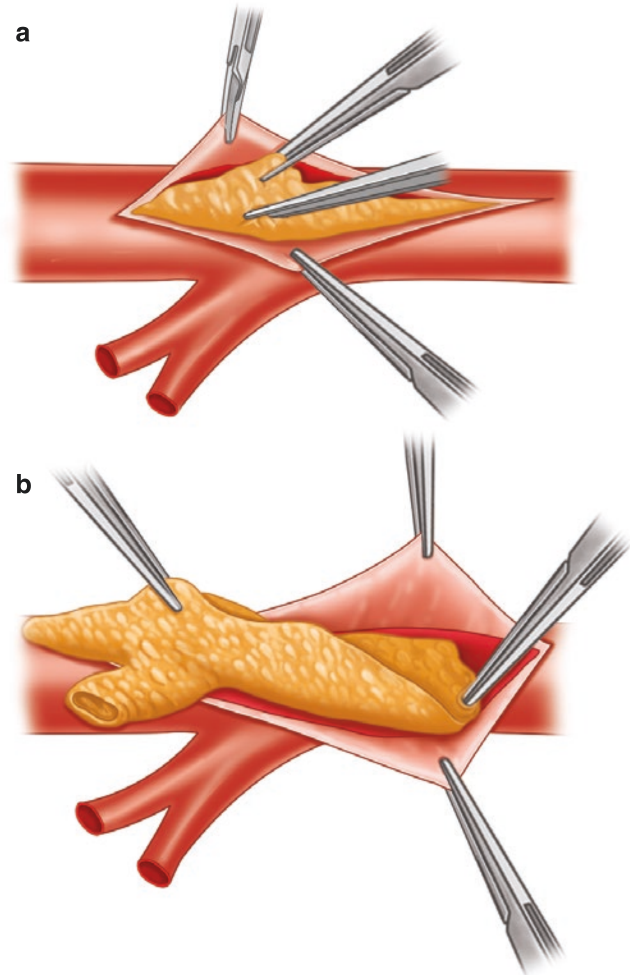


Fig. 15.13 Techniques of aortoiliac endarterectomy. (**a**) Initial separation of the plaque. (**b**) Endarterectomy is terminated by feathering to a tapered endpoint. If not, may need tacking sutures

Iliofemoral Bypass

With advances in catheter-based procedures, unilateral iliac disease rarely requires open surgical reconstruction. When endovascular intervention is impossible, unilateral iliofemoral bypass or extra-anatomical bypasses such as femoral-femoral or axilla-femoral bypass are viable options. Surgical technique of the iliofemoral bypass is similar to aorto-femoral bypass.

Extra-Anatomic Revascularization

Extra-anatomic revascularization was developed as an alternative to direct aorto-bifemoral bypass for patients with high comorbidities or with hostile abdomen from previous major abdominal surgery, infection, or radiation. The first femoral-femoral bypass was described by Freeman in 1952 [38] followed by introduction of axillo-femoral bypass in 1963 [39, 40]. After many years of experience and retrospective studies, these extra-anatomic bypasses have proven to be a safe and durable alternative of direct surgical revascularization.

Femoral-Femoral Bypass

Femoral-femoral bypass can be used in unilateral iliac disease when the donor iliac artery can supply enough blood flow to both donor and recipient legs (Fig. 15.14). Typical bilateral femoral incisions can be made (See Aorto-bifemoral Approach). The common, superficial, and deep femoral arteries are dissected and ready to be controlled.

Then the plane for tunneling of the bypass graft is created in the immediate prefascial subcutaneous layer. Similar to aorto-bifemoral bypass, blunt dissection using surgeon's finger from both sides is usually enough to create the space. Then a DeBakey aortic clamp or ring forceps can be used to pull the graft from one side to the other. At this time, attention should be paid to reduce risk of graft kinking or injury to hollow viscus in an unexpected hernia. An 8-mm diameter externally supported ringed PTFE graft is our preferred choice of graft.

After appropriate systemic anticoagulation was obtained, bilateral femoral arteries and their branches are controlled and longitudinal arteriotomy is made. The size of the arteriotomy is usually 2.5 to 3 times larger than diameter of the graft. End-to-side anastomosis is created using 5–0 or 6–0 vascular sutures in running fashion. Prior to completion of anastomosis, brief release of the arterial clamp and vessel loop will allow expulsion of air and other debris.

A sterile handheld Doppler will help to confirm successful inflow into the recipient femoral vessels. The incisions should be closed with at least two layers, preferably more, given the high incidence of wound infection.

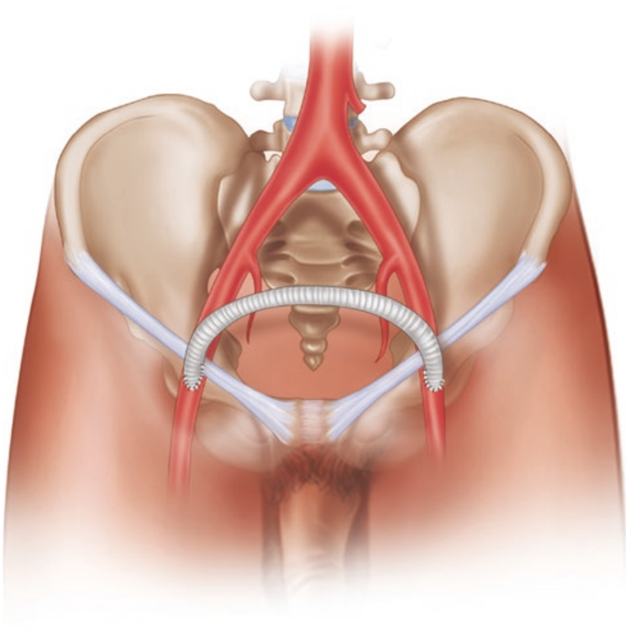


Fig. 15.14 Typical configuration of femoral-femoral bypass

Axillo-Femoral Bypass

Axillo-femoral bypass is another option for patients who are precluded from anatomic bypass or femoral-femoral bypass and often performed as axillo-bifemoral bypass in a patient.

Either axillary artery may be a donor artery. In the case of an axillo-unifemoral bypass, the ipsilateral axillary artery is almost always the donor vessel. With any evidence of donor artery stenosis (e.g., unequal arm blood pressure measurements), preoperative duplex ultrasonography or CT angiography is warranted.

A soft roll or gel pad is placed underneath the chest with the patient in supine position to increase the working area underneath the clavicle. Wide prepping and draping including ipsilateral neck, clavicle, chest, and sternum is necessary. In an obese patient, it may be necessary to abduct and prep the arm into the surgical field. Infraclavicular transverse incision is made below the mid to lateral clavicular area. The deep fascia is incised and pectoralis major muscle fibers are split. After mobilizing the axillary vein which is anterior, the axillary artery is dissected free close to clavicle.

After typical femoral dissection, a subcutaneous tunnel is created between the axillary artery and the ipsilateral groin. The tunnel should traverse below the pectoralis minor and medial to the ASIS. A tunneler can be used, but depending on the height of the patient, a counter incision at the lateral mid-thorax may be needed. An 8-mm externally ringed PTFE graft is the conduit of choice with premade axillo-bifemoral PTFE conduits available to decrease intraoperative time.

Appropriate systemic anticoagulation is achieved; end-to-side anastomosis is created using 5–0 or 6–0 vascular sutures in running fashion. Since the axillary artery can be easily pulled or kinked with arm abduction, medial placement of the proximal anastomosis close to the subclavian artery is recommended to limit tension of the graft with arm movement [41]. Femoral anastomosis and wound closure are the same as femoral-femoral bypass.

Results of Surgical Revascularization

In the most recent series, aorto-femoral bypass graft showed nearly 90% graft patency at 5 years (Table 15.1). Type of approach (transperitoneal vs retroperitoneal) or type of anastomosis (end-to-end vs end-to-side) does not appreciably alter the results.

Extra-anatomic bypass, in general, is inferior in longer-term outcome although this still revealed acceptable 5-year patency rate up to approximately 70%. Thus, these interventions should be reserved for patients who are not good candidates for direct aortic revascularization.

Table 15.1 Result of surgical revascularization

Procedure	5-year patency (%)	Perioperative morbidity (%)	Operative mortality (%)
Aorto-femoral bypass	80–95	10–30	2–4
Ilio-femoral bypass	80–90	10–25	1–3
Femoro-femoral bypass	55–85	10–25	1–3
Axillo-bifemoral bypass	50–75	10–40	1–4
Axillo-femoral bypass	45–70	10–40	1–4

Conclusion

Aortoiliac occlusive disease is a slow irreversible process of atherosclerosis. Modifiable risk factors such as hypertension, diabetes, dyslipidemia, and cigarette use have to be addressed early. Patients with lower extremity ischemic symptoms need a careful assessment of perioperative risk factors and a discussion of endovascular options. However, open surgical revascularization remains a viable option for patients with advanced disease or failed endovascular therapy.

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