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Lower Extremity Intervention

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INTRODUCTION

It is significant that nearly 40 years after the introduction of angioplasty by Dotter and Judkins and ultimate streamlining of the procedure through the introduction of the angioplasty balloon by Gruentzig, that this form of treatment remains the mainstay of therapy for patients with peripheral occlusive disease affecting the aortoiliac and superficial femoral segments (1, 2). In the interim, since these initial reports, numerous interventional therapies have been introduced to try and improve upon the effects of angioplasty. None of these technologies have proven effective in completely eradicating recurrent disease in these vessels. Significant advances have been made with the introduction of stents (3–5), atherectomy, and manipulations of the angioplasty balloon to try and improve its efficacy. While we are clearly making progress in terms of the minimally invasive treatment of occlusive disease of the lower extremity, much needs to be done in order to enhance the effectiveness of these less morbid procedures. In the current setting, there remains a significant role for bypass surgery as a method of treatment for patients with occlusive disease as well. It is important for the interventionalist not only to understand the benefits and roles of all of the interventional options available to treat lower extremity occlusive disease, but to also understand when surgical treatment of this disease would provide a better option for the patient. Because of the investigations into alternative therapies for treating these patients, it is likely that there will be continued change over the next several years in terms of options available to patients.

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Table 1
Therapies for Patients with Peripheral Arterial Disease

Smoking cessation
Weight reduction
Regular exercise program
Antiplatelet therapy
Lipid lowering agents
Primarily statin therapy
Diabetes management
Blood pressure control
ACE inhibitor therapy
Cilostazol
Percutaneous revascularization
Surgical revascularization

Hopefully these options will be critically assessed with randomized trials so that evidence-based decisions can be made regarding treatments for patients with peripheral occlusive disease (Table 1).

INDICATIONS

Indications for lower extremity intervention have not changed dramatically since the introduction of angioplasty for the treatment of occlusive disease. These indications are normally broken down into two different classification: those patients with disabling claudication and those with critical limb ischemia. The definition of disabling claudication varies widely among physicians caring for these patients, but it is more often based upon patients' impressions of their levels of disability and walking limitations. Claudication, simply put, is pain upon walking. It can have a vascular cause or in some situations other causes. Walking normally leads to an increase in oxygen demand in the muscles of the lower extremity. In normal individuals, the flow of blood increases as the need for oxygen increases. In patients with peripheral arterial disease, the ability of the flow to increase is limited because of fixed stenosis or occlusion in the blood vessels. In these individuals, the oxygen demand outstrips the blood supply. The lack of adequate oxygen supply leads to carbohydrate metabolism along anaerobic pathways leading to the production of lactic acid. The buildup of lactic acid in the muscle tissue leads to pain and ultimately, muscle failure. The patient may feel this as pain, cramping, or simply may label it fatigue. Even with normal blood pressure in the ankle at rest an individual may be unable to increase blood flow adequately during demand leading to claudication. The best test to assess for the presence of vascular disease as a cause of claudication is the exercise treadmill test with ankle-brachial pressure measurements. This test will reveal whether the patient's blood vessels in the lower extremity are able to accommodate to increase the amount of blood flow needed by the muscles of the lower extremity. In the setting in which the blood flow is fixed by the extent of disease above a dilated vascular bed, the pressure below the fixed defect will drop and the ankle-brachial index will fall with exercise. This is an important method of distinguishing vasculogenic from nonvasculogenic causes of claudication.

Critical limb ischemia refers to the situation where the ischemic threat to a patient's limb is such that the risk for limb loss is significant. Patients will either report rest pain or may have tissue loss or even gangrene of a portion of the foot. These patients will have such severe limitation of the arterial flow to the foot that the decrease in pressure generated by elevating the foot at night may be enough to lead to inadequate tissue oxygenation and subsequent lactic acidosis and pain. Often, the patient with rest pain will find relief in leaving the foot dependent. It is for this reason that some individuals with rest pain will present with significant edema, complicating the initial evaluation. For these patients, any small injury to the foot or overgrowth of fungus between the toes can lead to an infected wound and ultimately the risk of limb loss. For those patients with a wound on the foot and an ankle-brachial index below 0.4, the diagnosis of critical limb ischemia must be made. Often however, the patient will not have meaningful pressures at the ankle because of severe vascular calcification. In this situation additional testing with toe pressures or pulse volume recordings will be necessary to make the diagnosis. Patients with critical limb ischemia generally benefit from revascularization.

Therapy for the Patient with Peripheral Arterial Disease

It is important to remember that in the majority of patients with claudication in general, the progression of disease is slow and the likelihood of ultimately needing amputation is extremely small (6, 7). While over the long run, these patients can develop ischemic rest pain and ischemic ulceration, there is no evidence that withholding early intervention precludes later revascularization. It is also important to remember that in these patient populations, the largest risk to the patient derives from the likelihood of systemic vascular events (e.g., myocardial infarction) and the development of malignancy (6–8). As such, medical therapy for these patients must include aggressive intervention to lower their overall cardiovascular risk.

There is clear evidence that smoking cessation should be pursued aggressively in these patients to reduce the progression of their claudication and peripheral arterial disease as well as to reduce the overall risks to their health in terms of cardiovascular complications from atherosclerotic vascular disease (9, 10). Whether or not the patient receives intervention, smoking cessation should be a significant part of the treatment of these patients. Beyond smoking cessation, patients should also be counseled regarding the benefits of weight reduction and regular exercise. The benefits of weight reduction include a reduction in the incidence and progression of diabetic disease and complications as well as a lower overall mortality from cardiovascular diseases (11, 12).

In multiple studies, regular exercise has been proven to improve overall walking distance and pain free walking distance (13, 14). In addition to improving walking ability, there is evidence that regular exercise, especially when supervised, may be helpful in improving the cardiovascular risk profile of individuals undergoing this form of therapy (15).

In addition to these lifestyle modifications, which can benefit patients, there is significant evidence that basic medical therapy should accompany any form of treatment of patients with peripheral arterial disease. The primary medications that should be utilized in treating these patients include some form of antiplatelet therapy, medication for cholesterol level modification and lipid lowering, aggressive therapy for control of

diabetes and hypertension, along with the potential for pharmacologic therapies to improve walking distance. Of these varying therapies, the least likely to result in long-term health benefit is the medical therapy for claudication itself. For this reason, the associated medical therapies of antiplatelet treatment, diabetes and hypertension management and lipid modification, should remain as a primary form of therapy in all patients with peripheral vascular disease. The evidence for aspirin or at least some form of antiplatelet therapy has been well documented in multiple studies (16, 17). While there is some evidence that clopidogrel may offer improved risk reduction in these patients it is clear that at least some form of antiplatelet therapy should be incorporated as part of the treatment of these patients (18).

Diabetes in and of itself confers a markedly increased risk of developing claudication and the complications of peripheral arterial disease (19–22). In those patients with diabetes, aggressive glycemic treatment has been shown to reduce diabetes-related complications. While this treatment did not result in a lowering of the risk of amputation from peripheral arterial disease, there is clearly systemic benefit in the aggressive treatment of a patient's diabetes and this should be pursued in patients with peripheral arterial disease (23). As with diabetes, hypertension is associated with at least a two to threefold increased risk of atherosclerotic disease progression (24). These patients with hypertension are also at significantly increased risk for progression of their PAD to that of a symptomatic stage with claudication (19, 25, 26). While there is no direct evidence comparing aggressive management of hypertension in patients with peripheral arterial disease to a more lax approach to this problem, consensus still maintains that more aggressive management of blood pressure and hypertension is warranted in these patients to reduce atherosclerotic progression and overall occurrence of cardiovascular end points (26). In terms of choices of therapies to treat the hypertension, there is no evidence that beta-blockers worsen claudication and these agents can be used when indicated in treating patients with hypertension; however, angiotensin converting enzyme inhibitors (ACE inhibitors) are a more appealing initial therapy in patients with peripheral arterial disease (27). These agents have been shown to reduce atherosclerotic progression beyond that created solely by an antihypertensive effect and function with diminished cardiovascular complications (28–30).

There is no direct evidence that aggressive lipid management in patients with peripheral arterial disease alone affects cardiovascular morbidity and mortality. Despite this, there is significant evidence that in patients with coronary artery disease, aggressive management of lipids has significant beneficial effect in cardiovascular risk reduction and reduction in symptomatic atherosclerotic disease progression (31–33). There appears to be the potential for these lipid lowering agents to also have an effect on walking speed and distance as well as a lower rate of annual decline in walking ability (34, 35). All of this evidence favors an aggressive posture in dealing with the management of patients with peripheral arterial disease.

All of these medical interventions should be part of the treatment plan for patients with identified peripheral arterial disease. Once the patient becomes symptomatic, however, decisions need to be made regarding potential interventions to improve the functional status or perhaps even the limb retention of the patient in question. For those patients with claudication, an exercise regimen, especially when performed in a supervised setting, can have a more significant impact than any medical therapy that has been

developed to date (13, 36). There are clearly benefits to pharmacologic therapies for treatment of claudication. Both pentoxifylline and cilostazol have shown benefit in randomized placebo controlled trials (37–43). The benefits of these medical therapies, however, are limited. Pentoxifylline, while it has shown overall a benefit when compared with placebo, achieves limited benefit at best. Patients will not have tremendous improvement in their walking abilities with pentoxifylline alone. Cilostazol also, has shown the capacity to improve walking ability and, in one of the largest studies performed to date on this drug, the increase in walking ability was only twice that achieved with placebo given in randomized fashion to affected patients (39).

Because medical therapies have proven extremely limited in treatment of patients with claudication, many patients and physicians have looked to interventional therapies to improve functional status and walking ability with revascularization techniques.

Unfortunately, there is little meaningful evidence upon which to base decision making regarding revascularization. Randomized trials comparing angioplasty with medical therapy have shown conflicting results (44–49). Because of the confusing results of these trials which partly relates to the difficulties in performing this type of randomized trial, it is important in the long run to have additional data comparing the outcomes of the best medical therapy, which should include an exercise regimen, to best medical therapy with an exercise regimen and some form of revascularization procedure. In order to determine what to do with patients suffering from claudication, in each individual case, the physician will need to weigh the risks and benefits of intervention when compared with the disability caused by the peripheral arterial disease. The more significant the disability, the more likely the patient is to push the physician in the direction of interventional therapy. Additionally, for these extremely limited patients, the ability to even perform regular exercise is difficult at best. For those patients with mild claudication, initial attempts at medical therapy with an exercise regimen should be incorporated as the front-line of therapy. Failure of the medical regimen with progression of their symptoms may prompt an aggressive posture towards revascularization of the lower extremities. Conversely, in patients with severe limitation from their vascular disease, an earlier move to revascularization would be warranted not only to improve the symptoms for the patient, but to also allow the patient to begin an exercise regimen as part of their overall health maintenance.

For those patients with critical limb ischemia, which includes the patient with rest pain or tissue loss related to ischemia, there is no question that revascularization techniques have benefit in reducing the risks related to limb loss (50–53). Primary amputation without revascularization in this population ranges from 10 to 40% over 6 months after the initial identification of ischemic tissue loss (51, 52). It is particularly notable that in those patients with more limited flow to the foot, the amputation rates are exceedingly high. In addition, these patients carry significant risk of mortality with mortality rates from 10 to 30% per year (51, 52). In these patients, the choice between percutaneous revascularization and surgical revascularization has also not been answered (54). The results of the only randomized clinical trial comparing bypass with angioplasty, the BASIL trial, seem to be somewhat ambiguous (55). When the outcomes were assessed at 2 years after randomization, there appeared to be no difference between an interventional first versus a bypass first revascularization strategy. Beyond this 2-year point, there appeared to be a benefit for those patients who underwent open

bypass revascularization as the initial method of therapy. There are flaws with this trial that limit its applicability to the general population with critical limb ischemia. These problems include the large number of patients who were evaluated but did not meet the criteria, as well as varying definitions of suitability for interventional and surgical therapies. Furthermore, the authors examined patients with “severe leg ischemia” in contrast to critical limb ischemia, which is often more clearly defined in the literature. They did not provide any objective information regarding degree of limb ischemia such as ankle-brachial index, toe or ankle pressure, and transcutaneous oximetry. As such, the authors failed to distinguish different outcomes in the spectrum of patients that exists within the category of severe limb ischemia. For instance, although the authors did demonstrate that there was no difference in the number of patients with ankle pressures above and below 50 mmHg between the two arms, each group was individually inadequately powered. It is likely that patients with relatively higher ankle pressure may behave differently clinically in terms of overall survival and amputation-free survival, two of the primary endpoints, from those with lower pressures but the BASIL trial does not allow us to draw any easily translatable conclusions. With this said, it is fairly clear that in patients that have high risk for surgical revascularization either for medical reasons such as underlying cardiac or pulmonary disease, or for those patients who have high risk due to complicated surgical revascularization such as those patients with inadequate venous conduits, poor distal targets, and significant wound problems which would expose the bypass graft to infection, percutaneous intervention offers a reasonable initial attempt to revascularize the foot and save the limb. In fact, in many situations where surgical revascularization provides a viable option for limb salvage, percutaneous therapy may be a reasonable initial maneuver with surgical bypass reserved for those patients who fail this strategy. Until more information is collected regarding those patients who would benefit from surgical revascularization versus those who would benefit from percutaneous revascularization, the decision making will be in the hands of the physician caring for these patients. A thorough understanding of the risks and benefits associated with each form of therapy is necessary in order to make an educated decision regarding the strategy to treat each patient.

ROLE OF SCREENING TESTS: WHEN ARE THEY APPROPRIATE AND IN WHOM?

Routing screening for asymptomatic peripheral arterial disease in the general population has not proven to be cost effective and, in fact, the US Preventive Services Task Force guidelines have not recommended routine screening for peripheral arterial disease and intermittent claudication (56, 57). Briefly, the task force does not recommend screening with even an ankle-brachial index to detect asymptomatic peripheral arterial disease. These recommendations are based upon the potential harms of screening that include false positive results and adverse events associated with a more aggressive diagnostic work-up including angiography and the potential contrast and intervention related complications, which could ensue. Despite this, there are at least two well-performed screening studies that assessed the feasibility of detecting peripheral arterial disease and the intensity of risk factor treatment in those patients who were identified to have peripheral arterial disease during these screening evaluations (58, 59). In both

of these studies, a significant percentage of the patients were identified as having undocumented asymptomatic peripheral arterial disease, and notably in this extremely high-risk group of patients, few were receiving appropriate therapy in terms of antiplatelet therapy, adequate blood pressure control, cholesterol modification, and estrogen replacement therapy. As our population ages, the need for aggressive management of cardiovascular risk factors will increase. Specifically in those patients above the age of 60–65, the risk of peripheral arterial disease continues to increase dramatically. It is not until these patients are recognized and adequately treated for their overall atherosclerotic risk, that reduction in morbidity and mortality related to cardiovascular disease can be achieved. Clearly in the group of patients with underlying alternate site atherosclerotic disease, screening for peripheral arterial disease is warranted. In these patients, an understanding of the extent of the disease and its implications for the patient are important and should be part and parcel of treating these patients.

The screening test to perform for identifying patients with PAD is simple. The most straightforward and reproducible of the screening tests is the ankle-brachial index. This test is performed by measuring the arm blood pressure in both arms and comparing it to a pressure obtained with a blood pressure cuff just above the ankle and Doppler insonation of the posterior tibial and dorsalis pedis artery. The higher of the two pressures at the ankle level is compared to the higher of the two arm pressures to give an ankle to brachial pressure ratio. An ankle-brachial index of less than 0.9 is considered to be abnormal, indicative of peripheral arterial disease. The lower the index beyond 0.9, the more significant the peripheral arterial disease, and the more significant the risk of cardiovascular events in the patient. This test can be abnormal or difficult to interpret in the diabetic patient or those with calcified vessels; however, it is extremely reproducible and reliable in the vast majority of patients evaluated in the clinician's office.

CONTRAINDICATIONS

There are few contraindications to revascularization in the individual with severe claudication or critical limb ischemia. There are clearly situations where either percutaneous therapy or surgical therapy to revascularize the limb has a distinct advantage. But especially in the patient with critical limb ischemia, the only things that should limit the progression toward revascularization of the limb are systemic comorbidities that make any form of revascularization high risk. Since these patients are at significant risk of coronary and cerebrovascular disease, patients with symptomatic carotid disease and other severe congestive heart failure or symptomatic coronary ischemic syndromes or for that matter any ischemic symptomatology that affects a critical vascular bed, the revascularization strategy should initially involve treatment of the other ischemic bed to preserve the life of the patient prior to proceeding with revascularization of the ischemic limb. Table 2 highlights some situations where preference might be given to either surgical or percutaneous revascularization to deal with the limb ischemia a patient is experiencing.

The other situation in which revascularization may be contraindicated is in the patient with such severe limb ischemia that revascularization will not allow retention of a meaningful walking surface for the patient. This can happen in the diabetic with extensive infection that can spread to the midfoot and can also occur when the ischemia has

Table 2
Intervention Factors

Factors Favoring Percutaneous Intervention

Prohibitive patient comorbidities (e.g., severe CAD, CHF, COPD, etc.)

Symmetric lesions

Noncalcified lesions

Short segment disease

Tissue loss in anatomic configuration likely to predispose to graft infection

Factors Favoring Open Surgical Intervention

Eccentric lesions

Calcified lesions

Long segment disease

Lesions across joints in association with extensive disease above or below this region

Femoral bifurcation lesions

Extensive tissue loss in the foot

been long standing and not addressed. Exposing this patient to the risk of revascularization when there is an extremely high likelihood of progressing to amputation is not a reasonable alternative. There are situations when the co-existing diseases preclude the ability to achieve adequate revascularization necessitating continued medical therapy and perhaps primary amputation. An example of this might be a patient with symptomatic congestive heart failure. In this situation, even percutaneous therapy for revascularization carries some risk and in certain instances, continued medical therapy may offer the patient the best chance for survival.

TECHNIQUES

The methods for treating peripheral arterial disease are best divided between the iliac artery system and the infra-inguinal segment. Iliac artery disease is usually a bit easier to deal with and is usually addressed first in those patients with peripheral artery disease, so the technique for treatment of these vessels will be addressed first.

Iliac artery lesions can be addressed from one of three approaches. The first of these approaches is ipsilateral femoral access with retrograde passage through the lesion. The second approach is contralateral femoral access with wire passage over the aortic bifurcation and antegrade passage of the wire through the lesion, and finally the third approach is transbrachial with retrograde access in the brachial artery and passage through the descending thoracic and abdominal aorta to achieve antegrade passage of the wire through the iliac artery from the arm. The ipsilateral approach can be combined with either of the other approaches in challenging iliac artery occlusions, but in most instances, one of these approaches will be successful. It is helpful to have some assessment of the anatomic problem ahead of time in order to plan the approach. For common iliac artery stenosis, the simplest approach is the ipsilateral femoral puncture with retrograde wire passage. In this setting, access is obtained in the common femoral artery. This access can be achieved with percutaneous puncture or utilizing ultrasound guidance, depending upon the strength of the ipsilateral pulse and the familiarity of the

interventionalist with this approach. Passage through the lesion is facilitated by the use of a hydrophilic, angled guide wire, which can be rotated to assist with advancement across the lesion. Once access is achieved across the lesion, confirmation of placement in the true lumen of the vessel above the stenosis is mandatory. This is initiated by assessing for the passage of blood through a catheter passed over the wire and measuring pressures above the stenosis, by connecting the catheter to a pressure gauge, or in some instances, simply by injecting contrast through the catheter under fluoroscopic guidance to visualize the contrast within the vessel lumen. This concept of assessing the catheter position within the vessel beyond either the stenosis or the occlusion is routine and mandatory when treating these lesions. After completing the traversal, a flush catheter is advanced over a wire to within the aorta above the area of the blockage. Normally a pelvic aortogram will provide adequate images of the vasculature above the lesion and the vessels beyond the area to be treated. These images can provide a roadmap for proceeding with interventional therapy for the stenosis. The key issue of performing the intervention is achieving and maintaining wire access across the lesion. For most stenotic lesions, this can be achieved from the ipsilateral approach.

Occlusions on the other hand provide a more demanding approach and ipsilateral access may often not be the best strategy. Most plaque in the iliac arteries, especially when occurring in the common iliac arteries, originates in the aorta. In fact atherosclerotic plaque, in general, tends to become thicker and more heavily calcified the closer it is to the aortic wall. This thickening of the plaque close to the aorta makes traversing complete occlusions more challenging in the retrograde direction. In many situations, the best approach to cross these lesions will be either the contralateral femoral artery or the brachial approach. Both of these techniques allow the tip of the catheter to be lodged in the proximal “cap” of the occlusion and the wire slowly advanced into the occlusion. In most cases a rapid rotating motion, approximating a drill, with some forward pressure will allow initiation of the traversal across the cap of the lesion. This often proves the most vexing part of the recanalization process and usually, once entrance into the lesion is obtained, the wire can be advanced to the point at which it re-enters the true lumen of the vessel. This may involve subintimal passage of the wire through the arterial occlusion (60). In some situations, however, the true lumen cannot be re-entered and the wire remains in a subintimal plane even after the wire has been advanced beyond the point at which the vessel has reconstituted. This is particularly problematic when the re-entry cannot be achieved cephalad to the common femoral artery. In this situation, one can attempt to enter the same plane from the ipsilateral femoral approach. In advancing the wire here, the likelihood is that one will not be able to easily pass the wire into the true lumen at the other end of the occlusion. When this occurs, with access above and below the occlusion, and wires in the subintimal plane from both approaches, the wire from one end can be snared from the other end and through-and-through wire access can be achieved through the occlusion. To assist in the process of being able to either re-enter directly or to allow enough space to be created in which to snare the wire from the other direction, a low profile balloon can be inflated in the subintimal plane in the upper or lower portion of the occlusion. This inflation will enlarge the subintimal space and in some instances may create a channel directly into the true lumen, but in nearly all circumstances, will create enough space to allow for a wire to be snared and

through-and-through access to be achieved. In certain instances, access across the lesion will still remain elusive. Here one can use a re-entry device from either the arm or the groin to re-enter the true lumen at either the cephalad or caudad end of the occlusion. Using these combinations of techniques, nearly every iliac occlusion can be crossed and in most series evaluating this, at least 90% can be recanalized (61, 62). While some authors do advocate the use of lytic therapy to assist with lesion crossing (63, 64), this is rarely necessary to achieve access across iliac artery occlusions. Once access across the lesion has been achieved, treatment can be initiated.

In most instances, for noncomplex lesions of the iliac arteries, angioplasty of iliac lesions will provide adequate short- and long-term success rates that are comparable to primary stenting, and stenting can be reserved for those cases in which there is either recoil of the lesion, dissection or inability to achieve adequate luminal dilation.(65) When the lesions however are more complex, for example TASC C or D lesions (Table 3), the use of stents will likely need to be more liberal and the results are likely better with primary stenting (66). The only other technique in common practice that has been reported for treating iliac artery occlusive disease is covered stent placement (67, 68). There are limited data evaluating this and meaningful comparisons with uncovered stents is lacking. Situations where covered stents offer a clear advantage appear to be areas where there is extensive, irregular calcification which poses a rupture risk for dilation with balloon or uncovered stent. Additionally, in the setting of iliac rupture following initial treatment, covered stents provide the only reasonable method to avoid open surgical conversion. Results of interventional therapies for treating iliac artery occlusive disease are given in Table 4.

Determining equipment for treatment of the iliac artery lesions requires an understanding of the anatomy of this region and normal sizes of these vessels. Optimally, sizing of the interventional devices can be assisted by fluoroscopic measurement systems or intravascular ultrasound. These systems allow assessment of vessel diameters and lesion lengths. Balloon expandable stents are primarily utilized for origin stenosis of either the common iliac or in some instances the external iliac artery. These devices provide precision in placement and significant resistance to compression or crush. They tend to displace calcific lesions better and offer the ability to over-dilate the stents to an appropriate size. These stents, however, are less flexible and will often not be used in the external iliac arteries where arterial motion and flexion are common. These areas are treated with either angioplasty (Fig. 1) for noncomplex lesions or, if needed, self-expanding nitinol stents. These stents are usually oversized about 10–20% to provide adequate radial force to maintain the vessel lumen. It is important to remember that the most commonly ruptured peripheral artery undergoing interventional therapy is the external iliac artery, so caution must be used in deciding the diameter of the angioplasty balloon or stent to be used in this vessel.

Femoro-popliteal disease can be treated from one of three approaches as well. These approaches include contralateral femoral, retrograde access with treatment across the aortic bifurcation, ipsilateral femoral with antegrade femoral artery access, and finally, ipsilateral popliteal (with the patient in the prone position) and retrograde access in the popliteal artery to traverse the femoral lesion in retrograde fashion. The most commonly used of these approaches is the contralateral femoral approach with access across the

Table 3
TASC Classification (85).

TASC Classification of Iliac Disease**Type A**

- Unilateral or bilateral stenosis of the common iliac artery
- Unilateral or bilateral single short (less than or equal to 3 cm) stenosis of the external iliac artery

Type B

- Short (less than or equal to 3 cm) stenosis of infrarenal aorta
- Unilateral common iliac artery occlusion
- Single or multiple stenoses totalling 3–10 cm involving the external iliac artery not extending into the common femoral artery
- Unilateral external iliac artery occlusion not involving the origins of the internal iliac or common femoral arteries

Type C

- Bilateral common iliac artery occlusions
- Bilateral external iliac artery stenoses 3–10 cm long not extending into the common femoral artery
- Unilateral external iliac artery stenosis extending into the common femoral artery
- Unilateral external iliac artery occlusion that involves the origins of the internal iliac or common femoral artery or both
- Heavily calcified unilateral external iliac artery occlusion with or without involvement of origins of the internal iliac or common femoral artery or both

Type D

- Infra-renal aortoiliac occlusion
- Diffuse disease involving the aorta and both iliac arteries requiring treatment
- Diffuse multiple stenoses involving the unilateral common iliac artery, external iliac artery, and common femoral artery
- Unilateral occlusions of both common iliac and external iliac arteries
- Bilateral occlusions of the external iliac artery
- Iliac stenoses in patients with abdominal aortic aneurysms requiring treatment and not amenable to endograft placement or other lesions requiring open aortic or iliac surgery

TASC Classification of Femoropopliteal Disease**Type A**

- Single stenosis less than or equal to 10 cm in length
- Single occlusion less than or equal to 5 cm in length

Type B

- Multiple lesions (stenoses or occlusions), each less than or equal to 5 cm
- Single stenosis or occlusion less than or equal to 15 cm not involving the infrageniculate popliteal artery
- Single or multiple lesions in the absence of continuous tibial vessels to improve inflow for a distal bypass
- Heavily calcified occlusion less than or equal to 5 cm in length
- Single popliteal stenosis

Type C

- Multiple stenoses or occlusions totalling >15 cm with or without heavy calcification
- Recurrent stenoses or occlusions that need treatment after two endovascular interventions

Type D

- Chronic total occlusions of the common femoral or superficial femoral arteries (>20 cm, involving the popliteal artery)
 - Chronic total occlusion of popliteal artery and proximal trifurcation vessels
-

Table 4
Femoropopliteal interventions

	Primary Patency (Months)												Remarks
	% CLI	1	3	6	9	12	18	24	36	48			
PTA													
PTA with Stent	Conrad et al. (76)	46						64.3	54.3				Nitinol stent significantly superior
	Laird et al. (71)	0											
	PTA				47.4	36.7							
	PTA/S				94.2	81.3							
	Dearing et al. (77)	38.8											Nitinol stents
	PTA/S	TASC A/B				79	67	57					
	PTA/S	TASC C/D				52.7	36	19					
	Krankenberget al. (78)												
	PTA	3.5				38.6 ^a							Nitinol stent; no difference
	PTA/S	2.5				31.7							
	Schillinger et al. (70)												
	PTA	13		43 ^a		63 ^a							
	PTA/S	12		24 ^a		37 ^a							Nitinol stent significantly superior
Cryoplasty													
Directional Atherectomy	Gonzalo et al. (79)	100	100	91	91	91							56% of patients underwent PTA, 2% underwent stenting
	Laird et al. (80)	0				70.1							
	McKinsey et al. (81)	63.3					64.2	53.5					
Laser Atherectomy	Zeller et al. (82)						84	73					Adjuvant balloon angioplasty (96%) and stent (45%)
	Laird et al. (83)	100			93 ^b								
	Wissgott et al. (84)	11.9	93.8		78.2		58.8		42.8	33.6	26		

^aIndicates restenosis rates in lieu of primary patency.

^bIndicates limb salvage rate in lieu of primary patency.

PTA Percutaneous transluminal angioplasty; PTA/S Percutaneous transluminal angioplasty with stent.



Fig. 1. Iliac occlusion images.

aortic bifurcation. Normally, after imaging the pelvis nonselectively, access with catheter across the bifurcation can be achieved and selective access to the common femoral artery above the area of stenosis is obtained. Selective angiography of the lower extremity to be treated is performed from this position to assess the anatomy of the lesion and the runoff vessels beyond the area of disease. For stenotic lesions (Fig. 2), a 0.035-in hydrophilic guide wire is advanced across the lesion and the catheter then advanced over the wire through the lesion. Confirmation of access into a patent vessel beyond the area of stenosis is performed by manual aspiration of blood through the catheter followed by angiographic injection into the vessel. After confirming passage across the lesion, treatment can be initiated. In most instances, this will involve passage of a sheath across the aortic bifurcation to assist with passage of interventional devices and to allow for imaging of the lesion while maintaining wire access across the lesion.

In the setting of femoral artery occlusions (Fig. 3), following initial imaging of the vessels of the leg to be treated, one will likely need to obtain sheath access across the aortic bifurcation. Wire access normally must be achieved beyond the common femoral artery and in most instances, the wire is advanced into the profunda femoris artery and an interventional diameter sheath is advanced over the wire. The sheaths used are typically 6–8F and normally range in length from 45 to 55 cm. These are ring reinforced sheaths to prevent collapse of the sheath in areas of bending. This sheath provides stability for the catheter and wire during attempts to manipulate across the occlusion in the femoral artery. This sheath keeps the catheter from “buckling” up the aorta and lowers the potential for loss of wire access across the lesion. With the sheath firmly in place, an angled hydrophilic wire is advanced into the “cap” of the lesion and either an attempt at drilling across the lesion or subintimal techniques are utilized to cross the lesion. The subintimal technique has been described elsewhere (69) but involves forming the wire tip into a “J” configuration and advancing the wire through the occlusion and allowing it to re-enter the lumen after dissecting through the subintimal plane. Confirmation of access across the lesion into patent distal vessel must be confirmed.

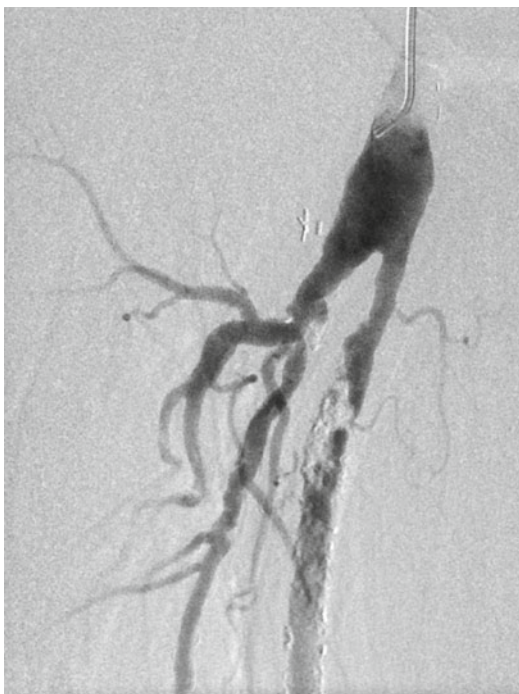


Fig. 2. Femoral artery stenosis images.



Fig. 3. Femoral artery occlusion images.

Sometimes the access from the contralateral groin will be impossible to achieve or will still limit recanalization attempts because of vessel tortuosity or buckling of sheath and catheter during attempts to cross the lesion. In these situations, the use of the ipsilateral femoral approach in antegrade fashion allows better pushability through the lesion without the concern for buckling of the access sheath. This approach, however, may be difficult with proximal superficial femoral artery (SFA) occlusions and in some situations may prove impossible to treat lesions that are high up along the path of the SFA. When alternate approaches have failed or the groin access is not useable because of infection or other issues, the patient can be placed in the prone position and access can be gained into the popliteal artery below the area of the occlusion. Surface ultrasound is routinely used to perform this access maneuver along with a lower diameter needle and wire access system for initial access into the artery. Normally forceful advancement of wire and catheter together will allow passage through the occlusion, and treatment can be initiated. Using this strategy, nearly 85% of femoral occlusive lesions will allow traversal, but there are still lesions which simply cannot be crossed with interventional therapies. As noted earlier, re-entry catheters can be utilized when the true lumen cannot be re-entered when using the subintimal technique.

Treatments for the femoro-popliteal segment are more varied related likely to the fact that the outcomes with all devices are not as successful as what is seen in the iliac arteries. Angioplasty with long, semicompliant balloons at low pressure for long periods of time (2–3 min) acts as a mainstay of therapy in this region, but there are clear advantages to stenting for occlusive lesions in this vascular bed (70, 71). Unfortunately, when recurrences do occur with stents, the treatment of these is much more complex. Angioplasty and stenting results are noted in Table 5 along with results for other interventional therapies for this segment. There is currently no single best therapy and each device has some advantages, while all have the disadvantage of limited patency rates. Atherectomy has the ability to allow avoidance of stents in areas of bifurcation or in areas of extensive flexion of the vessel, such as the popliteal artery. Cryoplasty has similar advantages with decreased need for stenting with similar patency rates. No one of these approaches has proven to be the answer to all issues and interventionalists treating patients in this area should have access to and experience with all of the differing types of devices. It is likely that some form of combined therapy (atherectomy and medicated stenting, or angioplasty and atherectomy) may provide the best alternative in therapeutic options, but none of these techniques, other than angioplasty and stenting have been compared in any meaningful way.

Postprocedural Care and Follow-Up

Care of patients following intervention is similar to that utilized after coronary stenting. The access site is compressed and activity level is limited depending upon how the access site has been treated. Careful attention to the access site must be maintained especially over the first 4–6 h and either additional compression or ultrasound guided compression or perhaps even thrombin injection should be utilized early if there are concerns and hematoma or pseudoaneurysm has been identified.

Nearly all patients are initiated and maintained on antiplatelet therapy with aspirin 325 mg (once daily) and clopidogrel 75 mg (once daily) to reduce platelet adhesion and activation. This aggressive antiplatelet approach is maintained for 4–6 weeks following

Table 5
Iliac interventions

		Primary Patency								Remarks
		% for CLI	1 Year	2 Year	3 Year	5 Year	6–8 Year	10 Year		
AbuRahma et al. (66)	Primary Stent	62	100	98	98	87			No difference between selective and primary stent groups for TASC A/B with significantly superior results for primary stenting in TASC C/D	
	TASC A/B									
	TASC C/D		96	90	72					
	Selective Stent	66								
	TASC A/B		100	93	85	85				
	TASC C/D		46	28	28					
Park et al. (72)	Primary Stent	N/A	95–96		84–85	81–85			No difference by TASC class	
	TASC A/B		93–94		74–94	74–78				
Klein et al. (65)	Primary Stent	5	96	94			90		No difference in freedom from lesion revascularization	
	Selective Stent	8	97	98			81			
Galaria et al. (73)	TASC A/B	23				53		24	Selective stenting in 51% without predefined criteria	
Powell et al. (74)		40	61		43				Multilevel iliac disease with stenting based on surgeon preference	
Tetteroo et al. (75)	Primary Stent	6							No difference	
	Selective Stent			71.3						
				69.9						

completion of the procedure. Follow-up for these procedures varies based upon the type of revascularization performed and there remains to be proven any advantage to routine imaging following these interventions; however, most interventionalists would recommend routine follow-up to allow intervention prior to failure of the revascularization, with an initial assessment performed within 6 weeks of the revascularization.

Duplex imaging of the revascularized vessel offers the best method of assuring patency of the revascularization strategy and assessment of the degree of narrowing. For iliac interventions, this will prove more challenging than with femoral artery interventions. The velocity criteria for determining stenosis vary; however, if the peak systolic velocity is >300 cm/s, one can assume that the degree of stenosis is significant enough to warrant further evaluation either with CTA or MRA or perhaps even direct angiography.

Although there are no standard recommendations as to when to perform this assessment, for iliac interventions, this assessment is usually performed at 6-month intervals for the first 24 months and then once annually following this. For interventions below the inguinal ligament, these assessments are routinely performed every 3 months for the first 12 months, then every 6 months for the next year and then annually thereafter. This is similar to imaging strategies performed for bypass grafting performed below the inguinal ligament. These duplex images are usually accompanied by ankle-brachial indices to assess the adequacy of blood flow to the feet. Evidence of significant elevation of the velocities or decrement in the ankle-brachial index should lead to a more in-depth assessment of the vascular status of the lower extremities. This assessment will also allow for evaluation of the contralateral extremity as it remains at increased risk of developing significant ischemia as well. Maintaining a close relationship with these patients is crucial and allows the physician to identify and treat those patients who develop problems early before these progress to a point where intervention becomes difficult.

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