INTRODUCTION
The treatment of lower peripheral artery disease (PAD) has evolved significantly over the last 30 years. Until the 1980s, interventions for PAD were all surgical in nature. Balloon catheter development has allowed for the treatment of atherosclerosis with endovascular techniques. What could once only be treated with a large operation and prolonged hospitalization can now often be treated with percutaneous intervention on an outpatient basis.

The risk factors for the development of PAD include increasing age, smoking, diabetes mellitus, hypertension, dyslipidemia and chronic renal insufficiency. It is estimated that in the United States and Europe, there are more than 27 million people with PAD. This number has risen by as much as 23.5% in the past 10 years.

The incidence of PAD increases with age and thus, as the “baby boomer” generation continues to age, the number of patients presenting with PAD will continue to increase over the coming years.

The inevitable outcome of untreated severe PAD is amputation. The five-year survival rate of patients with a below the knee amputation is around 50 percent. In fact patients who undergo below knee amputation have a lower five-year survival rate than patients with colon cancer, breast cancer, prostate cancer and melanoma. Only pancreatic cancer patients have a higher mortality rate. Thus, the treatment of PAD and its risk factors not only preserves quality of life but can also be life-saving.

SYMPTOMS
Patients with PAD may present with intermittent claudication (IC), critical limb ischemia (CLI), or acute limb ischemia (ALI).

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Arterial claudication is described as pain in one’s leg with ambulation of a set distance and is relieved by rest. This is typically located in the calf muscle and caused by mild to moderate arterial insufficiency. Claudication comes from the Latin word claudicare, which means “to limp.” It was first described by the French veterinary surgeon Jean-François Bouley Jeune in 1831. He performed an autopsy on a horse that was noted to limp while hauling its daily workload. The autopsy revealed bilateral femoral artery occlusion. Unlike the horse examined by Dr. Jeune, most patients do not limp, they stop walking to relieve the discomfort of claudication. These patients usually do not need to sit down to relieve the pain, as cessation of ambulation and standing immobile for a brief period of time will provide relief. While claudication can be disabling and prevent patients from being active or even working, it very rarely leads to limb loss.

On the other hand, critical limb ischemia is marked by rest pain with or without tissue loss. Tissue loss may include a non-healing lower-extremity ulcer or frank gangrene. Rest pain is a burning pain in the dorsum of the foot or toes when the leg is elevated (as when in bed, resting). It is caused by severe arterial insufficiency in the affected extremity. When the foot is in the dependent position, gravity helps pull blood into the foot, providing enough oxygen to the toes. When the leg is elevated, there is not enough blood flow to the toes and they hurt. The toes and dorsum of the foot are the first to hurt, because this is the part of the leg that is furthest from the heart and thus suffers the greatest decrease in blood flow from more proximal arterial blockage. Rest pain is a sign of severe arterial insufficiency and impending tissue loss. These patients require revascularization in the near future or they will develop ulcerations and eventually end up with an amputation. They will also have other signs of severe arterial insufficiency such as claudication, dependent rubor...
(redness of feet in dependent position and pale coloration with elevation) and hair loss. Patients with rest pain will often dangle their foot off their bed or sleep in a recliner with their legs dependent to relieve the pain and be able to sleep at night.

Acute limb ischemia (ALI) is identified by the sudden onset of severe symptoms. This often leads patients to seek immediate medical attention for unrelenting leg pain. Patients can often articulate the exact time of onset. ALI may be caused by acute thrombosis of chronic disease or embolic phenomena from a more proximal source such as an aneurysm or atrial fibrillation. No matter the etiology, ALI is a surgical emergency, and failure to restore blood flow in the first few hours will result in nerve injury, muscle necrosis and ultimately loss of limb.

DIAGNOSTIC STUDIES

Diagnostic tests used to diagnose and evaluate the severity of arterial insufficiency, be it acute or chronic, include ultrasound (US), non-invasive arterial studies such as the ankle brachial index (ABI) and pulse volume recordings (PVRs), computed tomography angiography (CTA) and angiography. Each of these has its own advantages and limitations.

US is non-invasive and inexpensive and an excellent screening tool for diagnosis of significant stenosis and occlusion. It is particularly useful in the acute setting for the diagnosis of an acute thromboembolism as it can confirm the paucity of flow in the artery of concern. It is somewhat limited, however, in its ability to evaluate deeper more proximal structures such as the iliac arteries in the pelvis. Further, it is very technologist dependent, and the severity of the disease may be severely over or underestimated depending on the experience of the technologist and technique used.

Non-invasive arterial studies utilize the ratio of the blood pressure in the legs as compared to the arms to assess degree of arterial insufficiency. These studies have no role in ALI but are very helpful in CLI. The ankle brachial index is determined by dividing the blood pressure at the ankle by the brachial artery blood pressure. It should be 1.0 or higher if there is no disease. As the ABI decreases, the severity of the arterial insufficiency increases. For example, with an ABI of 0.4 rest pain is common and tissue loss becomes a concern. PVRs evaluate the flow at multiple levels throughout the bilateral lower extremities and help to delineate the level of disease. If there is a drop of 20% from one level to the next, this suggests significant stenosis at that level. For example, if the high thigh index is 1.0 and the low thigh index is 0.8, then there is significant disease in the superficial femoral artery. Further, waveform analysis can help localize disease level and severity as the waveforms become blunted below the level of hemodynamically significant stenosis. This is especially useful in diabetics who may have falsely elevated ABIs or even non-compressible arteries. Toe pressures are also useful in diabetics to determine healing potential as these (continued on next page)
vessels are typically not calcified even with severe more proximal disease. CTA allows for evaluation of both the level and severity of lower extremity arterial insufficiency. It is useful for surgical planning and may help identify potential distal targets for bypass. It requires an intravenous contrast bolus and thus may be contraindicated in patients with renal insufficiency. It is further limited by the fact that it is diagnostic only and intervention at the time of the study is not possible.

Angiography is both diagnostic and potentially therapeutic as the surgeon performing the angiogram may be able to perform angioplasty with or without stenting at the time of the angiogram. Similar to CTA, angiography will show both the level and severity of disease within the extremity examined. The drawback to angiography is the fact that it is an invasive procedure that requires accessing an artery (typically the common femoral artery), which may potentially result in complications. Further, sometimes intervention is not possible nor needed, and the patient ends up undergoing an invasive procedure without gaining any benefit. Angiography uses contrast similar to a CTA, although the typical dose is a fraction of that needed for a CTA. We currently offer CO₂ angiography for patients who have renal insufficiency or a contrast allergy. CO₂ angiography allows us to gather the same information as conventional angiography and even intervene on these patients without the risks of using iodinated contrast agents.

TREATMENT

The medical management of risk factors associated with PAD such as diabetes, hypertension and dyslipidemia is the first step in the treatment of PAD. Management of these risk factors will limit the progression of arterial disease as well as help maintain the patency of bypasses and stents placed. Further, patients with PAD have an increased risk of mortality compared to the average population, this is primarily due to cerebrovascular and coronary artery disease. The management of these risks factors will also reduce these patients' risk of heart attack and stroke.

The intervention with the most impact on risk reduction is smoking cessation, and this should be the first therapeutic goal. Antiplatelet therapy with medications such as aspirin and clopidogrel, are also an important part of the treatment strategy in these patients, to reduce the risks of heart attack and stroke as well as potentially
help maintain patency of bypass grafts and stents. It is well recognized that lipid modification with statins in coronary disease patients also leads to a reduction in cardiovascular events; further, it slows the progression of PAD. Supervised walking regimens have been shown to significantly improve walking distances in these patients. In fact, several studies have shown walking regimens to be as effective as endovascular treatment of aortoiliac occlusive disease. One medication, cilostazol, has been shown to improve walking distance in this patient population but must be avoided in patients with congestive heart failure. Intervention should only be contemplated after conservative management fails to improve quality of life.

The management of CLI with open or endovascular interventions should include continued maximal medical therapy. The decision as to which interventional therapy is most appropriate for a given patient should take into account all of the following: surgical risks, life expectancy, severity of disease and symptoms, anatomical pattern of disease, and the availability of vein for bypass. Many vascular surgeons apply an “endovascular-first” approach to treatment of PAD. With careful application, this approach does not preclude future bypass surgery even if the initial endovascular therapy fails months or years later.

In 2000 and again in 2007, a multi-specialty group including both medical and surgical vascular specialists generated the Trans-Atlantic Inter-Society Consensus (TASC and TASC II) documents on the management of PAD. These are the basis for recommended treatment paradigms today. TASC and TASC II created a classification of arterial lesions into two areas, the aortoiliac and femoropopliteal arteries, and divided the severity of the disease in each of these levels into four categories A-D. The recommended treatment of the least complex (A) lesions is endovascular therapy, and the most complex (D) lesions is with bypass surgery. For TASC B and C lesions, there is insufficient evidence to recommend one modality over the other, but B lesions are thought to be best treated with endovascular techniques and C lesions with open surgery (Figures 2-3). As technology has improved, particularly with the routine use of stents, virtually all TASC A, B, and many C femoral artery lesions are being treated initially with endovascular techniques. Bypass is reserved for relatively healthy patients with TASC C and D lesions or in those patients in which previous endovascular therapy has failed.

The ultimate decision of mode of therapy should also take into account the patient’s comorbidities and risk factors as well as the clinician’s comfort with different treatment modalities. Further, as technology continues to improve, more and more complex lesions are becoming amenable to minimally invasive techniques. It is important, however, to make sure that as we become more aggressive with endovascular techniques, care is taken to avoid injury to potential future distal bypass targets, as many patients...
require repeat intervention for restenosis or occlusion. The bypass versus angioplasty in severe ischaemia of the leg (BASIL) trial randomized angioplasty vs. bypass of the femoral artery and suggested that angioplasty was more appropriate for patients with a short life expectancy, as it was less expensive than bypass, but that bypass grafting should be performed in patients expected to live longer than two years because it was a more durable procedure and cost equivalent beyond two years, as there were fewer re-interventions than with endovascular therapy.3

The treatment of tibial disease has other issues. Tibial vessels should only be treated in the setting of CLI when tissue loss is present and amputation impending. First, tibial disease does not cause claudication symptoms. Second, these vessels are extremely small, and poor outcomes with potential limb loss are more likely with intervention at this level. When revascularization of tibial vessels is required, vein bypass is the gold standard and the most durable therapy. More recently, endovascular interventions have become a part of the limb-salvage paradigm for tibial disease, particularly for elderly debilitated patients who might not tolerate an open operation.4

Hybrid operating rooms have now become standard in many hospitals. These rooms integrate an interventional radiology suite into an operating theater, combining the best that these two locations have to offer.

With the continued improvement of technology, endovascular interventions are now far more commonly performed than open surgery. It is important that the decision as to which therapy to utilize in the treatment of patients with PAD remains based on the factors outlined above—lesion location, severity, patient risk factors and comorbidities, rather than comfort level of the provider. Often we see patients with a failed percutaneous intervention who may have benefited more from an open intervention. We also see patients who have been told there are no other options for revascularization but have not been evaluated for open bypass. With proficiency in both percutaneous interventions and open procedures, vascular surgeons are uniquely positioned to provide the best care possible for these patients, improving quality of life and decreasing amputation rates and mortality.

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REFERENCES