PERIPHERAL ARTERIAL OCCLUSIVE DISEASE

Detection and Treatment of Peripheral Arterial Occlusive Disease
Case Study and Commentary, Ahmed M. Abou-Zamzam Jr, MD

Abstract

- **Objective:** To review the evaluation and treatment of patients with peripheral arterial occlusive disease (PAOD).
- **Methods:** Case studies and qualitative review of the literature.
- **Results:** The manifestations of PAOD reflect a spectrum of disease ranging from non–limb-threatening disease, typically manifested as walking-induced pain (claudication), and limb-threatening states, which can present with ischemic rest pain, ulceration, or gangrene. Determination of the ankle-brachial index is a simple, accurate exam that markedly improves the detection of PAOD. The nonoperative treatment of patients with claudication includes patient education about PAOD, a structured walking program, and smoking cessation. Pharmacotherapy is considered if these interventions do not improve the patient's symptoms. Importantly, all patients with PAOD must be suspected of having coronary artery disease (CAD), and appropriate risk factor modification and medical management should be instituted. Most patients with limb-threatening ischemia require a revascularization procedure to avoid amputation of the limb. Treatment options include surgical bypass, percutaneous-based interventions, or a combination of these 2 approaches. The prognosis for limb-threatening ischemia is favorable, with 5-year patency rates of nearly 60% and expected limb-salvage of 90% at 5 years.
- **Conclusion:** PAOD has significant effects on a patient's lifestyle and quality of life. Appropriate treatment by a vascular surgeon can improve the mild symptoms of PAOD and lead to successful limb salvage in severe PAOD. The risk to these patients in the long term lies in their coexistent CAD. Interventions at the primary care level to address the underlying atherosclerosis are key to improving outcomes in patients with PAOD.

**INSTRUCTIONS**

The following article, “Detection and Treatment of Peripheral Arterial Occlusive Disease,” is a continuing medical education (CME) article. To earn credit, read the article and complete the CME evaluation on pages 319 and 320.

**OBJECTIVES**

After participating in the continuing education activity, primary care physicians should be able to:

1. Understand the pathophysiology of peripheral arterial occlusive disease (PAOD)
2. Learn the key aspects of history and physical examination that help identify PAOD in the outpatient setting
3. Be familiar with the basic therapies utilized for patients with claudication
4. Understand the treatment options for limb-threatening ischemia and expected outcomes
5. Know when referral to a vascular surgeon is appropriate

The term peripheral arterial occlusive disease (PAOD) typically refers to chronic arterial disease in which arterial stenoses or occlusions lead to diminished distal perfusion. In the presence of occlusive disease, tissue perfusion is diminished in the target vascular territories beyond the areas of disease (ie, the leg muscles and skin). The manifestations of PAOD reflect a spectrum of severity depending on the location and magnitude of the occlusive disease. In mild cases, circulation is adequate to meet normal metabolic demands under resting conditions but is inadequate to meet the increased demands of the muscles during exercise (typically walking), resulting in walking-induced pain. This clinical scenario is referred to as claudication. Tissue perfusion that is inadequate to meet even resting metabolic demands is referred to as limb-threatening ischemia. Patients with

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limb-threatening ischemia may present with either ischemic rest pain or tissue loss (ulceration or gangrene).

The incidence of PAOD is often underestimated because most patients do not seek medical evaluation for mild symptoms of PAOD. Indeed, in patients with objectively determined PAOD, the ratio of symptomatic to asymptomatic disease varies from 1:2 to 1:5 [1–3]. The incidence and prevalence of PAOD increase with age [1,4–6]. The prevalence of PAOD is 2.2% in patients aged 38 to 82 years versus 17% in patients aged 55 to 74 years [7,8]. With the aging of the U.S. population and an increasing prevalence of diabetes mellitus, PAOD will continue to place a significant burden on the health care system.

PAOD is an important manifestation of systemic atherosclerosis. Early detection of PAOD is important not only as a first step toward alleviating the symptoms of PAOD but also in identifying the associated systemic atherosclerosis. By documenting the presence of atherosclerosis, the physician can initiate interventions to modify the patient’s risk factors for this disease, which will ultimately improve the patient’s PAOD as well as his or her quality of life and even life span. Unfortunately, public awareness and understanding of PAOD lags behind that of coronary artery disease (CAD) and cerebrovascular disease. Similarly, the primary care physicians’ role in diagnosing and treating PAOD is underappreciated. Because only a fraction of patients with PAOD actually complain of symptoms to their primary care physicians, physicians must be proactive in their approach to these patients [1,4–6].

Management decisions for patients with PAOD traditionally are driven by the differentiation between non-limb-threatening and limb-threatening states. In the following 2 case studies, approaches to a patient with claudication and a patient with limb-threatening ischemia are presented.

CASE STUDY 1
Initial Presentation

A 65-year-old man presents to his primary care physician with a chief complaint of bilateral calf pain when walking.

History

The patient states that he first noted difficulty with walking about 2 years ago, but over the past 6 months it has become progressively worse. He says the pain is brought on predictably by walking approximately 200 yards and is felt in both calves with equal severity. He describes the pain as “aching and cramping,” but sometimes it is quite severe when he “pushes” himself. The pain is usually relieved with 1 to 2 minutes of rest. Once the pain subsides, he can again walk a similar distance before needing to stop. The patient has never had any nonhealing wounds on either foot.

The patient’s medical history is significant for tobacco use, hypertension, and hypercholesterolemia. The patient continues to smoke 1 pack per day and has done so for 50 years. The patient has never had a myocardial infarction, angina, arrhythmia, or congestive heart failure. He has never had a cerebrovascular accident or transient ischemic attack, and he does not have diabetes. He currently takes an angiotensin-converting enzyme inhibitor and a statin drug.

• What is the approach to documenting the presence of PAOD?

The Vascular Evaluation

From the patient’s history alone, we can begin to formulate a diagnosis. The term claudication comes from the Latin word claudicatio, which means “to limp.” Key points of the history of claudication center on the location, quality, and precipitating and relieving factors of the leg pain. In the history, the predictable, reproducible pain that is precipitated by a certain amount of walking and relieved with just a few minutes of rest is pathognomonic for claudication. The pain is often described as cramping or aching, but occasionally it may be described as sharp and severe. The muscle groups usually involved are the calf muscles because the superficial femoral arteries are the most common site of arterial stenoses and occlusions in PAOD. The pain tends to occur one joint beyond the blockage, with superficial femoral artery disease resulting in calf muscle claudication. A less frequent site of arterial lesions is the distal aorta and iliac arteries (aortoiliac occlusive disease [A10]). Patients with A10 will manifest claudication symptoms initially in the thighs and buttocks and with continued exertion will develop calf pain.

In the differential diagnosis of leg pain, osteoarthritis of the hips and knees, spinal stenosis, lumbar disk disease, sciatica, gout, and chronic venous insufficiency should be considered. Most of these can be excluded by a careful history. In many cases, these disease processes can coexist with PAOD, and more information is necessary to determine the extent to which each disease is contributing to the patient’s symptoms.

When properly performed, the physical examination of the patient is quite sensitive in documenting the presence of PAOD. The physical examination of the vascular patient is built upon a good general examination. The neurologic examination should include an evaluation for signs of focal neurologic deficits suggestive of prior stroke. On the otolaryngologic exam, the physician should pay attention to any masses, since most patients with PAOD have a smoking history, and listen carefully for carotid bruits. On evaluation of the heart, lungs, and abdomen, arrhythmias, gallops, murmurs,
evidence of pulmonary edema, and any palpable pulsatile masses or bruits should be sought. The extremities should be assessed for signs of chronic ischemia, which typically include thinning of the skin, decreased or absent hair, and muscle atrophy (a very late finding in AIOD). A thorough inspection of the feet must be carried out to identify any skin lesions, ulcerations, or gangrene. In patients with diabetes, the presence of deformities or callosities should be noted, and any sensory neuropathy should be determined. In patients with PAOD, the temperature of the feet may be diminished, but this finding varies depending on the ambient room temperature.

The pulse examination is very important. The patient should be in the supine position when this examination is performed. Pulses are palpated in the carotid, brachial, radial, femoral, popliteal, posterior tibial (PT), and dorsalis pedis (DP) positions. Pulses are graded as 1+ (diminished), 2+ (normal), 3+ (prominent), or 4+ (aneurysm), or simply as present or absent. Auscultation for bruits is performed over the carotid and femoral regions.

Simple pedal pulse palpation is inadequate to determine the presence of PAOD [9]. A key aspect of the initial vascular evaluation is the determination of the ankle-brachial index (ABI). The ABI is a simple, accurate, reliable, reproducible exam that markedly improves the detection of PAOD [10,11]. A handheld Doppler probe (7.5–10 MHz) and a blood pressure cuff are required to determine the ABI. The brachial systolic blood pressure is measured in each arm by inflating the cuff over the arm (above the elbow) and insonating either the brachial artery at the elbow or the radial artery at the wrist. The cuff is then placed just above the ankle and the systolic pressure is measured while insonating over the PT artery. This procedure is then repeated for the DP artery. The ABI is calculated by dividing the highest ankle pressure (DP or PT) by the highest brachial pressure. A normal ABI is 0.9 to 1.1.

Patients with claudication often have AIBs between 0.5 and 0.9. Patients with limb-threatening ischemia often will have AIBs < 0.5. In patients with extensive vascular calcification, the cuff may not compress the artery at the ankle, and the ABI is reported as noncompressible. Other tests (eg, transcutaneous oxygen measurement) that may be useful in such settings are discussed below.

**Physical Examination**

On physical examination, the patient is a well-appearing man in no acute distress. His heart rate is 60 bpm and regular, and his right brachial blood pressure is 120/60 mm Hg. Examination is significant for a normal neurologic exam, the absence of any bruits in the neck, normal heart sounds, clear lungs, and a benign abdomen with no bruits. The patient's lower extremities are unremarkable, with normal hair pattern, temperature, and color and no skin lesions. The pulse examination reveals bilateral palpable carotid, radial, and femoral pulses. There are no palpable popliteal, DP, or PT pulses bilaterally. The ABIs are 0.8 on the right and 0.7 on the left.

- What additional tests may be helpful at this point?

**Lower Extremity Arterial Examination and Exercise ABI**

With the history and supporting physical examination, the diagnosis of claudication is clear in this patient. Combining the findings on the pulse examination with the low ABIs, the underlying arterial lesions appear to be in the bilateral superficial femoral arteries. Referral to a vascular surgeon would be appropriate when the diagnosis is clearly established. When there are confusing aspects (eg, the presence of palpable pulses) but a history strongly suggestive of claudication, a formal noninvasive lower extremity arterial (LEA) examination should be obtained. The LEA exam also may be used to confirm the diagnosis and establish a baseline in patients with a clear history of claudication, but in these cases it is not an essential test.

The LEA examination is analogous to the bedside ABI but is more precise. With this test, Doppler ultrasound is used to examine the arterial waveforms and segmental pressures in both legs. By showing the analog Doppler waveforms at the femoral, popliteal, PT, and DP positions as well as the associated pressures, the LEA can more precisely delineate the level and extent of occlusive disease (Figure 1). In a patient with abnormal ABIs bilaterally, if the femoral artery waveforms are abnormal, the occlusive disease likely resides in the iliac arteries (AIOD) and not in the superficial femoral arteries.

The LEA and the ABI may be conducted with a treadmill exercise portion. Arterial stenoses may not be hemodynamically significant at rest, but increased flow across the lesion caused by walking may lead to a significant pressure drop that was not present at rest (lower flow rate). Measuring the ABI immediately following treadmill walking may reveal stenoses that cause a significant drop in the postexercise ABI. A drop in the ABI greater than 0.15 following treadmill walking, especially when occurring with symptoms of calf or thigh pain, is diagnostic for claudication.

**Confirmation of Diagnosis**

The patient undergoes an LEA exam, and the results confirm the low ABIs bilaterally with normal femoral waveforms and stenotic waveforms at the knee and ankle. Treadmill exercise leads to a drop in the ABIs to 0.5 bilaterally (Figure 2). This finding confirms the diagnosis.
of claudication. The patient is referred to a vascular surgeon for further assessment and discussion of treatment options.

**What are the risk factors for PAOD?**

The arterial pathologic process associated with PAOD is atherosclerosis in more than 99% of patients with PAOD [1,2]. The pathologic lesions in PAOD are the same lesions seen in other vascular beds throughout the body, especially in the coronary and cerebrovascular beds. Therefore, it is not surprising that PAOD, CAD, and cerebrovascular disease share the same risk factors. Increasing age, male sex, hypertension, elevated cholesterol, diabetes mellitus, and tobacco use are the major risk factors for the development of PAOD.

The influence of risk factors on the development of PAOD is substantial. Tobacco use confers a fourfold increase in risk for the development of PAOD. Diabetes confers a two- to fourfold increase in the relative risk for PAOD. Elevated cholesterol confers a twofold increase, and hyperhomocysteinemia confers a 22-fold increase [1,12]. Importantly, these risks are additive and may be synergistic. The risk of PAOD increases with the duration of the presence of diabetes by 20 years, 80% of patients with diabetes will have some degree of PAOD [6,12].

In view of the similar pathophysiology and shared risk factors, the coexistence of PAOD with CAD and cerebrovascular disease must always be considered. In a large study evaluating patients with peripheral vascular disease who were undergoing interventions, CAD was documented by arteriography in 90% of the patients [13]. A majority of this disease was clinically silent. In addition, significant asymptomatic carotid artery occlusive disease has been detected in 16% to 50% of patients with PAOD [14,15]. In all interactions with patients with PAOD, it is best to assume the coexistence of some degree of CAD and cerebrovascular disease.

**What is the treatment for claudication?**

**Nonoperative Treatment of Mild PAOD**

The initial approach is nonoperative. Patient education is key, as fewer than one third of patients with PAOD understand its relation to systemic atherosclerosis [1,16]. In a frank discussion with the patient, the physician should point out the direct link between tobacco use and claudication. It is important for this to be done in a supportive, nonpunitive manner. In addition, the physician should stress the combined effect of multiple risk factors and explain the systemic nature of atherosclerosis.

The nonoperative approach to the patient with claudication can be summarized as "quit smoking and get walking." Risk factor modification is key to slowing the disease process. The number one modifiable risk factor in most cases of claudication is tobacco use, and the primary care physician plays a crucial role in smoking cessation. The physician must stress...
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**Figure 2.** Recording of treadmill exercise results in patient with bilateral calf claudication. The patient walked for 5 minutes at 1.2 mph and complained of bilateral calf pain after 3 minutes. There was a significant drop in the ankle brachial index (ABI) following exercise bilaterally. (BP = blood pressure; L = left; R = right; T1 = 1 minute postexercise, etc.)

The need to cease all use of tobacco products and should refer the patient to a smoking cessation program. It is helpful to underscore the positive aspects of tobacco abstinence, including the fact that within 2 months of smoking cessation, the average person with claudication will not see a doubling in their walking ability [1,17]. Also important is the fact that disease progression is far more common in those who continue smoking as compared with those who abstain [1]. Finally, the patient should be informed that any intervention to improve lower extremity blood flow will have a better long-term outcome if he or she abstains from tobacco [1,18,19].

The second pillar of treatment for claudication is daily walking. A structured exercise program consisting of walking approximately 1 hour daily has been shown to significantly improve walking ability in patients with claudication [20–22]. The instructions to the patient are simple: choose a flat, level area, often a park or shopping center, that offers many benches to rest, ambulate to the point of moderate discomfort, then stop and rest until the pain resolves. Repeat this process until approximately 1 hour has passed.

The key to successful participation in a daily walking program is to make this activity an integral part of the patient's daily routine. The benefits typically include up to a doubling of the patient's walking distance [20,22]. The benefits are maintained as long as the patient continues the exercise program. Supervised programs are better than unsupervised programs but are rarely reimbursed by third party payors [19]. The improvements in walking ability are related to improved efficiency of the muscle groups and not the development of new collateral circulation [1,19]. Unfortunately, up to half of patients are unable to participate in daily walking regimens due to associated illnesses, joint problems, or simply lack of desire.

**Initial Management**

The physician provides the patient with information regarding PAOD and instruction to quit smoking and engage in daily activity. He also advises him to take an antiplatelet agent as prophylaxis for associated cardiovascular disease. An appointment is made for the patient to see the physician again in 2 months. At the follow-up visit, the patient can walk nearly 400 yards without difficulty. He has quit smoking and walks daily. Follow-up will continue at 6-month intervals.

- What is the role of medical therapy or invasive interventions in patients with claudication?

**Medical Therapy and Invasive Intervention**

We advise all our patients to take an antiplatelet agent as prophylaxis for associated cardiovascular disease. The claudication symptoms should improve notably if the patient complies with the recommendation to quit smoking and engages in daily walking. Should the symptoms remain significant, then consideration is given to pharmacotherapy.

There are currently 2 drugs approved by the U.S. Food and Drug Administration for the treatment of claudication: pentoxifylline and cilostazol. Pentoxifylline is a hemorheologic agent that increases the deformability of red blood cells and presumably improves improvement in claudication through this mechanism. The precise mechanism of cilostazol remains unclear. Cilostazol is a phosphodiesterase-3 inhibitor that appears to have wide-ranging effects, including a mild antiplatelet effect, mild vasodilatation, and favorable alterations in the lipid profile. A recent comparison study suggested that cilostazol is more effective than pentoxifylline in the treatment of claudication [23]. Both medications have a low incidence of side effects, with headache and gastrointestinal complaints being the most common.

Importantly, a history of congestive heart failure is a contraindication to use of cilostazol. Unfortunately, the degree of benefit seen with either of these medications is mild: approximately a 30% to 50% increase in maximal walking distance [23]. This degree of improvement pales in comparison to the 100% increase in walking distance expected with either smoking cessation or a supervised walking regimen.

Invasive treatment for claudication is reserved for those patients who have failed conservative therapy and whose claudication is "life-limiting." There is no doubt that mild and severe claudication affect all patients' lifestyles, but only when the effects are very severe should any intervention be considered. This conservative approach to patients with claudication is supported by a study that examined the role of percutaneous transluminal angioplasty versus medical...
treatment for patients with claudication and documented no benefit of invasive procedures on walking ability or quality of life [24].

Any intervention should be predicated on knowledge of the natural history of the disease being treated. In patients with claudication, the natural history may be somewhat benign. The risk of eventual limb loss is only 2% to 10% over 10 years [25,26]. The risk of disease progression is on the order of 20% to 40% over 5 years [1]. Overall, patients who present with an ABI less than 0.5 and patients with diabetes are at the greatest risk for eventual limb loss. Most patients will remain stable over time, and a fair percentage will improve. All this is balanced by the knowledge that no intervention has a 100% success rate with 0% complications. However, when patients have clearly exhausted the nonoperative approaches and are truly disabled by their claudication, further evaluation is indicated and proceeds in much the same manner as in patients with limb-threatening ischemia. In many vascular practices, surgical intervention for claudication symptoms is a rare undertaking.

CASE STUDY 2

Initial Presentation

A 76-year-old woman presents to her primary care physician with a 2-month history of a nonhealing ulceration on her left great toe.

History

The patient states that she had a smaller ulcer like this many years ago which healed spontaneously, but this current ulcer has persisted. The ulceration began after minor trauma to the toe when she was clipping her toenails. The wound has progressed even though she placed topical antibiotic ointment on the wound. She has had no fevers or chills and has noted no drainage from the wound. The patient does report some mild pain in the toe that is easily controlled with analgesics.

The woman’s past medical history is significant for a 10-year history of diabetes mellitus, for which she has taken insulin for the past 5 years. She has some mild neuropathy but no retinopathy or nephropathy. She has been treated for hypertension and had a myocardial infarction 10 years ago. She denies any prior symptoms of claudication, although she notes that she never ambulates more than 1 or 2 blocks at a time. She has never had a stroke or transient ischemic attack and has never smoked cigarettes. Her current medications include daily aspirin, insulin, an angiotensin-converting enzyme inhibitor, and a β blocker.

Physical Examination

On physical examination, the woman is in no acute distress. Her blood pressure is 160/70 mm Hg and heart rate is 55 bpm. Her neurologic examination is normal. Head and neck examination reveals no masses or carotid bruits. Her lungs are clear, and her heart is regular with no gallops, murmurs, or rubs. She has a soft, nontender abdomen with no pulsatile masses or bruits. Both lower extremities are cool to the touch. Hair is absent on the legs, and the skin is thin and friable. There are calluses on both plantar aspects of the feet over the first metatarsal-phalangeal joints. On the medial aspect of the left first toe there is a shallow ulceration measuring 1 cm in diameter with no cellulitis or drainage. When probed with a sterile cotton-tipped applicator, the ulceration does not extend to the bone. Pulse examination reveals bilateral palpable carotid, radial, and femoral pulses. There are no palpable popliteal or pedal pulses bilaterally. The ABI is 0.6 on the right and 0.4 on the left.

- What are the physical findings in limb-threatening ischemia?

Limb-Threatening Ischemia

Limb-threatening ischemia is a result of the same pathologic process that leads to claudication. The presentation of limb-threatening ischemia includes nonhealing ulceration, gangrene, and ischemic rest pain. Delay in the recognition of these entities and in proper referral may have a significant adverse effect on the potential for limb salvage [27]. Ischemic rest pain is typically described as pain in the forefoot which is worse at night and often awakens the person from sleep. Often the patient will note that the pain is relieved by dangling the foot off the side of the bed or walking on the foot a little. This makes physiologic sense, as the circulation to the foot is so marginal that the additional effect of gravity with the foot dependent prevents the manifestation of ischemic pain, but at night when the foot is elevated in bed the pain returns. A physical finding in these patients may be dependent rubor, which results from an alteration in the normal venoarterial reflex in the foot vessels, and marked pallor with elevation of the leg, which reveals the ischemic nature of the foot.

Based on this patient’s history and physical examination, she clearly has severe PAOD. As PAOD is a spectrum of disease, she may have experienced symptoms of claudication in the past. Interestingly, many patients present with limb-threatening ischemia with no antecedent claudication, likely due to the sedentary lifestyle that many elderly persons have adopted. The history of the ulceration occurring in response to a mild traumatic event is extremely common and demonstrates the importance of good foot care and podiatric evaluation in elderly patients with diabetes and other risk factors for PAOD.
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- What are the next steps in the management of this patient?

Assessment of Wound Healing Potential
Given the presence of arterial insufficiency and the nonhealing ulcer, this patient requires further evaluation and treatment. Prompt referral to a vascular surgeon is necessary. The natural history of limb-threatening ischemia is much more virulent than claudication. Most patients will require a major amputation if revascularization is not performed. Although the majority of these patients require intervention to salvage the limb, approximately 20% may heal with local wound care [3]. Thus, a noninvasive assessment of wound healing may be conducted in certain patients. In patients who initially present with gangrene or progressive ischemic lesions and obvious physical findings of significant PAOD, noninvasive testing may be skipped and evaluation for revascularization undertaken promptly.

The role of noninvasive predictors of wound healing in patients with diabetes and PAOD has been extensively investigated. Transcutaneous oxygen measurements (TcPO₂) have been demonstrated to be quite accurate in assessing PAOD. In brief, TcPO₂ is a method of determining tissue oxygenation in order to predict the adequacy of the arterial circulation to heal minor foot lesions and minor foot amputations. A small sensor is placed on the skin and heated to 44°C, causing local skin hyperemia and decreased flow resistance and arteriolarization of capillary blood. The partial pressure of oxygen is then measured transcutaneously, and this approximates the true arterial oxygen pressure in the tissue in the area of interest [28]. A level of 30 mm Hg is a useful cutoff for predicting wound healing. Patients having measurements greater than 30 mm Hg having an excellent chance to heal wounds, while those with readings below this cutoff often require revascularization to attain healing [29,30].

In evaluating the case patient, a LEA exam and TcPO₂ should be the initial step, along with a foot radiograph to evaluate for osteomyelitis. Local wound care is restricted to simple cleansing and dressing with sterile gauze. If the TcPO₂ is greater than 30 mm Hg, an attempt at local wound care should be undertaken for 1 month. If no improvement is seen, further evaluation for revascularization is necessary. If the wound worsens during follow-up, no further delay is indicated and evaluation for revascularization should be undertaken.

Results of LEA Evaluation and TcPO₂ Measurement

The LEA exam detects bilateral femoral-popliteal occlusive disease, which is worse on the left. The patient’s TcPO₂ readings on the left leg are 8 mm Hg in the forefoot, 15 mm Hg in the hindfoot, and 40 mm Hg in the below-knee position. These findings suggest that attempts at local measures alone will lead to delay in definitive treatment, and any attempt at minor amputation (toe or forefoot) will lead to nonhealing amputation wounds and may prevent ultimate limb salvage.

- What testing is necessary prior to performance of a revascularization procedure?

When evaluating patients for revascularization, it is necessary to clearly delineate the arterial anatomy to determine the optimal revascularization approach. The most widely employed tool for this task continues to be contrast arteriography. This invasive test provides the best diagnostic accuracy and offers the option of catheter-based interventions. Other modalities such as duplex ultrasound, magnetic resonance arteriography, and computed tomographic arteriography have been developed and improved in recent years, but these still fall short of contrast arteriography, except in a very small number of specialized institutions. Invasive arteriograms are still recommended as the diagnostic test of choice in patients being evaluated for limb-threatening ischemia.

Contrast arteriography has a few small risks in experienced hands. Local complications such as hematomas and pseudoaneurysms occur in 0.3% [31]. More importantly, all iodinated contrast agents carry a small risk of contrast-induced nephropathy. This risk may be on the order of 0.01% overall [31]. Patients with diabetes and underlying renal dysfunction are at increased risk for this complication. All patients need to be adequately hydrated prior to arteriography, and pretreatment with acetylcysteine may offer some protection in patients with baseline elevated creatinine levels [32].

Results of Arteriography

Contrast arteriography is performed, and the arteriogram demonstrates occlusion of the left superficial femoral artery and the left popliteal artery. The tibial arteries are diseased, but there is reconstitution of the proximal anterior tibial artery with good collateral filling of the PT artery at the ankle. This pattern of disease is typical in patients with diabetes and limb-threatening PAOD.

- What are the revascularization options for limb-threatening ischemia?

- Which patients should not be offered surgery?
Limb Salvage Interventions

Treatment options include surgical bypass, percutaneous-based interventions, or a combination of these 2 approaches. Percutaneous transluminal angioplasty (PTA) has emerged as an effective treatment for arterial stenoses above the inguinal ligament. The results of PTA for AIOD rival those of surgery in selected cases, with much less morbidity. However, the results of PTA in infragenicular arteries (femoral, popliteal, and tibial arteries) have been less impressive. PTA is employed only for short-segment stenoses and is not applicable in cases of long-segment occlusions of the femoral and popliteal arteries [33–35]. With the evolution of techniques and burgeoning technology and the advent of drug-eluting stents, PTA may play a larger role in the future in the treatment of limb-threatening ischemia [34,36,37].

The results of surgical bypass in patients such as the case patient have proven excellent and durable. Surgical revascularization has been the mainstay of treatment for limb-threatening ischemia in the past 30 years. Generally, bypasses originate from the common femoral artery and terminate in the tibial or peroneal arteries. The configuration is dictated by the quality of the inflow (proximal) and outflow (distal) arteries. For lower extremity bypasses, the ideal conduit with which to construct the bypass is the greater saphenous vein. This may be obtained from the ipsilateral or contralateral leg depending on the availability of vein. The vein graft may be placed in a reversed manner (to allow the blood to flow in the direction of the venous valves) or left in situ (which requires disruption of the venous valves). When the greater saphenous veins are not available or are too short, bypasses may be constructed from other available veins, including the cephalic, basilic, and lesser saphenous veins. In certain instances, 2 or more pieces of vein may be spliced together to attain adequate length to perform the bypass.

Bypass with autologous vein has been repeatedly demonstrated to be superior to synthetic grafts [38–40]. Autologous bypasses have 5-year patency rates of 70% to 80% with limb-salvage rates in excess of 90% [41–43]. In similar settings, the best results with artificial grafts lead to 5-year patency rates of only 20% to 40% and limb-salvage rates of 30% to 60% [38,40,44,45].

Lower extremity bypass is a major operation and is accompanied by complications. Mortality rates are 2% to 3%, but morbidity rates are 20% to 30% [46]. The percent ischemic wounds take 4 months to heal on average [46,47].

While most patients should undergo an aggressive approach to limb salvage with revascularization, not all patients should be offered surgery. Patients with significant comorbidities presenting prohibitive operative risks, those who are nonambulatory, and those who are neurologically impaired should be considered candidates for primary major amputation (above-knee or below-knee) [48]. An especially difficult population in which to achieve limb salvage is the renal failure population, which demonstrates consistently poor outcomes following revascularization [49]. The case patient, however, has a good functional status and does not have any major contraindications to surgery.

Preoperative Considerations

The role of preoperative cardiac evaluation in the vascular patient has been extensively evaluated and remains hotly debated. In patients without active angina, congestive heart failure, or recent myocardial infarction, extensive preoperative evaluation prior to lower extremity revascularization is not necessary [50]. The protective role of perioperative β-blockade is clear, and all patients undergoing vascular reconstructions should be treated with β-blockers [51]. Aggressive medical treatment of the vascular patient is the norm, and coronary revascularization prior to lower extremity revascularization may indeed introduce delay with resultant diminished chances of limb salvage [52].

Surgical Bypass Procedure

The patient is treated with a left common femoral artery to anterior tibial artery bypass with reversed left greater saphenous vein. The patient returns home after a 5-day stay in the hospital. Follow-up at 2 weeks after surgery shows that her surgical wounds are healing while the toe wound demonstrates some signs of improvement. By 6 weeks following surgery, all of her wounds have completely healed.

- What is the approach to follow-up of patients who undergo a bypass procedure?

Follow-up and Prognosis

Close follow-up of the patient is crucial as the performance of the successful bypass is the beginning, not the end, of the relationship with the vascular surgeon. Following lower extremity bypass, duplex ultrasound surveillance is important to ensure continued patency. Surveillance of the bypass graft is performed by duplex ultrasound within the first month after surgery to provide a baseline evaluation. Follow-up duplex surveillance and patient evaluation is then performed every 3 months for the first year after surgery. This intensive surveillance is necessary because most stenoses that develop within vein bypass grafts become evident in the first year after surgery [53–55]. Follow-up after the first year consists of clinical examination with determination of the ABI and duplex scans every 6 months indefinitely. The patients may develop progressive atherosclerosis proximal or distal to the bypass or stenoses within the bypass graft that can be detected with ultrasound prior to
PERIPHERAL ARTERIAL OCCLUSIVE DISEASE

graft failure [55]. Interventions (surgical or PTA) can extend the life of the bypass and avoid the catastrophic event of limb loss associated with graft thrombosis [55–58].

Overall, the prognosis for the patient with limb-threatening ischemia is quite favorable. With 5-year patency rates of nearly 80% and expected limb-salvage of 90% at 5 years, the vast majority of patients similar to the case report do quite well. In one large study of functional outcome following lower extremity bypass, the large majority of patients continued to maintain their preoperative functional status: 99% were able to return home and 97% remained ambulatory [42]. Indeed, surgical revascularization has been shown to improve quality of life [59], be cost-effective [60], and have a positive impact on long-term survival [61]. Predictors of poor outcome are failure to comply with bypass graft surveillance and continued smoking [18]. Of patients undergoing a single leg bypass, future surgical revascularization of the contralateral extremity is necessary in only 20% [62,63].

The key issue in the long-term survival of all patients presenting with PAOD is CAD. Patients with claudication clearly have an excess cardiac mortality when compared with patients without claudication. The 10-year survival of patients with claudication is 50% as compared with 80% for age-matched controls [1]. Nearly 80% of the mortality in patients with claudication is due to cardiovascular disease [1]. The disproportionate role of CAD is demonstrated by the 50% 5-year survival of patients who present with limb-threatening ischemia.

Summary

The key in treating patients with PAOD is having a basic understanding of the disease pathology and a reasoned approach to patients with varying degrees of disease. PAOD has significant effects on a patient’s lifestyle and quality of life, but the true danger to these patients lies in their coexistent CAD. Any patient with PAOD must be suspected of having CAD, and appropriate risk factor modification and medical management should be instituted. Antiplalet agents, β blockers, and statin drugs should be used routinely. Patient education along with the aggressive treatment of diabetes and avoidance or termination of tobacco use play important roles. These issues, which can be addressed by the primary care physician, may be more important than the direct anatomic measures offered by revascularization.

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EVALUATION FORM: Detection and Treatment of Peripheral Arterial Occlusive Disease

DIRECTIONS: Each of the questions or incomplete statements below is followed by 4 or 5 possible answers or completions of the statement. Select the ONE lettered answer that is BEST in each case and circle the corresponding letter on the answer sheet.

1. Which of the following are risk factors for the development of peripheral arterial occlusive disease (PAOD)?
   (A) Increased age
   (B) Hypertension
   (C) Diabetes mellitus
   (D) Tobacco use
   (E) All of the above

2. In patients with PAOD, the underlying pathology leading to the arterial stenoses and occlusions is
   (A) Atherosclerosis
   (B) Fibromuscular dysplasia
   (C) Arteritis
   (D) Popliteal artery entrapment
   (E) Trauma

3. A 58-year-old man presents with complaints of bilateral calf pain when walking approximately one quarter mile. The history and physical examination confirm the presence of claudication. The initial recommended therapy for this patient includes
   (A) Lower extremity bypass
   (B) Infrapopliteal percutaneous transluminal angioplasty
   (C) Smoking cessation
   (D) Daily walking
   (E) C and D

4. The estimated 5-year limb-salvage rate in patients undergoing a lower extremity bypass procedure for limb-threatening ischemia is
   (A) 10%
   (B) 25%
   (C) 50%
   (D) 75%
   (E) 90%

5. The overall 5-year survival of patients who present with limb-threatening lower extremity ischemia is
   (A) 10%
   (B) 30%
   (C) 50%
   (D) 70%
   (E) 90%

6. An elderly woman presents with a gangrenous left great toe due to PAOD. Evaluation indicates that a common femoral to peroneal artery bypass is necessary. The preferred conduit for this lower extremity bypass procedure is
   (A) Radial artery
   (B) Woven polyester graft
   (C) Bovine arterial graft
   (D) Greater saphenous vein
   (E) Human umbilical vein graft
EVALUATION FORM: Detection and Treatment of Peripheral Arterial Occlusive Disease

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