SECOND EDITION

PRIMARY CARE

An Interprofessional Perspective

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CHAPTER 12

Peripheral Vascular Diseases

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Peripheral vascular diseases (PVDs) encompass a variety of vascular disorders in any arterial bed outside of the heart. Chronic venous insufficiency also falls under the main category of peripheral vascular disorders and diseases. The term PVD is often used interchangeably with peripheral artery disease (PAD); however, the latter term is generally reserved for a more specific process involving atherosclerotic disease of the lower extremities, and is associated with increased risk of cardiovascular morbidity and mortality (Nawaz & Carman, 2012). This chapter discusses a variety of peripheral vascular disorders with regard to their clinical presentation, diagnostic criteria, and treatment options, and also provides references for further study and recommendations for patient education.

ATHEROSCLEROSIS

Anatomy, Physiology, and Pathology

Atherosclerosis is a degenerative disease characterized by elevated lipid-containing plaques known as *atheromas* found within the intima, the innermost layer of an artery. Atheromas narrow the vessels, resulting in stenosis or occlusion of the artery. They can also rupture, resulting in the sudden formation of a blood clot (thrombosis). Atherosclerosis impairs the ability of the endothelium to prevent platelet aggregation and cholesterol buildup. The distal vessels of the lower extremities are often the target for atherosclerotic plaque, which is commonly found in arterial branches, but atherosclerosis can occur in any artery in the body. *Arterial insufficiency* is a general term that refers to vessels that are compromised and debilitated as a result of atherosclerotic changes that narrow the lumen of the medium and long arteries.

Epidemiology

Atherosclerosis is the most common vascular disorder affecting peripheral arteries (Nawaz & Carman, 2012). Atherosclerotic PAD often coexists with atherosclerotic changes in coronary and cerebrovascular beds and is the leading cause of death in persons 65 years of age or older. It is suggested that more than 8 million people in the United States have PAD (Nawaz & Carman, 2012) and that 20% of adults older than 55 years suffer from some form of PAD (Hankey, Norman, & Eikelboom, 2006). Although PAD affects between 12% and 14% of the population, most people are asymptomatic (Al-Qaisi, Nott, King, & Kaddoura, 2009). Patients with diabetes have an increased prevalence of atherosclerosis (Jude, Eleftheriadou, & Tentolouris, 2010). Atherosclerosis in the arteries of the lower extremities is a strong indicator of atherosclerosis elsewhere in the body.

Diagnostic Criteria

A diagnosis of PAD is based on patient history, physical examination, and noninvasive testing. An ankle/brachial pressure index (ABPI) of 0.7 to 0.9 indicates mild PAD, 0.41 to 0.69 indicates moderate disease, and ratios less than or equal to 0.4 indicate severe disease.

History and Physical Examination

The most common manifestation of lower extremity atherosclerosis is intermittent claudication (McDermott et al., 2010). Claudication comes from the Latin word *claudicatio*, meaning to limp. Intermittent claudication is a pain in the leg that is brought on by walking and relieved by rest. This pain, characteristic of peripheral arterial occlusion, results from diminished blood flow and the inability of the collateral circulation to meet the oxygen demand of the exercising muscles.

Claudication develops in a muscle distal to the complete or partial obstruction of a main artery. Localization of symptoms depends on the anatomic pattern of arterial occlusive disease. Pain is often felt in the muscle group below the level of the arterial obstruction. For example, aortoiliac occlusive disease may cause buttock and thigh claudication and absence of femoral pulses. This syndrome, known as Leriche's syndrome, causes atrophy and slow wound healing in the legs as well as erectile dysfunction. Iliofemoral occlusive disease results in thigh and calf claudication; femoropopliteal occlusive disease results in calf claudication.

The most common site of PAD in both diabetic and nondiabetic patients is the superficial femoral artery. The second most common site is the aortoiliac segment. Tibial vessel disease, if present, may lead to critical ischemia of the

leg, which is manifested by rest pain, nonhealing wounds, and gangrene (Nawaz & Carman, 2012).

The key to the diagnosis of arterial occlusive disease is the patient history. Signs and symptoms of arterial insufficiency as compared to venous insufficiency can be found in Table 12.1. In taking the patient's history, one must inquire about the onset and duration of symptoms, including walking compromised by leg pain, symptoms of ischemia at rest, impaired wound healing in patients older than 70 years or in patients older than 50 years who smoke and/or are diabetic (Hirsch et al., 2006). Questioning should focus on the distance the patient is able to walk before developing cramping pain, the muscle groups involved (e.g., calf, thigh, hips, buttock), and whether or not dangling the legs over the side of the bed relieves the pain. Males should be asked about erectile dysfunction. Additional questions should address the patient's personal medical history, including prior diagnosis of atherosclerosis, hypercholesterolemia, diabetes mellitus, and hypertension, as well as a family history of arterial insufficiency. The patient's social history (e.g., smoking, sedentary lifestyle, and nutritional status) and a list of medications the patient is taking should be obtained.

Intermittent claudication can be chronic in nature but may become more incapacitating. The body attempts to compensate for this ischemic state by developing collateral circulation. The collateral circulation may not be sufficient when oxygen demand exceeds supply. The patient may notice a decrease in endurance and tolerance with exercise, resulting in a decrease in the distance and amount of walking. The pain may begin to occur at night. This pain is often relieved by dangling the foot off the side of the bed. When arterial insufficiency has progressed to such a level that the pain is constant and severe, patients may be unable to function. At this point, arterial ulcers may appear in conjunction with limb-threatening ischemia and ensuing gangrene, necessitating amputation (Hirsch et al., 2006).

Symptoms of leg ischemia are frequently the presenting concerns reported by patients with PAD; however, in asymptomatic patients, ABPI screening may be the first indicator of PAD (European Stroke Organisation et al., 2011; Hirsch et al., 2006). The clinical presentation varies from asymptomatic (20%–50% of patients) to symptoms such as critical limb ischemia (1%–2%), classic claudication (10%–35%), and a typical leg pain (40%–50%). Just as many patients suffering from PAD (up to 50%) may present with either atypical leg pain or no symptoms at all (Hirsch et al., 2006).

Acute arterial occlusion differs from intermittent claudication in terms of the presentation of pain. Claudication is a progressively debilitating symptom that is more chronic in nature. Acute arterial occlusion is a sudden blockage of an artery; it is abrupt in onset and more severe than claudication. This excruciating, unrelenting pain may occur suddenly, and neither rest nor activity relieves it. With acute arterial occlusion, the progressive signs of arterial insufficiency (e.g., dry skin, brittle nails, and hair loss) may not be present. Often the foot is white and cold. The patient may experience muscle weakness, possible paralysis, and

TABLE 12.1 Comparison of Arterial and Venous Insufficiency

ASSESSMENT	ARTERIAL	VENOUS
Skin color	Extremely pale, pale when limb elevated, rubor when limb dependent	Brawny; brownish-red pigmentation, cyanotic when dependent
Skin texture	Thin, shiny, dry; hair loss on leg, ankle, and foot; thickened, rigid, yellow toe nails	Stasis dermatitis, eczema, skin mottling, lipodermatosclerosis, thickened skin
Skin temperature	Cool	Warm
Edema	Absent or mild, usually unilateral	Present, usually foot to calf; may be unilateral or bilateral
Pain	Pain in the muscle of the buttocks, hip, thigh, or calf while walking that disappears at rest, worse while supine, disappears when dependent	Ache, dull, vague, localized on medial ankle; relieved with walking, leg elevation, and/or graduated compression stockings
Blood flow	Bruit may be present; pressure readings lower below stenosis	Normal
Pulses	Diminished or absent	Normal, although they may be difficult to feel through edema and thickened skin
Ulceration	Severely painful; involves toes or other bony prominences of foot, areas of trauma	Mildly painful; develops at medial malleolus
Ulcer characteristics	Well-demarcated edges base: eschar or necrotic tissue common, punched-out appearance	Irregular edges, base varies from granular to necrotic. Exudate varies from none to copious
Impotence	May be present	Not present
Acute occlusion	Absent pulse, pale, cold, paralysis, and paresthesia present	Deep venous thrombosis or superficial phlebitis: redness, heat, calf tenderness, unilateral edema, acute dyspnea

paresthesia. Because of the cessation of blood flow to the extremity, there will be loss of pulses distal to the occlusion. This situation warrants immediate referral to a vascular surgeon.

Two classification systems have been developed to help identify and document chronic lower-extremity PAD: the Fontaine staging system and the Rutherford categorizing system. Both classification symptoms address the severity of symptoms and the presence of markers for severe chronic occlusive disease, such as ulceration and gangrene. Fontaine has four main stages, one of which is subdivided into two stages: Stage I (asymptomatic), Stage IIa (mild claudication), Stage IIb (moderate/severe claudication), Stage III (ischemic rest pain), and Stage IV (ulceration or gangrene). Rutherford established seven categories ranging from 0 to 6 (asymptomatic, mild claudication, moderate claudication, severe claudication, rest pain, minor tissue loss, and major tissue loss, respectively; Hirsch et al., 2006).

The physical examination involves inspecting the patient's body for changes in appearance. Hair growth may be absent over the affected area. The nails may appear thick, yellow, and brittle. Motor function of the affected part may be impaired or absent. The muscles may also appear atrophied from severe nerve and skeletal muscle ischemia. Patients often complain of numbness and tingling in the extremity, as well as an inability to distinguish touch from pressure, pain, and temperature change.

The skin texture may also change with arterial insufficiency. The skin may appear shiny, taut, and thin; scaly and dry from ischemia; or progress to a deep red when the feet are in a dependent position. To assess the degree of arterial insufficiency, a reactive hyperemia test may be performed. This involves raising the legs above the level of the heart until the legs become a cadaveric pale color, followed by placing the patient in a seated position with the legs dependent. If pink coloration does not return within 15 seconds, the circulation is compromised. If the legs turn a deep red before reverting to their normal pink color, significant arterial occlusion is likely present. The skin temperature may vary. It is usually cool from vascular occlusion or vasoconstriction, hindering the blood supply. The best way to assess the temperature is to gently palpate the extremity with the dorsum of the hand.

A thorough patient history and physical assessment can help to distinguish ischemic ulcers caused by arterial disease from other types of ulcers (e.g., venous, pressure, trauma, and vasculitis). Breakdown of the skin may occur with severe ischemia, resulting in ulceration. These ulcers are often found over pressure points such as the heels, toes, bony prominences, the dorsum of the foot, or the metatarsal heads. Ulcers, which cause severe pain, are often symmetrical and without drainage. Mild edema may also be present. Patients experiencing pain at rest may have edema because they keep their legs in a dependent position for pain relief.

Palpating the patient's pulses provides information about the condition of the arteries. With arterial obstruction, the pulses may be absent or weak. Pulses should be assessed bilaterally for equality and strength using a Doppler stethoscope, if necessary. The physical examination should also include auscultation and evaluation of the blood flow. Normally, no sound is heard over a vessel that is patent. When blood flow becomes turbulent through an obstructed vessel, a blowing sound, or bruit, can be heard. Although the presence of a bruit is not always hemodynamically significant, it often indicates the start of chronic arterial occlusive disease long before symptoms such as cramps and pain appear. It is important in this patient population to check pulses in all regions of the body where major vessels are located, including the carotid, abdominal aorta, iliac, femoral, popliteal, posterior tibial, and dorsalis pedis.

The clinical syndrome most difficult to distinguish from claudication is neurogenic claudication, more typically known as spinal stenosis. The pain characteristic of spinal stenosis is caused by a localized narrowing of the spinal canal from a structural abnormality that results in compression of the cauda equina. With spinal stenosis, the patient usually complains of pain in the lower back or buttock region as well as numbness and tingling in the feet with walking (Katz & Harris, 2008). Differentiation of claudication and spinal stenosis can be determined by the patient's response to exercise. Symptoms of intermittent claudication are brought on by exercise and relieved with rest. Onset at a given distance of walking can be predicted fairly accurately. Spinal stenosis may also be precipitated by walking, but the distance walked before symptoms appear will vary. Standing may cause discomfort in patients with spinal stenosis, whereas standing relieves pain in intermittent claudication (Katz & Harris, 2008).

Nocturnal muscle cramps may be another symptom that can mimic claudication. However, these cramps are a common complaint and have a tendency to occur in older persons. The cramps are not related to exercise. Tightness and pain in the calf after exercise can affect athletes with chronic compartment syndrome (Twaddle & Amendola, 2008). This syndrome is usually found in young persons, presents after vigorous exercise, and does not quickly subside with rest. Osteoarthritis of the hip may mimic thigh and buttock claudication. However, osteoarthritic pain occurs with variable amounts of exercise. It is relieved after long periods of rest and changes in severity from day to day.

Another differential diagnosis to be considered is Raynaud's disease, which is an interruption in arterial circulation to the extremities. In Raynaud's disease, episodic vasospasm produces closure of the small arteries in the distal extremities. This may be elicited by exposure to cold, vibration, or emotional stimuli. About 5% of the U.S. population suffers from Raynaud's disease. Although it is considered more of an inconvenience than a serious illness, in severe cases, gangrene may threaten tissues. If fingers or toes turn blue in response to even brief changes in temperature just below 60°F, followed by tingling, burning, or numbness, consultation with a primary care provider should be a priority. Diagnosis is difficult because there is no single test to confirm this diagnosis (James, Berger, & Elston, 2011).

Diagnostic Studies

The diagnosis of PAD is based on patient history, physical examination, and noninvasive testing. Examples of noninvasive tests that facilitate assessment of arterial disease include segmental limb pressures and the calculation of pressure index values (e.g., ABPI, wrist-brachial index), exercise testing, segmental volume plethysmography, transcutaneous oxygen measurements, and photoplethysmography. Doppler ultrasound, CT scans, and MRI are also valuable tools when assessing vascular disorders. CT scan and MRI are important alternative methods for vascular assessment, but their use for routine testing is limited by time and expense (Hirsch et al., 2006; Mohler & Mitchell, 2012; Rofsky & Adelman, 2000).

Doppler segmental pressures with an ABPI measurement provide information regarding the extent of the disease. Measurement of the ABPI is recommended in patients at high risk of PAD, defined as patients with exertional leg symptoms, nonhealing wounds, age >65 years, or age >50 years with a history of smoking or diabetes (Formosa, Gatt, & Chockalingam, 2012; Rooke et al., 2011). Further diagnostic testing is not recommended in asymptomatic patients.

Doppler segmental pressures are obtained by placing appropriately sized blood-pressure cuffs around the arm and at the proximal thigh, the distal thigh, the proximal calf, and the ankle of the affected leg. The ABPI is calculated by dividing the systolic blood pressure measured in the arterial conduits at the level of the ankle by the systolic blood pressure measured in the brachial artery (Al-Qaisi et al., 2009). The normal range of ABPI is 1.0 to 1.4 (Rooke et al., 2011). An ABPI >1.4 represents a noncompressible vessel. An ABPI of 0.91 to 0.99 is borderline abnormal. An ABPI <0.9 is abnormal, with 0.7 to 0.9 indicating mild disease, 0.41 to 0.69 indicating moderate disease, and a value <0.4 indicating severe disease. Ratios of <0.4 are typically seen in patients who present clinically with symptoms of critical ischemia, as would be associated with nonhealing wounds or pain at rest.

Occasionally, patients have normal ABPIs and segmental pressures at rest, but risk factors indicate an increased risk of PAD or their symptoms strongly suggest claudication. In these patients, segmental pressures and ABPIs should be obtained before and after exercise. For this diagnostic test, the patient may walk or lift the heels repeatedly to elicit a pain response. Exercise may reveal the arterial obstruction, resulting in a significant change from the Doppler segmental pressures and the ABPIs found at rest.

Pulse volume recordings (PVRs) can be obtained by plethysmography to evaluate limb perfusion. Arterial waveforms are recorded at different segments along the limb. The magnitude of the waveform correlates with blood flow; diminished waveforms indicate obstruction in the proximal limb segment. PVRs can be a useful screening tool in patients in whom ABPI shows noncompressible vessels.

Further diagnostic testing is not indicated in asymptomatic patients, and treatment focuses on risk factor reduction to slow disease progression. In patients with symptoms of claudication and abnormal ABPIs and/or PVRs, an imaging study is indicated to determine the location and severity of stenosis.

Contrast angiography is considered the gold standard diagnostic tool for evaluating arterial anatomy and is the test most widely performed prior to an intervention (Hirsch et al., 2006). It helps to reveal the exact location of the arterial obstruction and provides a road map for operative reconstruction. Contrast dye is used to visualize vessel anatomy and determine the degree of stenosis present. Contrast dye is associated with a low incidence of nephrotoxicity, especially in patients with baseline renal dysfunction, diabetes, or low output states. This risk, as well as other risks associated with any invasive procedure (e.g., bleeding, infection, vascular access complications), must be considered prior to ordering this test. Because of these risks, angiography is usually only performed when revascularization is being considered.

Significant advances have been made in duplex ultrasound, CT angiography, and MRI angiography, making these tests viable noninvasive alternatives. Doppler ultrasound is one of the most widely used noninvasive tools in the evaluation of PAD. It can be used to locate lesions, quantify disease severity, and follow the progression of disease. It is also recommended for periodic surveillance after bypass procedures. CT or MRI angiographies are other noninvasive imaging methods to evaluate for the location and severity of disease. An intravenous injection of iodinated contrast dye is given during CT angiography to fill vessels. However, contrast dye may be nephrotoxic in azotemic patients. The accuracy and effectiveness of CT angiography is not as well established as that of MRI angiography. MRI angiography with gadolinium enhancement can be used to visualize vessel anatomy through exposure to magnetic energy sources, without the use of radiation; but it is contraindicated in patients with pacemakers or other metallic implants.

Treatment Options, Expected Outcomes, and Comprehensive Management

There are several approaches to managing arterial insufficiency, beginning with risk factor modification. For asymptomatic patients with PAD, as evidenced by decreased ABPI, treatment focuses on risk factor modification. The single most important therapeutic intervention is smoking cessation. Patients should be offered a counseling program along with pharmacological therapy to assist in quitting. Hyperlipidemia should be controlled with dietary changes and, if needed, pharmacological intervention. Dietary goals include a reduction of saturated fat intake and a reduction of cholesterol levels. For patients with diabetes, excellent glycemic control should be stressed. Blood pressure should be monitored and adequately controlled through mechanisms such as dietary changes, weight reduction, limiting salt intake, stress reduction techniques, and pharmacological management as needed. Beta-blockers are effective blood pressure–lowering agents for patients with PAD. In symptomatic patients with PAD, angiotensin-converting

enzyme inhibitors should be considered to reduce adverse cardiovascular events (Hirsch et al., 2006).

The patient with claudication should be referred to a supervised exercise training program with sessions at least 3 days a week for 12 weeks (Hirsch et al., 2006). These exercise programs include an aggressive walking program for approximately 30 to 45 minutes at a pace that elicits claudication. When claudication occurs, the patient should be instructed to walk a little further, stop, wait for the discomfort to pass, and then continue walking. A successful walking program can increase the distance to onset of claudication and help to develop collateral circulation (Gardner, Ritti-Dias, Khurana, & Parker, 2010; Schmidt-Trucksäss, 2011).

Drug therapy for claudication enhances metabolic activity and increases blood flow to the affected muscles. Vasodilating agents have had little effect on patients with claudication. Anti platelet therapy (aspirin 75–325 mg daily) is indicated to reduce the risk of myocardial infarction, stroke, and vascular death in patients with symptomatic PAD or asymptomatic patients with an ABPI ≤0.90 (Rooke et al., 2011). Low-dose aspirin therapy has been correlated with protection from vascular events in patients with severe cardiovascular disease; however, the literature fails to support the same results for those who suffer with PAD or diabetes (Natarajan, Zaman, & Marshall, 2008). This failure is attributed to aspirin resistance in the PAD and diabetic patient population. Studies suggest that, in contrast to aspirin, clopidogrel, a thienopyridine derivative antiplatelet agent, seems to show promise in reduction of vascular events in patients with PAD and diabetes (Angiolillo, 2009). Clopidogrel (75 mg daily) could be considered as an alternative to aspirin for these patients.

Cilostazole, a phosphodiesterase type 3 inhibitor, given at 100 mg twice daily, has both vasodilator and platelet inhibitory properties. Its actual mechanism of action is unknown. It is a generally well-tolerated medication. It has been shown to improve claudication symptoms and increase walking distance by 40% to 60% after 12 to 24 weeks of therapy (Hirsch et al., 2006).

Pentoxifylline, a methylxanthine derivative, alters the structure of the red blood cell, decreases plasma viscosity, and decreases platelet aggregation to enhance blood flow through the obstructed artery. Pentoxifylline, given as 400 mg 3 times a day, may be considered as a second-line agent for patients with claudication (Hirsch et al., 2006). It is generally well tolerated and, when used in combination with lifestyle changes, has the potential for decreasing painful symptoms associated with walking in patients with intermittent claudication (Salhiyyah, Senanayake, Abdel-Hadi, Booth, & Michaels, 2012). It has been shown to increase walking distance by a modest degree but to a lesser extent than that seen with cilostazole.

Most patients with claudication respond to conservative therapy. Invasive procedures, including endovascular repair and surgical interventions, should only be performed on patients who have failed to respond to optimal therapy that includes risk factor modification, a supervised exercise program, and pharmacotherapy; on those who have symptoms so severe that quality of life is reduced; or on patients with progressive arterial occlusive disease that has clinical manifestation of critical limb ischemia (formerly known as limb-threatening ischemia) such as pain at rest, nonhealing wounds, or gangrene.

Local infusion of a thrombolytic agent or mechanical thrombectomy may be the next option before resorting to surgical revascularization in cases of acute limb-threatening ischemia of <14 days' duration (Hirsch et al., 2006). Local lysis of acute arterial occlusions is safe and effective in restoring blood flow (Wissgott, Richter, Kamusella, & Steinkamp, 2007); however, before a decision is made to perform an invasive procedure, the risk of limb loss and the overall cardiovascular risk to the patient must be considered.

In vitro studies have suggested that recovery of the vascular network might be possible some day using mesenchymal stem cells (Guiducci et al., 2010). This might prove to be a promising therapeutic strategy for treating severe PAD.

Clinical practice guidelines from the American College of Cardiology and the American Heart Association (ACC/AHA) for the management of PAD (Hirsch et al., 2006; Rooke et al., 2011) are available here:

- 2005 guideline: http://circ.ahajournals.org/content/113/11/e463.full.pdf+html
- 2011 Focused Update: http://circ.ahajournals.org/content/124/18/2020.full.pdf+html

Teaching and Self-Care

Refer to Table 12.2 for patient teaching guidelines.

TABLE 12.2 Patient Teaching Guidelines for Arterial Insufficiency

- Stop smoking
- Follow exercise plan
- Low-fat, low-cholesterol diet
- Maintain adequate blood pressure control
- Maintain adequate glucose control for the diabetic
- Control hyperlipidemia
- Avoid sitting or standing for prolonged periods
- Do not cross legs
- Inspect feet daily for ulceration, infection, and redness, especially around pressure points
- Protect bony prominences
- Wash, dry, and moisturize feet well
- Protect feet from trauma or direct heat
- Keep feet and legs warm; report any numbness, tingling, or pain
- Wear properly fitting shoes
- See podiatrist regularly

THROMBOANGIITIS OBLITERANS (BUERGER'S DISEASE)

Anatomy, Physiology, and Pathology

Thromboangiitis obliterans, more commonly referred to as Buerger's disease, is a recurring inflammatory occlusive process affecting the small- and medium-sized arteries and veins of the extremities.

Epidemiology

Buerger's disease is a rare disease process with only a few patients affected annually. It is most prevalent in the Mideast and Asia. Its incidence has been on the decline corresponding to a decrease in smoking. The incidence in the United States is 12.6 per 100,000 persons (Olin, 2000). The incidence of Buerger's disease is higher in males than females and occurs more commonly in patients younger than 45 years (Piazza & Creager, 2010). Risk factors include tobacco use and a family history (Olin & Shih, 2006).

Diagnostic Criteria

The diagnosis of Buerger's disease is based on patient history and physical examination findings. Diagnosis is made predominantly on the basis of five criteria: smoking history; age <45 years; the presence of distal extremity ischemia confirmed by noninvasive vascular testing; angiographic findings; and the absence of autoimmune disease, thrombophilia, diabetes, or proximal embolic sources (Piazza & Creager, 2010). Biopsy can provide a definitive diagnosis but is rarely needed if the previously mentioned criteria are met.

History and Physical Examination

Patients most often present with ischemic symptoms from stenosis or occlusion of the small arteries and veins in the distal extremities. Symptoms often present as intermittent claudication of the arms, hands, legs, or feet. Patients may also experience numbness and tingling as well as color and temperature changes. Although symptoms may begin in one extremity, multiple extremities are usually involved. It may progress to ischemic ulcerations or gangrene of the fingers and toes. Raynaud's phenomenon (sudden onset of cold digits associated with sharply demarcated color changes, skin pallor, or cyanosis) occurs in more than 40% of patients (Piazza & Creager, 2010).

Superficial thrombophlebitis, manifested as erythema, warmth, and swelling, often precipitates arterial signs and symptoms. Patients who develop ulceration have a greater chance of developing an infection, which may ultimately result in amputation of the affected body part.

The physical examination should include a full vascular examination with palpation of peripheral pulses, auscultation for bruits, and measurement of the ABPI (Piazza & Creager, 2010). Examine the extremities for superficial nodes and cords, in addition to signs of ischemia. Assessment reveals diminished or absent pulses and swelling is often noted in the feet.

The Allen test should be performed. To perform the Allen test, the patient is asked to make a tight fist to empty blood from the hand and fingers. The radial and ulnar arteries are then occluded by the examiner's fingers. The patient opens the hand while the pressure over the ulnar artery is released, leaving the radial artery compressed. If the hand does not refill with blood, an occlusion of the ulnar artery is present. A hand that quickly refills with blood indicates patency of the ulnar artery; the test should be repeated with pressure on the radial artery released while the ulnar artery remains occluded to evaluate for occlusion of the radial artery.

Diagnostic Studies

An ankle or wrist brachial index should be performed to evaluate for occlusive disease; however, the measure is often normal if the disease is limited to distal vessels. Digital segmental pressures can be obtained to evaluate for distal occlusive disease.

Angiographic studies, whether by CT, MRI, or invasive contrast angiography, are done to look for features suggestive of thromboangiitis obliterans: no evidence of atherosclerosis, no embolic sources, involvement of small- or medium-sized vessels, segmental occlusion, and collateralization around areas of occlusion.

Laboratory tests are ordered to rule out other diagnoses (Piazza & Creager, 2010). A laboratory workup should include a complete blood count, chemistry profile, liver function tests, fasting blood glucose, and inflammatory markers such as erythrocyte sedimentation rate, C-reactive protein, cold agglutinins, and cryoglobulins. Serological testing for autoimmune disease should include an antinuclear antibody, rheumatoid factor, anticentromere antibody, and anti-SCL-70 antibody. In patients with thromboangiitis obliterans, these tests will be normal or negative.

Treatment Options, Expected Outcomes, and Comprehensive Management

The recommendation to discontinue tobacco use remains the primary intervention for thromboangiitis obliterans. Nicotine replacement therapy, such as the patch or gum, should be avoided, as it may stimulate disease activity. Patients should be offered pharmacotherapy or support groups to aid in smoking cessation. In cases where critical limb ischemia is not already evident, smoking cessation alone might help the patient avoid amputation (Olin & Shih, 2006). Discontinuation of smoking as the primary intervention has yielded results that permit spontaneous healing of ulcers caused by thromboangiitis obliterans (Highlander, Southerland, Vonherbulis, & Gonzalez, 2011). The distal location of lesions makes surgical revascularization not a

viable treatment option (Lazarides, Georgiadis, Papas, & Nikolopoulos, 2006). Intermittent pneumatic compression has been used in patients with severe claudication and critical limb ischemia to augment perfusion to aid in ulcer healing (Piazza & Creager, 2010).

Intravenous iloprost, a prostaglandin analog, may be used to aid in pain management in patients with critical limb ischemia while they get through the initial period of smoking cessation. Benefits in ulcer healing and reduced risk of amputation were also seen with the use of intravenous iloprost (Piazza & Creager, 2010). Although calcium channel blockers are frequently used to manage vasospasm, their use has not been validated in clinical trials.

TABLE 12.3 Average Thoracic Aortic Diameters

	MALE (cm)	FEMALE (cm)
Aortic root	3.63–3.91	3.5–3.72
Ascending aorta	2.86	2.86
Mid-descending aorta	2.39–2.98	2.45–2.64
At diaphragm	2.43–2.69	2.40–2.44

Source: Adapted from Hiratzka et al. (2010).

Teaching and Self-Care

As smoking cessation remains the only definitive treatment option, teaching strategies should focus on the importance of ongoing cessation. Patients should be taught to protect their extremities from trauma. Hands and feet should be kept clean, dry, and moisturized. Circulation may be promoted by choosing exercises wisely; specifically, ankle rotations and leg lifts as are done during Buerger–Allen exercises. Pain can be controlled with analgesia or alternative therapies.

AORTIC ANEURYSMS

Anatomy, Physiology, and Pathology

An *aneurysm* is a defect in the anatomy of an artery resulting in weakness, stretching, and ballooning out of the arterial wall with at least a 50% increase in diameter compared to the normal diameter of the artery (Hiratzka et al., 2010). The most commonly affected artery is the aorta.

The aorta is the major arterial conduit for blood leaving the heart and traveling into systemic circulation. The thoracic aorta is divided into four parts: the aortic root, which begins immediately after the aortic valve; the ascending aorta; the aortic arch, which contains the origins of the head and neck arteries; and the descending aorta. The abdominal aorta begins at the hiatus of the diaphragm and extends to the bifurcation of the common iliac arteries. Average diameters of the thoracic aorta are shown in Table 12.3. Normal aortic diameters vary by age, gender, and body habitus. The average infrarenal aorta is 2.0 cm, and typically <3.0 cm. The portion of the aorta below the renal arteries is the section most commonly affected by an abdominal aortic aneurysm (AAA; Chaikof et al., 2009; Hirsch et al., 2006).

There are three types of aneurysms: fusiform, saccular, and dissecting. Fusiform aneurysms involve the ballooning of the entire circumference of the artery. In saccular aneurysms, only one side of the artery balloons. A dissection occurs from a tear in the intima of the vessel that allows blood to accumulate between the layers. A pseudo-aneurysm, also called a false aneurysm, is an accumulation of blood that, after having leaked from the artery, collects in the surrounding tissue.

Epidemiology

Men are four to five times more likely to develop an AAA and two to four times more likely to develop a thoracic aortic aneurysm (TAA) than women (Mohler, 2012; Woo & Mohler, 2013). Risk increases with age; the population older than 60 years is at greater risk than its younger counterparts. AAAs are more common in the Caucasian population. Screening studies show the incidence of AAAs to be 3.5 to 6.5 per 1,000 person-years (Mohler, 2012) and the incidence of TAA to be 6 to 10 per 100,000 person-years (Woo & Mohler 2013). Smoking is a major risk factor for aneurysm development. Family history and genetic predisposition also create an increased risk. TAAs are more commonly seen in patients with monogenetic disorders such as Marfan syndrome or Ehlers–Danlos syndrome.

Diagnostic Criteria

A variety of noninvasive imaging modalities are available to measure aortic diameter. Normal sizes of the thoracic aorta vary by location, age, gender, and body habitus. In general, a thoracic aortic diameter >3.5 cm is considered dilated; TAAs are defined as a diameter >4.5 cm. Risk of rupture increases with diameter, with the largest risk in TAAs ≥6.0 cm (Woo & Mohler, 2013).

The abdominal aorta is generally considered to be aneurysmal when the diameter is >3.0 cm (Hirsch et al., 2006). AAAs may be deemed small (diameter <4.0 cm), medium (diameter 4.0–5.5 cm), large (diameter ≥5.5 cm), or very large (diameter ≥6.0 cm). The larger the diameter, the greater the chances of rupture, with the risk increasing markedly for diameters >5.5 cm. According to the Joint Council of the American Association for Vascular Surgery and Society for Vascular Surgery, an AAA ≤4.0 cm in diameter has relatively zero risk of rupture, whereas an aneurysm with a diameter of 6.0 to 6.9 cm has a 10% to 20% risk; an aneurysm 7.0 to 7.9 cm has a 20% to 40% risk; and an aneurysm ≥8.0 cm is correlated with a 30% to 50% risk of rupture (Chaikof et al., 2009).

History and Physical Examination

Risk factors for atherosclerosis (e.g., hypertension, hyperlipidemia, smoking) should be assessed, as atherosclerosis often coexists with aneurysmal disease. Atherosclerosis is associated with 80% of TAAs (Latessa, 2002). Most often aneurysms are asymptomatic and discovered incidentally during chest x-ray, ultrasound, CT scanning, or MRI. However, if a patient complains of symptoms such as sudden onset of severe chest, flank, or back pain, with any of the associated risk factors or a family history of aneurysm, an aortic aneurysm should be considered in the differential diagnoses. The patient should be sent for immediate imaging of the aorta.

Ascending TAAs may present with heart failure from associated aortic regurgitation. Symptoms of myocardial ischemia may occur from compression of the coronary arteries. Pain from an AAA is often associated with hypogastric or low back pain that is steady, with a gnawing quality, lasting for hours at a time, and unaffected by movement (Hirsch et al., 2006). Rupture of an AAA is often associated with acute onset abdominal and back pain with associated tenderness and a palpable, pulsatile abdominal mass on physical examination. Patients may be hypotensive from blood loss and may progress rapidly to hypovolemic shock. A ruptured TAA is often catastrophic, presenting with acute onset chest pain and progressing rapidly to shock.

An abdominal examination focusing on palpation and auscultation of the aorta should be performed in all patients with risk factors for or a known AAA. Assessment for perfusion differences in the limbs should be performed. If suspicion of aortic aneurysmal disease arises, the patient should be sent for an imaging study and be referred to a vascular surgeon for consultation. A thorough medical and family history should be obtained to identify hereditary causes and risk factors of aneurysms.

Diagnostic Studies

A TAA may be suspected by the presence of a widening of the mediastinal silhouette on chest x-ray. Further evaluation of aneurysms may be obtained through the use of ultrasound, echocardiogram, CT scan with intravenous contrast, MRI, or contrast angiography.

Treatment Options, Expected Outcomes, and Comprehensive Management

Screening for AAAs is recommended for high-risk populations. Men 60 years and older with a family history of an AAA in either a sibling or child should have a screening ultrasound. Men, aged 65 to 75 years, who have a past or present history of smoking, should also be screened for AAA by ultrasound. Aortic imaging to screen for TAAs is recommended for patients with a first-degree relative with a history of a TAA.

Once an aortic aneurysm is diagnosed, treatment, either surgical or monitoring every 4 to 6 months by imaging, should be implemented, along with risk factor modification. The primary care provider should also evaluate these patients for aneurysmal disease elsewhere in the body. Recommendations and guidelines regarding treatment are specific to the size and type of aneurysm discovered. Specifically, location in the body, diameter, and health status of the tissue determines the course of treatment and prognosis (Chaikof et al., 2009; Hiratzka et al., 2010; Hirsch et al., 2006). Patients with an aortic root or ascending aorta >4.0 cm should have yearly imaging to measure aortic size. If the diameter of the aneurysm reaches 5.5 cm, the patient should be referred for surgical repair (Hiratzka et al., 2010).

The goal of treatment is to avoid rupture. The diameter of the aneurysm is positively associated with increased risk of rupture; that is, the greater the diameter, the greater the risk. The first step is to identify risk factors, which include age >60 years, male gender, smoking, race (Caucasians are at increased risk), a positive family history of aortic aneurysm, and a personal history of other large aneurysms, in addition to a history of or risk factors for atherosclerosis. Hypertension and hyperlipidemia should be well controlled to reduce the risk of progression of the size of the aneurysm. Blood pressure should be treated to achieve a goal of <140/90 mmHg. Beta-blockers should be prescribed for patients with Marfan syndrome to reduce the rate of aortic dilation. Smoking cessation should be encouraged. Close monitoring of at-risk patients by a vascular surgeon is important.

Clinical practice guidelines from the ACC/AHA for the management of TAAs (Hiratzka et al., 2010) are available at circ.ahajournals.org/content/121/13/e266.full.pdf

Clinical practice guidelines for the management of AAAs are available from the following organizations:

- The Society of Vascular Surgery (Chaikof et al., 2009): www.jvascsurg.org/article/S0741-5214%2809%2901368-8/fulltext
- The ACC/AHA:
  - 2005 Guideline (Hirsch et al., 2006): http://circ.ahajournals.org/content/113/11/e463.full.pdf+html
  - 2011 Focused update (Rooke et al., 2011): http://circ.ahajournals.org/content/124/18/2020.full.pdf+html

Teaching and Self-Care

Because personal history of atherosclerosis is strongly correlated with aortic aneurysms, controlling diet, promoting exercise, and encouraging a healthful lifestyle (e.g., smoking cessation) should be part of a patient's goals. Patients with a current aneurysm or a history of a repaired aneurysm should be counseled on avoiding strenuous activity. Heavy lifting, pushing, or straining may require the Valsalva maneuver, which causes an increase in systemic blood pressure that may result in dissection of an aneurysm. Routine daily aerobic

exercise only results in a modest increase in mean arterial pressure, which rarely results in dissection and, therefore, should be encouraged. Patients should be taught that aneurysmal disease is a lifelong condition. Surgical repair is not a cure and ongoing risk factor modification and participation in the medical regimen are necessary to reduce the risk of disease progression.

GIANT CELL (TEMPORAL) ARTERITIS

Anatomy, Physiology, and Pathology

Giant cell arteritis (GCA) is a chronic inflammation of large- and medium-sized vessels. This systemic compromise is most often expressed in the cranial branches of arteries originating from the aortic arch. Temporal arteritis is a form of GCA that affects branches of the carotid artery. Visual loss is one of the complications of this condition.

Epidemiology

GCA is the most common form of systemic vasculitis. It occurs twice as often in women than in men. It is seen more commonly in persons of Northern European descent older than 50 years, with an incidence of 18.8 cases per 100,000 persons (Warrington & Matteson, 2007). The incidence rises after the age of 50 years, with the highest rate seen between 70 and 80 years of age.

Diagnostic Criteria

For the diagnosis of temporal arteritis, at least three of the following criteria must be present:

- Onset after age 50 years
- New onset or new type of headache
- Temporal artery tenderness
- Elevated erythrocyte sedimentation rate (≥50 mm/hr)
- Abnormal artery biopsy

History and Physical Examination

A diagnosis of GCA should be considered in patients older than 50 years presenting with new onset of headaches, visual disturbances, jaw claudication, symptoms associated with polymyalgia rheumatica (aching/stiffness of the neck, shoulders, hips, and proximal extremities), fever of unknown etiology or anemia, high erythrocyte sedimentation rate, and/or high serum C-reactive protein. On examination, the patient may have localized temporal artery tenderness, redness, decreased pulsation, induration, or in extreme cases, scalp necrosis. Temporal arteries are normal in one third of the population. The patient may have ophthalmological findings such as ophthalmoplegia and visual loss. On fundoscopic examination, the patient may have pallor and swelling of the optic discs, an early sign of temporal arteritis; in the later stage of this disease, optic atrophy may exist. Systemic manifestations usually result from ischemia of affected arteries or inflammation. Bruits may be heard in the head and neck. The pulses in the upper extremities may be absent. Neurological deficits, memory loss, delirium, dementia, or transient ischemic attacks may appear should this condition worsen.

Diagnostic Studies

Laboratory evaluation should include an erythrocyte sedimentation rate, C-reactive protein, complete blood count, and liver function tests (Warrington & Matteson, 2007). The erythrocyte sedimentation rate will be at least 50 mm/hr in patients with GCA. C-reactive protein, a marker for inflammation, is typically elevated. Many patients have evidence of a normochromic normocytic anemia and mild abnormalities of liver function.

Temporal artery biopsy is the gold standard test for GCA (Warrington & Matteson, 2007). While a biopsy of the temporal artery should be performed to rule out GCA, it is not necessary for those who present only with polymyalgia rheumatica. In these patients, careful history of unusual facial pain (including throat and/or tongue) should be ascertained, as this may indicate GCA. Without biopsy, patients with polymyalgia rheumatica should be closely followed because a small percentage will develop GCA within several months, even while on low-dose glucocorticoid therapy for their condition. If a temporal artery biopsy is obtained, it is done on an outpatient basis under local anesthesia. A negative biopsy does not always rule out temporal arteritis.

MRI angiography, conventional angiography, Doppler ultrasound, and positron emission tomography are modalities that have been used for clinical investigation of GCA. They have possible potential, not only to diagnose GCA, but also to estimate disease activity.

Treatment Options, Expected Outcomes, and Comprehensive Management

Treatment goals are to alleviate symptoms and prevent complication such as vision loss. The treatment for temporal arteritis includes high-dose glucocorticoids (Hellmann, 2008; Warrington & Matteson, 2007). These should be initiated promptly when the suspicion of temporal arteritis is high and when visual symptoms are present. The initial dose is 40 to 60 mg of prednisone daily for 4 weeks. The initial doses should be given parenterally when there is a concern about visual compromise, but this must be started within the first 5 hours of visual impairment. Methylprednisolone is given as 1,000 mg intravenously daily for 3 days followed by the standard 40 to 60 mg prednisone dose. Most people begin to feel better within a few days of beginning treatment and most people make a full recovery, but disease flares are common if glucocorticoids are tapered too quickly. After 4 weeks of treatment, the steroid dose can be tapered

gradually by 10% every 2 to 4 weeks until the patient is on 10 mg daily. Then the dose is tapered by 1 mg at a time over approximately 36 weeks. The average duration of treatment is 3 years. Disease flares may necessitate an upward titration of the glucocorticoid dose to control symptoms. An elevated inflammatory marker in the absence of clinical symptoms does not require an increase in glucocorticoid dose.

While on glucocorticoid therapy, patients should have regular clinical and laboratory follow-up, including assessment of inflammatory markers. Patient should be monitored for complications from long-term glucocorticoid treatment, including hypertension, diabetes, and bone loss. Calcium, vitamin D, and bisphosphonates may be needed to prevent or manage steroid-induced osteoporosis. Unless contraindicated, patients should receive low-dose aspirin (81 mg) to reduce the risk of vision loss and cerebrovascular accidents (Warrington & Matteson, 2007).

Patients with GCA have an increased risk of aortic aneurysm (Warrington & Matteson, 2007). Screening should include an annual chest x-ray, in addition to an annual transthoracic echocardiogram and abdominal ultrasound to monitor aortic size. If an aneurysm is detected, CT scanning is recommended every 6 months.

For patients with significant steroid-related side effects, methotrexate given at 7.5 to 20 mg/wk along with folate 1 mg/d is an alternative glucocorticoid-sparing approach that may allow a reduction in the prednisone dose while still controlling symptoms. Cyclophosphamide, dapsone, and hydroxychloroquine have been used successfully in the treatment of GCA, but their use has not been widely studied in clinical trials (Warrington & Matteson, 2007).

Clinical practice guidelines for the management of GCA (Warrington & Matteson, 2007) are available at www.clinexprheumatol.org/article.asp?a=3191

Teaching and Self-Care

Many patients respond quickly to treatment, but relapse is common. Patients should report symptoms of a relapse immediately to their primary care provider. Patients should be educated as to the importance of continuing therapy to prevent relapse and reduce the risk of complications. Patients should be encouraged to quit smoking. Walking and weight-bearing exercise are important to reduce the risk of bone loss while on chronic glucocorticoid therapy.

FROSTBITE

Frostbite is a localized injury induced by exposure to cold temperature resulting in freezing of the tissue.

Anatomy, Physiology, and Pathology

The onset of frostbite can be rapid or insidious. The traumatic effect of extreme cold on the skin and subcutaneous tissue is first recognized by the distinct pallor of exposed skin surfaces. Vasoconstriction and damage to blood vessels impairs local circulation and can result in anoxia, edema, vesiculation, and necrosis. Ice crystals may form intra- or extracellularly, causing fluid and electrolyte shifts that result in cell lysis and death. An inflammatory process follows, leading to tissue ischemia and necrosis. Intracellular damage and inflammation may be made worse if thawing occurs followed by refreezing of the affected area (McIntosh et al., 2011).

Areas of the body at greatest risk from localized cold damage include the fingers, toes, hands, feet, nose, ears, and cheeks. Tissues that reach and maintain temperatures of –6°C (21°F) develop frostbite. This includes the epidermis, dermis, subcutaneous tissues, muscles, and bones, as well as nerves, lymphatics, and blood vessels.

Frostbite is divided into several categories by degree of injury (McIntosh et al., 2011):

- Frostnip is a superficial nonfreezing cold injury without ice crystal formation in the tissue or cell loss. Numbness and pallor resolve quickly with rewarming. No long-term tissue damage occurs.
- First-degree frostbite presents with numbness and erythema; mild edema is common, as is the presence of a white or yellow raised plaque. No gross tissue damage occurs.
- Second-degree frostbite is characterized by superficial fluid-filled blisters, erythema, and edema. No tissue loss occurs.
- Third-degree frostbite occurs when injury extends into the dermis and deeper hemorrhagic blisters develop. The skin forms a black eschar within several weeks.
- Fourth-degree frostbite occurs when injury extends completely through the dermis into the subcutaneous tissue with necrosis reaching the muscle and bone. Mummification occurs between 4 and 10 days.

Epidemiology

Lack of a formal reporting system precludes the ability to document accurate epidemiological data. Areas of the body most at risk include the extremities and areas that tend to have less-abundant circulation, including the hands, feet, face—especially the nose, cheeks, and ears (Mechem & Zafren, 2013).

Diagnostic Criteria

Frostbite is a localized cold injury to the surface of the body. Diagnosis is based on clinical assessment.

History and Physical Examination

The severity of the injury is difficult to determine on initial assessment of the patient with frostbite. In tissue that is damaged superficially, only the skin and subcutaneous tissues will be affected. Severe frostbite will penetrate deeper into muscles, nerves, blood vessels, and sometimes as deep as the bones. Frozen tissues will appear cold, white, bloodless, and

hard on assessment. Generally, tissues that appear reddish or dusky blue have thawed, or thawed and refrozen. Tissue that is freshly thawed varies in appearance and in symptomatology. Even minor damage is frequently painful. The patient may describe a throbbing, stinging, stabbing, burning, or aching pain; the pain is caused by the return of blood flow to the affected area. On inspection, the skin may appear flushed and may develop clear yellowish or pink-tinged blisters over the first 24 hours after thawing. Deeper damage is evident if the patient feels no pain or sensation in the identified tissues. These tissues take on a ruddy-violet to purple-black dehydrated appearance. Areas that are damaged even further will become necrotic, taking on a black, desiccated appearance.

It is important to assess the patient frequently for any changes. These early observations of frostbite damage include frequent monitoring of circulation to the affected tissues. The patient should be queried about sensations, numbness, tingling, pain, pressure, or anesthesia. Patients may complain of an achiness or unpredictable spasms of piercing pain. Peripheral pulses should be assessed through palpation or by using a Doppler. Color, discoloration, texture, lines of demarcation, patterns, and the fullness and shape of the extremity should also be noted for comparison.

Diagnostic Studies

Diagnosis is most often made by direct clinical presentation, observation, history of exposure, and visual assessment. In patients presenting more than 24 hours after thawing, imaging studies (e.g., bone scans or MRI) may aid in determining the extent of tissue involvement and tissue viability prior to amputation (McIntosh et al., 2011).

Treatment Options, Expected Outcomes, and Comprehensive Management

When treating frostbite, care is divided into two stages: prehospital and hospital-level care. The patient should be brought to a warm area as soon as possible. The affected areas should be protected to minimize injury. Refreezing must be avoided. If conditions are such that refreezing might occur, it is safer to keep the affected area frozen until the patient can be moved to a warm area and a thawed state can be maintained (McIntosh et al., 2011). If possible, prehospital rewarming should occur by immersion of the affected area in a warm water bath. The use of a fire, oven, or heater should be avoided, as burns may occur. Avoid rubbing frostbitten areas, as this can result in additional tissue damage.

Patients often have accompanying hypothermia. Hypothermia occurs when the body's core temperature drops below 35°C (95°F) and is considered severe when it falls below 28°C (82.4°F). Mild hypothermia can be treated concurrently; moderate to severe hypothermia must be corrected prior to treating the frostbite injury (McIntosh et al., 2011).

In the hospital, rapid rewarming can begin. Spontaneous thawing can occur. If tissue is completed thawed, further rewarming is not needed. Rewarming is performed by immersion in warm water baths with the temperature maintained between 37 and 39°C (98.6 and 102.2°F) until the tissue is soft to touch (approximately 30 minutes). An antiseptic solution is sometimes added to the rewarming water to reduce the risk of cellulitis. This practice is unlikely to result in harm; however, there is no evidence base to support its use (McIntosh et al., 2011). Pain management is essential during the rewarming process. Pain medication should be administered based on the individual needs of the patient (McIntosh et al., 2011).

Rewarming is complete when blood flow engorges the involved tissues, producing a pink or red flush. The tissue should then be allowed to air-dry or gently patted dry to prevent tissue damage. Clear blister can be drained by needle aspiration. Hemorrhagic blisters should be left intact. Topical aloe vera reduces prostaglandin and thromboxane. Aloe vera cream or gel should be applied to the affected area and then covered with a dry, bulky dressing. The affected body part should be elevated, if possible.

The patient should maintain adequate hydration, with either oral or intravenous fluids. Tetanus prophylaxis should be administered. Tissue plasminogen activator (tPA), when administered within 24 hours of thawing, has been shown to improve tissue salvage and to reduce the need for amputation (McIntosh et al., 2011). Low molecular weight heparin is commonly administered in the prehospital period to reduce microthrombi formation; however, no evidence exists to support its use (McIntosh et al., 2011). Vasodilators, such as prostaglandin E1, iloprost, and nitroglycerin, are sometimes used as adjunctive therapy. Vasodilator administration prior to tPA may improve outcomes. Pentoxifylline, a methylxanthine derivative used in the treatment of PAD, can also have positive results in patients with frostbite when given at 400 mg three times a day for 2 to 6 weeks (McIntosh et al., 2011).

Ibuprofen, a nonsteroidal anti-inflammatory drug (NSAID), is given at a dose of 12 mg/kg/d divided into twice-daily doses to reduce prostaglandin and thromboxane production that can cause vasoconstriction resulting in further tissue damage. Aspirin can be used as an alternative in patients with contraindications to NSAIDs. These agents should be started in the prehospital period if available.

Daily or twice-daily hydrotherapy at temperatures of 37 to 39°C (98.6–102.2°F) is recommended. Hydrotherapy is thought to improve circulation and debride tissue; however, evidence is lacking to support its use or provide specific recommendations on timing and duration or therapy (McIntosh et al., 2011). Hyperbaric oxygen therapy has been proposed as an alternative therapy. It increases oxygen tension in the blood to increase tissue oxygenation to promote healing. As blood supply may be compromised in frostbite injuries, its use may not prove successful.

Urgent surgical consultation for amputation may be necessary if the patient develops sepsis as a result of an infection in frostbitten tissue. Otherwise, decisions on amputations should be delayed as long as possible, as complete demarcation of tissue necrosis may take months to occur (McIntosh et al., 2011).

Clinical practice guidelines from the Wilderness Medical Society for the management of frostbite (McIntosh et al., 2011) are available at www.wildmedcenter.com/uploads/5/9/8/2/5982510/wms_frostbite.pdf

CLINICAL WARNING:

Do not try to speed thawing by using temperatures above the recommendation of 39°C (102.2°F), and avoid rubbing or massaging the affected extremity. Protect the injured extremity from mechanical injury.

Teaching and Self-Care

For patients with a frostbite injury, a diet high in protein, calories, vitamins, and minerals is recommended. Copious fluid intake is encouraged to replace preexisting deficits and to provide a full reservoir to enhance circulation and repair. The patient should avoid acts that could disrupt circulation, risk infection, or traumatize fragile tissues. Affected extremities should be elevated to reduce edema. If the patient's arterial flow pattern is of concern, the affected extremity should be maintained in a neutral position.

Frostbite is a preventable injury. Patients should minimize cold exposure and protect skin from moisture, wind, and cold. Wear warm clothing in layers as appropriate for environmental conditions. Patients should avoid smoking and alcohol consumption. Adequate caloric intake should be maintained. Exercise is recommended to maintain peripheral perfusion during periods of cold-induced peripheral vasodilation. Patients should be instructed on the signs of frostnip and superficial frostbite, and seek warmth should these symptoms develop.

CHRONIC VENOUS INSUFFICIENCY

Anatomy, Physiology, and Pathology

Chronic venous insufficiency is a condition that affects the lower extremities. It develops when blood pools in the leg veins instead of returning to the heart. Circulatory dysfunction involving veins may or may not present with symptoms. This condition may begin as early as in childhood. Signs of venous insufficiency can range from mild and/or long-standing skin discoloration to complex ulceration.

The normal anatomy of the venous system of the legs is divided into two main systems: deep and superficial. The veins that connect between a single system (deep to deep or superficial to superficial) are referred to as *communicating veins*. Veins connecting the two systems (superficial to deep) are referred to as *perforating veins*.

The deep veins and arteries are located parallel to each other in the legs. The anterior and posterior tibial veins, the peroneal veins, the popliteal veins, the superficial and deep femoral veins, and the common femoral veins are included in this system. The superficial veins, consisting of two major veins (the greater and lesser saphenous veins), are located in the subcutaneous tissue. The greater saphenous vein extends from the dorsum of the foot up the medial aspect of the leg to the groin, where it empties into the common femoral vein. The lesser saphenous vein begins behind the lateral malleolus and enters the popliteal vein at the popliteal fossa. There are approximately 100 communicating and perforating veins in each leg. These veins are located medially and laterally in the lower leg and allow oblique blood flow from the superficial system through the fascia into the deep system. The most important communicating leg veins are located around the medial malleolus and laterally in the lower third of the leg.

The venous system is a unique system consisting of valves that permit unidirectional flow of blood back to the heart. These delicate but very strong structures lie at the base of the segment of a vein that is expanded into a sinus. This arrangement permits the valves to open widely without coming into contact with the wall, thus allowing rapid closure when blood flow begins to reverse. There are fewer valves in the superficial veins. Approximately seven to nine valves exist in the greater and lesser saphenous veins. These valves allow blood flow to be directed centrally and prevent reflux. Perforating veins have valves that allow one-way flow of blood from the superficial system to the deep system. *Competent valves* are valves that ensure the unidirectional flow of blood to the heart (García-Gimeno et al., 2009).

For blood to return to the heart, the calf muscle must pump blood back into the central veins against gravity. As the calf muscle contracts, it exerts pressure on the vein, thus setting the blood in motion. The pressure in the deep veins increases to 200 mmHg when the calf muscle contracts, pushing the blood flow toward the heart. The pressure in the superficial veins does not change during this contraction. As the calf muscle relaxes, the pressure in the deep veins decreases to between 0 and 10 mmHg, allowing the blood to flow into them through the perforator veins. At this point, the pressure in the superficial venous system decreases to 30 mmHg. The calf pump functions normally when foot vein pressure decreases from 90 to 30 mmHg during exercise of the calf muscle.

Venous disease occurs when there is an obstruction to or reduction of venous blood return to the heart. This can happen in several different ways, including thrombus formation, incompetent valves, gravitational strain, or immobilization of the extremity. A thrombus or thrombophlebitis can obstruct a vein, producing acute pain or throbbing as a result of the inflammatory process. The valves in the veins can become incompetent, thereby causing a reduction in the venous blood flow. This in turn produces edema from the increased venous and capillary pressure, causing fluid to seep out into the surrounding tissues. The gravitational pressure of standing adds to the strain on veins because hydrostatic pressure increases venous pressure. Venous stasis occurs with immobilization or impairment of the pumping action of the calf muscles. Calf pump failure occurs when the foot vein pressure is increased rather than reduced as the calf muscle relaxes. This failure is seen when there is an outflow obstruction (e.g., intraluminal thrombosis, pelvic tumor), outflow tract regurgitation (e.g., deep

vein thrombosis [DVT], floppy valves), perforator vein incompetence (e.g., congenital vein wall weakness), superficial vein regurgitation, or muscle failure (e.g., paralysis; Coleridge-Smith et al., 2006). Immobility, obesity, prolonged standing or sitting, and pregnancy are conditions that can cause venous stasis.

Conditions that produce hypercoagulability (e.g., elevated platelet count, increased clotting factors, increased blood viscosity) can lead to the formation of thrombus that occludes venous circulation. These conditions include blood dyscrasias, the use of birth-control pills, malignant neoplasms, and pregnancy. Injury to the vein or vein wall can lead to decreased blood flow and can result from a variety of conditions, both surgical and nonsurgical, including trauma, chemical sclerosing agents, and radiopaque dyes (Bauer & Lip, 2013).

Epidemiology

Chronic venous insufficiency can be a debilitating condition. It occurs more commonly in women than men. Prevalence data differ by geographic region, but chronic venous insufficiency has been reported to be as high as 40% in women and 17% in men (Beebe-Dimmer et al., 2005). Chronic venous insufficiency of the legs is described throughout the literature as being among the most common medical problems. Approximately 25 million people in the United States have chronic venous insufficiency; 20% of these will develop venous ulcers (Eberhardt & Raffetto, 2005). The incidence of chronic venous insufficiency, both with and without ulcers, increases with age.

Diagnostic Criteria

Because chronic venous diseases vary in range from asymptomatic to debilitating, the Clinical–Etiology–Anatomy–Pathophysiology (CEAP) classification system has been developed to categorize the degree of venous disease in order to facilitate accurate diagnosis, treatment, and prognosis (Table 12.4). Within the clinical classification category, subdivisions range from C0 to C6, and symptomatic as well as asymptomatic conditions fall into this category. The etiology category is subdivided into four sections: congenital, primary, secondary, and no venous cause. Anatomic classification includes superficial, perforator, deep, and no venous location identified. The pathophysiological category encompasses reflux, obstruction, the combination of these, and no venous pathophysiology identified (Eklöf et al., 2004).

History and Physical Examination

The clinical manifestations of chronic venous insufficiency involve changes in the lower extremities. There are usually one or more visible cutaneous changes in the legs. These changes include edema, xerosis, brownish pigmentation (hemosiderin deposition), eczema, ankle flare, and lipodermatosclerosis. They may be unilateral or bilateral.

Edema, an early sign of chronic venous insufficiency, is caused by an increase in venous pressure resulting from calf pump failure. When edema occurs, the capillary bed becomes distended. A brown or brownish-red pigmentation occurs as a result of extravasation of red blood cells caused by venous hypertension, which distends the capillary walls and promotes leakage of the red blood cells through the endothelial cells into the surrounding tissues. This pigmentation, known as hemosiderin deposition, is noted on the skin, usually in the area superior to the medial malleolus in the gaiter area. Hemosiderin, an iron-containing pigment, is derived from hemoglobin as the red blood cell disintegrates. This pigmentation pattern may also be caused by melanin deposition.

Eczema is a condition that develops in response to xerosis, a chronic dryness, caused by the lack of oxygen and nutrients. It may present with erythema, scaling, pruritus, and occasional weeping. Ankle flare, a manifestation also called corona phlebectatica, is detected as dilated venules. These dilated venules are usually observed below the medial malleolus and extending onto the foot. The greater the number of capillaries noted in ankle flare, the greater the extent of venous disease.

Lipodermatosclerosis is the clinical presentation of panniculitis (inflammation of subcutaneous fat), a condition resulting from significant venous compromise over time (Bergan et al., 2006). Lipodermatosclerosis becomes a vicious cycle, ultimately strangling the lower limb. Fibrous tissue eventually replaces skin and subcutaneous tissue. The leg is no longer edematous; the lower third of the leg feels woody and has the appearance of an inverted champagne bottle or an inverted bowling pin. This dermal change, which may be mistaken for cellulitis, precedes and forebodes ulceration. The presence of lipodermatosclerosis, hemosiderin deposition, and epithelial scaling is referred to as venous dermatitis.

The patient's health history is of utmost importance when assessing for venous insufficiency. To determine the significance of the symptoms of venous disease, it is important to inquire about any family history of venous disease and about any previous surgical history involving the affected extremity. Patients should be queried regarding other risk factors as described in Table 12.5 (Chiesa, Marone, Limoni, Volontè, & Petrini, 2007; Fowkes et al., 2001; Iannuzzi et al., 2002).

The patient should identify and describe any areas of pain or heaviness in the limbs and rate the pain on a scale of 0 to 10, with 0 representing the least amount of pain and 10 being the worst amount of pain. It should be noted whether the patient has observed any changes in skin temperature or appearance, skin breakdown, or any history of ulcerations.

The physical examination of the patient with venous insufficiency involves inspecting the skin for breakdown and noting any scars from healed ulcers. The extremities should be inspected for edema, and if present, they should be palpated for pitting edema. It is important to inspect and palpate the extremities for varicosities (tortuous or dilated

TABLE 12.4 Clinical–Etiology–Anatomy–Pathophysiology (CEAP) Classification System for Chronic Venous Insufficiency

CLINICAL CLASSIFICATION	
C_0	No visible or palpable signs of venous disease
C_1	Telangiectasias, reticular veins, malleolar flares
C_2	Varicose veins
C_3	Edema without skin changes
C_4	Skin changes ascribed to venous disease (e.g., pigmentation, venous eczema, lipodermatosclerosis)
C_{4a}	Pigmentation or eczema
C_{4b}	Lipodermatosclerosis or atrophie blanche
C_5	Skin changes as defined above with healed ulceration
C_6	Skin changes as defined above with active ulceration
S	Symptomatic, including ache, pain, tightness, skin irritation, heaviness, and muscle cramps, and other complaints attributable to venous dysfunction
A	Asymptomatic
ETIOLOGICAL CLASSIFICATION	
E_c	Congenital
E_p	Primary
E_s	Secondary (post-thrombotic)
E_n	No venous cause identified
ANATOMIC CLASSIFICATION	
A_s	Superficial veins
A_p	Perforator veins
A_d	Deep veins
A_n	No venous location identified
PATHOPHYSIOLOGICAL CLASSIFICATION	
P_r	Reflux
P_o	Obstruction
$P_{r,o}$	Reflux and obstruction
P_n	No venous pathophysiology identifiable

Source: Adapted from Eklöf et al. (2004).

TABLE 12.5 Risk Factors for Venous Insufficiency

- Recent hospitalization with prolonged bed rest (e.g., surgery, illness, pregnancy)
- History of prolonged sitting or standing; sedentary lifestyle
- History of surgery or trauma to the leg
- Use of oral contraceptives
- History of superficial phlebitis or deep vein thrombosis
- Family history of venous disease
- Ligamentous laxity (e.g., flat feet, history of hernia)
- Presence of an arteriovenous shunt
- High estrogen states; pregnancy
- Obesity
- Smoking

veins). These are best seen in the standing position, when the gravitational pressure is greatest. The provider should also palpate for hard, cordlike segments along the veins. It is also important to palpate the feet and legs to detect any changes in the skin temperature and to assess all peripheral pulses. Any skin color changes, scaly skin, or open areas should be noted. Patients should be evaluated for a positive Homans's sign by dorsiflexing each foot. Calf pain elicited with this maneuver would indicate the need to further evaluate for a DVT.

A common problem that arises from chronic venous insufficiency is the formation of a venous stasis ulcer. Unlike arterial ulcers, venous ulcers do not form at pressure points. Venous ulcers tend to be in the gaiter area, usually situated over the medial and lateral malleoli. Ulcer borders are usually shaggy and irregular. There may be brown-red hemosiderin pigmentation of the surrounding skin and eczematous changes around the ulcer with redness, scaling, and itching. Varicose veins may be present and ankle edema is common. In long-standing venous ulcers, lipodermatosclerosis may be present. It is important to assess the patient's arterial circulation while treating venous disease because diseases of these two systems often coexist.

Diagnostic Studies

Several diagnostic tests are used to identify venous insufficiency. Doppler ultrasonography is used to establish the absence or presence of venous reflux and obstruction. Duplex scanning with color-flow imaging is used to locate venous reflux in the superficial, deep, and perforator systems. Impedance plethysmography is used to assess venous outflow and measure variations in electrical impedance that accompany changes in blood volume. Photoplethysmography is used to measure vascular volume to provide an index of valvular competence. Radionuclide venography is used to assess the venous system but does not allow for visualization of the tibial veins. CT or MRI venography can provide radiographic pictures of the venous system to further evaluate venous obstruction, reflux, or anomalies.

Treatment Options, Expected Outcomes, and Comprehensive Management

The physiological manifestations of long-standing venous hypertension and tissue hypoxia include edema, hyperpigmentation, subcutaneous fibrosis, and ulceration of tissue. Treatment ranges in accordance with severity of clinical presentation. The goal is to facilitate healing of tissue by encouraging circulation so that oxygenation at the molecular level can be achieved.

Compression therapy has been used successfully for decades in the healing of venous stasis ulcers. Elastic compression stockings, which vary in compression strength from 20 to 50+ mmHg, individualized in pressure to the patient's need, are used during maintenance phases. These

are applied from the toes to below the knee, and aid in venous return by exerting graduated pressure from distal to proximal aspects of the limb. These stockings should be put on as soon as the patient gets up in the morning, and work best if worn all day and removed at night.

Foot elevation is essential to promote venous return. This should be done several times daily with the feet elevated above the level of the heart. At night, the foot of the bed should be elevated on 6-inch blocks. To enhance patient participation in elevation of the extremities, a "feet-up chart" can be used, as shown in the display below (Capeheart, 1996).

Feet-Up Chart—Patient Log for Foot Elevation

DATE: _____

TIME: _____ LENGTH: _____
morning

TIME: _____ LENGTH: _____
afternoon

TIME: _____ LENGTH: _____
evening

Meticulous skin care is imperative in ulcer prevention. Corticosteroids may be used to manage severe cases of dermatitis and pruritus. Xerosis, also known as winter itch, is typically exacerbated during periods of low humidity and cold weather. It is prevalent on the lower extremities, and the patient may inadvertently cause the area to become inflamed through scratching because of the pruritic nature of the condition. Prevention measures include teaching the patient not to bathe every day, to use oils in the bath water, to use mild soaps or soapless cleansers, and to use a topical emollient to retard water loss from the epidermis. Patients should be instructed to buy emollients containing urea (10–20%) and lactic acid (5% or 12%). These ingredients assist in removing retained layers of stratum corneum and subsequently reduce the scaliness associated with xerosis. The patient should be educated to report any trauma sustained on the lower extremity or any signs of tissue breakdown.

Venous ulcers can be treated by several methods, including use of an Unna boot, hydrocolloid dressings, saline solution compresses, leg compression, and leg elevation. Various ointments and creams are also available and may be used in conjunction with dressings and elastic compression (Beidler et al., 2008). Although investigators have reported healing rates up to 80% with compression treatment, healing of ulcers, even with compression treatment, is often delayed in patients who suffer from arterial insufficiency (Beidler et al., 2008; Gohel et al., 2005).

The patient's nutritional status should be evaluated through either blood tests or a food diary. In particular, deficits in vitamins A and C, zinc, and albumin should be identified. Low albumin levels may increase lower extremity edema by extending the distance between blood vessels and the dermal surface. Albumin levels lower than 3.5 g/dL warrant consideration for protein supplementation. In addition, patients with diabetes mellitus must be educated regarding the importance of keeping blood sugar levels under control, because hyperglycemia and ketosis may impair leukocyte function. Obese patients should be instructed about and placed on a weight-reduction diet and encouraged to attend a weight-loss support group, available through various health care organizations, senior centers, churches, or community centers.

Follow-up care should include a reassessment of the lower extremities at least every 6 months, or more frequently if indicated. Review and reinforcement of self-care behaviors should occur at this time as well. This routine surveillance, feedback, and encouragement from the primary care provider can motivate the patient to participate actively in the prevention program.

Clinical practice guidelines from the Society for Vascular Surgery and the American Venous Forum for the management of varicose veins and associated chronic venous insufficiency (Gloviczki et al., 2011) are available at www.bendvein.com/downloads/Journal-Vascular-Surgery.pdf

Teaching and Self-Care

The goals in the management of venous insufficiency are to promote circulation, as well as prevent and eliminate infection. Patient should be educated about meticulous skin care (as described earlier) and the signs and symptoms of infection. Additional goals include stimulating the development of granulation tissue, implementing methods that promote venous return, and relieving pressure. Educating the patient is of prime importance in the management of venous disease (Table 12.6). Patients need to be instructed in the areas of foot care, exercise, nutrition, leg elevation, activity, elastic support, nonsmoking, and routine follow-up.

VARICOSE VEINS

Anatomy, Physiology, and Pathology

Varicose veins are superficial veins, predominantly in the lower extremities, that have become dilated, tortuous, and elongated and are unable to function adequately, thus rendering them incompetent. Varicosities present as superficial purple or bluish bulging veins, usually in the thigh or calf region. A weakness in their walls causes a dilation of the lumen and valve incompetence. As time progresses these distended, tortuous veins become increasingly visible. Although the exact cause of varicose veins remains unclear, certain risk factors or associations have been made (Table 12.7).

TABLE 12.6 Education Tips for the Patient With Chronic Venous Insufficiency

THINGS YOU SHOULD DO

- Keep your legs elevated higher than your heart while sitting or lying down.
- Under the supervision of your primary care provider, begin a walking program.
- If you are on your feet for prolonged periods, wear graduated compression stockings.
- Maintain your ideal weight.
- Eat a balanced, nutritious diet.
- Inspect your legs and feet daily.
- Report any changes in your legs, feet, or existing ulcer, including color, size, temperature, itch, pain, and odor.
- Keep legs and feet clean and well lubricated.
- Avoid bumping your legs.

THINGS YOU SHOULD NOT DO

- Stand or sit with legs in a dependent position for prolonged periods.
- Sit with your legs crossed.
- Wear constrictive clothing, such as girdles, nongraduated support stockings, tight shoes, or high heels.
- Use heating pads, hot water bottles, heat lamps, or ice packs.
- Take hot showers, hot baths, or use a hot tub or whirlpool.
- Drink alcohol.
- Smoke.
- Scratch your legs.
- Use adhesive tape on your legs.

TABLE 12.7 Risk Factors for Varicose Veins

- More common in women
- Overweight
- Pregnancy
- Family history
- History of trauma
- History of venous insufficiency or superficial phlebitis
- Occupation requiring prolonged standing

Epidemiology

Varicose veins are present in >20% of the adult population, with increased incidence correlating with increased age (Gloviczki et al., 2011). They are generally more common in women, with a 3:1 ratio to men (Eberhardt & Raffetto, 2005). Although the literature supports a general statement that the development of chronic venous disease strongly correlates with advanced age, flat feet, prolonged standing, high body mass index, smoking, trauma, hormonal imbalances, and pregnancy, and it has been suggested that the Western lifestyle (sitting and standing rather than walking) might contribute to the development of chronic venous diseases, evidence-based causational data are lacking to support this (Alguire & Scovell, 2013).

Diagnostic Criteria

Diagnosis is based on history and physical examination. The severity of symptoms correlates with the degree of venous reflux present (Alguire & Scovell, 2013). Duplex ultrasound evaluates the nature and extent of venous reflux. Results determine treatment choices.

History and Physical Examination

Dilated veins are a common finding on physical examination. Both lower limbs should be inspected for signs of venous disease. Visible varicosities should be palpated for tenderness or cords that could indicate thrombophlebitis. Patients should be evaluated for clinical findings using the CEAP categories described in the section on venous insufficiency (Table 12.4). Patients are often asymptomatic, but they may complain of heaviness, throbbing, and fatigue of the legs, at times accompanied by swelling that worsens as the day progresses. Itching, burning, and tingling, as well as leg cramps, are commonly reported. Mild swelling is not uncommon; however, marked swelling may be indicative of venous insufficiency affecting the deep vein system, which may progress to ulceration if left untreated.

Varicose veins may rupture as a result of trauma. Another concern is the development of superficial phlebitis, which occurs from the lack of smooth efficient transport of blood through the veins. Venous thrombophlebitis is divided into two types: superficial and deep. This chapter discusses superficial thrombophlebitis; refer to Chapter 74, "Venous Thromboembolism," for a discussion of DVTs.

Superficial thrombophlebitis may arise from a source of trauma such as surgery, injury, or infection. It may also arise because of a lack of forward blood flow (stasis) or a hypercoagulable state. The patient may complain of tenderness or pain over a specific region, swelling, redness, warmth, or a palpable cordlike lesion. This frequently occurs after plane or car travel with long hours of sitting and dehydration. Superficial venous phlebitis is of minor concern. It resolves quickly and does not usually travel to other areas of the body, as is the case with DVTs.

Diagnostic Studies

Visual examination determines whether or not superficial varicosities exist. Duplex ultrasound is used to determine the degree of disease. An evaluation for both deep and superficial venous reflux, in addition to ruling out the presence of thrombus, should be performed to guide treatment decisions.

Treatment Options, Expected Outcomes, and Comprehensive Management

The treatment goal is to relieve symptoms and prevent thromboembolitic complications (e.g., thrombus propagation into

the deep venous system). Care must be taken to consider differentials in diagnosing this presentation. Patients found to have a superficial venous thrombus should have a follow-up evaluation within a week of initial presentation to assess resolution or progression so that treatment options may be reconsidered as necessary.

The initial management of an uncomplicated superficial venous thrombosis (defined as one affecting <5 cm of a vein segment, remote from the saphenofemoral and saphenopopliteal junction, with no additional risk factors) begins with a supportive approach consisting of elevation of the involved extremity (above waist level), application of compresses (warm or cool, as is comfortable), and use of NSAIDs (Kearon et al., 2012). Anticoagulation therapy is individualized and often reserved for more extensive superficial thrombophlebitis. For a superficial venous thrombus >5 cm in length, treatment with fondaparinux (2.5 mg/d) or a prophylactic dose of low molecular weight heparin should be given for 45 days (Kearon et al., 2012). For patients already on anticoagulation for another condition, fondaparinux should be used. Graduated compression stockings are often recommended in conjunction with anticoagulation therapy; however, compression stockings are contraindicated in patients who have severe PAD (Kearon et al., 2012). Oral NSAIDs may be used to reduce symptoms in patients treated with anticoagulants. Surgical ligation or stripping is not recommended, as it is associated with higher rates of thromboembolism than treatment with anticoagulation (Kearon et al., 2012).

Conservative treatment of varicose veins starts with elevation of the legs and avoidance of prolonged standing. It is best to elevate the legs above the level of the heart intermittently throughout the day. Additionally, the patient should wear compression stockings, ideally with a 20 to 30 mmHg gradient (Gloviczki et al., 2011). These stockings must be worn every day and put on first thing in the morning, before the legs touch the floor. The third component is good local skin care to prevent breakdown or infection.

More aggressive approaches to treatment of superficial venous reflux include sclerotherapy, laser therapy, or surgical ligation. Deep venous reflux is managed conservatively with compression stockings and medical management for any resulting ulcerations. However, deep venous reflux may improve following ablation of the refluxing saphenous vein.

Sclerotherapy involves the injection of a sclerosing agent at the site of the varicosity, resulting in the complete fibrosis and collapse of the vein. Often, more than one treatment is required. This is used for smaller varicosities. External laser treatment also involves multiple treatments and may lead to pigment as well as textural changes of the skin. This treatment is also reserved for smaller varicosities.

Surgical treatment involves ligation or stripping of the refluxing vein segment. Surgery is more often reserved for patients with large, tortuous veins; with complications from varicose veins (e.g., vein hemorrhage, recurrent thrombophlebitis); or with contraindication to other less-invasive techniques. Removal of the vein can occur through an open incision or though several small incisions (phlebectomy). This procedure is more often performed on an ambulatory basis. Complications can include infection, nerve injury, and thromboembolism. Postsurgical care involves the application of compression bandages to provide support and reduce the incidence of swelling. When compared to less-invasive techniques, surgical ligation or stripping has a longer recovery time and more postoperative pain. Surgical management has a higher varicose vein recurrence rate compared to catheter-based approaches (Gloviczki et al., 2011).

Catheter-based, less-invasive approaches to treating varicose veins include endovenous laser and radiofrequency ablation therapy, both of which involve isolating and burning the vein from the inside. Endovenous laser ablation therapy (EVLT) is recommended over surgical treatment for both symptomatic varicose veins and cosmetic treatment of large varicosities in asymptomatic patients (Gloviczki et al., 2011; Khilnani et al., 2010). Success rates are reported to be between 85% and 100%; recanulation of the vein is usually due to inadequate thermal energy delivered (Khilnani et al., 2010). Contraindications to EVLT include acute DVT and pregnancy. Complications are usually minor and include superficial thrombophlebitis; however, DVTs and nerve injuries are possible risks. Ambulation is encouraged immediately following the procedure. Patients are instructed to walk for 5 to 10 minutes each waking hour, but vigorous activity should be avoided for 1 week. Compression stockings with a 30 to 40 mmHg gradient or a compression dressing is worn for at least 1 week and elevation of legs when not walking is recommended. Duplex ultrasound should be performed 2 to 3 days postprocedure to evaluate for DVT and closure of the treated vein. Periodic follow-up ultrasounds are performed to evaluate ongoing success until the treated vein is no longer visible (Gloviczki et al., 2011; Khilnani et al., 2010).

Clinical practice guidelines from the Society for Vascular Surgery and the American Venous Forum regarding the management of varicose veins and associated chronic venous disease (Gloviczki et al., 2011) are available at www.bendvein.com/downloads/Journal-Vascular-Surgery.pdf

Clinical practice guidelines from the Society of Interventional Radiology, Cardiovascular Interventional Radiological Society of Europe, American College of Phlebology, and Canadian Interventional Radiology Association for the treatment of superficial venous insufficiency with EVLT (Khilnani et al., 2010) are available at www.sirweb.org/clinical/cpg/Jan2010b.pdf

Clinical practice guidelines from the American College of Chest Physicians on antithrombotic therapy for venous thromboembolic disease (Kearon et al., 2012) are available at journal.publications.chestnet.org/data/Journals/CHEST/23443/chest_141_2_suppl_e419S.pdf

Teaching and Self-Care

Prevention is always important to teach. Preventive measures include leg elevation, leg exercises, and hourly ambulation (especially if traveling for prolonged periods by

car or plane) to promote circulation and prevent stasis of blood flow. This type of inactivity, especially in one predisposed, may lead to superficial thrombophlebitis, one of the acute complications associated with varicose veins (Allen, 2009).

Patients should be encouraged to wear compression stockings daily after arising, and continue until bedtime. Patients should be taught the signs and symptoms of thrombophlebitis, and report these to their provider immediately. Skin care is important. Patients should report new ulcerations to their provider for medical management.

LYMPHEDEMA

Anatomy, Physiology, and Pathology

The lymph system is made up of lymphatic capillaries, ducts, and lymph nodes. This system is responsible for the movement of fluid and products (proteins, fat from the gastrointestinal tract, and certain hormones) from the interstitial spaces to the blood, as well as returning excess interstitial fluid to the blood in the prevention of edema. Disruption of the normal drainage pattern in the lymph node system occurs after removal of even one lymph node.

Lymph fluid is a pale yellow interstitial fluid that diffuses through lymphatic capillary walls. It circulates through its own vasculature system, much like blood moves through blood vessels. The formation of lymph fluid increases when the interstitial fluid pressure rises because there is more volume in the lymphatic system. When this interstitial pressure rises too high and interferes with the reabsorption of lymph, lymphedema develops.

Lymphedema is a chronic swelling that results from the failure of the lymphatic system, causing accumulation of protein-rich interstitial fluid in the extremity. It affects one or more limbs and sometimes the adjacent quadrant of the trunk. The skin of the extremities and subcutaneous tissue is drained by the superficial lymphatic system; the subfascial structures (e.g., muscles and bone) are drained by a deeper system (Lawenda, Mondry, & Johnstone, 2009; Szuba, Shin, Strauss, & Rockson, 2003). The two systems of the upper extremities merge in the axilla and the two systems of the lower extremities merge in the pelvis. Thus, the pathophysiology of lymphedema is specifically related to an impaired lymphatic transport system. The accumulation of fluid causes an increase in colloid osmotic pressure. The body attempts to compensate for this by reducing the elevated pressure and by drawing water into the interstitial areas. Consequently, the lymphatic channels dilate and lymphatic valves become incompetent. The extra fluid is no longer drained appropriately and accumulates in the tissues.

Lymphedemas are classified into two categories: primary and secondary. Primary lymphedema is due to a congenital or inherited condition that causes malformation in the lymphatic vessels. Primary lymphedema is classified by age of onset:

- Congenital lymphedema occurs between birth and age 2 years
- Lymphedema praecox occurs before age 35 years, with a typical onset during puberty or pregnancy
- Lymphedema tarda occurs after age 35 years (Murdaca et al., 2012)

Secondary lymphedemas represent an acquired disruption in lymphatic flow. Whereas primary lymphedemas are caused by a poorly developed lymph system, secondary lymphedemas arise from an infection, a disease, or an iatrogenic process (e.g., surgery, radiation therapy) causing an obstruction that impairs the ability of the lymphatic channels to propel fluid forward to the vasculature (Szuba et al., 2003; Warren, Brorson, Borud, & Slavin, 2007).

Epidemiology

Lymphedema is a chronic, debilitating condition that affects 2 to 3 million Americans (Murdaca et al., 2012). Of patients attending lymphedema clinics, the incidence of primary lymphedema ranges from 8% of newly diagnosed patients to 28% with non-cancer-related diseases (Rockson & Rivera, 2008). Worldwide, the most common cause of secondary lymphedema is filariasis, an infection caused by the nematode *Wuchereria bancrofti* (Warren et al., 2007). Secondary lymphedema may also be caused by an infection or trauma. Most cases of secondary lymphedema in the developed world result from malignancy and cancer-related treatments, the most common cancer of which is breast cancer (DiSipio, Rye, Newman, & Hayes, 2013; Hayes, Janda, Cornish, Battistutta, & Newman, 2008). It is estimated that 17% of women with postmastectomy status will experience arm lymphedema (DiSipio et al., 2013); however, non-breast malignancies account for 16% of cancer-related lymphedemas (Cormier et al., 2010).

Diagnostic Criteria

Diagnosis is made by history and physical examination. Imaging is reserved where history and physical are not conclusive for a diagnosis of lymphedema.

History and Physical Examination

The diagnosis of lymphedema should be made only after a thorough history and physical examination are performed and the possibility of metastatic disease is ruled out. The onset of the swelling and any precipitating factors should be noted. A person with lymphedema will complain of heaviness or fullness of the extremity.

At the interview, the provider should inquire about the onset, location, duration, severity, and aggravating or alleviating factors, as well as associated symptoms. The provider should also determine if there is an association with pain,

changes related to the time of day, or changes with elevation of the extremity. The patient's use of other treatments for the condition should be noted. A thorough past medical history, including any coexisting medical problem, family history, and current pharmacotherapy, should also be obtained.

The physical examination should include inspection for signs of inflammation or infection, such as a red streak extending along the course of the lymphatics as they drain. The provider should also palpate the lymph nodes for enlargement or tenderness and the lower extremities for edema. Edema should be classified as pitting or nonpitting. The degree of edema should be measured by comparing the circumference of the affected limb to that of the unaffected limb. The degree of edema will influence the choice of treatment. Signs of venous disease may include signs of venous hypertension on the arms and legs. Venous incompetence will tend to influence the outcome of treatment. Signs of arterial insufficiency should be sought. Peripheral pulses should be assessed and measurements of the ABPI obtained.

Clinical manifestations of lymphedema are noted according to the signs and symptoms presented. These are categorized with respect to onset, laterality, and degree of swelling. Staging is in accordance with criteria established by the International Society of Lymphology (2013) on a scale of stages from 0 to III (Table 12.8). The diagnosis and classification consider degrees of softness/firmness of the affected limb. Within each stage, severity is documented from mild to severe.

The subclinical or latent stage of lymphedema can occur after a surgical procedure or trauma. There is impairment in the lymphatic transport without swelling. This stage may last for several months or even years before overt signs and symptoms manifest. In the subclinical stage, the presentation is essentially asymptomatic with a report of some heaviness in the limb.

In Stage I lymphedema, the patient has soft pitting edema that resolves with elevation of the limb. In Stage II, intradermal fibrosis occurs and pitting may or may not be present. Stage III lymphedema, also known as lymphostatic elephantiasis, is associated with significant fibrosis, marked swelling, and trophic skin changes such as acanthosis, fat deposition, and warty overgrowths (International Society of Lymphology, 2013).

Weakness, limited range of motion, stiffness, pain, and numbness of the extremity may occur. Skin changes are evident with advanced stages. The skin changes, which presumably are a result of the accumulation of fibroblasts and collagen, lead to brawny edema. Brawny edema is identified by a decrease in the tissue's ability to pit when pressure is applied. The capillaries and collecting vessels dilate, and the one-way valves become unable to function.

Permanent swelling involving only one of the extremities usually occurs. If bilateral swelling is present, it is asymmetric. A chronic, dull, heavy sensation develops in the affected extremity. Edema starts distally and progresses proximally until the entire limb becomes edematous. In chronic peripheral lymphedema, it is the appearance that brings the patient for treatment. In the later stages of the disease, the affected limb loses its normal contour because of swelling, and the toes appear square. The high protein concentration in the fluid changes the appearance of the extremity. These changes include deepened, enhanced natural skin creases and folds (hyperkeratosis). The tissue and skin become thick with less pitting and a positive Stemmer's sign, which is an ability to pick up a fold of skin at the base of the second digits. There is a distortion or exaggeration of the limb and an increased susceptibility to recurrent, acute inflammatory episodes such as cellulitis or fungal infections (Mohler & Mondry, 2013).

TABLE 12.8 Staging of Lymphedema

Stage 0	Subclinical condition where impaired lymphatic transport exists but swelling is not evident. The patient is often asymptomatic.
Stage I	Early accumulation of fluid relatively high in protein content, which subsides with elevation of the limb.
Stage II	Limb elevation alone rarely reduces swelling and pitting is present. Late in Stage II pitting may not be present as excess fat accumulates and fibrosis occurs.
Stage III	Lymphostatic elephantiasis where pitting can be absent and trophic skin changes such as acanthosis, further deposition of fat and fibrosis, and warty overgrowth have developed.

Diagnostic Studies

On occasion, imaging may be necessary to establish the diagnosis of lymphedema. Lymphoscintigraphy, the gold standard diagnostic study for the diagnosis of lymphedema, uses a low-dose radioactive colloid and a gamma camera for scanning. This procedure can be used to detect the movement of fluid in the lymphatic system and collateral pathways and to confirm that the edema is of lymphatic origin (International Society of Lymphology, 2013; Warren et al., 2007). The colloid is injected into the distal subcutaneous tissue of the affected extremity, and the area is scanned 30 to 60 minutes later. The patient then exercises that extremity for 20 minutes (if hand, squeezing of a ball; if foot, walking), after which another image is obtained. Visualization of regional lymph nodes as well as apparent dermal backflow indicate lymphatic function, noted as delayed, asymmetrical, or absent (Mohler & Mondry, 2013). Lymphedema is characterized by decreased or absent uptake of the radioactive isotope in the regional nodes, and is staged from 0 to III using the criteria established by the International Society of Lymphology (Table 12.8).

CT scan or MRI may be used as an alternative means of confirming the diagnosis of lymphedema. These imaging modalities may also be used to evaluate for obstruction caused by an underlying malignancy (Warren et al., 2007). Duplex ultrasound is used to rule out chronic venous insufficiency and DVT as potential causes of edema.

Treatment Options, Expected Outcomes, and Comprehensive Management

No curative treatment is available for lymphedema. The goals of therapy are to reduce the size of the swollen limb, to regain the original shape of the extremity, and to prevent recurrent acute inflammatory episodes. This may be achieved through an approach called complete or complex decongestive therapy (CDT), which includes an intensive treatment regimen followed by a maintenance treatment program. Patient should be referred to a lymphologist or a lymphologic center if available.

In the intensive phase, manual lymph drainage uses light pressure to promote movement of the fluid out of the extremity and the adjacent quadrant of the trunk (International Society of Lymphology, 2013; Lawenda et al., 2009; Rockson, 2008). Exercises and massage to promote maximum lymph flow and to increase joint mobility are performed. External compression with multilayer bandaging is used to reduce swelling. These are worn 24 hours a day during the intensive phase. Meticulous skin and nail care is crucial to preserve the integrity of the skin and reduce the risk of infection. The intensive phase involves daily treatment for 2 to 4 weeks or until maximal benefit, as measured by a plateau in limb measurements, is achieved.

The maintenance phase is a self-care program during which the patient continues self-manual lymph drainage using simple massage techniques (International Society of Lymphology, 2013; Lawenda et al., 2009; Warren et al., 2007). Compression stockings are worn during the day and may be worn at night if needed. The highest level of compression tolerated by the patient will provide the most benefit. Ongoing skin and nail care is essential to reduce infection risk. The patient should continue therapeutic exercises to promote maximal lymphatic flow and maintain range of motion of the limb. Because there is no cure for lymphedema, the maintenance treatment must continue for life.

Intermittent pneumatic compression is another nonoperative treatment. A pump is used to promote lymph drainage. External compression is then applied to maintain edema reduction (International Society of Lymphology, 2013). Low-level laser therapy that focuses laser light on the lymphatic channel has been shown to reduce lymphedema in two small studies (International Society of Lymphology, 2013; Lawenda et al., 2009). More evidence is needed to support its use.

If these methods do not control lymphedema, surgical intervention may be necessary. Failure may be caused by excessive swelling, uncontrollable persistent infection, or severe compromise of the patient's mobility.

The two main operative approaches are physiological and reductive techniques. The physiological technique is used for patients who present with early-stage lymphedema, characterized by the absence of fat deposits and extensive tissue fibrosis. The reductive technique is reserved for patients who present with advanced lymphedema—after fat deposits and tissue necrosis have occurred. The physiological technique facilitates transport of excess lymphatic fluid via lymphatic bypass, flap transposition, and lymph node transfer. Of these, lymphatic bypass is the most commonly used. Reductive procedures are used to reduce the bulk and are palliative rather than curative. Direct excision and liposuction are examples of reductive techniques (International Society of Lymphology, 2013).

Pharmacotherapy with appropriate antibiotics may be warranted to treat infections. Diuretic agents are of little use. Diuretic therapy is usually avoided in chronic management, unless comorbid conditions warrant their use, because it depletes the intravascular volume and produces metabolic abnormalities (International Society of Lymphology, 2013; Mohler & Mondry, 2013).

Clinical practice guidelines from the International Society of Lymphology (2013) for the management of lymphedema are available at www.u.arizona.edu/~witte/2013consensus.pdf

Teaching and Self-Care

For treatment to be successful, the patient needs to understand why the lymphedema occurs, what aggravates or worsens the swelling, and what helps to lessen swelling. Patients must understand the reasons behind the treatment program in which they are being encouraged to actively participate. No one component of the treatment program is effective on its own. For treatment to work, all components of therapy must be considered. Good results depend on ongoing, active participation and avoidance of infection. Patients require education regarding skin and nail care. Exercise should be encouraged. The compression garment should be worn during exercise. Psychosocial support is essential to promoting quality of life. Referral to a lymphatic program should be made if available.

Preventive education is essential for patients who will undergo any procedures that may put them at risk of developing lymphedema. Patients should be instructed on prophylactic exercises. Patients should be aware of the signs and symptoms of lymphedema and immediately report these to their provider.

COMMUNITY RESOURCES

- The American Heart Association: 7272 Greenville Avenue, Dallas, TX 75231 (1-800-AHA-USA-1); www.heart.org/HEARTORG/Conditions/More/PeripheralArteryDisease/Peripheral-Artery-Disease-PAD_UCM_002082_SubHomePage.jsp
- National Heart, Lung, and Blood Institute: NHLBI Health Information Center, Attention: Website, P.O. Box 30105, Bethesda, MD 20824-0105

(301-592-8573); www.nhlbi.nih.gov/health/health-topics/by-alpha/

- The PADC coalition: Vascular Disease Foundation, 550 M, Ritchie Highway PMB-281, Severna Park, MD 21146 (443-261-5564); http://vasculardisease.org/padcoalition/
- The National Lymphedema Network: National Lymphedema Network, Inc., 116 New Montgomery Street, Suite 235, San Francisco, CA 94105 (1-800-541-3259); www.lymphnet.org/
- Buerger's Disease: National Organization for Rare Disorders, 55 Kenosia Avenue, Danbury, CT 06810 (1-203-744-0100); www.rarediseases.org/rare-disease-information/rare-diseases/byID/712/viewAbstract

Referral Points and Clinical Warnings

While evaluating and following patients with arterial and venous insufficiency, several situations may arise that warrant referral to a vascular surgeon. Any cessation of blood flow, as evidenced by a loss of the pulse distal to an occlusion, should be immediately referred. The threat of gangrene is present when arterial insufficiency progresses to the point where pain is severe and persistent with loss of function. Arterial ulcers may appear in conjunction with limb-threatening ischemia and warrant immediate referral. Furthermore, any suspicion of aortic aneurysm should generate a consultation with a vascular surgeon. In patients with temporal arteritis, neurological deficits may be present and should be evaluated by both a neurologist and a vascular surgeon. Patients with frostbite should have the extremity protected from rubbing or mechanical injury. If the frostbite is severe or hypothermia is present, the patient should be admitted to an emergency department. Consultation with a vascular surgeon may also be warranted for aggressive therapy of varicose veins and lymphedema. Patients with lymphedema should be referred to a lymphatic center for specialist treatment.

Clinical Pearls

- Skin temperature of the extremity is best evaluated by palpating the extremity with the dorsum of the hand.
- Patients experiencing pain at rest may have edema because they keep their legs in a dependent position for pain relief.
- It is important in patients with PVD to check pulses in all regions of the body where major vessels are located, including the carotid, abdominal aorta, iliac, femoral, popliteal, posterior tibial, and dorsalis pedis.

(*continued*)

Clinical Pearls (*continued*)

- Nocturnal muscle cramps, a symptom that mimics claudication, are a common complaint in older persons, and are not related to exercise.
- Vasodilating agents have had little effect on patients with claudication.
- If temporal arteritis is suspected, it must be remembered that a negative biopsy does not always rule out temporal arteritis as the diagnosis.
- For patients with asymptomatic AAAs <5.5 cm, conservative management and follow-up are recommended. Surgical risk is greater than the risk of aneurysm rupture for aneurysms <5.5 cm.
- In the patient with frostbite, deeper damage is evident if the patient feels no pain or sensation in the identified tissues.
- "Winter itch," in patients with venous insufficiency, also known as xerosis, is typically exacerbated during periods of low humidity and cold weather.
- In patients with lymphedema, permanent swelling involving only one of the lower extremities usually occurs. If bilateral swelling is present, it is asymmetric.
- Circumferential measurement of the patient with lymphedema may be necessary to determine the degree of edema between extremities.

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