This chapter focuses on circulation to the arms and legs. It includes the arteries, the veins, the capillary bed that connects them, and the lymphatic system with its lymph nodes.

**Arteries**

Arterial pulses are palpable when an artery lies close to the body surface. In the arms, there are two or sometimes three such locations. Pulsations of the *brachial artery* can be felt in and above the bend of the elbow, just medial to the biceps tendon and muscle. The brachial artery divides into the radial and ulnar arteries. *Radial artery* pulsations can be felt on the flexor surface of the wrist laterally. Medially, pulsations of the *ulnar artery* may be palpable, but overlying tissues frequently obscure them.

The radial and ulnar arteries are interconnected by two vascular arches within the hand. Circulation to the hand and fingers is thereby doubly protected against possible arterial occlusion.
In the legs, arterial pulsations can usually be felt in four places. Those of the femoral artery are palpable below the inguinal ligament, midway between the anterior superior iliac spine and the symphysis pubis. The femoral artery travels downward deep within the thigh, passes medially behind the femur, and becomes the popliteal artery. Popliteal pulsations can be felt in the tissues behind the knee. Below the knee, the popliteal artery divides into two branches, both of which continue to the foot. There the anterior branch becomes the dorsalis pedis artery. Its pulsations are palpable on the dorsum of the foot just lateral to the extensor tendon of the big toe. The posterior branch, the posterior tibial artery, can be felt as it passes behind the medial malleolus of the ankle.

Like the hand, the foot is protected by an interconnecting arch between its two chief arterial branches.

Veins

The veins from the arms, together with those from the upper trunk and the head and neck, drain into the superior vena cava and on into the right atrium. Veins from the legs and the lower trunk drain upward into the inferior vena cava. Because the leg veins are especially susceptible to dysfunction, they warrant special attention.

The deep veins of the legs carry about 90% of the venous return from the lower extremities. They are well supported by surrounding tissues.
In contrast, the superficial veins are located subcutaneously, and are supported relatively poorly. The superficial veins include (1) the great saphenous vein, which originates on the dorsum of the foot, passes just in front of the medial malleolus, and then continues up the medial aspect of the leg to join the deep venous system (the femoral vein) below the inguinal ligament; and (2) the small saphenous vein, which begins at the side of the foot and passes upward along the back of the leg to join the deep system in the popliteal space. Anastomotic veins connect the two saphenous veins superficially and, when dilated, are readily visible. In addition, communicating (or perforating) veins connect the saphenous system with the deep venous system.

Deep, superficial, and communicating veins all have one-way valves. These allow venous blood to flow from the superficial to the deep system and toward the heart, but not in the opposite directions. Muscular activity contributes importantly to venous blood flow. As calf muscles contract in walking, for example, blood is squeezed upward against gravity, and competent valves keep it from falling back again.
The Lymphatic System and Lymph Nodes

The lymphatic system comprises an extensive vascular network that drains fluid, called lymph, from bodily tissues and returns it to the venous circulation. The system starts peripherally as blind lymphatic capillaries, and continues centrally as thin vascular vessels and then collecting ducts that finally empty into major veins at the root of the neck. The lymph transported in these channels is filtered through lymph nodes that are interposed along the way.

Lymph nodes are round, oval, or bean-shaped structures that vary in size according to their location. Some lymph nodes, such as the preauriculars, if palpable at all, are typically very small. The inguinal nodes, in contrast, are relatively larger—often 1 cm in diameter and occasionally even 2 cm in an adult.

In addition to its vascular functions, the lymphatic system plays an important role in the body’s immune system. Cells within the lymph nodes engulf cellular debris and bacteria and produce antibodies.

Only the superficial lymph nodes are accessible to physical examination. These include the cervical nodes (p. 133), the axillary nodes (p. 300), and nodes in the arms and legs.
Recall that the axillary lymph nodes drain most of the arm. Lymphatics from the ulnar surface of the forearm and hand, the little and ring fingers, and the adjacent surface of the middle finger, however, drain first into the *epitrochlear nodes*. These are located on the medial surface of the arm about 3 cm above the elbow. Lymphatics from the rest of the arm drain mostly into the axillary nodes. A few may go directly to the infraclaviculars.

The lymphatics of the lower limb, following the venous supply, consist of both deep and superficial systems. Only the superficial nodes are palpable. The *superficial inguinal nodes* include two groups. The *horizontal group* lies in a chain high in the anterior thigh below the inguinal ligament. It drains the superficial portions of the lower abdomen and buttock, the external genitalia (but not the testes), the anal canal and perianal area, and the lower vagina.

The *vertical group* clusters near the upper part of the saphenous vein and drains a corresponding region of the leg. In contrast, lymphatics from the portion of leg drained by the small saphenous vein (the heel and outer aspect of the foot) join the deep system at the level of the popliteal space. Lesions in this area, therefore, are not usually associated with palpable inguinal lymph nodes.

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**Fluid Exchange and the Capillary Bed**

Blood circulates from arteries to veins through the capillary bed. Here fluids diffuse across the capillary membrane, maintaining a dynamic equilibrium between the vascular and interstitial spaces. Blood pressure (*hydrostatic pressure*) within the capillary bed, especially near the arteriolar end, forces fluid out into the tissue spaces. In effecting this movement, it is aided by the relatively weak osmotic attraction of proteins within the tissues (*interstitial colloid oncotic pressure*) and is opposed by the hydrostatic pressure of the tissues.

As blood continues through the capillary bed toward the venous end its hydrostatic pressure falls, and another force gains dominance. This is the *colloid oncotic pressure of plasma proteins*, which pulls fluid back into the vascular tree. Net flow of fluid, which was directed outward on the arteriolar side of the capillary bed, reverses itself and turns inward on the venous side. Lymphatic capillaries, which also play an important role in this equilibrium, remove excessive fluid, including protein, from the interstitial space.
Lymphatic dysfunction or disturbances in hydrostatic or osmotic forces can all disrupt this equilibrium. The most common clinical result is the increased interstitial fluid known as edema (see Table 14-4, Some Peripheral Causes of Edema, p. 464).

### Changes With Aging

*Aging* itself brings relatively few clinically important changes to the peripheral vascular system. Although arterial and venous disorders, especially atherosclerosis, do afflict older people more frequently, they probably cannot be considered part of the aging process. Age lengthens the arteries, makes them tortuous, and typically stiffens their walls, but these changes develop with or without atherosclerosis and therefore lack diagnostic specificity. Loss of arterial pulsations is not a part of normal aging, however, and demands careful evaluation. Skin may get thin and dry with age, nails may grow more slowly, and hair on the legs often becomes scant. Because these changes are common, they are not specific for arterial insufficiency, although they are classically associated with it.

### Common or Concerning Symptoms

- Pain in the arms or legs
- Intermittent claudication
- Cold, numbness, pallor in the legs, hair loss
- Color change in fingertips or toes in cold weather
- Swelling in calves, legs, or feet
- Swelling with redness or tenderness

To assess possible peripheral vascular disease, begin by asking patients about any *pain in the arms and legs*. Be aware that pain in the extremities may arise from the skin, the peripheral vascular system, the musculoskeletal system, or the nervous system. In addition, visceral pain may be referred to the ex-
tremities, like the pain of myocardial infarction that radiates to the left arm or cervical arthritis that radiates to the shoulder.

To elicit symptoms of arterial peripheral vascular disease in the legs, inquire about intermittent claudication, which is exercise-induced pain that is absent at rest, makes the patient stop exertion, and remits within about 10 minutes. Ask “Have you ever had any pain or cramping in your legs when you walk or exercise?” and “How far can you walk without stopping to rest?” Also, “Does the pain get better with rest?” These questions clarify what makes the patient stop and how quickly the pain is relieved. Ask also about coldness, numbness, or pallor in the legs or feet or loss of hair over the anterior tibial surfaces.

Many patients with arterial peripheral vascular disease have few symptoms, so it is important to identify background risk factors. Assess the patient’s history of tobacco abuse. Ask if the patient has had hypertension, diabetes, or hyperlipidemia. Further, is there any history of myocardial infarction or stroke? Such patients warrant further evaluation, even if without symptoms in the extremities (see p. 448).

To elicit symptoms of arterial spasm in the fingers or toes, ask “Do your fingertips ever change color in cold weather or when you handle cold objects?” . . . “What color changes do you notice?” . . . “What about your toes?”

There may be symptoms of venous peripheral vascular disease, such as swelling of the feet and legs. Ask about any ulcers on the lower legs, often the near ankles.

The redness, swelling, and tenderness of local inflammation are seen in some vascular disorders and in other conditions that mimic them. In contrast, relatively brief leg cramps that commonly occur at night in otherwise healthy people do not indicate a circulatory problem, and cold hands and feet are so common in healthy people that they have relatively little predictive value.

Atherosclerosis can cause symptomatic limb ischemia with exertion; distinguish this from spinal stenosis, which produces leg pain with exertion that may be reduced by leaning forward (stretching the spinal cord in the narrowed vertebral canal) and less readily relieved by rest.

Hair loss over the anterior tibiae in decreased arterial perfusion. “Dry” or brown-black ulcers from gangrene may ensue.

Only about 10% of affected patients have the classic symptoms of exertional calf pain relieved by rest.

Digital ischemic changes of blanching, followed by cyanosis, then rubor with cold exposure and rewarming in Raynaud’s phenomenon or disease.

Hyperpigmentation, edema, and possible cyanosis, especially when legs are dependent, in venous stasis ulcers.

Inflammation in cellulitis, superficial thrombophlebitis, and erythema nodosum.

Etiology of common leg cramps and “restless legs” not well understood. Leg cramps sometimes from diuretic use with hypokalemia.
Peripheral arterial disease (PAD) generally refers to atherosclerotic occlusion of arteries in the lower extremities. The femoral and popliteal arteries are involved most commonly, followed by the tibial and peroneal arteries. PAD affects from 12% to 25% of community populations; however, recent studies* have shown that despite significant associations with cardiovascular and cerebrovascular disease, PAD often is underdiagnosed in office practices. Most patients with PAD have either no symptoms or a range of nonspecific leg symptoms, such as aching, cramping, numbness, or fatigue. The classic triad for vascular claudication, exercise-induced calf pain that causes stopping of exercise and results in relief of pain in 10 minutes or less, may be present in only about 10% of affected patients.*

Patients with current or past tobacco use, diabetes, hypertension, hyperlipidemia, or cardiovascular or cerebrovascular disease are at increased risk of atherosclerotic PAD. Such patients should be screened for subclinical PAD and targeted for aggressive risk factor intervention. For screening, clinicians should consider use of the ankle–brachial index (ABI), a highly accurate test for detecting 50% or greater stenoses of 50% or more in major vessels of the legs. The ABI is readily performed by clinicians or office staff, and consists of measuring the systolic blood pressure with Doppler ultrasonography in each arm and in the dorsalis pedis and posterior tibial pulses. The ABI is calculated on both the right and left by dividing the higher right ankle pressure by the higher right arm pressure, and the higher left ankle pressure by the higher left arm pressure. ABI values are as follows: 0.90–1.30 is considered normal; 0.41–0.90—mild to moderate peripheral arterial disease, usually with symptoms of claudication; and 0.00–0.40—severe peripheral vascular disease with critical leg ischemia.

The severity of peripheral vascular disease closely parallels the risk of myocardial infarction, ischemic stroke, and death from vascular causes. Patients with ABIs in the lowest category have a 20% to 25% annual risk of death.* A wide range of interventions is available to reduce both onset and progres-

sion of subclinical PAD, including meticulous foot care and well-fitting shoes, tobacco cessation, treatment of hyperlipidemia, optimal control and treatment of diabetes and hypertension, use of antiplatelet agents, and, if needed, surgical revascularization.

(Students should consult specialty texts for less common forms of vascular occlusion from arterial or venous thrombosis or endarteritis from infection, inflammation, or autoimmune disease.)

**Preview: Recording the Physical Examination—The Peripheral Vascular System**

Note that initially you may use sentences to describe your findings; later you will use phrases. The style below contains phrases appropriate for most write-ups. Unfamiliar terms are explained in the next section, Techniques of Examination. Recall that the written description of lymph nodes appears after the Head and Neck section (see p.143). Likewise, assessment of the carotid pulse is recorded in the Cardiovascular section (see p. 265).

“Extremities are warm and without edema. No varicosities or stasis changes. Calves are supple and nontender. No femoral or abdominal bruits. Brachial, radial, femoral, popliteal, dorsalis pedis (DP), and posterior tibial (PT) pulses are 2+ and symmetric.”

OR

“Extremities are pale below the midcalf, with notable hair loss. Rubor noted when legs dependent but no edema or ulceration. Bilateral femoral bruits; no abdominal bruits heard. Brachial and radial pulses 2+; femoral, popliteal, DP and PT pulses 1+.“ (Alternatively, pulses can be recorded as below.)

<table>
<thead>
<tr>
<th></th>
<th>Radial</th>
<th>Brachial</th>
<th>Femoral</th>
<th>Popliteal</th>
<th>Dorsalis Pedis</th>
<th>Posterior Tibial</th>
</tr>
</thead>
<tbody>
<tr>
<td>RT</td>
<td>2+</td>
<td>2+</td>
<td>1+</td>
<td>1+</td>
<td>1+</td>
<td>1+</td>
</tr>
<tr>
<td>LT</td>
<td>2+</td>
<td>2+</td>
<td>1+</td>
<td>1+</td>
<td>1+</td>
<td>1+</td>
</tr>
</tbody>
</table>

Suggests atherosclerotic peripheral arterial disease
Assessment of the peripheral vascular system relies primarily on inspection of the arms and legs, palpation of the pulses, and a search for edema. See Chapter 3 for a method of integrating these techniques into your examination of the limbs. Additional techniques may be useful when you suspect an abnormality.

**Arms**

*Inspect both arms* from the fingertips to the shoulders. Note:

- Their size, symmetry, and any swelling
- The venous pattern
- The color of the skin and nail beds and the texture of the skin

*Palpate the radial pulse* with the pads of your fingers on the flexor surface of the wrist laterally. Partially flexing the patient’s wrist may help you feel this pulse. Compare the pulses in both arms.

**The Arms**
- Size, symmetry, skin color
- Radial pulse, brachial pulse
- Epitrochlear lymph nodes

**The Legs**
- Size, symmetry, skin color
- Femoral pulse and inguinal lymph nodes
- Popliteal, dorsalis pedis, and posterior tibial pulses
- Peripheral edema

Prominent veins in an edematous arm suggest venous obstruction.

Lymphedema of arm and hand may follow axillary node dissection and radiation therapy.

In Raynaud’s disease, wrist pulses are typically normal but spasm of more distal arteries causes episodes.
TECHNIQUES OF EXAMINATION

There are several systems for grading the amplitude of the arterial pulses. One system is to use a scale of 0 to 4, as below; however, you should check to see what scale is used in your institution.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>4+</td>
<td>Bounding</td>
</tr>
<tr>
<td>3+</td>
<td>Increased</td>
</tr>
<tr>
<td>2+</td>
<td>Brisk, expected</td>
</tr>
<tr>
<td>1+</td>
<td>Diminished, weaker than expected</td>
</tr>
<tr>
<td>0</td>
<td>Absent, unable to palpate</td>
</tr>
</tbody>
</table>

If you suspect arterial insufficiency, feel for the brachial pulse. Flex the patient’s elbow slightly, and with the thumb of your opposite hand palpate the artery just medial to the biceps tendon at the antecubital crease. The brachial artery can also be felt higher in the arm in the groove between the biceps and triceps muscles.

Feel for one or more epitrochlear nodes. With the patient’s elbow flexed to about 90° and the forearm supported by your hand, reach around behind the arm and feel in the groove between the biceps and triceps muscles, about 3 cm above the medial epicondyle. If a node is present, note its size, consistency, and tenderness.

Epitrochlear nodes are difficult or impossible to identify in most normal people.

Legs

The patient should be lying down and draped so that the external genitalia are covered and the legs fully exposed. A good examination is impossible through stockings or socks!

EXAMPLES OF ABNORMALITIES

of sharply demarcated pallor of the fingers (see Table 14-1, Painful Peripheral Vascular Disorders and Their Mimics, pp. 460–461).

Note that if an artery is widely dilated, it is aneurysmal.

Bounding carotid, radial, and femoral pulses in aortic insufficiency; asymmetric diminished pulses in arterial occlusion from atherosclerosis or embolism

An enlarged epitrochlear node may be secondary to a lesion in its drainage area or may be associated with generalized lymphadenopathy.
TECHNIQUES OF EXAMINATION

Inspect both legs from the groin and buttocks to the feet. Note:

- Their size, symmetry, and any swelling
- The venous pattern and any venous enlargement
- Any pigmentation, rashes, scars, or ulcers
- The color and texture of the skin, the color of the nail beds, and the distribution of hair on the lower legs, feet, and toes.

Palpate the superficial inguinal nodes, including both the horizontal and the vertical groups. Note their size, consistency, and discreteness, and note any tenderness. Nontender, discrete inguinal nodes up to 1 cm or even 2 cm in diameter are frequently palpable in normal people.

Palpate the pulses in order to assess the arterial circulation.

- The femoral pulse. Press deeply, below the inguinal ligament and about midway between the anterior superior iliac spine and the symphysis pubis. As in deep abdominal palpation, the use of two hands, one on top of the other, may facilitate this examination, especially in obese patients.

EXAMPLES OF ABNORMALITIES

See Table 14-2, Chronic Insufficiency of Arteries and Veins (p. 462).

See Table 14-3, Common Ulcers of the Feet and Ankles (p. 463).

Lymphadenopathy refers to enlargement of the nodes, with or without tenderness. Try to distinguish between local and generalized lymphadenopathy, respectively, by finding either (1) a causative lesion in the drainage area, or (2) enlarged nodes in at least two other non-contiguous lymph node regions.

A diminished or absent pulse indicates partial or complete occlusion proximally; for example, at the aortic or iliac level, all pulses distal to the occlusion are typically affected. Chronic arterial occlusion, usually from atherosclerosis, causes intermittent claudication, (pp. 460–461), postural color changes (p. 458), and trophic changes in the skin (p. 462).

An exaggerated, widened femoral pulse suggests a femoral aneurysm, a pathologic dilatation of the artery.
The popliteal pulse. The patient’s knee should be somewhat flexed, the leg relaxed. Place the fingertips of both hands so that they just meet in the midline behind the knee and press them deeply into the popliteal fossa. The popliteal pulse is often more difficult to find than other pulses. It is deeper and feels more diffuse.

An exaggerated, widened popliteal pulse suggests an aneurysm of the popliteal artery. Neither popliteal nor femoral aneurysms are common. They are usually due to atherosclerosis, and occur primarily in men over age 50.

If you cannot feel the popliteal pulse with this approach, try with the patient prone. Flex the patient’s knee to about 90°, let the lower leg relax against your shoulder or upper arm, and press your two thumbs deeply into the popliteal fossa.

Atherosclerosis (arteriosclerosis obliterans) most commonly obstructs arterial circulation in the thigh. The femoral pulse is then normal, the popliteal decreased or absent.
**Techniques of Examination**

- **The dorsalis pedis pulse.** Feel the dorsum of the foot (not the ankle) just lateral to the extensor tendon of the great toe. If you cannot feel a pulse, explore the dorsum of the foot more laterally.

- **The posterior tibial pulse.** Curve your fingers behind and slightly below the medial malleolus of the ankle. (This pulse may be hard to feel in a fat or edematous ankle.)

**Tips on feeling difficult pulses:** (1) Position your own body and examining hand comfortably; awkward positions decrease your tactile sensitivity. (2) Place your hand properly and linger there, varying the pressure of your fingers to pick up a weak pulsation. If unsuccessful, then explore the area deliberately. (3) Do not confuse the patient’s pulse with your own pulsating fingertips. If you are unsure, count your own heart rate and compare it with the patient’s. The rates are usually different. Your carotid pulse is convenient for this comparison.

**Note the temperature of the feet and legs** with the backs of your fingers. Compare one side with the other. Bilateral coldness is most often due to a cold environment or anxiety.

**Examples of Abnormalities**

- The dorsalis pedis artery may be congenitally absent or may branch higher in the ankle. Search for a pulse more laterally.

- Decreased or absent foot pulses (assuming a warm environment) with normal femoral and popliteal pulses suggest occlusive disease in the lower popliteal artery or its branches—a pattern often associated with diabetes mellitus.

- **Sudden arterial occlusion,** as by embolism or thrombosis, causes pain and numbness or tingling. The limb distal to the occlusion becomes cold, pale, and pulseless. Emergency treatment is required. If collateral circulation is good, only numbness and coolness may result.

- Coldness, especially when unilateral or associated with other signs, suggests arterial insufficiency from inadequate arterial circulation.
Look for edema. Compare one foot and leg with the other, noting their relative size and the prominence of veins, tendons, and bones.

Check for pitting edema. Press firmly but gently with your thumb for at least 5 seconds (1) over the dorsum of each foot, (2) behind each medial malleolus, and (3) over the shins. Look for pitting—a depression caused by pressure from your thumb. Normally there is none. The severity of edema is graded on a four-point scale, from slight to very marked.

Edema causes swelling that may obscure the veins, tendons, and bony prominences.

See Table 14-4, Some Peripheral Causes of Edema (p. 464).

Shown below is 3+ pitting edema.
If you suspect edema, *measurement of the legs* may help you to identify it and to follow its course. With a flexible tape, measure (1) the forefoot, (2) the smallest possible circumference above the ankle, (3) the largest circumference at the calf, and (4) the midthigh a measured distance above the patella with the knee extended. Compare one side with the other. A difference of more than 1 cm just above the ankle or 2 cm at the calf is unusual in normal people and suggests edema.

If edema is present, look for possible causes in the peripheral vascular system. These include (1) recent deep venous thrombosis, (2) chronic venous insufficiency due to previous deep venous thrombosis or to incompetence of the venous valves, and (3) lymphedema. Note the extent of the swelling. How far up the leg does it go?

Is the swelling unilateral or bilateral? Are the veins unusually prominent?

Try to identify any venous tenderness that may accompany deep venous thrombosis. Palpate the groin just medial to the femoral pulse for tenderness of the femoral vein. Next, with the patient’s leg flexed at the knee and relaxed, palpate the calf. With your fingerpads, gently compress the calf muscles against the tibia, and search for any tenderness or cords. Deep venous thrombosis, however, may have no demonstrable signs, and diagnosis often depends on high clinical suspicion and other testing.

Note the *color of the skin*.

- Is there a local area of redness? If so, note its temperature, and gently try to feel the firm cord of a thrombosed vein in the area. The calf is most often involved.
- Are there brownish areas near the ankles?
- Note any ulcers in the skin. Where are they?
- Feel the thickness of the skin.

Ask the patient to stand, and *inspect the saphenous system for varicosities*. The standing posture allows any varicosities to fill with blood and makes them visible. You can easily miss them when the patient is in a supine position. Feel for any varicosities, noting any signs of thrombophlebitis.

**Examples of Abnormalities**

- Conditions such as muscular atrophy can also cause different circumferences in the legs.
- In deep venous thrombosis, the extent of edema suggests the location of the occlusion: the calf when the lower leg or the ankle is swollen, the iliofemoral veins when the entire leg is swollen.
- Venous distention suggests a venous cause of edema.
- A painful, pale swollen leg, together with tenderness in the groin over the femoral vein, suggests deep iliofemoral thrombosis. Approximately half of patients with deep venous thrombosis in the calf have tenderness and cords deep in the calf. Calf tenderness is nonspecific, however, and may be present without thrombosis.
- Local swelling, redness, warmth, and a subcutaneous cord suggest superficial thrombophlebitis.
- A brownish color or ulcers just above the ankle suggest chronic venous insufficiency.
- Thickened brawny skin occurs in lymphedema and advanced venous insufficiency.
- Varicose veins are dilated and tortuous. Their walls may feel somewhat thickened. Many varicose veins can be seen in the leg on p. 459.
Special Techniques

Evaluating the Arterial Supply to the Hand. If you suspect arterial insufficiency in the arm or hand, try to feel the ulnar pulse as well as the radial and brachial pulses. Feel for it deeply on the flexor surface of the wrist medially. Partially flexing the patient’s wrist may help you. The pulse of a normal ulnar artery, however, may not be palpable.

The Allen test gives further information. This test is also useful to assure the patency of the ulnar artery before puncturing the radial artery for blood samples. The patient should rest with hands in lap, palms up.

Ask the patient to make a tight fist with one hand; then compress both radial and ulnar arteries firmly between your thumbs and fingers. Next, ask the patient to open the hand into a relaxed, slightly flexed position. The palm is pale.

Release your pressure over the ulnar artery. If the ulnar artery is patent, the palm flushes within about 3 to 5 seconds.

Patency of the radial artery may be tested by releasing the radial artery while still compressing the ulnar.

Arterial occlusive disease is much less common in the arms than in the legs. Absent or diminished pulses at the wrist in acute embolic occlusion and in Buerger’s disease, or thromboangiitis obliterans.
Postural Color Changes of Chronic Arterial Insufficiency.

If pain or diminished pulses suggest arterial insufficiency, look for postural color changes. Raise both legs, as shown at the right, to about 60° until maximal pallor of the feet develops—usually within a minute. In light-skinned persons, either maintenance of normal color, as seen in this right foot, or slight pallor is normal.

Then ask the patient to sit up with legs dangling down. Compare both feet, noting the time required for:

- Return of pinkness to the skin, normally about 10 seconds or less
- Filling of the veins of the feet and ankles, normally about 15 seconds.

This right foot has normal color and the veins on the foot have filled. These normal responses suggest an adequate circulation.

Look for any unusual rubor (dusky redness) to replace the pallor of the dependent foot. Rubor may take a minute or more to appear.

Normal responses accompanied by diminished arterial pulses suggest that a good collateral circulation has developed around an arterial occlusion.

Color changes may be difficult to see in darker-skinned persons. Inspect the soles of the feet for these changes, and use tangential lighting to see the veins.

Persisting rubor on dependency suggests arterial insufficiency (see p. 462). When veins are incompetent, dependent rubor and the timing of color return and venous filling are not reliable tests of arterial insufficiency.

Marked pallor on elevation suggests arterial insufficiency.

The foot below is still pale and the veins are just starting to fill—signs of arterial insufficiency.

**Mapping Varicose Veins.** You can map out the course and connections of varicose veins by transmitting pressure waves along the blood-filled veins. With the patient standing, place your palpating fingers gently on a vein and, with your other hand below it, compress the vein sharply. Feel for a pressure wave transmitted to the fingers of your upper hand. A palpable pressure wave indicates that the two parts of the vein are connected.

A wave may also be transmitted downward, but not as easily.

**Evaluating the Competency of Venous Valves.** By the retrograde filling (Trendelenburg) test, you can assess the valvular competency in both the communicating veins and the saphenous system. Start with the patient supine. Elevate one leg to about 90° to empty it of venous blood.

Next, occlude the great saphenous vein in the upper thigh by manual compression, using enough pressure to occlude this vein but not the deeper vessels. Ask the patient to stand. While you keep the vein occluded, watch for venous filling in the leg. Normally the saphenous vein fills from below, taking about 35 seconds as blood flows through the capillary bed into the venous system.

After the patient has stood for 20 seconds, release the compression and look for any sudden additional venous filling. Normally there is none: competent valves in the saphenous vein block retrograde flow. Slow venous filling continues.

When both steps of this test are normal, the response is termed negative–negative. Negative–positive and positive–negative responses may also occur.

Rapid filling of the superficial veins while the saphenous vein is occluded indicates incompetent valves in the communicating veins. Blood flows quickly in a retrograde direction from the deep to the saphenous system.

Sudden additional filling of superficial veins after release of compression indicates incompetent valves in the saphenous vein.

When both steps are abnormal, the test is positive–positive.
TABLE 14-1  Painful Peripheral Vascular Disorders and Their Mimics

<table>
<thead>
<tr>
<th>Problem</th>
<th>Process</th>
<th>Location of Pain</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Arterial Disorders</strong></td>
<td><strong>Atherosclerosis</strong> (<em>arteriosclerosis obliterans</em>)</td>
<td></td>
</tr>
<tr>
<td>Intermittent claudication</td>
<td>Episodic muscular ischemia induced by exercise, due to obstruction of large or middle-sized arteries by atherosclerosis</td>
<td>Usually the calf, but also may be in the buttck, hip, thigh, or foot, depending on the level of obstruction</td>
</tr>
<tr>
<td>Rest pain</td>
<td>Ischemia even at rest</td>
<td>Distal pain, in the toes or forefoot</td>
</tr>
<tr>
<td><strong>Acute Arterial Occlusion</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Raynaud’s Disease and Phenomenon</td>
<td>Raynaud’s <em>disease</em>: Episodic spasm of the small arteries and arterioles; no vascular occlusion. Raynaud’s <em>phenomenon</em>: Syndrome is secondary to other conditions such as collagen vascular disease, arterial occlusion, trauma, drugs</td>
<td>Distal portions of one or more fingers. Pain is usually not prominent unless fingertip ulcers develop. Numbness and tingling are common.</td>
</tr>
<tr>
<td><strong>Venous Disorders</strong></td>
<td><strong>Superficial Thrombophlebitis</strong></td>
<td>Clot formation and acute inflammation in a superficial vein</td>
</tr>
<tr>
<td><strong>Deep Venous Thrombosis</strong></td>
<td>Clot formation in a deep vein</td>
<td>Pain, if present, is usually in the calf, but the process more often is painless.</td>
</tr>
<tr>
<td><strong>Chronic Venous Insufficiency (deep)</strong></td>
<td>Chronic venous engorgement secondary to venous occlusion or incompetency of venous valves</td>
<td>Diffuse aching of the leg(s)</td>
</tr>
<tr>
<td><strong>Thromboangiitis Obliterans (Buerger’s disease)</strong></td>
<td>Inflammatory and thrombotic occlusions of small arteries and also of veins, occurring in smokers</td>
<td></td>
</tr>
<tr>
<td><strong>Acute Lymphangitis</strong></td>
<td>Acute bacterial infection (usually streptococcal) spreading up the lymphatic channels from a portal of entry such as an injured area or an ulcer</td>
<td>An arm or a leg</td>
</tr>
<tr>
<td><strong>Mimics</strong>*</td>
<td><strong>Acute Cellulitis</strong></td>
<td>Acute bacterial infection of the skin and subcutaneous tissues</td>
</tr>
<tr>
<td><strong>Erythema Nodosum</strong></td>
<td>Subcutaneous inflammatory lesions associated with a variety of systemic conditions such as pregnancy, sarcoidosis, tuberculosis, and streptococcal infections</td>
<td>Anterior surfaces of both lower legs</td>
</tr>
</tbody>
</table>

* Mistaken primarily for acute superficial thrombophlebitis.
TABLE 14-1  ■ Painful Peripheral Vascular Disorders and Their Mimics

<table>
<thead>
<tr>
<th>Timing</th>
<th>Factors That Aggravate</th>
<th>Factors That Relieve</th>
<th>Associated Manifestations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fairly brief; pain usually forces the patient to rest.</td>
<td>Exercise such as walking</td>
<td>Rest usually stops the pain in 1–3 min.</td>
<td>Local fatigue, numbness, diminished pulses, often signs of arterial insufficiency (see p. 462)</td>
</tr>
<tr>
<td>Persistent, often worse at night</td>
<td>Elevation of the feet, as in bed</td>
<td>Sitting with legs dependent</td>
<td>Numbness, tingling, trophic signs and color changes of arterial insufficiency (see p. 462)</td>
</tr>
<tr>
<td>Sudden onset; associated symptoms may occur without pain.</td>
<td>Exposure to cold, emotional upset</td>
<td>Warm environment</td>
<td>Color changes in the distal fingers: severe pallor (essential for the diagnosis) followed by cyanosis and then redness</td>
</tr>
<tr>
<td>Relatively brief (minutes) but recurrent</td>
<td></td>
<td></td>
<td>Local redness, swelling, tenderness, a palpable cord, possibly fever</td>
</tr>
<tr>
<td>An acute episode lasting days or longer</td>
<td></td>
<td></td>
<td>Possibly swelling of the foot and calf and local calf tenderness; often nothing</td>
</tr>
<tr>
<td>Often hard to determine because of lack of symptoms</td>
<td></td>
<td></td>
<td>Chronic edema, pigmentation, possibly ulceration (see pp. 462, 463)</td>
</tr>
<tr>
<td>Chronic, increasing as the day wears on</td>
<td>Prolonged standing</td>
<td>Elevation of the leg(s)</td>
<td>Distal coldness, sweating, numbness, and cyanosis; ulceration and gangrene at the tips of fingers or toes; migratory thrombophlebitis</td>
</tr>
<tr>
<td>■ Fairly brief but recurrent</td>
<td>■ Exercise</td>
<td>■ Rest</td>
<td>Red streak(s) on the skin, with tenderness, enlarged, tender lymph nodes, and fever</td>
</tr>
<tr>
<td>■ Chronic, persistent, may be worse at night</td>
<td></td>
<td>■ Permanent cessation of smoking helps both kinds of pain (but patients seldom stop)</td>
<td>A local area of diffuse swelling, redness, and tenderness with enlarged, tender lymph nodes and fever; no palpable cord</td>
</tr>
<tr>
<td>An acute episode lasting days or longer</td>
<td></td>
<td></td>
<td>Raised, red, tender swellings recurring in crops; often malaise, joint pains, and fever</td>
</tr>
<tr>
<td>An acute episode lasting days or longer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pain associated with a series of lesions over several weeks</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Chapter 14  ■ The Peripheral Vascular System**
### TABLE 14-2  ■  Chronic Insufficiency of Arteries and Veins

<table>
<thead>
<tr>
<th>Chronic Arterial Insufficiency <em>(Advanced)</em></th>
<th>Chronic Venous Insufficiency <em>(Advanced)</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Pain</td>
<td>None to an aching pain on dependency</td>
</tr>
<tr>
<td>Decreased or absent</td>
<td>Normal, though may be difficult to feel through edema</td>
</tr>
<tr>
<td>Pale, especially on elevation; dusky red on dependency</td>
<td>Normal, or cyanotic on dependency. Petechiae and then brown pigmentation appear with chronicity.</td>
</tr>
<tr>
<td>Cool</td>
<td>Normal</td>
</tr>
<tr>
<td>Absent or mild; may develop as the patient tries to relieve rest pain by lowering the leg</td>
<td>Present, often marked</td>
</tr>
<tr>
<td>Trophic changes: thin, shiny, atrophic skin; loss of hair over the foot and toes; nails thickened and ridged</td>
<td>Often brown pigmentation around the ankle, stasis dermatitis, and possible thickening of the skin and narrowing of the leg as scarring develops</td>
</tr>
<tr>
<td>If present, involves toes or points of trauma on feet</td>
<td>If present, develops at sides of ankle, especially medially</td>
</tr>
<tr>
<td>May develop</td>
<td>Does not develop</td>
</tr>
</tbody>
</table>

### TABLE 14-3 | Common Ulcers of the Feet and Ankles

<table>
<thead>
<tr>
<th>Location</th>
<th>Arterial Insufficiency</th>
<th>Chronic Venous Insufficiency</th>
<th>Neuropathic Ulcer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skin Around the Ulcer</td>
<td>Toes, feet, or possibly in areas of trauma (e.g., the shin)</td>
<td>Inner or sometimes outer ankle</td>
<td>Pressure points in areas with diminished sensation, as in diabetic</td>
</tr>
<tr>
<td>Pain</td>
<td>No callus or excess of pigment; may be atrophic</td>
<td>Pigmented, sometimes fibrotic</td>
<td>polyneuropathy</td>
</tr>
<tr>
<td>Associated Gangrene</td>
<td>Often severe, unless neuropathy masks it</td>
<td>Not severe</td>
<td>Calloused</td>
</tr>
<tr>
<td>Associated Signs</td>
<td>May be present</td>
<td>Absent</td>
<td>Absent (and therefore the ulcer may go unnoticed)</td>
</tr>
<tr>
<td></td>
<td>Decreased pulses, trophic changes, pallor of the foot on elevation, dusky rubor on dependency</td>
<td>Edema, pigmentation, stasis dermatitis, and possibly cyanosis of the foot on dependency</td>
<td>In uncomplicated neuropathic ulcer, absent</td>
</tr>
</tbody>
</table>

About one third of total body water is extracellular, or outside the body’s cells. About 25% of extracellular fluid is plasma and the remainder is interstitial fluid. At the arteriolar end of the capillaries, hydrostatic pressure in the blood vessels and the colloid oncotic pressure in the interstitium cause fluid to move into the tissues; at the venous end of the capillaries and in the lymphatics, hydrostatic pressure in the interstitium and the colloid oncotic pressure of plasma proteins cause fluid to return to the vascular compartment. A number of clinical conditions disrupt this balance, resulting in edema, or a clinically evident accumulation of interstitial fluid. Not depicted below is capillary leak syndrome, where protein leaks into the interstitial space, seen in burns, angioedema, snake bites, and allergic reactions.

<table>
<thead>
<tr>
<th>Nature of Edema</th>
<th>Pitting Edema</th>
<th>Chronic Venous Insufficiency</th>
<th>Lymphedema</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skin Thickening</td>
<td>Soft, pits on pressure</td>
<td>Soft, pits on pressure; later may become brawny (hard)</td>
<td>Soft in early stages, then becomes indurated, hard, nonpitting</td>
</tr>
<tr>
<td>Ulceration</td>
<td>Absent</td>
<td>May be present, especially near ankle</td>
<td>Becomes marked</td>
</tr>
<tr>
<td>Pigmentation</td>
<td>Absent</td>
<td>Common</td>
<td>Rare</td>
</tr>
<tr>
<td>Edema of Foot</td>
<td>Present</td>
<td>Common</td>
<td>Absent</td>
</tr>
<tr>
<td>Bilaterality</td>
<td>Always</td>
<td>Often present</td>
<td>Present, including toes</td>
</tr>
<tr>
<td>Examples/</td>
<td>↑ Interstitial fluid from: legs dependent from prolonged standing or sitting → ↑ hydrostatic pressure in veins, capillaries; congestive heart failure → ↓ cardiac output, ↑ hydrostatic pressure in veins, capillaries; nephrotic syndrome, cirrhosis, malnutrition → low albumin, ↓ intravascular colloid oncotic pressure; drugs</td>
<td>Occasionally</td>
<td>Often</td>
</tr>
<tr>
<td>Mechanisms</td>
<td></td>
<td>Chronic obstruction or valvular incompetence of the deep veins</td>
<td>Lymph channels obstructed by tumor, fibrosis, inflammation; also from axillary node dissection, radiation</td>
</tr>
</tbody>
</table>