eBook Pro 1533

Advancements in Treatment Interventions for Peripheral Artery Disease

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Overview

Peripheral artery disease is caused by a buildup of plaque in the arteries of the arms, legs, or pelvis. After thorough screening and diagnosis, the condition is often treated with conservative measures. Patient education is vital to the success of these methods. If pain persists or blood flow is compromised, revascularization is warranted. This learning activity will focus on the stages of peripheral artery disease, best medical treatment options based on current guidelines, and various endovascular and surgical revascularization techniques, such as stenting, atherectomy, and thrombectomy.

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ADVANCEMENTS IN TREATMENT INTERVENTIONS FOR PERIPHERAL ARTERY DISEASE

LEARNING OBJECTIVES

After completing this continuing education activity, the participant should be able to:

1. Review the stages of peripheral artery disease including chronic limb ischemia.
2. Outline best medical treatment options for peripheral artery disease.
3. Describe the atherectomy procedure including the various atherectomy devices.

INTENDED AUDIENCE/ EDUCATIONAL NEED

This continuing education activity is intended for a registered nurse, surgical technologist, or other healthcare professionals who want to learn more or need to gain knowledge and skills about stages of peripheral artery disease, best medical treatment options based on current guidelines, and various endovascular and surgical revascularization techniques, such as stenting, atherectomy, and thrombectomy

TEACHING METHODOLOGIES

The education activity is a self-paced, independent learning activity. Course goals are presented, followed by corresponding content. Learners can evaluate attainment of objectives by completing the test questions and comparing with the answer key. References can be reviewed for additional information.

This continuing education activity is governed by principles of adult learning and consists of written content with illustrations to complement the narrative. Learner comprehension will be assessed through post-test questions following the content.

STEPS FOR SUCCESSFUL COURSE COMPLETION

To earn continuing education credit, the participant must complete the following steps:

1. Complete course content and review learner objectives.
2. Once you complete your review, the post-test will unlock in the menu. Answer questions correctly to access the evaluation.
3. Finish course evaluation to complete and receive credit for this activity.
4. Upon completion of the above requirements, a Certificate of Attendance is awarded. This Certificate is found in your My Learning profile on the Pfiedler Education website.

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This continuing education activity was planned and provided in accordance with accreditation criteria. This material was produced in June 2024 and expires June 2026.

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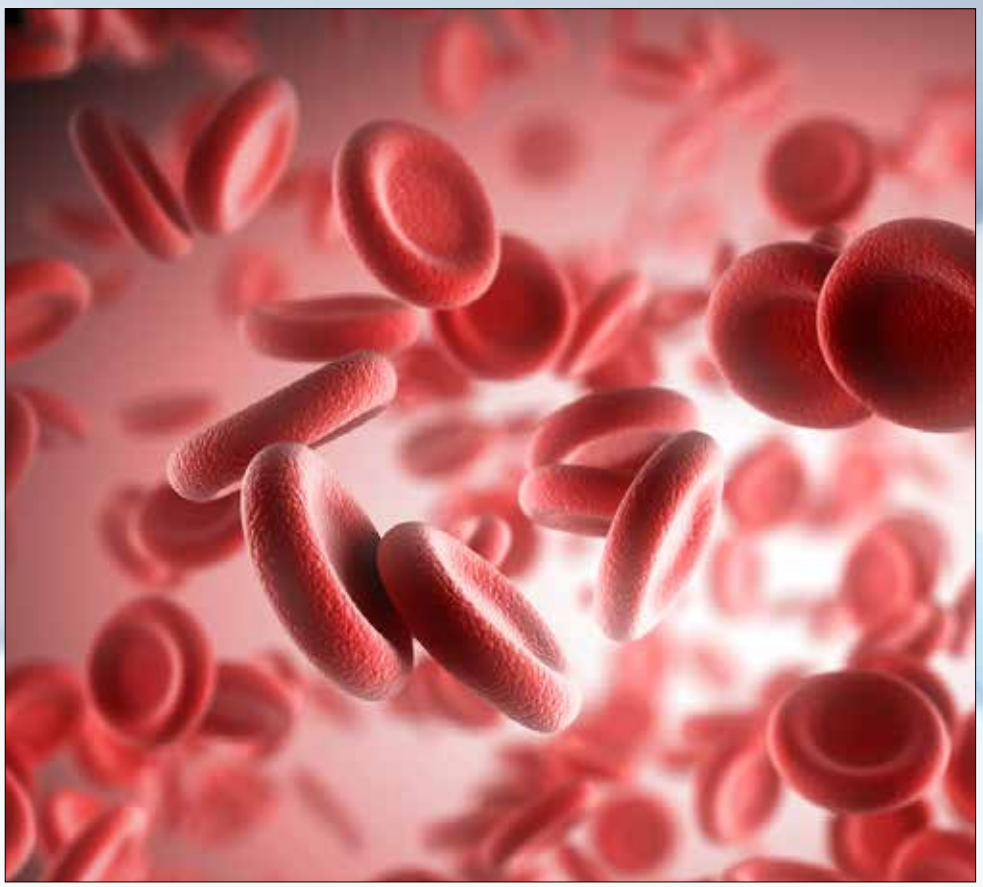
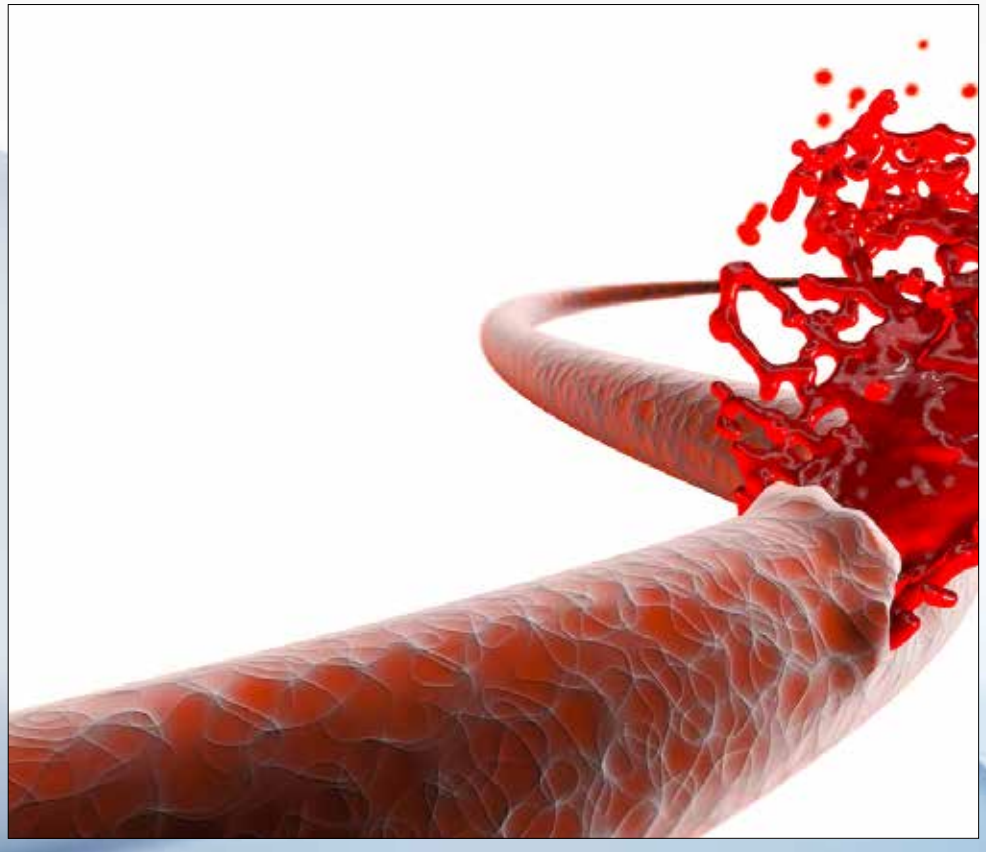
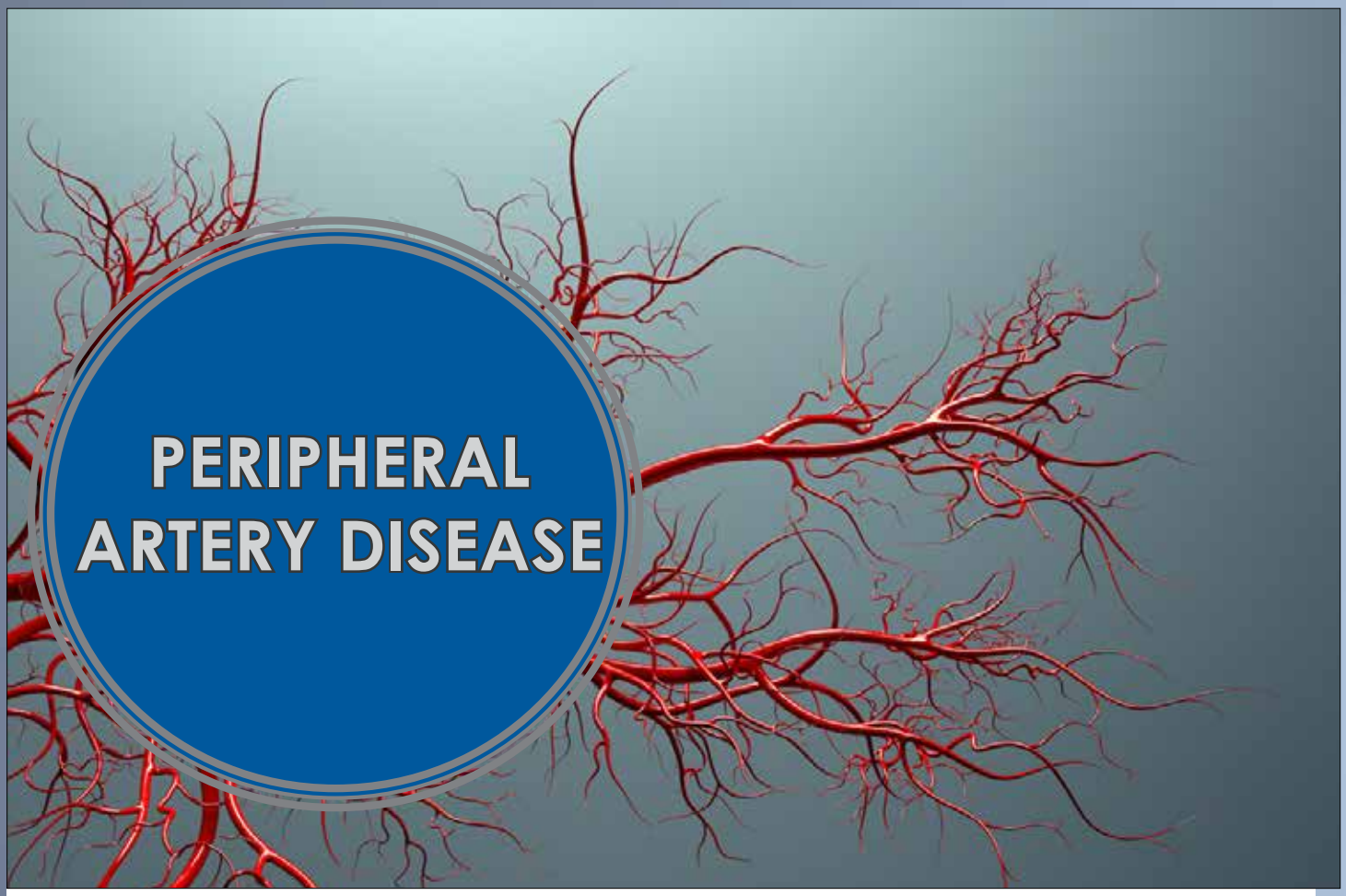




INTRODUCTION

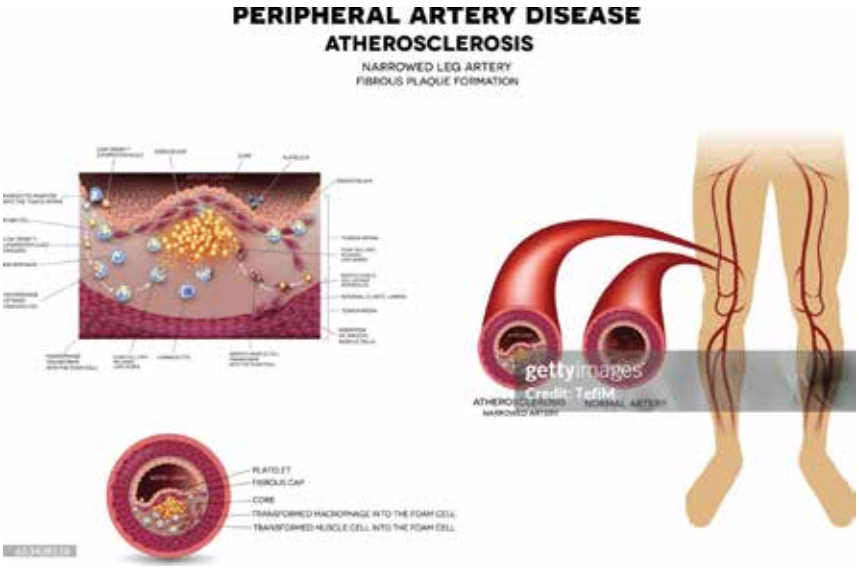
Peripheral artery disease (PAD) is a debilitating condition resulting from plaque buildup in the arteries of the arms, legs, or pelvis. The plaque restricts blood flow, leading to lack of oxygenation in the affected limb.[1] The resulting ischemia can lead to persistent pain while walking and performing activities of daily living that is typically relieved by rest. PAD can be diagnosed using a simple, noninvasive outpatient test. Initial treatments include smoking cessation, statin and antiplatelet medication, a structured exercise program, and management of comorbidities. If pain persists during rest or if blood flow to the limb becomes compromised, revascularization is initiated.[2] Endovascular, minimally invasive options include balloon angioplasty, stent placement, atherectomy, intravascular lithotripsy, and thrombectomy. In later stages of PAD or for individuals who do not qualify for endovascular treatment, bypass graft surgery may be the final option to save the limb.[3] This program goes over the pathophysiology of PAD as well as treatment options for improving quality of life for patients with PAD.



PAD is caused by atherosclerosis, the gradual buildup of plaque in the arteries of the arms, legs, or pelvis. The plaque is comprised of fat, cholesterol, and other substances that stick to the walls of the arteries. This buildup of plaque causes the arteries to become thick and hard.[1]

Atherosclerosis (see Figure 1) is the most common type of arteriosclerosis and can occur in different arteries throughout the body. It is called different terms depending on its location. For example, atherosclerosis in the coronary arteries is named coronary artery disease (CAD), while atherosclerosis in the limbs and pelvis is called PAD.[1]

Figure 1 – Atherosclerosis Comparison to Normal Artery



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Statistics

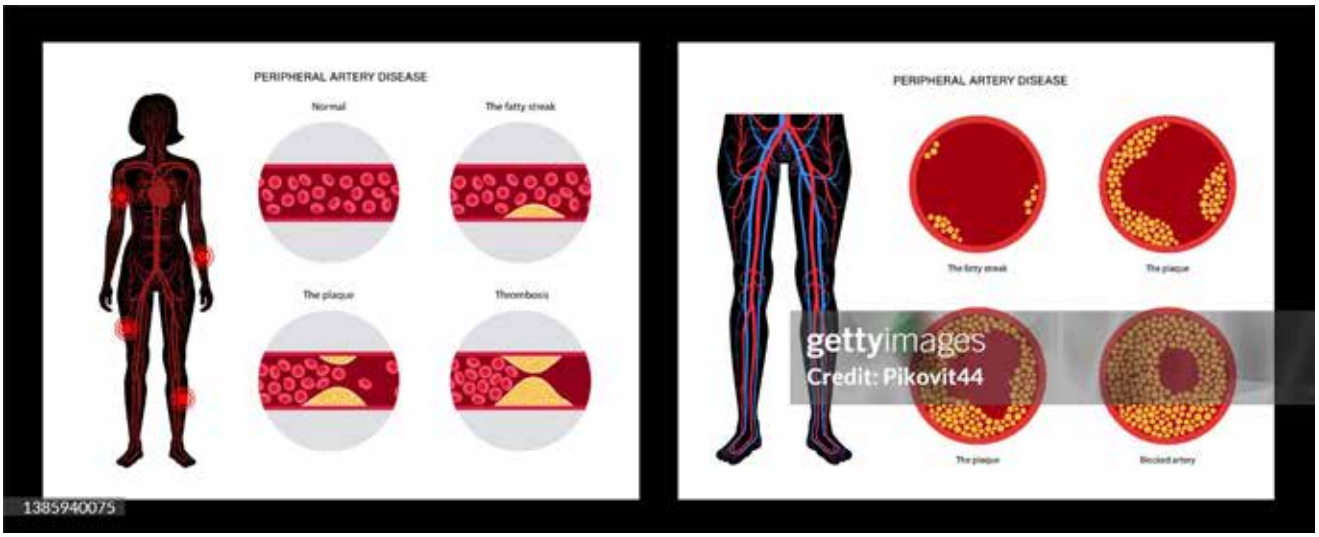
An estimated 230 million individuals around the world are affected by PAD.[4] Approximately 5 million individuals in the United States have PAD, with 29% of individuals over the age of 70 having the condition.[4,5]

Individuals in the lowest income groups are twice as likely to have PAD.[4] Prevalence of PAD is also higher among Black men, Black women, and Indian American women.[4]

Causes of PAD

PAD is caused by the buildup of plaque in the arteries of the limbs, resulting in lesions and narrowing of the arteries (see Figure 2).

Figure 2 – Narrowing of Arteries Due to Plaque



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Lesions

Early fatty streak lesions begin in childhood and constitute the initial phase of atherosclerosis. Over time, the fatty streaks can become fibrous plaques that turn into lesions. Lesions may cause claudication or limb ischemia which may warrant revascularization treatment.[6]

To qualify as "hemodynamically significant", the American Heart Association (AHA)/American Colleague of Cardiology (ACC) Guidelines state that a stenosis must reduce the diameter of the artery by 70% or have a hemodynamically noteworthy decline at rest or after a vasodilator challenge.[9]

Narrowing

As the plaque builds up, the walls of the arteries narrow.[1] Stenosis from the restriction of blood flow means blood is restricted and less oxygen is delivered to cells.[6] The arteries dilate to maximize blood flow, and collateral circulation develops to improve oxygenation. However, the collateral circulation may not be sufficient in providing adequate blood flow and oxygenation. Eventually, the blood flow is occluded to the point where the oxygen being delivered cannot meet the oxygen demand.[7] This leads to chronic limb-threatening ischemia (CLTI), considered the end stage of PAD.[8]

Risk Factors for PAD

The following are risk factors for PAD:[4]

- Smoking (greatest risk factor)
- Diabetes (second greatest risk factor)
- Advanced age
- Family history
- Socioeconomic status
- Systolic hypertension
- Hypercholesterolemia[7]
- Obesity[7]
- Chronic kidney disease[8]

Individuals who are at increased risk of PAD include those who are:[10]

- 65 years of age or older,
- Between the ages of 50 and 64 and have risk factors for atherosclerosis or family history of PAD,
- Younger than 50 years old with diabetes and at least 1 risk factor for atherosclerosis, or
- Known to have atherosclerosis in another location, such as CAD.

Symptoms of PAD

The varying symptoms of PAD, or lack thereof, create a challenge for accurate and timely diagnosis, since:

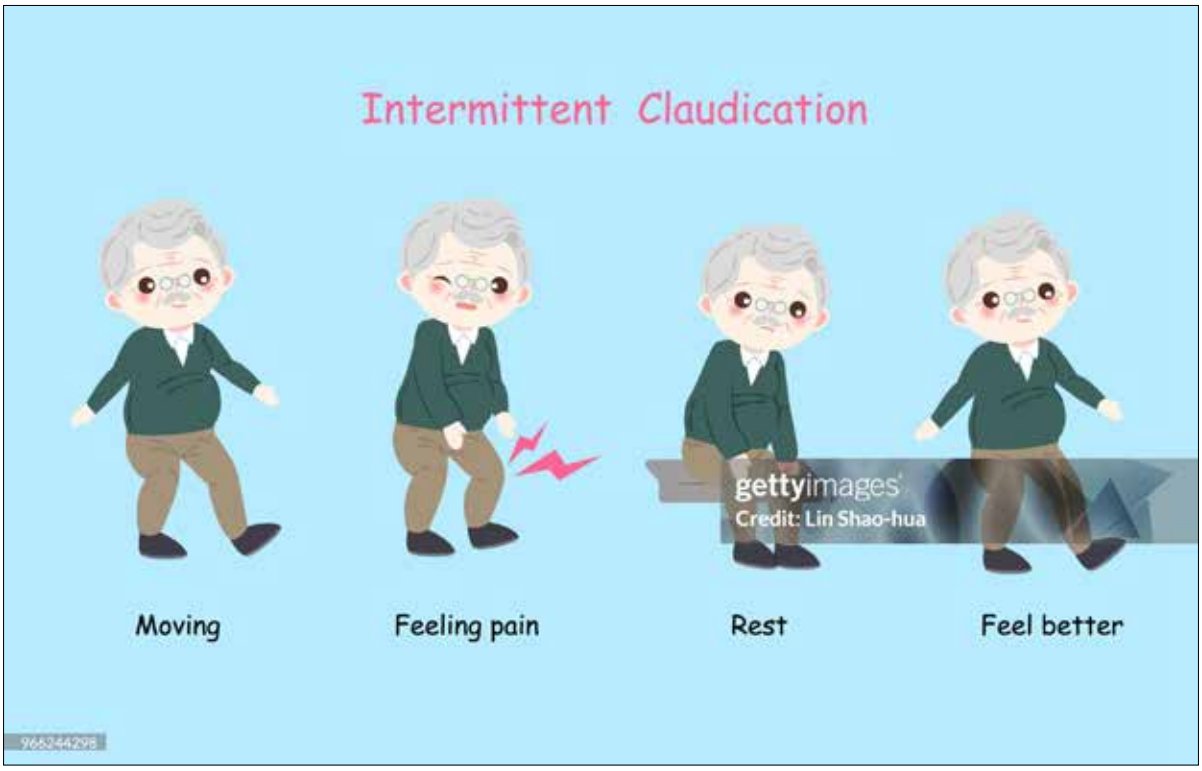
- Approximately 40% of individuals with PAD do not have symptoms;[4]
- Half of individuals with PAD have atypical symptoms;[4] and
- The remaining 10% have symptoms of intermittent claudication.[4]

What is Claudication?

Claudication is an important term used when discussing PAD. It is defined by the AHA/ACC Guidelines as "cramping, discomfort, and/or weakness in the legs and especially the calves when walking that resolves after short rest and is associated with inadequate blood supply to the muscles."[9] Claudication reproducibly occurs during physical activity but goes away with rest (see Figure 3).[11]

A patient with PAD who has claudication that affects their quality of life may receive different treatment than a patient with PAD who has no symptoms or atypical symptoms.

Figure 3 – Animation of Claudication



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Atypical symptoms of PAD include pain or discomfort that:[10]

- Starts when at rest and gets worse with physical activity, or
- Does not go away after resting for 10 minutes.

Screening and Signs of PAD

A history and physical exam are important components of screening for PAD in patients who are at increased risk (see Table 1). The ACC/AHA Task Force's most recent clinical practice guidelines recommend conducting a comprehensive medical history and review of symptoms to screen for PAD in patients who are at increased risk.[10]

Screening for PAD is a recommended component of examinations of patients over the age of 40 who have any of the risk factors of PAD.[4]

A thorough assessment of skin can reveal signs of PAD, such as:[4]

- Pale white skin when the limb is raised,
- Redness when the limb is lowered,
- Patches of hair loss,
- Impaired wound healing, and
- Ulcers, particularly on the feet.

When assessing the lower extremities, the physical exam should screen for:[7]

- Cool, shiny skin,
- Reduced or absent pulses,
- Reduced capillary refill,
- Pallor with elevation,
- Dependent rubor, and
- Bruits in large vessels such as the femoral and/or popliteal arteries.

KNOWLEDGE CHECK

Which of the following individuals has the highest risk of developing PAD?

A. A 37-year-old Hispanic male with hypercholesteremia

B. A 53-year-old White female with hypertension

C. A 59-year old Black male who smokes a pack of cigarettes a day

D. A 50-year-old White male with type 2 diabetes

[Click Here for Answer]

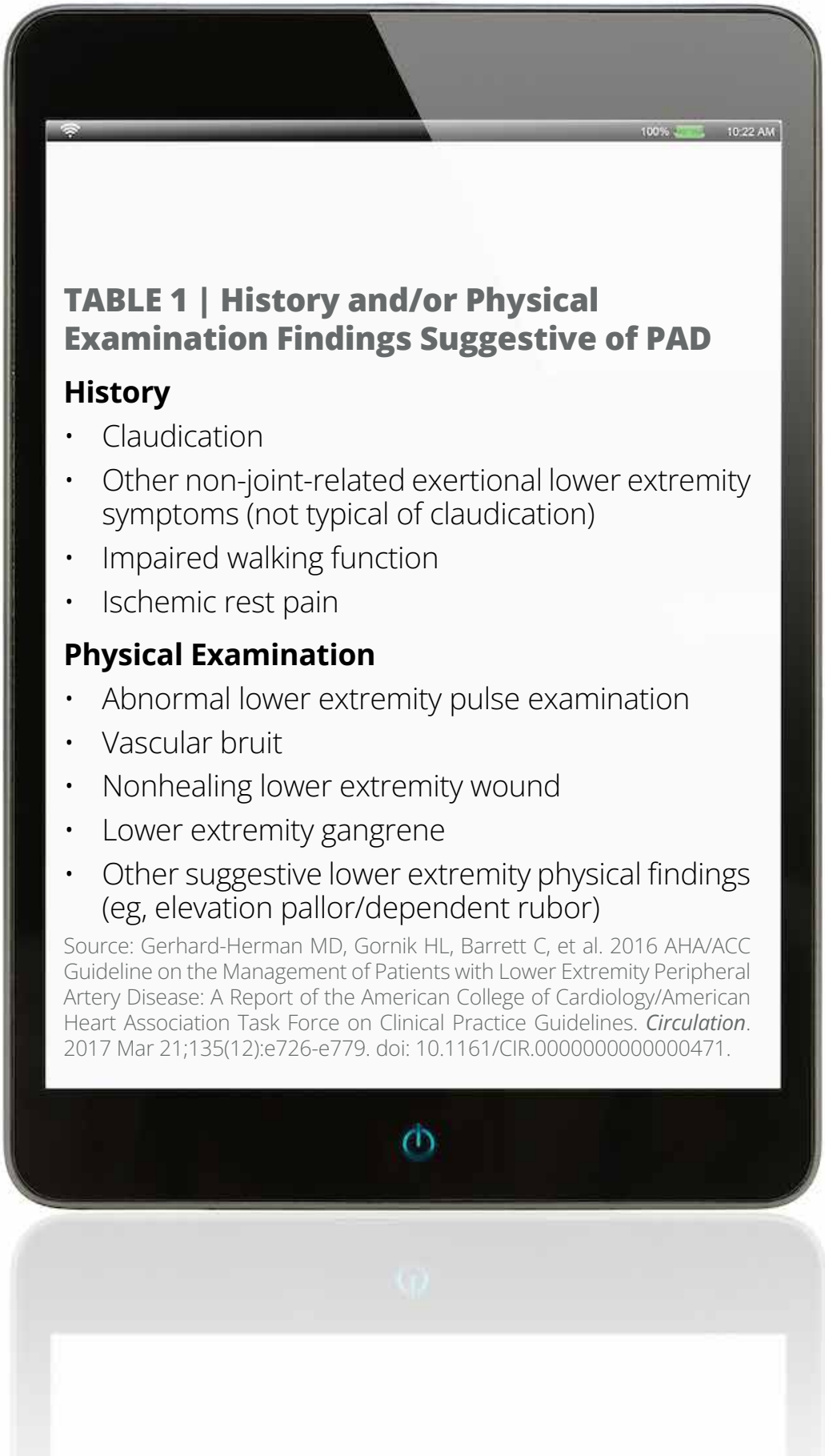

TABLE 1 | History and/or Physical Examination Findings Suggestive of PAD

History

- Claudication
- Other non-joint-related exertional lower extremity symptoms (not typical of claudication)
- Impaired walking function
- Ischemic rest pain

Physical Examination

- Abnormal lower extremity pulse examination
- Vascular bruit
- Nonhealing lower extremity wound
- Lower extremity gangrene
- Other suggestive lower extremity physical findings (eg, elevation pallor/dependent rubor)

Source: Gerhard-Herman MD, Gornik HL, Barrett C, et al. 2016 AHA/ACC Guideline on the Management of Patients with Lower Extremity Peripheral Artery Disease: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. ***Circulation***. 2017 Mar 21;135(12):e726-e779. doi: 10.1161/CIR.0000000000000471.

Tests Used to Diagnose PAD

Diagnostic tests used to diagnose PAD include the ankle-brachial index, duplex ultrasonography, and magnetic resonance angiography.

The Ankle-Brachial Index

An economical and noninvasive screening tool for PAD is the measurement of the ankle-brachial index (ABI) (see Figure 4).[7] A resting ABI is indicated for any patient who is at risk for and/or has signs of PAD.[4] The ABI is found by comparing the systolic ankle pressure ratio of each foot to the systolic brachial pressure (blood pressure taken in the arm).[7] To take the systolic ankle pressure, a blood pressure cuff is placed above the ankle and a Doppler ultrasonography probe is placed on the dorsalis pedis or posterior tibialis pulse.[7] The patient should be in the supine position during the measurement.[12] The cuff is then inflated until the point where the pulse cannot be heard from the probe, then slowly deflated until the pulse can be heard again.[7] The pressure indicated when the pulse is heard again is the systolic ankle pressure. The systolic ankle pressure is found for each leg, then that number is divided by the systolic brachial pressure. A value below 0.9 indicates PAD.[7]

Figure 4 – Ankle-Brachial Index

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The severity of PAD is indicated by the ABI measurement:[4]

- An ABI between 0.9 and 0.4 is linked to intermittent claudication,
- An ABI between 0.4 and 0.2 is linked to pain while at rest, and
- An ABI between 0.4 and 0.0 is linked with ulcers and gangrene.

Patients who measure 0.9 or below on the ABI should receive additional testing such as duplex ultrasonography and/or magnetic resonance angiography to determine the severity of their PAD.[4]

Duplex Ultrasonography

Duplex ultrasonography is also considered an economical and safe way to diagnose PAD. Duplex ultrasonography uses sound waves to provide additional information regarding the location of the PAD, the severity and plaque features of the patient's PAD, and measurements of the dimensions of the stenosis or occlusion. This additional information can assist clinicians to individualize care and determine necessary interventions.[7]

Magnetic Resonance Angiography or Computed Tomography Angiography

Magnetic resonance angiography (MRA) or computed tomography angiography (CTA) are diagnostic tests that give the clinician detailed vascular imaging, including the ability to see tiny pathways that have been created for collateral circulation. This test is particularly helpful in deciding whether a patient may benefit from bypass surgery or angioplasty (interventions that will be discussed in detail further on in this course).[7]

Diagnosis of PAD

PAD is diagnosed based on the following clinical findings:[7]

- Individual risk factors,
- Signs and symptoms, and
- Physical exam findings.

The complex nature of patient symptoms, along with absence of public awareness, can lead to delayed diagnosis of PAD until the disease has reached later stages. Additionally, inconsistency in treatment patterns among clinicians exist, resulting in disparity in treatment options and patient outcomes.[8]

Morbidity and Mortality of PAD

Patients diagnosed with PAD are at increased risk for cardiovascular morbidity and mortality.[5] At 5 years, individuals with PAD experience mortality rates similar to those from conditions like colorectal cancer or Hodgkin disease.[5]

Increased Risk of Major Cardiovascular Events

Individuals with PAD are at increased risk for major adverse cardiovascular events, which include myocardial infarction, stroke, and death. A subgroup of a major clinical trial found that individuals who have PAD have a 10.4% risk of experiencing a major adverse cardiovascular event, compared to a 7.6% risk in individuals with only CAD.[13]

An individual with PAD is more likely to have a major adverse cardiovascular event than a patient with CAD alone.[13]

Increased Risk of Amputation

In 2015 approximately 504,000 people in the United States had received a major amputation attributed to PAD. By 2050, the number is projected to double to at least one million individuals.[8]

Rutherford Classification Stages

The Rutherford classification was developed in 1986 and revised in 1997. The Rutherford classification is a staging system to describe acute and chronic limb ischemia and to stage the severity of PAD to guide appropriate treatment.[11]

Chronic Limb Ischemia

In the Rutherford classification system for chronic limb ischemia, treadmill testing for specific distances is used to evaluate the severity of ischemia.[4] (See Table 2) The resting ABI can be very different than the ABI taken after exercise, because of the hemodynamics of blood flow and movement. If the ABI drops at least 20% or 30 mmHg after exercising, this confirms a diagnosis of PAD.[12] A walking test over 6 minutes determines the total distance a patient can walk, as well as the length it takes for the claudication to begin.[12] The Rutherford classification system also evaluates the patient's pain and extent of tissue loss from ulcers and/or gangrene.[4]

KNOWLEDGE CHECK

_____ is considered an economical and safe way to diagnose PAD.

A. MRI

B. Duplex ultrasonogrphy

C. CT scan

D. X-ray

[Click Here for Answer]

TABLE 2 | History and/or Physical Examination Findings Suggestive of PAD

Grade	Category	Clinical Description	Objective Criteria
0	0	Asymptomatic – no hemodynamically significant occlusive disease	Normal treadmill or reactive hyperemia test
	1	Mild claudication	Completes treadmill exercise; AP after exercise >50 mmHg but at least 20 mmHg lower than resting value
I	2	Moderate claudication	Between categories 1 and 3
	3	Severe claudication	Cannot complete standard treadmill exercise, and AP after exercise <50 mmHg
II	4	Ischemic rest pain	Resting AP <40 mmHg, flat or barely pulsatile ankle or metatarsal PVR; TP <30 mmHg
III	5	Minor tissue loss – nonhealing ulcer, focal gangrene with diffuse pedal ischemia	Resting AP <60 mmHg, ankle or metatarsal PVR flat or barely pulsatile; TP <40 mmHg
	6	Major tissue loss – extending above TM level, functional foot no longer salvageable	Same as category 5

Abbreviations: AP- ankle pressure, PVR- pulse volume recording, TM- transmetatarsal, TP-toe pressure

Hardman RL, Jazaeri O, Yi J, Smith M, Gupta R. Overview of classification systems in peripheral artery disease. *Semin Intervent Radiol.* 2014;31(4):378-88. doi: 10.1055/s-0034-1393976.

The WIfI Classification System

In 2014, a new classification system was introduced by the Society for Vascular Surgery Lower Extremity Guidelines Committee called Wound, Ischemia, and foot Infection (WIfI).[14] With the increase in rates of diabetes and neuropathy, the WIfI schematic is more reliable than the Rutherford classification which does not account for these varied etiologies.[4] The WIfI classification system can be useful when evaluating limb perfusion and foot wounds of patients who have both diabetes and PAD.[11]

Envato Image

Acute Limb Ischemia

Acute limb ischemia is a vascular emergency that indicates an abrupt hypoperfusion of a limb resulting in a critical danger to limb viability.[11,15] Skeletal muscle can endure ischemia for only about 4 to 6 hours before the damage starts.[10] Acute limb ischemia is very serious with approximately 20-40% of cases resulting in death and up to half of cases leading to loss of the limb.[16] The condition occurs within two weeks from when symptoms first appear and is caused by a thrombosis broken off from atherosclerosis in the artery or after procedures such as embolization or bypass graft.[11,16] Approximately 1.7% of Americans with PAD in the advanced stages experience acute limb ischemia each year.[15]

The six symptoms of acute limb ischemia (the "rule of P's") are:[15]

- Pain,
- Paralysis,
- Paresthesia,
- Pulselessness,
- Poikilothermia (inability to regulate temperature), and
- Pallor.

There is a separate Rutherford Classification for acute limb ischemia because the condition occurs abruptly, preventing the limb from creating collateral circulation the way it can during chronic limb ischemia.[15] The Rutherford Classification for Acute Limb Ischemia (See Table 3) is endorsed by the Society of Vascular Surgery and the International Society of Cardiovascular Surgery.[15]

TABLE 3 | Rutherford Classification for Acute Limb Ischemia

Category	Description/ Prognosis	Sensory Loss	Muscle Weakness	Arterial Doppler Signal	Venous Doppler Signal
I. Viable	Not immediately threatened	None	None	Audible	Audible
II. Threatened					
a. Marginally	Salvageable if promptly treated	Minimal (toes) or none	None	Inaudible	Audible
b. Immediately	Salvageable with immediate revascularization	More than toes, associated with rest pain	Mild, moderate	Inaudible	Audible
III. Irreversible	Major tissue loss or permanent nerve damage inevitable	Profound, anesthetic	Profound, paralysis	Inaudible	Inaudible

Hardman RL, Jazaeri O, Yi J, Smith M, Gupta R. Overview of classification systems in peripheral artery disease. *Semin Intervent Radiol*. 2014;31(4):378-88. doi: 10.1055/s-0034-1393976.

Acute limb-threatening ischemia can be thought of as the ST elevation myocardial infarction (STEMI) of the limb.[13]

Patients with acute limb-threatening ischemia are at high risk for limb amputation and often experience lengthy stays in the hospital (including intensive care).[13] Acute limb ischemia necessitates fast revascularization through immediate endovascular treatments and/or surgery to save the limb.[15] Every patient diagnosed with acute limb ischemia is treated with intravenous heparin if not contraindicated. Further treatments are typically endovascular for patients with categories I and IIa acute limb ischemia. Patients with category IIb acute limb ischemia necessitate immediate revascularization through surgical procedures like thrombectomy and bypass graft, and patients with category III acute limb ischemia require amputation.[11]

Chronic Limb-Threatening Ischemia

Chronic limb-threatening ischemia, also called critical limb ischemia, is characterized by pain not relieved by rest, pain at night, and ischemic skin lesions.[11] Chronic limb-threatening ischemia is considered the final stage of chronic PAD (patients with acute limb ischemia are not included in this designation).[8] Fewer than 10% of patients with PAD progress to chronic limb-threatening ischemia.[8] To be diagnosed with chronic limb-threatening ischemia, a patient will have PAD in addition to ischemic rest pain that lasts longer than 2 weeks or tissue loss such as gangrene or a nonhealing ulcer.[8]

A Change in Terms

"Chronic limb-threatening ischemia" was introduced in the 2019 Global Vascular Guidelines on the Management of Chronic Limb-Threatening Ischemia to replace the term "critical limb ischemia." Per the authors, "critical limb ischemia" is an outdated term that does not encompass the broad array of patients who are evaluated and treated for limb-threatening ischemia in modern practice. The updated term "chronic limb-threatening ischemia" includes a broader base of patients who have differing degrees of ischemia.[8] The new term has also been adapted for use by the European Society of Cardiology as well as the European Society for Vascular Surgery.[14]

Epidemiology and Risk Factors

There is an insufficient amount of high-quality data from research to determine why some patients with PAD develop chronic limb-threatening ischemia. This is due to the fact that PAD symptoms do not lead to the development of chronic limb-threatening ischemia in a way that can be predicted.[8]

Individuals with PAD who are at a higher risk to develop chronic limb-threatening ischemia include:[8]

- Men,
- Those with a history of stroke,
- Those with heart failure, and
- Those with diabetes.

Prognosis

Chronic limb-threatening ischemia is marked by significantly high morbidity and mortality, loss of limb, pain and reduced quality of life.[8] Without aggressive medical management, the prognosis of chronic limb-threatening ischemia is bleak.[8] Data from a meta-analysis revealed that if an individual with chronic limb-threatening ischemia does not receive treatment, their risk for amputation and/or death is 22% after one year.[8]

Another study involving 574 patients with chronic limb-threatening ischemia who did not receive intervention through revascularization found that 31.6% had died after 2 years and 23% needed an amputation.[8]

The AHA/ACC Appropriate Use Guidelines state that "revascularization, whether endovascular or surgical, is critical for the reduction of high morbidity and mortality rates associated with limb loss."[9]

GUIDELINE-DIRECTED MANAGEMENT AND BEST MEDICAL THERAPY

Current research about PAD has shown that the prognosis of individuals with PAD can be greatly enhanced with intensive medical management of risk factors.[8] Medical therapy is endorsed by the Society for Vascular Surgery (SVS) clinical practice guidelines as first-line therapy for patients with PAD and claudication.[17] The goal of treatment is to salvage the limb and lower the risk of cardiovascular complications by managing modifiable risk factors such as smoking, hypertension, diabetes, sedentary lifestyle, and hyperlipidemia.[8] Guideline-directed management and therapy is supported by AHA/ACC class 1 recommendations.[10]

Smoking Cessation

Smoking cessation is an integral component of treatment of PAD, since tobacco use is a risk factor for PAD development and disease progression. Smoking also increases the risk of cardiovascular ischemic events, failure of bypass graft, amputation, and death for patients who have PAD.[10]

The AHA/ACC Guidelines on PAD recommend that each patient who uses tobacco should be advised by their clinician to quit at each visit, since this advice improves rates of quitting. The clinician should also develop a plan with the patient that involves pharmacotherapy designed to help them quit, as well as provide a referral to a smoking cessation program. Patients with PAD should also be advised to avoid passive smoke exposure.[10]

Patients with PAD who smoke should be counseled by their clinician to quit at each visit.[10]

Exercise

A supervised exercise program is a recommended component of care for patients with claudication and has been shown to be safe and effective.[10] A supervised exercise program is conducted at a hospital or outpatient facility and overseen by a qualified healthcare provider. The program is comprised of a warm-up, periods of walking alternated by periods of rest, and cool-down.[10]

Data from clinical trials indicates that supervised exercise training can improve quality of life and reduce the symptoms of claudication.[10] Results from a meta-analysis found that exercise allowed patients with claudication to walk 120% further.[5] A randomized trial of patients with PAD came to the conclusion that supervised exercise and stent revascularization were more effective than optimal medical management.[10]

A walking or exercise program has been shown to improve symptoms of claudication better than drug therapy.[5]

Pharmaceutical Management

The most current AHA/ACC Guidelines on PAD recommend that patients with PAD be prescribed antiplatelet therapy and statin medication.

Antiplatelet Therapy

There is strong, high-quality evidence that for patients with symptomatic PAD, antiplatelet therapy consisting of 75 to 325 mg per day of aspirin or 75 mg per day of clopidogrel should be prescribed to reduce their risk of heart attack, stroke, and vascular death.[10]

Statin Medication

According to AHA/ACC Guidelines, a statin medication is indicated for all patients with PAD, even patients with PAD whose baseline LDL levels are normal.[10,4] The risk for complications can be reduced and the worsening of symptoms of claudication can be stopped by lowering LDL cholesterol levels.[4]

A clinical trial (the Heart Protection Study) involving 6,748 patients who had PAD concluded that those in the intervention group taking simvastatin 40 mg each day had a 22% reduction in initial major vascular event compared to the control group.[10] However, results from a review involving roughly 250,000 patients with PAD showed that 40% were not prescribed any type of lipid-reducing medication.[4]

Cilostazol

In a meta-analysis, cilostazol administration was associated with improvement in claudication symptoms. However, there were no noted changes in reported quality of life or cardiovascular death. There is strong, high-quality evidence that cilostazol can be helpful for patients with PAD claudication symptoms.[10]

Management of Other Health Conditions

Glycemic control and the reduction of cardiovascular risk factors are important aspects to reducing the advancement of PAD.[18]

Diabetes Mellitus

Individuals with type 2 diabetes mellitus are at greater risk for development of PAD, since constant hyperglycemia increases the risk of developing vascular disease.[8] Approximately 20% to 30% of individuals

with diabetes have also been diagnosed with PAD.[18] Individuals who have both type 2 diabetes mellitus and PAD have a greater risk of developing complications that can lead to limb amputation and death.[8,10] The AHA/ACC Guidelines recommend developing an individualized care plan for these patients that includes lifestyle modifications for diet and weight management, appropriate medical management to control blood glucose, and preventative foot care.[10] In the Strong Heart Study, patients with diabetes mellitus and PAD with glycemic control of a hemoglobin A1C <6.5% had lower age-adjusted odds for amputation when compared to patients with hemoglobin A1C ranging from 6.5% to 9.5%.[10]

Hypertension

Individuals who have both PAD and hypertension require antihypertensive therapy, as hypertension increases their risk of heart attack, stroke, heart failure, and death. However, studies have shown that blood pressure reduction may reduce limb perfusion. Other studies have shown that it does not worsen claudication pain or reduce the ability of individuals with PAD to function. Clinicians should follow the most current published guidelines for blood pressure management when deciding on treatment.[10]

Poor Adherence to Medical Management

An international study of 1,830 patients with chronic limb-threatening ischemia (the most advanced stage of PAD) found that:[1]

- 87% had hypertension,
- 69% had diabetes,
- 73% had hyperlipidemia, and
- 35% were current smokers.

This study, called the Best Endovascular vs Best Surgical Therapy in Patients with CLTI (BEST-CLI) trial, highlights the poor adherence to medical management guidelines for individuals with PAD.[19] Even though the evidence shows that statin medications decrease risk of amputation by 25% and risk of a fatal event by 38%, approximately one-third of patients in the trial were not taking a statin medication at the start of the trial.[19]

Diet

The AHA/ACC Guidelines state that research is needed to determine the effect of dietary interventions on the progression of PAD.[10] Although research is lacking in this aspect, there is research on the association of diets high in saturated fat and carbohydrates with major adverse cardiac events.[8] Clinicians can recommend a low-fat or Mediterranean diet when counseling patients with PAD, since these diets have been linked with a reduction in plaque burden.[8]

A statement from the AHA from 2023 recommends that individuals with PAD modify their diet to consume the following types of foods:[20]

- Fruits and vegetables to reduce risk of atherosclerosis,
- High-fiber foods to lower cholesterol,
- Minimally processed foods,
- Foods low in saturated and trans fats,
- Mediterranean and DASH (Dietary Approaches to Stop Hypertension) diets, and
- Foods high in vitamin D.

Envato Image

REVASCULARIZATION

Revascularization is a procedure that provides "a new, additional, or augmented blood supply to a body part or organ."[21] With the improved methods for diagnosing PAD, there have been an increasing number of endovascular treatment methods.[9] Each medical care team should evaluate which method is best for each individual patient. Revascularization for PAD includes both minimally invasive endovascular treatments as well as open surgical procedures.

An endovascular procedure is defined by the American College of Cardiology/American Heart Association/Society for Cardiovascular Angiography and Interventions/Society of Interventional Radiology/Society for Vascular Medicine (ACC/AHA/SCAI/SIR/SVM) Guidelines as "a minimally invasive percutaneous procedure in which treatment for artery disease is delivered via catheter-based devices." Balloon angioplasty and stenting are both considered endovascular treatments.[9]

A surgical treatment for PAD is defined by the ACC/AHA/SCAI/SIR/SVM Guidelines as an "artery revascularization procedure that requires skin incision and manipulation of the target artery under direct visualization." Examples of surgical treatments for PAD include endarterectomy of the artery and bypass grafts.[9]

The decision of which type of surgical intervention is needed depends on the comorbidities of the patient as well as the extent to which the PAD has progressed.[2]

The indications for revascularization may include:

- improvement in claudication symptoms or
- salvage of the limb in more advanced cases.[2]

For patients in the advanced stages of PAD who have critical limb-threatening ischemia, revascularization is recommended, when possible, in order to avoid further loss of tissue.[10] The ACC/AHA/SCAI/SIR/SVM Guidelines state that at this point, continuing medical therapy without revascularization is "not considered reasonable treatment."[9]

An interdisciplinary team should go through the various options for revascularization to determine whether the limb can be preserved or whether an amputation is necessary.[10] The most recent AHA/ACC Guidelines detail findings for which endovascular or surgical revascularization should be considered for patients with critical limb-threatening ischemia (see Table 4).

TABLE 4 | AHA/ACC Guidelines for Consideration of Surgical or Endovascular Revascularization

Findings That Favor Consideration of Endovascular Revascularization	Findings that Favor Consideration of Surgical Revascularization
The presence of patient comorbidities may place patients at increased risk of perioperative complications from surgical revascularization. In these patients, an endovascular-first approach should be used regardless of anatomy. Examples of patient comorbidities include: • Coronary ischemia • Cardiomyopathy • Congestive heart failure • Severe lung disease • Chronic kidney disease	Factors associated with technical failure or poor durability with endovascular treatment, such as: • Lesion involving common femoral artery, including origin of deep femoral artery • Long segment lesion involving the below-knee popliteal and/or infrapopliteal arteries in a patient with suitable single-segment autogenous vein conduit Diffuse multilevel disease that would require endovascular revascularization at multiple anatomic levels • Small diameter target artery proximal to site of stenosis or densely calcified lesion at location of endovascular treatment
Patients with rest pain and disease at multiple levels may undergo a staged approach as part of endovascular-first approach	Endovascular treatment likely to preclude or complicate subsequent achievement of in-line blood flow through surgical revascularization, such as: • Single-vessel runoff distal to ankle
Patients without suitable autologous vein for bypass grafts, such as: • Patients who have had veins harvested for previous coronary artery bypass surgery and do not have adequate remaining veins for use as conduits. • Patients who may not have undergone prior saphenous vein harvest, but available vein is of inadequate diameter	

Gerhard-Herman MD, Gornik HL, Barrett C, et al. 2016 AHA/ACC Guideline on the Management of Patients with Lower Extremity Peripheral Artery Disease: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. *Circulation*. 2017;21;135(12):e726-e779. doi: 10.1161/CIR.0000000000000471.

The Transatlantic Intersociety Consensus (TASC) also has a guideline that can aid clinicians in deciding whether endovascular or surgical revascularization is the preferred choice. The guideline classifies femoropopliteal lesions and infrapopliteal lesions into 4 types (see Table 5). Treatment is specified depending on the type of lesion.[22]

TABLE 5 | Types of Lesions in Terms of Complexity and Length

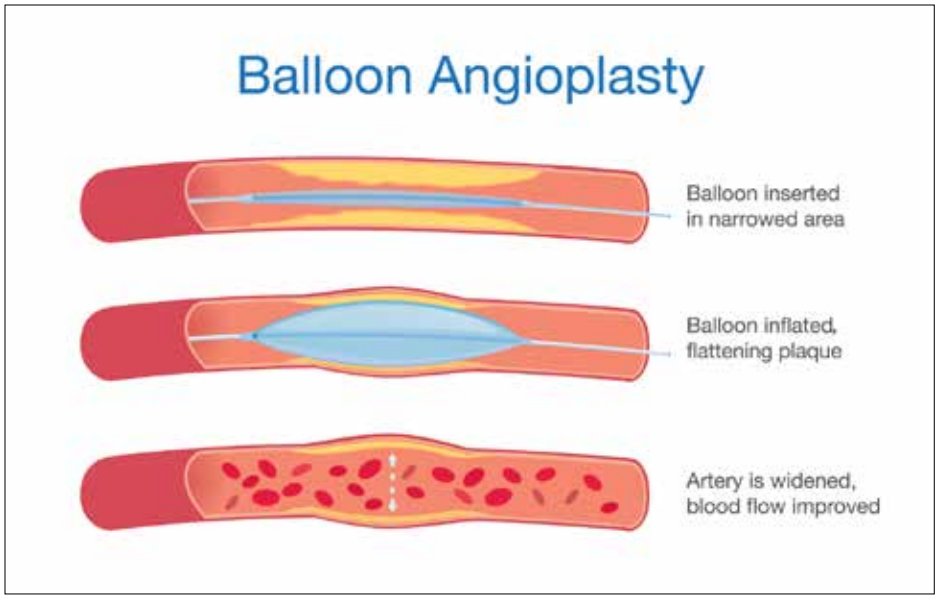
	Femoropopliteal Lesions	Infrapopliteal Lesions	Treatment
Type A	Single stenosis up to 3 cm long	Single stenosis shorter than 1 cm in the tibial or peroneal arteries	Endovascular revascularization
Type B	Single stenosis or occlusion up to 10 cm long	Multiple focal stenosis of the tibial or peroneal vessels, each less than 1 cm long	Either endovascular or surgical revascularization can be used, but endovascular treatments are more commonly used
Type C	Single stenosis or occlusion >10 cm long	• Stenoses 1 to 4 cm long • Occlusions 1 to 2 cm long of the tibial or peroneal vessels	Either endovascular or surgical revascularization can be used, but surgery is more commonly used
Type D	• Complete common femoral artery and or superficial femoral artery occlusion • Complete popliteal and proximal trifurcation occlusion	Tibial or peroneal occlusions longer than 2 cm	Bypass surgery

Violari E, Payomo A, Schiro BJ, Powell A, Gandhi RT, Pena CS. Endovascular treatment of infrainguinal peripheral arterial disease (PAD): Update on stent technology. *Tech Vasc Interv Radiol*. 2022;25(3):100840. doi: 10.1016/j.tvir.2022.100840.

Angioplasty

Balloon angioplasty is a core endovascular treatment used for PAD.[22] The ACC/AHA/SCAI/SIR/SVM Guidelines define angioplasty as "endovascular repair or recanalization of a blood vessel, especially by balloon dilation."[9] (See Figure 5.)

Figure 5 – Balloon Angioplasty



Getty Image

In 1964, the first angioplasty procedure was conducted.[22] Angioplasty has been the main method of endovascular treatment but does have its limitations, such as elastic recoil and restenosis of the vessel.[22]

The ACC, AHA, SCAI, SIR, and SVM compiled an Appropriate Use Criteria for Peripheral Artery Intervention Guideline in 2018. The document specifies appropriate uses for balloon angioplasty according to the peripheral artery chosen (see Table 6).

TABLE 6 | Options for Balloon Angioplasty per the ACC/AHA/ SCAI/SIR/SVM Appropriate Use Criteria Guideline

Isolated Common Iliac Artery	Isolated External Iliac Artery	Diffuse Common Iliac Artery and External Iliac Artery	SFA and Popliteal Artery	Below the Knee
Appropriate for discrete stenosis	Appropriate for discrete stenosis	May be appropriate for unilateral external iliac artery stenosis with multiple common iliac artery stenoses	Appropriate for length less than 100 mm	Appropriate for length less than 100 mm
May be appropriate for diffuse disease or multiple stenoses of the common iliac artery		May be appropriate for chronic total occlusion	May be appropriate for length greater than or equal to 100 mm	Appropriate for length greater than or equal to 100 mm

Bailey SR, Beckman JA, Dao TD, et al. ACC/AHA/SCAI/SIR/SVM 2018 Appropriate use criteria for peripheral artery intervention: A report of the American College of Cardiology Appropriate Use Criteria Task Force, American Heart Association, Society for Cardiovascular Angiography and Interventions, Society of Interventional Radiology, and Society for Vascular Medicine. *J Am Coll Cardiol*. 2019;73(2):214-237. doi: 10.1016/j.jacc.2018.10.002.

Overview of Procedure

Various types of balloon angioplasty available on the market today include:[22]

- Standard balloons,
- Cutting balloons,
- Drug-coated balloons,
- Cryoplasty balloons, and
- Lithoplasty balloons.

The procedure starts by accessing the desired artery. Then a guidewire is inserted and a balloon-tipped catheter goes over the guidewire to the designated site for the procedure. Once at the site, contrast is injected and imaging obtained to map out the characteristics and extent of the stenosis. Then, the catheter is moved forward through the part of the artery that has stenosis and the balloon is inflated. The inflation of the balloon compresses the plaque and widens the inner circumference of the artery. If stenting or atherectomy are planned, this is done next. After the balloon is dilated, the catheter is taken out and imaging is

obtained again. Hemostasis of the accessed artery is done through manual compression or use of compression bands or vascular closure devices.[23]

Recovery and Patient Education

Percutaneous transluminal angioplasty using either balloon angioplasty or stent insertion are treatment options for PAD, primarily because patients experience fewer complications and recover faster afterwards following stent insertion.[24] Patients should be educated about signs and symptoms of vascular complications, which occur in approximately 6% of angioplasty procedures. These complications may include but are not limited to bleeding at the access site and thrombosis.[23]

Benefits and Possible Complications

Possible complications of balloon angioplasty include:[22]

- Elastic recoil (loss of diameter of artery),
- Intimal dissection (a tear in the inner lining of the artery), and
- Restenosis.

In this study, restenosis after percutaneous transluminal angioplasty occurred in 20 to 50% of cases after 1 year, and in as many as 60% of cases after 2 years.[24]

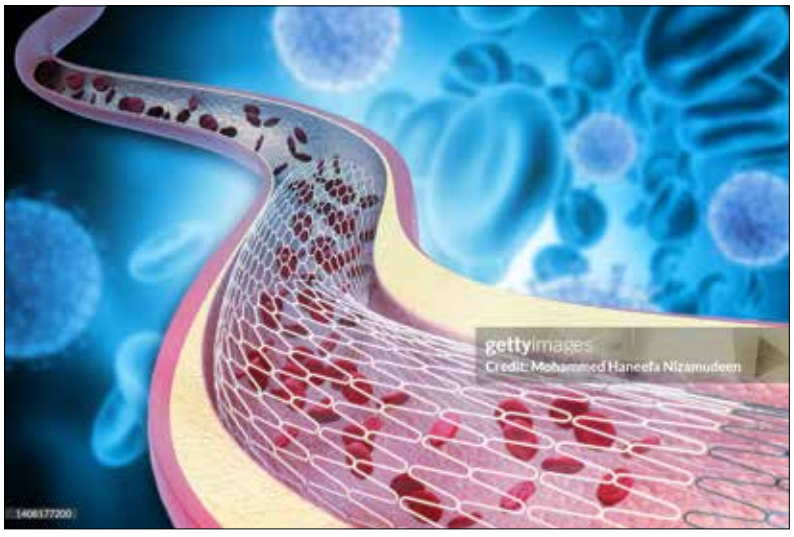
Stent Placement

A stent is defined by the ACC/AHA/SCAI/SIR/SVM Guidelines as "a small, narrow metal or plastic tube often in the form of a mesh that is inserted into the lumen of an artery, especially to keep a previously blocked passageway open"[9] (see Figure 6).

Stent placement is a procedure that is typically performed for the following reasons:[22]

- Suboptimal outcome post-angioplasty,
- More than 30% residual stenosis post-angioplasty, or
- Flow-limiting dissection.

Figure 6 – Image of Stent Placed in Vessel



Getty Image

The ACC/AHA/SCAI/SIR/SVM Appropriate Use Criteria for Peripheral Artery Intervention Guideline specifies appropriate use for stent placement according to the peripheral artery chosen (see Table 7).

TABLE 7 | Options for Stent Placement per the ACC/AHA/SCAI/SIR/SVM Appropriate Use Criteria Guideline

Isolated Common Iliac Artery	Isolated External Iliac Artery	Diffuse Common Iliac Artery and External Iliac Artery	SFA and Popliteal Artery	Below the Knee
Appropriate for discrete stenosis	Appropriate for discrete stenosis	Appropriate for unilateral external iliac artery stenosis with multiple common iliac artery stenoses	Bare metal stent: Appropriate for length less than 100 mm	Bare metal stent: May be appropriate for length less than 100 mm
Appropriate for diffuse disease or multiple stenoses of the common iliac artery		Appropriate for chronic total occlusion	Bare metal stent: Appropriate for length greater than or equal to 100 mm	Bare metal stent: May be appropriate for length greater than or equal to 100 mm
			Drug-eluting stent: Appropriate for length less than 100 mm	Drug-eluting stent: Appropriate for length less than 100 mm
			Drug-eluting stent: Appropriate for length greater than or equal to 100 mm	Covered stent: Rarely appropriate for length less than 100 mm
			Covered stent: May be appropriate for length less than 100 mm	Covered stent: Rarely appropriate for length greater than or equal to 100 mm

Bailey SR, Beckman JA, Dao TD, et al. ACC/AHA/SCAI/SIR/SVM 2018 Appropriate use criteria for peripheral artery intervention: A report of the American College of Cardiology Appropriate Use Criteria Task Force, American Heart Association, Society for Cardiovascular Angiography and Interventions, Society of Interventional Radiology, and Society for Vascular Medicine. *J Am Coll Cardiol*. 2019;73(2):214-237. doi: 10.1016/j.jacc.2018.10.002

Types of Stents

Examples of the various types of stents available on the market today for the treatment of PAD include:[9]

- Bare metal nitinol self-expanding stents,
- Covered self-expanding stents, and
- Drug-eluting stents.

Bare Metal Stents

Bare Metal stents (see Figure 7) were the first type of stent used and are most often used for patients who are not able to tolerate dual antiplatelet therapy or for whom it is contraindicated.[22]

Figure 7 – Bare Metal Stent

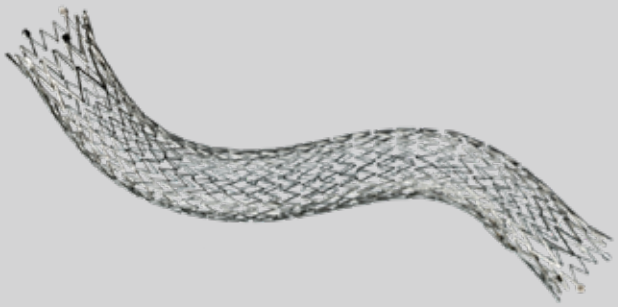


Image courtesy of BD

Studies show that stents can result in superior outcomes compared with angioplasty. In two randomized trials specific to tubular nitinol stents in mid-length femoropopliteal lesions, a comparison of a group who received bare metal stents and a group who underwent angioplasty showed that 37% of the stent group had restenosis after 1 year, while 63% of the angioplasty group had restenosis after 1 year.[22]

Covered Stents

Covered stents, also called stent grafts, were created to improve restenosis rates.[22] One study found that covered stents had similar outcomes to vascular bypass graft outcomes.[22] Results from another study called the VIBRANT trial found that patency rates were 73% 1 year after covered stent placement.[22]

Drug-Eluting Stents

The next iteration of stents, drug-eluting stents, were created after covered stents to continue to improve the patency rates of stents.[22] Medications that drug-eluting stents can be covered with include paclitaxel, everolimus, or sirolimus. The medication is designed to elute for a specific time frame and then washed out from the artery.

Overview of Procedure

Stent procedures begin similarly to angioplasty procedures described above for vessel access and lesion mapping. Percutaneous balloon angioplasty is then conducted to make room to ensure the stent can be properly placed. The stent (or stents) is then placed and the balloon can be dilated once more to make sure the stent is fully expanded. Stents are placed sequentially until patency is achieved and, if using a self-expanding stent, it should be 1 mm larger than the reference vessel. The last intra-procedural angiography is then completed to check for residual stenosis and any clots that may have formed during the procedure.[22] Additionally, the use of intravascular ultrasound (IVUS) has been gaining momentum. While originally used for coronary procedures, medical professionals are recognizing the benefits of using IVUS in non-coronary procedures.[25] This has led to the innovation and increased usage of IVUS in peripheral interventions.[25]

Recovery and Patient Education

Once the procedure is complete and the patient is in recovery, per physician preference they may be administered a 300 mg loading dose of clopidogrel for post treatment anticoagulation. They also may be prescribed 81 mg aspirin, 75 mg of clopidogrel, and a statin to be taken daily. The patient should be educated on aggressive management of modifiable risk factors related to diabetes, hypertension, hyperlipidemia, and smoking.[22]

The patient will need follow-up appointments following procedure, then at approximately 4-6 weeks, 6 months, and 12 months after the procedure. During these appointments, the clinician will assess:[22]

- new cardiovascular risk factors,
- patient adherence to medical therapy,
- subjective symptoms from the limb where the stent was placed, and
- pulses and ABI.

The clinician should counsel the patient on the importance of continuing to follow best practice for guideline-directed management and therapy, such as complying with a regular walking program. Most patients, especially those who received bare metal and covered stents, will need to continue dual antiplatelet therapy with aspirin and clopidogrel for at least 6 months and possibly for life.[22]

Benefits and Possible Complications

The patency of stents depends on the type of stent used.

In a study comparing the post-treatment success and failure rates in patients with femoropopliteal arterial disease, 1-year patency rates were evaluated and included:[22]

- 66% patency for bare metal stents,
- 83% patency for drug-eluting stents, and
- 68% patency for covered stents.

A possible complication after stent placement includes in-stent restenosis (reoccurrence of stenosis). Treatment can be complex and a careful atherectomy can be helpful to repair the restenosis. In-stent restenosis may also be treated with drug-coated balloon angioplasty or relining of the stent.[22]

Another complication that affects the patency of the stent is **fracturing of the stent**. Stents may fracture because of how they were placed, the individual anatomy of the patient in whom it was placed, how stents were overlapped, and the length of the stenosis.[22] In one study, 90 stents were evaluated in 42 treated limbs 12 months after placement.[26] Sixteen fractures were found and 6 included loss of patency.[26] The clinical impact of fracture still needs further research, as this is still a matter of controversy.[26]

Getty Image

Atherectomy

An atherectomy is defined by the AHA/ACC Guidelines as "*removal of atheromatous plaque from within a blood vessel by utilizing a catheter usually fitted with a cutting blade, laser, or grinding burr.*"[9]

The ACC/AHA/SCAI/SIR/SVM Appropriate Use Criteria for Peripheral Artery Intervention Guideline specifies appropriate use for atherectomy according to the peripheral artery chosen (see Table 8).

TABLE 8 | Options for Atherectomy per the ACC/AHA/SCAI/SIR/SVM Appropriate Use Criteria Guideline

Isolated Common Iliac Artery	Isolated External Iliac Artery	Diffuse Common Iliac Artery and External Iliac Artery	SFA and Popliteal Artery	Below the Knee
Rarely appropriate for discrete stenosis	Rarely appropriate for discrete stenosis	Rarely appropriate for unilateral external iliac artery stenosis with multiple common iliac artery stenoses	May be appropriate for length less than 100 mm	May be appropriate for length less than 100 mm
Rarely appropriate for diffuse disease or multiple stenoses of the common iliac artery		Rarely appropriate for chronic total occlusion	May be appropriate for length greater than or equal to 100 mm	May be appropriate for length greater than or equal to 100 mm

Bailey SR, Beckman JA, Dao TD, et al. ACC/AHA/SCAI/SIR/SVM 2018 Appropriate use criteria for peripheral artery intervention: A report of the American College of Cardiology Appropriate Use Criteria Task Force, American Heart Association, Society for Cardiovascular Angiography and Interventions, Society of Interventional Radiology, and Society for Vascular Medicine. *J Am Coll Cardiol*. 2019;73(2):214-237. doi: 10.1016/j.jacc.2018.10.002.

According to the ACC/AHA/SCAI/SIR/SVM Appropriate Use Criteria for Peripheral Artery Intervention Guideline published in 2019, there is a lack of data supporting the use of atherectomy, except in cases where there is severe calcification and lesions that will not dilate. This does not mean that the procedure has been proven to be unsafe or ineffective, but that the rating panel determined that there was a lack of comparative evidence to support general use. The authors state, *"given the expense and paucity of data regarding atherectomy, further comparative investigation is recommended into the risks and benefits of atherectomy in femoral popliteal lesions."*[9]

Recently, there has been a surge in the use of atherectomy for peripheral vascular intervention (PVI) procedures. Results from a retrospective review of 205,377 PVI procedures found that the rate of atherectomy procedures increased from 8.5% in 2010 to 19.7% in 2019.[27] High-quality, randomized data has been lacking regarding the efficacy of atherectomy over PVI methods that have undergone extensive research over a much longer period of time.[28]

May Occur Prior to Angioplasty and Stenting

Atherectomy can be used to prepare the blood vessel prior to angioplasty and stenting. This is called "vessel prepping" with atherectomy. Potential benefits to this approach include:[29]

- improving drug elution,
- enhancing the compliance of the artery, and
- minimizing barotrauma and dissection.

"Atherectomy differentiates itself from balloon angioplasty with or without stenting by its ability to debulk the atherosclerotic disease burden, instead of redistributing it."[30]

Types and Devices

The four main types of atherectomy devices are excisional, rotational, laser, and orbital. There is also a combination device that uses both excisional and rotational technology.

Excisional (Directional)

Excisional atherectomy devices have rotating disks that cut out and take away the plaque as they move through it. A benefit of the excisional device is that it avoids barotrauma, which may reduce the risk of neointimal hyperplasia and dissection. This system does share a common disadvantage with other types of devices, which is the risk of dislodging a thrombus where it travels further into the artery and causes a blockage (distal embolization).[31]

Rotational/Aspiration

A rotational atherectomy device (see Figure 8) spins rapidly through the blood vessel to break up the plaque and remove it through aspiration.[31] Some atherectomy devices combine excisional and rotational technologies to spin and excise the plaque.[31] This type of device can go through severely stenotic lesions and may be useful in lesions with various morphologies.[31]

Figure 8 – Rotational Atherectomy

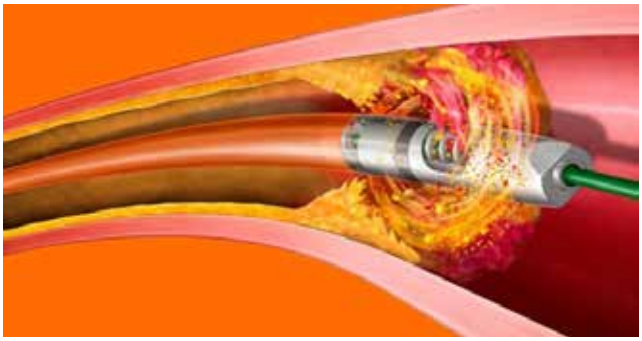


Image courtesy of BD. Illustration by Mike Austin © 2024

Laser Ablation

Laser atherectomy devices use a "high-energy, monochromatic light beam" to break up plaque without damaging the surrounding tissue. An advantage of laser atheroablation is that it has been shown to be able to break through the tough end cap that is found in chronic total occlusions.[31]

Orbital

The orbital atherectomy device spins 360 degrees around within the artery and, as it works, the circumference of the plaque is sanded down. The advantage of orbital atherectomy is that it can be particularly helpful to remove heavily calcified lesions potentially reducing the risk of trauma or necessitating a stent to be placed afterward. Newer, lower profile devices may even be conducive to a tibiopedal approach.[31]

Benefits and Possible Complications

A benefit of atherectomy is that devices that employ aspiration have the ability to remove plaque outside of the body, as opposed to angiography where the plaque is redistributed in the artery.[30] If done too aggressively, atherectomy can potentially damage the deeper layers of the artery. This could lead to wider dissection flaps which result in an increased risk of restenosis and thrombosis.[29]

Lithotripsy

Overview of Procedure

Intravascular lithotripsy (IVL) was approved for use by the United States Food and Drug Administration (FDA) in June 2018.[32] IVL is an endovascular technique that uses sonic pressure waves deployed through a balloon catheter to break up intra-arterial calcium.[32,33] The sonic pressure waves go through soft tissue to break up the calcified stenosis without harming the rest of the artery.[33] After the pulses are generated, the balloon is expanded in the artery in order to expand the artery completely.[32]

Benefits and Possible Complications

A meta-analysis that included nine studies and 681 patients receiving intravascular lithotripsy (75.53% of whom had severe calcification), found the procedure to be effective with few vascular complications.[32] Advantages of the IVL procedure include the ability to break up superficial and deep calcification as well as consistent reduction in stenoses.[32] Possible complications that have been reported in studies include types ABC dissection and the risk of perforation.[32] Of note, results from the meta-analysis indicated no reports of distal embolization or thrombus and the overall pooled event rate for stent placement was 15.89%.[32]

Patient Education

Patient education should include discussion of possible complications and counseling on the importance of continuing to follow best practice for guideline-directed management and therapy, such as complying with a regular walking program and continuing to take statin medication.

Arterial Thrombectomy

Percutaneous thrombectomy is "endovascular thrombus fragmentation and removal using dedicated devices."[34] Findings from a study of 112 patients with acute limb ischemia who received percutaneous mechanical thrombectomy showed rates of limb salvage at 83.8% after 1 year and 74.7% after 2 years.[35]

KNOWLEDGE CHECK

Bypass grafts create a/an _____ between arteries in the lower extremity that may be partially or completely blocked.

A. disccection
B. disconnection
C. anastomosis
D. transection

[Click Here for Answer]

Overview of Procedure

Depending on the type of device, mechanical thrombectomy devices, and even some atherectomy devices, break up a clot using pressurized saline, vacuum aspiration, a rotating vortex, or pulse waves (see Table 9).

TABLE 9 | Overview of Select Mechanical Thrombectomy Devices

Type of Mechanical Thrombectomy Device	Mechanism of Action
Pharmacomechanical (rheolytic) thrombectomy	Uses pressurized saline to provide active aspiration and lytic delivery
Aspiration system	Uses continuous vacuum aspiration suction to remove thrombus and monitor blood flow in real time
Rotational mechanical thrombectomy	Uses modifying beveled tip, a rotating abrading vortex, and a continuous active aspiration with fixed inner serrated cylinder
Ultrasound enhanced lysis	Applies acoustic pulse to speed the dispersion of thrombolytic agent, break up the target, and accelerate the dissolution of a clot

Ontario Health. Mechanical thrombectomy for acute and subacute blocked arteries and veins in the lower limbs: a health technology assessment. *Ont Health Technol Assess Ser*. 2023;23(1):1-244.

After the selected artery is accessed, the patient is given anticoagulation to achieve an activated clotting time of 250 to 300 seconds. Then, a guidewire and catheter are inserted. Then a wire specific to the mechanical thrombectomy device is inserted and the catheter is used to remove the thrombus. Angiography is done again to confirm effectiveness of the thrombectomy.[35]

Benefits and Possible Complications

Percutaneous thrombectomy is often the intervention of choice for acute limb ischemia to salvage the limb.[34] The benefits of this technique are that it can quickly remove a clot and the risk of bleeding is low because thrombolytic drugs are not used.[35]

A frequent complication of rheolytic thrombectomy is red blood cell hemolysis due to the amount of fluid used and the pressure placed on the blood during the procedure. This could lead to acute kidney injury, therefore clinicians taking care of patients after rheolytic thrombectomy should be alert for signs of renal failure.[34]

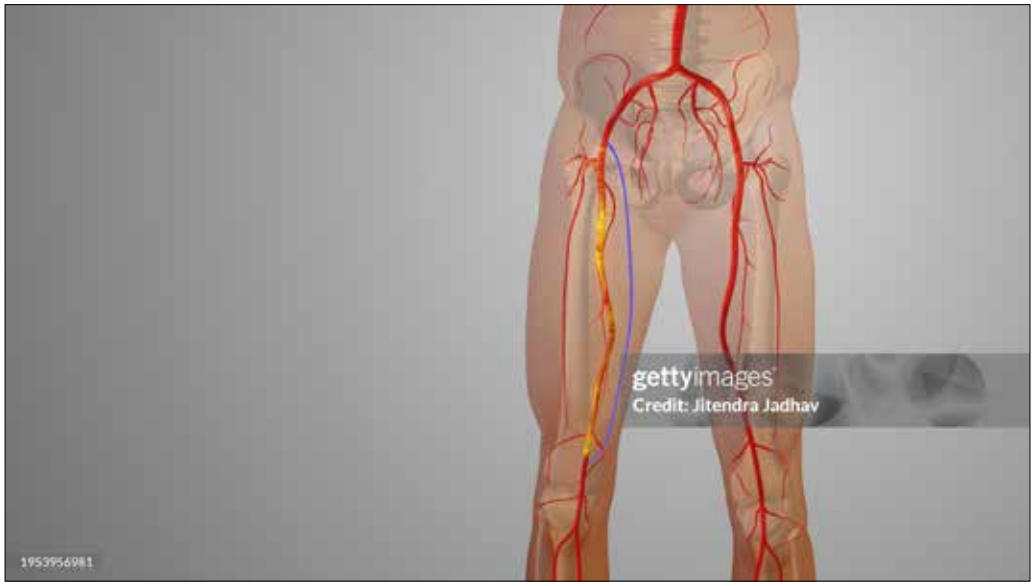
Patient Education Post-Procedure

Patient education should include education about bleeding risk, since select patients may need to take anticoagulation treatment after the procedure. In one study by Liang et al,[34] all patients received low-molecular weight heparin and were discharged from the hospital 24 hours after the procedure post-mechanical thrombectomy. Patients were educated on the importance of keeping follow-up visits (often scheduled at 3, 6, and 12 months) in order to be monitored for worsening or recurring symptoms of acute limb ischemia.[35]

Bypass Grafts

Peripheral vascular bypass is a surgical procedure that reroutes circulation from a blocked artery using a graft (see Figure 9).[3] The first bypass procedure to save a lower limb was conducted in 1949.[36] Bypass grafts create an anastomosis (cross-connection) between arteries in the lower extremity that may be partially or completely blocked.[3]

Figure 9 – Peripheral Vascular Bypass Graft

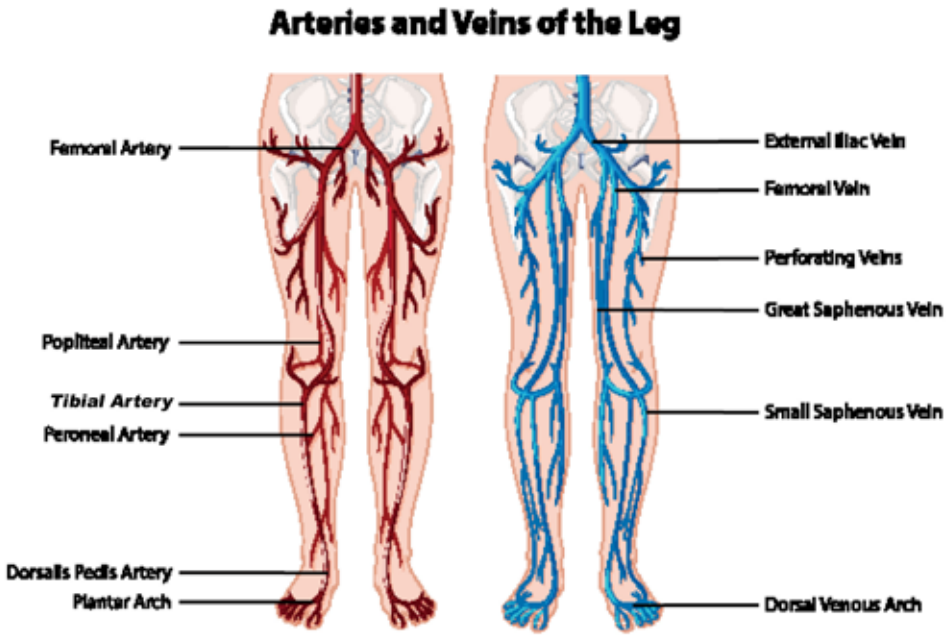


Getty image

The following arteries in the abdomen and lower extremity are frequently bypassed:[3]

- Abdominal aorta,
- Common iliac artery,
- External iliac artery,
- Common femoral artery,
- Superficial femoral artery,
- Popliteal artery,
- Anterior tibial artery,
- Posterior tibial artery, and
- Peroneal artery.

Figure 10 – Arteries and Veins of the Leg



Getty image

Overview of Procedure

Peripheral vascular bypass is a type of vascular surgery and is a high-risk procedure. The majority of vascular surgeries have more than a 5% risk for an acute cardiac event, and mortality risk is higher for patients who are older and/or have cardiac disease or diabetes.[3]

During the procedure, a graft is placed to redirect blood flow around the blockage. The proximal and distal anastomoses where the graft is connected need to be patent and free of disease in order for the graft to function.[3]

Benefits and Possible Complications

Surgical peripheral vascular bypass may be performed for patients in whom this is the preferred surgical option or who are not eligible for endovascular intervention. Successful bypass could save the patient's limb from needing to be amputated.

Possible complications during peripheral vascular bypass include:[3]

- Wound infection,
- Bleeding,
- Pneumonia,
- Conduit occlusion, and
- Peripheral nerve damage.

Autologous graft failure rates after peripheral arterial bypass occurs in about 20% of grafts in the first year. After five years, approximately half of the grafts fail.[37]

Patient Education

To prevent the graft from failing, patients should be educated on the importance of taking their prescribed anticoagulation medication, such as low-dose aspirin. Patients should also be educated about continuing best medical treatment for all patients with PAD, including a healthy diet, controlling blood glucose, regular exercise, and smoking cessation.[37]

SUMMARY

PAD affects millions of Americans and can be a painful condition that leads to disability. Even with treatment, PAD can result in major cardiovascular complications and death.[5] Tests used for diagnosing and staging PAD are economical and some are noninvasive. After diagnosis, patients should be educated about important lifestyle interventions that can improve their pain and stop the progression of their disease. Smoking cessation and a supervised exercise program have been shown to be effective at improving symptoms of claudication and reducing risk of major cardiovascular events.[5] Guideline-directed management from the AHA and ACC recommends that all patients with PAD be prescribed a statin medication, and patients with claudication should receive antiplatelet therapy.[10] Revascularization through endovascular procedures or open surgical procedures may be necessary if there is no improvement in claudication symptoms after medical management or if critical limb-threatening ischemia occurs.[2] Balloon angioplasty and stenting have been core endovascular treatments used for PAD, but restenosis remains a risk with these methods. Atherectomy, lithotripsy, and percutaneous mechanical thrombectomy are novel endovascular treatment techniques that have been gaining popularity in recent years. Further studies are needed to determine their efficacy compared to balloon angioplasty and stenting without vessel preparation. Bypass grafting is the most invasive treatment of PAD but in some cases may be the preferred option prior to limb amputation.

Glossary

Acute Limb Ischemia: A vascular emergency that indicates an abrupt hypoperfusion of a limb resulting in a critical danger to viability.

Anastomosis: Surgical connection between two body channels such as vessels or parts of the intestine.

Atherectomy: "Removal of atheromatous plaque from within a blood vessel by utilizing a catheter usually fitted with a cutting blade, laser, or grinding burr."[9]

Atherosclerosis: Plaque buildup in the arteries.

Arteriosclerosis: Hardening of the arteries.

Chronic Limb-threatening Ischemia: Also called critical limb ischemia, is characterized by pain not relieved by rest, pain at night, and ischemic skin lesions.

Claudication: "Cramping, discomfort, and/or weakness in the legs and especially the calves when walking that resolves after short rest and is associated with inadequate blood supply to the muscles."[9]

Endovascular Treatment: "A minimally invasive percutaneous procedure in which treatment for [peripheral] artery disease is delivered via catheter-based devices."[9]

Intimal Dissection: A tear in the inner lining of the artery.

Poikilothermia: Inability to regulate temperature.

Restenosis: Recurrence of stenosis.

Revascularization: A procedure that provides "a new, additional, or augmented blood supply to a body part or organ."[21]

Stenosis: Narrowing of the artery.

Stent: "A small, narrow metal or plastic tube often in the form of a mesh that is inserted into the lumen of an artery, especially to keep a previously blocked passageway open."[9]

REFERENCES

1. NHLBI What is atherosclerosis? National Heart, Lung, and Blood Institute. Updated March 24, 2022. https://www.nhlbi.nih.gov/health/atherosclerosis. Accessed May 9, 2024.
2. Bierowski M, Galanis T, Majeed A, Mofid A. Peripheral artery disease: treatment of claudication and surgical management. *Med Clin North Am*. 2023;107(5):823-827. doi: 10.1016/j.mcna.2023.05.008.
3. Young J, Lotfollahzadeh S, Patel SK. Peripheral Vascular Bypass. 2023. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing. https://www.ncbi.nlm.nih.gov/books/NBK499827/. Accessed May 9, 2024.
4. Bierowski M, Galanis T, Majeed A, Mofid A. Peripheral artery disease: overview of diagnosis and medical therapy. *Med Clin North Am*. 2023;107(5):807-822. doi: 10.1016/j.mcna.2023.05.007.
5. Del Conde I, Baumann F. Medical management of peripheral arterial disease. *Tech Vasc Interv Radiol*. 2022;25(3):100837. doi: 10.1016/j.tvir.2022.100837.
6. Pahwa R, Jialal I. Atherosclerosis. 2023. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing. https://www.ncbi.nlm.nih.gov/books/NBK507799/. Accessed May 9, 2024.
7. Gul F, Janzer SF. Peripheral vascular disease. 2023. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing. https://www.ncbi.nlm.nih.gov/books/NBK557482/. Accessed May 9, 2024.
8. Conte MS, Bradbury AW, Kolh P, et al. Global vascular guidelines on the management of chronic limb-threatening ischemia. *J Vasc Surg*. 2019;69(6S):3S-125S. doi: 10.1016/j.jvs.2019.02.016.
9. Bailey SR, Beckman JA, Dao TD, et al. ACC/AHA/SCAI/SIR/SVM 2018 Appropriate use criteria for peripheral artery intervention: A report of the American College of Cardiology Appropriate Use Criteria Task Force, American Heart Association, Society for Cardiovascular Angiography and Interventions, Society of Interventional Radiology, and Society for Vascular Medicine. *J Am Coll Cardiol*. 2019;73(2):214-237. doi: 10.1016/j.jacc.2018.10.002.
10. Gerhard-Herman MD, Gornik HL, Barrett C, et al. 2016 AHA/ACC Guideline on the management of patients with lower extremity peripheral artery disease: A report of the American College of Cardiology/American Heart Association task force on clinical practice guidelines. *Circulation*. 2017;21;135(12):e726-e779. doi: 10.1161/CIR.0000000000000471.
11. Hardman RL, Jazaeri O, Yi J, Smith M, Gupta R. Overview of classification systems in peripheral artery disease. *Semin Intervent Radiol*. 2014;31(4):378-88. doi: 10.1055/s-0034-1393976.
12. Nordanstig J, Behrendt CA, Bradbury AW, et al. Peripheral arterial disease (PAD) - A challenging manifestation of atherosclerosis. *Prev Med*. 2023;171:107489. doi: 10.1016/j.ypmed.2023.107489.
13. Morrison JT, Hsia J, Bonaca MP. Medical therapy for secondary prevention of atherothrombotic events in peripheral artery disease. *Heart Int*. 2021;15(1):14-19. doi: 10.17925/HI.2021.15.1.14.

14. Azuma N. The diagnostic classification of critical limb ischemia. *Ann Vasc Dis*. 2018;11(4):449-457. doi: 10.3400/avd.ra.18-00122.

15. Natarajan B, Patel P, Mukherjee A. Acute lower limb ischemia-etiology, pathology, and management. *Int J Angiol*. 2020;29(3):168-174. doi: 10.1055/s-0040-1713769.

16. Hemingway J, Emanuels D, Aarabi S, et al. Safety of transfer, type of procedure, and factors predictive of limb salvage in a modern series of acute limb ischemia. *J Vasc Surg*. 2019;69(4):1174-1179. doi: 10.1016/j.jvs.2018.08.174.

17. Weaver ML, Neal D, Columbo JA, et al. Market competition influences practice patterns in management of patients with intermittent claudication in the vascular quality initiative. *J Vasc Surg*. 2023;78(3):727-736. doi: 10.1016/j.jvs.2023.04.032.

18. McDermott KM, Srinivas T, Abularrage CJ. Multidisciplinary approach to decreasing major amputation, improving outcomes, and mitigating disparities in diabetic foot and vascular disease. *Semin Vasc Surg*. 2023;36(1):114-121. doi: 10.1053/j.semvascsurg.2022.11.001.

19. Menard MT, Jaff MR, Farber A, et al. Baseline modern medical management in the BEST-CLI trial. *J Vasc Surg*. 2023;78(3):711-718. doi: 10.1016/j.jvs.2023.05.006.

20. Allison MA, Armstrong DG, Goodney PP, et al. Health disparities in peripheral artery disease: a scientific statement from the American Heart Association. *Circulation*. 2023;148(3):286-296. doi: 10.1161/CIR.0000000000001153.

21. Revascularization. Merriam-Webster. n.d. https://www.merriam-webster.com/dictionary/revascularization. Accessed May 9, 2024.

22. Violari E, Payomo A, Schiro BJ, Powell A, Gandhi RT, Pena CS. Endovascular treatment of infrainguinal peripheral arterial disease (PAD): Update on stent technology. *Tech Vasc Interv Radiol*. 2022;25(3):100840. doi: 10.1016/j.tvir.2022.100840.

23. Majeed H, Chowdhury YS. Percutaneous transluminal angioplasty and balloon catheters. 2022. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing. https://www.ncbi.nlm.nih.gov/books/NBK565853/. Accessed May 9, 2024.

24. Zhu Z, Yu H, Jiang M, Wu H, Wang J, Xu F. Status and influencing factors of frailty in patients with restenosis after percutaneous transluminal angioplasty for peripheral arterial disease: A cross-sectional study. *Medicine (Baltimore)*. 2023;102(29):e34465. doi: 10.1097/MD.0000000000034465.

25. Secemsky EA, Parikh SA, Kohi M, Lichtenberg M, Meissner M, et al. Intravascular ultrasound guidance for lower extremity arterial and venous interventions. *EuroIntervention*. 2022;18(7):598-608.

26. Davaine JM, Azema L, Huyomarch B, et al. One-year clinical outcome after primary stenting for Trans-Atlantic Inter-Society Consensus (TASC) C and D femoropopliteal lesions (the STELLA “STEnting Long de L’Artere femorale superficielle” cohort). *EJVES*. 44(4):432-441, 2023. doi: 10.1016/j.ejvs.2012.07.015.

27. Nfor T, Dababneh E, Jan MF, et al. National trends and variability of atherectomy use for peripheral vascular interventions from 2010 to 2019. *J Vasc Surg*. 2022;76(3):778-785. doi: 10.1016/j.jvs.2022.03.864.

28. Hicks CW, Holscher CM, Wang P, et al. Use of atherectomy during index peripheral vascular interventions. *JACC Cardiovasc Interv*. 2021;14(6):678-688. doi: 10.1016/j.jcin.2021.01.004.

29. Shammas NW. Peripheral arterial vessel prepping with intravascular ultrasound and atherectomy: an interventionalist's perspective. *J Invasive Cardiol*. 2021;33(2):E95-E98.

30. Gupta R, Siada S, Lai S, et al. Critical appraisal of the contemporary use of atherectomy to treat femoropopliteal atherosclerotic disease. *J Vasc Surg*. 2022;75(2):697-708. doi: 10.1016/j.jvs.2021.07.106.

31. Charitakis K, Feldman DN. Atherectomy for lower extremity intervention: why, when, and which device? American College of Cardiology. June 16, 2015. https://www.acc.org/latest-in-cardiology/articles/2015/06/16/07/58/atherectomy-for-lower-extremity-intervention. Accessed May 9, 2024.

32. Wong CP, Chan LP, Au DM, Chan HWC, Chan YC. Efficacy and safety of intravascular lithotripsy in lower extremity peripheral artery disease: a systematic review and meta-analysis. *Eur J Vasc Endovasc Surg*. 2022;63(3):446-456. doi: 10.1016/j.ejvs.2021.10.035.

33. Adams G, Shammas N, Mangalmurti S, et al. Intravascular lithotripsy for treatment of calcified lower extremity arterial stenosis: initial analysis of the Disrupt PAD III Study. *J Endovasc Ther*. 2020;27(3):473-480. doi: 10.1177/1526602820914598.

34. Isernia G, Pasqui E, de Donato G, et al. Endovascular thrombectomy devices for acute limb ischemia management. *J Cardiovasc Surg (Torino)*. 2023;64(3):233-239. doi: 10.23736/S0021-9509.23.12696-6.

35. Liang S, Zhou L, Ye K, Lu X. Limb salvage after percutaneous mechanical thrombectomy in patients with acute lower limb ischemia: a retrospective analysis from two institutions. *Ann Vasc Surg*. 2019;58:151-159. doi: 10.1016/j.avsg.2018.11.025.

36. Akingba AG, Chow WB, Rowe VL. Lower extremity bypass. *Surg Clin North Am*. 2023;103(4):767-778. doi: 10.1016/j.suc.2023.04.014.

37. Valdes PJ, Dorosh J, Lin JC, Diaz MA. Vein graft stenosis. 2022. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing. https://www.ncbi.nlm.nih.gov/books/NBK499947/. Accessed May 9, 2024.

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