

Peripheral Artery Disease (PAD) — Definition, Stages and Treatment

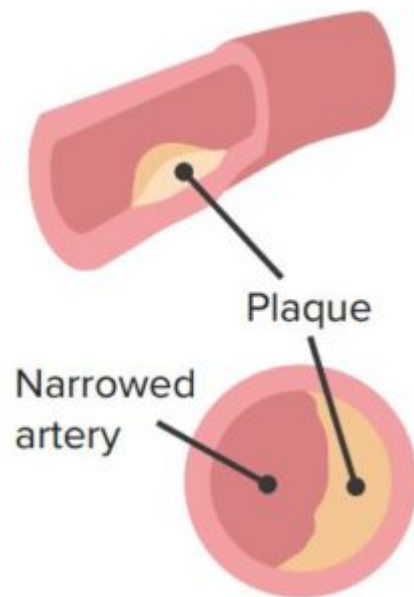
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Peripheral artery disease, shortly referred to as PAD, is a condition caused due to atherosclerosis. Estimated to be affecting around 200 million people in 2010, the intermittent claudication is a medical entity of rising impact, which every prospective physician should master. The underlying atherosclerosis is not only the most common arterial vascular disease but also the pathologic substrate for many other common and often life-threatening diseases. These include strokes, heart attacks or aneurysms—comorbidities and risks, which can first manifest as PAD. This article’s purpose is to illustrate how PAD is diagnosed and treated as well as to provide exam-oriented information.



Definition of PAD

PAD — the peripheral artery occlusive disease



"Peripheral arterial disease" Image created by Lecturio

Peripheral artery occlusive disease (the main cause of intermittent claudication) is a chronic disease involving arterial circulatory vessels in the extremities. Most times it also affects arteries of the feet. The chronic atherosclerotic process leads to **arterial stenosis** and, at a later stage, to the complete occlusion of the arteries. The resulting hypoperfusion leads to pain in the extremities – described as intermittent claudication with walking, which is also the primary symptom of the disease.

Many patients tend to stop while walking, suffering a great limitation on the distances they can manage. Clinically, as the disease progresses, hypoperfusion causes the affected extremity to become pale, cold and paresthetic. Trivial wounds heal much slower in these circumstances and, in the worst-case scenario, may evolve into necrosis or, through an infection, to gangrene.

Peripheral arterial disease is caused by [atherosclerosis](#) in 85 – 95 % of the cases.

The acute peripheral artery occlusive disease falls, by definition, also under the PAD and involves the complete blockage of an **arterial vessel**. It may occur suddenly, due to embolic incidents or—as part of PAD—as a complication.

Epidemiology of PAD

Prevalence of PAD

The prevalence of PAD rises with age and affects 15 – 21 % of people over 70 years of age. Studies conducted in 2014 show that the prevalence of PAD in the age group under 40 is less than 1 %. It is important to remember, however, that an asymptomatic PAD is more common than a symptomatic one and, in fact, not age-related.

Etiology of PAD

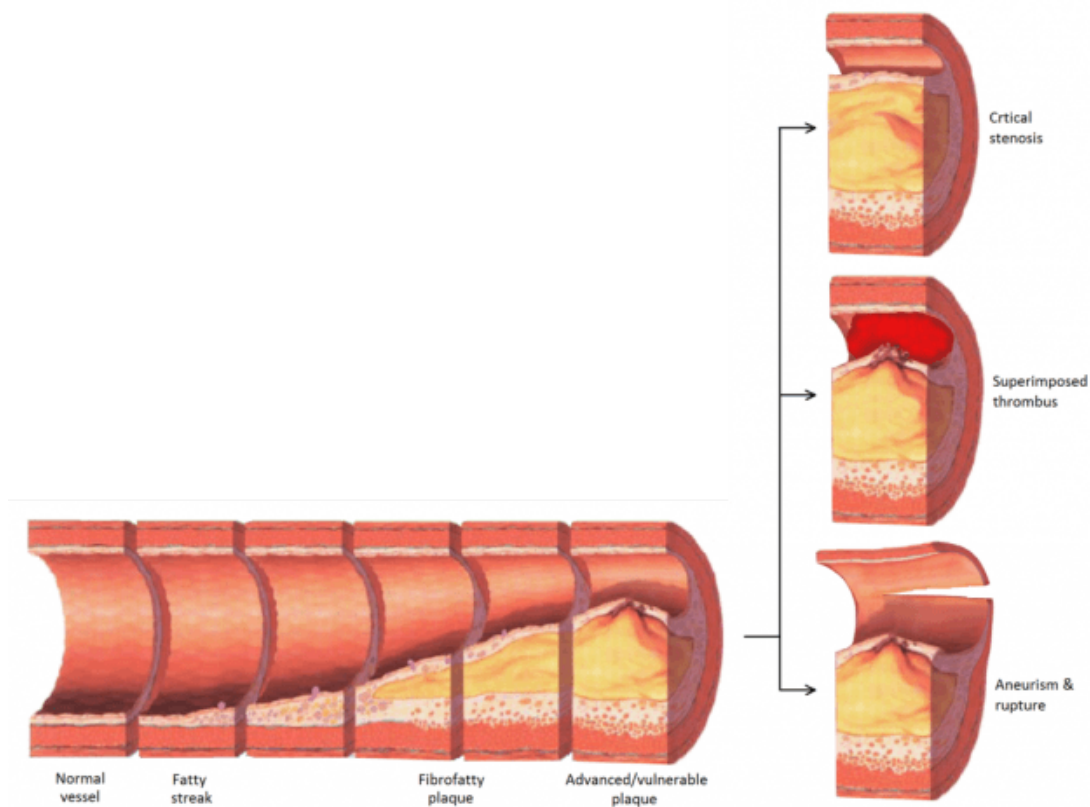
Causes of PAD

In 85 – 95 % of the cases, peripheral artery occlusive disease is caused by atherosclerotic plaques, namely deposits consisting of lipids, [connective tissue](#), thrombi or calcium on the arterial walls. Atherosclerosis involves, by definition, the entire arterial wall, but it is often referred to as atherosclerosis of the **tunica intima**. In terms of clinical use, both expressions are interchangeably used and are practically synonymous.

The primary risk factors for atherosclerosis are the following:

- Nicotine abuse
- [Diabetes Mellitus](#)
- [Arterial Hypertension](#)
- Dyslipidemia

In less than 5 % of the cases, PAD is a result of recurrent emboli, **thrombotic aneurysms**, compartment syndrome or **vascular injury**.



[Image](#): "Atherosclerosis disease progression" by Npatchett. License: [CC BY—SA 3.0](#)

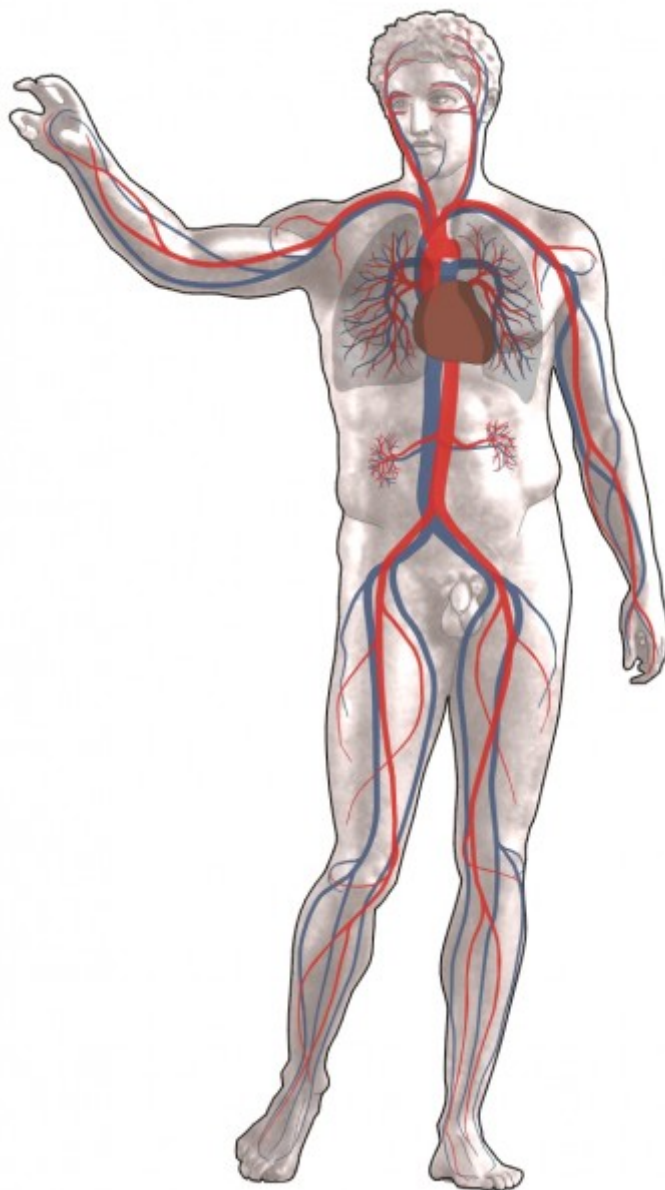
Note: The list of primary risk factors for atherosclerosis is basic and important knowledge both for every physician and for the final exams!

Symptoms of PAD

The primary symptom of PAD is pain occurring with physical activity, typically located distally to the **stenotic vessel**. Pain causes patients to often come to a halt when walking, and the symptom is referred to as **intermittent claudications** (Latin for the "occasional limp").

Interesting fact: Due to the unavoidable halts, to which patients with PAD come when walking on a street, the Germans unofficially refer to it as the window-shopping disease! Typically, claudication is relieved after a pause during walking. Also, keeping the feet at a lower level than that of the heart helps restore part of the circulation, which, faulty as it is, leads to tissue **hypoxia** and pain in the feet. Due to this, the skin becomes cold and pale distally to the stenosis, often with no palpable pulse.

The body is generally able to overcome small stenosis through collateral circulation. The full panel of symptoms does not appear until stenosis has reached more than 90 %—this actually explains the extremely high percentage of asymptomatic PAD patients. Diminished circulation constitutes fertile ground for ulcers, healing disorders, necrosis or gangrene in the affected areas.



[Image:](#) "The human circulatory system. Red indicates oxygenated blood, blue indicates deoxygenated blood." by Sansculotte. License: [CC BY—SA 2.5](#)

A classification based on the stenosis location and the symptoms is also possible:

Stenosis location	Symptoms
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Aortoiliac type	Aortic bifurcation syndrome, buttocks, thighs
Femoral type	Shanks
Shank/Peripheral type	Feet

Symptoms of acute arterial occlusion

When the disease has reached the late-stage phase, a complete blockage of the artery is possible. This acute **peripheral arterial occlusion**, also acute ischemia of the extremities, can result in losing the affected extremity as it may lead to necrosis, which will require an amputation and can be potentially life-threatening.

The massive hypoperfusion in the extremities causes symptoms that can be synopsized with the mnemonic of “the 6 P’s” rule according to Pratt, which you have to keep in mind as a student.

1. Pain
2. Pulselessness
3. Pallor
4. Paresthesia
5. Paralysis
6. Poikilothermia

Note: An aortic occlusion distally to the renal arteries, at the level of the aortic bifurcation, or a complete occlusion of both iliac arteries, leads to erectile dysfunction/impotence in men. That is called an aortic bifurcation syndrome or Leriche syndrome”.

Stages of PAD

Progress of the disease

Based on the symptoms, PAD is classified in stages, which also constitute a criterion for its proper treatment plan.

Stage	Characteristics	Therapy plan
Stage I	Symptom—free	
Stage II	Pain during physical activity. IIa: distances walked without pain > 200 m. IIb: distances walked without pain < 200 m.	Intermittent claudication, no acute danger to the extremities yet.
Stage III	Ischemic rest pain.	
Stage IV	Necroses, gangrene, ulcers. IVa: dry necroses, trophic disorders. IVb: infected necroses, moist gangrene.	Indication for systematic therapeutic action, otherwise danger for (partly) losing the extremity. 1 year mortality rate lies between 20 % - 40 %.

Diagnosis of PAD

In order to diagnose PAD, a physician needs to go through a multi-level assessment of the patient’s medical history, physical examination, and imaging. A medical history and physical examination can determine the first indications of PAD and also help classify the disease.

PAD medical records

The patient should describe the circumstances under which the symptom occurs: the duration of the pain, its location, the distances they are able to walk as well as the quality of pain. Questions regarding risk factors of underlying atherosclerosis and diseases connected to it, like coronary heart disease, should also be asked. Nicotine abuse, diabetes mellitus, hypercholesterolemia, arterial hypertension, and hyperlipidemia are assessed as the most important risk factors.

Physical examination in PAD

Decreased blood flow in the affected extremity can be detected early by inspection: What is the quality of the skin? A pale color, lower temperature, and increased sweat production are indications of diminished perfusion. Are there visible lesions or complications such as **ulcers, necrosis** or **moist gangrene**? Is auscultation of the assumed-to-be-affected artery, possible? In severe stenosis, with an occlusion of over 60 – 70 %, a **systolic murmur** can be heard.

Note (back to anatomy): For your exams, you should note that the **dorsalis pedis artery pulse** can be palpated readily lateral to the **extensor hallucis longus tendon**. Since many patients have an asymptomatic PAD, clinical diagnosis is made possible with the palpation of the foot pulses (comparing the two), or the determination of the **ankle-brachial index**. A treadmill ergometer is also possible, so as to objectify the distances deemed by a patient as “walkable” and assess the severity of the disease.

The Ratschow positioning test is a non-invasive test, involving maneuvering the position of the feet, used to diagnose PAD. The patient lies on their back, and as the legs are lifted to a 90 degrees angle and then returned to a sitting position, a physician can visually assess the blood circulation and venous filling, depending on how much time is needed before the feet regain their normal color.

Ankle-brachial index in PAD

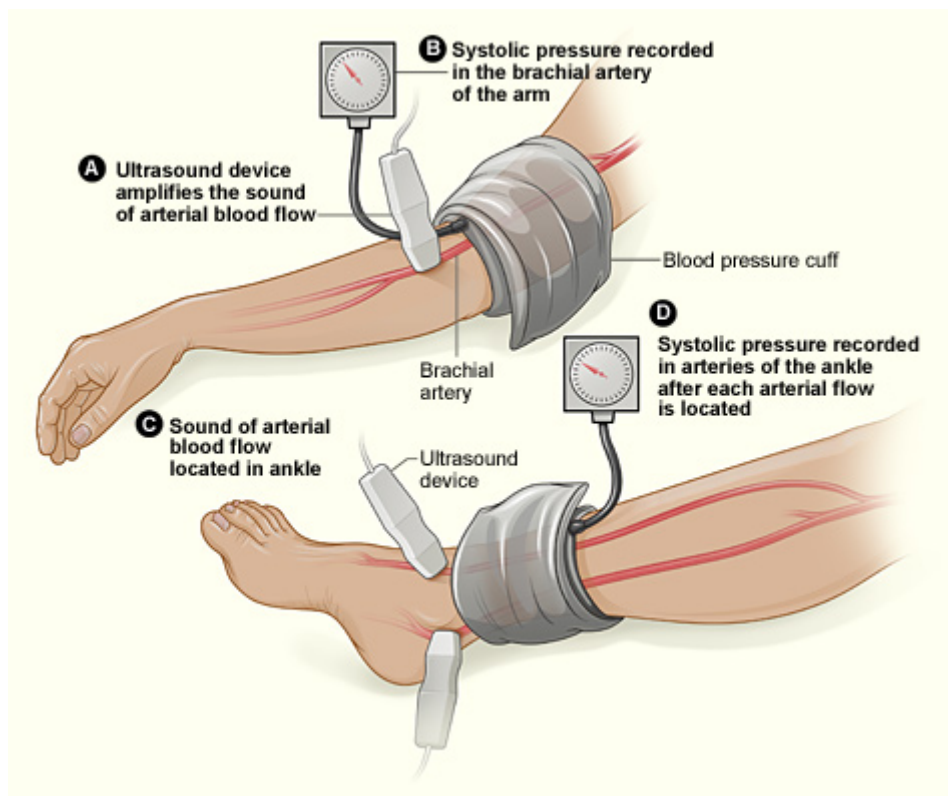


Image: "Measuring the ankle-brachial index" by National Heart Lung and Blood Institute (NIH). License: [Public Domain](#)

The ankle-brachial index (ABI) is a Doppler pressure measurement and is expressed via the ratio of the blood pressure at the ankle to the blood pressure in the upper arm.

Characterization	Value
Normal value	0.9 - 1.2
Mild PAD	0.75 - 0.9
Moderate PAD	0.5 - 0.75
Severe PAD	< 0.5

Note: Diabetic patients may be affected by Mönckeberg's atherosclerosis, where the arterial walls are hardened due to calcification of the tunica media. The rigid arterial walls can have a misleading effect on the ABI measurement, showing falsely high values > 1.3.

Imaging in PAD

In order to confirm the diagnosis of PAD and locate the stenosis, first-choice options include various non-invasive imaging methods.

- **Color-flow Doppler sonography:** Allows for reliable conclusions concerning the extent and location of the stenosis.
- **Digital subtraction angiography (DSA):** Constitutes the gold-standard test for the diagnosis.
- **Magnetic resonance angiography (MR-angiography):** It is the gold standard of interventions. It allows for the comprehensive depiction of the vascular system, helps in difficult differential diagnosing and is mandatory before performing any operative procedure.
- **CT-angiography with contrast material:** Comes into use when indicated, e.g., in case of an **aortic aneurysm**.

Differential Diagnoses of PAD

Conditions with clinical pictures similar to PAD

The differential diagnosis should primarily debate whether the patient's symptoms actually have an arterial cause, or there is an alternative causality for the symptoms arising with physical activity. Other possible causes for this clinical picture are, for instance:

- Arteriopathies
- Venous disorders
- Neuralgias
- Neurologic conditions
- Degenerative/inflammatory joint diseases

Therapy of PAD

Treatment of PAD pursues four chief aims, which provide the basis of every therapeutic measure taken:

1. Improvement of the affected leg's functionality, namely the ability to walk longer distances without pain, so that the patient's quality of life is significantly enhanced.
2. Impeding the progression of atherosclerosis.
3. Lowering the secondary risk of cardiac and cerebral events, such as a myocardial infarction or stroke.
4. The extremity should, under all possible circumstances, be preserved, and amputation should be avoided.

Therapeutic plans for PAD can be conservative, medicinal, interventional and operative. Important general measures include keeping the feet at a lower level than that of the heart, taking good and regular care of the feet and avoiding cold temperatures, infections, and trauma, especially in the last stages of the condition.

Next, one of the most important therapeutic measures is the treatment of the atherosclerosis risk factors. One of the first steps a physician has to take is to advise the patient to quit smoking. Then comes medical control of blood sugar levels, lowering LDL-cholesterol and restoration of normal blood pressure.

Stage	Treatment
Stage I	In asymptomatic patients, there is no indication for measures regarding circulation boost or invasive procedures. Recommended is a daily 1 - 2 hour gait training as well as a prophylactic scheme with platelet aggregation inhibitors due to increased cardiovascular risks (Acetylsalicylic acid—ASA 100 - 300 mg/day).
Stage II	The affected extremity is in no acute danger, but patient symptoms should be treated. Therapeutic measures include daily gait training and ASA (like stage I) as well as vasoactive substances like Cilostazol or Naftidrofuryl. Invasive procedures have a limited indication: they are only deployed after careful weighing of the risks versus the benefits and when the patient's quality of life is severely diminished.

Stage III/IV	<p>Patients are plagued by rest pain, which may also be accompanied by necroses. In these stages, revascularizing medication is the top option, in order to avoid the loss of an extremity. In these cases, patients strictly follow individualized therapy schemes, the adjustment of which requires the interdisciplinary cooperation of physicians from many different medical disciplines. As far as medication is concerned, vasoactive prostaglandin E1 can be introduced to the scheme or, under different circumstances, as an alternative when operative revascularization is not possible. Sufficient pain-relieving therapy involves Metamizole, Paracetamol, ASA or Clopidogrel as basic treatment, whereas in cases of severe pain, opioid medication is legally indicated. Invasive measures include, depending on the circumstances, PTA, bypass operation, thromboendarterectomy.</p>
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Invasive measures are indicated for stages III/IV, with an aim to avoid the amputation of an extremity: performing a **Percutaneous Transluminal Angioplasty (PTA)** with/without stent insertion, leads to the dilation of the affected vessel through a balloon catheter. Operative procedures include local **thromboendarterectomy**, during which the thrombus is extracted alongside a part of the vascular wall, as well as bypass implantation.

Here, an **autologous vein**, usually the **great saphenous vein**, is used as a substitute vessel. Operation and PTA are commonly used as a combined treatment, with an aim to the more considerate handling of the case. In general, the success rate rises with the increase in a vessel's size.

Note: A vital take-home message concerning PAD therapy is that 1) for stages I and II, an hour- to the two-hour-long daily gait training program is sufficient, and 2) in a bypass operation, the autologous vessel used is the **great saphenous vein**.

Complications of PAD

Possible dangers in PAD



Image: "Gangrene of the 1st to 4th toes of the right foot in person with diabetes." by James Heilman, MD. License: [CC BY-SA 3.0](#)

If left untreated, and in progressed stages, PAD can cause several complications due to hypoperfusion of the tissues. These include healing disorders, wound infections and even sepsis. Acute arterial occlusion of an extremity can lead to necrosis and amputation as a worst-case scenario. Furthermore, PAD patients run a higher risk of atherosclerotic secondary diseases, such as myocardial infarctions and strokes.

Review Questions

You can find the answers below the references.

1. An elderly patient with a diagnosed PAD can still walk distances of 100 - 200 m without painful symptoms. Which Fontaine (-Ratschow) stage does this clinical picture correspond to?

- A. Stage I
- B. Stage IIa
- C. Stage IIb
- D. Stage III
- E. Stage IV

2. What is true about an ankle-brachial index (ABI) of 0.5?

- A. It lies within the normal range.
- B. It indicates a mild PAD.
- C. It indicated a moderate PAD.
- D. It indicates a severe PAD.
- E. It is a calculation error. The examination should be repeated.

3. Which is the least probable risk factor for atherosclerotic vascular damage and therefore for PAD?

- A. Diabetes Mellitus
- B. Arterial Hypertension
- C. Hyperlipidemia
- D. Nicotine abuse
- E. Female gender

References

Bekwelem, W., & Hirsch, A. T. (2017). Epidemiology of Peripheral Artery Disease. *Peripheral Artery Disease*, 1-35. doi:10.1002/9781118775998.ch1

Films for the Humanities & Sciences (Firm), Films Media Group, KramesStayWell, & LLC. (2009). *Peripheral Arterial Disease*. New York, NY: Films Media Group.

Information Television Network. (2006). *PAD: Peripheral arterial disease*. Boca Raton, FL: Author.

Rosenberg, L. (2013). Peripheral Arterial Disease (PAD)/Vascular Disease. *Encyclopedia of Behavioral Medicine*, 1456-1457. doi:10.1007/978-1-4419-1005-9_1278

Correct answers: 1C, 2D, 3E

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