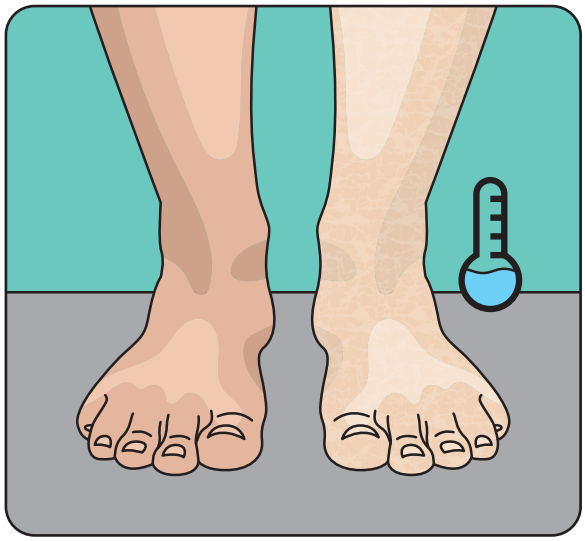
A STEP-BY-STEP GUIDE TO TESTING THE PERIPHERAL ARTERIAL DISEASE OF THE LOWER LIMB

For an overview of the main symptoms of peripheral arterial disease (PAD) to be evaluated during the subjective examination, we suggest readers to integrate this supplementary resource with the one proposed by Morley et al. (Morley et al., 2018) (https://www.bmj.com/content/bmj/suppl/2018/02/01/bmj.j5842.DC1/morr041877.wi.pdf)

SKIN OBSERVATION AND PALPATION

(Boyko et al., 1997; Conte and Vale, 2018; Gerhard-Herman et al., 2017; Khan et al., 2006)

With significantly diminished blood flow, the skin of the lower extremities can present different alterations and temperature changes. The skin may appear thinner, dry, shiny, and hairless in specific areas. Also, the skin may be cooler and presents blue color or pallor compared to the contralateral limb. Hypertrophic and ridged nails may be present. The examiner will start the evaluation by observing the skin and palpating it with the back of the hand to detect any difference in the temperature between sides. PAD can also produce focal areas of ischemia with full-thickness skin necrosis.



PULSE PALPATION

(Brearley et al., 1992; Deakin and Low, 2000; Hill and Smith, 1990; Hobson et al., 2003; Tibballs and Weeranatna, 2010)

Pulses are accurately measured when the examiner palpates deeply, placing the fingertips on the skin overlying the vessel and focusing on different aspects of the pulse:

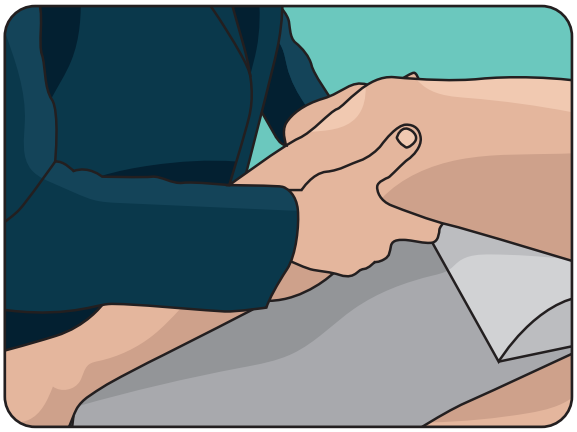
1. Initial screening about whether the pulse is bounding or weak, fast or slow, irregular or regular, and equal or unequal bilaterally.

2. Intensity, which is subjectively graded on a scale of 0 to 4, followed by convention by a “plus”. 0 refers to a nonpalpable pulse; 1+ is a barely detectable pulse; 2+ is slightly diminished; 3+ is a normal pulse (should be easily palpable); and 4+ is “bounding” (e.g., stronger than normal).

3. Rhythm, to be certain that the variation in rhythm is not due to minor fluctuations that occur with the respiratory cycle.

4. Rate, counting the total number of palpable beats that occur during a minimum of 15 seconds (multiplied by four to get the number of beats per minute); note, more extended periods probably increase the accuracy.

5. When relevant, the examiner can auscultate the heart while palpating a peripheral pulse to ascertain if every pulse gets transmitted as a palpable beat.



1 FEMORAL PULSES PALPATION

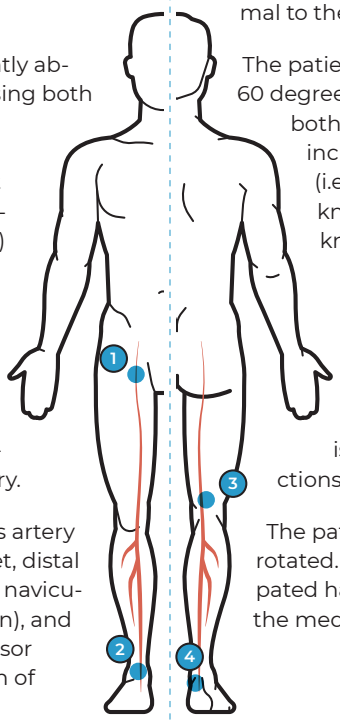
is used to evaluate the presence of restrictions proximal to the femoral artery.

The patient lies supine, with the hip slightly abducted. The femoral artery is palpated using both hands, one on top of the other, to deeply palpate the femoral pulse in the femoral triangle (i.e., below the inguinal ligament and about midway between the symphysis pubis and anterior superior iliac spine)

2 DORSALIS PEDIS PULSE PALPATION

is used to evaluate the presence of restrictions proximal to the dorsalis pedis artery.

The patient lies supine. The dorsalis pedis artery is palpated in the dorsal aspect of the feet, distal to the dorsal most prominent part of the navicular bone (a reliable landmark for palpation), and lateral to the tendon of the muscle extensor hallucis longus (or medially to the tendon of the muscle extensor digitorum longus).



3 POPLITEAL PULSES PALPATION

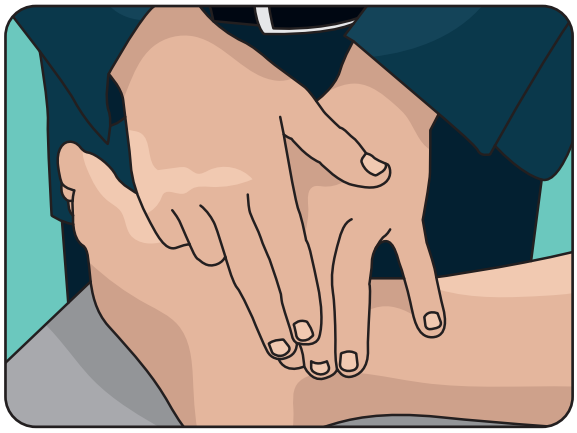
is used to evaluate the presence of restrictions proximal to the popliteal artery.

The patient lies supine, with the knee flexed at 60 degrees. The popliteal artery is palpated using both hands, pressing with the fingertip with increasing pressure in the popliteal fossa (i.e., middle portion of the back middle of knee), until pulsation in the back of the knee is felt.

4 POSTERIOR TIBIAL PULSES PALPATION

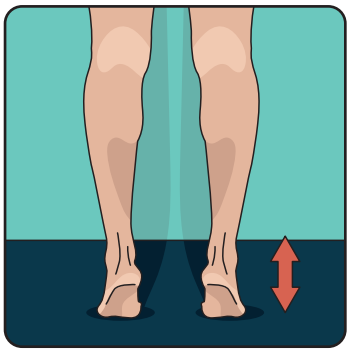
is used to evaluate the presence of restrictions proximal to the posterior tibial artery.

The patient lies supine, with the hip externally rotated. The posterior tibial artery is readily palpated halfway between the posterior border of the medial malleolus and the Achilles tendon.



INTERPRETATION

An altered rhythm, frequency, and/or quality, compared to the contralateral, are suggestive of a proximal vascular obstruction.



PLANTAR FLEXION TEST (PFT)

(Brindisino et al., 2021; McPhail et al., 2001; Yamamoto et al., 2007; McPhail et al., 2001)

The PFT is a non-invasive, safe, objective, and economic assessment for lower extremity arterial occlusion disease. It has been shown that this test stresses the calf muscles (i.e., the typical location of symptoms in most patients with PAD) similarly to the treadmill test but affecting less the whole cardiovascular system.

The patient is asked to perform 50 sequential, symptom-limited calf raises, lifting the heels maximally off the floor. Patients with PAD frequently report pain that does not allow them to continue after a low number of repetitions. Sensitivity and specificity have not been reported to date for this test.

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6 MINUTE WALKING TEST (6MWT)

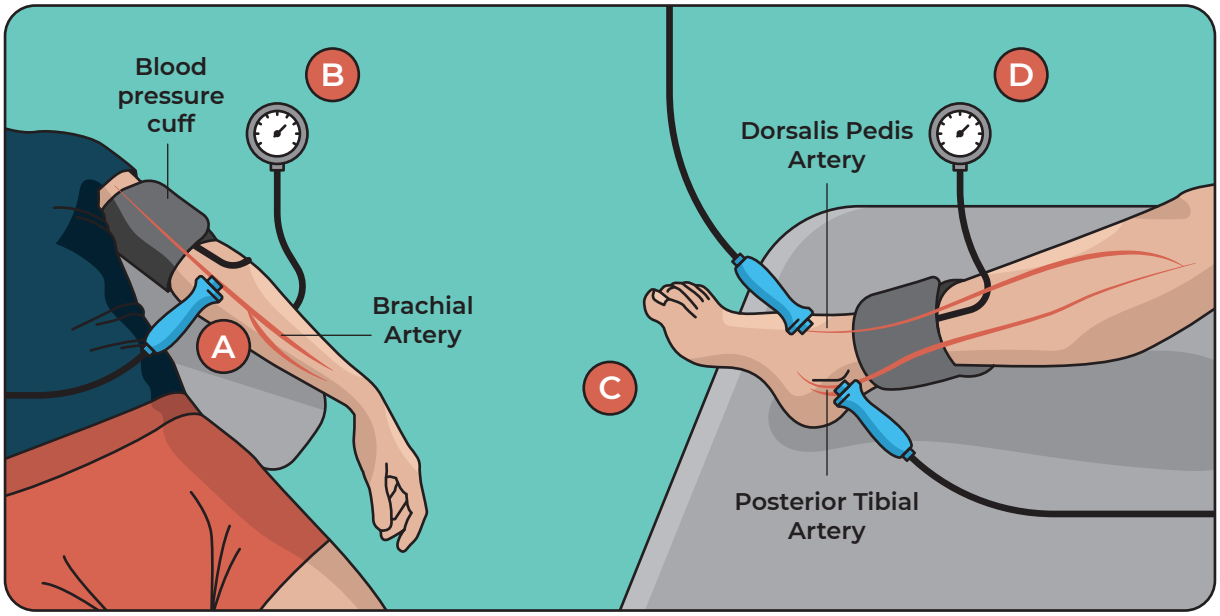
(Enright, 2003; Rasekaba et al., 2009)

The 6MWT can be used in patients with PAD for two purposes: as an outcome measure and as a test to reproduce patients' complaints (e.g., prior to the ABI). The 6MWT is performed in an indoor corridor with cones placed at the starting and end positions. Ideally, the corridor's length should be around 30 meters. The patient is asked to walk as far as possible for 6 minutes, using canes or other aids if necessary. When necessary, rest is allowed, but the patient is encouraged to resume walking as soon as possible.

The clinician's encouragement is a part of the test, with their frequencies depending on the protocol used. The clinician records the total distance traveled in the 6 minutes, comparing the results with well-known reference tables. It is also vital to report the pain's onset and after how much resting the pain disappear in patients with PAD.

ANKLE – BRACHIAL INDEX (ABI)

(Aboyans et al., 2012; Al-Qaisi et al., 2009; Feringa et al., 2006; Gerhard-Herman et al., 2017; McDermott et al., 2000; NICE, 2019; Rooke et al., 2011; Wild et al., 2006)



- A Ultrasound device amplifies the sound of arterial blood flow
- B Systolic pressure recorded in the brachial artery of the arm
- C Sound of arterial blood flow located in ankle
- D Systolic pressure sequentially recorded in the arteries of the ankle after each arterial flow is located

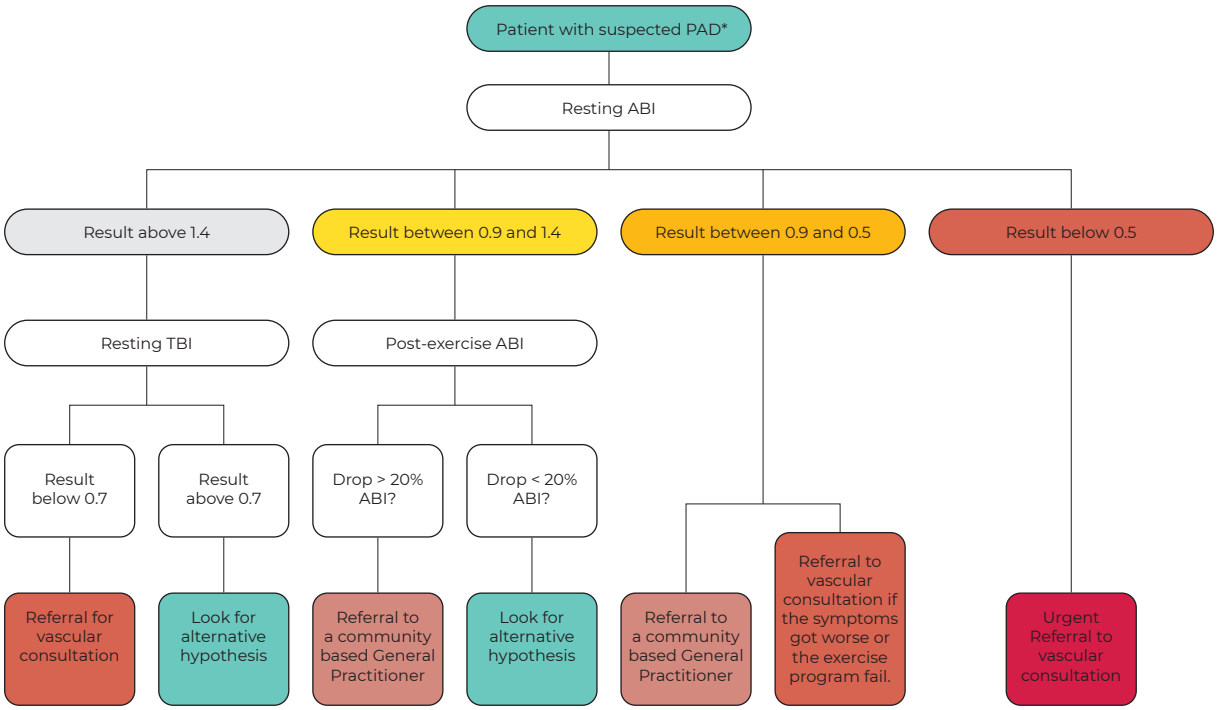
The ABI is the most used non-invasive test for assessing a peripheral vascular disease (PVD). The ABI assesses the severity of arterial insufficiency. The ABI showed high sensitivity and specificity (respectively, 90 and 98% compared to angiogram) for detecting hemodynamically severe stenosis >50% in major leg arteries. However, a recent systematic review observed that the sensitivity of ABI was classically overestimated, being found at 61%. The index is calculated as the ratio of the systolic blood pressure measured at the ankle divided to the systolic blood pressure measured at the arm. The traditional equipment to perform ABI measurement is a sphygmomanometer (blood pressure cuff) and a Doppler probe (Doppler ultrasound blood flow detector). The cuff is inflated proximal to the artery to be assessed until the pulse ceases at the doppler probe; then, the blood pressure cuff is slowly deflated. When the artery's pulse is re-detected through the Doppler probe, it indicates the systolic pressure of that artery.

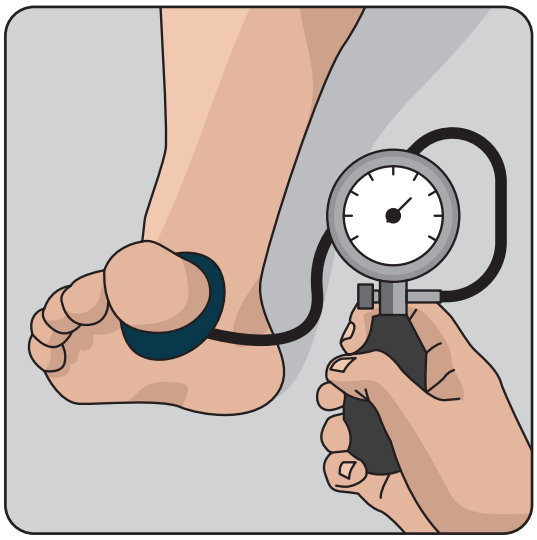
The blood pressure is measured at both the brachial and the ankle sites, while the person is at rest. As the resting ABI may fail in detecting peripheral arterial disease (PAD) or underestimate its severity, the test is repeated after 5 minutes of walking on a treadmill, or after performing standing heel rises. In fact, lower extremity exercises decrease the ABI, enhancing the test sensitivity. The patient lies supine, with upper and lower limbs at the heart level; notably, the seated position will overestimate the ratio by approximately 0.3. The higher systolic reading of the left and right arm brachial artery is generally used in the assessment. The pressures in each foot's posterior tibial artery and dorsalis pedis artery are measured with the higher of the two values used to calculate the ABI for that leg. In a normal subject, the pressure at the ankle is slightly higher than at the arm level. That is, the blood pressure at the arms is an indicator of the general blood pressure of the body. However, when blood flows distally through the arteries, the pressure changes according to the arteries' general health and condition.

The procedure to obtain the ABI is time-consuming and requires specific training. A possibility is to use an automated system that gives in output an immediate printout of the results within minutes. These systems generally comprise two chamber cuffs for each extremity. One chamber occludes the vessel while the second distal chamber senses the returning signals. These automatic systems require minimal training, the client does not need to rest before the measurement, and they provide rapid ABI measurements. However, their cost is considerable and then their use is referred to specialized departments. In the following table, we summarize the significant ABI values recommended by both the AHA/ACC and the NICE guideline for PAD management. The table was designed to provide a decision tool for primary care clinicians, detailing the risk profile (by different colours), the interpretation of the ABI, the related clinical presentation, and the following recommended actions.

ABI value	**Interpretation**	**Clinical presentation**	**Action**	**Follow-up**
>1.4	Abnormal (Vessel hardening/ calcification)	Diabetes or chronic kidney disease	Refer or measure toe pressure/ toe-brachial Index	For resting TBI interpretation see the flow chart
1.4 – 0.9	Normal range/ Acceptable		None/vigilance	Refer for a post-exercise ABI if the patient present exertional claudication (see the flow chart)
<0.90	Some arterial disease	Asymptomatic Claudication and	- Refer to a community based General Practitioner for further investigation and/or treatment of health conditions associated with PAD (i.e., hypertension, high cholesterol, risk of diabetes, etc.) - Exercise	Monitor
<0.90	Some/ moderate arterial disease	Intermittent Claudication and Absence/ reduced pulses	- Refer to a community based General Practitioner for further investigation and/or treatment of health conditions associated with PAD (i.e., hypertension, high cholesterol, risk of diabetes, etc.) - Exercise	Refer to vascular consultation if the symptoms got worse or the exercise program fail.
<0.50	Severe arterial disease	Rest pain, ulceration, wound	Refer to vascular consultation	
<0.50	50% of diabetic foot ulcer have PAD	Diabetic foot	Refer urgently to diabetic foot multidisciplinary team with vascular assessment	
<0.20	Limb ischemia	Tissue loss, gangrene	Refer urgently to vascular consultation	

If the ABI is below 0.9 is diagnostic for PAD. If the ABI is between 0.9 and 1.4 and the patient has exertional non-joint related leg symptoms, the literature suggests measuring post-exercise ABI. A decrease of the ABI by more than 20 percent between the normal resting ABI and the post-exercise ABI is considered indicative of PAD and suggests the need for onward referral. When the ABI is above 1.4, an additional toe-brachial index (TBI) is recommended because of the ABI's unreliability in patients with vascular stiffness. Notably, abnormal value of the ABI (>1.4) reflects the burden of atherosclerosis and may be an independent predictor of mortality. Thus, it has the potential for screening for coronary artery disease in high-risk patients. A score below 0.5 is suggestive of a severe arterial disease and then suggestive of critical limb ischemia. For a comprehensive overview of the ABI examination process refer to the following flow chart. We suggest readers to consult the table integrating the flowchart.





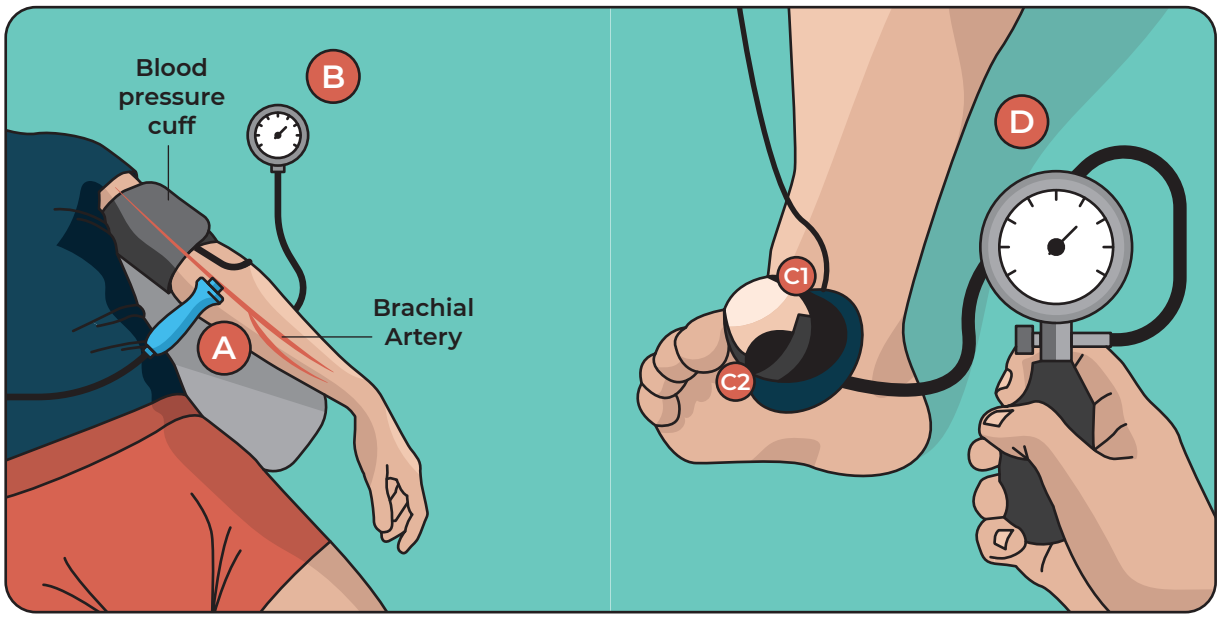
BLOOD PRESSURE IN TOE

(Kröger et al., 2003)

When ankle pressure is unreliable because of severe artery disease (e.g., diabetes or atherosclerosis), peripheral blood pressure may be measured with a specific pressure cuff in the toe. Toe pressure usually is lower than the arm one; however, a difference greater than 30 mmHg (50mmHg in diabetics) is associated with severe artery obstruction and risk of amputation.

TOE – BRACHIAL INDEX (TBI)

(Herraiz-Adillo et al., 2020; Park et al., 2012)



- A Ultrasound device amplifies the sound of arterial blood flow
- B Systolic pressure recorded in the brachial artery of the arm
- C1 Arterial blood flow visually detected by toe color change
- C2 Arterial blood flow detected using a plethysmography infrared light sensor
- D Systolic pressure sequentially recorded in the arteries of the toe

A TBI is a specific test and is performed when the ABI is unreliable or presents abnormal results (i.e., > 1.4) due to plaque and calcification of the leg arteries. Typically, TBI is measured using special equipment, such as a plethysmography infrared light sensor and a tiny blood pressure cuff placed around the toe. The TBI consists of the ratio between the toe systolic blood pressure divided by the systolic brachial pressure. A TBI below 0.7 is considered abnormal. Overall, ABI and TBI showed similar diagnostic performance. However, in those patients with an arterial stenosis greater than 50%, TBI has been shown to possess better overall diagnostic accuracy (16.4 vs 11.0 diagnostic odds ratio), and sensitivity (82% vs. 52%), but lower specificity (77% vs. 94%) when compared to ABI.

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