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Diagnostic modalities in peripheral artery disease

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Peripheral artery disease (PAD) affects approximately one in five persons older than 70 years of age and it is often present in patients with concomitant vascular disease in different body territories (e.g. coronary artery disease). Diagnosis at an early stage is important in order to achieve improvement in patient's symptoms and prognosis. Remarkable improvements in the field of noninvasive and invasive imaging techniques have led to an advanced level the management of patients with PAD. Throughout this review article, the clinically available diagnostic modalities in PAD are presented. Strong and weaker points are stressed out in a manner that elucidates that no perfect diagnostic method exists. Based on the patient's individual profile, as well as on certain aspects of the disease (e.g. morphology of carotid plaque lesions) the attending physician will ultimately decide which diagnostic path will lead to a prompt and correct diagnosis of PAD with the minimum amount of exams and risk for the patient.

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Ankle–brachial index (ABI)

The resting ABI is the most used test regarding screening for PAD and diagnosis of lower extremity artery disease (LEAD) (Table 1). The ABI is defined as the ratio of the systolic blood pressure measured over the ankle to the systolic blood pressure measured over the brachial artery (Figure 1) [1••,2]. Systolic blood pressure is measured after the patient has rested for 5–10 min in the supine position [3] using a manual sphygmomanometer and a handheld Doppler ultrasound probe [4], although specific techniques may vary. One ABI value corresponds to each leg. Different modes of ABI calculation have been used in the literature. Typically, the ABI of each leg is calculated by dividing the highest ankle SBP by the highest corresponding arm SBP although in some reports the lowest arterial pressure serves to determine the ABI. Alternatively, only the posterior tibialis or dorsalis pedis pressure is used, or the pressures of one leg are averaged. This variation in protocols of measurement may lead to differences in the ABI values obtained [5–7]. Overall, the ABI has good reproducibility (variance of about 0.10) [8].

ABI values of 1.00–1.40 are considered normal, while ABI values <0.90 indicate PAD, 0.91–0.99 are considered borderline, and greater than 1.40 indicate non-compressible arteries [1••]. An ABI <0.90 has 75% sensitivity and 86% specificity to diagnose LEAD [9]. Its sensitivity is poorer in patients with diabetes or end-stage CKD because of medial calcification [10]. Patients with borderline ABI (0.90–1.00) need further diagnostic tests. When LEAD is clinically suspected, a normal ABI (>0.90) does not definitely rule out the diagnosis of LEAD; further post-exercise ABI and/or DUS are necessary.

The prevalence of abnormal ABI in primary care varies depending on the population's age and cardiovascular risk profile. For example, prevalence of low ABI (≤0.9) is as low as 2% among adults younger than age 60 years, or populations without known CVD [11,12]. This prevalence increases dramatically, however, with older age and increased cardiovascular risk factors. The prevalence of a low ABI was 29% in a sample of 6979 people who were either 70 years or older without risk factors, or were 50–69 years but with a history of smoking or diabetes [13] (Figure 1).

In every-day clinical practice, ABI should be measured in patients with certain clinical findings for LEAD (lower extremities weak pulse and/or arterial bruit, claudication intermittens, lower extremity wounds with abnormal long-healing period). It is also recommended that ABI measurement should be considered in patients with coronary artery disease, heart failure, PAD other than LEAD and chronic kidney disease. Experts also suggest using the ABI index in asymptomatic but with an elevated risk for LEAD population (men and women >65 years, or <65 years but classified as high CV risk according to European Society of Cardiology risk SCORE, as well as in men and women >50 years with family history for LEAD).

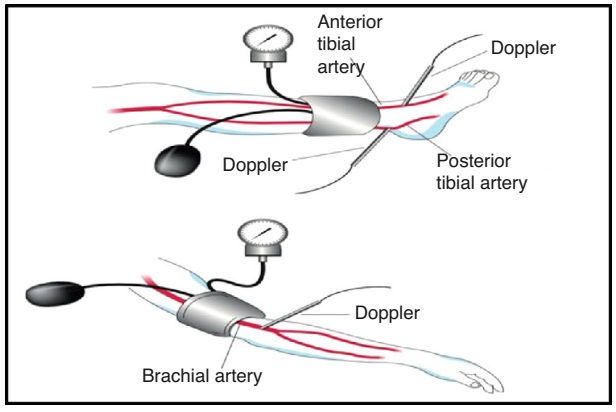
The ABI, except from being an ideal LEAD diagnostic tool, is also a risk predictor for cardiovascular disease.

Table 1

Recommendations for ankle–brachial index (ABI) measurement and duplex ultrasound (DUS) according to the 2017 European Society of Cardiology Guidelines on the Diagnosis and Treatment of Peripheral Arterial Diseases.

Recommendation	Class of recommendation	Level of evidence
Measurement of the ABI is indicated as a first-line non-invasive test for screening and diagnosis of LEAD.	I	C
DUS is indicated as a first-line imaging method to confirm LEAD lesions	I	C
DUS (as first-line imaging), is recommended for evaluating the extent and severity of extracranial carotid stenoses.	I	B
In patients with suspected chronic mesenteric ischaemia, DUS is recommended as the first-line examination.	I	C
DUS is recommended as first-line imaging modality to establish a diagnosis of renal artery disease.	I	C

Figure 1



How to measure the ABI? In supine position, with cuff placed just above the ankle, avoiding wounded zones. After a 5–10-min rest, the SBP is measured by a Doppler probe (5–10 MHz) on the posterior and the anterior tibial arteries of each foot and on the brachial artery of each arm. The ABI of each leg is calculated by dividing the highest ankle BP by the highest arm BP.
Source: (Adopted from 2017 ESC Guidelines on the Diagnosis and Treatment of Peripheral Arterial Diseases).

Data from the ABI Collaboration meta-analysis [14] showed that ABI had the potential to reclassify both men and women in a higher or lower level of cardiovascular risk group regarding their 10-year risk of total CAD events (CAD death, MI, and angina). This reclassification analysis included 13 population-based cohort studies ($n = 43\,919$) and demonstrated that 19% of men and 36% of women could be reclassified based on their ABI results when added to the FRS [14].

Duplex ultrasound (DUS)

Duplex ultrasound includes continuous, pulsed wave, colour and power Doppler modalities. It is mostly useful in detecting and localizing lesions in different (but not all) territories of the vascular bed, as well as quantifying their grade of severity with the application of velocity and pressure gradient criteria. It is very often the first-line test in the diagnostic algorithm both for screening and diagnosis of PAD (Table 1). DUS can also diagnose arterial disease at a very early stage (e.g. carotid plaque), an element critical for the assessment of the patient's total cardiovascular risk [15••].

Carotid artery disease

In patients presenting with symptoms that imply TIA/stroke, prompt imaging of the brain and supra-aortic vessels is crucial. DUS is the first-line carotid imaging modality when assessing extracranial internal carotid artery stenosis. Doppler velocity measurements and ratios provide evaluation of stenosis severity with a great level of accuracy. According to recent European Association of Cardiovascular Imaging (EACVI) recommendations [16] and 2017 ESC Guidelines on the Diagnosis and Treatment of Peripheral Arterial Diseases [1••], several different but complementary criteria should be used in order to achieve a reliable estimation of stenosis. Further, in