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Imaging Evaluation of Lower Extremity Infrainguinal Disease: Role of the Noninvasive Vascular Laboratory, Computed Tomography Angiography, and Magnetic Resonance Angiography

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Peripheral arterial disease (PAD) is a manifestation of systemic atherosclerosis that commonly affects the lower extremities. The diagnosis of PAD and the subsequent treatment decisions rely on clinical exam and non-invasive imaging. The imaging modalities that aid in both diagnosis and treatment are the non-invasive vascular laboratory, computed tomography angiography (CTA) and magnetic resonance angiography (MRA). Each modality has its own advantages and limitations. Non-invasive vascular laboratory testing can be used as a good screening tool for PAD and is often used in conjunction with an additional imaging modality if necessary. CTA and MRA have similar advantages when compared to the "gold standard" of digital subtraction angiography. CTA utilizes ionizing radiation, however is readily available and cheaper when compared to MRA. CTA is attractive due to its 3-D reconstruction and multiplanar ability, but CTA can be limited in the presence of calcification. MRA also is attractive for its 3-D multiplanar imaging. It is important for a clinician to be familiar with the principles and technical aspects of each modality as it relates to lower extremity infrainguinal disease.
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Peripheral arterial disease (PAD) is a manifestation of systemic atherosclerosis, usually in the arteries distal to the aortic arch. The arteries become narrow, which in turn may cause a cascade of symptoms usually starting with intermittent claudication. The diagnosis of PAD has increased with improved education and awareness in the medical community. Epidemiologic studies have estimated the prevalence of PAD in the population to be in the range of 3%-10%.[1] These numbers are likely to increase in the near future as PAD is still a grossly underdiagnosed condition.[2] Patients with PAD can be divided into 3 categories: patients with intermittent claudication, patients with acute limb ischemia, and patients with chronic critical limb ischemia. The treatment algorithms for each subcategory of PAD patients differ, as do the eventual patient outcomes. The first manifestation of PAD is usually intermittent claudication. In a minority of patients, the disease progresses to critical limb ischemia. The initial work-up of PAD patients can vary greatly from one provider to the next.

The noninvasive vascular laboratory can serve as a valuable initial screening gateway for PAD patients, especially in patients with a working diagnosis of intermittent claudication. The goals of noninvasive imaging are to help clinicians assess whether a patient has PAD to begin with. After PAD is confirmed, noninvasive imaging can help assess the location of the disease and confirm whether the disease is consistent with the patient's symptoms. Computed tomography angiography (CTA) is a modality that has seen increased utility in the work-up and treatment of PAD patients. CTA visualization and characterization of lower extremity occlusive lesions can aid in assessment of patients with PAD, especially if the noninvasive testing is equivocal. CTA can also aid in the preoperative planning of interventions, allowing for localization and assessment of severity for potentially correctable lesions. Contrast-enhanced magnetic resonance angiography (MRA) is a frequently used noninvasive modality. In many

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centers, MRA is the preferred imaging technique. MRA can noninvasively provide accurate 3-dimensional (3-D) assessment of the lower extremity arterial vasculature. MRA and CTA have similar high sensitivities when compared with digital subtraction angiography (DSA).[3] MRA has an advantage over CTA as it can provide this information without ionizing radiation or iodinated contrast agents. The noninvasive vascular laboratory, CTA, and MRA are all noninvasive modalities that are important links in the treatment chain for PAD.

Noninvasive Vascular Laboratory

The noninvasive vascular laboratory can be an important tool in the work-up of a patient with suspected PAD. It serves as an important adjunct to careful history-taking and physical examination. Patients tested include claudicants, patients with decreased pulses, and patients with poorly healing lower extremity wounds. Tests performed in the laboratory include ankle-brachial index (ABI) measurements, segmental limb pressure measurements, pulse volume recordings (PVR), and Doppler waveform evaluation. Noninvasive hemodynamic measurements can help in identifying the possible location of an occlusive lesion. It can also shed light on the severity of arterial occlusive disease. Peripheral intervention may be performed based on duplex findings, depending on the preference and confidence of the clinician. Tests in the noninvasive vascular laboratory can be performed serially to assess disease progression or to assess stability or progression after intervention.

Ankle Brachial Measurements

Ankle brachial measurement can be performed in almost any clinical setting. It is commonly performed as part of a noninvasive evaluation coupled with an additional physiologic evaluation. Technically, a sphygmomanometer cuff is inflated above the ankle and a Doppler device is used to measure the systolic pressure of the dorsalis pedis and posterior tibial arteries. The pressures are then divided by the highest brachial pressure of either arm to calculate the ABI. An abnormal ABI in a symptomatic patient implies the presence of a hemodynamically significant occlusive disease between the heart and the ankle. An ABI

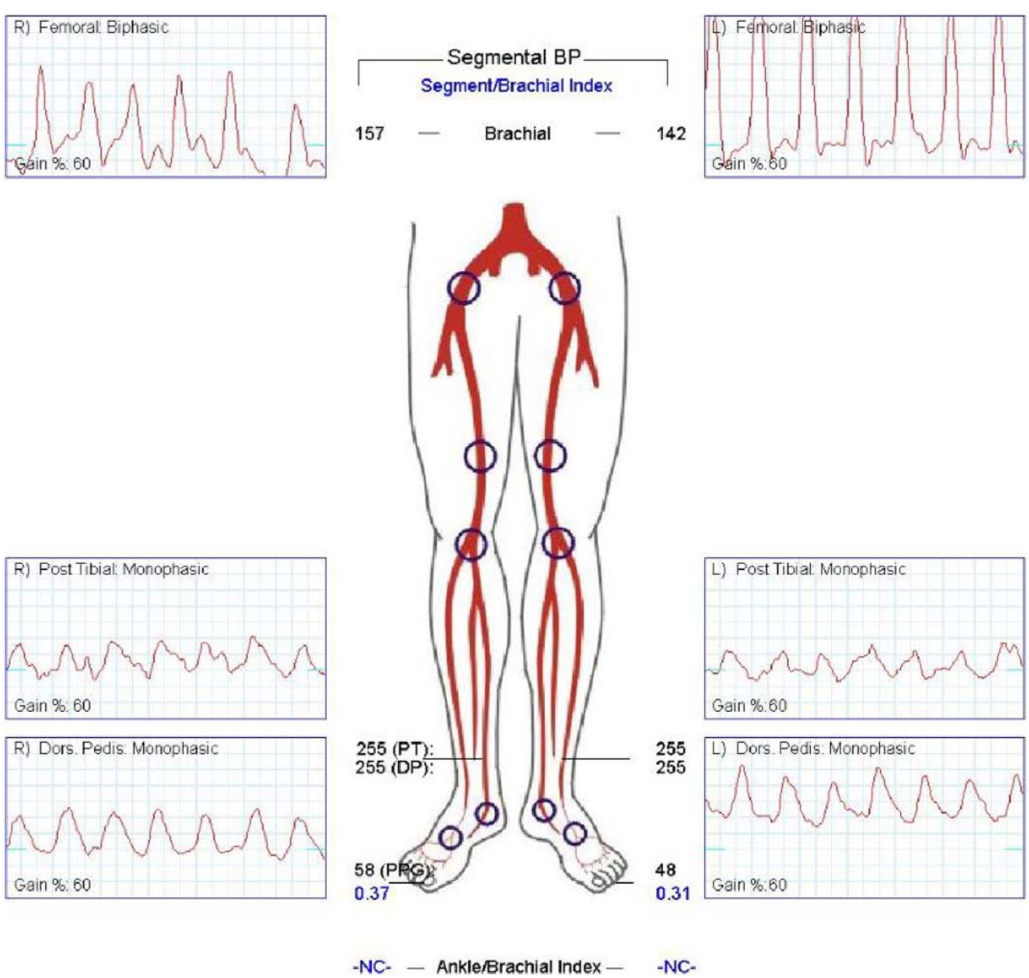

Figure 1 The noninvasive arterial examination demonstrated toe brachial indices (TBIs) of 0.31 and 0.37 and toe pressures of 58 and 48 mm Hg in the right and left foot, respectively. Ankle brachial indices (ABIs) were unattainable because of noncompressible vessels with ankle pressures of >255 mm Hg. Doppler waveform analysis showed bilaterally biphasic waveforms at the common femoral level with monophasic waveforms below the knee bilaterally. (Color version of figure is available online.)