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Ankle–Brachial Index for the Assessment of Peripheral Arterial Disease in the Emergency Department

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ABSTRACT
Peripheral arterial disease, both acute and chronic ischemia, is a clinical diagnosis encountered in the emergency department setting. The emergency nurse practitioner should be able to recognize the clinical presentation, understand the diagnostic tools available to make an appropriate clinical diagnosis, and know how to coordinate the appropriate treatment plan with a vascular surgeon. Timely and appropriate diagnosis of limb-threatening arterial disease is imperative to restore arterial perfusion and prevent the loss of the lower extremity. **Key words:** acute limb ischemia, ankle–brachial index, chronic limb ischemia, peripheral arterial disease

PERIPHERAL ARTERIAL DISEASE (PAD) is the term used to describe disease of the aorta and arteries supplying lower extremities that can progress to stenosis or occlusion of the affected vascular beds resulting in ischemia (Gerhard-Herman et al., 2017). The presentation of PAD can occur as an acute or chronic event. Acute limb ischemia (ALI) is considered a time-sensitive medical emergency with significant associated morbidity and mortality. Acute limb ischemia diagnosis is essentially a clinical diagnosis; however, an ankle–brachial index (ABI) is a diagnostic tool that can augment the physical findings. The ability of an emergency nurse practitioner (ENP) to rapidly diagnose ALI is imperative to ensure that the patient receives timely treatment needed to restore perfusion and prevent the loss of the lower extremity.

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PREVALENCE OF PAD

Peripheral arterial disease is estimated to affect approximately 8.5 million Americans older than 40 years (Gerhard-Herman et al., 2017), with the estimated incidence of ALI to be 1.5 cases per 10,000 persons per year (Creager, Kaufman, & Conte, 2012). It is associated with significant morbidity and mortality due to ischemic events

involving cerebral, coronary, or peripheral arterial circulation and the potential for limb loss (Norgren et al., 2007). It is also a marker of system atherosclerosis, such as coronary artery disease or cerebrovascular disease (Lewis & Rossi, 2014). Peripheral arterial disease affects men slightly more than women and disproportionally affects African Americans (Hirsh et al., 2007; Selvin & Erlinger, 2004).

A national cross-sectional survey, PAD Awareness, Risk and Treatment: New Resources Survival (PARTNERS), reported that PAD affects 29% of adults who are 70 years of age and older, those 50–69 years of age with a least a 10 pack-per-year history of smoking, or those 50–69 years of age with a history of diabetes. Furthermore, the study found that more than 70% of primary care physicians were unaware that the patient had the diagnosis in patients screened for PAD. Despite the incidence of PAD, the disease is widely underdiagnosed because patients often present with atypical symptoms or no symptoms of leg pain at all (Hirsh et al., 2001). Recognizing that patients are undiagnosed despite a high prevalence of PAD and varying clinical presentations, the ENP must understand these factors and the diagnostic tools available.

CLINICAL PRESENTATION OF PAD

The presentation of PAD can occur as an acute or chronic event. Acute arterial occlusion or ALI is a sudden interruption of arterial perfusion that threatens limb viability and is considered a medical emergency. Acute limb ischemia may be the first manifestation of arterial disease in an otherwise asymptomatic patient or may occur as an acute event in a patient with known PAD that causes symptomatic deterioration (Creager et al., 2012; Norgren et al., 2007).

The onset of symptoms for ALI ranges from a few hours to days but not longer than 14 days (Creager et al., 2012). The classic symptoms of ALI are the six Ps, including pain, pallor, pulselessness, poikilothermia (coolness of the extremity), paresthesia, and paralysis (Lewis & Rossi, 2014). The patient's severity of symptoms and timing of the presentation to the emergency department are important factors in determining the appropriate plan of care (Creager et al., 2012). The ENP must discuss the duration and intensity of the pain and change in severity over time (Santistevan, 2017). The duration and intensity of the pain and the presence of motor or sensory changes are essential determinants in the urgency for surgical revascularization (Creager et al., 2012). Therefore, the prognosis and outcome for a patient with ALI greatly depend on the ENP rapidly diagnosing the patient and initiating the appropriate treatment in consultation with a vascular surgeon (Norgren et al., 2007).

Chronic limb ischemia can present on a spectrum from intermittent claudication to limb-threatening ischemia. Intermittent claudication is the most common manifestation, defined as consistent and reproducible calf muscle pain casing exercise-induced ischemia (Shishebor et al., 2016). Symptoms of claudication should subside when the exercise is ceased (Lewis & Rossi, 2014). The diagnosis of intermittent claudication is subjective. Generally, these symptoms occur in a muscle Group 1 level beyond the level of the disease (Meru, Mittra, Thyagarajan, & Chugh, 2006). For example, solitary calf claudication indicates superficial femoral artery disease, manifesting as a reduced popliteal pulse. In contrast, pain in the buttocks or thighs indicates aortoiliac disease, resulting in a weak femoral pulse (Norgren et al., 2007).

Limb-threatening ischemia can present in various ways and has a high potential risk factor for major amputation (Norgren et al., 2007). Usually, the first symptom of severe limb ischemia is rest pain. Rest pain is described as sharp, localized pain in the forefoot below the ankle and the foot and is commonly associated with dependent rubor and elevation pallor (Gerhard-Herman et al., 2017). The patient often explains that this pain occurs at night and is relieved by dangling his or her foot from the bed

(Gerhard-Herman et al., 2017). Nearly 95% of patients with ischemic rest pain will lose their limb within a year unless they undergo surgical revascularization (Norgren et al., 2007). Rest pain is associated with a minimum of two hemodynamically significant arterial occlusive lesions (Gerhard-Herman et al., 2017).

Limb-threatening ischemia may not be associated with symptoms of pain but may present with tissue loss. Nonhealing ulcers of the distal foot can result from ischemia. The typical sign of ischemia in the soft tissue is gangrene. Without infection, gangrene looks like mummified tissue, whereas wet gangrene is moist with a foul odor and has a combination of necrotic tissue and infection. Once a patient has progressed to gangrene, the possibility of limb loss rises significantly. In 1 year, 25% of patients will die, 30% will have undergone amputation, and only 45% will remain alive with both limbs (Gerhard-Herman et al., 2017).

PHYSICAL EXAMINATION

Given the varied symptoms associated with PAD from acute to chronic presentations, the diagnosis is based on both subjective and objective findings in the history and physical examination (Christensen & Lewis, 2014). The ENP should ask the patient the following questions related to his or her clinical history:

- Review the classic 6 Ps of ALI and onset of the symptoms.
- Determine whether the patient has longstanding symptoms of claudication or rest pain.
- Previous history of PAD requiring surgical intervention or history of arterial thrombosis.
- Past history of cardiac disease including dysrhythmias or myocardial infarction (Christensen & Lewis, 2014; Creager et al., 2012).

Regardless of the patient's clinical presentation, the physical examination includes the entire arterial system to discover the underlying atherosclerotic disease. The physical examination should include the following:

- Measurement of bilateral upper extremity blood pressures
- Neck auscultation for carotid bruits
- Cardiac auscultation for murmurs or gallops
- Abdominal palpation to assess for pulsatile masses
- Abdominal auscultation for bruits
- Palpation of all lower extremity pules (femoral, popliteal, dorsalis pedis [DP], and posterior tibial [PT])
- Inspection of the lower extremities and feet to assess for ulcers, gangrene, or evidence of previous amputations
- Palpation of the lower extremities and the feet to assess skin temperature or tenderness (Christensen & Lewis, 2014).

INDICATIONS FOR ABI

When assessing patients who have identified risk factors of atherosclerotic disease or clinical presentation of acute or chronic symptoms of PAD, an ABI is a safe, effective, and reliable method for screening and diagnosing PAD (Gerhard-Herman et al., 2017). There are four segments that are evaluated for the level of stenosis with an arterial Doppler with an ABI: aortoiliac, iliofemoral, femoral–popliteal, and distal circulation (Lewis & Rossi, 2014). In addition, an ABI is helpful to determine the prognosis of patients with acute disease, diffuse chronic disease, and for the evaluation of surgical revascularization procedures effectiveness such as angioplasty, stenting, or lower extremity bypass surgery.

Obtaining an ABI is simple (Gerhard-Herman et al., 2017) and is easily performed by various clinicians, including a vascular sonographer, nurse, physician, or nurse practitioner at the bedside in the emergency department, without the need for a formal arterial Doppler study. As previously discussed in specific clinical situations, time is of the essence to ensure a rapid clinical diagnosis of ALI and prevent limb loss. The ability of an

ENP to effectively perform an ABI is beneficial in underresourced emergency departments where a vascular technologist is not in-house to conduct the study.

CONTRAINDICATIONS FOR ABI

The contraindications of performing an ABI include the presence of a deep venous thrombosis, which can lead to thrombus dislodgement, and the patient who presents with severe leg or foot pain (Christensen & Lewis, 2014). A venous duplex is an appropriate study to obtain if the patient has a suspected venous thrombosis before proceeding with an ABI (Gerhard-Herman et al., 2017).

PREPARATION

To perform a bedside ABI, the ENP will need a few pieces of equipment, including a 5–10-MHz continuous wave Doppler, a sphygmomanometer with appropriate blood pressure cuffs for arms and ankles, and ultrasonic gel (see Figures 1–3). A handheld Doppler probe is usually adequate to obtain a bedside ABI. The right size of the blood pressure cuff is required to avoid inaccurate measurements. The width of the cuff should

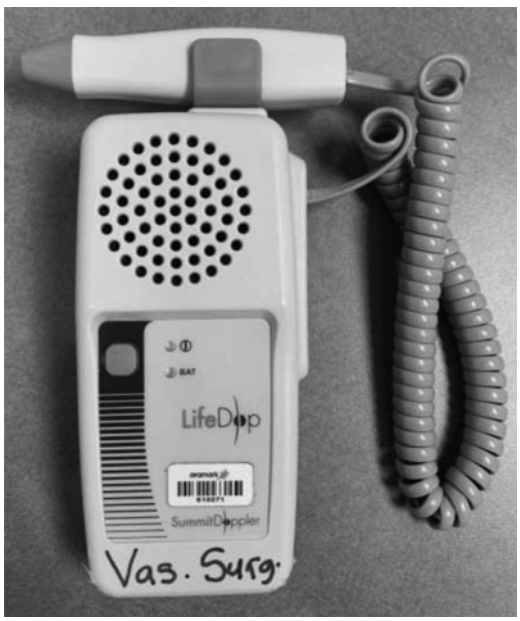

Figure 1. Five- to 10-MHz continuous wave Doppler.

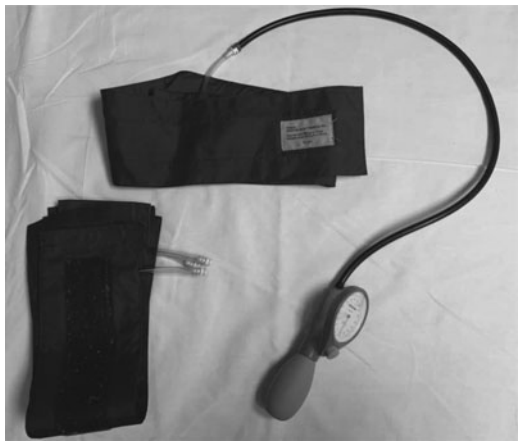

Figure 2. Sphygmomanometer with appropriate blood pressure cuffs for the arms and ankles.

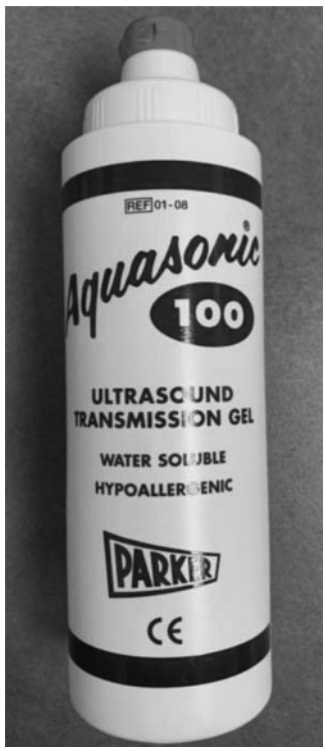

Figure 3. Ultrasonic gel.

Figure 4. Patient positioning for the procedure.

be at least 40% of the limb's circumference (Manning, Kuchirka, & Kaminski, 1983).

PROCEDURE

First, the patient should be placed in a supine position and in a warm environment to ensure the patient's comfort and accuracy of the procedure (see Figure 4). The ENP applies the blood pressure cuff to the patient's right or left arm and palpates the brachial pulse of the same arm. The ENP applies ultrasonic gel to the site of the palpated brachial pulse, and the Doppler probe is used at a 60° angle to obtain a Doppler signal (see Figure 5). The ENP may have to change the angle of the Doppler probe or position to obtain an appropriate signal. The blood pressure cuff is inflated 20–30 mmHg above the point of cessation of the brachial artery signal. Then, the blood pressure cuff is slowly deflated until the signal returns, which indicates the systolic pressure. The ENP records the systolic pressure measurement, wipes the gel from the patient's skin upon completion, and repeats the procedure on the contralateral arm (Lewis & Rossi, 2014).

Upon measuring the systolic blood pressures in both arms, the ENP places the blood pressure cuff above the ankle on the right or

Figure 5. Blood pressure cuff placement with Doppler signal for brachial artery.

left leg. The DP artery, lateral to the extensor hallucis longus tendon, is palpated. The ENP applies ultrasonic gel to the site of the palpated brachial pulse, and the Doppler probe is used at a 60° angle to obtain a Doppler signal. Again, the blood pressure cuff is inflated 20–30 mmHg above the point of cessation of the DP signal and then slowly deflated until the signal returns; this indicates the systolic pressure (see Figure 6). The ENP repeats the steps for the PT artery and records both measurements (see Figure 7). The same procedure should be conducted for the contralateral leg to obtain systolic pressures for the DP and PT arteries. Finally, the ENP wipes the gel from the patient's skin on both legs (Lewis & Rossi, 2014).

To calculate the ABI, the ENP divides each ankle systolic pressure (DP and PT) by the higher of the two brachial pressures (Christensen & Lewis, 2014). The higher brachial systolic pressure is chosen for the calculation because the arm vessels may

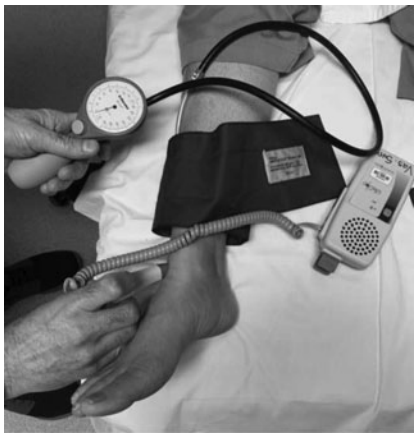

Figure 6. Blood pressure cuff placement with Doppler signal for dorsalis pedis artery.

also be affected by arterial occlusive disease (Christensen & Lewis, 2014; see Figure 8). The higher of the two ABI calculations is the one that is used for clinical diagnoses (Christensen & Lewis, 2014).

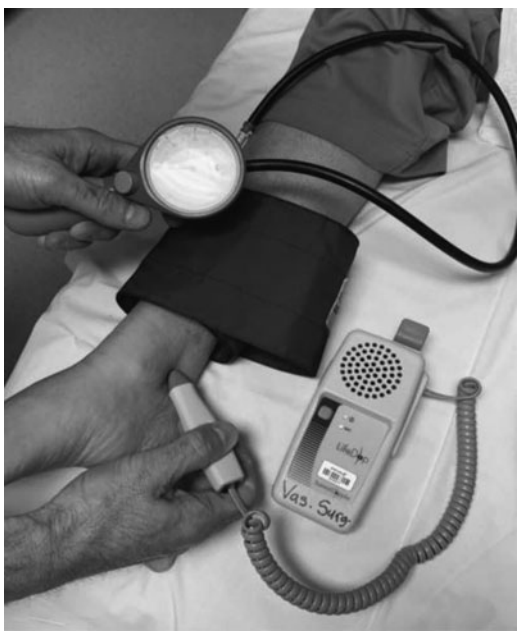

Figure 7. Blood pressure cuff placement with Doppler signal for posterior tibial artery.

$$\text{Ankle-Brachial Index (ABI)} = \frac{\text{Lower extremity systolic pressure}}{\text{Highest brachial artery systolic pressure}}$$

Figure 8. Formula for ankle–brachial index calculation.

INTERPRETATION OF ABI

When a patient is at rest, a normal ABI ranges from 0.9 to 1.2. An ABI of less than 0.9 serves as a marker for systemic atherosclerosis. An ABI between 0.4 and 0.9 is a definite sign of PAD and chronic claudication. An ABI less than 0.4 is indicative of limb-threatening ischemia (Christensen & Lewis, 2014). Ankle–brachial index values greater than 1.2 are considered falsely elevated in patients with diabetes mellitus and renal failure due to medial calcinosis and poor compressibility of the tibial vessels (Gerhard-Herman et al., 2017). Patients with falsely elevated ABI values should be referred for a formal arterial Doppler with toe pressure measurements to quantify their distal perfusion (Gerhard-Herman et al., 2017; Lewis & Rossi, 2014).

CONCLUSION

The ability of an ENP to understand the clinical presentation of both ALI and chronic ischemia will provide the patient with the best possible outcomes related to mortality and morbidity and possibility reduce the incidence of limb loss (Santistevan, 2017). The measurement of an ABI provides the ENP with an objective, noninvasive diagnostic tool for diagnosing PAD (Gerhard-Herman et al., 2017). The ability of the ENP to perform an ABI is a valuable skill, minimizing the need for a vascular sonographer.

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