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## **Ankle Brachial Index: Quick Reference Guide for Clinicians**

### **Purpose:**

This document was originally developed by the WOCN® Society's Clinical Practice Wound Subcommittee as a best practice document for clinicians (WOCN®, 2005). Its purpose is to provide clinicians with relevant information about the ankle brachial index (ABI) and a research-based protocol to use in performing the ABI to insure reliability and validity of the results.

### **Originated By:**

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### **Background:**

#### **Introduction to Problems/Needs**

Lower extremity arterial disease (LEAD) is a chronic, progressive disease. Risk factors for LEAD are advanced age, tobacco use, diabetes, dyslipidemia, hypertension, hyperhomocysteinemia, chronic renal insufficiency, family history of cardiovascular disease and African American ethnicity (WOCN®, 2008). Current data about prevalence and incidence of LEAD in the U.S. are limited. According to a hallmark U.S. study (N = 6979), 29% of individuals aged 70 years or older and 29% of individuals aged 50 through 69 years (that have a history of tobacco use or diabetes), had LEAD based on an ABI of less than 0.9 (Hirsch et al., 2001). More recently, investigators in a population-based study in Sweden (N = 5080), reported the prevalence of LEAD was 18% (Sigvant et al., 2007).

Approximately half of individuals with LEAD are undiagnosed because they are asymptomatic or have atypical symptoms and health care providers use unreliable methods to assess for LEAD such as pulse palpation or a history of claudication (Beckman, Jaff, & Creager, 2006; Bonham, Kelechi, Mueller, & Robison, 2010; Mourad et al., 2009; WOCN®, 2008). It is recommended that health care providers use valid and reliable, non-invasive tests such as the

ABI to detect LEAD (Bonham, Cappuccio, Hulsey, Michel, Kelechi, Jenkins, & Robison, 2007; Hirsch et al., 2006; Hopf et al., 2006; WOCN<sup>®</sup>, 2008).

## **Definition of ABI**

ABI is a noninvasive vascular screening test to identify large vessel, peripheral arterial disease by comparing systolic blood pressures in the ankle to the higher of the brachial systolic blood pressures, which is the best estimate of central systolic blood pressure (Bonham, 2006; Bonham et al., 2007; Criqui et al., 1989; Rumwell & McPharlin, 2009). ABI is performed using a continuous wave Doppler, a sphygmomanometer and pressure cuffs to measure brachial and ankle systolic pressures (Grenon, Gagnon, & Hslang, 2009; Rumwell & McPharlin, 2009). The use of pulse palpation or automated blood pressure devices to measure blood pressures for the ABI are not considered reliable (Aboyans et al., 2008; Ena, Lozano, Verdu, Argente, & Gonzalez, 2011).

The ABI has high sensitivity and specificity and its accuracy to establish the diagnosis of LEAD has been well established (Grenon et al., 2009; Hirsch et al., 2006). ABI is a ratio derived from dividing the higher of the ankle pressures (i.e., dorsalis pedis and posterior tibial) for each leg by the higher of the right and left arm's brachial systolic pressures (Bonham et al., 2010). If blood flow is normal in the lower extremities, the pressure at the ankle should equal or be slightly higher than that in the arm with an ABI of 1.0 or more.

An ABI less than 0.9 indicates LEAD (Bonham, 2006; Bonham et al., 2007, 2010; Hirsch et al., 2006; WOCN<sup>®</sup>, 2008). If performed by an educated professional, using proper equipment and following a research-based procedure, the ABI obtained using a pocket Doppler is interchangeable with vascular laboratory tests to detect LEAD (Bonham et al., 2007; Saskia et al., 2008).

## **Purpose of ABI**

The purpose of the ABI is to support the diagnosis of vascular disease by providing an objective indicator of arterial perfusion to a lower extremity.

## **Limitations of ABI**

- The ABI is an indirect examination that infers the anatomical location of an occlusion or stenosis. The exact location of the stenosis or occlusion cannot be determined by ABI alone (Bonham et al., 2007).
- The ABI might be elevated (> 1.3) due to calcification of medial arteries at the ankle in patients with diabetes, renal failure and rheumatoid arthritis; and in such cases, other vascular tests should be performed (Brooks et al., 2001; del Rincon et al., 2005; O'Hare, Glidden, Fox, & Hsu, 2004; Silvestro, 2006).
  - Investigators in a study of 1,762 individuals, referred for a vascular evaluation, reported that the ABI was elevated in 8.4% and the prevalence of LEAD in those individuals was 62.2% (Suominen, Rantanen, Venermo, Saarinen, & Salenius, 2008).

- Some individuals with arterial stenosis can experience claudication symptoms with activity and normal ankle pressures at rest, warranting referral for further vascular evaluation and testing (Stein et al., 2006).

### **Indications for ABI**

- Rule out LEAD in any patient with a lower extremity wound (WOCN<sup>®</sup>, 2008).
- Establish diagnosis of arterial disease in patients with suspected LEAD (Hirsch et al., 2006):
  - Intermittent claudication.
  - Over 70 years of age.
  - Over 50 years of age with a history of tobacco use or diabetes.
- Determine adequate arterial blood flow in lower extremities prior to compression therapy, or wound debridement:
  - If the ABI is less than 0.8, sustained, high compression (i.e., 30-40 mmHg at the ankle) is not recommended (WOCN<sup>®</sup>, 2008).
  - In mixed venous/arterial disease (i.e., ABI is > 0.5 to < 0.8), reduced compression levels (i.e., 23-30 mmHg) are advised (WOCN<sup>®</sup>, 2008, 2011). If the ABI is less than 0.5, compression should be avoided and the patient referred to a vascular surgeon for surgical evaluation and/or further testing (WOCN<sup>®</sup>, 2008).
- Assess wound healing potential.

### **Contraindications for ABI (Grenon et al., 2009)**

- Excruciating pain in lower legs/feet.
- Deep vein thrombosis, which could lead to dislodgement of the thrombosis, where referral would be indicated for a duplex ultrasound test.
- Severe pain associated with lower extremity wound(s).

### **Guideline for Performing ABI**

Before performing ABI, it is important to obtain a thorough history and physical. The following table addresses relevant factors in assessment and performing the ABI: history/physical findings, considerations, and decision to proceed with ABI.

**Table: Relevant Factors in Assessment and Performing the ABI**

History/Physical Findings	Considerations	Decision to Proceed with ABI
<ul style="list-style-type: none"> <li>• Diabetes, renal failure, or rheumatoid arthritis.               <ul style="list-style-type: none"> <li>○ Diabetes increases risk of lower extremity arterial disease two to four fold (Hirsch et al., 2006).</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• The ABI might be elevated (&gt; 1.3) due to calcification of the medial arteries at the ankle resulting in stiffness and non-compressible arteries, which can occur in some persons with diabetes, renal failure, or arthritis (Brooks et al., 2001; del Rincon et al., 2005; Faglia et al., 2005; O’Hare, Glidden, Fox, &amp; Hsu, 2004; Silvestro, 2006).</li> </ul>	<ul style="list-style-type: none"> <li>• Toe pressures/toe brachial index are recommended if the ABI is &gt; 1.3 because the digital arteries are generally less affected by calcification than the ankle arteries (Bonham, 2006; Brooks et al., 2001; Carter &amp; Tate, 2001; Hirsch et al., 2006; WOCN<sup>®</sup>, 2008).               <ul style="list-style-type: none"> <li>○ An absolute toe pressure &lt; 30 mmHg (or &lt; 50 mmHg for persons with diabetes) indicates critical limb ischemia and predicts failure of wounds to heal (Carter &amp; Tate, 2001; deGraaff, Ubbink, Legemate, Jijssen, &amp; Jacobs, 2003; Hirsch et al., 2006; Norgren et al., 2007; WOCN<sup>®</sup>, 2008; Wutschert &amp; Bounameaux, 1998).</li> <li>○ A toe brachial index (TBI) compares the toe pressure to the arm pressure and is derived by dividing the toe systolic pressure by the higher of the right and left arm’s systolic pressures (Bonham, 2006).</li> <li>○ TBI &lt; 0.64 indicates LEAD (Bonham, 2006; WOCN<sup>®</sup>, 2008; WOCN<sup>®</sup>, 2009).</li> <li>○ Continuous wave Dopplers are not reliable to measure toe pressures due to the small size of digital arteries and vasospasms if toes are cold (Bonham, et al., 2007; WOCN<sup>®</sup> 2009).</li> <li>○ Toe pressures are commonly measured in the vascular laboratory by vascular technicians using standard laboratory photoplethysmography (PPG) equipment.</li> <li>○ Toe pressures can be measured by clinicians using a portable PPG if the clinician is educated/skilled in the use of the equipment</li> </ul> </li> </ul>

History/Physical Findings	Considerations	Decision to Proceed with ABI
<ul style="list-style-type: none"> <li>• Pain (WOCN®, 2008).               <ul style="list-style-type: none"> <li>○ Intermittent claudication (i.e., pain that occurs with activity and is relieved only by a period of rest).</li> <li>○ Nocturnal leg pain (i.e., pain that occurs when in bed).</li> <li>○ Resting leg pain (i.e., pain that occurs in the absence of activity and with the legs in the dependent position).</li> <li>○ Painful ulcer.</li> <li>○ Any painful condition, such as arthritis.</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• Pain may make obtaining blood pressures at the ankle impossible if the patient cannot tolerate the procedure. To rate pain levels use a validated pain scale (e.g., Wong-Baker Faces Pain Rating Scale or 0-10 Numeric Pain Intensity Scale; Krasner, 2011).               <ul style="list-style-type: none"> <li>○ Ask patient what alleviates or exacerbates pain.</li> <li>○ Patient might need to be pre-medicated prior to the ABI.</li> </ul> </li> </ul>	<p>and it is available (Bonham, Kelechi, Mueller, &amp; Robison, 2010).</p> <ul style="list-style-type: none"> <li>• Proceed with the ABI only if the patient is able to tolerate the procedure.               <ul style="list-style-type: none"> <li>○ Continuously monitor the pain level by encouraging the patient to notify the clinician if they are unable to tolerate the procedure.</li> <li>○ Refer to health care provider for further evaluation or alternative diagnostic testing if unable to perform ABI due to pain.</li> </ul> </li> </ul>
<ul style="list-style-type: none"> <li>• Acute deep vein thrombosis.               <ul style="list-style-type: none"> <li>○ Swelling, pain, and redness of the extremity; superficial vein dilation, Homan’s sign (i.e., pain in calf or behind knee on dorsiflexion; Kline, 2011).</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• Applying compression with the blood pressure cuff may dislodge clot (Grenon et al, 2009).</li> </ul>	<ul style="list-style-type: none"> <li>• Do not proceed with ABI</li> <li>• Refer to health care provider for further evaluation of acute DVT.</li> </ul>
<ul style="list-style-type: none"> <li>• Cellulitis: A diffuse spreading infection of the dermis and subcutaneous tissue (Berger, 2011).               <ul style="list-style-type: none"> <li>○ Swelling, erythema, pain, chills, fever, and malaise.</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• Might not be able to obtain ankle pressure because of patient discomfort and/or edema.</li> </ul>	<ul style="list-style-type: none"> <li>• Proceed with ABI, but continuously monitor discomfort level by encouraging the patient to notify the clinician if unable to tolerate the procedure.               <ul style="list-style-type: none"> <li>○ Refer to health care provider for further evaluation if unable to perform ABI due to discomfort and/or edema.</li> </ul> </li> </ul>
<ul style="list-style-type: none"> <li>• Lower extremity edema, lymphedema, and/or obesity.</li> </ul>	<ul style="list-style-type: none"> <li>• Extremity edema, lymphedema, and/or obesity can result in diminished sound transmission and obtaining a Doppler signal (sound of pulse) might be difficult.               <ul style="list-style-type: none"> <li>○ A 5 MHz Doppler might be needed to detect sounds in cases of large amounts of edema (Allison et al., 2010; Hirsch et al., 2006; McDermott et al., 2002).</li> <li>○ Might need to use a large sized adult blood pressure cuff to accommodate a larger extremity.</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• Proceed with ABI if able to obtain an audible signal.</li> </ul>
<ul style="list-style-type: none"> <li>• Previous trauma or surgery to lower extremities.</li> </ul>	<ul style="list-style-type: none"> <li>• Scar tissue might interfere with obtaining a pulse.</li> <li>• Injury might increase lower extremity edema.</li> </ul>	<ul style="list-style-type: none"> <li>• Proceed with ABI if able to obtain an audible signal.</li> </ul>

History/Physical Findings	Considerations	Decision to Proceed with ABI
<ul style="list-style-type: none"> <li>• Absence of a palpable dorsalis pedis artery pulse and/or posterior tibial artery pulse.</li> </ul>	<ul style="list-style-type: none"> <li>• Locate pulses using a Doppler. <ul style="list-style-type: none"> <li>○ Doppler is more sensitive in the presence of low blood flow or edema and in some cases, you can hear pulses by Doppler when unable to detect a pulse by palpation.</li> </ul> </li> <li>• Presence of palpable pulses (alone) does not rule out LEAD (Bjellerup, 2003; Collins, Suarez-Almazor, &amp; Peterson, 2006; WOCN<sup>®</sup>, 2008). <ul style="list-style-type: none"> <li>○ Approximately 12% of the population has a congenital absence of the dorsalis pedis pulse (Criqui, Fronek, Barrett-Conner, et al., 1985; Kazmers, Koski, Groeh, et al., 1996; Lundkin, Wikson, Perakyla, et al. 1999; Magee, Stanley, Mufti, Simpson, &amp; Campbell, 1992; Moffiatt &amp; Ohare, 1995).</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• Proceed with ABI if able to obtain an audible signal.</li> </ul>
<ul style="list-style-type: none"> <li>• History of leg wounds and/or current wounds or alterations in skin integrity.</li> </ul>	<ul style="list-style-type: none"> <li>• Inquire if an ABI has been done previously and if results are available for comparison. <ul style="list-style-type: none"> <li>○ Because atherosclerosis is a progressive disease, the ABI can deteriorate over time and a change of 15% indicates progression of the disease (WOCN<sup>®</sup>, 2008).</li> </ul> </li> <li>• If ulcers are present or there are other alterations in the skin integrity, place a protective barrier (e.g., plastic wrap) over the affected area before cuff placement (Bonham, 2006; Vowden &amp; Vowden, 2001). <ul style="list-style-type: none"> <li>○ Use universal/standard precautions if open wounds/draining areas are present.</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• Proceed with ABI if cuff tolerated by patient.</li> </ul>
<ul style="list-style-type: none"> <li>• History or current use of tobacco, caffeine, or alcohol.</li> </ul>	<ul style="list-style-type: none"> <li>• Note if patient uses or has used tobacco, caffeine, or alcohol. <ul style="list-style-type: none"> <li>○ Patient should be encouraged to avoid use of stimuli that elevate blood pressure one hour prior to test (Bonham, 2006; Carter &amp; Lezack, 1971).</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• Proceed with ABI test and make a note of any tobacco, caffeine, or alcohol use within an hour immediately prior to the test if it is not feasible or practical to reschedule.</li> </ul>
<ul style="list-style-type: none"> <li>• Findings consistent with lower extremity venous disease (Carmel, 2012; WOCN<sup>®</sup>, 2011).</li> </ul>	<ul style="list-style-type: none"> <li>• Apply a protective dressing or barrier to any open areas prior to placement of pressure cuff. <ul style="list-style-type: none"> <li>○ Use universal/standard precautions if open wounds</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• Proceed with ABI.</li> <li>• Refer to health care provider for uncontrolled edema, dermatitis, and/or a non-healing</li> </ul>

History/Physical Findings	Considerations	Decision to Proceed with ABI
<ul style="list-style-type: none"> <li>○ Edema.</li> <li>○ Lipodermatosclerosis (e.g., hardened, thickened, scaly skin).</li> <li>○ Hemosiderin staining (e.g., brown discoloration of lower leg: brown sock-like appearance).</li> <li>○ Atrophie blanche.</li> <li>○ Varicose veins.</li> <li>○ Ankle flare.</li> <li>○ Warm skin temperature venous dermatitis (e.g., itching, redness, scaly, and weeping skin typically due to a reaction to topical products).</li> <li>○ Scarring from previous ulcers.</li> <li>○ Wound in medial malleolar area (i.e., gaiter area).</li> </ul>	<p style="text-align: center;">or draining areas.</p> <ul style="list-style-type: none"> <li>● Inquire if a previous ABI has been performed, and if results are available for comparison.</li> </ul>	<p>wound.</p>
<ul style="list-style-type: none"> <li>● Findings consistent with lower extremity arterial disease (Doughty, 2012; WOCN<sup>®</sup>, 2008). <ul style="list-style-type: none"> <li>○ Diminished/absent dorsalis pedis/posterior tibial pulses.</li> <li>○ Cyanosis.</li> <li>○ Pallor on elevation and dependent rubor.</li> <li>○ Prolonged capillary/venous refill.</li> <li>○ Loss of hair on lower limb.</li> <li>○ Atrophy of skin, subcutaneous tissue, and muscle.</li> <li>○ Shiny, taut, thin, dry skin.</li> <li>○ Skin temperature cool to touch.</li> <li>○ Decreased sensation.</li> <li>○ Weakness of limb, gait abnormalities.</li> <li>○ Pain (e.g., intermittent claudication, rest pain, nocturnal pain); pain on elevation.</li> <li>○ Paresthesias.</li> <li>○ Dystrophic (i.e., abnormal) nails.</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>● Inquire if a previous ABI has been performed and if results are available for comparison. <ul style="list-style-type: none"> <li>○ If a non-healing wound is present in patients with LEAD, check the ABI every 3 months as it can decrease over time (WOCN<sup>®</sup>, 2008).</li> <li>○ In one study, 31% of 117 patients with LEAD had progression within 5 years (Nicoloff et al., 2002).</li> </ul> </li> <li>● Locating and palpating pulses or locating pulses with the Doppler might be difficult. <ul style="list-style-type: none"> <li>○ Might require further vascular evaluation.</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>● Proceed with ABI if able to obtain audible signal for pressure readings.</li> </ul>

History/Physical Findings	Considerations	Decision to Proceed with ABI
<ul style="list-style-type: none"> <li>○ Wound on area exposed to pressure or trauma (e.g., lateral malleolus, phalangeal heads, tips toes/web spaces).</li> </ul>		
<ul style="list-style-type: none"> <li>● Findings consistent with lower extremity neuropathy (Driver, LeBretton, Landowski, &amp; Madsen, 2012; WOCN<sup>®</sup>, 2004). <ul style="list-style-type: none"> <li>○ Anhydrosis, xerosis, fissures.</li> <li>○ Callus formation.</li> <li>○ Musculoskeletal-foot deformities.</li> <li>○ Dystrophic (i.e., abnormal) nails.</li> <li>○ Decreased sensitivity to touch, temperature, and vibration.</li> <li>○ Altered sensation (e.g., numbness, warmth, prickling, tingling, pins/needles, shooting).</li> <li>○ Skin warm to touch.</li> <li>○ Wounds on the plantar surface of the foot, over bony prominences, tips of toes, metatarsal head, interphalangeal joints, interdigital spaces, and heels.</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>● Diabetic neuropathy is the most common type of neuropathy (WOCN<sup>®</sup>, 2004). <ul style="list-style-type: none"> <li>○ Studies have shown that, LEAD is present in 29% of persons 50 through 69 years of age who have diabetes (Hirsch et al., 2001; Kavros, A., &amp; Bubnik-Sotosek, 2009).</li> <li>○ ABI might be elevated due to non-compressible vessels.</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>● Proceed with ABI.</li> <li>● Obtain toe pressures/TBI if ABI is elevated over 1.3.</li> <li>● Transcutaneous oxygen test (TcPO<sub>2</sub>) is indicated to assess tissue perfusion if a lower extremity wound is not healing and/or ABI/TBI cannot be performed due to incompressible arteries or toe amputation (Norgren et al., 2007; WOCN<sup>®</sup>, 2004, 2008). <ul style="list-style-type: none"> <li>○ TcPO<sub>2</sub> &lt; 40 mmHg is hypoxic and associated with impaired healing.</li> <li>○ TcPO<sub>2</sub> &lt; 30 mmHg indicates critical ischemia.</li> </ul> </li> </ul>
<ul style="list-style-type: none"> <li>● Hypertension. <ul style="list-style-type: none"> <li>○ Systolic pressure ≥ 140 mmHg; diastolic pressure ≥ 90 mmHg (Pickering et al., 2005).</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>● Hypertension is associated with a two to three fold risk for LEAD (Norgren et al., 2007; WOCN<sup>®</sup>, 2008). <ul style="list-style-type: none"> <li>○ Hypertension often has no symptoms.</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>● Proceed with ABI and note if patient has taken blood pressure medication.</li> <li>● Refer to health care provider for evaluation of uncontrolled hypertension.</li> </ul>
<ul style="list-style-type: none"> <li>● Dementia.</li> </ul>	<ul style="list-style-type: none"> <li>● Cognitive impairment can interfere with a patient's ability to understand and follow the instructions necessary for the ABI procedure.</li> </ul>	<ul style="list-style-type: none"> <li>● Proceed with ABI if patient is able to cooperate.</li> <li>● Refer to health care provider if unable to perform ABI due to dementia.</li> </ul>

## ABI Procedure

**Prepare Equipment and Supplies** (Bonham, 2006; Hirsch et al., 2006; Rumwell & McPharlin, 2009).

1. Gather equipment and supplies for the ABI.
  - Portable Doppler with 8-10 MHz probe.
    - Use a 5 MHz probe if a large amount of edema is present at the ankle.
  - Aneroid sphygmomanometer.
  - Ultrasound transmission gel.
  - Alcohol pads to clean the Doppler.
  - Gauze, tissue or pads to remove transmission gel from patient's skin.
  - Towels, sheets, or blankets to cover trunk and extremities.
  - Paper and pen for recording test results; calculator.
  - Inspect equipment for damage and check batteries if a battery-operated Doppler is used.
  - Replace equipment if damaged or not properly calibrated.
2. Pressure cuffs for ankles and arms should be long enough to fully encircle the limb. The cuff bladder width should be 40% of the limb circumference and long enough to cover 80% of the arm circumference (Pickering et al., 2005).
  - Typically, 12 cm wide cuffs are used for arms and 10 cm wide cuffs at the ankles.
  - Extra large adult cuffs might be needed (14 cm).

**Prepare Patient and Environment** (Bonham, 2006; Hirsch et al., 2006; Rumwell & McPharlin, 2009).

1. Inquire about recent use of tobacco, caffeine, alcohol; recent heavy activity, and presence of pain. (Note: When possible, advise patient to avoid stimulants or heavy exercise for an hour prior to the test.)
2. Perform the ABI in a quiet, warm environment to prevent vasoconstriction of the arteries (21-23 + 1 °C; Bonham, 2006).
3. The best ABI results are obtained when the patient is relaxed, comfortable, and has an empty bladder.
4. Explain the procedure to the patient.
5. Remove socks, shoes, and tight clothing to permit placement of pressure cuffs and access to pulse sites by Doppler.
6. Place the patient in a flat, supine position. Place one small pillow behind the patient's head for comfort.
7. Prior to placement of the cuff, apply a protective barrier (e.g., plastic wrap) on the extremities if any wounds or alterations in skin integrity are present (Vowden & Vowden, 2001).
8. Place pressure cuffs with the bottom of the cuff approximately 2-3 cm above the cubital fossa on the arms and malleolus at the ankle (Augustine, 2000; Bonham, 2006; Pickering et al., 2005).
  - Cuffs should be wrapped without wrinkles and placed securely to prevent

- slipping and movement during the test.
9. Cover the trunk and extremities to prevent cooling.
  10. Ensure the patient is comfortable and have the patient rest for a minimum of 10 minutes prior to the test to allow pressures to normalize. The authors of a major vascular technology textbook suggest 20 minutes rest prior to the ABI (Rumwell & McPharlin, 2009).

**Measure Brachial Pressures with Doppler** (Bonham, 2006; Hirsch et al., 2006; Rumwell & McPharlin, 2009).

1. After the rest period, measure the arm and ankle pressures.
2. The arm should be relaxed, supported and at heart level.
3. Palpate the brachial pulse to determine location to obtain an audible pulse.
4. Apply transmission gel over the pulse site.
5. Place the tip of the Doppler probe at a 45° angle pointed towards the patient's head until an audible pulse signal is obtained.
6. Inflate the pressure cuff 20-30 mmHg above the point where the pulse is no longer audible (Bonham, 2006; Grenon et al., 2009; Pickering et al., 2005).
7. Deflate the pressure cuff at a rate of 2-3 mmHg per second (McDermott et al., 2002; Pickering et al., 2005), noting the manometer reading at which the first pulse signal is heard and record that systolic value.
8. Cleanse/remove gel from pulse site.
9. Repeat the procedure to measure the pressure on the other arm.
10. If a pressure needs to be repeated, wait 1 minute before re-inflating the cuff.
11. Use the higher of the right or left arm's brachial systolic pressures to calculate the ABI for both legs.

**Measure Ankle Pressures with Doppler** (Bonham, 2006; Hirsch et al., 2006; Rumwell & McPharlin, 2009).

1. Place the cuff on the patient's lower leg with the bottom of the cuff approximately 2-3 cm above the malleolus.
2. Prior to placing the cuff, apply a protective barrier (e.g., plastic wrap) on the extremity if any wounds or alterations in skin integrity are present.
3. Measure both dorsalis pedis and posterior tibial pulses in each leg.
4. Locate the pulses by palpation or with the Doppler probe.
5. Apply transmission gel to the pulse site.
6. Place the tip of the Doppler probe at a 45° angle pointed towards the patient's knee until an audible pulse signal is obtained.
7. Inflate the pressure cuff 20-30 mmHg above the point where the pulse is no longer audible
8. Deflate the cuff slowly at a rate of 2-3 mmHg per second, noting the manometer reading at which the first pulse signal is heard and record that systolic value.
9. Cleanse/remove gel from pulse site.
10. Repeat the procedure to measure pressures on the other ankle.
11. If a pressure needs to be repeated, wait one minute before re-inflating the cuff.

12. Use the higher of the ankle pressures of each leg to calculate the ABI for each leg.

**Calculate the ABI** (Bonham, 2006; Hirsch et al., 2006; Hopf et al., 2006; Vowden & Vowden, 2001).

1. Divide the higher of the dorsalis pedis or posterior tibial systolic pressure for each ankle by the higher of the right and left brachial pressures to obtain the ABI for each leg.

$$\text{ABI} = \frac{\text{Higher of either the dorsalis pedis or posterior tibial pressures}}{\text{Higher of the brachial pressures}}$$

2. Interpret and compare the ABI values from each leg (WOCN<sup>®</sup>, 2008).

<b><u>ABI</u></b>	<b><u>Perfusion Status</u></b>
> 1.3	Elevated, incompressible vessels
> 1.0	Normal
≤ 0.9	LEAD
≤ 0.6 to 0.8	Borderline
≤ 0.5	Severe ischemia
< 0.4	Critical ischemia, limb threatened

### **Documentation.**

1. Describe the patient's tolerance of the procedure, any problems encountered in the test or inability to perform ABI.
2. Document all brachial and ankle pressures in the medical record. Note any differences between the extremities.
  - If there is a 15-20 mmHg difference in the brachial pressures, this suggests subclavian stenosis (Rumwell & McPharlin, 2009).
  - A difference of 20-30 mmHg in pressures between ankles, suggests obstructive disease in the leg with the lower pressure (Rumwell & McPharlin, 2009).
3. Document the ABI values and the interpretation of perfusion status.
4. Document any education provided to the patient/family and their understanding or response.
5. Notify the referring health care provider of any inconsistency in the ABI and clinical findings or inability to perform ABI.
6. Document any follow-up plans and referrals/communications to other health care providers.
7. Note: If a waveform is obtained with the procedure, it should be interpreted by a qualified clinician and a copy placed in the medical record.

**Indications for Referral to a Vascular Surgeon for Further Evaluation/Testing**  
(WOCN<sup>®</sup>, 2008).

1. New onset of LEAD.
2. ABI < 0.9 in cases where an ulcer fails to improve in 2-4 weeks of proper treatment or patient has severe rest pain or intermittent claudication
3. Toe pressure < 30 mmHg or TBI < 0.6.
4. Borderline, severe, or critical ischemia.
5. Inconsistency between ABI and clinical complaints or observations (i.e., normal ABI and patient complains of intermittent claudication).
6. Inability to perform ABI.
7. Elevated ABI > 1.3 warrants further vascular testing such as photoplethysmography, transcutaneous oxygen measures, segmental pressures, duplex ultrasound, magnetic resonance angiography, or computed tomography (Bonham et al., 2010; Hirsch et al., 2006; WOCN<sup>®</sup>, 2008).

**Indications for Urgent Referral to a Vascular Surgeon or Emergency Room**  
(WOCN<sup>®</sup>, 2008).

1. Gangrene.
2. Wound infection or cellulitis in an ischemic limb.
3. Sudden onset of 6 Ps (i.e., pain, pulselessness, pallor, parathesia, paralysis, polar [coldness]), which indicates acute limb ischemia associated with a thrombosis.

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## **Glossary:**

**Acute deep vein thrombosis (DVT):** A thrombus or the formation of a blood clot that causes an outflow obstruction in the deep veins of the extremity. Veins distal to the obstruction become distended and venous pressure increases resulting in venous stasis. Signs and symptoms include pain, edema, erythema of the extremity and a positive Homan's sign.

**Adult blood pressure cuff, large:** Upper extremity, large, adult blood pressure cuff, which is appropriate for an arm circumference of 32.1-43.4 cm (12.6-17.1 in.). It has a length of 64.39 cm (25.35 in.) and a width of 17.02 cm (6.70 in.).

**Arterial insufficiency:** Lack of sufficient blood flow in arteries to extremities, which can be caused by cholesterol deposits (atherosclerosis), clots (emboli), or damaged, diseased, or weakened vessels.

**Compression therapy:** Application of sustained external pressure to the affected lower extremity to control edema and aid the return of venous blood to the heart. May be achieved by static compression (i.e., elastic and/or inelastic wraps, garments, or orthotics with single or multi-components/layers) or dynamic compression (i.e., intermittent pneumatic compression pumps).

**Doppler scanning:** Doppler velocity waveform analysis uses continuous-wave Doppler ultrasound to record arterial pulsations in various lower-extremity arteries.

**Dorsalis pedis artery:** The continuation of the anterior tibial artery of the lower leg. It starts at the ankle joint, divides into five branches, and supplies various muscles of the foot and toes. The dorsalis pedis pulse can be palpated on the mid-dorsum of the foot, between the first and second metatarsals.

**Duplex ultrasound:** Test combines traditional ultrasound that uses sound waves that bounce off blood vessels to create images with Doppler ultrasonography that examines how sound waves reflect off moving objects such as red blood cells.

**Non-compressible blood vessels:** The process in which vessels become hardened by the deposition of calcium salts in the tissues.

**Pain scale:** A means to measure the existence and intensity of pain. A standardized pain assessment instrument, such as the Wong-Baker Faces Pain Rating Scale or 0-10 Numeric Pain Intensity Scale.

**Photoplethysmography (PPG):** PPG determines blood flow by attaching a photosensor/transducer to the skin, which emits an infrared light that is reflected by the red blood cells in the vessels and is detected by the transducer. The amount of light reflected, corresponds to pulsatile changes and the tissue's blood volume. Toe pressure is obtained by attaching a PPG photosensor to the toe pad to record pulse changes and a small digit pressure cuff is placed at the base of the toe to measure the pressure.

**Posterior tibial artery:** One of the parts of the popliteal artery of the leg. It divides into eight branches, which supply blood to different muscles of the lower leg, foot, and toes. It is situated midway between the medial malleolus and the medial process of the calcaneal tuberosity. The posterior tibial pulse can be palpated in the groove behind the medial malleolus.

**Purpura:** A disorder with bleeding beneath the skin or mucous membranes. It causes black and blue spots (ecchymoses) or pinpoint bleeding.

**Toe brachial index (TBI):** TBI is a noninvasive test of arterial perfusion of the lower extremity that is obtained by comparing the systolic pressure in the great toe or second toe (if great toe is absent) to the higher of the right or left arm's systolic pressures. The TBI is a ratio derived by dividing the toe pressure by the arm pressure.

**Transcutaneous oxygen measurement:** A test to determine the oxygen tension in the skin by placement of a sensor that measures the oxygen pressure at a localized area on the surface of the skin.

**Venous insufficiency:** Failure of the valves of the veins to function that leads to decreased return of venous blood from the legs to the trunk of the body; may produce edema.

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