

**Ultrasound – Lower Extremity Arterial Evaluation: Ankle-Brachial Index (ABI) with Toe Pressures and Index**

**PURPOSE:**

To determine the presence, severity, and general location of peripheral arterial occlusive disease.

**SCOPE:**

Applies to all ultrasound ABI Lower Extremity Arterial Evaluation studies performed in:

- UT Southwestern
  - Zale-Lipshy University Hospital
  - William P. Clements Jr. University Hospital
  - University Hospital-based Clinics Imaging Services (UTSW)
- Parkland Health and Hospital System Department of Radiology (PHHS)

**INDICATIONS:**

- Claudication
- Rest pain
- Gangrene or ischemic ulceration
- Evaluation of non-healing ulcers and skin changes
- Pre and Post-surgical/interventional procedures
- Follow-up patients with known PAD

**ABSOLUTE CONTRAINDICATIONS:**

- None

**LIMITATIONS AND RELATIVE CONTRAINDICATIONS:**

- Patients with known or suspected ACUTE DVT
- Casts and/or bandages that cannot be removed
- Incompressible vessels
- Patients with stents and/or arterial bypass grafts

**EQUIPMENT:**

- Parks Flo-lab
- Vasculab
- 4-8 MHz probe
- Cuffs ranging in sizes 2.5-12 cm

**PATIENT PREPARATION:**

- The patient should rest for at least 15 minutes prior to examination
- The patient should lay supine with the heart at approximately the same level as the extremities

**EXAMINATION:**

**GENERAL GUIDELINES:**

- The examination must be bilateral unless otherwise contraindicated
- Review any prior studies, clinical indications, and relevant history
- A complete examination includes evaluation of the accessible portions of each vessel for the standard ABI and, if necessary, additional CW Doppler measurements or non-compressible PVR protocols as outlined below
- Variations in technique must be documented (i.e., stents)
- An angle of 45-60 degrees must be maintained between the transducer and the skin
- Gain or size setting must remain the same throughout the entire exam
- Document waveform as triphasic, biphasic, monophasic, or absent based on audible sound, which should be explicitly documented in the reported sheet (radiologist can then interpret relative to the waveform provided)
- The cuff should be inflated 30 mm Hg above the last audible Doppler signal

**EXAM INITIATION:**

- Introduce yourself to the patient
- Verify patient identity using patient name and DOB
- Explain procedure
- Obtain patient history including symptoms

**TECHNIQUE:**

- If the patient has a documented acute DVT (within 7 days), inform ordering provider that a progress note needs to be written in the patient's chart prior to the ABI exam being performed, that states that the ordering provider approves an ABI study and that the benefits of the study outweigh the risks, despite the contraindication of DVT.
  - Perform basic ABI study.
- Standard bilateral ankle brachial index (ABI) includes the following for all studies:
  - Brachial pressures, Ankles, and Toes
  - Ankle Pressures and Doppler waveforms at dorsalis pedis and posterior tibial arteries
  - Ankle PVRs
  - Toe pressure and PPG waveform at the great toe or next available toe
  - Calculation of Ankle (ABI) and Toe (TBI) brachial indices
    - The highest ankle pressure is used to obtain ABI's by dividing the ankle pressure by the highest brachial pressure
- If the ABI is abnormal (< 0.9), perform additional evaluation as follows:
  - Doppler waveforms at common femoral and popliteal arteries
- If the patient has incompressible vessels (pressure is > 250 mmHg) and pressures cannot be obtained:
  - If ankle waveforms are absent, monophasic, or biphasic – obtain Doppler waveforms at common femoral and popliteal
  - If ankle waveforms are triphasic, no further testing is required.
- If the patient has a bypass graft or stent:
  - Perform standard bilateral ankle brachial index (ABI) (Follow previous guidelines if ABI is abnormal)

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- If the ordering provider requests stent/bypass graft evaluation, an additional arterial duplex imaging order is required
- Toe pressures and PPG
  - Obtained at the great toe bilaterally
  - If the patient presents with a great toe ulcer or gangrene obtain from the second toe or most adjacent toe on the same foot that is not diseased. On the contralateral foot, obtain pressures and waveforms from the great toe and the second toe or from the most adjacent toe that is not diseased.
- VIR Radiology Faculty or Vascular Faculty may request full segmental pressures and/or PVRs as clinically indicated.

### DOCUMENTATION:

- A basic ABI study should be documented as a minimum on all patients. This includes ankle pressures, brachial pressures, toe pressures, ankle Doppler waveforms, ankle PVRs, and digit PPG waveforms.
- Additional documentation as needed for the following (as above):
  - ABI < 0.9
  - Incompressible vessels
  - Bypass grafts/stents
- Any protocol deviation MUST be documented with a reason

### PROCESSING:

- Review examination data
- Export all images to PACS
- In the event of a significant finding, i.e. acute arterial occlusion, ABI of 0.3 or lower, acute graft occlusion, blue toe syndrome, presence of pseudoaneurysm or A-V fistula, or progression of disease post intervention, the technologist will page the IR physician
- Note any study limitations or protocol deviations

### Diagnostic Criteria for Physiological Lower Extremities Arterial Exam

Ankle Brachial Index	Clinical Findings	Interpretation
> 1.3		Incompressible, calcified arteries
0.9-1.3	None	No significant blockage
0.7-.89	Generally asymptomatic	Mild arterial disease
.51-.69	Claudication symptoms	Moderate arterial disease
<.5	Rest pain	Severe arterial disease
<.35	Possible tissue loss	Critical stenosis
Toe Brachial Index		
> 0.7	None	Normal
<0.7	Claudication, Rest pain or Tissue loss	Abnormal
Toe Pressures		
>50 mmHg	Adequate for healing	Adequate
</=50 mmHg	Inadequate for tissue healing	Inadequate
<=30 mmHg	Critically low	Critical

Fontaine Classification		Rutherford Classification		
Stage	Clinical	Grade	Category	Clinical
I	Asymptomatic	0	0	Asymptomatic
IIa	Mild claudication	I	1	Mild claudication
IIb	Moderate to severe claudication	I	2	Moderate claudication
		I	3	Severe claudication
III	Ischemic rest pain	II	4	Ischemic rest pain
IV	Ulceration or gangrene	III	5	Minor tissue loss
		III	6	Major tissue loss

**Segmental Pressure Measurement Interpretation:**

- A normal standard ABI exam consists of pressures, indices, and Doppler signals with no signs of arterial claudication.
- Pressures should be compared to the contralateral side, a pressure difference  $\geq 30\text{mmHg}$  is indicative of an arterial obstruction.
- Compare pressures vertically, a pressure difference  $\geq 20\text{mmHg}$  is indicative of an arterial obstruction.
- A difference  $\geq 20\text{mmHg}$  between the brachial pressures indicates a hemodynamically significant obstruction.
- High-thigh systolic pressure is normally 30-40 mmHg > brachial pressure with thigh pressure index of 1.2 or greater.
- The presence of pressure gradient of 20mmHg or greater from one segment to the distal segment is suggestive of an arterial occlusive disease to where the lower pressure obtained.
- Incompressible vessels are suggested when: no amount of pressure in the pneumatic cuff causes the Doppler signal to obliterate; ABIs are greater than 1.4 (most likely in elderly patients, patients with long standing diabetes, or chronic renal failure), and when the technologist has to inflate the cuff more than 30mmHg higher than the actual systolic pressure just to obliterate the Doppler signal.
- ABIs are considered inaccurate if there is incompressibility of the vessels.

**Doppler Waveform Interpretation:**

- Normal Doppler arterial signal is multiphasic.
- Alterations in the sharp upstroke, the relatively sharp peak and the loss of diastolic components may indicate an arterial obstruction. Additional imaging should be recommended i.e. CTA, MRA, or focal US Doppler.
- The waveform will appear blunted with a loss of diastolic flow distal to a moderate stenosis.
- The waveform will be monophasic with a decrease in amplitude and a delayed upstroke proximal to an occlusion.
- Diabetic patients frequently have Biphasic waveforms due to loss of elasticity.

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## **PVR Waveform Interpretation:**

- Fast acceleration of systolic peak and the presence of a dicrotic notch are normal characteristics of PVR waveforms.  
Dicrotic notch must be present on the diastolic limb of the PVR waveforms for a normal healthy artery. Absence of the dicrotic notch is suggestive of a non-compliant artery. A decrease of 20mmHg in pressure between adjacent levels of the ipsilateral extremity denotes disease.  
A 20mmHg pressure difference between right and left extremities denotes disease. There should be a slight increase in amplitude between low thigh and calf.

## **REFERENCES:**

- Measurement and Interpretation of the Ankle-Brachial Index. A Scientific Statement from the American Heart Association. Circulation. 2012;126:2890-2909
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## **CHANGE HISTORY:**

<b>STATUS</b>	<b>NAME &amp; TITLE</b>	<b>DATE</b>	<b>BRIEF SUMMARY</b>
<b>Submission</b>	Mark Reddick, MD	<b>6/9/2016</b>	Submitted
<b>Approval</b>	David Fetzer, MD, Director	<b>6/20/2016</b>	Approved
<b>Review</b>	Melissa Foreman, ADV PRAC SONOGRAPHER	<b>11/26/2018</b>	Reviewed
<b>Revisions</b>	Mark Reddick, MD	<b>07/20/2016</b>	Updates to ABI diagnostic criteria
<b>Revisions</b>	Rehan Quadri, MD + Jayesh Soni, MD	<b>9/8/2021</b>	Updates to all sections
	Rehan Quadri, MD & Monica Morgan, US Technical Supervisor; reviewed and approved by Surekha Patel, PHHS US Manager	<b>1/18/2022</b>	Reviewed