



## **AIUM Practice Parameter for the Performance of Physiologic Evaluation of Extremity Arteries**

*Parameter developed in conjunction with the American College of Radiology (ACR), the Society of Interventional Radiology (SIR), and the Society of Radiologists in Ultrasound (SRU).*

The American Institute of Ultrasound in Medicine (AIUM) is a multidisciplinary association dedicated to advancing the safe and effective use of ultrasound in medicine through professional and public education, research, development of parameters, and accreditation. To promote this mission, the AIUM is pleased to publish, in conjunction with the American College of Radiology (ACR), the Society of Interventional Radiology (SIR), and the Society of Radiologists in Ultrasound (SRU), this AIUM Practice Parameter for the Performance of Physiologic Evaluation of Extremity Arteries. We are indebted to the many volunteers who contributed their time, knowledge, and energy to bringing this document to completion.

The AIUM represents the entire range of clinical and basic science interests in medical diagnostic ultrasound, and, with hundreds of volunteers, the AIUM has promoted the safe and effective use of ultrasound in clinical medicine for more than 65 years. This document and others like it will continue to advance this mission.

Practice parameters of the AIUM are intended to provide the medical ultrasound community with parameters for the performance and recording of high-quality ultrasound examinations. The

parameters reflect what the AIUM considers the minimum criteria for a complete examination in each area but are not intended to establish a legal standard of care. AIUM-accredited practices are expected to generally follow the parameters with recognition that deviations from these parameters will be needed in some cases, depending on patient needs and available equipment. Practices are encouraged to go beyond the parameters to provide additional service and information as needed.

## **I. Introduction**

The clinical aspects contained in specific sections of this parameter (Introduction, Indications/Contraindications, Specifications of the Examination, and Equipment Specifications) were developed collaboratively by the American Institute of Ultrasound in Medicine (AIUM), the American College of Radiology (ACR), the Society of Interventional Radiology (SIR), and the Society of Radiologists in Ultrasound (SRU). Qualifications and Responsibilities of Personnel, Written Request for the Examination, Documentation, and Quality Control and Improvement, Safety, Infection Control, and Patient Education vary among the organizations and may be addressed by each separately.

This parameter has been revised to assist physicians and allied health care professionals performing a nonimaging physiologic examination of the extremity arteries. Although it is not possible to detect every abnormality with physiologic testing, following this practice parameter will maximize the detection of abnormalities of the arterial blood supply to the extremities.

## **II. Indications/Contraindications**

Indications for the examination include but are not limited to:

- A. Evaluation of exercise-induced limb pain (claudication).<sup>1</sup>
- B. Assessment of digital or extremity ulceration, gangrene, and/or pain at rest.<sup>1,2</sup>
- C. Follow-up of surgical and endovascular procedures.<sup>3</sup>
- D. Evaluation of wound-healing potential.<sup>1</sup>

- E. Preprocedure assessment of patients with chronic kidney disease requiring dialysis.<sup>4,5</sup>
- F. Evaluation of cold sensitivity or discoloration of extremities or digits.<sup>6</sup>
- G. Evaluation of suspected thoracic outlet syndrome.<sup>6</sup>
- H. Evaluation of a suspected steal distal to an arteriovenous fistula or graft.<sup>7,8</sup>
- I. Preoperative assessment for arterial harvesting.<sup>9,10</sup>
- J. Assessment for the presence of peripheral vascular disease as part of assessment of the overall atherosclerosis burden.<sup>2,11,12</sup>
- K. Preoperative assessment for renal transplantation.

There are no absolute contraindications for this examination.

### **III. Qualifications and Responsibilities of Personnel**

See [www.aium.org](http://www.aium.org) for AIUM Official Statements, including *Standards and Guidelines for the Accreditation of Ultrasound Practices* and relevant Physician Training Guidelines.<sup>13</sup>

### **IV. Written Request for the Examination**

The written or electronic request for an ultrasound examination should provide sufficient information to allow for the appropriate performance and interpretation of the examination.

The request for the examination must be originated by a physician or another appropriately licensed health care provider or under the physician's or provider's direction. The accompanying clinical information should be provided by a physician or another appropriate health care provider familiar with the patient's clinical situation and should be consistent with relevant legal and local health care facility requirements.

### **V. Specifications of the Examination**

Physiologic tests are indirect tests. Results are used to infer the presence or absence of disease and its severity. Specific locations in the arterial tree are less directly assessed with physiologic techniques compared with duplex ultrasound. See the *AIUM–ACR–SRU Practice Parameter for the Performance of Peripheral Arterial Ultrasound Using Color and Spectral Doppler*<sup>14</sup> for duplex evaluation of the arteries. Duplex Doppler ultrasound permits direct assessment of the arterial segments that may be involved with disease.

The physiologic examination may be done at 1 level only (eg, the ankles) or at multiple levels of the extremity. Whether done at 1 level or at multiple levels, the examination should be bilateral when possible so that flow in the 2 limbs can be compared. Physiologic testing of the extremities should include pulse volume recordings (PVRs) or continuous wave (CW) Doppler waveforms at the ankle or wrist to allow the accuracy of the ankle-brachial index (ABI) at the ankle to be internally validated. This is particularly helpful in cases of noncompressible calcified arteries.

The examination is best performed in a warm room so that the effects of peripheral vasoconstriction are minimized. The patient should be recumbent for the examination and ideally should be at rest for at least 5 minutes before starting the examination to diminish any effects that prior physical activity might have on the examination. Physiologic tests, particularly ankle pressure measurements, may be repeated after exercise of the involved limb when indicated.<sup>14</sup> This is particularly valuable for the assessment of claudication when the ABI at rest is normal or higher than would be clinically anticipated. When patients are exercised, use of a treadmill is recommended at 2 mph at a 12° grade for 5 minutes or until they become symptomatic and cannot continue.<sup>15</sup> Treadmill exercise provides for reproducible quantification of exercise while allowing simultaneous assessment of symptoms produced during exercise. Symptoms that occur during exercise should also be recorded, as well as the elapsed time from the start of exercise to the point at which the symptoms occurred. The total time of exercise should be recorded. Pressure measurements that are taken after the exercise stops should be done as quickly as possible to achieve the highest accuracy and compared to the brachial pressure in the arm with the highest pressure. Serial postexercise pressure measurements can be taken in both legs at 1- to 3-minute intervals for the first 5 to 10 minutes or until the ABI returns to baseline. Exercise performed without the use of a treadmill may instead be used and may supply valuable information.



## Description of the Component Parts of the Examination

### 1. Segmental Limb Pressures

The laboratory should have a protocol specifying the size cuff to be used at each location where blood pressure is commonly obtained. Extremity pressures are taken in the legs at the dorsalis pedis and posterior tibial arteries using a handheld CW Doppler device to listen for return of arterial blood flow. In the upper extremity, the radial and ulnar arteries are selected. Waveforms should also be recorded at these locations. Segmental or digital blood pressure readings can be assessed using spectral Doppler tracings or photoplethysmography to determine when blood flow returns as the blood pressure cuff is deflated. (The method used to assess return of blood flow should be consistent.) Digital pressure can be assessed using CW Doppler ultrasound or photoplethysmography to determine when blood flow returns. Bilateral brachial pressure measurements are obtained when possible. The higher brachial pressure is the pressure used in index calculations (eg, ABI) for the lower extremities, upper extremities, or digits.<sup>12,16</sup>

### 2. Continuous Wave Doppler Waveforms<sup>8,16</sup>

Continuous wave Doppler waveforms can be obtained from 1 or more arteries. In the lower extremity, the arteries most commonly assessed are the common femoral, superficial femoral, popliteal, posterior tibial, and dorsalis pedis. In the upper extremity, arteries that may be assessed are the subclavian, axillary, brachial, radial, and ulnar. Those performing the examination should be familiar with the appropriate external anatomic landmarks to ensure accurate performance of the examination. Waveforms should be audibly and visually optimized. The Doppler angle should be maintained constant throughout the examination when possible (technical constraints may prevent this), and either legs or arms should be evaluated using a similar technique (a consistent Doppler angle will allow waveforms at one site to more readily be compared with those from a different site and from the opposite leg/arm).

### 3. Pulse Volume Recordings

Air-calibrated PVRs can be obtained at 1 or more levels. In the lower extremity, the most common places to obtain waveforms are in the upper thigh, lower thigh, calf, and ankle. In the upper extremity, the analogous locations are the upper arm, upper forearm, and above the wrist. Waveforms can be obtained in the toes and digits using a photoplethysmographic cell.<sup>8</sup> Unlike CW Doppler waveforms, plethysmographic tracings reflect global tissue perfusion at a particular

location rather than a specific artery. Unlike segmental pressures, readings are not affected by arterial calcification.

#### 4. Transcutaneous Oxygen Tension Measurements

Measurement of the transcutaneous oxygen tension (tcPO<sub>2</sub>) can be used to assess the delivery of oxygen to the skin in an area of questionable viability.<sup>17</sup> The usual locations on the lower extremities are on the foot, ankle, and calf, with a reference point on the chest. After the desquamated cells are cleaned from the skin, a coupling solution such as distilled water is applied to the skin, and the tcPO<sub>2</sub> sensor is affixed to the testing site with an overlying occlusive adhesive dressing that prevents exposure to room air. Transcutaneous oxygen tension measurements, when used for determination of ulcer healing, have had variable sensitivity and specificity.

## VI. Documentation

Adequate documentation is essential for high-quality patient care. There should be a permanent record of the ultrasound examination and its interpretation. Comparison with prior relevant studies should be performed when available. Data from all appropriate arterial segments, both normal and abnormal, should be recorded. There should be a permanent record of all CW Doppler waveforms, plethysmographic waveforms, and segmental blood pressure measurements and their interpretation. The initials of the operator should be accessible on the study or electronically on a picture archiving and communication system. The study should be labeled with the patient identification, facility identification, and examination date. An official interpretation (final report) of the examination should be included in the patient's medical record. Retention of data should be based on clinical needs and relevant legal and local health care facility requirements.

Reporting should be in accordance with the *AIUM Practice Parameter for Documentation of an Ultrasound Examination*.

## **VII. Equipment Specifications**

Peripheral arterial waveforms are obtained with a CW Doppler instrument operating at 5 to 10 MHz with a zero-crossing detector (waveforms may also be sampled using standard duplex imaging equipment). The instrument should have audio output through a speaker or headphones. The instrument should also have digital or analog recording connectivity so that waveforms can be saved.

The same CW Doppler instrument can be used to detect arterial waveforms for obtaining segmental pressures. Appropriately sized blood pressure cuffs attached to a manometer are necessary to obtain segmental blood pressures. A rapid inflation device is helpful. Small cuffs are necessary to measure digital pressures. A photoelectric plethysmograph can be used for digital pressure measurement. A treadmill with adjustable speed and incline is recommended for reproducible, quantifiable exercise testing for lower extremities. Exercise parameters used should be recorded.

Pulse volume recordings can be performed with the same cuffs used to measure pressures, connected to an air-calibrated plethysmograph.

## **VIII. Quality Control and Improvement, Safety, Infection Control, and Patient Education**

Policies and procedures related to quality control, patient education, infection control, and safety should be developed and implemented in accordance with the AIUM *Standards and Guidelines for the Accreditation of Ultrasound Practices*.

Equipment performance monitoring should be in accordance with the AIUM *Standards and Guidelines for the Accreditation of Ultrasound Practices*.

## **IX. ALARA Principle**

The potential benefits and risks of each examination should be considered. The ALARA (as low as reasonably achievable) principle should be observed when adjusting controls that affect the acoustic output and by considering transducer dwell times. Further details on ALARA may be found in the AIUM publication *Medical Ultrasound Safety*, Third Edition.

### **Acknowledgments**

This parameter was revised by the American Institute of Ultrasound in Medicine (AIUM) in collaboration with the American College of Radiology (ACR), the Society of Interventional Radiology (SIR), and the Society of Radiologists in Ultrasound (SRU) according to the process described in the AIUM *Clinical Standards Committee Manual*.

Collaborative Committee: Members represent their societies in the initial and final revision of this parameter.

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