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 multidisci-
plinary 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 volun-
teers 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 ultra-
sound in clinical medicine for more than 50 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 developed to assist physicians performing a nonimaging physiologic examination of the extremity arteries. Although it is not possible to detect every abnormality with physiologic testing, following this 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.¹
B. Assessment of digital or extremity ulceration, gangrene, and/or rest pain.¹²
C. Follow-up of surgical and endovascular procedures.³
D. Evaluation of wound-healing potential.¹
E. Evaluation of patients with chronic kidney disease requiring dialysis.⁵⁶
F. Evaluation of cold sensitivity or discoloration of extremities or digits.⁶
G. Evaluation of suspected thoracic outlet syndrome.⁶
H. Evaluation of suspected steal distal to an arteriovenous fistula or graft.⁷⁸
I. Preoperative assessment for arterial harvesting.⁹¹⁰
J. Assessment for the presence of peripheral vascular disease as part of assessment of the overall atherosclerosis burden.²¹²
K. Preoperative assessment for renal transplant.

There are no absolute contraindications for this examination.

III. Qualifications and Responsibilities of Personnel

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

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 using a handheld continuous wave (CW) Doppler instrument to listen for return of arterial blood flow. Blood pressure readings can be assessed instead using spectral Doppler tracings or photoplethysmography to determine when blood flow returns as the blood pressure cuff is deflated. Digital pressure can be assessed using photoplethysmography to determine when blood flow returns. Bilateral brachial pressures are obtained when possible. The highest brachial pressure is the pressure used in index calculations (e.g., ankle-brachial index [ABI]) for the upper extremities, lower extremities, or digits.¹²,¹³

2. Continuous Wave Doppler Waveforms
   Continuous wave Doppler waveforms can be obtained from one or more arteries.⁸,¹³ 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 commonly 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. There should be strict adherence to technique, including attempting to maintain as close to a 60° Doppler angle as possible.

3. Pulse Volume Recordings
   Pulse volume recordings (PVRs) can be obtained at one or more levels. In the lower extremity, the most common places to obtain waveforms are in the upper thigh, lower thigh, calf, and ankle. A waveform can be obtained in the toes using photoplethysmography cell.⁸

4. Transcutaneous Oxygen Tension Measurements
   Measurement of the transcutaneous oxygen tension (tcPO₂) can be used to assess the delivery of oxygen to the skin in an area of questionable viability.¹⁴ The tcPO₂ probe has an oxygen sensor composed of a central platinum cathode that is surrounded by a circular silver-silver halide anode. Surrounding the oxygen sensor is a heating element that warms the skin to 43°C to 45°C to optimize cutaneous vasodilatation and oxygen delivery. After cleaning desquamated cells from the skin, a coupling solution such as distilled water is applied to the skin, and the tcPO₂ sensor is
affixed to the testing site with an overlying occlusive adhesive dressing that prevents exposure to room air. Free oxygen diffuses from the vascular space through the extravascular soft tissues and skin. On contact with the tcPO2 sensor, it undergoes a chemical reduction that generates a recordable electrical current that is proportional to the oxygen tension.

Physiologic tests are indirect tests. Results are used to infer the presence or absence of disease. Specific locations in the arterial tree are not directly assessed with physiologic techniques. See the AIUM Practice Parameter for the Performance of Peripheral Arterial Ultrasound Examinations Using Color and Spectral Doppler Imaging 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 one level only (e.g., the ankle) or at multiple levels of the extremity. Whether done at one level or at multiple levels, the examination should be bilateral when possible so that flow in the two limbs can be compared. If possible, it should include PVRs or CW Doppler waveforms at the ankle to allow the accuracy of the ABIs at the ankle to be internally validated.

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. This is particularly valuable for the assessment of claudication. When the patient is exercised, use of a treadmill is recommended when possible (although nontreadmill exercise using heel lifts has also been validated). 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. Pressures that are taken immediately after exercise should be done as expeditiously as possible to achieve the highest accuracy. Postexercise pressures are taken in each of the legs. Subsequently, they may be taken in the arm with the highest pressure.

VI. Documentation

Adequate documentation is essential for high-quality patient care. There should be a permanent record of the ultrasound examination and its interpretation. Images of all appropriate areas, both normal and abnormal, should be recorded. Variations from normal size should be accompanied by measurements. Images should be labeled with the patient identification, facility identification, examination date, and side (right or left) of the anatomic site imaged. An official interpretation (final report) of the ultrasound findings should be included in the patient’s medical record. Retention of the ultrasound examination should be consistent both with clinical needs and with 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

Arterial waveforms are obtained with a 2- to 10-MHz CW Doppler instrument with a zero-crossing detector. The instrument should have audio output through a speaker or headphones. The instrument should also have a digital or analog recording device 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 to assist in digital pressure measurement. A treadmill with adjustable speed and incline is recommended for reproducible, quantifiable exercise testing. A digital or analog display is desirable to allow for recording of the exercise parameters used. Pulse volume recordings can be performed with the same cuffs used to measure pressures, connected to an air-filled 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, Second Edition.

Acknowledgments

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

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References


