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The American College of Radiology will periodically define new practice parameters and technical standards for radiologic practice to help advance the science of radiology and to improve the quality of service to patients throughout the United States. Existing practice parameters and technical standards will be reviewed for revision or renewal, as appropriate, on their fifth anniversary or sooner, if indicated.

Each practice parameter and technical standard, representing a policy statement by the College, has undergone a thorough consensus process in which it has been subjected to extensive review and approval. The practice parameters and technical standards recognize that the safe and effective use of diagnostic and therapeutic radiology requires specific training, skills, and techniques, as described in each document. Reproduction or modification of the published practice parameter and technical standard by those entities not providing these services is not authorized.

Revised 2017 (Resolution 17)\*

## **ACR–AIUM–SIR–SRU PRACTICE PARAMETER FOR THE PERFORMANCE OF PHYSIOLOGIC EVALUATION OF EXTREMITY ARTERIES**

### **PREAMBLE**

This document is an educational tool designed to assist practitioners in providing appropriate radiologic care for patients. Practice Parameters and Technical Standards are not inflexible rules or requirements of practice and are not intended, nor should they be used, to establish a legal standard of care<sup>1</sup> For these reasons and those set forth below, the American College of Radiology and our collaborating medical specialty societies caution against the use of these documents in litigation in which the clinical decisions of a practitioner are called into question.

The ultimate judgment regarding the propriety of any specific procedure or course of action must be made by the practitioner in light of all the circumstances presented. Thus, an approach that differs from the guidance in this document, standing alone, does not necessarily imply that the approach was below the standard of care. To the contrary, a conscientious practitioner may responsibly adopt a course of action different from that set forth in this document when, in the reasonable judgment of the practitioner, such course of action is indicated by the condition of the patient, limitations of available resources, or advances in knowledge or technology subsequent to publication of this document. However, a practitioner who employs an approach substantially different from the guidance in this document is advised to document in the patient record information sufficient to explain the approach taken.

The practice of medicine involves not only the science, but also the art of dealing with the prevention, diagnosis, alleviation, and treatment of disease. The variety and complexity of human conditions make it impossible to always reach the most appropriate diagnosis or to predict with certainty a particular response to treatment. Therefore, it should be recognized that adherence to the guidance in this document will not assure an accurate diagnosis or a successful outcome. All that should be expected is that the practitioner will follow a reasonable course of action based on current knowledge, available resources, and the needs of the patient to deliver effective and safe medical care. The sole purpose of this document is to assist practitioners in achieving this objective.

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<sup>1</sup>Iowa Medical Society and Iowa Society of Anesthesiologists v. Iowa Board of Nursing, 831 N.W.2d 826 (Iowa 2013) Iowa Supreme Court refuses to find that the *ACR Technical Standard for Management of the Use of Radiation in Fluoroscopic Procedures* (Revised 2008) sets a national standard for who may perform fluoroscopic procedures in light of the standard's stated purpose that ACR standards are educational tools and not intended to establish a legal standard of care. See also, Stanley v. McCarver, 63 P.3d 1076 (Ariz. App. 2003) where in a concurring opinion the Court stated that "published standards or guidelines of specialty medical organizations are useful in determining the duty owed or the standard of care applicable in a given situation" even though ACR standards themselves do not establish the standard of care.

## **I. INTRODUCTION**

The clinical aspects contained in specific sections of this practice parameter (Introduction, Indications, Specifications of the Examination, and Equipment Specifications) were developed collaboratively by the American College of Radiology (ACR), the American Institute of Ultrasound in Medicine (AIUM), the Society of Interventional Radiology (SIR), and the Society of Radiologists in Ultrasound (SRU). Recommendations for physician requirements, written request for the examination, procedure documentation, and quality control vary among the organizations and may be addressed by each separately.

This practice 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 arterial blood supply to the extremities.

## **II. INDICATIONS/CONTRAINDICATIONS**

Indications for the examination include, but are not limited to:

1. Evaluation of exercise-induced limb pain (claudication) [1]
2. Assessment of digital or extremity ulceration, gangrene, and/or pain at rest [1,2]
3. Follow-up of surgical and endovascular procedures [3]
4. Evaluation of wound healing potential [1]
5. Preprocedure assessment of patients with chronic kidney disease requiring dialysis [4,5]
6. Evaluation of cold sensitivity or discoloration of extremities or digits [6]
7. Evaluation of suspected thoracic outlet syndrome [6]
8. Evaluation of suspected steal distal to an arteriovenous fistula or graft [7,8]
9. Preoperative assessment for arterial harvesting [9,10]
10. Assessment for the presence of peripheral vascular disease as part of an assessment of overall atherosclerosis burden [2,11,12]
11. Preoperative assessment for renal transplantation

There are no absolute contraindications for this examination.

## **III. QUALIFICATIONS AND RESPONSIBILITIES OF PERSONNEL**

Core Privileging: This procedure is considered part of or amendable to image-guided core privileging.

Each organization will address this section in its document. ACR language is as follows:

See the [ACR–SPR–SRU Practice Parameter for Performing and Interpreting Diagnostic Ultrasound Examinations](#) [13].

## **IV. WRITTEN REQUEST FOR THE EXAMINATION**

Each organization will address this section in its document. ACR language is as follows:

The written or electronic request for a physiologic evaluation of extremity arteries should provide sufficient information to demonstrate the medical necessity of the procedure and allow for its proper performance and interpretation.

Documentation that satisfies medical necessity includes 1) signs and symptoms, 2) relevant history (including known diagnoses), and/or 3) prior imaging. Additional information regarding the specific reason for the procedure or a provisional diagnosis would be helpful and may at times be needed to allow for the proper performance and interpretation of the procedure.

The request for the procedure must be originated by a physician or other appropriately licensed health care provider. The accompanying clinical information should be provided by a physician or other appropriately licensed health care provider familiar with the patient's clinical problem or question and consistent with the state scope of practice requirements. (ACR Resolution 35, adopted in 2006)

## 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 as compared with duplex ultrasound. See the [ACR–AIUM–SRU Practice Parameter for the Performance of Peripheral Arterial Ultrasound Using Color and Spectral Doppler](#) [14] 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 non-compressible 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 [14]. 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-degree grade for 5 minutes or until they become symptomatic and cannot continue [15]. 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. 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 post-exercise 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

The laboratory should have a protocol specifying the size of the cuff to be used at each location where blood pressure is commonly obtained. Extremity pressure measurements are taken in the legs at the dorsalis pedis and posterior tibial arteries using a handheld CW Doppler 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 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 [12,16].

2. CW Doppler waveforms [8,16]

CW 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. 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. PVRs Pulse volume recordings

Air-calibrated plethysmography 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 photoplethysmography cell [8]. 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 [17]. 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 a determination of ulcer healing, have had variable sensitivity and specificity.

## VI. DOCUMENTATION

Each organization will address this section in its document. ACR language is as follows:

Adequate documentation is essential for high-quality patient care. There should be a permanent record of the 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 PACS. 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 need and relevant legal and local healthcare facility requirements.

Reporting and communication efforts should be in accordance with the [ACR Practice Parameter for Communication of Diagnostic Imaging Findings](#) [18].

## 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 the performance of segmental pressures. Appropriately sized blood pressure cuffs attached to a manometer are necessary to perform 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.

PVRs 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

Each organization will address this section in its document. ACR language is as follows:

Policies and procedures related to quality, patient education, infection control, and safety should be developed and implemented in accordance with the ACR Policy on Quality Control and Improvement, Safety, Infection Control, and Patient Education appearing under the heading *Position Statement on QC & Improvement, Safety, Infection Control, and Patient Education* on the ACR website (<http://www.acr.org/guidelines>).

Equipment performance monitoring should be in accordance with the [ACR–AAPM Technical Standard for Diagnostic Medical Physics Performance Monitoring of Real Time Ultrasound Equipment](#) [19].

### ACKNOWLEDGEMENTS

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\*Practice parameters and technical standards are published annually with an effective date of October 1 in the year in which amended, revised or approved by the ACR Council. For practice parameters and technical standards published before 1999, the effective date was January 1 following the year in which the practice parameter or technical standard was amended, revised, or approved by the ACR Council.

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