The American College of Radiology, with more than 30,000 members, is the principal organization of radiologists, radiation oncologists, and clinical medical physicists in the United States. The College is a nonprofit professional society whose primary purposes are to advance the science of radiology, improve radiologic services to the patient, study the socioeconomic aspects of the practice of radiology, and encourage continuing education for radiologists, radiation oncologists, medical physicists, and persons practicing in allied professional fields.

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.

Amended 2014 (Resolution 39)*

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. 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.

1 Iowa Medical Society and Iowa Society of Anesthesiologists v. Iowa Board of Nursing, ___ N.W.2d ___ (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 developed to assist physicians performing a nonimaging physiological examination of the extremity arteries. Although it is not possible to detect every abnormality with physiological 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 [1].
2. Assessment of digital or extremity ulceration, gangrene, and/or rest pain [1,2].
3. Follow-up of surgical and endovascular procedures [3].
4. Evaluation of wound healing potential [1].
5. 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].

There are no absolute contraindications for this examination.

III. QUALIFICATIONS AND RESPONSIBILITIES OF PERSONNEL

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.

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

Description of the component parts of the examination:

1. Segmental limb pressures
   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 pressures are taken using a hand held continuous wave (CW) Doppler 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. CW (continuous wave) Doppler waveforms [8,13]
   CW Doppler waveforms can be obtained from one 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 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-degree Doppler angle as possible.

3. Pulse volume recordings (PVRs)
   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 a 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 comprised 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 to 45 degrees C in order to optimize cutaneous vasodilatation and oxygen delivery. After the desquamated cells are cleaned 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. Upon contact with the tcPO2 sensor it undergoes a chemical reduction that generates a recordable electrical current that is proportional to the oxygen tension.

Physiological 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 physiological techniques. See the ACR–AIUM–SRU Practice Parameter for the Performance of Peripheral Arterial Ultrasound Using Color and Spectral Doppler for duplex evaluation of the arteries. Duplex Doppler ultrasound permits direct assessment of the arterial segments that may be involved with disease.

The physiological 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.

Physiological tests, particularly ankle pressure measurements, may be repeated after exercise of the involved limb when indicated [13]. This is particularly valuable for the assessment of claudication. When the patient is exercised, use of a treadmill is recommended when possible (though nontreadmill exercise using heel lifts has also been validated) [13]. 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 highest accuracy. Postexercise pressures are taken in each leg. Subsequently, they may be taken in the arm with the highest pressure.

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 may prove helpful. Data from all appropriate areas, both normal and abnormal, should be recorded. There should be a permanent record of all CW Doppler waveforms, plethysmographic waveforms and segmental blood pressures 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.

VII. EQUIPMENT SPECIFICATIONS

Arterial waveforms are obtained with a CW Doppler instrument 2 to 10 MHz 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 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 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.

PVRs 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

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 Technical Standard for Diagnostic Medical Physics Performance Monitoring of Real Time Ultrasound Equipment.

ACKNOWLEDGEMENTS

This practice parameter was revised according to the process described under the heading The Process for Developing ACR Practice Parameters and Technical Standards on the ACR website (http://www.acr.org/guidelines) by the Committee on Practice Parameters of the ACR Commissions on Interventional and Cardiovascular Radiology and Ultrasound, in collaboration with the AIUM, the SIR, and the SRU.

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

ACR
Raymond E. Bertino, MD, FACR, Chair
Beverly E. Hashimoto, MD, FACR
Michael S. Stecker, MD
Aradhana M. Venkatesan, MD

AIUM
Edward I. Bluth, MD, FACR
John S. Pellerito, MD

SIR
Suvranu Ganguli, MD
Steven C. Rose, MD
Venkataramu N. Krishnamurthy, MD

SRU
Edward G. Grant, MD, FACR
Mark E. Lockhart, MD, MPH
Michelle L. Robbin, MD, FACR

Committee on Practice Parameters – Interventional and Cardiovascular
(ACR Committee responsible for sponsoring the draft through the process)
Donald L. Miller, MD, FACR, Chair
Aradhana M. Venkatesan, MD, Vice-Chair
Stephen Balter, PhD, FACR
Lawrence T. Dauer, PhD
Robert G. Dixon, MD
Joshua A. Hirsch, MD, FACR
Sanjoy Kundu, MD
Philip M. Meyers, MD
John D. Statler, MD
Michael S. Stecker, MD
Timothy L. Swan, MD, FACR
Raymond H. Thornton, MD

Committee on Practice Parameters – Ultrasound
(ACR Committee responsible for sponsoring the draft through the process)
Mary C. Frates, MD, FACR, Chair
Beverly E. Hashimoto, MD, FACR, Vice-Chair
Sandra O. DeJesus Allison, MD
Marcela Bohm-Velez, MD, FACR
Helena Gabriel, MD
Ruth B. Goldstein, MD
Robert D. Harris, MD, MPH, FACR
Leann E. Linam, MD
Maitray D. Patel, MD
REFERENCES


*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.*

**Development Chronology for this Practice Parameter**

2007 (Resolution 32)
Revised 2012 (Resolution 28)
Amended 2014 (Resolution 39)