ACR–AIUM–SRU PRACTICE PARAMETER FOR THE PERFORMANCE OF PERIPHERAL ARTERIAL ULTRASOUND USING COLOR AND SPECTRAL DOPPLER

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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.

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[1]. 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 considering 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 variables such as the condition of the patient, limitations of available resources, or advances in knowledge or technology after publication of this document. However, a practitioner who employs an approach substantially different from the guidance in this document may consider documenting in the patient record information sufficient to explain the approach taken.

The practice of medicine involves the science, and 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 purpose of this document is to assist practitioners in achieving this objective.

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1 *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), and the Society of Radiologists in Ultrasound (SRU). Recommendations for Qualifications and Responsibilities of Personnel, Written Requests for the Examination, Documentation, and Quality Control and Improvement, Safety, Infection Control and Patient Education vary among the four organizations and are addressed by each separately.

These practice parameters are intended to assist practitioners performing noninvasive evaluation of the peripheral arteries using color and Doppler waveform analysis ultrasound. The sonographic examination of patients with peripheral vascular disease will, in general, complement the use of other physiologic tests, such as pressure measurements, plethysmographic recordings, and continuous wave Doppler. In selected cases a tailored examination is used to answer a specific diagnostic question. Although it is not possible to detect every abnormality, adherence to the following practice parameters will maximize the probability of detecting most of the abnormalities that occur in the extremity arteries.

II. INDICATIONS FOR PERIPHERAL ARTERIAL EXAMINATIONS

The indications for peripheral arterial ultrasound examination include, but are not limited to, the following:

1. The detection of stenoses or occlusions in segment(s) of the peripheral arteries in symptomatic patients with suspected arterial occlusive disease. These patients could present with recognized clinical indicators, such as claudication, rest pain, ischemic tissue loss, aneurysm, or arterial embolization [1-18].

2. The monitoring of sites of previous surgical interventions, including sites of previous bypass surgery with either synthetic or autologous vein grafts [19-25]

3. The monitoring of sites of various percutaneous interventions, including angioplasty, thrombolysis/thrombectomy, atherectomy, or stent placement [22,26-30]

4. Follow-up for progression of previously identified disease, such as documented stenosis in an artery that has not undergone intervention, aneurysms, atherosclerosis, or other occlusive diseases

5. The evaluation of suspected vascular and perivascular abnormalities, including such entities as arteritis, fibromuscular dysplasia, masses, aneurysms, pseudoaneurysms, arterial dissections, vascular injuries, arteriovenous fistulae, thromboses, emboli, or vascular malformations [31-36]

6. Mapping of arteries prior to surgical interventions [37-41]

7. Clarifying or confirming the presence of significant arterial abnormalities identified by other imaging modalities

8. Evaluation of arterial integrity in the setting of trauma

9. Evaluation of patients suspected of thoracic outlet syndrome, such as those with positional numbness, pain, tingling, or a cold hand

10. Allen's test to establish patency of palmar arch [42,43]

11. Temporal artery evaluation for temporal arteritis and/or to localize temporal arterial biopsy for suspected diagnosis of temporal arteritis [32,33]

Additional uses of Doppler ultrasound can include preoperative mapping for dialysis access and postoperative follow-up (see the ACR–AIUM–SRU Practice Parameter for the Performance of Ultrasound Vascular Mapping for Preoperative Planning of Dialysis Access [44] and the ACR–AIUM Practice Parameter for the Performance of Vascular Ultrasound for Postoperative Assessment of Dialysis Access) [45].

III. QUALIFICATIONS AND RESPONSIBILITIES OF THE PHYSICIAN

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

See the ACR–SPR–SRU Practice Parameter for the Performance and Interpretation of Diagnostic Ultrasound Examinations [46].

IV. SPECIFICATIONS OF THE EXAMINATION

The written or electronic request for a peripheral arterial ultrasound examination should provide sufficient information to demonstrate the medical necessity of the examination and allow for its proper performance and interpretation.

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

The request for the examination 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 – revised in 2016, Resolution 12-b)

The sonographic examination consists of grayscale imaging and spectral Doppler waveforms in the appropriate arterial segments. Color Doppler should be used to improve detection of arterial lesions by identifying visual narrowing and changes in color seen in stenoses and to guide placement of the sample volume for spectral Doppler assessment [10].

IV. SPECIFICATIONS OF THE EXAMINATION

A. Appropriate Techniques and Diagnostic Criteria

Specific sonographic techniques must be tailored to the clinical indication, the different arterial segments studied, and the specific pathology being evaluated. Diagnostic criteria for stenosis differ between native and postoperative and postprocedural arteries.

Velocity measurements are obtained from angle-corrected spectral Doppler waveforms obtained from longitudinal images. Every attempt should be made to acquire images where the angle created by the direction of blood flow and the direction of the ultrasound beam is kept at =60 degrees. Velocity estimates made from images using larger angles are less reliable.

For spectral Doppler, velocity ratio, absolute velocity, pulsatility indices and acceleration time have published criteria. One or more criteria may be used. The criteria may be validated for some but not all arterial segments (eg, acceleration time has been studied in the iliac and common femoral arteries). Waveform shape, presence or absence of turbulence and direction of flow may be used for appropriate indications.

For arterial stenoses, color Doppler should be optimized to detect narrowing of the lumen and high velocity (typically seen as aliasing) in the stenotic region.

IV. SPECIFICATIONS OF THE EXAMINATION

B. Arterial Occlusive Disease (Peripheral Arterial Disease)

Physiologic tests of the arterial system such as ankle brachial index (ABI), segmental pressure, continuous wave Doppler and plethysmographic waveform analysis are frequently the initial examinations performed to determine the presence of arterial disease and to identify patients appropriate for imaging [1,36,47]. These studies are

complementary and not equivalent to the sonographic examination.

The ABI may help evaluate the hemodynamic consequences of lower extremity arterial disease. A contemporaneous ABI, along with imaging, is complementary and supports the imaging findings or may suggest non visualized disease, or if discrepant, helps avoid pitfalls.

Representative longitudinal color Doppler and/or gray scale images along with angle-corrected spectral Doppler waveforms with velocity measurements should be documented for each normal arterial segment(s).

Suspected abnormalities should be documented with longitudinal gray scale and color Doppler images. Transverse images may be helpful. Documentation of flow abnormality can be performed by obtaining cine clips.

Angle-corrected spectral Doppler waveforms should be obtained from longitudinal images proximal to, at, and distal to sites of suspected stenosis. The sonographer/technologist should evaluate the vessel thoroughly throughout the stenosis to determine the highest peak systolic velocity (PSV). The highest PSV within the abnormal segment should be compared to the normal segments.

The highest angle-corrected peak systolic velocity in a stenosis should be recorded from a longitudinal image. A spectral Doppler waveform with velocity measurements should be recorded in the normal arterial segment 1 to 4 cm proximal (upstream) to a suspected stenosis. A waveform distal to a stenosis should be recorded since it is helpful to document a drop in velocity beyond the stenosis and poststenotic disturbed flow/turbulence. Distal abnormalities, as well as a poststenotic tardus parvus waveform, are signs of hemodynamic significance. If present, collateral branches should be recorded and documented including direction of flow within the reconstituted artery.

The location of any diseased or occluded segment(s) should also be documented. Estimated lengths of diseased or occluded segments may be helpful.

Gray scale, color and spectral Doppler evaluation of the following arterial segments should generally be performed as indicated below. The accessible portion of the entire vessel or the arterial segment(s) of interest should be evaluated.

1. Lower extremity
    a. Common femoral artery
    b. Proximal deep femoral artery
    c. Proximal superficial femoral artery
    d. Mid superficial femoral artery
    e. Distal superficial femoral artery above the knee
    f. Popliteal artery PSVs above and below the knee

If clinically appropriate, gray scale, color and spectral Doppler imaging of the common and external iliac, tibioperoneal trunk, anterior tibial, posterior tibial, peroneal, and dorsalis pedis arteries should be performed.

Evaluating multiple sites in an artery may be needed to adequately evaluate the vessel.

However, a focused or limited examination may be appropriate in certain clinical situations.

2. Upper extremity
    a. Subclavian artery
    b. Axillary artery
    c. Brachial artery

    If clinically appropriate, gray scale, color and spectral Doppler imaging of the innominate, radial, and ulnar arteries and the palmar arch should be performed.

    A focused or limited examination may be appropriate in certain clinical situations.

IV. SPECIFICATIONS OF THE EXAMINATION

C. Evaluation of Surgical and Percutaneous Interventions

1. Bypass grafts

   An attempt should be made to scan the full length of any arterial bypass graft using gray scale and color Doppler
   Representative longitudinal color Doppler and/or gray scale images should be documented for normal segments.
   Angle-corrected spectral Doppler waveforms should be obtained from longitudinal images.
   Angle-corrected spectral Doppler waveforms and peak systolic velocity measurements should be documented in the native artery proximal to the graft anastomosis, at the proximal anastomosis, at representative sites along the graft, at the distal anastomosis, and in the native artery distal to the anastomosis.
   Suspected abnormalities should also be imaged with longitudinal gray scale ultrasound. Representative longitudinal color and/or gray scale images of stenoses should be documented. Transverse images may be helpful.
   Angle-corrected spectral Doppler waveforms should be obtained from longitudinal images proximal to, at, and distal to sites of suspected stenosis. The sonographer/technologist should evaluate the graft conduit and the contiguous segments of the native arteries thoroughly throughout the stenosis to determine the highest peak systolic velocity.
   The highest angle-corrected peak systolic velocity in a stenosis should be recorded from longitudinal image.
   A spectral Doppler waveform with velocity measurements should be recorded in the normal arterial segment 1 to 4 cm proximal (upstream) to a suspected stenosis. A waveform distal to a stenosis should be recorded since it is helpful to document a drop in velocity beyond the stenosis and poststenotic disturbed flow/turbulence. Distal abnormalities, as well as a poststenotic tardus parvus waveform, are signs of hemodynamic significance. The presence of low PSVs and low-resistance waveforms within an otherwise normal graft should be noted as this can imply an increased risk of graft occlusion.

2. Endovascular interventions

   An attempt should be made to sample the site of arterial interventions as well as the segment immediately proximal (upstream) and distal (downstream) to the site of intervention. Stents should generally be scanned longitudinally along their entire length by gray scale and color Doppler, and representative images within the stent should be obtained. Transverse images may be helpful to document stent distortion or luminal narrowing by the outside plaque.
   Representative longitudinal color Doppler and/or gray scale images should be documented.
   All velocity measurements must be obtained from a longitudinal image.
   Angle-corrected spectral Doppler waveforms obtained from a longitudinal image and peak systolic velocity measurements should be documented in the native artery proximal to the intervention, at representative sites within an area of intervention (eg. proximal stent, mid stent, distal stent), and in the native artery distal to the intervention.
   Angle-corrected spectral Doppler waveforms should be obtained from longitudinal images proximal to, at, and distal to sites of suspected stenosis. The sonographer/technologist should evaluate the vessel thoroughly throughout the stenosis to determine the highest peak systolic velocity.
   The highest angle-corrected peak systolic velocity in a stenosis should be recorded from longitudinal image.
   A spectral Doppler waveform with peak systolic velocity measurements should be recorded in the normal arterial segment 1 to 4 cm proximal (upstream) to a suspected stenosis. A waveform distal to a stenosis should be recorded since it is helpful to document a drop in velocity beyond the stenosis and poststenotic disturbed flow/turbulence. Distal abnormalities, as well as a poststenotic tardus parvus waveform, are signs of hemodynamic significance.

IV. SPECIFICATIONS OF THE EXAMINATION

D. Other

1. Suspected soft-tissue abnormalities in proximity to arteries

The entire area of a suspected soft-tissue abnormality should be imaged. Spectral and color Doppler should be performed to document presence or absence of blood flow in the region of the suspected abnormality.

2. Pseudoaneurysms

   In evaluating patients with suspected pseudoaneurysms, the sonographer/technologist should evaluate vasculature and adjacent soft tissues in transverse and longitudinal planes, using color Doppler, at, above, and below the arterial puncture site since the vessel may have been punctured at or several centimeters away from the skin wound. For example, for evaluation of the groin area, Doppler interrogation should be performed from the distal external iliac artery to the proximal superficial femoral artery. Imaging in the longitudinal plane must also be obtained with representative color and spectral Doppler.
   When a pseudoaneurysm is identified, the overall size of the pseudoaneurysm sac, the size of the residual lumen (in cases of partially thrombosed PSA), and the length and width of the communicating channel (neck) should be documented with appropriate gray scale and color Doppler techniques. Spectral Doppler waveforms should be obtained in the communicating channel to demonstrate "to-and-fro" flow.
   In case of therapeutic intervention, color and/or spectral Doppler may be used as a guide to therapy and as a means of documenting therapeutic success [36,48-52].
   When present, the size and location of hematomas should be documented.
   The presence of hematomas should be documented and differentiated from pseudoaneurysms with Doppler image optimization to demonstrate absence of flow.

3. Abnormal communication between artery and vein (arterio-venous fistula (AVF)

   Color and spectral Doppler may be used to document the location of abnormal vascular communications. Spectral Doppler waveforms should be documented from the artery proximal to, in the area of, and distal to abnormal communications. Flow within the fistula should be recorded, if found. A spectral Doppler waveform from the draining vein should be documented above and below the fistula.
   Color Doppler is particularly useful for identifying the level of such communications because the flow disturbances in a fistula often create color Doppler signals in the adjacent soft tissue from transmitted vibrations and pressure changes (color bruit).

4. Peripheral aneurysms

   The location of aneurysms should be documented. The widest diameter of the artery or aneurysm should be measured (outer wall to outer wall) on gray scale images in short axis of the lumen. If present, patency of the vessel and the presence of intraluminal thrombus should be documented with gray scale and color and spectral Doppler images.

V. 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 imaging studies may prove helpful. Images of all appropriate areas, both normal and abnormal, should be recorded. Variations from normal size should generally be accompanied by measurements. Images should be labeled with the patient identification, facility identification, examination date, and image orientation. An official interpretation (final report) of the ultrasound examination should be included in the patient's medical record. Retention of the ultrasound examination images should be consistent both with clinical need and with relevant legal and local health care facility requirements.

Reporting should be in accordance with the ACR Practice Parameter for Communication of Diagnostic Imaging Findings [53].

VI. EQUIPMENT SPECIFICATIONS

Peripheral arterial sonography should be performed with a linear array or curved array transducer equipped with

pulsed Doppler and color Doppler capability. (Power or energy Doppler may be used if needed.) A linear array transducer helps visualize vessels with better resolution than most curved array transducers. The transducer should operate at the highest clinically appropriate frequency, recognizing that there is a trade-off between resolution and penetration. This should usually be at a frequency of 3.5 MHz or greater, with the occasional need for a lower frequency transducer. Evaluation of the flow signals originating from within the lumen of the vessel should be conducted with a carrier frequency of 2.5 MHz or greater.

VII. QUALITY CONTROL, AND IMPROVEMENT, SAFETY, INFECTION CONTROL, AND PATIENT EDUCATION

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 (https://www.acr.org/Advocacy-and-Economics/ACR-Position-Statements/Quality-Control-and-Improvement).

Equipment performance monitoring should be in accordance with the ACR–AAPM Technical Standard for Diagnostic Medical Physics Performance Monitoring of Real Time Ultrasound Equipment [54].

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