AIUM Practice Parameter for the Performance of Peripheral Arterial Ultrasound Examinations Using Color and Spectral Doppler Imaging

Introduction

The clinical aspects of this practice parameter were revised collaboratively among the American Ultrasound in Medicine (AIUM) and other organizations whose members use ultrasound for performing peripheral arterial ultrasound examinations using color and spectral Doppler imaging (see “Acknowledgments”). Recommendations for personnel requirements, the written request for the examination, documentation, quality control, and safety vary among the 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.

Indications/Contraindications

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, and 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, and 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, and vascular malformations.31-36
6. Mapping of arteries before 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 the 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 AIUM Practice Parameter for the Performance of Ultrasound Vascular Mapping for Preoperative Planning of Dialysis Access44 and the AIUM Practice Parameter for the Performance of Vascular Ultrasound for Postoperative Assessment of Dialysis Access.45)

Qualifications and Responsibilities of Personnel

See www.aium.org for AIUM Official Statements including Standards and Guidelines for the Accreditation of Ultrasound Practices and relevant Training Guidelines. If a sonographer performs the ultrasound examination, the sonographer should be credentialed in accordance with the AIUM Accreditation policies.

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 other appropriately licensed health care provider or under the provider’s direction. The accompanying clinical information should be provided by a physician or appropriate health care provider familiar with the patient’s clinical situation and should be consistent with relevant legal and local health care facility requirements.

Specifications of the Examination

The sonographic examination consists of gray scale 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

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° or less. 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.

B. Arterial Occlusive Disease (Peripheral Arterial Disease)

Physiologic tests of the arterial system such as the 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. 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 1–4 cm proximal (upstream) to a suspected stenosis. A waveform distal to a stenosis should be recorded because 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.

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 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 a longitudinal image. A spectral Doppler waveform with velocity measurements should be recorded in the normal arterial segment 1–4 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.

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 a longitudinal image. A spectral Doppler waveform with peak systolic velocity measurements should be recorded in the normal arterial segment 1–4 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.

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 pseudoaneurysm), 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 cases of therapeutic intervention, color and/or spectral Doppler imaging may be used as a guide to therapy and as a means of documenting therapeutic success.36,47-50

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 (arteriovenous fistula)

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 locations 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 an intraluminal thrombus should be documented with gray scale and color and spectral Doppler images.

Documentation

Adequate documentation is essential for high-quality patient care. Ultrasound images that contain diagnostic information and/or direct patient management (both normal and abnormal) should be recorded in accordance with the AIUM Practice Parameter for Documentation of an Ultrasound Examination.

Equipment Specifications

Peripheral arterial sonography should be performed with a linear 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 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.

Quality Control and Improvement, Safety, Infection Control, and Patient Education

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

ALAR A 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.51
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