AIUM Practice Parameter for the Performance of an

Ultrasound Examination of the Extracranial Cerebrovascular System

Parameter developed in collaboration with the American College of Radiology, the Society for Pediatric Radiology, and the Society of Radiologists in Ultrasound.

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The American Institute of Ultrasound in Medicine (AIUM) is a multidisciplinary 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 for Pediatric Radiology (SPR), and the Society of Radiologists in Ultrasound (SRU), this AIUM Practice Parameter for the Performance of an Ultrasound Examination of the Extracranial Cerebrovascular System. We are indebted to the many volunteers 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 ultrasound 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, 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 for Pediatric Radiology (SPR), and the Society of Radiologists in Ultrasound (SRU). Recommendations for physician requirements, written request for the examination, procedure documentation, and quality control vary between the 4 organizations and are addressed by each separately.

Ultrasound imaging, using grayscale imaging, Doppler spectral analysis, and color Doppler imaging (CDI), is a proven useful procedure for evaluating the extracranial cerebrovascular system. Although it is not possible to detect every abnormality, adherence to the following parameters will maximize the probability of detecting most extracranial cerebrovascular abnormalities. Occasionally, an additional and/or specialized examination may be necessary.

II. Indications

Indications for an ultrasound examination of the extracranial carotid and vertebral arteries include but are not limited to:

1. Evaluation of patients with hemispheric neurologic symptoms, including stroke, transient ischemic attack, and amaurosis fugax;\(^1\)
2. Evaluation of patients with a cervical bruit;
3. Evaluation of pulsatile neck masses;
4. Preoperative evaluation of patients scheduled for major cardiovascular surgical procedures;
5. Evaluation of nonhemispheric or unexplained neurologic symptoms;
6. Follow-up evaluation of patients with proven carotid disease;
7. Evaluation of postoperative or postinterventional patients after cerebrovascular revascularization, including carotid endarterectomy, stenting, or carotid-to-subclavian artery bypass graft;
8. Intraoperative monitoring of vascular surgery;
9. Evaluation of suspected subclavian steal syndrome;\(^5\)
10. Evaluation for suspected carotid artery dissection, arteriovenous fistula, or pseudoaneurysm;
11. Evaluation of patients with carotid reconstruction after extracorporeal membrane oxygenation bypass;
12. Evaluation of patients with syncope, seizures, or dizziness;
13. Screening high-risk patients: atherosclerosis elsewhere, history of head and neck radiation, known fibromuscular dysplasia (FMD), Takayasu arteritis, or other vasculopathy in another circulation;
14. Neck trauma; and
15. Hollenhorst plaque visualized on retinal examination.
III. Qualifications and Responsibilities of the Physician

See www.aium.org for AIUM Official Statements including *Standards and Guidelines for the Accreditation of Ultrasound Practices* and relevant Physician Training Guidelines.\(^7\)

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 other appropriately licensed health care provider or under the provider’s direction. The accompanying clinical information should be provided by a physician or other 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

Extracranial cerebrovascular ultrasound evaluation consists of assessment of the accessible portions of the common carotid, external and internal carotid, and the vertebral arteries.

A. Scanning Technique

All arteries should be scanned using appropriate gray scale and Doppler techniques and proper patient positioning.\(^2,3,8\) The common carotid and internal carotid arteries should be scanned in grayscale and with color Doppler as completely as possible. Caudal angulation of the transducer in the supraventricular area and cephalad angulation at the level of the mandible may aid analysis.\(^3,4\) The vertebral arteries can be evaluated between the vertebral transverse processes in the middle neck or at their origins. Grayscale imaging of the common carotid artery, its bifurcation, and both the internal and external carotid arteries should be performed in longitudinal and transverse planes. Gain should be optimized to detect the vessel wall, plaque, and other abnormalities.

Color Doppler imaging should be used to detect areas of narrowing and abnormal flow to select areas for spectral analysis. Color Doppler is also helpful to detect external carotid artery branches to definitively identify this vessel. Color Doppler should be used to clarify the cause of image/pulsed Doppler mismatches and to detect narrow flow channels at sites of stenosis.\(^7\) Power Doppler evaluation may be complementary to color Doppler to search for a narrow channel of residual flow in suspected occlusion or near occlusion.

Long axis spectral Doppler velocity measurements with angle correction should be obtained at representative sites in all vessels. Additionally, scanning in and through areas of stenosis or suspected stenosis must be adequate to determine the maximal peak systolic velocity associated with the stenosis and to document disturbances in the waveform distal to the stenosis.
Consistent angle correction is essential for determining blood flow velocity. All angle-corrected spectral Doppler waveforms must be obtained from longitudinal images.

All patients at a facility should be scanned with the same angle-correction technique (either parallel to the vessel wall or in line with the color lumen) to ensure consistency between serial examinations and between patients. The angle between the direction of flowing blood and the applied Doppler ultrasound signal (angle $\theta$ [theta], the Doppler angle) should be between 45 and 60 degrees whenever possible. The potential velocity error related to incorrect angle assignment increases with the Doppler angle, especially at angles above 60 degrees. Angles exceeding 60 degrees should be avoided whenever possible since the calculated velocity using overly high angles is fallible. Techniques to obtain an appropriate angle (eg, heel and toe angulation of the transducer) may be necessary. Deviations from the protocol may be unavoidable (eg, it may not be possible to obtain an appropriate angle with a very tortuous vessel) but should be minimized. Spectral Doppler gain should be appropriate for the vessel scanned. Either excessive or inadequate gain may lead to errors in diagnosis. The Doppler scale should be set to maximize the size of the waveforms without resulting in aliasing to improve accuracy and reproducibility of measurement. Images must be obtained with appropriate color Doppler technique to demonstrate filling of the normal lumen and/or flow disturbances associated with stenoses. The color Doppler scale should be chosen to avoid aliasing at typical carotid velocities, and the gain should be set to minimize artifacts.

**B. Recording**

1. **Grayscale:** At a minimum, for each normal side evaluated, grayscale images must be obtained at each of the following levels:
   a. Long axis of common carotid artery;
   b. Long axis, at the carotid artery bifurcation;
   c. Long axis of internal carotid artery to include its origin; and
   d. Short axis of proximal internal carotid artery.

   If abnormalities are found, additional images must be recorded:
   a. If atherosclerotic plaques are present, location, extent, and characteristics should be documented with grayscale imaging in both longitudinal and transverse planes.
   b. Other vascular or significant perivascular abnormalities should be documented.

2. **Color Doppler:** At a minimum, for each normal side evaluated, color Doppler images (using color alone or as part of the spectral Doppler image) must be obtained at each of the following levels:
   a. Long axis of distal common carotid artery;
   b. Long axis of proximal and midinternal carotid artery;
   c. Long axis of external carotid artery (with identification of a branch if possible); and
   d. Long axis of vertebral artery.
If abnormalities are found, additional images must be recorded.
   a. If atherosclerotic plaques are present, extent and effect on the lumen should be recorded.
   b. In cases of occlusion, a color and/or power Doppler image of the abnormal vessel should be obtained.
   c. Other vascular or significant perivascular abnormalities should be documented.
3. Spectral Doppler: For each normal side evaluated, spectral Doppler waveforms and maximal peak systolic velocities must be recorded at each of the following levels:
   a. Proximal common carotid artery;
   b. Middle or distal common carotid artery (2–3 cm below the bifurcation);
   c. Proximal internal carotid artery;
   d. Mid to distal cervical internal carotid artery;
   e. Proximal external carotid artery; and
   f. Vertebral artery (in neck or near origin).

If significant stenosis is found or suspected, additional images must be recorded and the location of the stenosis determined:
   a. At the site of maximum velocity due to the stenosis; and
   b. Distal to the site of maximal velocity to document the presence or absence of disturbed flow.

Velocity ratios and diastolic velocities may also be calculated as warranted depending on the laboratory interpretation criteria.

The peak systolic velocity and flow direction in each of the vertebral arteries should be recorded.

Stents require additional images. In patients with indwelling stents, grayscale, spectral, and color Doppler should be used to evaluate the lumen, stent deployment, and flow within each stent, and flow proximal and distal to each stent. The site of highest peak systolic velocity as well as the waveforms distal to this site should be recorded.

C. Interpretation

The interpretation of cerebrovascular ultrasound images requires careful attention to protocol and interpretation criteria.

1. Each laboratory must have interpretation criteria that are used by all members of the technical and physician staff.
2. Diagnostic criteria must be derived from the literature or from internal validation based on correlation with other imaging modalities or surgical and/or pathologic correlation.1,3,6,10–15
3. The report must indicate internal carotid artery stenosis categories that are clinically useful and nationally or internationally accepted and based primarily upon velocity criteria and waveform analysis. Stenoses above 50% should be graded to within a range (eg, 50%–69% or 70% to near occlusion) or a numeric grade (eg, 60% ± 10%) to provide adequate information for clinical decision making.

4. Numerous factors may falsely increase or decrease velocities (eg, systemic disease, cardiovascular disease, contralateral severe disease or occlusion, near occlusive stenoses). Simple velocity criteria may not be valid for a younger-than-usual population. Secondary criteria such as ratios may be helpful in these circumstances.

5. The report should describe abnormal waveforms, if present.

6. The report must indicate vertebral artery flow direction.

7. The report may characterize plaques, depending on the laboratory interpretation criteria.

8. The report should describe significant nonvascular abnormalities.

9. The criteria for common carotid and vertebral artery stenosis differ from internal carotid artery criteria.

10. A velocity threshold that indicates an external carotid stenosis is not established. A simple description indicating a stenosis, if present, may be reported. Identification of stenosis can be based on grayscale and/or color flow narrowing, elevated velocity through the stenosis, and typical poststenotic waveforms.

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

The examination should be conducted with a real-time scanner with Doppler capability, preferably using a linear transducer. The examination should use the highest clinically appropriate frequency, realizing that there is a trade-off between resolution and beam penetration.
Imaging frequencies should be 5.0 MHz or greater. Doppler flow analysis should be conducted with a carrier frequency of 3.0 MHz or greater. Lower frequencies are occasionally appropriate in patients with a large body habitus or densely calcified vessels. Examination using lower-frequency transducers can also be useful when the vessels are not adequately imaged at higher frequencies. Color Doppler imaging can be used to localize blood flow abnormalities for range gate placement for the Doppler spectral analysis, thus facilitating the examination.

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, Third Edition.

Acknowledgments

This parameter was revised by the American Institute of Ultrasound in Medicine (AIUM) in collaboration with the American College of Radiology (ACR), the Society for Pediatric Radiology (SPR), and the Society of Radiologists in Ultrasound (SRU) according to the process described in the AIUM Clinical Standards Committee Manual.

Collaborative Committee

Members represent their societies in the initial and final revisions of this parameter.
References


