ACR–AIUM–SPR–SRU PRACTICE PARAMETER FOR THE PERFORMANCE OF AN ULTRASOUND EXAMINATION OF THE EXTRACRANIAL CEREBROVASCULAR SYSTEM

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), 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 four organizations and are addressed by each separately.

Ultrasound using grayscale imaging, Doppler spectral analysis, and color Doppler imaging (CDI) is a proven diagnostic procedure for evaluating the extracranial cerebrovascular system. Although it is not possible to detect every abnormality, adherence to the following practice parameters will maximize the probability of detecting most extracranial cerebrovascular abnormalities.

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 [1-3]
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 known or documented carotid disease
7. Postoperative or postintervention evaluation of patients following cerebrovascular revascularization, including carotid endarterectomy, stenting, or carotid to subclavian artery bypass graft
8. Intraoperative monitoring of vascular surgery
9. Evaluation for suspected subclavian steal syndrome [4]
10. Evaluation for suspected carotid artery dissection [5], arteriovenous fistula, or pseudoaneurysm
11. Evaluation of patients with carotid reconstruction after extracorporeal membrane oxygenation (ECMO) bypass
12. Evaluation of patients with syncope, seizures, or dizziness
13. Screening high-risk patients including atherosclerosis elsewhere, history of head and neck radiation, known fibromuscular dysplasia (FMD), Takayasu arteritis, or other vasculopathy in another circulation
14. Neck trauma
15. Hollenhorst plaque visualized on retinal examination

III. QUALIFICATIONS AND RESPONSIBILITIES OF THE PHYSICIAN

See the ACR–SPR–SRU Practice Parameter for the Performance and Interpretation of Diagnostic Ultrasound Examinations [6].

IV. WRITTEN REQUEST FOR THE EXAMINATION

The written or electronic request for extracranial cerebrovascular 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). 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's scope of practice requirements. (ACR Resolution 35 adopted in 2006 – revised in 2016, Resolution 12-b)

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 are scanned using appropriate grayscale and Doppler techniques and proper patient positioning [2,3,7]. The common carotid and internal carotid arteries are scanned in grayscale and with color Doppler, as completely as possible. Caudad angulation of the transducer in the supraclavicular area and cephalad angulation at the level of the mandible may aid visualization [3,8]. The vertebral arteries can be evaluated in the mid neck between the vertebral transverse processes, proximally in the preforaminal (extraosseous) segment, or as they originate from the subclavian arteries. Grayscale imaging of the common carotid artery, its bifurcation, and both the internal and external carotid arteries is performed in longitudinal and transverse planes. Gain is optimized to detect the vessel wall, plaque, and other abnormalities.

Color Doppler is used to detect areas of narrowing and abnormal flow to select areas for spectral analysis. Color Doppler is also helpful to detect external carotid branches to definitively identify the external carotid artery. Color Doppler is used to clarify the cause of image/pulsed Doppler mismatches and to detect narrow flow channels at sites of stenoses [9]. Power Doppler evaluation may be complementary to color Doppler to search for narrow channels of residual flow in arteries in which occlusion or near occlusion is suspected.

Long-axis spectral Doppler velocity measurements with angle correction should be obtained at representative predetermined sites in all vessels. Additionally, scanning in and through an area of stenosis or suspected stenosis must be adequate to determine the maximal peak systolic velocity and end diastolic 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 [2]. 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 flow lumen) to ensure consistency on serial examinations and among patients. The angle of insonation should be between 45 and 60 degrees whenever possible. The potential velocity error related to incorrect angle assignment increases with increasing Doppler angle, especially at angles above 60 degrees [3]. Angles exceeding 60 degrees should be avoided whenever possible. Techniques to obtain an appropriate angle (eg, heel and toe angulation of the transducer) may be necessary. Deviations from protocol may be unavoidable (eg, it may not be possible to obtain an appropriate angle with a very tortuous vessel) but should be minimized and documented on the technologist worksheet and final report.

Spectral Doppler gain should be appropriate for the vessel scanned. Either excessive or inadequate gain may lead to errors.

The Doppler scale should be set to maximize the size of the waveforms without 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 adjusted to avoid aliasing at typical carotid velocities, and the gain should be set to minimize artifacts.

B. Recording

1. Grayscale: For each normal side evaluated, representative grayscale images must be obtained at the following levels:
    a. Long axis of common carotid artery
    b. Long axis at carotid artery bifurcation

c. Long axis of internal carotid artery to include its origin
d. Short axis of proximal internal carotid artery

If abnormalities are found, additional images must be acquired:

e. If atherosclerotic plaques is present, location, extent, and characteristics should be documented with grayscale imaging in both longitudinal and transverse planes.
f. Other vascular or significant perivascular abnormalities should be documented.

2. Color Doppler: 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 mid internal carotid artery
   c. Long axis of external carotid artery (with identification of a branch if possible)
   d. Long axis of vertebral artery

   If abnormalities are found, additional images of the abnormality must be acquired.

   e. If atherosclerotic plaque is present, the extent and effect on the lumen should be determined and documented with a color flow Doppler image
   f. In cases of occlusion, a color and/or power Doppler image of the occluded vessel must be acquired
   g. 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 and end diastolic velocities must be recorded at each of the following levels:
   a. Proximal common carotid artery
   b. Mid to distal common carotid artery (generally 2-3 cm proximal to the bifurcation where the walls are parallel to one another, namely, proximal to the bulb)
   c. Proximal internal carotid artery
   d. Mid to distal cervical internal carotid artery
   e. Proximal external carotid artery
   f. Vertebral artery (in the mid neck or at/near the origin)

   If a significant stenosis is found or suspected, additional images must be recorded and the location of the stenosis determined:

   g. At the site of maximum velocity due to the stenosis
   h. Distal to the site of maximal velocity to document the presence or absence of poststenotic turbulent flow.

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

   The peak systolic velocity, end diastolic velocity, waveform shape, and flow direction in each of the vertebral arteries should be recorded.

   The duplex ultrasound examination after carotid angioplasty and/or stenting requires additional images. In these patients, grayscale, spectral, and color Doppler should be used to evaluate the lumen of the stented vessel, the stent deployment and apposition to the artery wall at the most proximal and distal extent of the stent/s, flow within the stents, and flow proximal and distal to the stent(s). The maximal in-stent peak systolic velocity and the waveforms distal to this site should be documented.

C. Interpretation

The interpretation of cerebrovascular ultrasound 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 correlation with surgery or pathology [2,3,5,10-14].
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 [1-3,15].
4. Stenoses above 50% should be graded to within a range to provide adequate information for clinical decision-making.
5. Numerous factors may falsely increase or decrease velocities (eg, systemic disease, cardiovascular disease, contralateral severe disease or occlusion, near occlusive stenoses) [7,16-18]. Simple velocity criteria may not be valid for children or younger adults, and other criteria, such as ratios, may be helpful in these circumstances.
6. The report should describe abnormal waveforms, if present [4,19,20].
7. The report must indicate vertebral artery flow direction.
8. The report may characterize plaques, depending on the laboratory interpretation criteria [21-25].
9. The report should describe significant nonvascular abnormalities.
10. The criteria for common carotid and vertebral artery stenosis differ from internal carotid artery criteria [26,27].
11. 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.
12. The velocity criteria for stenosis after interventions may require different criteria than native vessels [28,29]. Stents require different velocity criteria than native vessels [30-33].

VI. DOCUMENTATION

Reporting should be in accordance with the ACR Practice Parameter for Communication of Diagnostic Imaging Findings [34].

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. The initials of the operator should be accessible on the images or electronically in the electronic record (eg, PACS or radiology information system (RIS)). 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 should be based on clinical need and relevant legal and local health care facility requirements.

VII. EQUIPMENT SPECIFICATIONS

Equipment performance monitoring should be in accordance with the ACR-AAPM Technical Standard for Diagnostic Medical Physics Performance Monitoring of Real Time Ultrasound Equipment [35].

The examination should be conducted with a real-time scanner with color, flow and spectral 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. CDI 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 EDUCATIONS

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 *ACR Position Statement on Quality Control & 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).

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