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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.

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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 care¹. 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 physician or medical physicist in light of all the circumstances presented. Thus, an approach that differs from the practice parameters, 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 the practice parameters 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 the practice parameters. However, a practitioner who employs an approach substantially different from these practice parameters 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 these practice parameters 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 these practice parameters 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 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 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 practice 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 [1-4]
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 following 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 [6], arteriovenous fistula, or pseudoaneurysm
11. Evaluation of patients with carotid reconstruction after ECMO (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
15. Hollenhorst plaque visualized on retinal examination

III. QUALIFICATIONS AND RESPONSIBILITIES OF THE PHYSICIAN

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](#) [7].

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 extracranial cerebrovascular ultrasound 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)

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 grayscale 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. Caudad angulation of the transducer in the supraclavicular 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 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 [9]. 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 [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 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 θ [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 [3]. 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 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 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 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)
 - 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-to-3 cm below the bifurcation)
 - c. Proximal internal carotid artery
 - d. Mid to distal cervical internal carotid artery
 - e. Proximal external carotid artery
 - f. Vertebral artery (in neck or near origin)

If a 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
- 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 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 pathological correlation [2,3,6,10-15].
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 [1-3]. Stenoses above 50% should be graded to within a range (eg, 50% to 69%, 70% to near occlusion) or a numerical grade (eg, 60% \pm 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) [8,16-18]. 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 [5,19].
6. The report must indicate vertebral artery flow direction.
7. The report may characterize plaques, depending on the laboratory interpretation criteria [20-24].
8. The report should describe significant nonvascular abnormalities.
9. The criteria for common carotid and vertebral artery stenosis differ from internal carotid artery criteria [25,26].
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.
11. The velocity criteria for stenosis after interventions may require different criteria than native vessels [27,28]. Stents require different velocity criteria than native vessels [29-32].

VI. DOCUMENTATION

Each organization will address this section in its document. ACR language is as follows:

Adequate documentation is essential for high quality in 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 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.

Reporting should be in accordance with the [ACR Practice Parameter for Communication of Diagnostic Imaging Findings](#) [33].

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. 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 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](#) [34].

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Collaborative Committee – members represent their societies in the initial and final revision of this practice parameter

ACR

Laurence Needleman, MD, FACR, Chair
Monica S. Epelman, MD
Edward G. Grant, MD, FACR

AIUM

David M. Paushter, MD, FACR
John S. Pellerito, MD, FACR
Leslie M. Scoult, MD, FACR

SPR

Harris L. Cohen, MD, FACR
Harriet J. Paltiel, MD

SRU

Barbara S. Hertzberg, MD, FACR
Mark A. Kliewer, MD

Committee on Practice Parameters – Ultrasound

(ACR Committee responsible for sponsoring the draft through the process)

Beverly E. Hashimoto, MD, FACR, Chair
Sandra O. DeJesus Allison, MD
Teresita L. Angtuaco, MD, FACR
Marcela Böhm-Velez, MD, FACR
Maria A. Calvo-Garcia, MD
Nirvikar Dahiya, MD
Helena Gabriel, MD
David U. Kim, MD
Gail N. Morgan, MD
Harriet J. Paltiel, MD
Henrietta Kotlus Rosenberg, MD, FACR
Sheila Sheth, MD, FACR

Maryellen R.M. Sun, MD
Sharlene A. Teefey, MD, FACR
Jason M. Wagner, MD

Committee on Practice Parameters – Pediatric Radiology
(ACR Committee responsible for sponsoring the draft through the process)

Beverley Newman, MB, BCh, BSc, FACR, Chair
Lorna P. Browne, MB, BCh
Timothy J. Carmody, MD
Brian D. Coley, MD, FACR
Lee K. Collins, MD
Monica S. Epelman, MD
Lynn Ansley Fordham, MD, FACR
Kerri A. Highmore, MD
Sue C. Kaste, DO
Tal Laor, MD
Terry L. Levin, MD
Marguerite T. Parisi, MD, MS
Sumit Pruthi, MBBS
Nancy K. Rollins, MD
Pallavi Sagar, MD

Beverly G. Coleman, MD, FACR, Chair, Commission on Ultrasound
Marta Hernanz-Schulman, MD, FACR, Chair, Commission on Pediatric Radiology
Jacqueline A. Bello, MD, FACR, Chair, Commission on Quality and Safety
Matthew S. Pollack, MD, FACR, Chair, Committee on Practice Parameters and Technical Standards

Comments Reconciliation Committee

Andrew Moriarity, MD, Chair
Amy L. Kotsenas, MD, Co-Chair
Jacqueline A. Bello, MD, FACR
Edward I. Bluth, MD, FACR
Harris L. Cohen, MD, FACR
Beverly G. Coleman, MD, FACR
Monica S. Epelman, MD
Edward G. Grant, MD, FACR
Beverly E. Hashimoto, MD, FACR
Marta Hernanz-Schulman, MD, FACR
William T. Herrington, MD, FACR
Barbara S. Hertzberg, MD, FACR
Mark A. Kliewer, MD
Paul A. Larson, MD, FACR
Neel Madan, MD
Laurence Needleman, MD, FACR
Beverley Newman, MB, BCh, BSc, FACR
Harriet J. Paltiel, MD
David M. Paushter, MD, FACR
John S. Pellerito, MD, FACR
Matthew S. Pollack, MD, FACR
Leslie M. Scoutt, MD, FACR
Timothy L. Swan, MD, FACR

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