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The American College of Radiology will periodically define new practice guidelines 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 guidelines and technical standards will be reviewed for revision or renewal, as appropriate, on their fifth anniversary or sooner, if indicated.

Each practice guideline 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, requiring the approval of the Commission on Quality and Safety as well as the ACR Board of Chancellors, the ACR Council Steering Committee, and the ACR Council. The practice guidelines 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 guideline and technical standard by those entities not providing these services is not authorized.

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

PREAMBLE

These guidelines are an educational tool designed to assist practitioners in providing appropriate radiation oncology care for patients. They are not inflexible rules or requirements of practice and are not intended, nor should they be used, to establish a legal standard of care. For these reasons and those set forth below, the American College of Radiology cautions against the use of these guidelines 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 guidelines, 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 guidelines 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 guidelines. However, a practitioner who employs an approach substantially different from these guidelines 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 guidelines 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 guidelines is to assist practitioners in achieving this objective.

I. INTRODUCTION

The clinical aspects contained in specific sections of this guideline (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 physician requirements, written request for the examination, procedure documentation, and quality control vary between the three organizations and are addressed by each separately.

Ultrasound, using grayscale imaging, Doppler spectral analysis, and color Doppler imaging (CDI), is a proven and useful procedure for evaluating the extracranial cerebrovascular system. While it is not possible to detect every abnormality, adherence to the following guidelines 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 of patients with proven carotid disease.
7. Evaluation of postoperative patients following cerebrovascular revascularization, including carotid endarterectomy, stenting, or carotid to subclavian bypass.
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. Patients with carotid reconstruction after ECMO (extracorporeal membrane oxygenation) bypass.

III. QUALIFICATIONS AND RESPONSIBILITIES OF THE PHYSICIAN

Each organization addresses this requirement individually. ACR language is as follows:

See the [ACR–SPR–SRU Practice Guideline for Performing and Interpreting Diagnostic Ultrasound Examinations](#).

IV. WRITTEN REQUEST FOR THE EXAMINATION

Each organization addresses this requirement individually. 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

A. Technique

Extracranial cerebrovascular ultrasound evaluation consists of assessment of the accessible portions of the common and internal carotid arteries, and basic assessment of the external carotid and vertebral arteries. All arteries should be scanned using appropriate grayscale and Doppler techniques and proper patient positioning [2-3,7]. 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. The internal carotid and common carotid arteries should be imaged as completely as possible with caudad angulation of the transducer in the supraclavicular area and cephalad angulation at the level of the mandible [3-4].

CDI should be used to detect areas of narrowing and abnormal flow to select areas for Doppler spectral analysis. CDI should also be used to clarify the cause of image/pulsed Doppler mismatches and to detect narrow flow channels seen in high-grade (near occlusive) stenoses [8]. Power Doppler evaluation may be helpful to search for a narrow channel of residual flow in suspected occlusion or near-occlusion.

Spectral Doppler with angle-corrected blood-flow velocity measurements should be obtained at representative sites in the vessels. Additionally, scanning in 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.

Angle correction should be applied in a consistent manner for all measurements (typically either parallel to the vessel wall or in line with the color lumen but not both). The angle between the direction of flowing blood and the applied Doppler ultrasound signal (angle θ [theta], the Doppler angle) should not exceed 60 degrees. The reliability of velocity measurements decreases

significantly at angles above 60 degrees, and the use of velocity measurements obtained at angles above 60 degrees is discouraged [3]. Deviations from protocol may be unavoidable (e.g., with a very tortuous vessel) but should be minimized. Gain should be appropriate for the vessel scanned (undergaining or overgaining may affect velocity measurements).

B. Recording

1. Grayscale image: At a minimum, for each normal side evaluated, grayscale images must be obtained at each of the following levels:
 - a. Long axis common carotid artery.
 - b. Long axis at carotid artery bifurcation.
 - c. Long axis internal carotid artery.
 - d. Short axis proximal internal carotid artery.

If abnormalities are found, additional images must be recorded:

- a. If atherosclerotic plaques are present, their extent, location, and characteristics should be documented with grayscale imaging in both the longitudinal and transverse planes.
 - b. Other vascular or significant perivascular abnormalities should be documented.
2. Color Doppler: Color images may be recorded using appropriate color technique to demonstrate filling of the normal lumen and/or flow disturbances associated with stenoses. In cases of occlusion, a color and/or power Doppler image of the abnormal vessel should be obtained to confirm that it is occluded.
 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. Mid or distal common carotid artery (generally 2 to 3 cm below the bifurcation).
 - c. Proximal internal carotid artery.
 - d. Distal 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.

Diastolic velocities and velocity ratios 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. Indwelling stents should be sampled within, proximal, and distal to each stent, and the site of highest velocity should be determined and 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 from internal validation based on correlation with other imaging modalities or from surgical and/or pathological correlation [2-3,6,9-11].
3. The report must indicate internal carotid artery stenosis categories that are clinically useful and nationally accepted [1-3]. Stenosis above 50% should be graded as a range (e.g., 50% to 69%, 70% to near occlusion) or a numerical grade (e.g., 60% \pm 10%) to provide adequate information for clinical decision-making. Numerous factors affect interpretation criteria, (e.g., contralateral severe disease or occlusion, ipsilateral near occlusion) [7,12-14].
4. The report must indicate vertebral artery flow direction and should indicate abnormal waveform shape [5,15].
5. The report may indicate plaque characterization depending on the laboratory interpretation criteria [16-20].
6. The report should indicate other significant nonvascular abnormalities.
7. The criteria for common and external carotid artery stenosis differ from internal carotid artery criteria [21-22].
8. Stents require different criteria than native vessels [23-26].

When available, modalities, parameters, and tests other than duplex ultrasound may add valuable information to the cerebrovascular Doppler ultrasound examination.

VI. DOCUMENTATION

Each organization addresses this requirement individually. 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 on PACS. 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 Guideline for Communication of Diagnostic Imaging Findings](#).

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 addresses this requirement individually. 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 web site (<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](#).

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