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## Examination of the Extracranial Cerebrovascular System Ultrasound Protocol

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### 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.
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.
10. Evaluation for suspected carotid artery dissection, arteriovenous fistula or pseudoaneurysm.
11. Patients with carotid reconstruction after ECMO (extracorporeal membrane oxygenation) bypass.

### Required Images

#### 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. Grayscale imaging of the common

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- 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.
- 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. 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. 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  $\theta$  [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. 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**

- Grayscale image: At a minimum, for each normal side evaluated, grayscale images must be obtained at each of the following levels:
  1. Long axis common carotid artery.
  2. Long axis at carotid artery bifurcation.
  3. Long axis internal carotid artery.
  4. Short axis proximal internal carotid artery.
- If abnormalities are found, additional images must be recorded:

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1. If atherosclerotic plaques are present, their extent, location, and characteristics should be documented with grayscale imaging in both the longitudinal and transverse planes.
  2. Other vascular or significant perivascular abnormalities should be documented.
- 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.
  - Spectral Doppler: For each normal side evaluated, spectral Doppler waveforms and maximal peak systolic velocities must be recorded at each of the following levels:
    1. Proximal common carotid artery.
    2. Mid or distal common carotid artery (generally 2 to 3 cm below the bifurcation).
    3. Proximal internal carotid artery.
    4. Distal internal carotid artery.
    5. Proximal external carotid artery.
    6. 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:
    1. At the site of maximum velocity due to the stenosis.
    2. 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.

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## 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.
  3. The report must indicate internal carotid artery stenosis categories that are clinically useful and nationally accepted. 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).
  4. The report must indicate vertebral artery flow direction and should indicate abnormal waveform shape.
  5. The report may indicate plaque characterization depending on the laboratory interpretation criteria.
  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.
  8. Stents require different criteria than native vessels.

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