

ULTRASOUND - CAROTID DOPPLER COMPLETE EVALUATION

PURPOSE: To evaluate the extracranial carotid and vertebral arterial system for atherosclerosis or stenosis

SCOPE:

Applies to all US Doppler studies of the carotid arteries performed in Imaging Services / Radiology

ORDERABLE:

- US Doppler Carotid Bilateral / Complete

INDICATIONS:

- Carotid bruit
- Hemispheric neurological symptoms (eg. stroke, TIA, amaurosis fugax)
- Non-hemispheric neurological symptoms (eg. vertigo, ataxia, diplopia, drop attacks, sudden blurred vision, bilateral paresthesia)
- Unexplained neurological symptoms (eg. syncope, headache, memory loss, and confusion)
- Trauma
- Pulsatile neck mass
- History of stenosis
- Prior endarterectomy
- Transplant or other major surgery evaluation
- Carotid stent evaluation

CONTRAINDICATIONS:

- Dizziness alone is not sufficient indication for this exam

EQUIPMENT:

Select a transducer that allows for appropriate penetration and resolution depending on body habitus.

- Linear transducer with a frequency range > 9 MHz

PATIENT PREPARATION:

- Introduce yourself to the patient
- Verify patient identity using patient name and DOB
- Explain test
- Obtain patient history including symptoms. Enter and store data page.
- Place patient in supine position

GENERAL GUIDELINES:

A complete examination includes evaluation of the bilateral common, extracranial internal carotid, and proximal external carotid arteries as well as the extracranial portions of bilateral vertebral arteries.

- The examination must be bilateral unless otherwise contraindicated
- A complete examination includes evaluation of the entire course of the accessible portions of each vessel
- Variations in technique must be documented (i.e., stents)

TECHNICAL CONSIDERATIONS:

- Supine position with head tilted away from side of interest
- Equipment gain and display settings will be optimized while imaging vessels with respect to depth, dynamic range, and focal zones
 - Color-flow Doppler images with proper color scale to demonstrate areas of high flow and color aliasing
 - Spectral Doppler gains will be set to allow a spectral window and optimized to reduce artifact
 - An angle of 60 degrees or less will be used to measure velocities
 - Doppler angle should always be parallel to the vessel wall
- Perform evaluation in transverse followed by longitudinal, first right side then left.
 - Transverse images are taken perpendicular to the long axis of the vessel
 - Longitudinal images are taken along the long axis of the vessel
- In transverse plane, label External (E) and Internal (I) carotid arterials just distal to the bifurcation.
- Sites of interrogation will include spectral Doppler waveforms and velocity measurements from the proximal, mid, and distal sites
- Plaque should be assessed and characterized as smooth, irregular, homogenous, or heterogeneous.
 - Color and angle corrected spectral Doppler imaging may provide additional information including improved visualization of hypoechoic plaque
 - Transverse grayscale and color images of moderate to severe plaque should be documented
- For ICA/CCA Peak Systolic Velocity ratio, use the highest PSV in the internal carotid artery and the PSV in the distal common carotid artery.
- Obtain bilateral brachial blood pressures.
- If unable to obtain brachial blood pressures:
 - Image bilateral subclavian arteries;
 - Measure subclavian PSV and compare right to left.
- If there is a > 20 cc/sec difference in the PSV or the BP from left to right, consider subclavian steal. Obtain waveforms of both the medial and lateral aspects of the subclavian artery.
- Areas of suspected stenosis or obstruction will include:
 - Spectral Doppler waveforms and velocity measurements recorded at and distal to the stenosis or obstruction
 - **Carotid Cine Clips:**
 - Only in areas of at least moderate stenosis (>49%);
 - Dual-screen W/O and W/ color (LONG ONLY).
 - If only mild plaque (<50%), no cine loops needed.
- Special instructions for duplex of carotid stent:
 - Location of the carotid stent should be determined
 - Most typically, stent is placed from CCA-to-ICA;
 - Less commonly, may lie in the ICA only, CCA only, or CCA-to-ECA rarely.

IMAGE DOCUMENTATION: CAROTID ARTERY DUPLEX

Anatomy (Perform on right side first, then left side)	Grey Scale [^]	Color Doppler [^]	Waveform	PSV	EDV
Routine Carotid Duplex					
CCA transverse: proximal*	X	X			
CCA transverse: mid*	X	X			
CCA transverse: distal*	X	X			
CCA bifurcation: transverse; label "I" and "E"*	X	X			
ICA transverse: bulb*	X	X			
CCA longitudinal: proximal*	X	X	X	X	X
CCA longitudinal: mid*	X	X	X	X	X
CCA longitudinal: distal*	X	X	X	X	X
ICA longitudinal: bulb*	X	X			
ICA longitudinal: proximal*	X	X	X	X	X
ICA longitudinal: mid*	X	X	X	X	X
ICA longitudinal: distal*	X	X	X	X	X
ECA longitudinal: proximal* <i>Show branching vessels, or use temporal tap to confirm ECA</i>	X	X	X	X	X
Vertebral artery: longitudinal	X	X	X	X	X
%Subclavian artery: medial			X	X	
Included for Carotid Stent					
Mid/distal CCA before stent (to establish inflow velocity): longitudinal	X	X	X	X	X
Proximal stent (in CCA/bulb): longitudinal	X	X	X	X	X
Mid stent in proximal ICA (usually site of original stenosis): longitudinal	X	X	X	X	X
Distal stent in Distal ICA: longitudinal	X	X	X	X	X
ICA immediately beyond stent: longitudinal	X	X	X	X	X
ECA: longitudinal	X	X	X	X	X
<p>*Carotid Cine Clips: Only in areas of at least moderate stenosis (>49%); dual-screen W/O and W/ color (LONG ONLY). If <u>only mild plaque (<50%), no cine loops needed.</u></p> <p>[^]Prefer dual/split screen image format</p> <p>[%]Obtain if unable to obtain bilateral brachial pressures. If subclavian steal is suspected, obtain same images for lateral aspect of subclavian artery as well.</p>					
PSV = peak systolic velocity		EDV = end diastolic velocity			
CCA = common carotid artery		ICA = internal carotid artery			
ECA = external carotid artery					

PROCESSING:

- Review examination data
- Export all images to PACS
- Confirm data in Imorgon (if applicable)
- Note any cardiac devices (eg. aortic balloon pump; LVAD; external cardiac pacers; etc).
- Note any study limitations (in Tech Study Note or paper communication to radiologist, per workflow)

REFERENCES:

- ACR-AIUM-SRU Practice Guideline (revised 2010)
- IAC Standards and Guidelines for Vascular Testing Accreditation (revised 2018)
- IAC Updated Recommendations for Carotid Stenosis Interpretation Criteria, October 2021
- ACR Accreditation Grading Sheet
- Society of Radiologists in Ultrasound Consensus Conference Radiology 2003; 229; 340-346
- Gornik H, et al: Optimization of duplex velocity criteria for diagnosis of internal carotid artery (ICA) stenosis: A report of the Intersocietal Accreditation Commission (IAC) Vascular Testing Division Carotid Diagnostic Criteria Committee; May 2021
- Carotid duplex ultrasound after carotid stenting – John Swinnen; AJUM August 2010
- Grant, EG, et al: Carotid artery stenosis: Grayscale and Doppler US diagnosis- Society of Radiologists in Ultrasound Consensus Conference, *Radiology* 229:340-346, 2003
- Pellerito, John and Polak, Joseph Introduction to Vascular Ultrasonography, 6th Edition. Philadelphia Elsevier/Saunders; 2012
- Zierler, R. Eugene, Strandness's Duplex Scanning in Vascular Disorders, 4th Edition Philadelphia: Lippincott Williams & Wilkins; 2010
- Setacci C, Chisci E, Setacci F, et al. Grading carotid intrastent restenosis: a 6 year follow-up study. Stroke. 2008;39(4):1189-1196.

CHANGE HISTORY:

STATUS	NAME & TITLE	DATE	BRIEF SUMMARY
Submission	David Fetzer, MD, Director	6/20/2016	Submitted
Approval	David Fetzer, MD, Director	6/20/2016	Approved
Review	Cecelia Brewington, MD, FACR	11/2018	Reviewed
Revisions	Cecelia Brewington, MD, FACR	10/30/2018	Added indication of carotid stent; added characterization of plaque description; added detail on BP or substitution of subclavian PSV.
	David Fetzer, MD, Director	12/11/2019	Reviewed/confirmed image order to conform with on-cart protocols
	David Fetzer, MD	2/22/2021	Removed contraindication of Swan Ganz catheter based on Dr. Vijay's lit review
	Kanupriya Vijay, MD	1/16/2022	Updated Recommendations for Carotid Stenosis Interpretation Criteria
	US Core Faculty	1/24/2022	Voted to approve new cutoffs; unify criteria between UTSW and Parkland
	US Core Faculty	04/17/2024	Added cine clip requirements for stenosis

APPENDIX:

- Routine Carotid Duplex Consensus Panel Criteria modified based on local validation data

Consensus Panel Criteria

Diameter Stenosis (Category)	Peak Systolic Velocity (cm/sec)	End Diastolic Velocity (cm/s)	Systolic Velocity Ratio (ICA/CCA)	Presence of Plaque	Flow Distally
0% (Normal)	< 180	< 40	< 2.0	No	Laminar
1-49% (Mild)	< 180	< 40	< 2.0	Yes, <50%	Laminar
50-69% (Moderate)	180-230	40-100	2.0-4.0	Yes, at least 50%	Turbulent
70-99% (Severe)	> 230	> 100	> 4.0	Yes, at least 50%	Turbulent
String Sign (Critical)	Variable	Variable	Variable	Yes; visible to no lumen	Tardus Parvus
100% (Occlusion)	N/A Undetectable	N/A Undetectable	N/A	Yes; no lumen visible	Absent

In interpreting the findings from the internal carotid artery, the category of stenosis is determined by the category most represented from the data.

However, if PSV, EDV, or ICA/CCA ratio falls outside of the anticipated category, the category of stenosis is then determined by the preponderance of data. For example, if an ICA has a PSV of 200cm/s (50-69%), but an EDV of 40cm/s and ICA/CCA ratio of 1.7, then the stenosis category ought to be 1-49%.

Proper explanation and rationale for any discrepancy between the preliminary report and final report, as well as any deviation outside of the established criteria must be stated in the final report.

Plaque Characteristics

Plaque descriptors: homogeneous, heterogeneous, and/or calcific
Possible surface characteristics: smooth, irregular, or ulcerated

Flow Characteristics

1-49% Minimal or no spectral broadening
50-69% Increased spectral broadening
70-99% Marked spectral broadening
Occlusion Absent flow, thumping signal may be noted at the origin of the occlusion

Carotid Artery Stenosis Grading After Stent		
Degree of stenosis	PSV (cm/sec)	EDV (cm/sec)
<30%	≤104	
30%-49%	105-174	
50%-70%	175-299	
≥70%	≥300	≥140
*≥70% Recommend CTA PSV, peak systolic velocity		

References:

- Setacci C, Chisci E, Setacci F, et al. Grading carotid intrastent restenosis: a 6 year follow-up study. Stroke. 2008;39(4):1189-1196.