MARY WASHINGTON HEALTHCARE IMAGING SERVICES

CAROTID DUPLEX ULTRASOUND

I. Patient Preparation: None

II. Equipment:
Performed with a real-time duplex scanner with a transducer imaging frequencies of 8.0 MHz or higher and Doppler frequencies of 3.0 MHz or higher. Equipment capabilities include pulsed Doppler with directional flow, visual and audio output signals and Color Doppler Imaging.

III. General comments

A. Clinical Indications

. 1. At least one of the following should be listed as a clinical indicator for the exam: dysphasia, dizziness, syncope, numbness/tingling or weakness, TIA, CVA, bruit, known carotid stenosis, prior CEA/stent. The clinical indicator for the exam along with relevant patient history and technologist initials must be documented either on the patient data screen or an image is to be taken with this information typed on a blank screen.
2. When possible, obtain and review prior carotid duplex, MRA or CTA of neck reports. Have results available for the radiologist to review.

B. Patient Position

1. The patient is placed supine on a stretcher. A support device such as a small pillow or towel may be placed under the head for comfort.
2. The neck/chin is extended and the head is rotated away from the side being examined. This position may be varied during the examination to optimize vessel identification.
3. The ipsilateral shoulder is dropped as much as possible to maximize exposure of the neck.

C. Equipment Set-up

1. Transducer Selection and Placement:
    a. Linear array transducer, occasionally a curved array may need to be used to visualize deep vessels.
    b. Choice of imaging frequency is made depending on the multiple factors including patient body habitus and vessel depth. A frequency that will maximize resolution while providing adequate penetration should be chosen.
    c. Multiple transducer positions may be necessary to evaluate the entire course of the cervical carotid vessels.
        - **anterolateral** position between the trachea and sternocleidomastoid muscle
        - **lateral** position most common position used to view common and internal carotid arteries
        - **posterolateral** position helps visualize posterior walls of ICA, used for imaging deep carotid vessels and the distal internal carotid artery.

2. Image Optimization:
    a. Optimize gray scale images using carotid artery preset, DGC controls, depth, and transmit/focal zones, I-scan, AGC and harmonics to allow for vessel wall and plaque identification.
    b. Optimize color flow before acquiring images ensuring the color does not "bleed" out of the vessel walls, adjusting the color scale/gain if necessary. The color box should be angle corrected to match the lie of the artery or for tortuous vessels, try center steer for better filling. Plaque surfaces are best evaluated with power Doppler. For string sign type flow, try low flow and/or high persistence setting for complete color filling of artery.

V. A. Plaque Morphology – CLASSIFICATIONS:

1. **Hypoechoic** -uniform dark gray to black echo pattern, smooth surface, "soft" echo texture a high lipid plaque generally isoechoic to the blood and less echogenic than the sternomastoid muscle
2. **Hyperecoic** – uniform medium to light gray echogenic pattern, smooth surface, a fibrous echo texture which is moderately echogenic and is more echogenic than the sternomastoid muscle and similar to the arterial adventitia.
3. **Heterogeneous** – Complex echo pattern when more than 50% of plaque is mixed with echogenic areas. Calcification can be a cause of heterogeneity.
4. **Calcified**- highly reflective, uniformly echogenic may have shadow, is brighter than arterial adventitia and can be difficult to classify plaque surface.

B. Plaque surface

1. **Smooth**- edges of the plaque are uniform.
2. **Irregular**- edges of plaque are rough, not smooth surfaces.
3. **Ulcerated**- a cavity within the plaque that has sharp margins (overhanging edges) and has blood flow within the cavity.

C. Extent:

1. Described as **focal, mild, moderate or severe**.

Note: Plaque severity may be overestimated or underestimated in the longitudinal view. Transverse views must also be obtained to determine the extent of plaque formation as well as correlating the velocities obtained with our laboratory established stenosis criteria.

VI. Examination Protocol

A. Annotation

1. right or left
2. vessel identification – suggested abbreviations
    a. Proximal common carotid artery – **PCCA**
    b. Mid common carotid artery – **MCCA**
    c. Distal common carotid artery – **DCCA**
    d. External carotid artery – **ECA**
    e. Proximal Internal carotid artery – **PICA**
    f. Mid internal carotid artery – **MICA**
    g. Distal internal carotid artery – **DICA**
    h. Vertebral artery – **VERT**

B. Measurement Protocol

1. The sample volume size is kept small, approximately 1.5-2mm, depending on the size of the vessel. It is generally placed in the center of the vessel lumen to obtain the highest peak systolic and end diastolic velocities, but still parallel to the vessel walls. Exceptions to this may occur when careful Doppler analysis reveals the highest velocity eccentrically located within the vessel lumen due to carotid disease or vessel tortuousity. In these instances, the sample volume is placed within the center of flow stream.
2. Maintain a ***Doppler angle of 60 degrees or less with respect to the vessel wall or direction of blood flow*** throughout the exam. Optimize spectral Doppler display, paying close attention to obtaining "clean" spectral window, if appropriate, to avoid measuring artifact. Utilize the color flow as a guide to obtain the highest velocity. Careful flow analysis is obtained by methodically moving the sample volume within the vessel lumen to the area of maximum peak systolic and end diastolic velocity. Close attention should be paid in the region of the distal common carotid artery/bulb and proximal internal carotid artery. Only use measurements where you can clearly visualize the course of the vessel distal to the spectral gate.
3. Spectral analysis waveforms are recorded above the baseline when appropriate. It may be necessary to invert the spectral display depending on the angle of the vessel.
4. ***The IC/CC peak systolic ratio is calculated bilaterally by dividing peak systolic velocity of ICA by the DCCA systolic velocity. Use the peak systolic velocity in the bulb if it is higher than the ICA velocities when calculating the ratio (bulb/DCCA ratio)***
5. When measuring the spectral velocities, the same waveform should be used for peak systolic and end diastolic measurements. If possible, in the presence of arrhythmias, do not select a waveform of a premature ventricular contraction (PVC) to measure velocities.

IMAGE SEQUENCE:

A. Transverse
   1. Perform a real-time gray scale survey, tracing the entire course of the common, internal and external carotid arteries from the supraclavicular notch to the angle of the mandible. Carefully evaluate each vessel for any areas of intimal thickening or visible plaque formation.
   2. Obtain images of the following vessels during the exam, as well as any abnormalities noted during initial survey:
      a. PCCA
      b. MCCA
      c. DCCA
      d. Bulb
      e. Bifurcation

B. Longitudinal
   1. Obtain gray scale and color images of the following vessels:
      a. PCCA
      b. MCCA
      c. DCCA
      d. Bulb/Bifurcation
      e. PICA
      f. MICA
      g. DICA
      h. ECA
   2. Carefully evaluate each vessel for any areas of intimal thickening or visible plaque formation. As a general guide, the thickness of the intima and media

should not be more than 1 mm. To prevent distortion it helps to have a vein interposed between the artery and the transducer.

3. Record gray scale images of any incidental findings. Incidental findings may include lymph nodes, thyroid masses, and thrombosed jugular veins.

C. Spectral Doppler Analysis

1. **Measure and record** the peak systolic and end diastolic velocities for the PCCA and include the measurement in the calcs package.
2. **Repeat step #1 for the following vessel segments, in the order stated:**
    a. MCCA
    b. DCCA
    c. Bulb
    d. PICA
    e. MICA
    f. DICA
    g. Prox.ECA
    h. DCCA (color image w/spectral Doppler to show direction only-do not remeasure velocities)
    i. Vertebral (see next step to obtain Doppler signal)

    To obtain the vertebral artery Doppler signal: Return to the DCCA area and generally sweep the transducer posterolaterally to demonstrate antegrade flow in the vertebral artery flow using spectral Doppler, located between the transverse vertebral processes (identifiable by periodic acoustic shadowing). The Doppler gain and the scale may be changed but no changes to the angle or color box.

3. **Documentation of areas of suspected stenosis MUST include representative waveforms recorded before, AT and DISTAL TO the stenosis.** Documentation of sites of peripheral intervention, including but not limited to sites of stenting, must include representative gray scale, color, Doppler waveform and velocity measurements recorded from the distal common carotid artery, proximal, mid and distal stent and distal internal carotid native artery

4. **Repeat the IMAGE SEQUENCE for the other side.**

5. After completing the exam, the technologist will scan the order for the exam into iSite and track the exam in the Syngo system.

6. When critical findings are present or a wet reading is requested by the ordering physician, the technologist should discuss the exam with an available radiologist (preferably one on-site), then reserve the exam with the RadReserve system. If necessary, the Radiologist will provide a verbal wet reading to the ordering physician with a priority written report to follow.

Note: When an occlusion is suspected, transverse color images of the bifurcation into the proximal ICA & ECA should be obtained. Low flow settings should also be used to demonstrate vessel patency.

Note: A complete examination includes evaluation of the entire course of the accessible portions of each vessel.

Vessel Identification

	INTERNAL CAROTID ARTERY	EXTERNAL CAROTID ARTERY	VERTEBRAL ARTERY
SIZE	Generally larger than ECA	Generally smaller then ECA	
LOCATION	Posterolateral to ECA generally	Anteromedial to ICA generally	Located between transverse processes of vertebral bodies
EXTRACRANIAL BRANCHES	No extracranial branches, occasionally may see Superior Thyroid Artery branch arising from the distal CCA	Have many branches.	
DOPPLER FLOW PATTERN	Low resistance	High resistance	Low resistance
DOPPLER FLOW PATTERN	Less pulsatile	More pulsatile	Less pulsatile
DOPPLER FLOW PATTERN	Continuous, forward flow during entire cardiac cycle with about 80% of CCA blood entering ICA	Diminished or absent diastolic flow with about 20% of CCA blood entering ECA	Generally continuous, forward during entire cardiac cycle
DOPPLER FLOW PATTERN	Slightly rounded peaks	Sharp upstroke in systole, decreasing rapidly in diastole, transient early flow reversal in diastole (dicrotic notch)	Normally prograde flow. “Rabbit ear” and to & fro flow suggestive of subclavian stenosis. Retrograde flow suggestive of steal.
SPECTRAL WINDOW	Open	Open	Broader spectrum, “filled in” window due to small vessel caliber
TEMPORAL TAP	No deflections or oscillations in Doppler waveform with temporal tap maneuver	Temporal tap deflections in Doppler waveform apparent with maneuver- “sawtooth appearance in waveform”	N/A

Image Summary

Image	Measurement
1. Patient information screen	
2. Trans PCCA Grayscale	
3. Trans MCCA Grayscale	
4. Trans DCCA Grayscale	
5. Trans Bulb Grayscale	
6. Trans Bifurcation Grayscale	
7. Long PCCA Grayscale	
8. Long PCCA Color	
9. Long PCCA Color &Spectral Doppler	PSV & EDV
10. Long MCCA Grayscale	
11. Long MCCA Color	
12. Long MCCA Color & Spectral Doppler	PSV & EDV
13. Long DCCA Grayscale	
14. Long DCCA Color	
15. Long DCCA Color & Spectral Doppler	PSV & EDV
16. Long Bulb/Bifurcation Grayscale	
17. Long Bulb/Bifurcation Color	
18. Long Bulb/Bifurcation Color & Spectral Doppler	PSV & EDV
19. Long PICA Grayscale	
20. Long PICA Color	
21. Long PICA Color & Spectral Doppler	PSV & EDV
22. Long MICA Grayscale	
23. Long MICA Color	
24. Long MICA Color & Spectral Doppler	PSV & EDV
25. Long DICA Color	
26. Long DICA Color & Spectral Doppler	PSV & EDV
27. Long ECA grayscale	
28. Long ECA (with branch if possible) Color	
29. Long ECA Color & Spectral Doppler (w/Temporal Taps as nec)	PSV & EDV
30. Long CCA spectral window at same angle as Vert. with Color	
31. Long Vertebral Color & Spectral Doppler	PSV & EDV
32. Report summary pages	

Document any incidental findings such as jugular vein thrombosis, lymph nodes, thyroid nodules or masses.

Note: When an occlusion is suspected, transverse color images of the bifurcation into the proximal ICA & ECA should be obtained and low flow settings should be used to demonstrate vessel patency.

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