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| https://www.ahcs.ac.uk/wordpress/wp-content/uploads/2014/05/IQIPSlogo-300x106.png | **Clinical Physics** |  |
| **Name of Department: Vascular Ultrasound** | |

# Carotid Duplex Scan

**Patient Preparation:**

Check patients identification

Explain test procedure

Obtain verbal consent or implied consent (if patient gets undressed / lies down for scan)

Take relevant history from patient

Ask patient to undress as appropriate and remove jewellery if necessary.

**Scanner Preparation:**

The probes should be cleaned with T-Spray (which must be allowed to dry on the probe for 10 minutes). Alternatively, Distel disinfectant wipes can be used to clean probes for immediate use, in between patients. After scanning an infectious patient, the room should be deep cleaned (order though the helpdesk) and the scanner cleaned according to the manufacturer’s protocol.

**Procedure:**

1. Scan ideally performed with the patient lying supine, the patient’s head turned and the neck extended.
2. The accessible length of the common carotid artery (CCA), internal carotid artery (ICA), the proximal external carotid artery (ECA) and a segment of the vertebral artery are examined using B-mode, colour flow imaging and spectral Doppler bilaterally. It is necessary to assess and compare the arteries on each side in order to account for any collateral flow effects.
3. The peak systolic velocity (PSV) and end diastolic velocity (EDV) should be recorded from the distal CCA (within 2cm of the bifurcation at a point where the vessel still has uniform diameter) and the ICA and ECA at the location where the highest PSV is seen.
4. The highest PSV in the diseased ICA will be seen at the point of tightest stenosis or in the jet immediately distal to the stenosis.
5. All velocity measurements should be made with the vessel in longitudinal section, the centre-line velocity measured and the correct Doppler gain.
6. The Doppler angle should be 45-60° with proper correction/calibration applied using the angle correction cursor. In the case of a tortuous vessel the cursor should be aligned to the tangent of curvature at the measurement point. In the case of the eccentric jet within a stenosis the angle cursor should be aligned to the jet.
7. For investigation of Carotid Body Tumour, often suggested by abnormal hormone levels or activity (i.e. catecholamins), image both carotid bifurcations. Note any hypervascular formation seen nestled in or surrounding the bifurcation. If a mass is seen splaying the ICA and the ECA, but no colour flow signal is obtained, adjust the PRF to enable detection of any low velocity flow within the mass.

**Criteria for classification of stenosis:**

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| --- | --- | --- | --- | --- |
| **Percentage**  **Stenosis (NASCET)** | ICA PSV\* (cm/s) | ICA EDV\* (cm/s) | ICA PSV/CCAPSV \* | ICAPSV/CCAEDVc+  (St Mary’s Ratio) |
| <50 | <125a | <40 | <2a | <8 |
| 50-59 | >125a | 40-100 | 2-4a | 8-10 |
| 60-69 | 11-13 |
| 70-79 | >230a | >100 | >4a | 14-21 |
| 80-89 | 22-29 |
| >90 but less than near occlusion | >400b | >5b | >30 |
| Near occlusion | High, low–string flow | Variable | Variable | Variable |
| Occlusion | No flow | Not applicable | Not applicable | Not applicable |

* a Grant et al 2003
* b Filis at al 2002
* c Nicolaides et al 1996
* \* Primary Parameters, + Additional Parameters

Disease of less than 50% may be graded using the B-mode and colour flow imaging. An approximation of the diameter reduction may be given.

An ECA PSV of >200cm/s combined with colour aliasing and evidence of disease on B-mode may suggest a >50% stenosis of the ECA (Kronick et al 2020).

**Limitations of the criteria:**

1. Large plaques in large bulbs (e.g. >10mm diameter) but with a good residual lumen may still be a significant risk factor for embolic events. If this is the case than the bulb diameter and plaque thickness can be measured, noting that there is a good residual lumen.
2. An irregular heartbeat makes the velocity measurements less reliable. Where possible, the velocity should be measured on the second or subsequent cardiac cycle of a string of consecutive regular cycles.
3. Potential sources of variability in the ICA PSV:
   1. Variation in the geometry of the bifurcation and the size of the bulb (Schuluz and Rothwell, 2001a)
   2. Variation in the vessel size that reflects body size (Schuluz and Rothewell, 2001b)
   3. Collateral flow effects (Henderson et al, 2000 and Ray et al, 2000)
   4. Change in ICA flow over the menstrual cycle (Krejza et al, 2001)
   5. Change with age and blood pressure (Spencer et al, 2001)
   6. The physical parameters of the ultrasound machine (Hoskins 1999)

The effect of these factors on blood velocities in diseased vessels is mitigated by the use of velocity ratios.

1. Where there is bilateral zero or retrograde end-diastolic flow in the CCA (possible aortic valve disease) the St Mary’s ratio should not be used.
2. Where there is bilateral reduction in diastolic flow, there may be reduced vessel wall compliance due to arteriosclerosis, the St Mary’s ratio should not be used.
3. Where there is moderate to severe disease on one side and severe disease on the contralateral side, velocities tend to overestimate the stenosis on the less severe side as the vessel is acting as a collateral.
4. Inadequate visualisation – this should be recorded in the report and an alternative imaging modality recommended.
5. Unusual waveforms that may suggest inflow or outflow problems.

**Report:**

The report should include velocity measurements made in the CCA and ICA which are used to quantify degree of narrowing using the criteria above. The location of atheroma should be noted on the diagram. In the presence of >70% stenosis, the absence of a normal calibre patent ICA distal to the stenosis should be highlighted.

Diagrams will be drawn in complex cases and where they add value to the report.

Reports will be available on PACS.

If a >70% stenosis is identified during an inpatient scan, the referring doctor should be informed by telephone. If a >70% stenosis is identified during an outpatient scan, a copy of the report or outcome should be emailed to the referring consultant. No verbal report needs to be given to the patient at the time of the scan.

**Recommended images to be stored on PACS:**

* Spectral Doppler image of waveform velocities in bilateral CCA
* Spectral Doppler image of waveform in bilateral ECA
* Spectral Doppler image of waveform velocities in bilateral ICA
* Spectral Doppler image of waveform in bilateral vertebral artery
* If stenosis is present, store images of highest velocity detected within / post stenosis
* If stenosis is present, store B-mode and colour flow images of plaque
* Store images of any other relevant pathology detected
* Nb. In a one-stop clinic environment where time is limited, it may be difficult to record all of the above images

**References:**

Filis, K.A., Arko, F.R., Johnson, B.L., Pipinos, I.I., Harris, E.J., Olcott 4th, C. et al (2002) Duplex ultrasound criteria for defining the severity of carotid stenosis. Ann Vasc Surg; **16:** 413-421.

Grant, E.G., Benson, C.B., Moneta, G.L., Alexandrov, A.V., Baker, J.D., Bluth, E.L. et al (2003) Carotid artery stenosis: gray-scale and Doppler ultrasound diagnosis - society of radiologists in ultrasound consensus conference. Radiology **229**:340-346.

Henderson, R.D., Steinman, D.A., Eliasziw, M. and Barnett, H.J. (2000) Effect of contralateral carotid artery stenosis on carotid ultrasound velocity measurements. Stroke; **31:** 2636-2640.

Hoskins, P.R. (1999) A review of the measurement of blood velocity and related quantities using Doppler ultrasound. Proc Inst Mech Eng; **213**: 391-400.

Krejza, J., Mariak, Z., Huba, M., Wolczynski, S. and Lewko, J. (2001) Effect of endogenous estrogen on blood flow through carotid arteries. Stroke; **32:** 30-36.

Kronick, M. D., Chopra, A., Swamy, S., Brar, V., Jung, E., Abraham, C. Z., … Moneta, G. L. (2020) Peak systolic velocity and color aliasing are important in the development of duplex ultrasound criteria for external carotid artery stenosis. Journal of Vascular Surgery.

Nicolaides, A.N., Shifrin, E.G., Bradbury, A., Dhanjil, S., Griffin, M., Belcaro, G. et al (1996) Angiographic and duplex grading of internal carotid stenosis: can we overcome the confusion? J Endovasc Surg; **3:** 158-165.

Oates, C.P., Naylor, A.R., Hartshorne, T., Charles, S.M., Fail, T., Humphries, K., Aslam, M. and Khodabkhsh, P. (2009) Joint Recommendations for Reporting Carotid Ultrasound Investigations in the United Kingdom. Euro J of Vasc and Endovasc Surg; **37:** 251-261.

Ray, S.A., Lockhart, S.J., Dourado, R., Irvine, A.T. and Burnand, K.G. (2000) Effect of contralateral disease on duplex measurements of internal carotid artery stenosis. Br J Surg; **87:** 1057-1062.

Schulz, U.G. and Rothwell, P.M. (2001a) Major variation in carotid bifurcation anatomy: a possible risk factor for plaque development? Stroke; **32:** 2522-2529.

Schulz, U.G. and Rothwell, P.M. (2001b) Sex differences in carotid bifurcation anatomy and the distribution of atherosclerotic plaque. Stroke; **32:** 1525-1531.

Spencer, E.B., Sheafor, D.H., Hertzberg, B.S., Bowie, J.D., Nelson, R.C., Carroll, B.A. et al (2001) Nonstenotic internal carotid arteries: effects of age and blood pressure at the time of scanning on Doppler US velocity measurements. Radiology; **220:** 174-178.