

**CLINICAL PROTOCOL**

# Extra-cranial Carotid and Vertebral Artery Duplex Protocol

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| Protocol: | Extra Cranial Carotid and Vertebral Duplex Ultrasound Protocol |
| Protocol No: | **4.0** |
| Version | V3 |
| Implementation date: | 21/11/2016 |
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| Position Held | Chief Clinical Vascular Scientist |
| Intended Use: | As a clinical protocol |
| Related policies: | Pathway for Abnormal carotid findings;  Infection control policy;  Prevention of work related injuries |
| Next review date: | January 2019 |

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# Purpose

The purpose of this ultrasound protocol is to provide staff with a specific procedure to follow for every examination undertaken. This will ensure a uniform standardised investigation for the purpose of diagnosis and reporting.

All Clinical Vascular scientists must adhere to this protocol.

# Examination overview

This examination is undertaken to assess for the presence of pathology, and the haemodynamic status of the carotid and vertebral arteries in the neck, and where indicated, the Innominate and Subclavian arteries.

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|  | Common indications for Carotid Duplex investigation include: |
| * Transient Ischemic Attack (TIA) * Cerebrovascular attack (CVA) * Amaurosis Fugax * Carotid bruit * Follow-up for known carotid stenosis * Post intervention follow-up (carotid endarterectomy, stent or bypass) * Trauma in the distribution of the carotid artery e.g. Suspected dissection, arteriovenous fistula or pseudo aneurysm * Asymptomatic Pulsatile neck masses/carotid bruit * Pre-operative assessment for high risk patients e.g. coronary artery bypass surgery (CABG) * Evaluation of suspected subclavian steal syndrome | |

This specialist examination should be carried out by a trained Clinical Vascular Scientist (CVS) using high-resolution colour duplex ultrasound. It is the CVS’s responsibility to ensure a thorough examination of the carotid and vertebral arteries is carried out, with images and relevant haemodynamic data recorded. A report should be generated with 24 hours of the examination and where possible immediately after the examination. The images taken and report generated are subject to peer review and audit.

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# 3.0 Contraindications and Limitations

Contraindications for carotid duplex are few; however, some limitations exist and may include the following:

* Patients with short, thick, muscular necks
* Patients who have had recent surgery (penetration of ultrasound may be

Limited, secondary to the presence of oedema, hematoma, surgical staples, and/or dressings)

* Calcified plaque may limit penetration of the ultrasound beam resulting in and acoustic shadowing limiting the Doppler and B-mode image assessment
* Patients with chronic obstructive pulmonary disease (COPD) and arthritic necks may not be able to lie flat (however, they could possibly tolerate the examination with the head of the bed raised or while sitting in a chair)
* Patients who are unable to cooperate with the examination due to reduced cognitive functions; e.g. dementia, Alzheimer’s, other mental incapacities and involuntary movement. Studies performed at the bedside may be limited due to limited access to the patient due to machinery and room dimensions.

# 4.0 Equipment

A high-resolution ultrasound machine, which has colour, power and pulsed Doppler modalities, is required. This equipment must be maintained and regularly checked by the medical physics department in line with local governing laws within the Trust.

A midrange linear array transducer of frequencies 5.0MHz or greater is the preferred for this examination. A lower frequency curved array transducer (frequencies of at least 3MHz should be available, to enable examination of carotid and vertebral arteries at depth due to oedema or in patients with short thick muscular neck (SVT professional standards committee 2012)

In order to reduce risk of injury to the Clinical vascular scientist (CVS), positioning of the patient and CVS must be taken into consideration.

A height adjustable, preferably electronic, examination couch must be available along with a height adjustable sonographer’s chair, with lumbar support, that can fit closely beside the examination couch to optimise CVS positioning close to the patient’s side.

**5.0 Consent**

The consent process is a continuum beginning with the referring consultant who requested the ultrasound examination, and ending with the clinical vascular scientist or sonographer who carries it out.

It is the responsibility of the referring professional to provide sufficient information to the patient to enable the latter to consent to the ultrasound assessment being requested.

It is the responsibility of the clinical vascular scientist or sonographer to ensure the patient understands the scope of the ultrasound examination prior to commencing the examination. Verbal consent must be obtained prior to commencing the ultrasound scan.

Additional verbal consent must be obtained where a student clinical vascular scientist or sonographer is undertaking part or all of the examination under supervision.

**6.0 Examination Preparation**

Patients should receive their outpatient appointment with enough notice to prepare for their examination, where possible at least 2 weeks’ notice.

Information on the examination to be undertaken should be provided to the patient along with their appointment letter.

No specific patient preparation is required for Carotid and Vertebral artery Duplex ultrasound assessment.

* The Clinical Vascular Scientist (CVS) should begin by introducing themselves  
  Confirm the patient’s full name and date of birth, for inpatients check the patient’s identity wrist tag.
* Give an explanation of the procedure and its duration – consideration should be made to the patient’s age and mental status
* Obtain consent to perform the examination.
* Obtain relevant medical history from the patient or from the patient’s notes, this is to ensure consistency and correlation with clinical indications provided on the request form and the presenting symptoms of the patient you are about to assess.
* Document any other cardiovascular risk factors
* Diabetes, hypertension, smoking, hypercholesterolemia, angina, previous stroke or TIA
* Presence of cerebrovascular disease e.g. aphasia, dysphasia, paralysis (noting the side effected), visual symptoms, tinnitus.
* Verify the requested procedure correlates with the patient’s clinical presentation; in instances where this is unclear seek out a senior colleague to discuss further before proceeding.

**Patient preparation**

Patients are asked to adjust their clothing to expose their neck, opening shirt collars or removing other clothing or jewellery in the region of the neck area. The patient is examined in the supine position.

The head and shoulders should be slightly raised for comfort with a small neck support to allow chin extension.

During the examination the patient’s mental and physical status should be monitored and modifications made to the examination accordingly. The patient’s dignity and privacy should be maintained at all times.

**Operator set-up**

The clinical vascular scientist should ensure they are in a comfortable, ergonomic position that is causing no strain on the wrist, arms, neck, back or shoulders.

The ultrasound chair should be positioned beside the examination couch to ensure the CVS do not have to reach/overstretch to examine the patient.

For carotid scanning, the CVS can sit behind the head of the examination couch facing the back/top of the patient’s head, with their arm resting on the examination couch beside the patient’s head. The ultrasound machine should be pulled in close to the side of the CVS to ensure no overreaching when manipulating ultrasound controls. The ultrasound screen should be angled towards the CVS to reduce turning of the CVS’s neck.

The CVS may also sit adjacent to and facing the patient, in this position the CVS should move the ultrasound chair closer to the head of the bed, by the patient’s shoulder, to reduce over stretching/reaching over the patient.

**7.0 Examination protocol**

The standard examination should examine bilaterally, the arterial supply to the head and neck encompassing the Common Carotid artery (CCA), carotid bifurcation, external carotid artery (ECA) and internal carotid artery (ICA) to its most accessible distal extra-cranial segment. The vertebral artery (VA) should be assessed and flow direction noted. If flow is reversed within the VA the subclavian artery (SCA) should be assessed also.

These vessels should be examined thoroughly in B-mode and colour Doppler in both transverse and longitudinal planes to assess for pathology.

Pulsed wave spectral Doppler assessment should be taken at regular intervals throughout the Common (CCA), Internal (ICA) and External (ECA) carotid arteries and at sites of plaque formation. PW Doppler assessment should be in the longitudinal orientation, maintaining a Doppler angle of 45-60 degree’s.

In the case of a tortuous vessel the cursor should be aligned to the tangent of curvature at the point of measurement. In the case of an eccentric jet within a stenosis the angle cursor should be aligned to the jet (Oates et al 2012).

When recording PSV the spectral Doppler trace should be free of noise and have the scale adjusted to allow for accurate measurement of PSV and EDV.

Specific sites for recording Peak Systolic (PSV) and End Diastolic (EDV) velocities are in **1)** the mid-distal CCA (~ 2cm proximal to bifurcation)**, 2)** the proximal ICA, **3)** the proximal ECA and at any sites of significant atheroma, kinking or within a stent. Velocities to be recorded on the examination report PSV and EDV of CCA and ICA.

The focus and gain settings should be optimised to minimise noise in the arterial lumen (keep an echo free lumen). The TGC should be kept standardised (straight with gradual increase with increasing depth) throughout the examination to allow for time gain compensation of the image, it should not be manipulated to produce an echo free lumen whilst increasing gain elsewhere on the ultrasound image.

At sites of significant atheroma images should be taken in B-mode and with colour flow to show delineation of the plaque from the blood flow stream.

**Carotid Plaque characterisation:**

Atherosclerotic plaque can be analysed using high resolution B-mode ultrasound, to assess the plaque for morphological features, the following settings should be standardised before the image can be used for plaque characterisation analysis;

**Settings for Image acquisition:**

1. Ensure vessel is at an adequate depth to be optimally imaged,
2. The focus should be moved to be in line with the point of investigation (vessel lumen), or just below the vessel.
3. B-mode gain should be adjusted so that the vessel lumen is free of echoes in contrast with the surrounding musculature and tissues, increase B-mode gain until echo’s appear in the blood vessel lumen then reduce until the lumen becomes free of echoes.
4. The TGC toggles should be set in a uniform straight line slightly increasing with greater depths to provide amplification of signals returning from depth to compensate for attenuation.

**Plaque surface:**

Atherosclerotic plaque surface should be described using the following terms;

* **Smooth,**
* **Irregular**
* **Ulcerated**

Plaque surfaces can be described as *1. smooth* an intact echogenic and uninterrupted intima/plaque capsule. *2. Irregular* a disruption in the intima/plaque capsule echogenicity indicating a thinning or irregular surfaced plaque, this type of plaque can lead to an ulcerated plaque. *3. Ulcerated* with disruption of the capsule that creates a break/gap in the plaque capsule measuring at least 2mm, flow should be seen entering the crater for a positive identification.

Plaque ulceration can be detected using high-resolution B-mode ultrasound, plaque ulceration is classified as flow entering a plaque, or circulation of blood flow within a plaque.

**Overall echogenicity and echo texture of the plaque:**

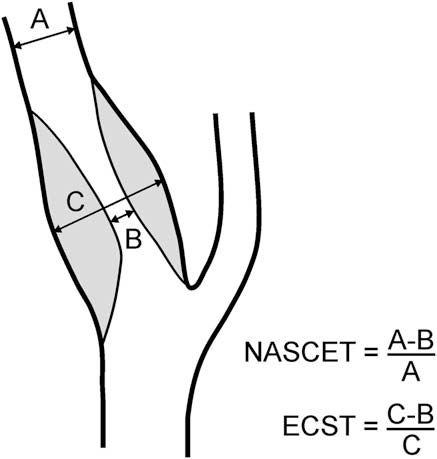
The reference points for echogenicity of a plaque, should be; blood flow, the artery lumen for hypoechoic, and the sternomastoid, neck muscle for fibrous tissue known as isoechoic, and bone for hyperechoic, the brightest echogenicity indicating a solid hard density.

* **Homogenous:** uniform echo pattern, indicating the plaque is made up of the same material consistency. This describes the consistency and not the level of echogenicity. There can be uniform echolucent plaque’s and uniform echogenic plaques.
* **Heterogeneous:** mixed echogenicity (regions of different echogenicity/echo texture) indicating a plaque is composed of differing density materials, of different consistencies, varying density of the plaque composition.

**The Large Bulb**

The carotid bulb should be assessed for atherosclerotic plaque. In cases where there is a large bulb with a large volume of plaque present, however, is not causing any haemodynamic significant changes, diameter reduction measurements can be made on the B-mode image, these will be dependent on appropriate gain selection and choice of imaging plane.

Diameter measurements made in the bulb should be made using the NASCET method to correlate with the velocity criteria used,



*‘It is recognized that large plaques in large bulbs but with a good residual lumen may still be a significant risk factor We therefore recommend as an exception, that in the case of a large carotid bulb (e.g.: greater than 10 mm diameter),20,21 direct measurements of the bulb diameter and plaque thickness is made and reported with a note that there remains a good residual lumen.’ (Oates et al 2012)*

**7.1 Grading of Stenosis**

**Criteria for the grading of extra-cranial internal carotid artery stenosis:**

**Table 1 Joint recommendation’s**

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| **Percentage Stenosis (NASCET)** | **ICA peak systolic velocity cm/sec** | **Peak Systolic velocity ratio ICAPSV/CCAPSV** | **St Mary’s Ratio ICAPSV/CCAEDV** |
| **<50** | **<125** | **<2** | **<8** |
| **50-59** | **>125** | **2-4** | **8-10** |
| **60-69** |  |  | **11-13** |
| **70-79** | **>230** | **>4** | **14-21** |
| **80-89** |  |  | **22-29** |
| **>90 but less than near occlusion** | **>400** | **>5** | **>30** |
| **Near occlusion** | **High, low-string flow** | **Variable** | **Variable** |
| **Occlusion** | **No flow** | **Not applicable** | **Not applicable** |

**NB: The St Mary’s Ratio should be disregarded in the case where it is the only measure to indicate greater than 70% stenosis and the CCA EDV is less than 8cm/sec(2).**

**Peak Systolic Velocity**

**Positioning and Angulation**

The Doppler waveform should be obtained with an angle of isonation less than or equal to 60 degrees, the Doppler gate or sample volume should be placed at the centre of the flow lumen and the Doppler angle adjusted to the tangent of the vessel walls.

The Sample volume placement is crucial in detecting the highest PSV within a stenosis. The Sample volume should be placed within the area of greatest stenosis as seen when using Doppler colour flow.

The colour flow aliasing should alert the operator to the region of highest velocities, the sample volume should be placed in the centre of the blood flow stream, angled correctly (<=60degree beam steer) and a Doppler angle of 45-60 degree. The sample volume should be ‘walked’ or ‘tracked’ through the entire length of stenosis and further upstream distal to the stenotic jet. From this preliminary walk through the region with the highest velocities can be detected and the sample volume returned to this region and further interrogated to record a maximum PSV.

For grading for stenosis the following measurement’s the following parameters should also be consulted to assist with grading and confirmation of degree of stenosis:

**From the North American Consensus Conference (NACC)**

ICA*psv* and CCA*psv* measurements and the PSVR (Peak Systolic Velocity Ratio) ICApsv/CCApsv.

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| A <50% ICA stenosis | ICA PSV <125cm/sec and PSVR <2.0 |
| A >/= 70% stenosis | ICA PSV >230cm/sec and PSVR >4.0 |
| A >/=90% stenosis | ICA PSV >400cm/sec and PSVR >5.0 |

**Table 2. NACC Recommendations**

The additional criteria parameter Internal Carotid Artery **end diastolic velocity** (ICA EDV) may considered useful:

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| **Stenosis using NASCET** | **End Diastolic Velocity (EDV)** |
| **<50%** | <40cm/sec |
| **50-69%** | 40-100cm/sec |
| **>70%** | >100cm/sec |
| **Near Occlusion** | Variable |

**Table 3. NACC Recommendations**

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|  | Examination recommendations (C.P. Oates et al 2012) |
| 1 | Carotid duplex should be a bilateral scan and include a basic assessment of the vertebral arteries. |
| 2 | * All results and calculations to refer to the NASCET method of measurement |
| 3 | The following four velocities to be measured and recorded:   * **PSV and EDV in CCA 1-2 cm below bifurcation** * **PSV and EDV in ICA at point of highest velocity**, i.e. stenosis jet or ICA   distal to bulb in the absence of significant disease |
| 4 | * All velocities to be measured at a Doppler angle of 45-60 degree’s, with proper correction/calibration applied using the angle correction cursor |
| 5 | * PSV in ICA and PSVR to stratify 50% and 70% levels (see Table 1) |
| 6 | St Mary’s Ratio to stratify in deciles (see Table |
| 7 | * In the case of a large plaque in a large bulb (>10 mm dia) measure and report the bub diameter, plaque  thickness and residual lumen |
| 8 | * Qualitatively note the nature of the plaque (calcified,  irregular, echo-poor, etc.) |
| 9 | * Record length of longer stenosis |
| 10 | * Record distance of bifurcation below mastoid process in  (cm) |
| 11 | * Record presence or otherwise of clear distal lumen and note size if it is reduced |
| 12 | * Note any cautions in diagnostic reliability of the report i.e. calcified plaque, technically difficult scan, arrhythmia |



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