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Carotid and vertebral ultrasound		Dec 2020	1.0

Scope & purpose

Extracranial cerebrovascular duplex ultrasound examinations are carried out to assess for the presence of pathology and the haemodynamic status of the common carotid, internal carotid, external carotid and vertebral arteries.

Common indications for performance of this examination can include:

- Transient ischemic attacks (TIA)
- Amaurosis fugax
- Carotid bruit
- Cerebrovascular Accident (CVA)
- Follow-up of known carotid stenosis
- Post intervention follow-up e.g. carotid endarterectomy, stent or bypass
- Trauma in the distribution of the carotid artery e.g. suspected dissection, arteriovenous fistula or pseudoaneurysm
- Pulsatile neck masses
- Evaluation of suspected subclavian steal syndrome

Personnel

Clinical vascular scientists (CVS), including trainees.

Principles / performance characteristics

To determine the presence or absence of carotid and vertebral artery disease, including anatomical variants; using B mode, colour and spectral Doppler.

Service users & background

Patients with a suspected TIA or stroke may be referred as part of their work up, in conjunction with other imaging modalities. This diagnostic investigation aims to establish if extracranial disease is a possible cause for their symptoms and if the patient's disease is amenable for surgical intervention. Common indications for the scan are outlined in 'scope and purpose'.

There are few contraindications for carotid duplex ultrasound; however, limitations may include the following:

- Obesity or short, thick muscular necks
- Dressings, open wounds, staples, haematoma etc.
- Acoustic shadowing
- Patients who are unable to lie flat
- Patients who are unable to cooperate due to reduced cognitive functions e.g. Alzheimer's or dementia and through involuntary movements
- Examinations undertaken at the patient's bedside may be limited due to equipment and room dimensions
- Patient discomfort

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Facilities, equipment & special supplies

Duplex ultrasound machine with both linear and curvilinear transducers available. There should be a selection of transducers delivering a wide range of frequencies (high and low).

Ultrasound gel to provide a couplant between transducer and patient.

Examination couch should be height adjustable. The CVS's chair should provide good lumbar support, be height adjustable and allow for the CVS to move close to the examination couch.

Cleaning materials should be available in line with local and manufacturer's guidelines. These are available either in each procedure room or located in the laboratory store room.

Calibration

Across all sites annual calibration and safety checks of the ultrasound equipment are performed by Clinical Engineering (Trust contract with GE Healthcare).

Quality control

Second opinions from vascular scientist colleagues are requested routinely if clarification is sought.

Trainee vascular scientists have all carotid scans checked until they are signed off by a senior colleague for competency.

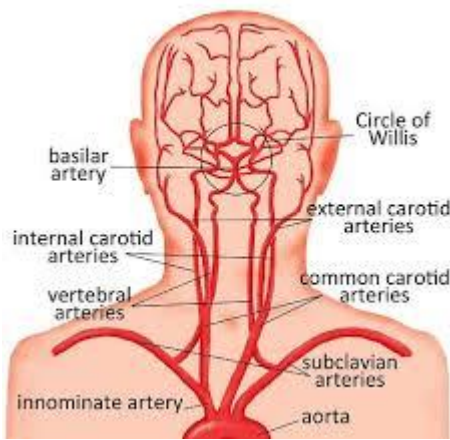
Environmental & safety controls

Infection control procedures followed in accordance with Trust infection control and risk assessment policies – Please see 'Personal Protective Equipment (PPE) for infection prevention and control' policy, 'Hand Hygiene' policy and 'Staff Risk Assessments' which are all available through the Trust Intranet.

Tristel wipes are for cleaning the ultrasound machines and probes after patient use. Universal Clinell wipes are for cleaning all other equipment. Where high risk infection presents or post-op wounds are present use probe covers with sterile gel or Tegaderm dressings, in addition to routine cleaning.

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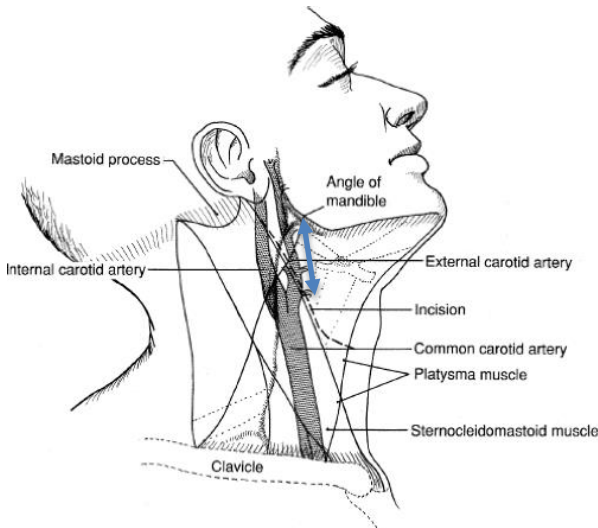
Carotid ultrasound procedure

	Preceding document: <i>VAS-MP-6 Patient management</i>
1.	The patient is asked to adjust their clothing to expose the neck area and remove jewellery if necessary. Ideally, the patient is examined in the supine position with their head/neck positioned in such a manner that allows the CVS maximum access to the vessels to be examined. On rare occasions, it may be necessary to scan the patient in a chair if they have limited mobility and are unable to transfer.
2.	<p>The scan is performed in both colour flow imaging and B-mode in both longitudinal and transverse planes, from the origin of the common carotid artery (CCA) on the right and as proximal as possible on the left. The right proximal subclavian artery is assessed where possible. If a significant stenosis is identified, bilateral blood pressures should be recorded. The CCA is scanned from as proximal as possible, then distally to the bifurcation and then as far distally as possible into the internal carotid artery (ICA). The external carotid artery (ECA) is imaged proximally.</p>  <p><i>Image taken from Children's Wisconsin</i></p>
3.	Peak and end diastolic velocities of the distal CCA, the ECA and the ICA are measured bilaterally and documented on the diagram. A peak systolic velocity (PSV) and waveform should be measured in the right proximal subclavian artery. Vertebral artery peak and end diastolic velocities are measured and direction of flow identified. In the presence of reversed or partially reversed flow, the subclavian artery should be examined bilaterally and bilateral blood pressures recorded.
4.	In the presence of a significant stenosis (>50%) located in the CCA the velocities pre-stenosis and within stenosis are measured and documented. See CCA grading criteria in reporting section. For lesions <50% B-mode is used to measure the diameter reduction (measuring internal diameter and luminal diameter) in the plane of greatest stenosis.
5.	In the presence of a significant stenosis (>50%) located in the ICA the following

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	<p>measurements are made:</p> <ul style="list-style-type: none"> The highest peak systolic velocity and corresponding end systolic velocity A visual diameter reduction measurement (see diagram A) <div data-bbox="331 450 877 701" data-label="Diagram"> </div> <div data-bbox="948 468 1418 692" data-label="Text"> <p>Diagram A: ICA visual diameter reduction measurements should follow the European Carotid Surgery Trial (ECST) method of grading.</p> </div> <ul style="list-style-type: none"> Detailed ICA grading criteria and method of reporting can be found in the reporting section
6.	There is no consensus document for ECA grading criteria, therefore B mode diameter reduction and peak systolic velocities are used to guide grading stenosis.
7.	The ICA and ECA should be clearly distinguished. If a >50% stenosis is detected in the ECA or ICA a temporal tap (tapping over the ipsilateral superficial temporal artery to detect a change in spectral waveform) must be performed, then documented on the report. A second opinion from a senior colleague must be obtained if there is any uncertainty.
8.	<p>When measuring velocities the Doppler angle should be 60 degrees or less and parallel with the flow of blood. Any disease noted is classified into plaque characteristics (smooth, irregular, dense, soft, mixed, calcified and/or ulcerated).</p> <div data-bbox="277 1361 646 1630" data-label="Image"> </div> <p>Smooth, mixed plaque</p> <div data-bbox="686 1361 1000 1630" data-label="Image"> </div> <p>Irregular, calcified plaque</p> <div data-bbox="1054 1373 1386 1630" data-label="Image"> </div> <p>Ulcerated plaque</p> <div data-bbox="272 1724 620 2009" data-label="Image"> </div>

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	Soft plaque
9.	<p>For a symptomatic, significant stenosis (>50%) in the ICA, the length of the plaque extension into the ICA from the bifurcation is measured. The distance of the bifurcation apex to the angle of the mandible is also measured and the line of the jaw is drawn on the report (demonstrated by the blue arrow on the diagram below).</p>  <p><i>Image taken from Basic medical key (2020)</i></p>
10	<p>The intimal medial thickness is measured ~1.0cm proximal to the carotid bifurcation on the posterior medial wall and documented in cm (normal <0.07cm, ref 4). If plaque is on the posterior wall, measure on the anterior wall or as close to 1cm from the bifurcation as possible.</p>
11.	<p>For patients with poor access, or who are moving excessively, it is acceptable to not record velocities if genuinely not possible, and describe any plaque on its colour and B-mode appearance. This would be considered a very rare occurrence and only after asking for assistance from a colleague.</p>
12.	<p>For preop marking of the carotid prior to endarterectomy, the operation side must be rescanned in full by a different CVS (where possible) for quality control, and a new report produced. The head should be tilted up with head facing forward. Using a blue marking pen, mark on the patient's neck the level of the bifurcation in transverse and the extent of the ICA plaque in longitudinal - an inverted 'T' should be apparent. If significant plaque extends into the CCA, extend the blue line into the CCA - a '+' sign will be apparent. If significant plaque is in the CCA only, a 'T' will be apparent.</p> <p>On a copy of the new report, a replica of the blue lines drawn on the patient should be drawn on the report with blue pen. The report then needs to be signed and dated in the blue pen.</p>
	<p>Subsequent documents: VAS-MP-6 Patient management, VAS-MP-1 Results</p>

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	<i>processing</i>
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Reporting

The diagrammatic report is a record and interpretation of observations made during the carotid duplex ultrasound examination; it should be written by the CVS undertaking the examination.

The report should include correct patient demographics, date of examination, examination type, the name and status of the CVS and any clinical history deemed relevant.

The report is the diagram. All disease or variable anatomy, must be drawn on the diagram together with the PSV and EDV for ICA, CCA, ECA and vertebral arteries. The PSV of the right subclavian artery should be documented.

Comment on any dissections, abnormal distal resistance, or any unusual pathology on the report.

For the grading of CCA stenoses, velocity ratios are used (see table 1).

Table 1: Arterial velocity grading criteria.

Stenosis %	Velocity Ratio (Vs/Vp)
0-49%	< 2
50-74%	≥ 2
75-99%	≥ 4
Occluded	No flow detected

Vs = Highest PSV at site of stenosis, Vp = pre-stenosis PSV.
Adapted from Thrush A & Hartshorne T, 2010, *Vascular Ultrasound: How, why and when*, 3rd edn, Elsevier Limited, London (pg 138).

Table 2: ICA stenosis velocity grading criteria (see refs 1, 2, 5 & 6).

Diameter reduction %	Peak systolic velocity (cm/s)
50-59%	≥ 125
60-69%	≥ 200
70-79%	≥ 230
80-89%	≥ 250
>90%	≥ 400

To grade ICA stenoses, haemodynamic velocity criteria (as shown in table 2) and visual diameter reductions are both used and denoted on the report. The table on the report will be

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used to denote the haemodynamic grading of the stenosis. The visual diameter reduction is to be written on the side of the report beside the diagram.

Haemodynamic velocity grading will always be given in 10% ranges as follows:

Velocity between 125 and 199cm/s = 50-59%
Velocity between 200 and 229cm/s = 60-69%
Velocity between 230 and 249cm/s = 70-79%
Velocity between 250 and 399cm/s = 80-89%
Velocity >400cm/s = >90%

Visual diameter reductions will always be written in 5% ranges e.g. 55-60%, 65-70%.

Both visual and haemodynamic stenosis will always be reported when the stenosis is >50%.

The CVS should write their own conclusion, using their professional clinical judgment, at the bottom of the report. The CVS should bear in mind that there may be unusual cases - e.g. recanalised thrombus in an ICA with "trickle flow" - This can be directly written into the box.

Any caveats for a mismatch between haemodynamic velocity and visual diameter reduction must be commented on in the report.

Visual diameter reduction measurements use ECST method of grading.

If the findings differ grossly from another modality's findings, or from a scan performed elsewhere, an immediate second opinion should be sought from another colleague when possible.

If the stenosis is considered haemodynamically or visually to be >50% and symptomatic then the referring clinician and a vascular registrar (ext 28737) must be contacted immediately. Document on the report the name of the vascular registrar that has been contacted.

If synthetic grafts, stents or patches are present they should be drawn on the diagram with dashes on the sides of the artery or graft.

Any incidental findings should be documented and further imaging recommended when clinically appropriate.

References

1. Society for Vascular Technology of Great Britain & Ireland (2019). Available at: <https://www.svtgbi.org.uk/>
2. Oates, C.P. et al. (2009). 'Joint recommendations for reporting carotid ultrasound investigations in the united kingdom', *European Journal of Vascular and Endovascular Surgery*, 37(3), pp.251-261

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3.	Cossman, D.V. et al. (1989). 'Comparison of contrast arteriography to arterial mapping with color-flow duplex imaging in the lower extremities', <i>Journal of Vascular Surgery</i> , 10(5), pp.522-529
4.	Howard, G. et al. (1993). 'Carotid artery intimal-medial thickness distribution in general populations as evaluated by B-mode ultrasound. ARIC Investigators', <i>Stroke</i> , 24(9), pp.1297-1304
5.	Bluth, E.I et al. (1988). 'Carotid duplex sonography: a multicentre recommendation for standardized imaging and Doppler criteria', <i>RadioGraphics</i> , 8(3), pp.487-506
6.	Filis, K.A. et al. (2002). 'Duplex ultrasound criteria for defining the severity of carotid stenosis. Annals of Vascular Surgery', <i>Annals of Vascular Surgery</i> , 16(4), pp.413-421
7.	Osiro, S. et al. (2012). 'A review of subclavian steal syndrome with clinical correlation', <i>Medical Science Monitor</i> , 18(5), RA57-63
8.	Basic medical key. 2020. Available at: https://basicmedicalkey.com/carotid-endarterectomy-2/ Accessed: 04/11/2020.
9.	Children's Wisconsin. 2020. https://childrenswi.org/medical-care/birthmarks-and-vascular-anomalies-center/conditions/phace-syndrome/phace-syndrome-handbook/abnormalities-of-the-head-and-neck-arteries Accessed 04/11/2020.