CSVS

THE COLLEGE AND SOCIETY
FOR CLINICAL VASCULAR SCIENCE
Great Britain and Ireland

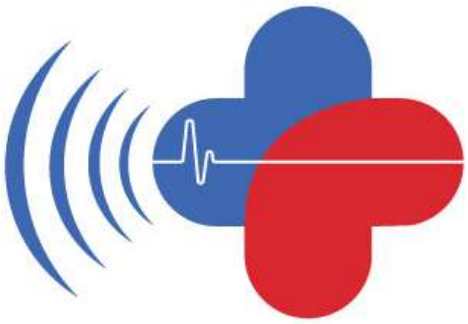
Protocol Guidelines

Extracranial Cerebrovascular Duplex Ultrasound Examination

Version 2.0

April 2025

Doc Ref PS-PG005



CSVS

THE COLLEGE AND SOCIETY
FOR CLINICAL VASCULAR SCIENCE
Great Britain and Ireland

Protocol Guidelines

Extracranial Cerebrovascular Duplex Ultrasound Examination

Version 2.0

April 2025

Doc Ref PS-PG005

Version Number	Change	Author	Date
2.0	**Review and re-formatting**	**Author: Jo Walker, CSVS 2025 Professional Standards Committee Chair Review: Professional standards committee Approval: CSVS 2025 Executive Committee**	**April 2025**

Introduction

This document was prepared by the Professional Standards Committee (PSC) of the College and Society for Clinical Vascular Science (CSVS) to support the practise and delivery of high quality standardised Clinical Vascular Science. This document may be used in its entirety (or referenced in part with suitable additions made by local policy implementers) by all parties involved with clinical vascular science. Suggestions for improving this document are welcome and should be sent to the Chair of the PSC (see csvs.org.uk for current PSC Chair details).

This document may be used in conjunction with Vascular Ultrasound Service Specifications[1].

In addition, the SVU publication [2] provides detailed indications for carotid artery Duplex investigations.

Purpose

Extracranial cerebrovascular Duplex ultrasound examinations are carried out to assess for the presence of pathology and the haemodynamic status of the common carotid artery (CCA), internal carotid artery (ICA) external carotid artery (ECA) and vertebral artery.

Common Indications

- 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
- Pre-operative assessment for high risk patients e.g. coronary artery bypass surgery (CABG)
- Pulsatile neck masses
- Evaluation of suspected subclavian steal syndrome
- Pre- maxillo-facial surgery

Contraindications and Limits

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

- Patients with short, thick muscular necks
- Patients who have had recent surgery, ultrasound visualisation may be limited due to oedema, haematoma, surgical staples, dressings etc
- Calcified plaque may cause acoustic shadowing limiting Doppler and B-mode image assessment
- Patients who are unable to lie flat due to pre-existing co-morbidities e.g. chronic obstructive pulmonary disease (COPD) and arthritis – although these patients may be able to tolerate being examined seated in a chair or with the head of the bed raised
- Patients who are unable to cooperate or those with involuntary movements
- Examinations undertaken portably at the patient's bedside may be limited due to equipment and room dimensions

Patient Pathway

Carotid duplex scanning will be utilised and apply to TIA and stroke patient pathway. Carotid surgery or stenting is a possible endpoint of this pathway. Therefore, if this diagnostic test is appropriate, it should be carried out urgently, preferably within 24 hours of the onset of symptoms ideally in a one-stop TIA clinic[3,4,5,6].

Patient Referral

A suspected neurological event (stroke, TIA or amaurosis fugax) that may have resulted from an embolic event arising from atherosclerotic disease at the carotid bifurcation is the most appropriate clinical indication for a carotid duplex scan. There are other less common indications such as a pulsatile mass in the neck. The referral should include details of the presenting symptoms.

Patient Preparation

No specific preparation is required. Good access will be required to the patient's neck. The patient will need to maintain the desired head position and be asked not to talk during the scan.

Explanation of Examination

The person undertaking the examination should:

- Introduce themselves

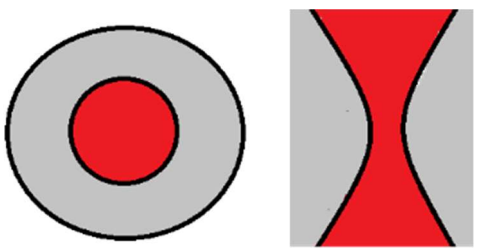
- Confirm the patient's identity e.g. full name and date of birth
- Explain why the examination is being performed and given an indication of the test's anticipated duration
- Obtain verbal consent for the examination
- Obtain a pertinent relevant medical history from the patient and/or notes
- Presence of risk factors e.g. diabetes, hypertension, hypercholesterolemia etc
- Presence of cerebrovascular disease e.g. aphasia, dysphasic, paralysis etc
- Result of other relevant diagnostics
- Verify that the requested procedure correlates with the patient's clinical presentation

Examination

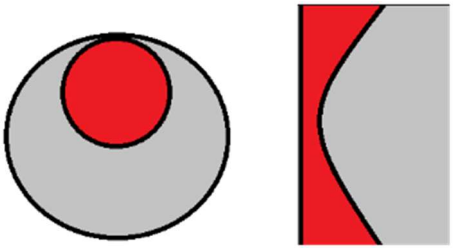
The patient is asked to adjust their clothing to expose the neck area and lie or sit with their neck extended. The patient may be asked to turn their head away from the side being assessed to ensure maximum access to the vessels to be examined. The patient's dignity and privacy should be maintained at all times.

The standard examination should examine bilaterally the arterial supply to the head encompassing the common carotid artery (CCA), carotid bifurcation, external carotid artery (ECA) and internal carotid artery (ICA) to its most accessible distal extracranial segment. The vertebral artery should be identified to confirm patency and direction of flow. In the presence of reversed or partially reversed vertebral artery flow the subclavian artery should be examined.

The CCA, carotid bifurcation, ECA and ICA are identified in B Mode using the transverse plane and longitudinal plane, and images recorded as appropriate; B-mode can be used to classify echogenicity of any plaque and the surface characteristics e.g. irregular, smooth or ulcerated 7. In the presence of minor wall disease the intima-medial thickening (IMT) or atheroma measurement can be made in the CCA. IMT should ideally be measured at the distal 1cm of the CCA in longitudinal section on the posterior wall, and recorded in mm. Care must be taken to ensure accurate measurement in the presence of eccentric plaques in order not to over-estimate disease burden. For lower grades of disease in the ICA a caliper NASCET measurement can be made to stratify the degree of diameter reduction.



Concentric plaque



Eccentric plaque

Using longitudinal plane with colour and spectral Doppler (angle of 45-60°) [8] the extracranial carotid arteries should be assessed for any areas for velocity increase or turbulence from the CCA to the distal ICA, and the vertebral artery.

Peak systolic velocities (PSV) and end diastolic velocities (EDV) should be measured, image recorded for a minimum of the CCA and ICA. Direction of flow must also be recorded, in the vertebral artery [8]. The joint recommendations document [8] also gives detailed information on how velocity measurements should be made, including control settings such as Doppler gain and the placement of the velocity cursor in order to make measurements consistent.

It is recognised that ultrasound scanning is operator dependent and recording of images may not fully represent the entire examination. Recording of images should be done in accordance with a locally agreed protocol. Images which document the findings of the investigation are appropriate. Any stored images should have patient identification, examination date, organisation and department identification. Further explanation and guidance is given in CSVS image storage guidelines[9].

The anatomical location of any haemodynamically significant lesion or disease should be recorded using appropriate image capture and documented in the report.

Haemodynamically significant stenoses are diagnosed by using the standard criteria :

Percentage Stenosis (NASCET)	Internal carotid peak systolic velocity cm/sec	Peak systolic velocity ratio ICA $_{psv}$ / CCV $_{psv}$	St Mary's Ratio ICA psv / CCA EDV
<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

Table 1. Criteria for Extracranial carotid artery duplex assessment [8]

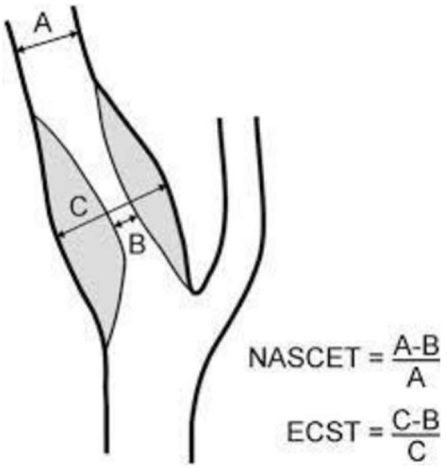
The additional criteria parameter Internal Carotid Artery end diastolic velocity (ICA $_{EDV}$)[10] may considered useful:

<50% <40cm/sec
50-69% 40-100cm/sec
>70% but less then near occlusion >100cm/sec
Near Occlusion variable

Plaque characteristics, the length of the lesion, appearance and/or diameter of the distal ICA lumen, and level of bifurcation should also be documented, where surgical decisions and planning is required.[10,11,12]

Carotid plaque surface characteristics either in the form of surface irregularities or ulceration [13] represent an important factor of vulnerability and are associated with the occurrence of neurologic symptoms.

Diameter reduction measurements can be made on the B-mode image; however these will be dependent on appropriate gain selection and choice of imaging plane and should be according to the NASCET method [3,8]. When diameter measurements are made in the bulb, these should be made using the NASCET method to correlate with the velocity criteria used, (unless clearly stated as being ECST measurements, see below). Diameter measurements are particularly useful when a significant burden of disease is noted without any significant velocity increase.



8

Reporting

The report is a recording and interpretation of observations made during the extracranial carotid arterial duplex ultrasound examination; it should be written by the person undertaking the examination and viewed as an integral part of the whole examination.

The written report should include the correct patient demographics; date of examination; examination type and the name and status of the person reporting the examination. This report should be available along with the associated images and recordings.

The report should include:

- Which arteries have been assessed & record the presence/absence of disease
- The following four velocities [8].
  - PSV & EDV in the CCA 1-2cm below the bifurcation
  - PSV & EDV in the ICA at the point of highest velocity
- Qualitatively note the nature of the plaque e.g. calcified, echolucent, irregular, smooth, ulcerated etc, the length and anatomical position
- Percentage degree of stenosis and calculation method used (velocities and/or diameter reduction methods i.e. ECST or NASCET) [8]

- Any limitation e.g. calcified plaque causing acoustic shadowing
- An appropriate number of annotated images that represent the entire ultrasound examination – in accordance with local protocols and CSVS Image Storage Guidelines [9]

Result of Ultrasound

Carotid scan can be reported as either 'normal' or 'zero disease' or 'disease-free' in vessels except in the presence of intima-medial thickening (IMT). IMT is generally defined as a wall thickness in the CCA of more than 1mm. It is an important measurement, as it is an accepted marker of subclinical atherosclerosis, which can help clinicians in cardiovascular risk stratification[13]. For accuracy and reproducibility an automated IMT measurement package should be used, otherwise careful calliper placement on an appropriately optimised B mode image, taking a mean value from several measurements. Departments should be aware of the resolution achievable versus transmission frequency to report measurements to a level of precision that is line with the known uncertainty of measurement[14].

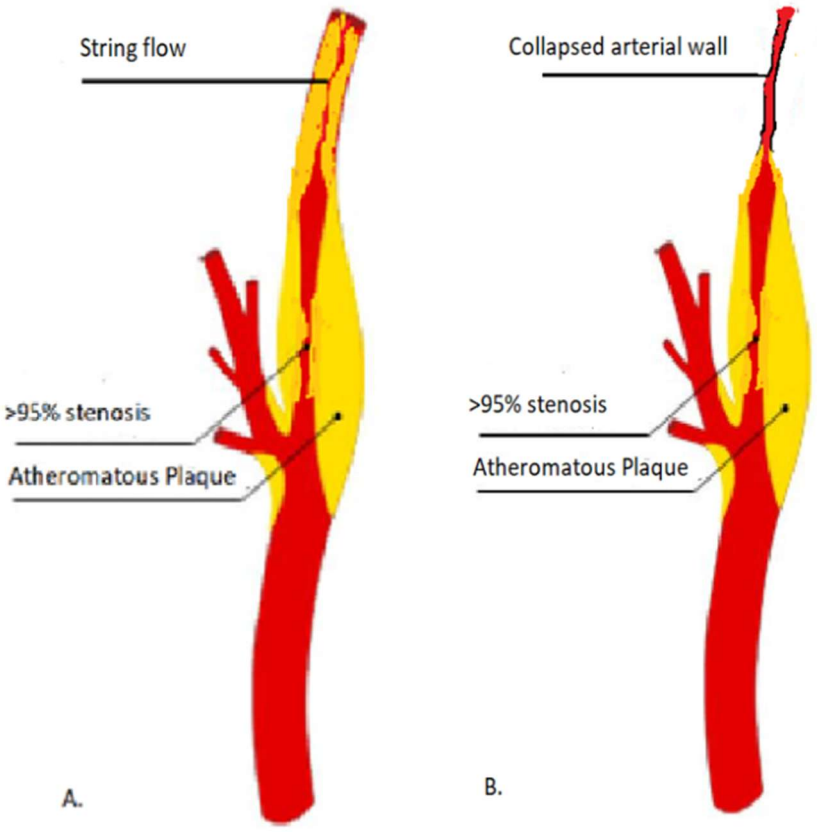
For lower grades of disease in the ICA the NASCET % diameter reduction can be reported where measured.

Carotid Web

Another abnormality that is important to report are carotid web lesions, which have been identified as a potential source of distal cerebral embolization[15] typically in younger patients who have experienced a significant stroke. Carotid webs are sometimes associated with fibromuscular dysplasia (FMD). They may be identified by intimal disruption (flap or shelf-like appearance) on the posterior wall and may not be easily detectable on B mode. Subtle colour flow disturbances often demonstrated without stenosis or significant velocity increase. Carotid webs may be static or mobile in appearance. It is important to utilise a combination of views and modalities including colour Doppler, power Doppler, B flow. Significance of a carotid web finding should be highlighted in a report regardless of the degree of stenosis.

>95% stenosis:

The imaging and reporting is to ensure you can determine an end-point to the length of disease in the ICA lumen (critical stenosis or pin-hole stenosis) or whether the disease extends beyond the point of accessible view on ultrasound (distal ICA) suggesting sub-occlusion or 'string sign'. The flow Doppler waveform should be recorded to assist in determining distal patency and trickle/under-perfused versus pulsatile flow. The visible distal ICA lumen diameter should be measured to establish if the under-perfused vessel demonstrates a collapse in normal calibre. These important findings are to enable surgical decision making and/or requirement for additional alternative imaging.



A. String flow in distal diseased ICA. B. Collapsed, distal disease free, ICA

Subclavian steal syndrome

Subclavian 'steal' [16] phenomenon is a function of the proximal subclavian artery steno-occlusive disease, with subsequent retrograde blood flow in the ipsilateral vertebral artery (VA). Doppler ultrasound is a useful screening tool, but the diagnosis can also be confirmed by CT or MR angiography. It is not only useful in assessing the severity of the vertebral-steal haemodynamics, but can also show other lesions in the neck vessels as subclavian artery or innominate artery.

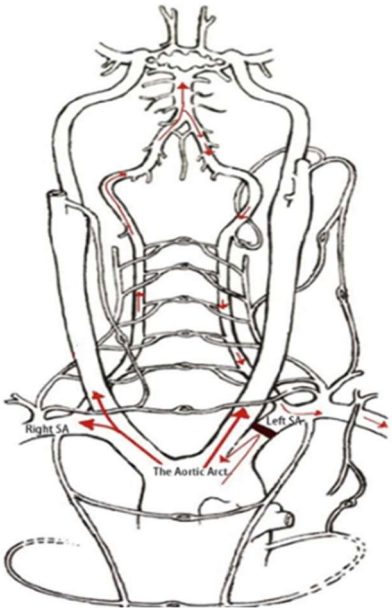
Severity is classified into three stages or grades:-

Grade I (pre-subclavian steal): reduced antegrade vertebral flow,

Grade II (intermittent/partial/latent): alternating flow – antegrade flow in the diastolic phase and retrograde flow in the systolic phase,

Grade III (permanent/advanced): permanent retrograde vertebral flow.[16]

Other classification can also be found.



Left subclavian steal syndrome with subclavian artery occlusion

Referral of critical ultrasound results should be made to the referring consultant or appropriate medical/surgical team (as per local protocol) prior to the patient being discharged so that treatment plans can be developed and expedited accordingly.

The Joint Working Group[8] recommended the use of a reporting proforma that includes an illustrative diagram. The report should also include incidental findings including, carotid dissection, carotid body tumour, carotid aneurysm and carotid tortuousity. Confirmation of patency and direction of flow in both vertebral arteries should also be included. Any limitations of the scan must be included in the report.

REFERENCES:

[1] The College and Society for Clinical Vascular Science. Service Specification Document The College and Society for Clinical Vascular Science | The College and Society for Clinical Vascular Science

[2] Society for Vascular Ultrasound Vascular Technology Professional Performance Guidelines Extracranial Cerebrovascular Duplex Ultrasound Evaluation 2011 www.svunet.org

3. NHSE, Integrated Stroke Delivery Networks National Stroke Service Model May 2021

stroke-service-model-may-2021.pdf

[4] NICE guidance (ng128) "Stroke and transient ischaemic attack in over 16s: diagnosis and initial management" https://www.nice.org.uk/guidance/ng128/resources/stroke-and-transient-ischaemic-attack-in-over-16s-diagnosis-and-initial-management-pdf-66141665603269

5 Implementing the National Stroke Strategy – An Imaging Guide May 2008

http://www.csnlc.nhs.uk/uploads/files/stroke/documents/national_documents/dh_085145.pdf

6 National clinical guidelines for stroke fifth edition prepared by the intercollegiate stroke working party 2016 https://www.rcplondon.ac.uk/guidelines-policy/stroke-guidelines

7 European Carotid Plaque Study Group 1995 Carotid artery plaque composition – relationship to clinical presentation and ultrasound B-mode imaging. European Journal of Endovascular Surgery 10: 23-30 https://pubmed.ncbi.nlm.nih.gov/21855017/

8 Oates CP et al., Joint Recommendations for Reporting Carotid Ultrasound Investigations in the United.

https://pubmed.ncbi.nlm.nih.gov/19046904/

[9] The College and Society for Clinical Vascular Science. Image Storage Guidelines The College and Society for Clinical Vascular Science | The College and Society for Clinical Vascular Science

[10] Carotid artery stenosis: grey-scale and Doppler ultrasound diagnosis – Society of Radiologists in Ultrasound Consensus Conference' Grant EG et al Radiology 2003; 229: 340-346 https://pubmed.ncbi.nlm.nih.gov/14500855/

[11] de Bray J M, Baud J M, Dauzat M 1997 Consensus concerning the morphology and the risk of carotid plaques, Cerebrovascular Disease 7: 289-296 https://www.semanticscholar.org/paper/Consensus-Concerning-the-Morphology-and-the-Risk-of-Bray-Baud/836f6a0692b7038b6947b31afcee709334fbb9de

12 Bock RW et al Carotid plaque morphology and interpretation of the echolucent lesions. Diagnostic vascular ultrasound. Edward Arnold, London pp 225-236 1992 https://www.sciencedirect.com/science/article/pii/S1078588405801947

13 Rafailidis, V., Chryssogonidis, I., Tegos, T. et al. Imaging of the ulcerated carotid atherosclerotic plaque: a review of the literature. Insights Imaging 8, 213–225 (2017). https://doi.org/10.1007/s13244-017-0543-8

https://insightsimaging.springeropen.com/articles/10.1007/s13244-017-0543-8

14 The College and Society for Clinical Vascular Science. Professional Standards Committee Uncertainty of measurement in vascular technology. https://www.csvs.org.uk/media/resources/SVT_Uncertainty_of_Measurement_document_-_March_2021.pdf

15 Labeyrie M-A, Serrano F, Civelli V, et al. Carotid artery webs in embolic stroke of undetermined source with large intracranial vessel occlusion. International Journal of Stroke. 2021;16(4):392-395. doi:10.1177/1747493020929945

16 Osiro S, Zurada A, Gielecki J, Shoja MM, Tubbs RS, Loukas M. A review of subclavian steal syndrome with clinical correlation. Med Sci Monit. 2012 May;18(5):RA57-63. doi: 10.12659/msm.882721. PMID: 22534720; PMCID: PMC3560638.

https://pmc.ncbi.nlm.nih.gov/articles/PMC3560638/