

ULTRASONIC ANGIOLOGY DEPARTMENT

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PURPOSE

The purpose of the extracranial cerebrovascular duplex scan is to assess the common carotid artery (CCA), internal carotid artery (ICA), external carotid artery (ECA), vertebral and subclavian arteries, and determine the haemodynamic status of these vessels, identify any significant pathology that can be correlated with neurological symptoms.

All referrals for suspected cerebral ischemia should be accompanied by a scan of the vertebral, subclavian and basal cerebral arteries.

COMMON INDICATIONS

Common indications for extracranial cerebrovascular evaluation include:

- Transient ischaemic attack (TIA)
- Stroke
- Amaurosis fugax
- Carotid bruit
- Progression of known carotid stenoses
- Follow-up post carotid intervention (i.e. carotid endarterectomy, carotid stent)
- Pre-operative TAVI or CABG assessment
- Other major surgery in high risk patients (e.g. thoracic aortic stenting)

Contraindications and Limitations

Contraindications and limitations for extracranial cerebrovascular evaluation include:

- Patients with short, thick or muscular necks
- Recent surgery leading to the presence of scarring, oedema, haematoma or the presence of open wounds and surgical bandages
- Calcified plaques causing acoustic shadowing and preventing penetration of the ultrasound beam
- Patients that are unable to lie flat for the duration of the investigation (e.g. COPD or other respiratory problems, severe back pain, arthritic neck)
- Lack of cooperation from patient due to altered mental state (e.g. dementia, Alzheimer's)

PATIENT COMMUNICATION AND POSITIONING

- Prepare scanning area for patient and follow all hygiene guidelines
- Introduce self to patient and explain the reason why they have been referred for the extracranial scan
- Confirm the identity of the patient by checking full name and date of birth prior to undertaking investigation
- Obtain a detailed clinical history including all symptoms likely to be related to the extracranial arteries (limb weakness, visual or speech disturbances, facial palsy), when symptoms occurred, duration of symptoms, what side of the body was affected, and whether symptoms completely resolved. Ask patient regarding family history of cardiovascular disease, smoking status and whether diabetic.
- Explain the procedure to the patient taking into account the age and mental status of the patient
- Position the patient supine with the head turned away from the side of the neck being investigated and the chin lifted, allowing for maximum access to the vessels being examined. The scan can be performed with the patient seated in a wheelchair in cases of immobility or disability.

EXAM PROTOCOL

Bilateral assessments are performed for each extracranial cerebrovascular investigation in order to ensure complete evaluation.

Carotid Arteries

- Extracranial duplex scans in Ultrasonic Angiology can be performed with the Philips EPIQ7, iU22 or CX50.
- Select the linear array transducer (e.g. L9-3, L12-3) and carotid preset. Optimise colour scale and colour gain to minimise aliasing and colour 'bleeding'. Set pulsed Doppler sample volume and ensure Doppler angle is set $\leq 60^\circ$.
- Starting at the base of the neck, as close to the origin of the CCA as possible, track the length of the vessel in cross-section noting the level of the bifurcation, and identifying any non-circumferential plaque.

- Obtain a longitudinal B-mode image of the proximal CCA. Normal vessels will show a thin-walled appearance with a uniform intima-media layer.
- Obtain a colour and spectral Doppler image of the proximal CCA. Measure the peak systolic velocity (PSV) and end diastolic velocity (EDV) on the obtained waveform.
- Assess the CCA using B-mode, colour and spectral Doppler in the distal CCA, just proximal to the carotid bifurcation.
- Obtain a B-mode image of the carotid bulb, identifying any plaque present. Colour Doppler should also be used to identify echolucent plaque. Normal bulbs should feature complete colour filling with evidence of recirculatory flow.
- Scan to the level of the bifurcation, and correctly identify the ICA and ECA. The ICA is typically located postero-laterally. Assess the ICA proximally and distally, obtaining a B-mode image and a colour image for each. Obtain a waveform in each segment and measure PSV and EDV. Normal ICA waveforms should be low resistance with typically larger EDVs than the ECA. Antegrade flow should be detected throughout the cardiac cycle. Normal ECA waveforms are more pulsatile, high resistance waveforms with a prominent diastolic notch caused by aortic valve closure.
- If ICA disease is present, measure the PSV and EDV at the site of maximum velocity. Beam steering and angle correction should be used to position the sample volume in line with the stenotic jet. Post stenotic turbulence should also be documented.
- In cases of significant plaque, measure the length of the lesion and the distal ICA diameter. Plaques should be characterised depending on its echogenicity (e.g. fibrous, calcified, echolucent, mixed echo).
- Image the origin of the ECA and obtain both a B-mode image and a colour image with spectral Doppler waveform. Branches are also present arising from the ECA.

Vertebral and Subclavian Arteries

- Vertebral arteries are assessed bilaterally, and are located posterior and deeper relative to the CCAs. The vertebral arteries travel through the vertebral processes towards the head, therefore can only be visualised in segments.

- Use colour flow to identify the vertebral artery and obtain a spectral Doppler waveform, and document direction of flow. Normal vertebral artery waveforms are low resistance with flow towards the head. Reversal of flow (i.e. away from the head) may be caused by significant disease in the ipsilateral subclavian artery.
- Subclavian arteries are assessed by angling the probe to look behind the clavicle. Subclavian arteries are triphasic in normal circumstances. Severe stenoses or occlusion proximal to the vertebral origin results in subclavian steal and reversal of flow in the vertebral artery.

DIAGNOSTIC CRITERIA

Local diagnostic criteria are used to grade the severity of carotid disease:

- I. Normal: 0%
 - ICA PSV <125cm/s
 - Flow reversal in the carotid bulb
- II. Minor disease: 1-15%
 - ICA PSV <125cm/s, no focal increase in PSV
 - No flow reversal in the carotid bulb
 - Spectral broadening during systole
- III. Minor to moderate disease: 16-49%
 - ICA PSV <125cm/s, no focal increase in PSV
 - ICA EDV <125cm/s
 - Spectral broadening throughout cardiac cycle
 - Use "moderate disease" as PSV approaches 125cm/s and focal plaque noted
- IV. Moderate to severe stenosis: 50-79%
 - ICA PSV >125cm/s, focal increase in PSV
 - ICA EDV <125cm/s
 - Spectral broadening
 - "Moderate" used for stenoses of 50-64%
 - "Severe" used for stenoses of ≥65%

V. Critical stenosis: 80-99%

- ICA PSV >125cm/s, focal increase in PSV
- ICA EDV >125cm/s
- Spectral broadening

VI. Occlusion/Trickle Flow

- High-grade, pre-occlusive lesion
 - Low flow, low pressure, collapsed distal ICA
 - ICA PSV <20cm/s
 - CCA EDV approaching zero
- Occlusion
 - EDV in CCA nearly always falls to zero
 - Thump signal at point of occlusion
 - Image distal ICA for confirmation

VII. Contralateral ICA occlusion

- Collateral flow effects alter duplex criteria – increase PSV threshold
- Moderate to severe stenosis: 50-79%
 - ICA PSV >140cm/s, ICA EDV <140cm/s
- Critical stenosis: 80-99%
 - ICA PSV >140cm/s, ICA EDV >140cm/s

Criteria for discrete grading of ICA stenosis (ICA:CCA PSV Ratio)

STENOSIS (%)	PSV RATIO	PSV (cm/s)	EDV (cm/s)
50	2.0	>125	<125
60	2.5	>125	<125
70	3.4	>125	<125
80	5.0	>125	>125
90	10.0	>125	>125
>90	-	<20	<20

It is important to be aware that other departments may use differing disease grading criteria. Criteria discussed in the UK Joint Recommendations are commonly used (Oates et al., 2009)

Plaque Characterisation

Composition of carotid plaques is associated with stroke risk, with echolucent plaques being of greater risk than stable, echogenic plaques and ulcerated plaques being higher risk than smooth plaques. Plaques are graded as follows:

- I. Echolucent (High-risk plaque)
 - Unable to visualize plaque in B-mode alone, colour filling defines plaque border
- II. Mixed echo plaque
 - Presence of low, mid and high echoes, describe as predominantly echolucent (>50% low echoes) or predominantly echogenic (>50% high echoes)
- III. Fibrous/calcified plaque (Low-risk plaque)
 - Indicated by the presence of uniform high echoes.
 - i. Calcified plaques are differentiated from fibrous plaques if acoustic shadowing is indicated as this may mask echolucent regions

Describe the plaque border in relation to the colour flow-filled lumen and vessel wall as:

- Smooth
- Irregular
- Ulcerated – if the irregularity is >1mm and discrete filling is demonstrated on dynamic colour filling

REPORTING

- Scribble sheets are completed with full patient details, clinical history and date and location of scan.
- As a minimum requirement, the carotid artery schematic is annotated with PSV and EDV measurements of the proximal and distal CCA, proximal and distal ICA and the ECA.
- Plaques are drawn on to the diagram, with information of composition, plaque length and distal ICA diameter
- Waveform shapes should also be added.

Urgent Referral

If immediate attention is indicated, alert the Stroke team & Head of Department before the patient leaves the department, for example if there is:

- An ICA stenosis $\geq 50\%$ identified and the patient is symptomatic
- An ICA occlusion
- Retrograde flow in the CCA, ICA or ECA caused by for example occlusion of the innominate artery
- Significant progression of a known ICA stenosis
- A new carotid artery dissection
- A carotid body tumour
- Aneurysmal disease

REFERENCES

1. Society for Vascular Ultrasound (2011). *Vascular Technology Professional Performance Guidelines – Extracranial cerebrovascular duplex ultrasound evaluation*. Available from www.svunet.org