CORE MODALITY 1								
Scan Number	Date	Patient Hospital Number	Scan type	Pathology (Y/N)	Aided (A)/ Unaided (U)	Agreement with supervisor? Y/N	Comments, learning points, etc.	Supervisor
1	February 05, 2024	RRKA202455	Carotid Doppler	N	U	Y	Normal appearance with normal flow velocities in the bilateral CCA. Minimal heterogenous hyperechoic plaques in the bilateral carotid bulb. Normal flow velocities in the bilateral ICA and proximal ECA. Antegrade flow in the vertebral arteries.	Ivan Kalik
2	February 05, 2024	RRKK235384	Carotid Doppler	N	U	Y	Normal appearance with normal flow velocities in the bilateral CCA. Minimal heterogenous hyperechoic plaques in the bilateral carotid bulb. Normal flow velocities in the bilateral ICA and proximal ECA. Antegrade flow in the vertebral arteries.	Ivan Kalik
3	February 05, 2024	RRKS883963	Carotid Doppler	N	U	Y	RIGHT Slightly thickened intima media with normal flow velocities in the CCA. Normal flow velocities in the ICA to the jaw-line area and proximal ECA. Normal antegrade waveform seen in the vertebral artery with reduced flow velocities compared to the left. LEFT Mildly atheromatous CCA with normal flow velocities. Heterogenous plaque in the carotid bifurcation extending to the proximal ICA and ECA origin. Normal flow velocities in the ICA to the jaw-line area and proximal ECA. Normal antegrade flow seen in the vertebral artery.	Ivan Kalik
4	February 05, 2024	RRKA148162	Carotid Doppler	N	U	Y	RIGHT Normal looking CCA with normal flow velocities. Normal looking ICA with normal flow velocities. Discrete heterogenous plaque in the proximal ECA with normal flow velocities. Antegrade flow in the vertebral artery. LEFT Normal looking CCA with normal flow velocities. Discrete heterogenous plaque in the carotid bifurcation. Normal flow velocities in the ICA and proximal ECA. Antegrade flow in the vertebral artery.	Ivan Kalik
5	February 05, 2024	RRKV183009	Carotid Doppler	N	U	Y	RIGHT Normal looking CCA with normal flow velocities. Minimal heterogenous hyperechoic plaques seen in the carotid bifurcation. Normal flow velocities in the ICA to the level of jaw-line area and proximal ECA. Antegrade flow seen in the vertebral artery. LEFT Normal looking CCA with normal flow velocities. Minimal heterogenous hyperechoic plaques seen in the carotid bifurcation. Normal flow velocities in the ICA to the level of jaw-line area and proximal ECA. Antegrade flow seen in the vertebral artery.	Ivan Kalik
6	January 31, 2024	RRKK406261	Carotid Doppler	N	U	Y	Smooth intima lining with normal peak systolic flow velocities seen bilaterally throughout CCA's, ICA's and proximal ECA's. Normal antegrade flow seen bilaterally in the vertebral arteries.	Ivan Kalik

7	January 31, 2024	RRK1385092	Carotid Doppler	N	U	Y	Normal appearance and flow velocities seen bilaterally throughout CCA's, ICA's and proximal ECA's. Normal antegrade flow was seen bilaterally in the vertebral arteries.	Ivan Kalik
8	January 31, 2024	RRKS220232	Carotid Doppler	N	U	Y	RIGHT Slight intima media thickening of the CCA with normal flow velocities. Heterogenous hyperechoic plaques seen in the bifurcation extending to proximal ICA and ECA. Despite of the plaques causing luminal reduction appearance, there is no significantly raised PSV of >125 cm/sec and there was no evidence of turbulent flow. Flow velocities were within normal range from the proximal to the distal ICA at the jaw-line area. No raised PSV noted in the ECA. Antegrade flow in the vertebral artery. Carotid atherosclerotic disease of <50% in the right proximal internal carotid artery (carotid bulb). LEFT Slight intima media thickening of the CCA with normal flow velocities. Minimal heterogenous hyperechoic plaques seen in the bifurcation extending to proximal ICA. Normal flow velocities throughout ICA to the distal ICA at the jaw-line area. Normal flow velocities in the proximal ECA. Antegrade flow seen in the vertebral artery.	Ivan Kalik
9	January 30, 2024	RRKA246744	Carotid Doppler	N	U	Y	RIGHT Normal looking CCA with normal flow velocities. Slight intima media thickening in the bifurcation. Normal flow velocities throughout ICA to the distal ICA at the jaw-line. Normal flow velocities in the proximal ECA. Normal antegrade flow in the vertebral artery. LEFT Normal looking CCA with normal flow velocities. Small heterogenous hyperechoic plaque seen in the ICA origin. Normal flow velocities throughout ICA to the distal ICA at the jaw-line. Normal flow velocities in the proximal ECA. Normal antegrade flow in the vertebral artery.	Ivan Kalik
10	January 30, 2024	RRKA249241	Carotid Doppler	N	U	Y	Normal appearance and flow velocities seen bilaterally throughout CCA's, ICA's and proximal ECA's. Antegrade flow was seen bilaterally in the vertebral arteries.	Ivan Kalik
11	January 30, 2024	RRKG762498	Carotid Doppler	N	U	Y	RIGHT Normal looking CCA with normal flow velocities. Calcified atherosclerotic plaques seen in the bifurcation extending to proximal ICA and ECA. Despite of the plaques causing luminal reduction appearance, there is no significantly raised PSV of >125 cm/sec and there was no evidence of turbulent flow. Flow velocities were within normal range to the distal ICA at the jaw-line area. No raised PSV noted in the ECA. Normal antegrade flow in the vertebral artery. Carotid atherosclerotic disease of <50% in the right proximal internal carotid artery. LEFT	Ivan Kalik

							Small atherosclerotic plaque seen in the CCA with normal flow velocities. Calcified atherosclerotic plaques seen in the bifurcation extending to proximal ICA and ECA. Flow velocities were within normal range in the ICA to the level of jaw-line and ECA. Normal antegrade flow in the vertebral artery.	
12	January 30, 2024	RRKK171851	Carotid Doppler	N	U	Y	Normal appearance and flow velocities seen bilaterally throughout CCA's, ICA's and proximal ECA's. Antegrade flow was seen bilaterally in the vertebral arteries.	Ivan Kalik
13	January 30, 2024	RRKA186035	Carotid Doppler	N	U	Y	Normal appearance and flow velocities seen bilaterally throughout CCA's, ICA's and proximal ECA's. Antegrade flow was seen bilaterally in the vertebral arteries.	Ivan Kalik
14	January 30, 2024	RRKS923361	Carotid Doppler	N	U	Y	RIGHT Normal looking CCA with normal flow velocities. Heterogenous hyperechoic plaque seen in the carotid bifurcation extending to the ICA origin. Normal flow velocities in the ICA to the distal ICA at jaw-line area. Normal flow velocities in the proximal ECA. Antegrade flow seen in the vertebral artery. LEFT Normal looking CCA with normal flow velocities. Minimal calcified atherosclerotic plaques seen in the carotid bifurcation extending to the proximal ICA and ECA origin. Despite of the plaques seen causing slight luminal reduction, there was no evidence of significantly raised PSV. Flow velocities were within normal range throughout ICA to the distal ICA at the jaw-line area. No significantly raised PSV in the proximal ECA. Antegrade flow seen in the vertebral artery. CONCLUSION Carotid atherosclerotic disease of <50% in the left ICA (carotid bulb).	Ivan Kalik
15	January 26, 2024	RRKV247644	Carotid Doppler	N	U	Y	RIGHT Normal looking CCA with normal flow velocities. Minimal heterogenous plaques in the carotid bifurcation extending to proximal ICA. Normal flow velocities in the ICA to the distal ICA at the jaw-line area. Normal flow velocities in the proximal ECA. Normal antegrade flow seen in the vertebral artery. LEFT Small plaque seen in CCA with normal flow velocities throughout. Minimal heterogenous plaques in the carotid bifurcation extending to proximal ICA and ECA origin. Normal flow velocities in the ICA and proximal ECA. Normal antegrade flow in the vertebral artery.	Ivan Kalik
16	January 25, 2024	RRKV266469	Carotid Doppler	N	U	Y	RIGHT Normal looking CCA with normal peak systolic velocities. Normal flow velocities in the ICA and proximal ECA. Normal antegrade flow in the vertebral artery. LEFT Slight intima media thickening in the distal CCA to carotid bifurcation with normal flow velocities throughout. Normal peak systolic velocities in the ICA and proximal ECA. Normal antegrade flow in the vertebral artery.	Ivan Kalik

17	January 25, 2024	RRKV002720	Carotid Doppler	N	U	Y	RIGHT Normal looking CCA with normal flow velocities. Minimal heterogenous hyperechoic intima thickening in the carotid bifurcation. Normal flow velocities in the ICA and proximal ECA. Antegrade flow in the vertebral artery. LEFT Normal looking CCA with normal flow velocities. Minimal heterogenous hyperechoic intima thickening in the carotid bifurcation. Normal flow velocities in the ICA and proximal ECA. Antegrade flow in the vertebral artery.	Ivan Kalik
18	January 25, 2024	RRKK547547	Carotid Doppler	N	U	Y	Normal appearance and flow velocities seen bilaterally throughout CCA's, ICA's and proximal ECA's. Normal flow antegrade was seen bilaterally in the vertebral arteries.	Ivan Kalik
19	January 22,2024	RRKK965529	Carotid Doppler	N	U	Y	RIGHT Normal looking CCA with normal flow velocities. Minimal interrupted heterogenous hyperechogenic plaques in the carotid bifurcation extending to the proximal ICA. Normal flow velocities in the ICA to the distal ICA at the jaw-line area. Normal flow velocities in the proximal ECA. Normal antegrade flow in the vertebral artery. LEFT Normal looking CCA with normal flow velocities. Discrete heterogenous hyperechogenic plaque seen in the carotid bifurcation. Normal flow velocities in the ICA to the distal ICA at the jaw-line area. Normal flow velocities in the proximal ECA. Normal antegrade flow in the vertebral artery.	Ivan Kalik
20	January 22, 2024	RRK113086	Carotid Doppler	N	U	Y	RIGHT Normal looking CCA with normal flow velocities. Slight intima thickening (heterogenic hyperechogenic) in the carotid bifurcation. Normal flow velocities in the ICA to the distal ICA at the jaw-line. Normal flow velocities in the proximal ECA. Normal antegrade flow in the vertebral artery. LEFT Normal looking CCA with normal flow velocities. Normal flow velocities in the ICA to the distal ICA at the jaw-line. Normal flow velocities in the proximal ECA. Normal antegrade flow in the vertebral artery.	Ivan Kalik
21	January 22, 2024	RRKV444537	Carotid Doppler	N	U	Y	RIGHT Normal looking CCA with normal flow velocities. Patent full color flow in the carotid bifurcation. Normal flow velocities in the ICA to the level of jaw-line. Normal flow velocities in the proximal ECA. Normal vertebral antegrade flow. LEFT Normal looking CCA with normal flow velocities. Patent full color flow in the carotid bifurcation. Normal flow velocities in the ICA to the level of jaw-line. Normal flow velocities in the proximal ECA. Normal vertebral antegrade flow.	Ivan Kalik

22	January 22, 2024	RRKK626498	Carotid Doppler	N	U	Y	RIGHT Mildly atheromatous CCA extending to the carotid bifurcation with normal flow velocities. Normal flow velocities in the ICA. Normal flow velocities in the proximal ECA. Antegrade flow in the vertebral artery. LEFT Normal looking CCA with normal flow velocities. Slight intima media thickening in the carotid bifurcation. Normal flow velocities in the ICA. Normal flow velocities in the proximal ECA. Antegrade flow in the vertebral artery.	Ivan Kalik
23	January 19, 2024	RRKK070413	Carotid Doppler	N	U	Y	RIGHT Normal looking CCA with normal flow velocities. Slight intima media thickening in the carotid bifurcation. Normal flow velocities in the ICA to the distal ICA at the jaw-line area and proximal ECA. Normal antegrade flow in the vertebral artery. LEFT Normal looking CCA with normal flow velocities. Slight intima media thickening in the carotid bifurcation. Normal flow velocities in the ICA to the distal ICA at the jaw-line area and proximal ECA. Normal antegrade flow in the vertebral artery.	Ivan Kalik
24	January 18, 2018	RRKV601778	Carotid Doppler	N	U	Y	RIGHT Slight intima-media thickening of the CCA to the level of carotid bifurcation with normal flow velocities. Normal flow velocities in the ICA to the distal ICA at the jaw-line area. Normal flow velocities in the proximal ECA. Normal antegrade flow in the vertebral artery. LEFT Slight intima-media thickening of the CCA to the level of carotid bifurcation with normal flow velocities. Normal flow velocities in the ICA to the distal ICA at the jaw-line area. Normal flow velocities in the proximal ECA. Normal antegrade flow in the vertebral artery.	Ivan Kalik
25	January 16, 2024	RRKK126627	Carotid Doppler	Y	U	Y	US Doppler carotid artery Both: RIGHT Normal looking CCA with normal flow velocities. Minimal heterogenous hyperechoic type III plaques in the carotid bifurcation extending to the proximal ICA. Normal flow velocities in the ICA to the jaw-line area. Normal flow velocities in the proximal ECA. Antegrade flow in the vertebral artery. LEFT Normal looking CCA with normal flow velocities. Presence of mixed echogenic density plaques but predominantly hyperechoic type III plaques in the carotid bifurcation extending to the proximal internal carotid artery. Flow velocities in the ICA indicate the presence of a >90% stenosis (PSV of 641 cm/sec, PSV ratio of 8.5, St Mary's ratio of 40). Mild post stenotic turbulence in the mid ICA. Reduced flow velocity in the distal ICA compared to the right. Normal flow velocities present in the proximal ECA. Antegrade waveform present in the vertebral artery.	Ivan Kalik

							CONCLUSION Carotid, atherosclerotic diseased, with; a. <50% stenosis in the right internal carotid artery (1-15%) b. >90% stenosis in the left proximal internal carotid artery	

PROTOCOL FEBRUARY 2016-JANUARY 2023

Carotid and Vertebral Duplex Scan

EXAMINATION PROTOCOL

- ✓ Transverse view (B-mode) from proximal common carotid to bifurcation of ICA and ECA
- ✓ Transverse view (C-mode) from proximal common carotid to bifurcation of ICA and ECA
- ✓ B-mode Imaging (Gray Scale), C-mode (Color Mode) and Doppler Mode (PW Doppler)- Longitudinal View of the following:

    - Common Carotid Artery (Proximal Segment, Middle Segment, Distal Segment)
      Obtain intimal media thickness in the distal common carotid artery.
    - Internal Carotid Artery (Bulb, Proximal Segment, Middle Segment, Distal Segment)
    - External Carotid Artery
    - Vertebral Artery (Vertebral 2 Segment, Vertebral 1 segment, Vertebral 0 Segment)
      Obtain anteroposterior diameter of vertebral 2 segment.

NOTE: Color Power Angio is used/applied in the blood vessel segment where there is presence of significant finding or abnormality.

When there is an abnormal waveform noted in Vertebral Arteries-
Perform Induce Reactive Hyperemia to confirm Subclavian Steal Phenomenon

1. If early systolic deceleration is seen in the waveform pattern of the vertebral artery, perform induced reactive hyperemia to confirm the findings. Performing this maneuver will differentiate subclavian steal phenomenon secondary to hemodynamically significant proximal subclavian artery stenosis from physiological variants of the vertebrobasilar circulation.
2. Inform patient of the additional test, which will involve high pressure cuff on their upper arm for 5 minutes and might cause discomfort, slight pain and numbness of the hands. Assure the patient of the safety and importance of doing this additional procedure.
3. Obtain bilateral brachial systolic blood pressure measurements.
4. If there is an asymmetrical pressure gradient of more than 20 mmHg, the arm with the lower pressure is likely to have significant proximal disease and this finding supports the systolic deceleration of the
   ipsilateral vertebral artery
5. Inflate cuff on the arm ipsilateral to the vertebral artery in question to a pressure that exceeds the patient's systolic pressure by more than 50 mmHg (approximately 200 mmHg). Maintain the cuff for 3 to 5 minutes or as long as tolerated by the patient to induce ischemia in the arm.
6. After 3-5minutes, insonate the ipsilateral vertebral artery to obtain the spectral Doppler waveform. The early systolic deceleration should be unnoticeable.
7. Deflate, the cuff rapidly and observe for changes in the spectral Doppler waveform of the ipsilateral vertebral artery due to post-ischemic increase in blood flow to the arm. In the presence of true subclavian steal, there will be marked accentuation of the early systolic deceleration or an increase in retrograde flow or even complete flow reversal with systolic reversal below the baseline.
8. If there is no significant change in the vertebral artery waveform pattern, subclavian steal is not
   likely to be present. To rule out subclavian steal phenomenon, obtain bilateral artery Doppler waveform patterns and bilateral vertebral artery diameter measurements.
9. To support the findings of subclavian steal phenomenon, insonation of the bilateral subclavian arteries is recommended.

Carotid Stent Surveillance

If the patient has a stent deployed in their carotid artery, a more detailed scanning protocol should be followed. In addition, different stenosis profile parameters are utilized for intra-stent hemodynamics because the stent does not restore the original diameter of the artery. Therefore, expect a higher velocity within the stent compared to the native carotid artery.

1. In grey scale imaging mode, scan in the transverse plane. Look for areas of intra-stent narrowing that may be due to plaque encroachment into the lumen, neointimal hyperplasia, stent kinking and/or damage.
2. Confirm findings in color mode through the presence of color aliasing and on spectral Doppler analysis by demonstrating a significant velocity increase.
3. Obtain representative images and spectral Doppler velocity measurements in the native pre-stent, intra-stent (proximal, mid and distal) and native post-stent arterial segments. Measure the PSV and EDV.

4. Calculate the PSV ratio by dividing the intra-stent PSV by the PSV of the CCA proximal to the stent.

If there is significant stenosis within the stent, sample from the narrowest segment and divide by the proximal CCA PSV to obtain the ratio, which will be used to grade the degree of antra-stent stenosis. Refer to the annex for the criteria of grading of stenosis and the severity of disease.

1. Document the stent morphology, its apposition to the arterial wall, tapering, kinking and any evidence of migration.
2. Document of incidental findings such as vascular pathophysiological variants and abnormalities.

Criteria for Classification of NORMAL or ABNORMAL

(Results are categorized as abnormal if any of the following listed below is/ are met or presented/noted)

PLAQUE MORPHOLOGY		
Type I	Homogeneous hypoechoic	Uniformly echolucent
Type II	Heterogeneous hypoechoic	Predominantly echolucent (>50%) of plaque structure
Type III	Heterogeneous hyperechoic	Predominantly echogenic (>50%) of plaque structure
Type IV	Homogeneous hyperechoic	Uniformly echogenic
Type V	Calcified acoustic shadowing	

The less echogenic the plaque is, the higher the risk for plaque rupture/hemorrhage and embolization regardless of its % stenosis.

COMMON CAROTID AND EXTERNAL CAROTID ARTERIES	
NORMAL	No visible plaque with laminar flow and no velocity increase
< 50% stenosis	Visible plaque but < 50% diameter reduction and without >100% focal velocity increase
> 50% stenosis	Visible plaque with > 50% diameter reduction and with >100% focal velocity increase from its plaque-free pre-stenotic segment followed by a post-stenotic turbulence.

VERTEBRAL ARTERY	
normal antegrade flow	Color red vertebral artery lumen in color mode. Above baseline (+ Doppler shift) waveform in spectral Doppler.
partial steal	Early systolic deceleration (pre-bunny waveform) in spectral Doppler waveform
complete steal	Retrograde flow / below baseline (- Doppler shift) waveform in spectral Doppler.
significant stenosis	>100% focal velocity increase from its pre-stenotic segment followed by a post stenotic turbulence.
high resistant waveform pattern	low or absent end diastolic velocity
tardus parvus	blunted systolic peak with delayed systolic acceleration

Internal Carotid Artery (ICA)	Primary Parameter
Normal	ICA PSV <140 cm/sec with NO PLAQUE
< 50% stenosis	ICA PSV < 140 cm/sec with visible plaque of < 50% diameter reduction
50-69% stenosis	ICA PSV 140 - 230 cm/sec with visible plaque estimate of ≥ 50% diameter reduction
≥70-99% stenosis	ICA PSV > 230 cm/sec with visible plaque estimate of > 50% diameter reduction
Total Occlusion	Undetectable flow with visible plaque, no detectable lumen

Transcranial Doppler Study

EXAMINATION PROTOCOL

- Color Mode and Spectral Doppler (transverse view) analysis measuring ***peak systolic velocity, end diastolic velocity, mean velocity and pulsatility index*** in all of the following segments:

- Bilateral ophthalmic artery and carotid siphon (orbital window).
- Middle cerebral artery (MCA) (temporal window)
    - MCA 2 (distal)
    - MCA mid
    - MCA 1 (proximal)

- Anterior cerebral artery (ACA) (temporal window)
- Posterior cerebral artery (PCA) (temporal window)
    - PCA 2 (distal)
    - PCA 1 (proximal)
- Terminal internal carotid artery (TICA) (temporal window)
- Bilateral vertebral arteries (V4 segment) (suboccipital window)
- Basilar artery (suboccipital window)

1. During scanning, areas with color aliasing are noted as they may suggest stenosis. Note for focal velocity increase, bruit and turbulence.
2. Color flow reversal are noted as well as they may suggest collateralization secondary to a hemodynamically significant disturbance.

NOTE: Color Power Angio is used/applied in the blood vessel segment where there is presence of significant finding or abnormality

Criteria for NORMAL

CEREBRAL ARTERY	DEPTH OF INSONATION (cm)	FLOW DIRECTION	COLOR FLOW	PSV (cm/sec)	MEAN VELOCITY (cm/sec)
Orbital window					
Ophthalmic artery	4.0 – 6.0	forward	red	-	21 ± 5
Carotid siphon	-	-	-	-	-
supraclinoid	5.5 – 8.0	reverse	blue	-	41 ± 11
genu	5.5 – 8.0	bidirectional	red or blue	-	-
parasellar	5.5 – 8.0	forward	red	-	47 ± 14
Temporal window					
MCA 2	4.0 – 4.9	forward	red	58 - 154	55 ± 12
MCA mid	5.0 – 5.9	forward	red	58 - 154	55 ± 12
MCA 1	6.0 – 6.5	forward	red	58 - 154	55 ± 12
ACA	6.0 - 8.0	reverse	blue	33 - 99	50 ± 11
PCA 1	6.0 -7.0	forward	red	36 - 99	39 ± 10

PCA 2	6.0 – 7.0	reverse	blue	36 - 99	39 ± 10
TICA	5.5 – 6.5	bidirectional	red or blue	-	39 ± 9
Suboccipital window					
Vertebral artery	6.0 -9.0	reverse	blue	20 - 89	38 ± 10
Basilar artery	8.0 – 12.0	reverse	blue	28 - 89	41 ± 10

Criteria for ABNORMAL RESULTS

(Results are categorized as abnormal if any of the following listed below is/ are met or presented/noted)

TCD PSV CRITERIA FOR STENOSIS		
	< 50% stenosis	> 50% stenosis
MCA	≥ 155	≥ 220
ACA	≥ 120	≥ 155
PCA	≥ 100	≥ 145
Vert A	≥ 90	≥ 120
Basilar A	≥ 100	≥ 140

TCD MEAN VELOCITY CRITERIA FOR STENOSIS AND VASOSPASM		
ARTERY	**M E A N V E L O C I T Y (cm/sec)**	
	< 60% STENOSIS	VASOSPASM
MCA	≥ 80	≥ 120
ACA	≥ 80	> 100
ICA siphon	≥ 70	> 80
PCA	≥ 50	> 80
Basilar	≥ 60	> 75
Vertebral	≥ 50	> 60

Absent color flow and Doppler signal denotes TOTAL occlusio

PROTOCOL FROM JANUARY 31, 2023- PRESENT

Extracranial Cerebrovascular Duplex Ultrasound Examination

CATEGORY:	Clinical Guidelines
CLASSIFICATION:	Clinical
Controlled Document Number:	CG327
Version Number:	2.0
Controlled Document Sponsor:	Clinical Guidelines Group
Controlled Document Lead (Author):	Ivan Kalik
Approved By:	Clinical Guidelines Group
On:	July 2023
Review Date:	July 2026

Extracranial Cerebrovascular Duplex Ultrasound Examination

Purpose

The scan is performed on patients with a history of stroke, transient ischaemic attack (TIA) or known arterial disease to ascertain whether there is atheroma causing a stenosis or occlusion within the carotid arteries. A significant stenosis may act as a source of emboli or cause a reduction in blood flow to the brain.

Common Indications

- Transient ischemic attacks (TIA)
- Amaurosis fugax
-
- 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
-
- Pulsatile neck masses
- Evaluation of suspected subclavian steal syndrome

Contraindications and Limitations

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 due to reduced cognitive functions e.g.Alzheimer's or dementia and through involuntary movements.
- Examinations undertaken portably at the patient's bedside maybe limited due to equipment and room dimensions.

If any of the above limitations are present, it may result in the patient having to be reported as a 'non-visual'. In this circumstance, depending on the cause, the patient will either be called for a repeat scan (for example if visualisation was poor due to swelling post op) or they would be recommended for alternative imaging. A note would also be made on the report stating the reason for the sub-optimal scan.

Equipment

- Regularly safety checked and maintained Duplex Doppler ultrasound machine with imaging frequencies of 5.0MHz or greater; Doppler frequencies of at least 3.0MHz and linear array transducer/s with colour Doppler capability1.
- Examination couch should be height adjustable preferably electrical. The operators chair should provide good lumbar support, be height adjustable and allow for the operator to move close to the examination couch2 3.
- The examination room should be temperature controlled with adjustable lighting levels suitable for examination2.
  Suitable cleaning materials should be available in line with local and manufactures guidelines1.

Minimum skills and knowledge required for undertaking the procedure

- Minimum requirement is Band 7 Vascular Scientist or equivalent

Explanation of examination and patient history

The member of staff undertaking the examination should:

- Welcome the patient and relatives.
- Introduce themselves and any other members of staff in the room.
- Confirm the patient's identity e.g. full name and date of birth
- Explain why the examination is being performed and give an indication of the test's duration
- Give an explanation of the procedure and it's duration – consideration should be made to the age and mental status of the patient
- Obtain verbal consent for the examination.
- Obtain a pertinent relevant medical history from the patient and/or notes
- Presence of cerebrovascular disease e.g. aphasia, dysphasic, paralysis etc.
- Verify that the requested procedure correlates with the patient's clinical presentation.

- The test can be terminated at any point if the patient withdraws their consent for the procedure.
- Post procedure the patient must be informed how, when and by whom results/reports will be communicated.

Examination

- During the examination patients must be treated with respect, dignity and discretion.
- Patient comfort should be monitored throughout the test and alterations be made should a patient become uncomfortable.
- The patient is asked to adjust their clothing to expose the neck area.
- The patient is examined in the supine position with their head/neck positioned in such a manner that allows the operator 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 direction of flow. In the presence of reversed or partially reversed 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; B-mode can be used to classify echogenicity of any plaque and the surface characteristics e.g. irregular, smooth or ulcerated [4, 5, 6, 7].
- Using longitudinal plane with colour and spectral Doppler (angle of 40-600)5, 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 and documented for the CCA and ICA . Direction of flow must also be documented in the vertebral artery
- The anatomical location of any haemodynamically significant lesion should be documented. A significant stenosis is noted by using the standard criteria:

Percentage Stenosis (NASCET)	**Internal carotid peak systolic velocity (cm/sec)**	**Peak Systolic Velocity Ratio ICA psv/CCA psv**	**St Mary's Ratio ICA psv/CCA psv**
<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 assessment8

- Plaque characteristics should also be documented and the length of the lesion may also be documented.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 operator undertaking the examination and viewed as an integral part of the whole examination5.
- The report should include correct patient demographics; date of examination; examination type and the name and status of the operator.
- In presence of abnormal velocities, the following are included in report:
    - PSV in ICA at point of highest velocity
    - PSVR
    - St Mary's ratio
    - Percentage degree of stenosis
- Qualitatively note the nature of the plaque e.g. calcified, echolucent, irregular, smooth etc, the length and anatomical position.

- Any limitations e.g. calcified plaque causing acoustic shadowing.
- Referral of critical ultrasound results should be made to the referring consultant or appropriate medical/surgical team
- A critical result is defined as an ICA stenosis > 50%. Evidence of a pseudoaneurysm, dissection or carotid body tumour.
- Unexpected results must be verbally communicated to the on-call specialist registrar/consultant on the day of the test. Evidence of this communication should be noted on CRIS
- All reports will be available on CRISwithin 24hrs of the scan being performed.
- Incidents will be managed in line with the Trust incident management Policy.
-

Quality Assurance

- Equipment is purchased in line with the Trust Procurement Policy
- Scanners are serviced in accordance with manufactures recommendation.
- Equipment faults are reported on the same day to medical engineering.
- Staff will perform test under supervision until they have been signed off as competent by a senior member of staff.

Monitoring

- Equipment is checked for damage on a weekly basis. Any damage is reported to medical engineers.
- Staff will have competency checked against the SOP on a annual basis by a senior member of staff.
- Carotid duplex are audited against CTA.
- Stakeholder feedback is obtained bi-annually through the Vascular Laboratory feedback questionnaire

Resources

Society for Vascular Ultrasound Vascular Technology Professional Performance Guidelines Extracranial

Cerebrovascular Duplex Ultrasound Evaluation 2011 www.svunet.org

American Institute of Ultrasound in Medicine Practice Guideline for the Performance of an Ultrasound

Examination of the Extracranial Cerebrovascular System 2011 www.aium.org

Australasian Society for Ultrasound in Medicine Policies and Statements D17 Extracranial Cerebrovascular Ultrasound www.asum.com.au

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