CASE 2. CAROTID ARTERY DISEASE

Request

[redacted], a 70-year-old man visiting from interstate, presented with recurrent episodes of left upper limb weakness. He had a history of cigarette smoking, hypertension, diabetes and dyslipidaemia, and was already taking aspirin, rosuvastatin, telmisartan and metformin. He had previously seen a vascular surgeon in his home state and had a carotid duplex demonstrating 50-69% stenosis at the right internal carotid artery (ICA), and <15% stenosis of the left ICA. On admission, the CT brain was suggestive of a right MCA territory infarct.

He was referred to the inpatient vascular surgery team and to the vascular lab to confirm the presence of carotid occlusive disease.

Conduct of the Scan

1. The patient was positioned on the examination table supine with the head end elevated to 45 degrees. As his neck was reasonably slim, a high frequency (3-11MHz) linear transducer was selected. The machine was configured for the carotid examination using the appropriate pre-set.
2. The right carotid was examined first, by surveying the neck from proximal to distal in short axis to demonstrate the CCA. Short axis B-mode images were taken from the CCA, carotid bifurcation and of the ICA. Note was made of any visible plaque. Long axis B-mode images together with colour Doppler flow was obtained making note of areas of increased velocity demonstrated by the presence of colour aliasing.

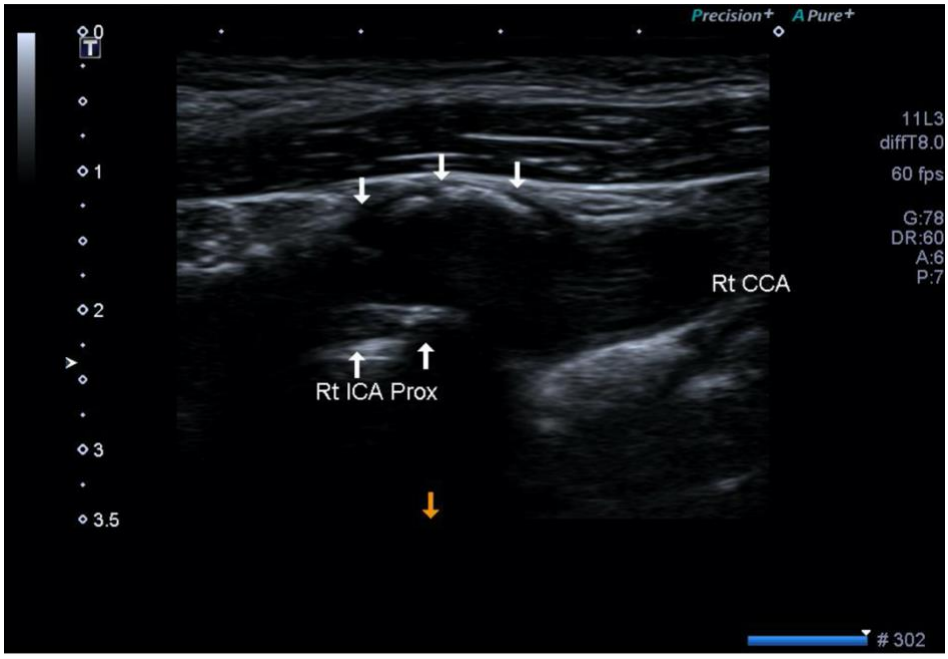

Figure 2.1. Visible plaque is noted at the carotid bulb, but visually it appears to be less than 50% stenosis. Calcification in the superficial part of the bulb causes shadowing on the deeper side due to its highly echogenic nature. As described below.

3. The CCA (proximal and distal), ICA (proximal, mid, distal), ECA and vertebral arteries were interrogated in long-axis using US (B-mode, colour and spectral Doppler). The procedure was repeated on the contralateral side. Angle correction is critical for accurate velocity measurements as the velocity is part of the diagnostic criteria and is strongly affected by the Doppler angle (Figure 2).
    - Normal ICA spectral waveform consists of low resistance continuous forward flow with minimal spectral broadening (due to laminar flow).
    - Normal ECA spectral waveform consists of high resistance biphasic flow.
    - Normal CCA spectral waveform consists of a mixture of ICA and ECA waveforms.
    - Normal PSVs are in the order of 60-100cm/s

4. Tips for identifying the ECA from the ICA

    - The ICA tends to be posterolateral, whereas the ECA anteromedial.
    - The ECA has branches, whereas the ICA very rarely has branches
    - The ECA responds to the temporal tap, the ICA does not.

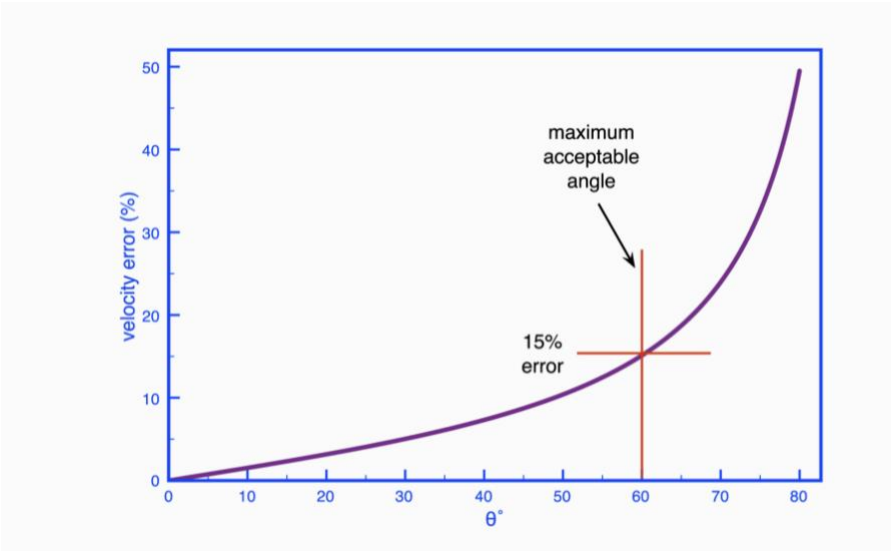

Figure 2.2. The error in velocity calculation per the Doppler equation is negligible when the Doppler angle is close to zero, but increases dramatically after this. At a Doppler angle of 60 degrees, a 5-degree error in Doppler angle will cause a 15% error in the calculated blood velocity.

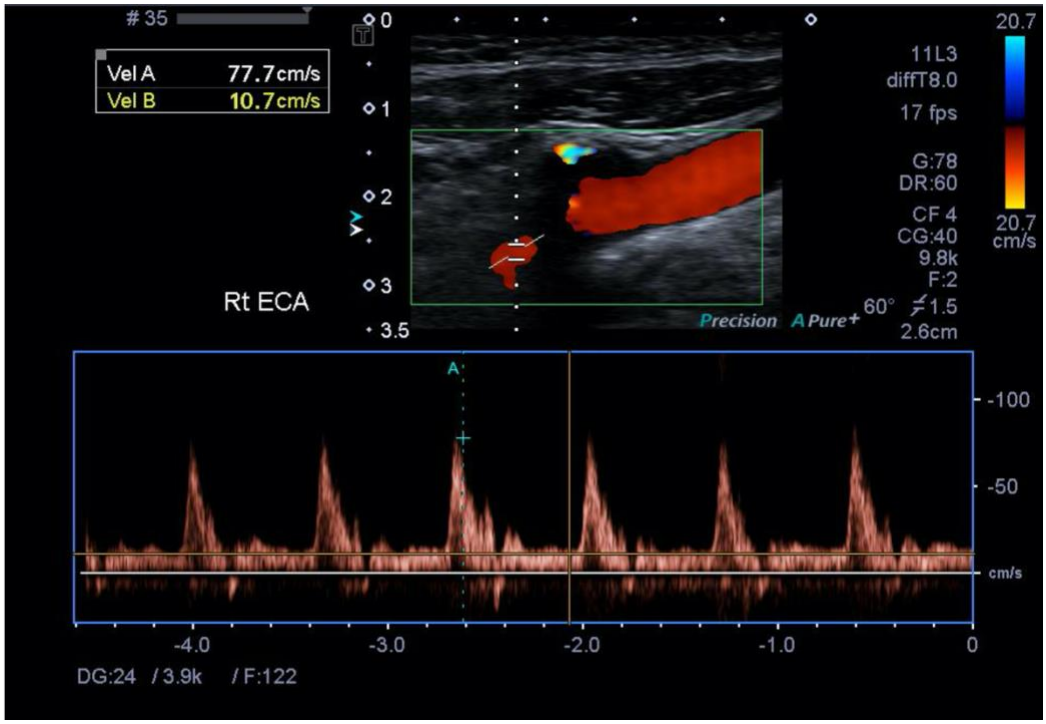

Figure 2.3. The ECA is typically placed anteromedially and the ECA spectral waveform is characterised by a high resistance biphasic flow.

5. The diagnostic ultrasound criteria for internal carotid occlusive disease is summarised by Oates et al. (2009) and is shown in the table below. St Mary's criteria allows the classification into increasing deciles of stenosis. The stenosis described in the definition is considered equivalent to that obtained by the NASCET criteria as opposed to the ECST criteria.

Table 2.1. Spectral analysis diagnostic criteria for carotid occlusive disease.

	ICA PSV (cm/s)	ICA:CCA PSV ratio	St Mary's Ratio (ICA_{PSV}:CCA_{EDV})
<50%	<125	<2	<8
50-69%	≥125	2-4	8-10
60-69%			11-13
70-79%	≥230	>4	14-21
80-89%			22-29
>90%, but not near occlusion	≥400	≥5	≥30
Near occlusion	High, low – string flow	Variable	Variable
Occlusion	No flow	N/A	N/a

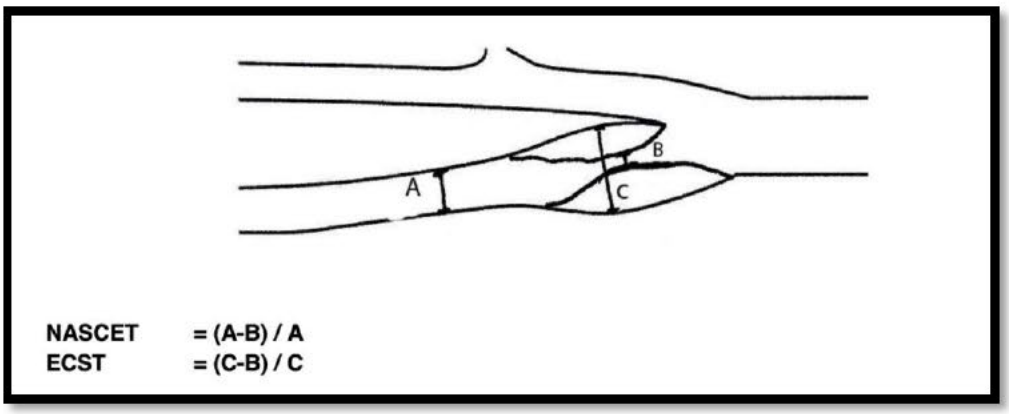

Figure 2.4. Schematic representation of the different methods of ICA stenosis quantification. The ECST uses the carotid bulb as the denominator, whereas the NASCET criteria uses the normal distal ICA diameter.

6. Plaque morphology can also be described based on the B-mode image.
    - Echogenicity
        i. Anechoic (lipids and intraplaque haemorrhage)
        ii. Hypoechoic (fibrofatty plaque)
        iii. Hyperechoic (fibrous plaque)

    iv. Calcific (highly reflective with acoustic shadowing)

- Texture
    i. Homogenous (uniform composition)
    ii. Heterogenous (multiple areas of differing echogenicity)
- Surface
    i. Smooth (continuous without irregularities)
    ii. Irregular (discontinuous surface, multiple echoes, possible ulceration)

7. The patients DUS scan of the right carotid artery demonstrated a normal CCA free of plaque on B-mode and without colour aliasing or increased PSV (102 cm/s).

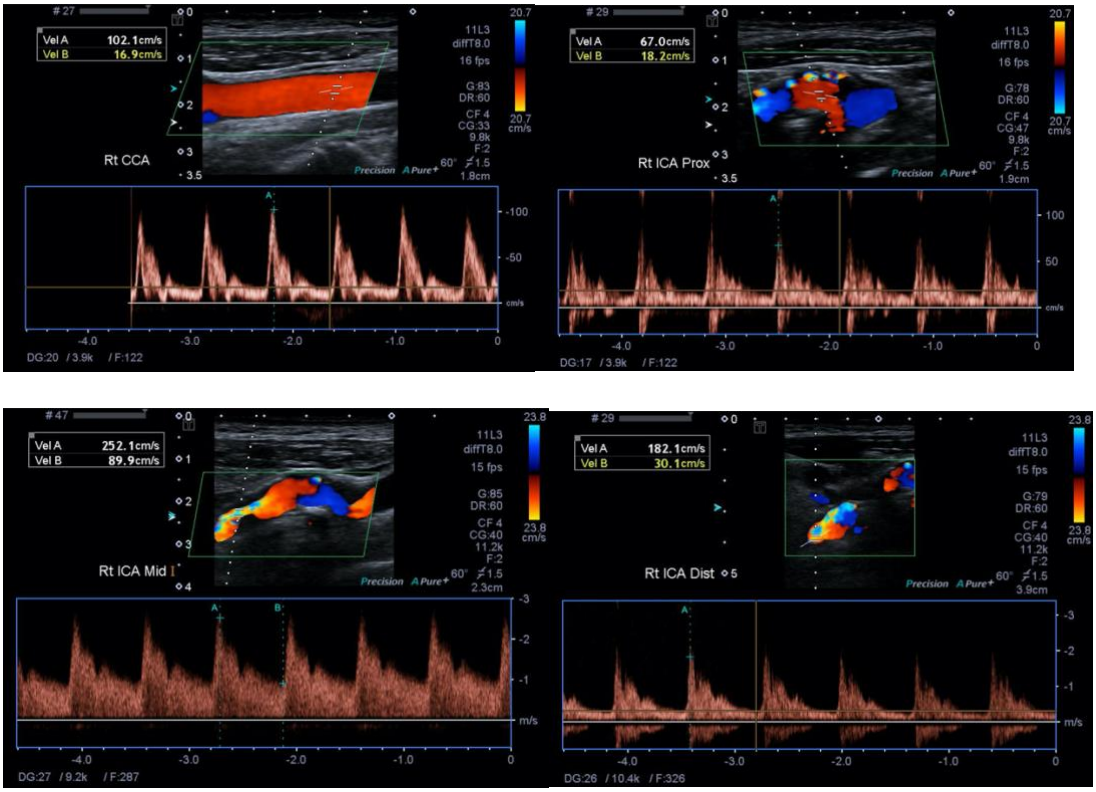

Figure 2.5. Selected US images demonstrated normal CCA (top left), normal proximal ICA (top right), a stenosis in the mid right ICA (bottom left), and elevated velocities in the distal right ICA (bottom right). Colour aliasing in the image on the bottom right image highlights the likely area of maximal velocity increase to which the PW Doppler sample-box is placed with an angle parallel to the vessel walls (direction of flow) and <60 degrees relative to the PW beam.

Indicate how the examination assisted diagnosis

- Calcified plaque of the ICA bulb was also noted, and the mid right ICA colour aliasing was identified on colour Doppler together with an increased PSV of 252 cm/s on PW

spectral Doppler with associated spectral broadening. The ICA:CCA ratio was 2.4 indicative of a stenosis of >50%. A CTA confirmed the degree of stenosis >50%.

Indicate how the examination assisted management

- The patient was commenced on dual antiplatelets by way of aspirin and clopidogrel and was scheduled for semi-elective carotid endarterectomy and patching on the next available elective vascular list. The procedure was performed in a routine fashion under general anaesthesia utilising a Sundt shunt. The internal carotid artery was patched with a polyurethane patch. The patient made an uneventful recovery and was discharged back to their home state to follow-up with their local vascular surgeon.

- The endarterectomised plaque was submitted for histopathological examination, which confirmed the diagnosis of calcified atheromatous plaque.

Copy of Report

Progress Note Allied Health
Carotid and vertebral artery duplex study

There was moderately severe atheromatous disease in the carotids. On the right side, there was heterogeneous plaque in the internal carotid artery approximately 2 cm from the origin which resulted in a haemodynamically significant stenosis (> 50% but < 70%). On the left side, there was a moderate amount of heterogeneous plaque at the origin of the internal carotid artery which resulted in 16-49% stenosis at this site. There was minor atheroma in the common and external carotid vessels bilaterally.

Both vertebral arteries had normal waveform patterns.

MICROSCOPIC REPORT

(Dr [redacted]

CAROTID PLAQUE: Sections show calcified atheromatous plaque. Foamy macrophages and cholesterol clefts are present. There are no atypical features.

SUMMARY

CAROTID PLAQUE:

- Calcified atheromatous plaque

References

1. Pellerito J, Polak JF. Ultrasound Assessment of Carotid Stenosis. In: Introduction to Vascular Ultrasonography. 6th ed. Philadelphia: Elsevier Health Sciences; 2012. p. 158–172.
2. Size GP, Lozanski L, Russo T, French-Sherry E, Skelly CL. Carotid Artery Duplex Ultrasound. In: Inside ultrasound vascular reference guide. 1st ed. Pearce, Arizona: Inside Ultrasound; 2016. p. 81–94.
3. Oates CP, Naylor AR, Hartshorne T, Charles SM, Fail T, Humphries K, et al. Joint Recommendations for Reporting Carotid Ultrasound Investigations in the United Kingdom. Eur J Vasc Endovasc Surg. 2009 Mar;37(3):251–61.
4. Curtis N, Necas M, Versteeg M. The clinical implications of adopting new criteria for the grading of internal carotid artery stenosis. Australas J Ultrasound Med. 2018 Feb 1;21(1):36–44.