Carotid Artery Duplex:

Technique & Pitfalls

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Context: What & Why?

What?

What is a carotid artery duplex?

An ultrasound scan using B-mode, colour and spectral doppler to assess blood flow within the carotid and vertebral arteries.

Includes quantitative measurements of blood flow velocity as well as qualitative assessment of disease.

Why?

Importance & Epidemiology

- 50 People per 100,000 per year are affected by TIA.
- 1.3 million people in the UK living with stroke after-effects.
- Between 2% and 17% of people who have TIA will go on to have a stroke within 90 days.
- It is estimated that ~15% of ischemic strokes are caused by carotid artery disease.

Why?

Importance

- As shown, there is a huge need for quality imaging to be performed in a timely manner to improve outcomes for patients

- As such, more and more practitioners are being asked to perform carotid artery duplex- not just vascular scientists.

Why?

What questions are we answering?

- Is there any haemodynamically significant disease?
- What is the degree of stenosis?
- Is it the cause of the symptoms?
- Is it amenable to surgery?
  - Plaque length, distal ICA patent, high bifurcation, thick neck, limited mobility
- Are there any other arterial abnormalities?

Scanning Technique- Quick Guide

How?

Equipment

- High Spec ultrasound machine with high-resolution greyscale B-mode imaging as well as colour and spectral doppler imaging

- Linear Transducer 7-12MHz. Higher frequency may lose penetration (not good for larger neck)

- Don’t be afraid to experiment with different transducers i.e. Curved for proximal CCA or larger neck.

- Most machines will have a carotid preset but always change controls as you go.

How?

Practical Scanning Technique- What can go wrong?

- Multiple scanning positions- use what you prefer.
- RSI is real, carotid scanning can definitely increase your risk!
- First Pitfall- Poor positioning will lead to a poor quality scan and risk to yourself

Scanning Technique

Patient Related Challenges

Large, short neck/ deep vessels:

- Adjust controls accordingly (lower freq., use TGC)
- Change transducer.

Heavy Breathing:

- Talk to your patient- ensure they are comfortable
- Can ask them to hold their breath for a short moment

High Bifurcation:

- Change positioning- turn head further away or tilt chin further back
- Use different scanning plane- behind ear
- Always mention this in your report!!!

How?

Protocol- Basic Principles

B-mode imaging:

- Assess arterial wall, plaque morphology and narrowing of vessel lumen.

Spectral Doppler:

- Measure blood flow velocity to assess haemodynamics (Very important!!!)

Colour Doppler:

- Assess direction of blood flow and flow turbulence.

How?

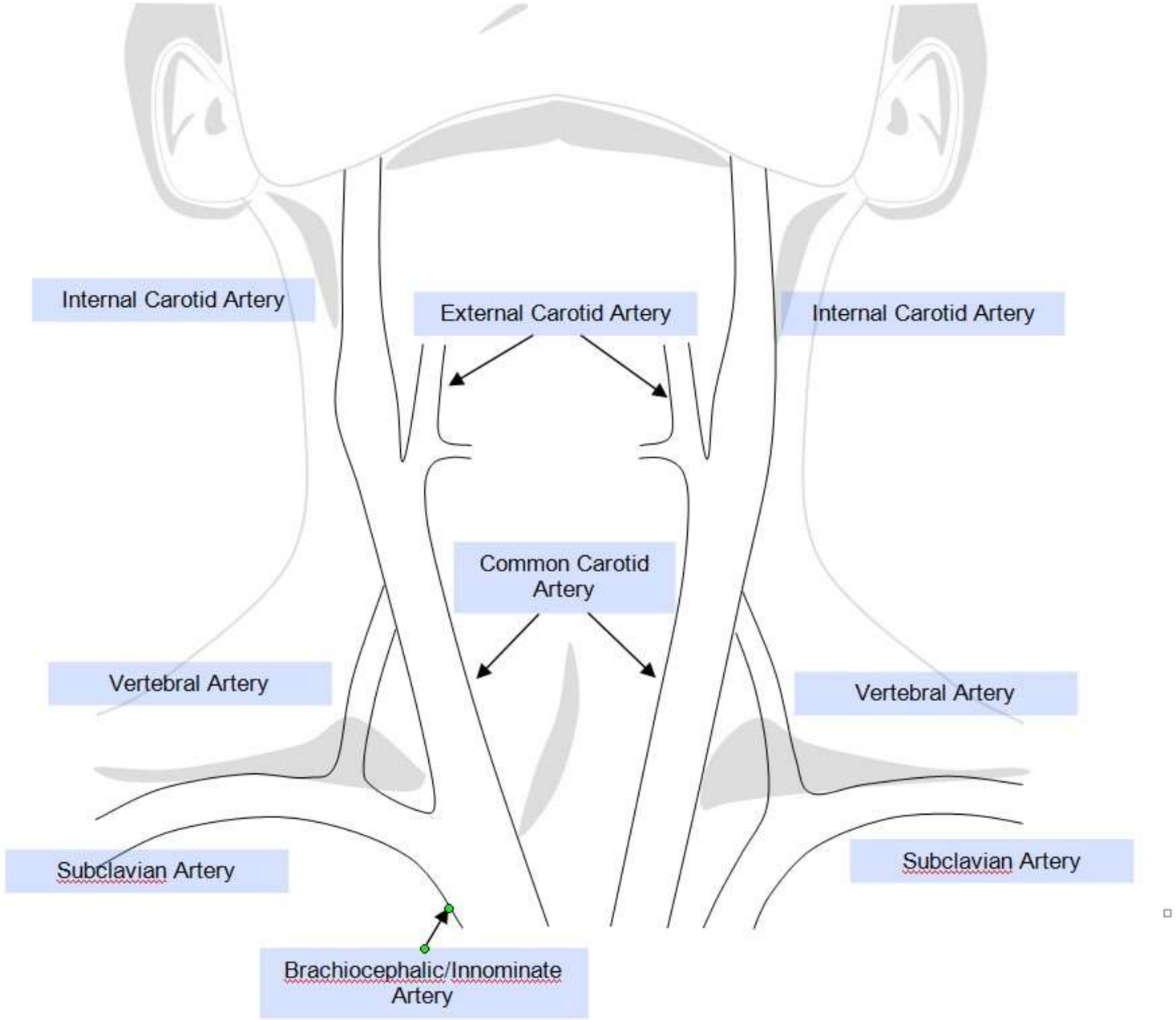
Protocol- Imaging

The following vessels should be assessed using B-mode, Colour and Spectral Doppler:

- Subclavian Artery
- Common Carotid Artery
- Vertebral Artery (Check flow direction + Any obvious evidence of stenosis)
- Internal Carotid Artery- As distally as possible
- External Carotid Artery

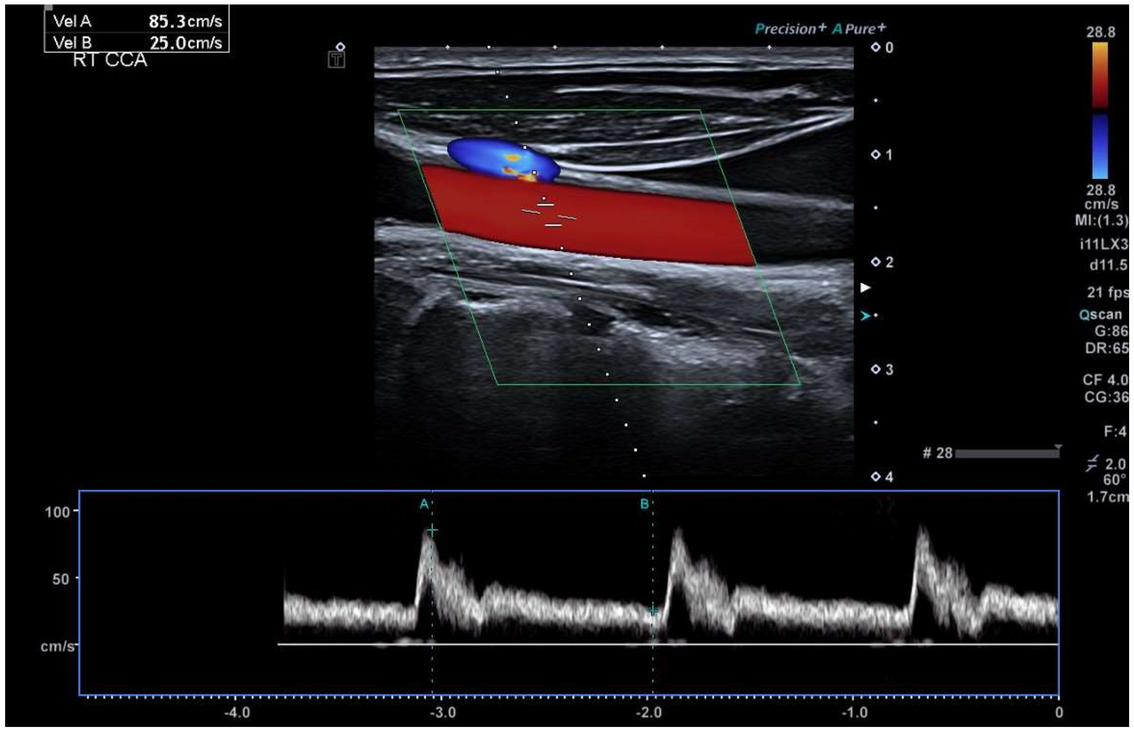
Take note of any disease present and measure plaque length.

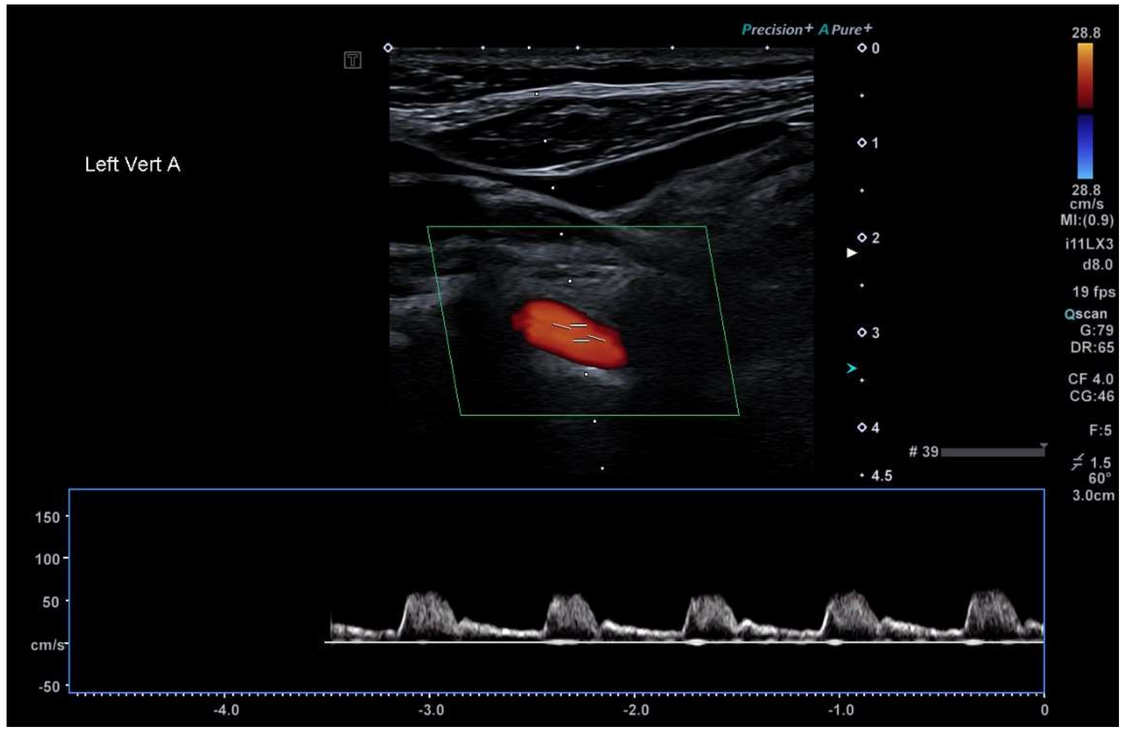
Basic Anatomy



Normal Waveforms

CCA + Vert





Normal Waveforms

ICA + ECA

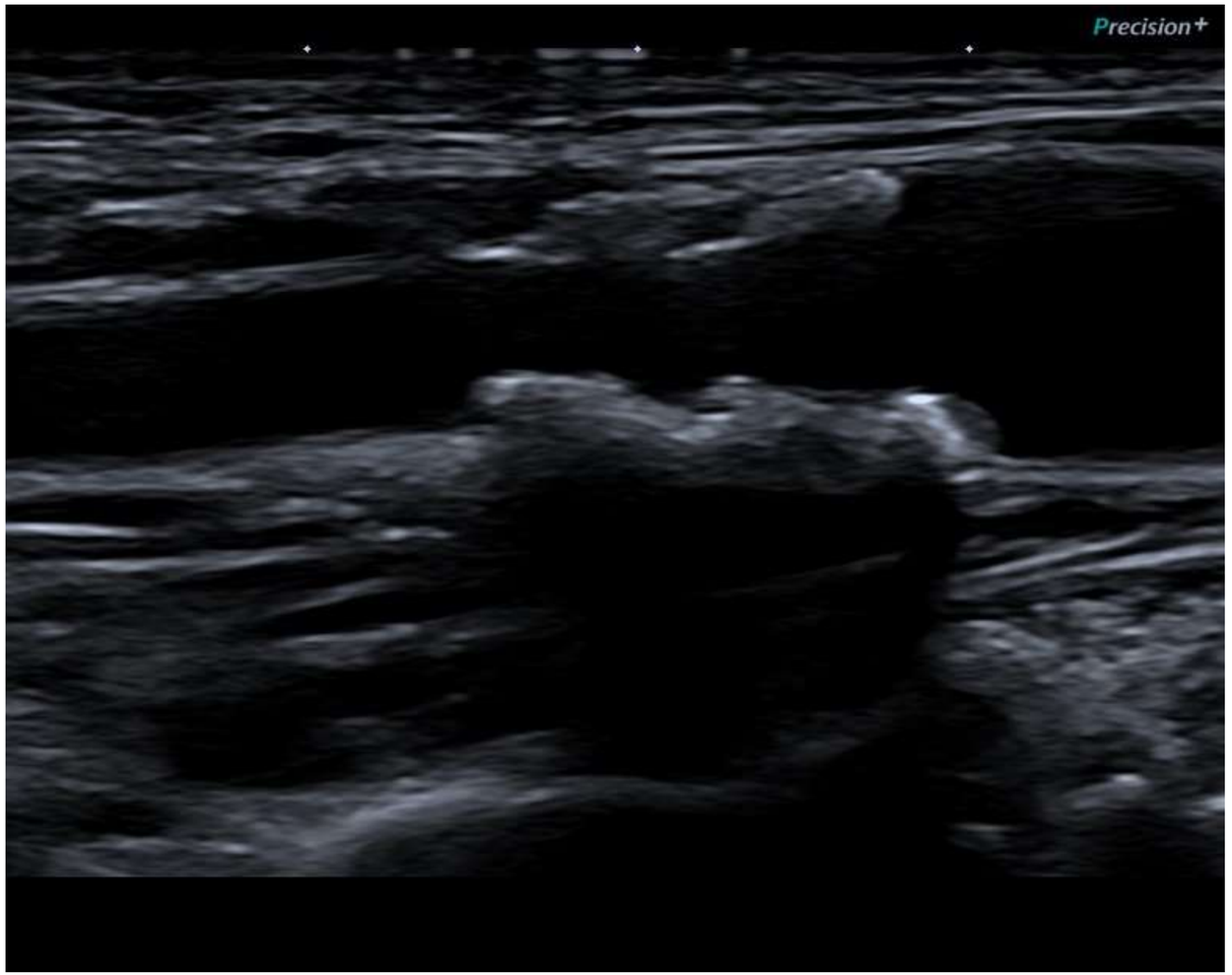
Normal Waveforms

Subclavian

What are we looking for?
& Where do things go wrong?

Stenosis

Significant vs Not Significant



Stenosis

Velocity Grading Criteria- Joint Recommendations (Oates et al., 2009)

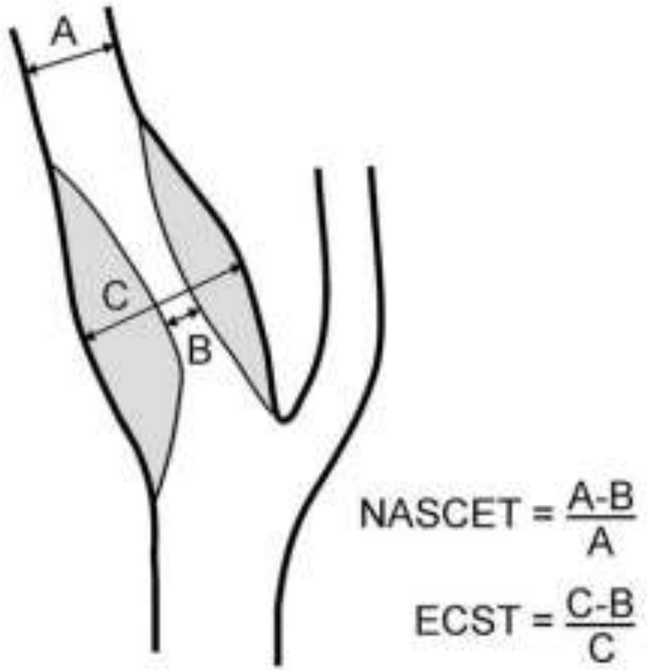


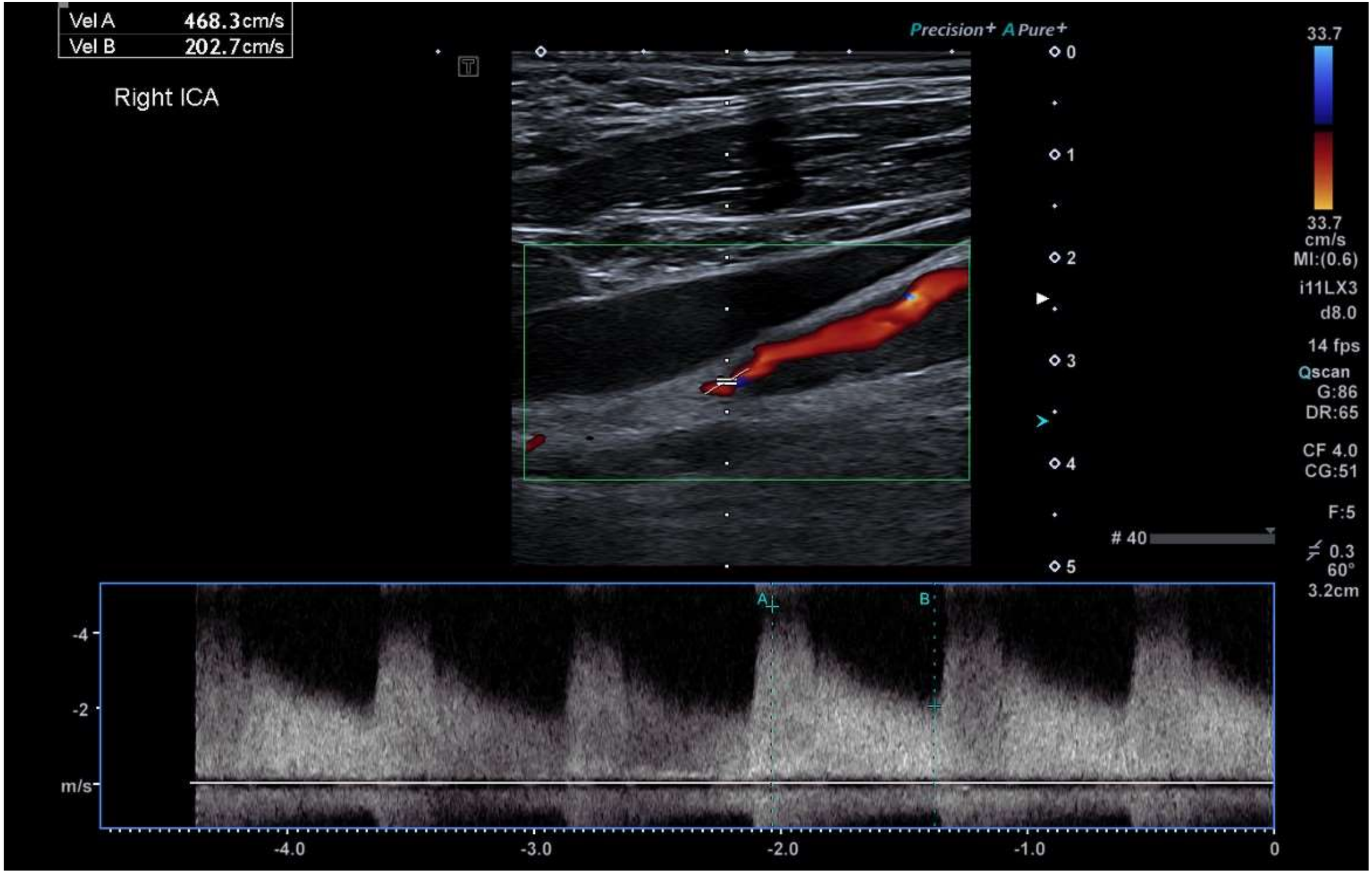
Table 1 Diagnostic criteria to be applied

Percentage stenosis (NASCET)	Internal carotid peak systolic velocity cm/sec	Peak systolic velocity ratio ICA_{PSV}/CCA_{PSV}	St Mary's ratio[c] ICA_{PSV}/CCA_{EDV}
<50	<125[a]	<2[a]	<8
50–59	>125[a]	2–4[a]	8–10
60–69			11–13
70–79	>230[a]	>4[a]	14–21
80–89			22–29
>90 but less than near occlusion	>400[b]	>5[b]	>30
Near occlusion	High, low – string flow	Variable	Variable
Occlusion	No flow	Not applicable	Not applicable

[a] NACC[17].
[b] Filis et al.[37].
[c] Nicolaides et al.[33].

Pitfall- Velocities to be assessed at doppler angle 45-60

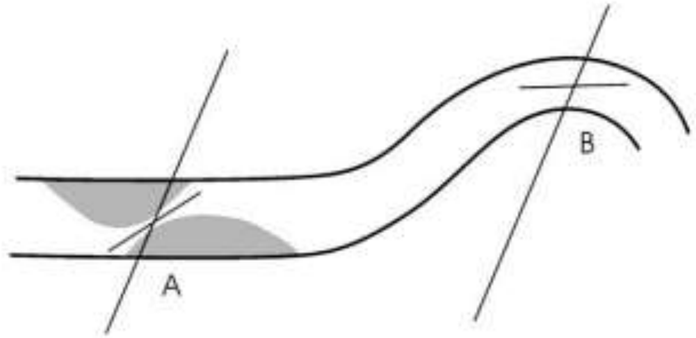
Pitfall- St Marys Ratio not always applicable (Aortic valve regurgitation)


Vel A 468.3 cm/s
Vel B 202.7 cm/s
Right ICA
Precision+ A Pure+
33.7
33.7 cm/s
MI:(0.6)
i11LX3
d8.0
14 fps
Qscan
G:86
DR:65
CF 4.0
CG:51
F:5
0.3
60°
3.2cm
40
A
B
-4
-2
m/s
-4.0
-3.0
-2.0
-1.0
0

Stenosis

Pitfalls

- Eccentric stenotic jet- Always assess velocity in line with flow direction



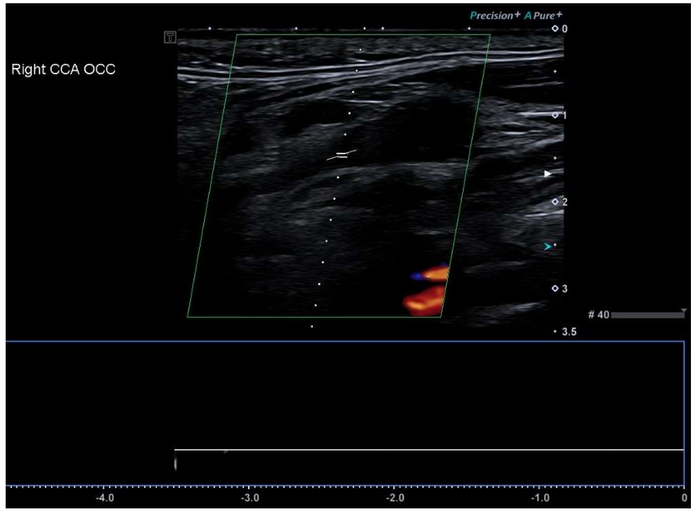
- Keep doppler angle at 45- 60 (Heel-toe technique)

- Dilated carotid bulb- If over 1cm, measure and report ECST stenosis.

- Missed high velocities- Importance of PRF!!

Occlusion


Precision+ A Pure+
CA OCC THROMBUS
0
1
2
3
130
3.5
-4.0
-3.0
-2.0
-1.0


Precision+ A Pure+
Right CCA OCC
0
1
2
3
40
3.5
-4.0
-3.0
-2.0
-1.0
0

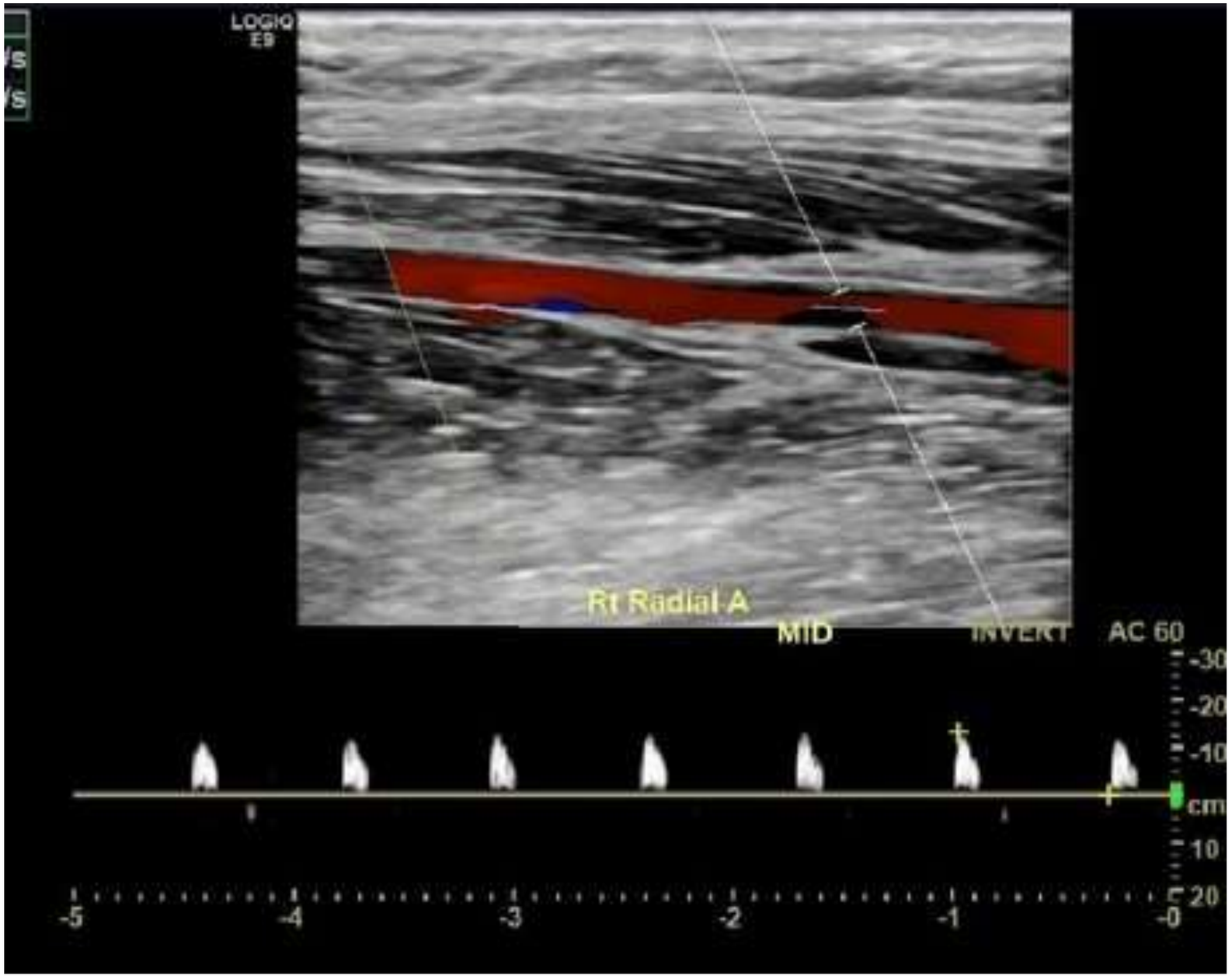

Precision+
ight CCA OCC
0
1
2
3
3.5

Occlusion

Pitfalls

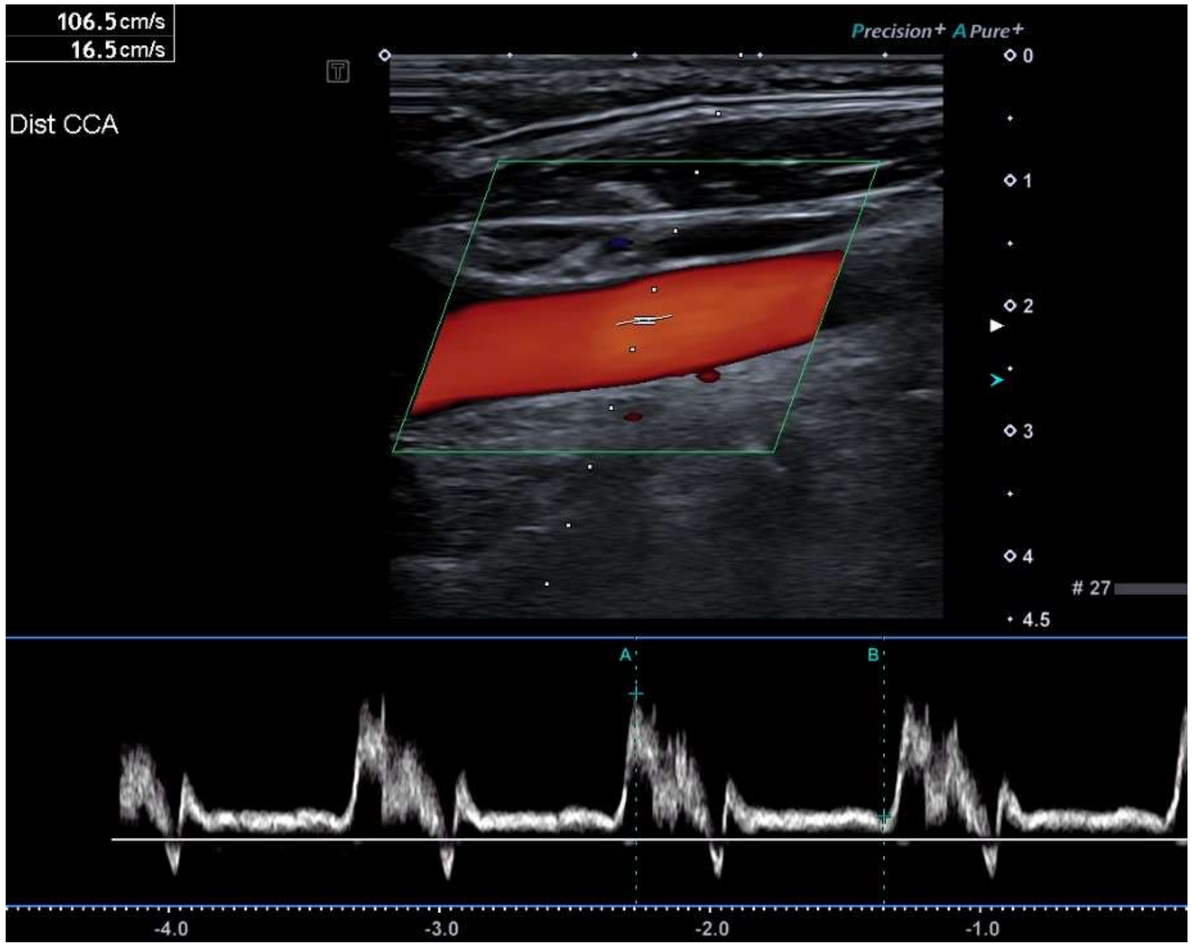
- Missed tight stenosis- Use power doppler to avoid missing low flow.

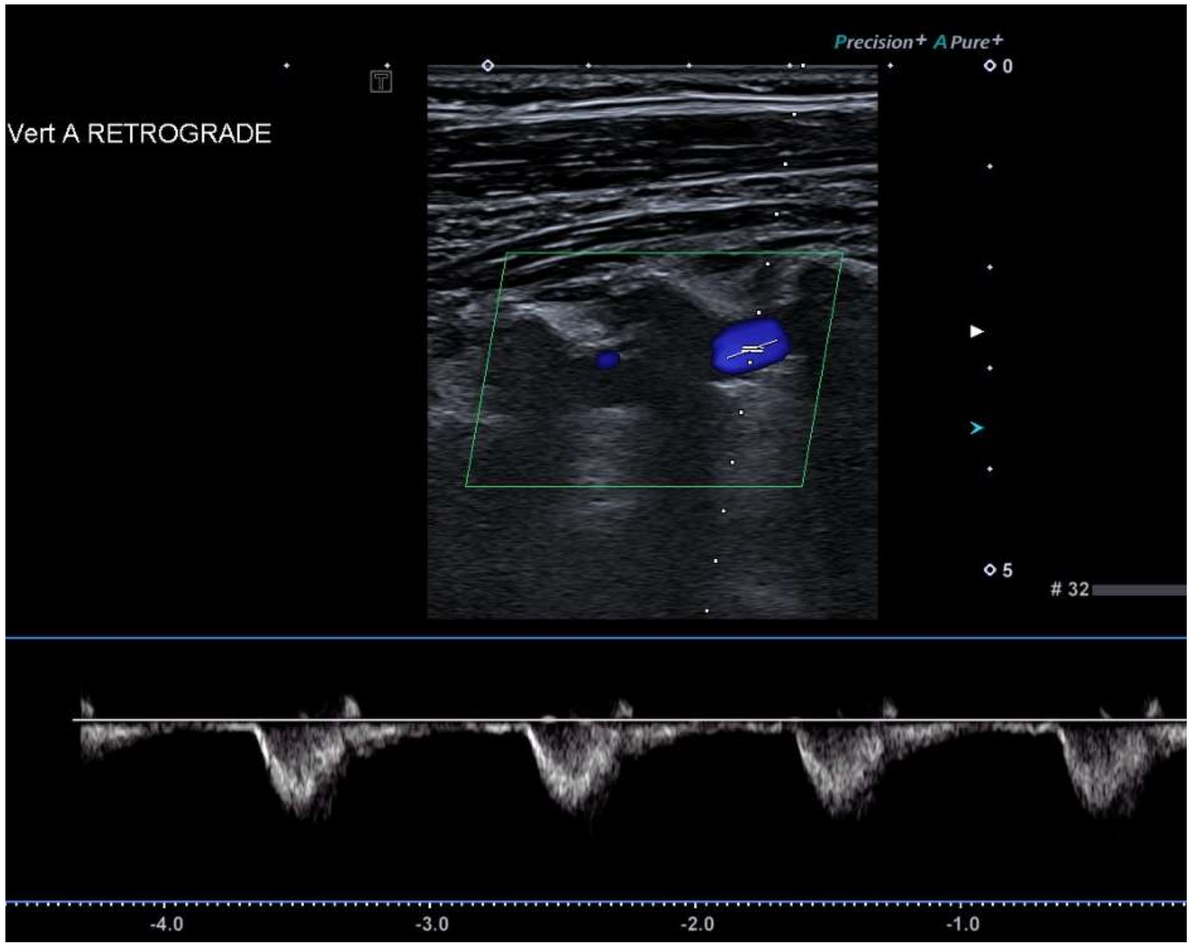
- Distal Occlusion- Check for pre-occlusive (Thump) waveform


LOGIQ
E9
Rt Radial A
MID
INVERT
AC 60
-30
-20
-10
cm
10
20
-5
-4
-3
-2
-1
-0

Flow Direction

Subclavian Steal Syndrome





Flow Direction

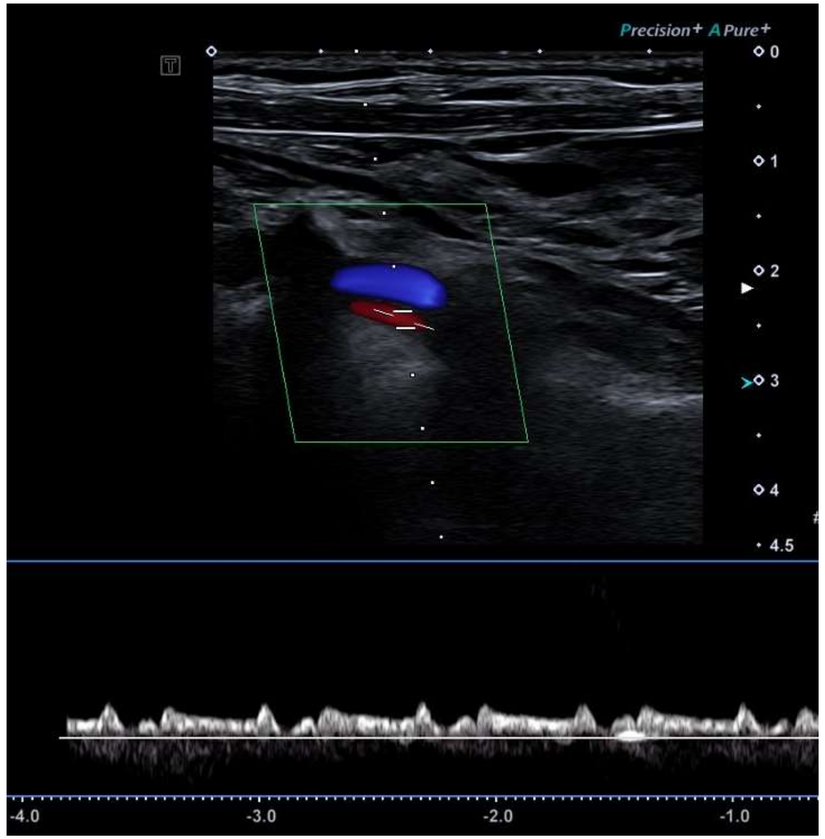
Pitfalls

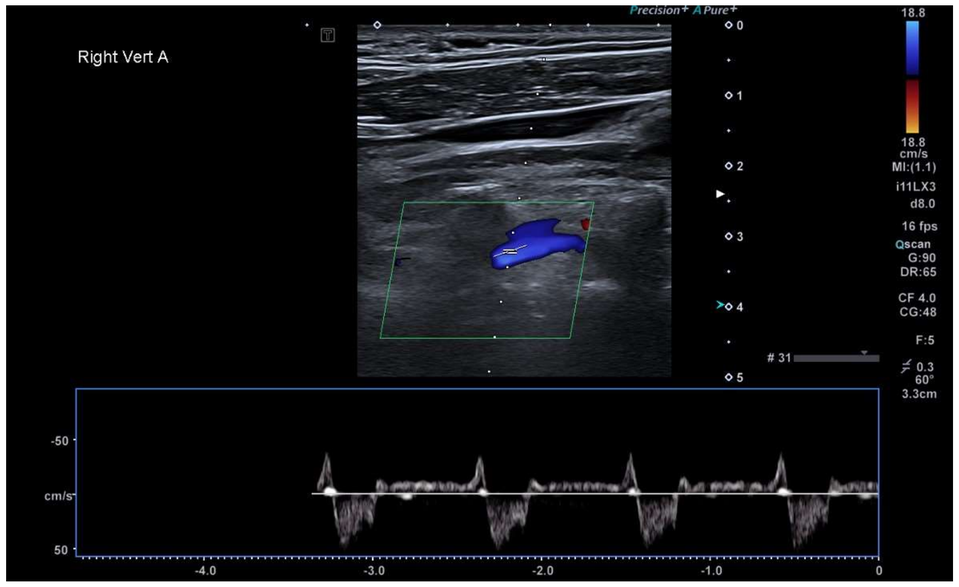
- Accidental turning of transducer- keep the probe marker towards the head
- Be mindful of venous flow.
- Do not just invert the colour if it seems incorrect- Compare against another vessel e.g. CCA
- If vertebral appears retrograde assess Subclavian Artery. Does it match up?
- Antegrade flow in the vertebral artery doesn’t completely exclude Subclavian Stenosis

Flow Direction

Pitfalls- Partial Steal

- Oscillatory waveform with at least cessation of flow.
- May see a transient reversal of flow.
- Whilst there is some antegrade flow, it is not a typical waveform.





Plaque/ Disease Morphology

Qualitative Assessment

Soft Plaque/ Thrombus:

- Predominantly lipid- low echogenicity. Black appearance on greyscale imaging.
- High rupture/ embolism risk.

Mixed Plaques:

- Combination of lipid, fibrous and calcified components. Grey “speckled” appearance on greyscale imaging.

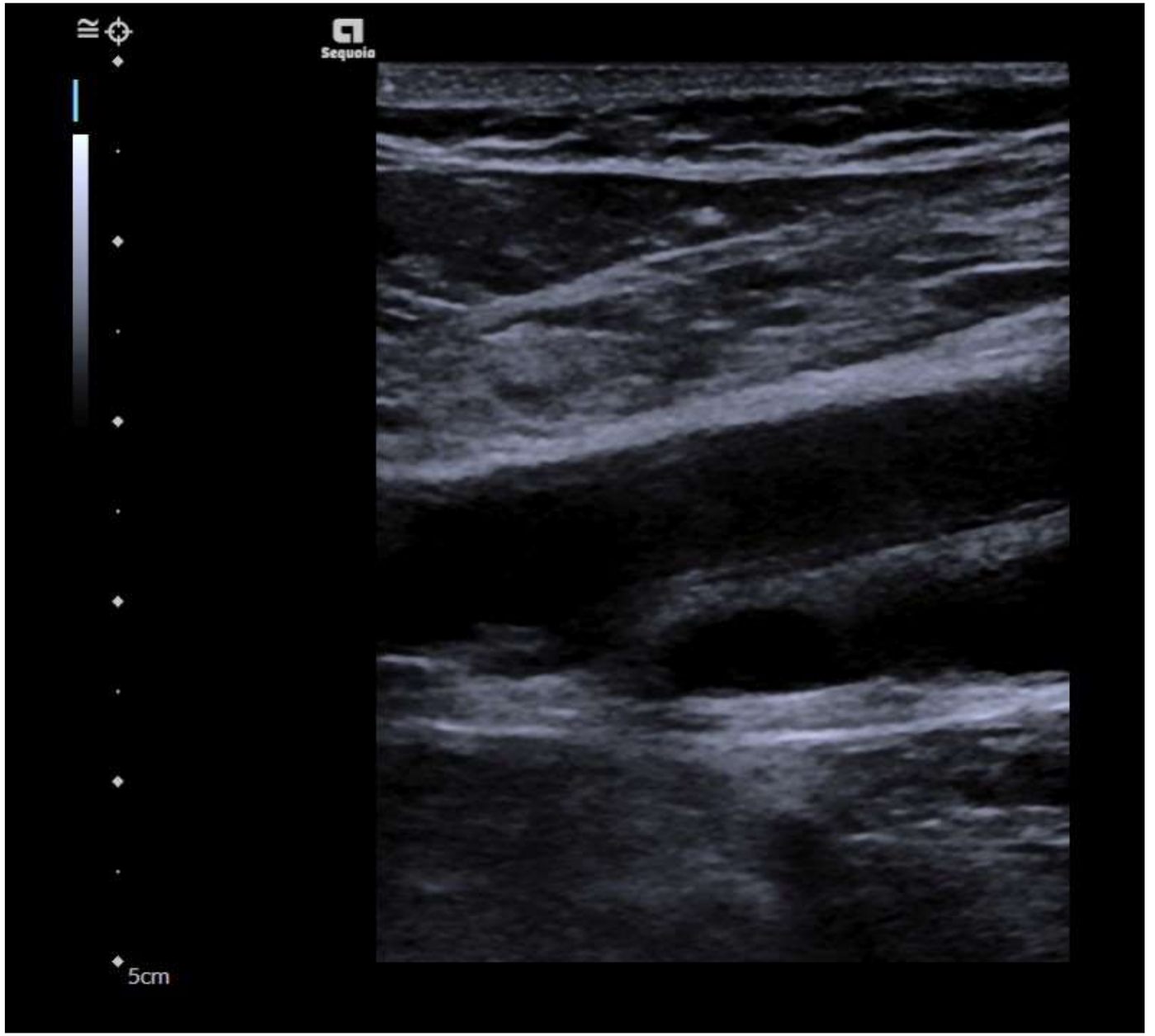
Dense Fibrous Plaques:

- Echogenic, fibrotic stable plaques. Brighter, appearance on greyscale with no acoustic shadow.
- Lower embolic risk.

Calcified Plaques:

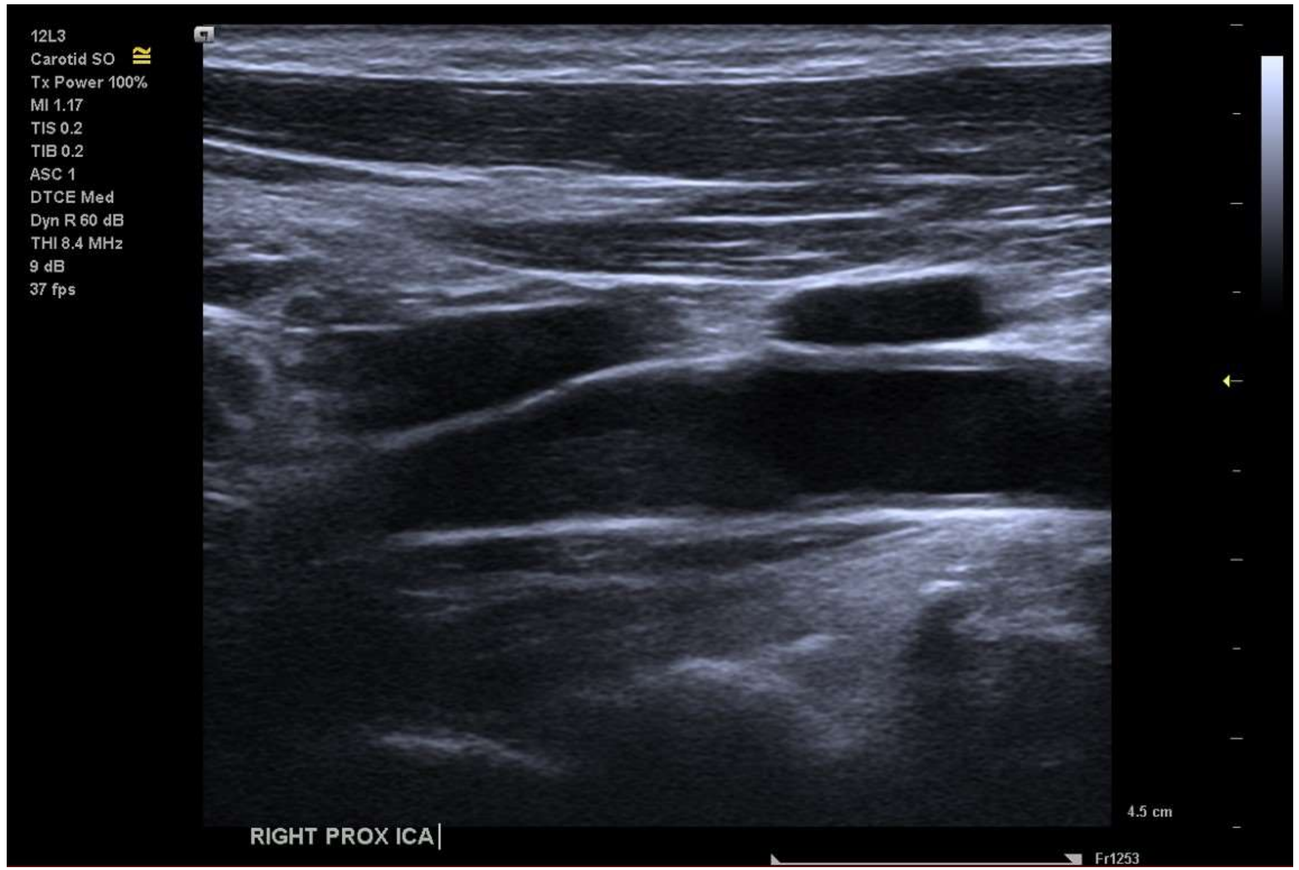
- Very bright echogenic plaques with acoustic shadowing at posterior wall.

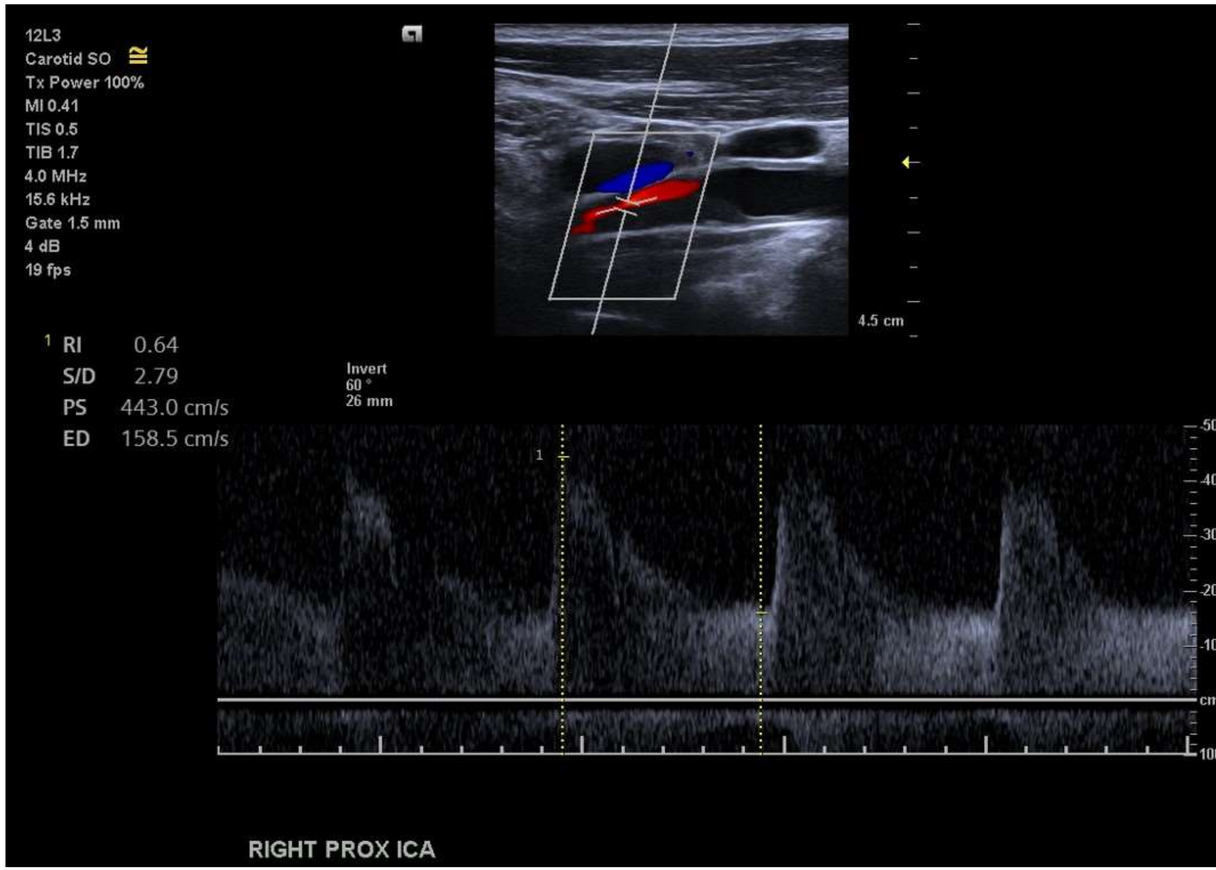
Soft Plaque/ Thrombus



Soft Plaque/ Thrombus

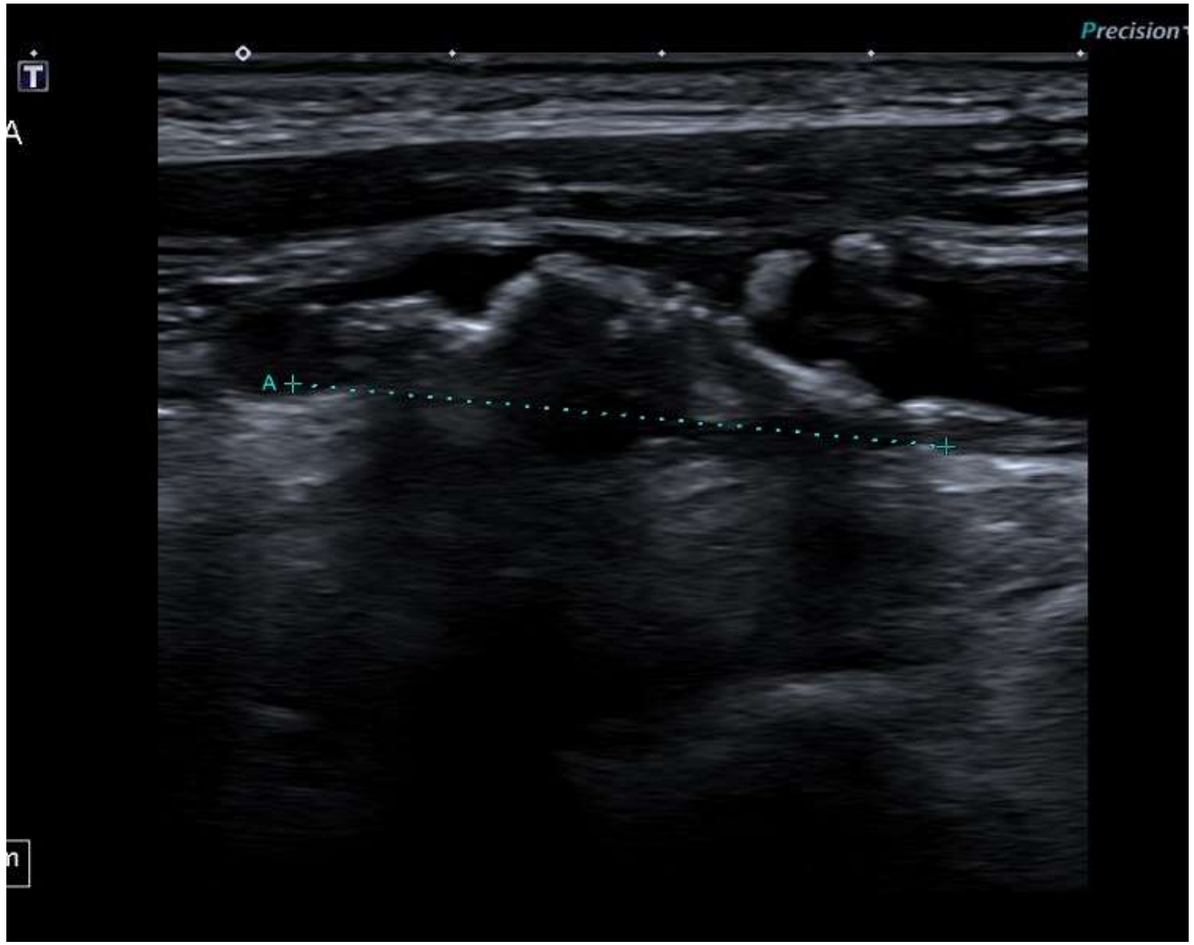
Soft Plaque/ Thrombus

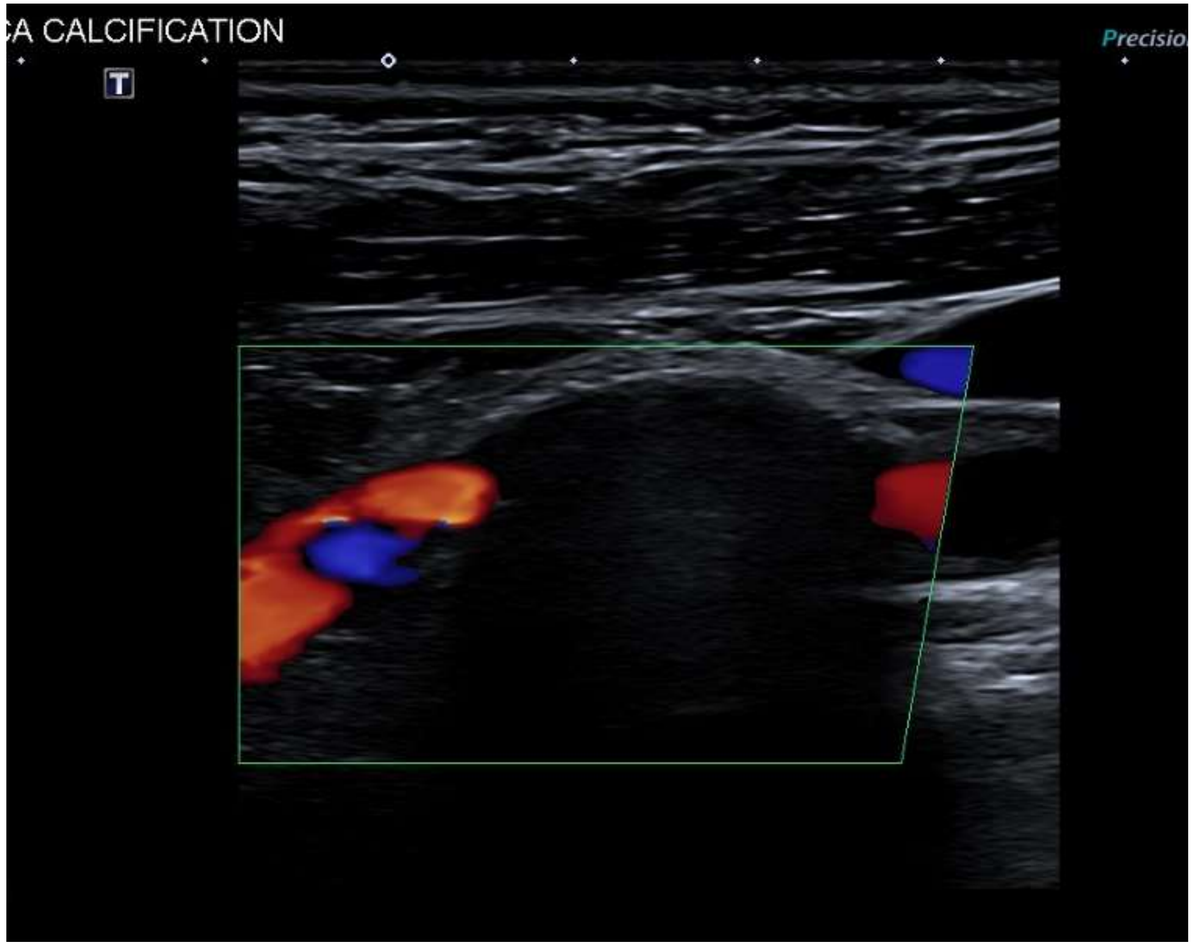




Mixed Plaque

Dense/ Calcified Plaques





Plaque Morphology

Pitfalls

Soft Plaque/ Thrombus:

- Low echogenicity makes them difficult to spot on greyscale imaging- use colour imaging thoroughly and in multiple planes.

Mixed Plaques:

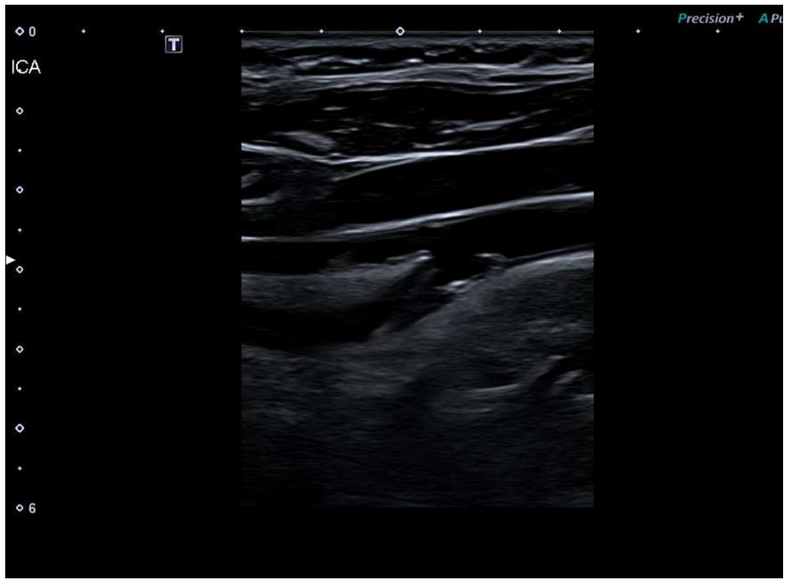
- Complex echo texture can make characterisation difficult- always adjust controls throughout.
- May be difficult to distinguish from surrounding features.

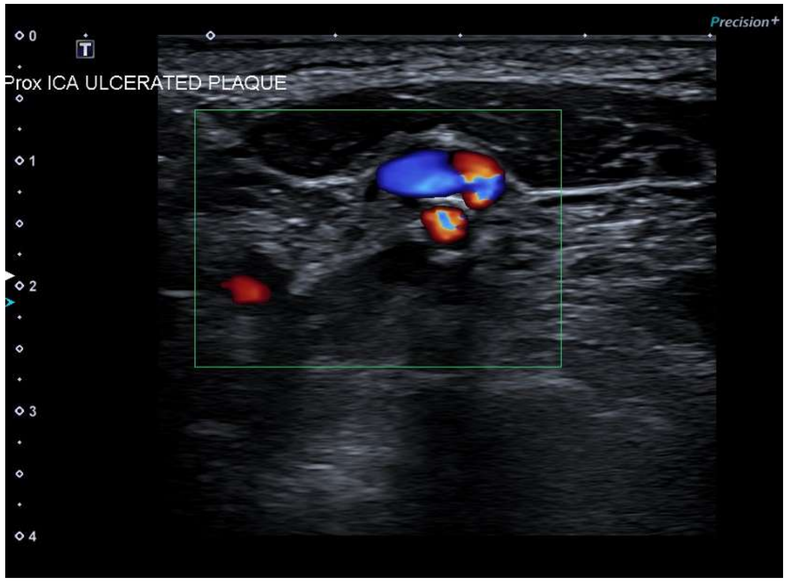
Calcified Plaques:

- Acoustic shadowing may obscure critical area- use multiple scanning planes
- May underestimate stenosis due to obscured regions- always mention limitations in your report

Plaque Morphology

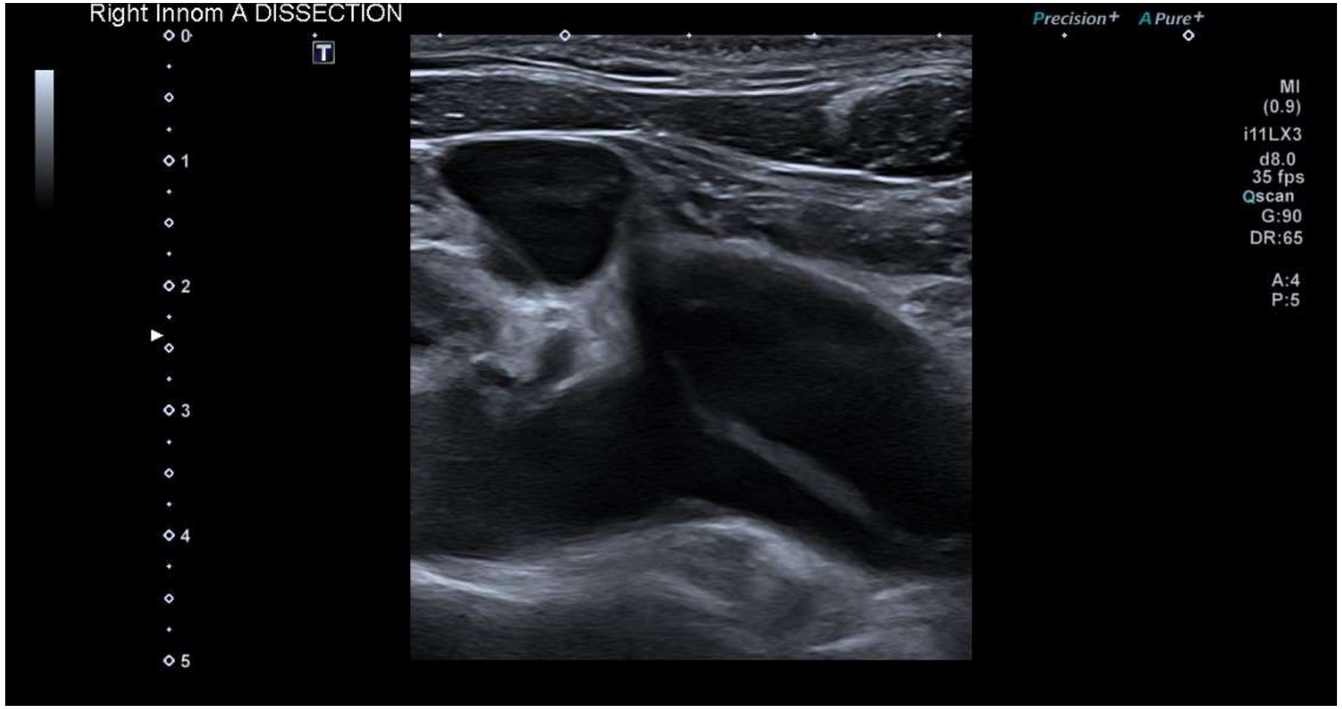
Pitfalls- Ulceration

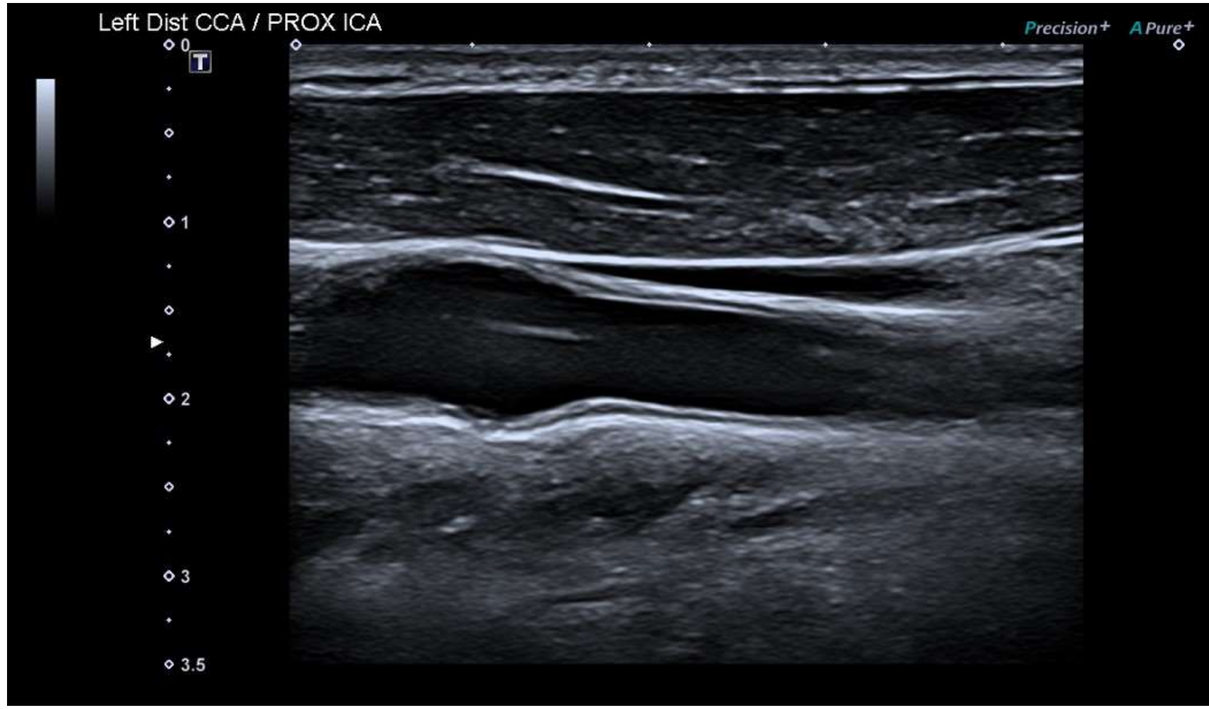




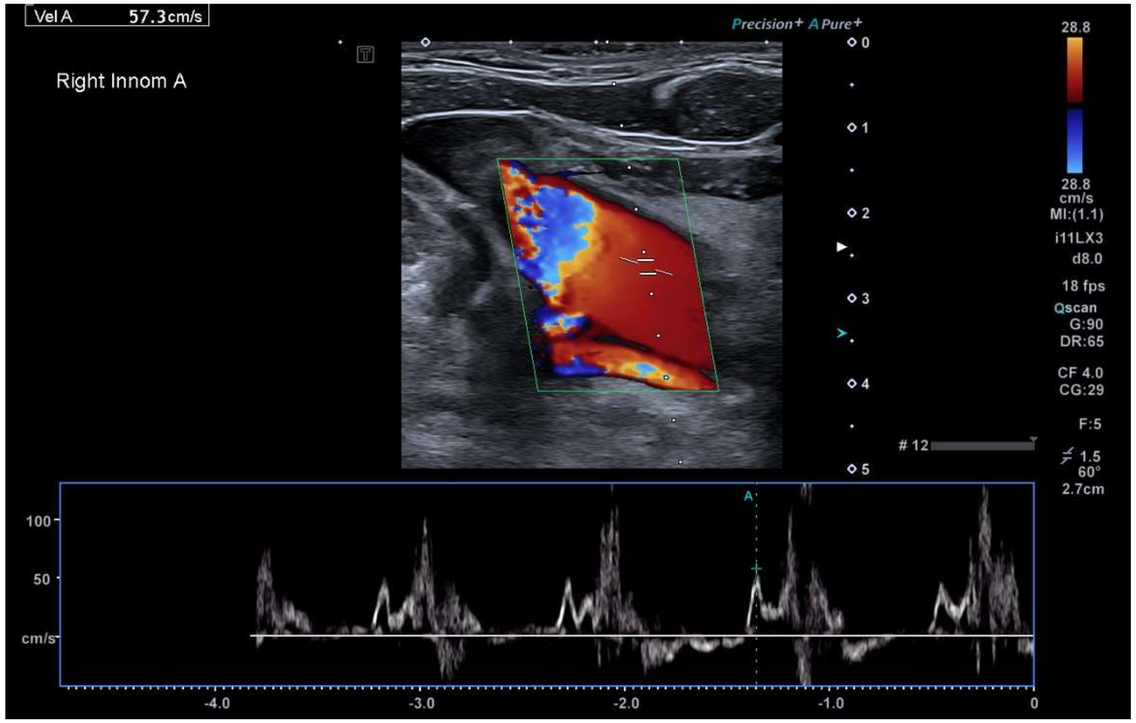
Less Common Pathologies

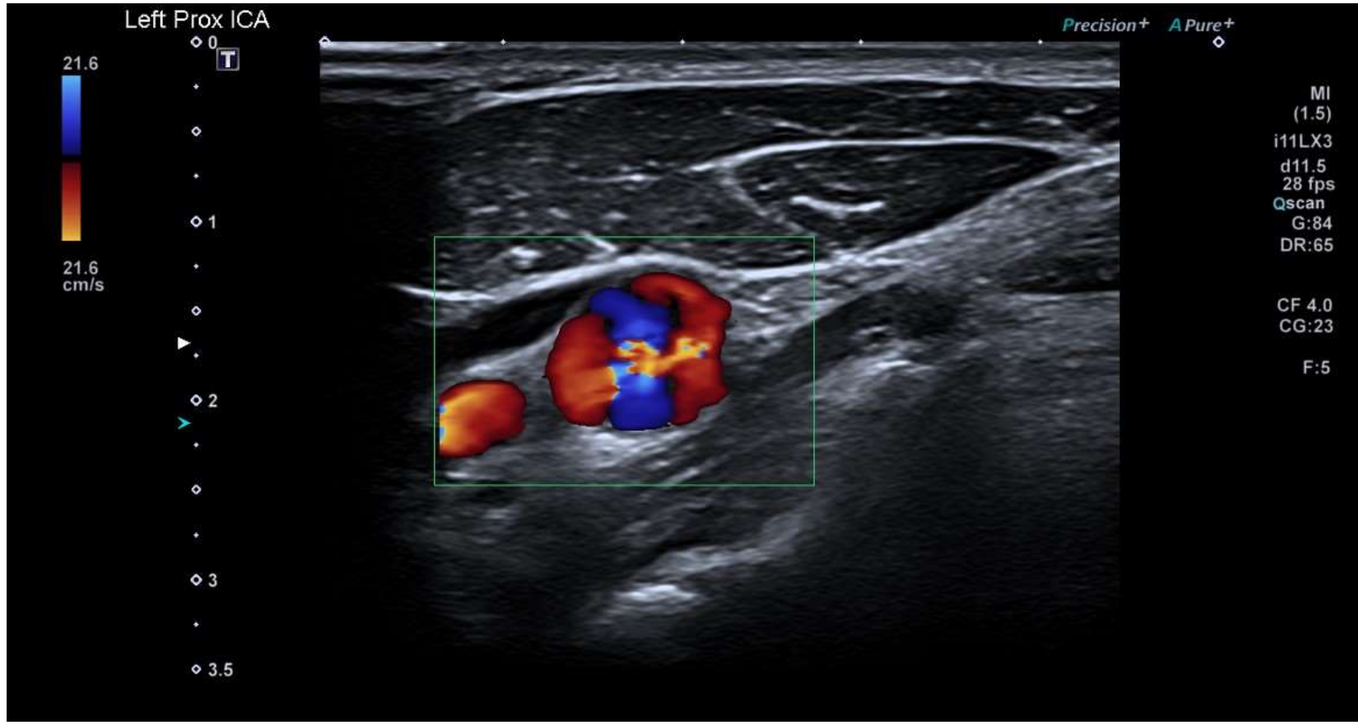
Carotid Dissection





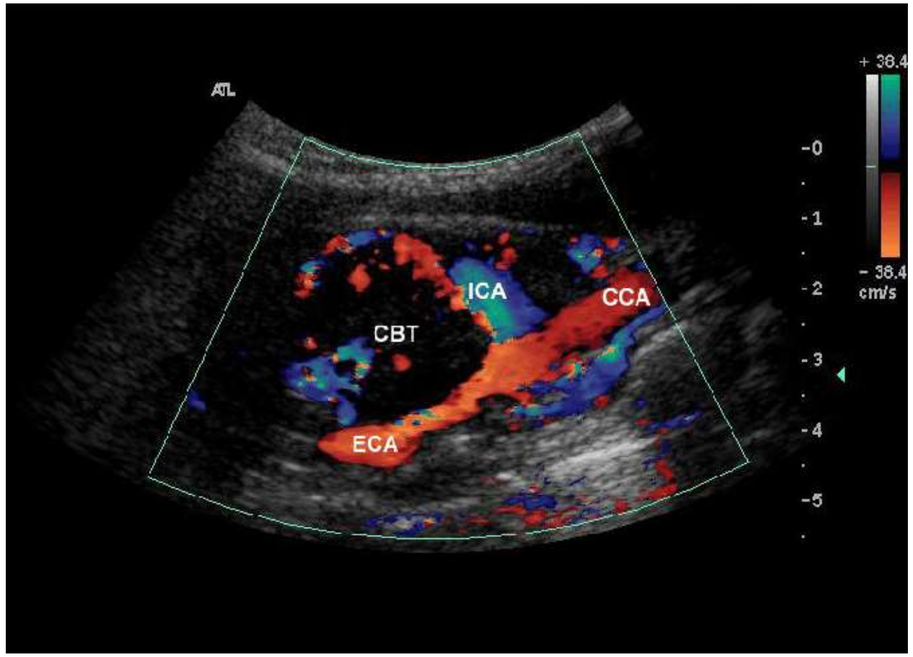
Carotid Dissection





Carotid Body Tumor

- Slow growing mass that develops at the carotid bifurcation
- “Goblet” Appearance
- Difficult to miss

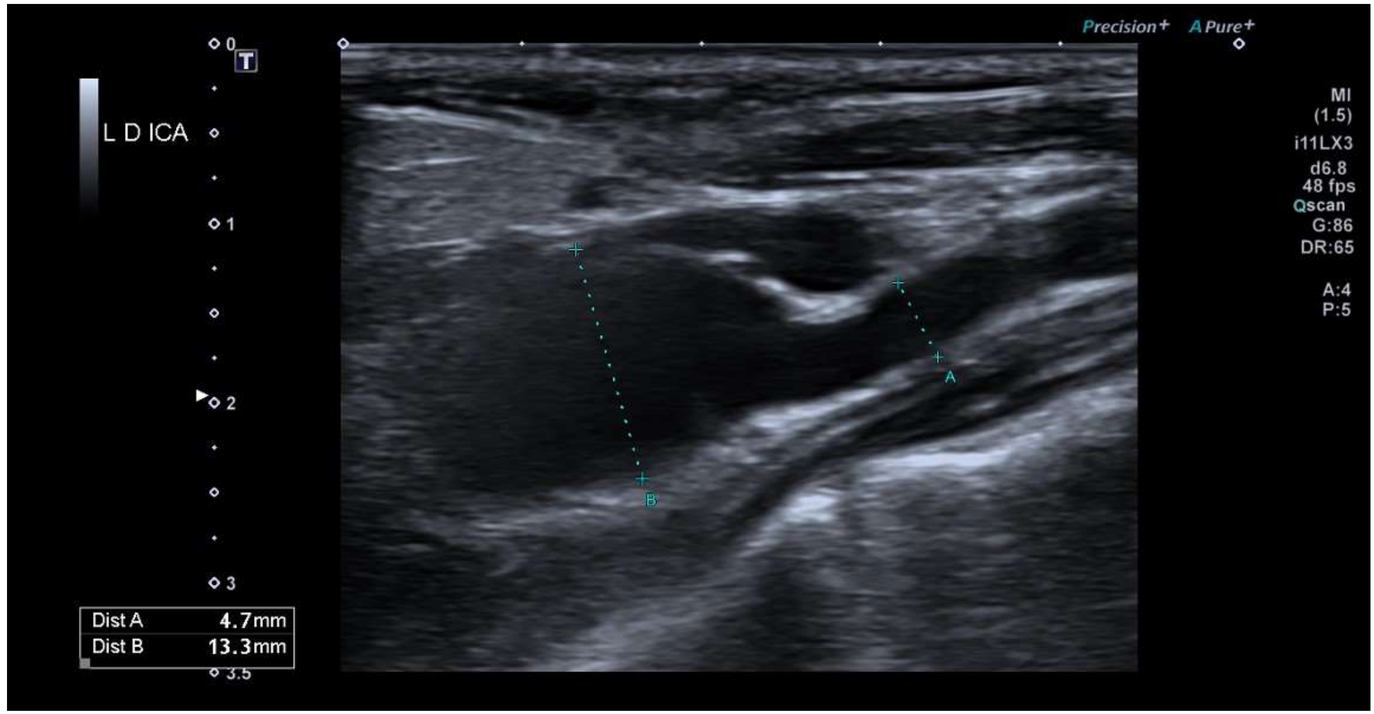


Carotid Web

- Thin, linear membrane arising at the carotid bulb- extending into the lumen
- Can cause significant stenosis in the absence of plaque/thrombus.
- Easily mistaken for insignificant plaque

Carotid Aneurysm

- “Bulge” in carotid artery
- May be caused by prior trauma/ surgery (Take a good history)
- Risk of clotting or rupture

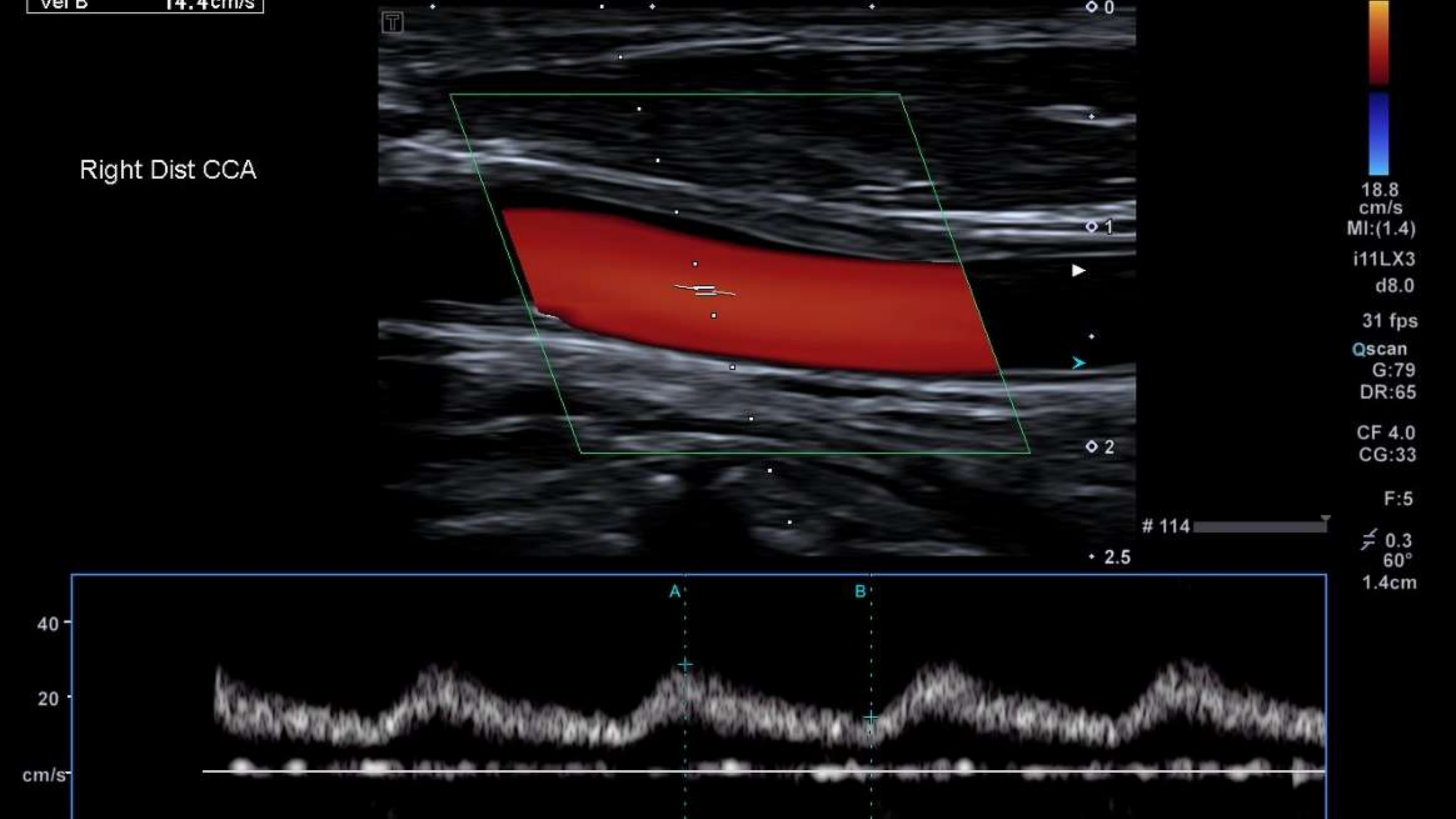


Case Study

Carotid Artery Duplex

Case Study

- 65 Year old Female
- Heavy smoker
- Symptoms of right arm weakness lasting approx. 4 hours
- Presented to A&E following this episode- referred for carotid duplex


Vel B 14.4cm/s
Right Dist CCA
0
1
2
18.8
cm/s
MI:(1.4)
i11LX3
d8.0
31 fps
Qscan
G:79
DR:65
CF 4.0
CG:33
F:5
0.3
60°
1.4cm
114
2.5
A
B
40
20
cm/s


Vert A
T
1
2
3
3.5
18.8
cm/s
MI:(1.0)
i11LX3
d8.0
31 fps
Qscan
G:83
DR:65
CF 4.0
CG:48
F:5
0.3
60°
2.6cm
18
100
50
cm/s
-50


Precision+
A Pure+
T
MI
(1.4)
i8CX1
d6.0
29 fps
Qscan
G:79
DR:65
A:3
P:5
R BRACHIOCEPHALIC ?OCC
0
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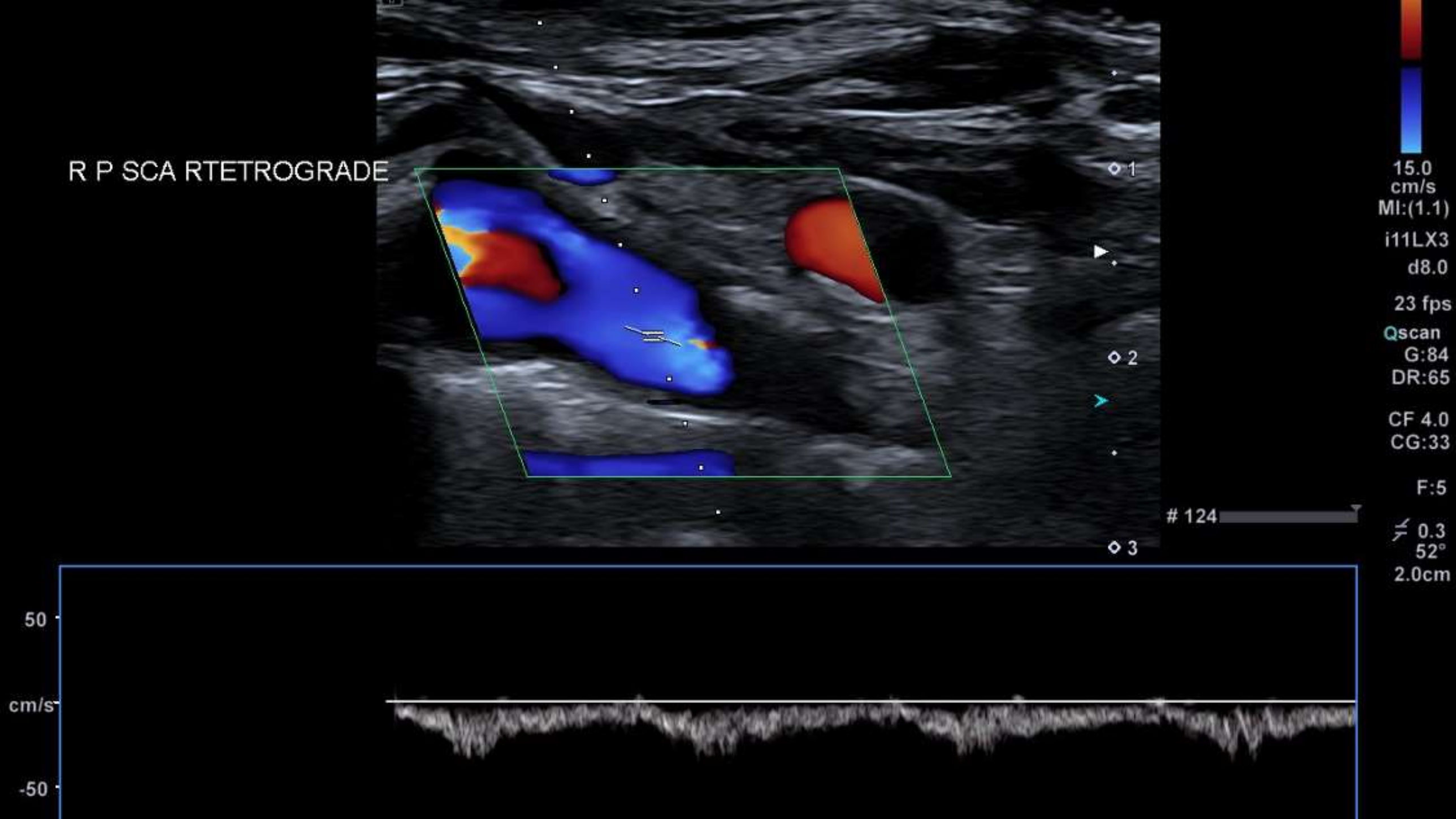
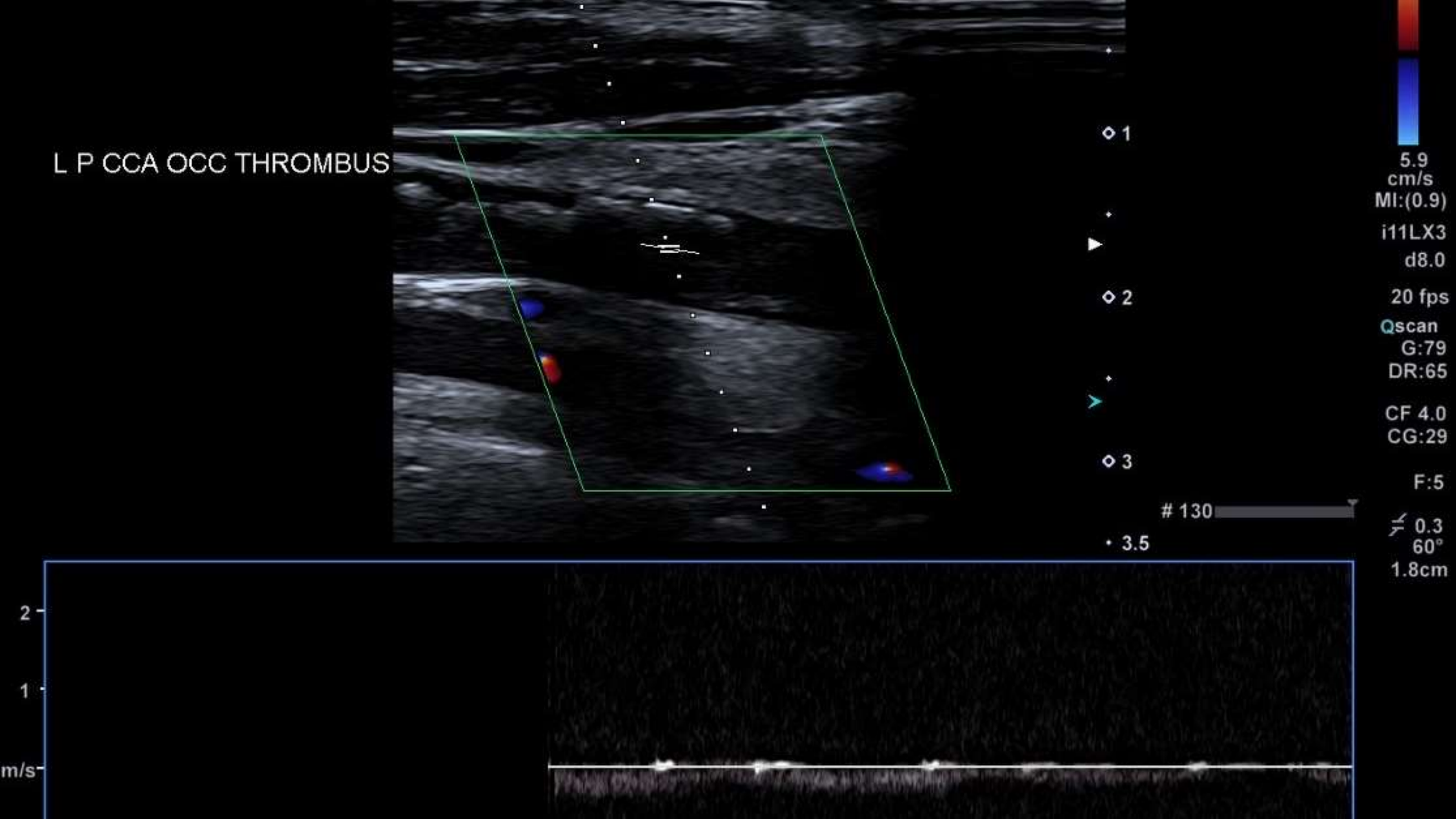
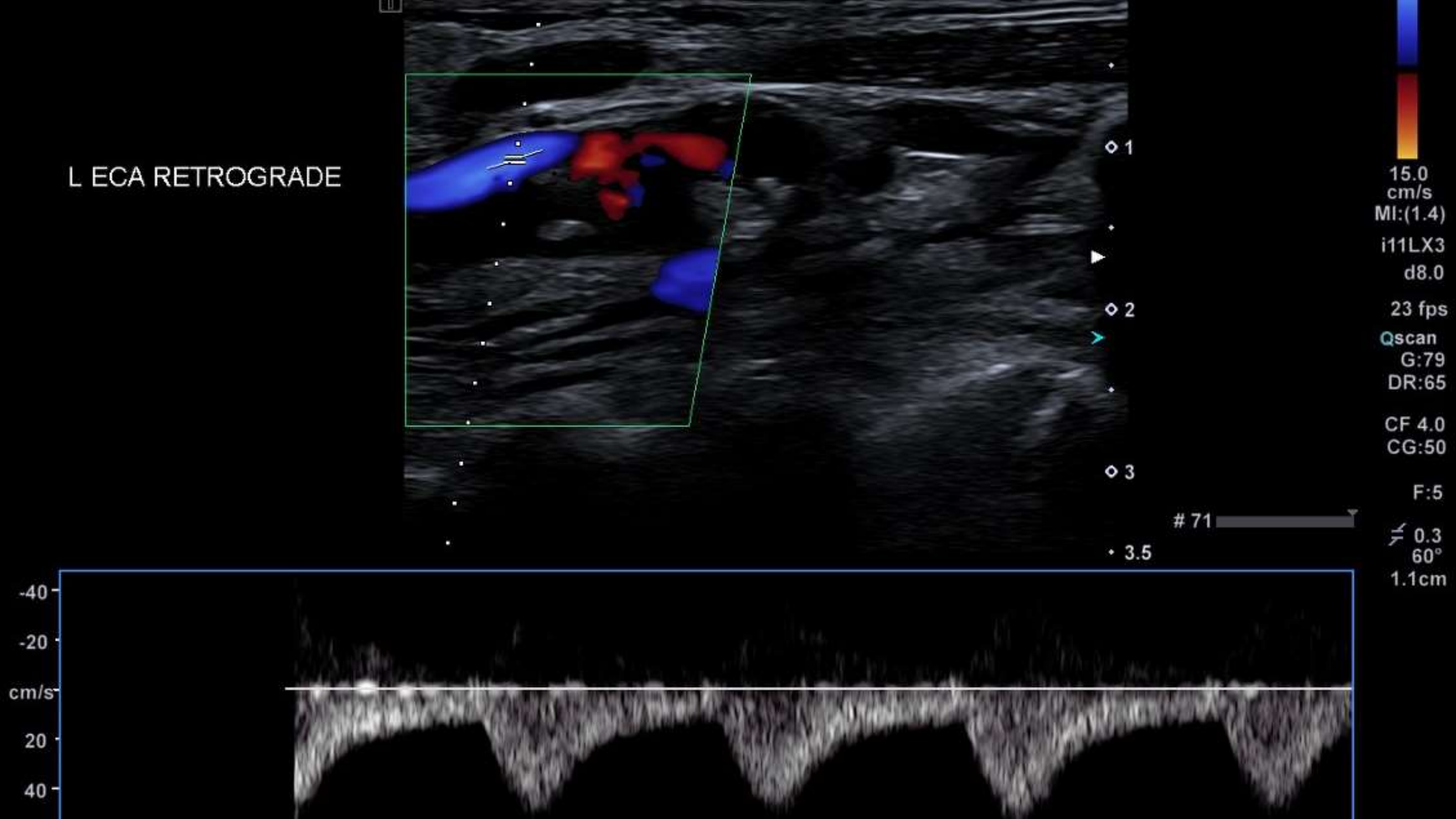
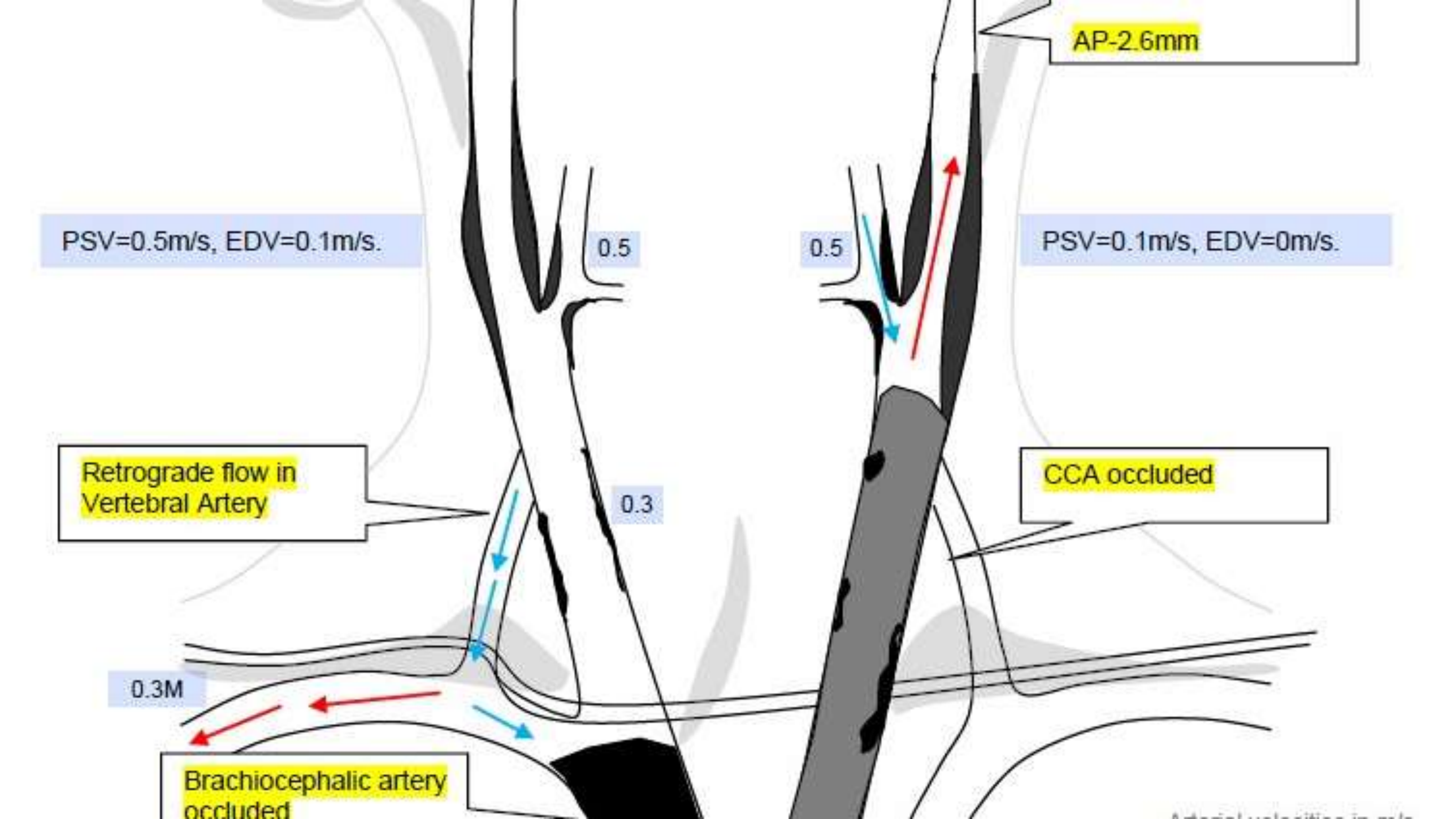
2
3
4


R P SCA RTETROGRADE
15.0
cm/s
MI:(1.1)
i11LX3
d8.0
23 fps
Qscan
G:84
DR:65
CF 4.0
CG:33
F:5
0.3
52°
2.0cm
124
1
2
3
50
cm/s
-50


L P CCA OCC THROMBUS
1
2
3
5.9
cm/s
MI:(0.9)
i11LX3
d8.0
20 fps
Qscan
G:79
DR:65
CF 4.0
CG:29
F:5
130
0.3
60°
1.8cm
3.5
2
1
m/s


L ECA RETROGRADE
1
2
3
15.0
cm/s
MI:(1.4)
i11LX3
d8.0
23 fps
Qscan
G:79
DR:65
CF 4.0
CG:50
F:5
0.3
60°
1.1cm
71
3.5
-40
-20
cm/s
20
40


AP-2.6mm
PSV=0.5m/s, EDV=0.1m/s.
0.5
0.5
PSV=0.1m/s, EDV=0m/s.
Retrograde flow in Vertebral Artery
0.3
CCA occluded
0.3M
Brachiocephalic artery occluded

Thank you for listening!

References

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- Renard, D. *et al.* (2018) *Teaching neuroimages: Multimodality imaging of carotid web*, *Teaching NeuroImages: Multimodality imaging of carotid web*. Available at: https://www.neurology.org/doi/10.1212/WNL.0000000000005359 (Accessed: 10 December 2024).