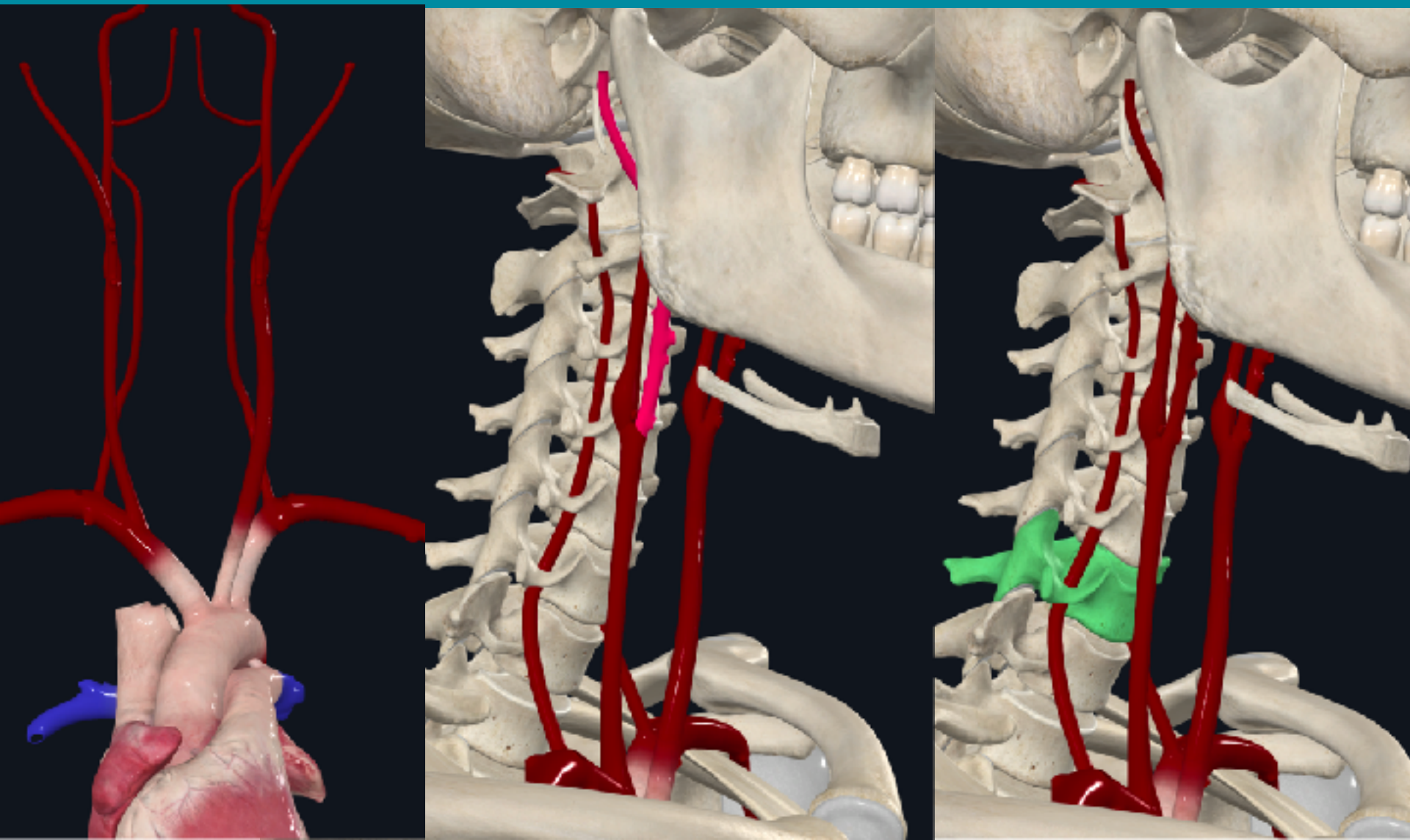
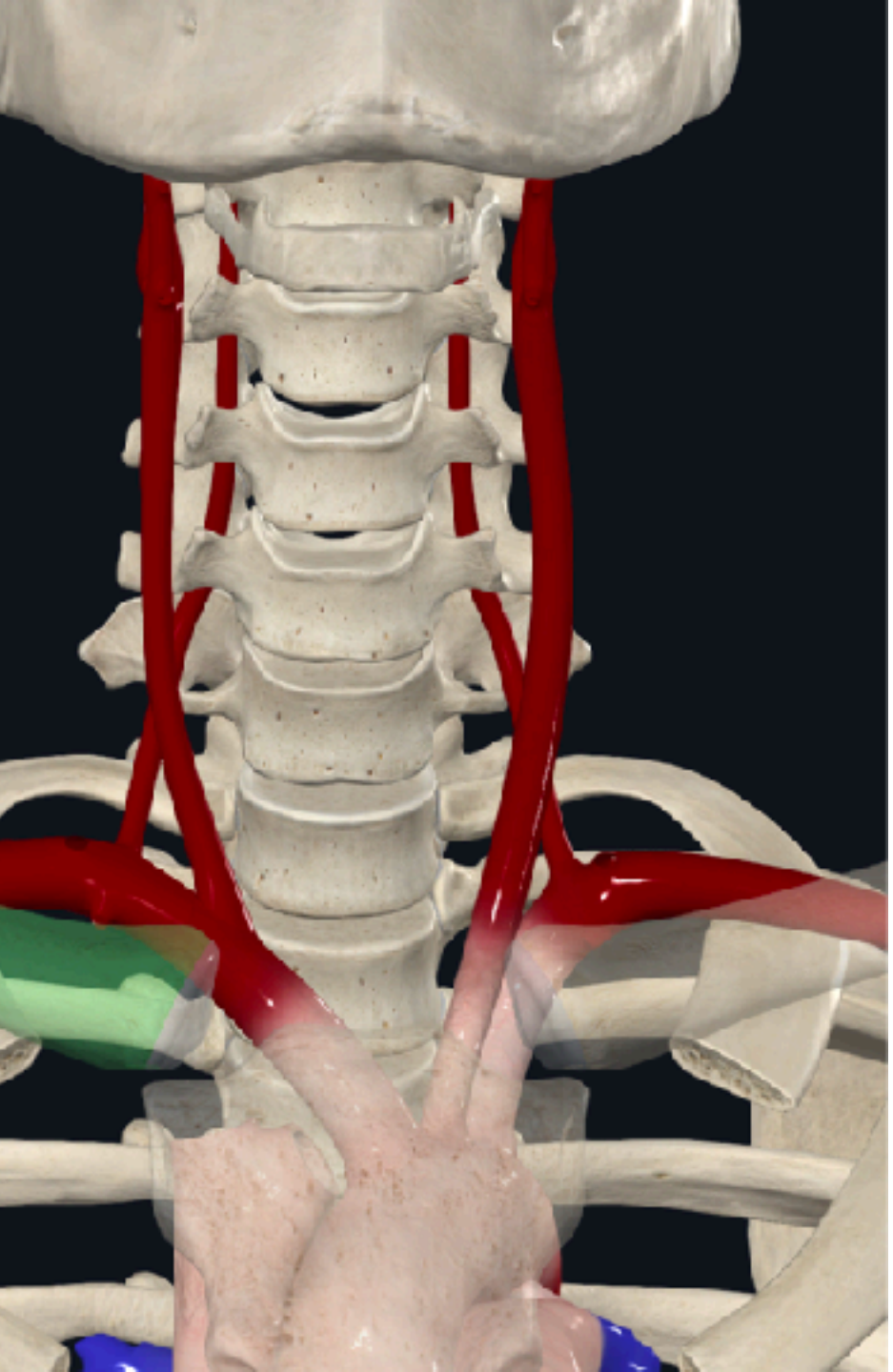
BASIC ECD IN ER



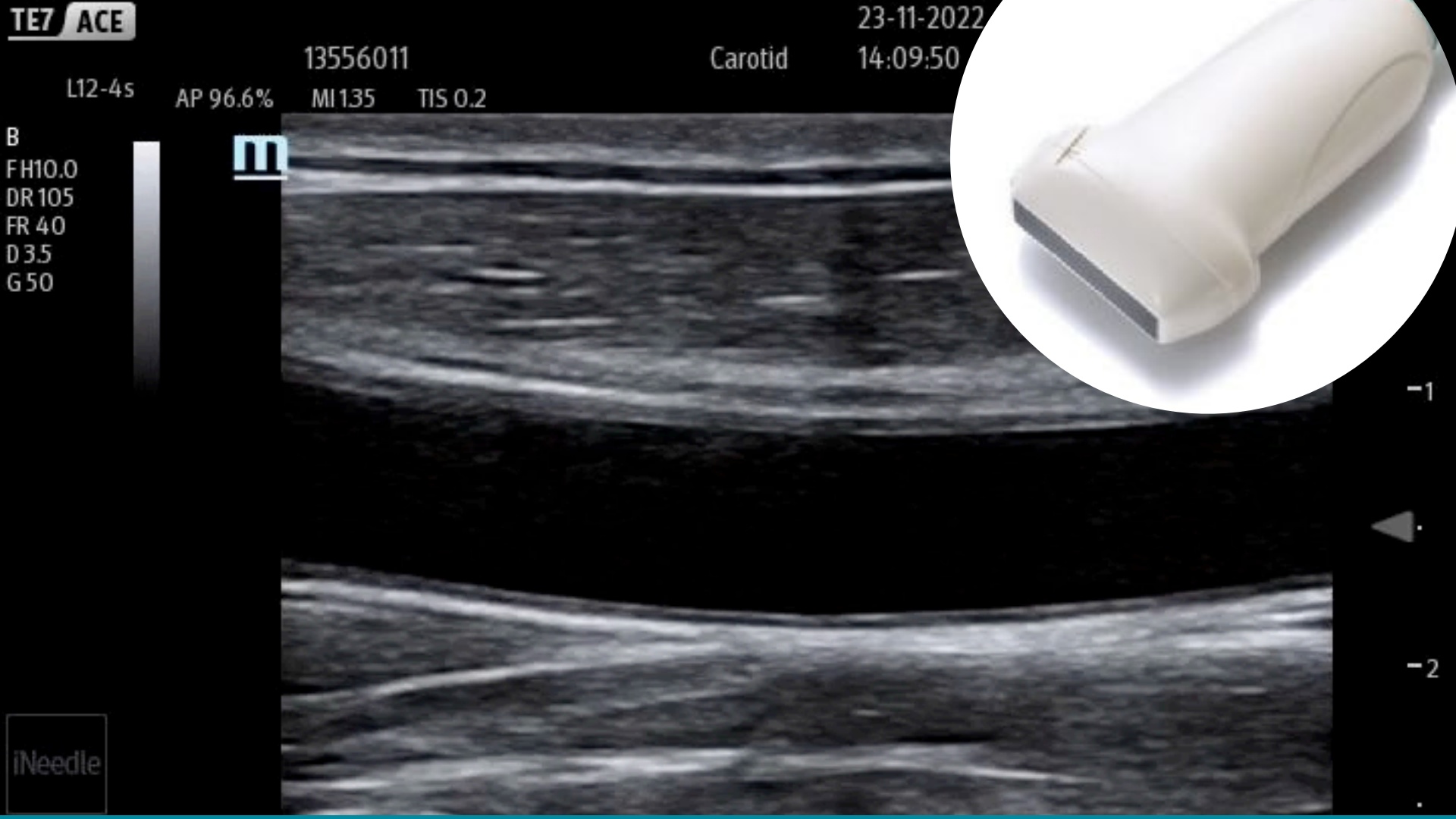


Anatomy

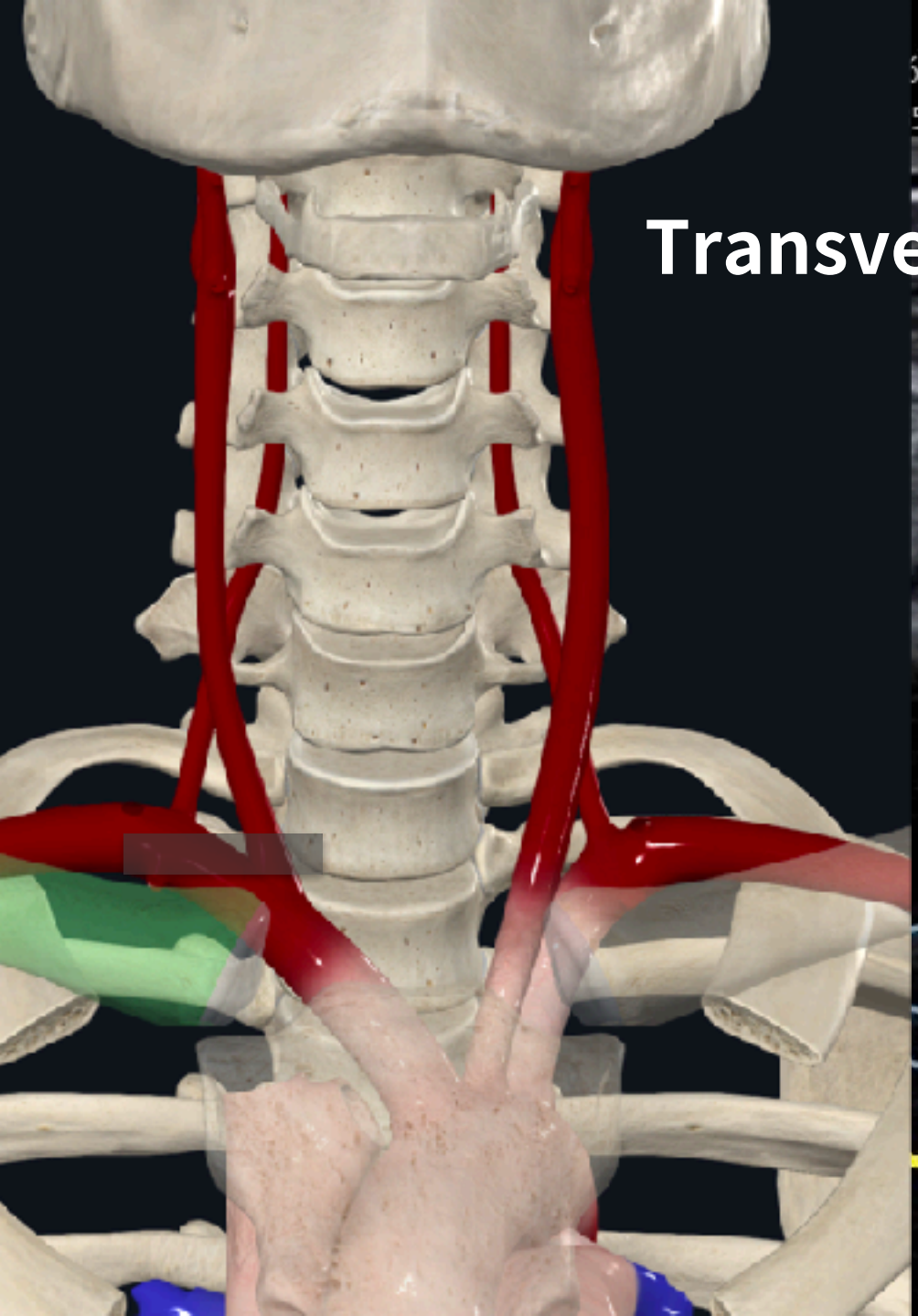
CCA/ICA/ECA/VA

Function

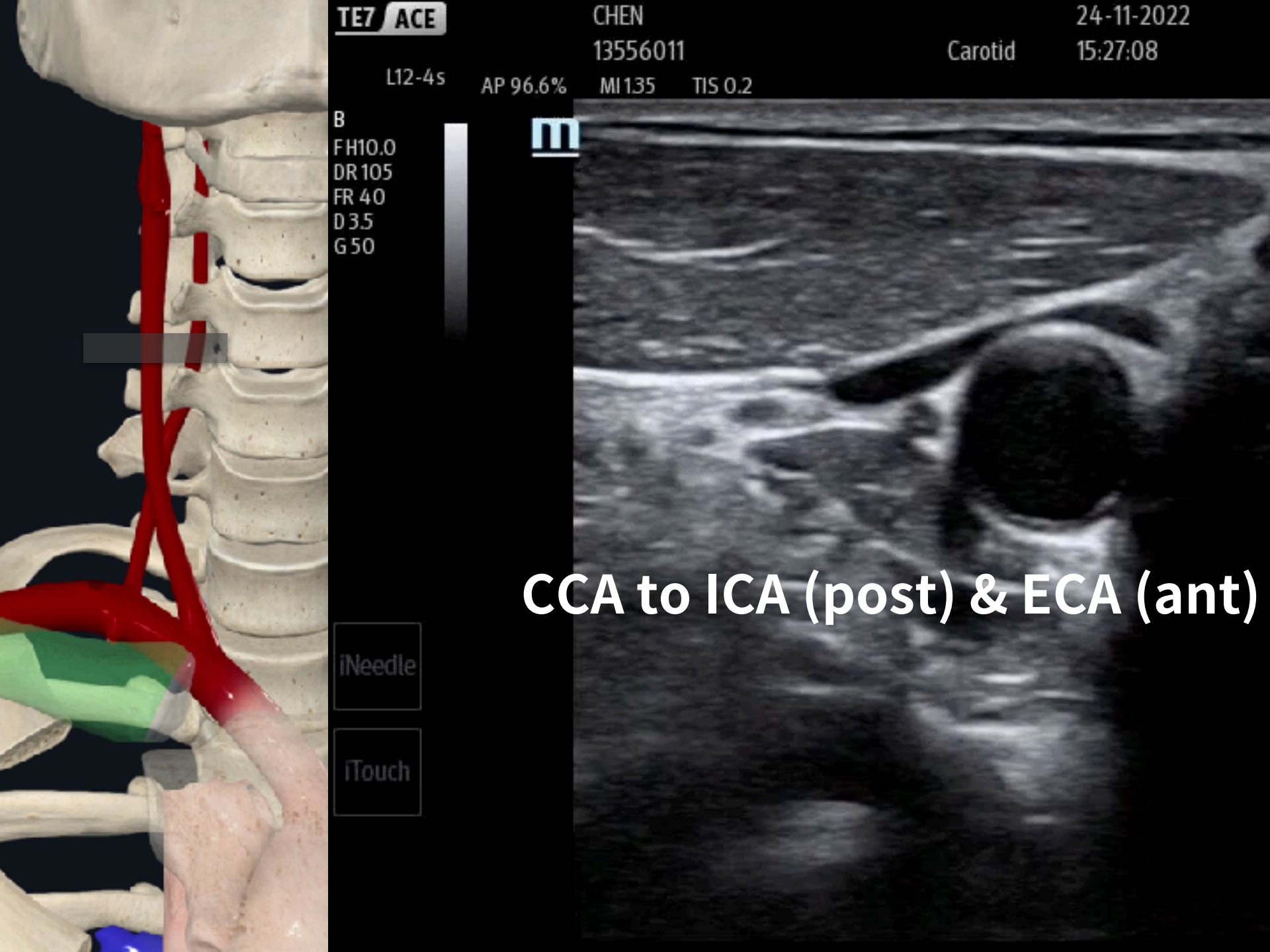
CD/PW/Flow

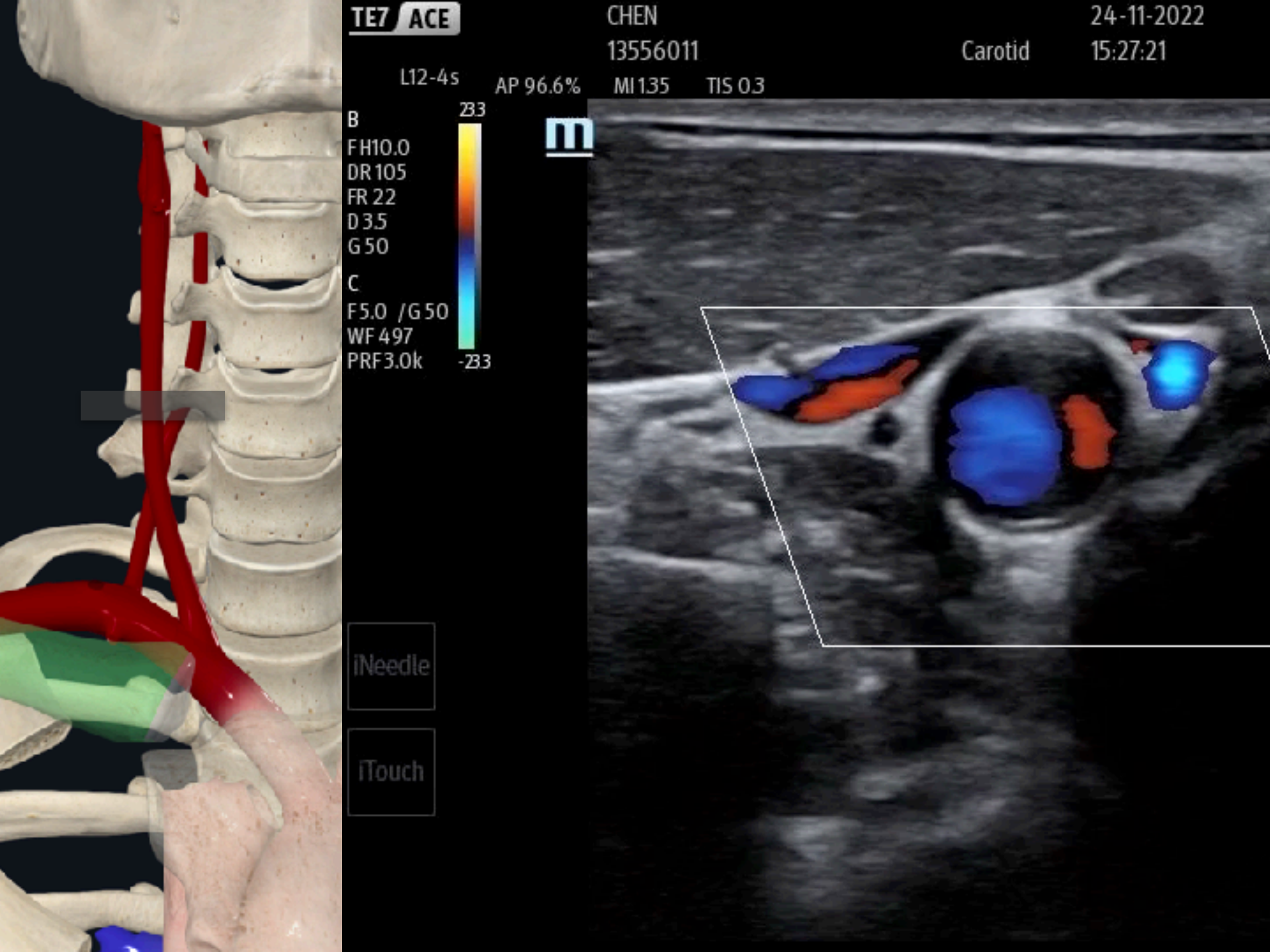


SONOANATOMY

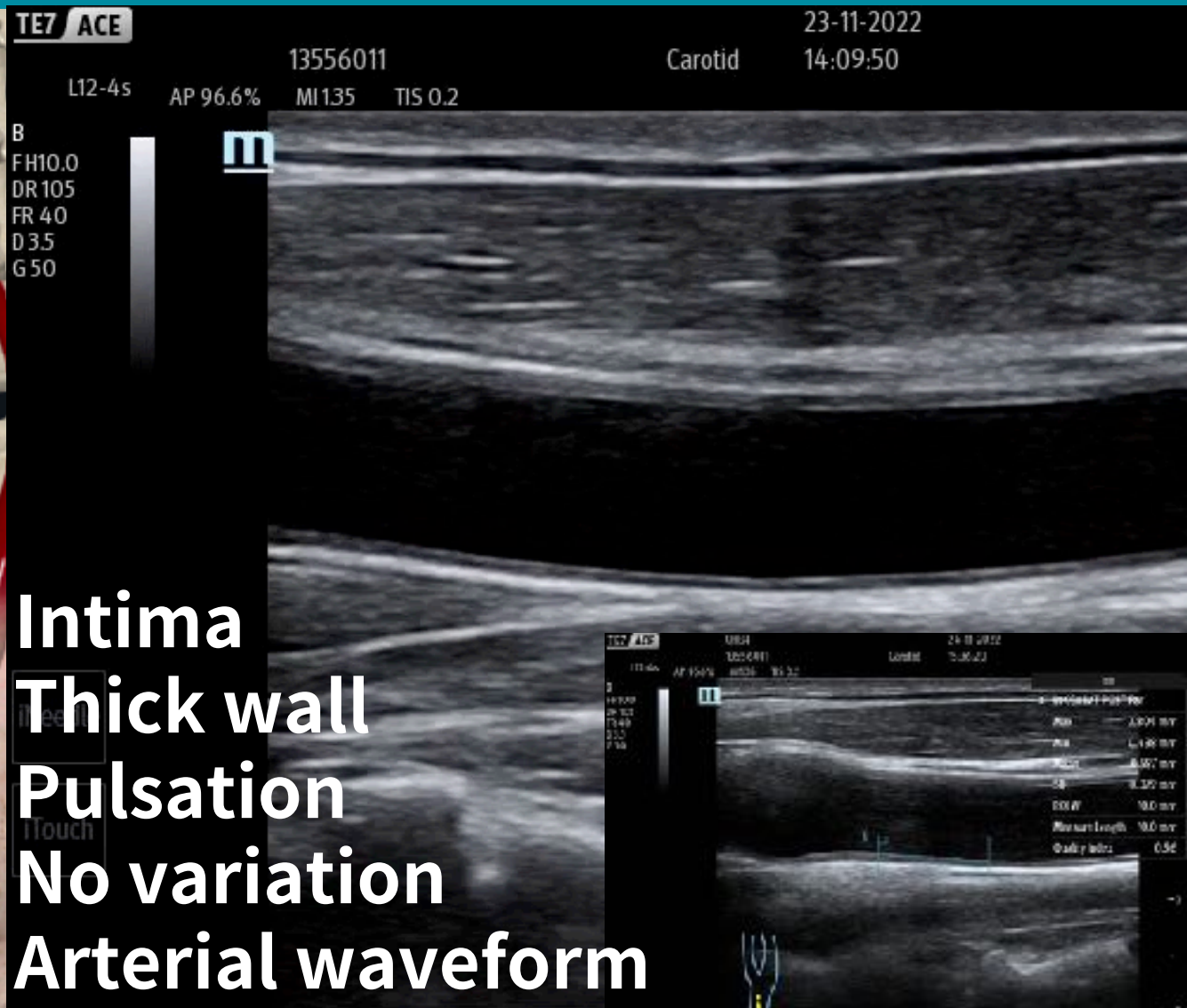


Transverse on medial clavicle

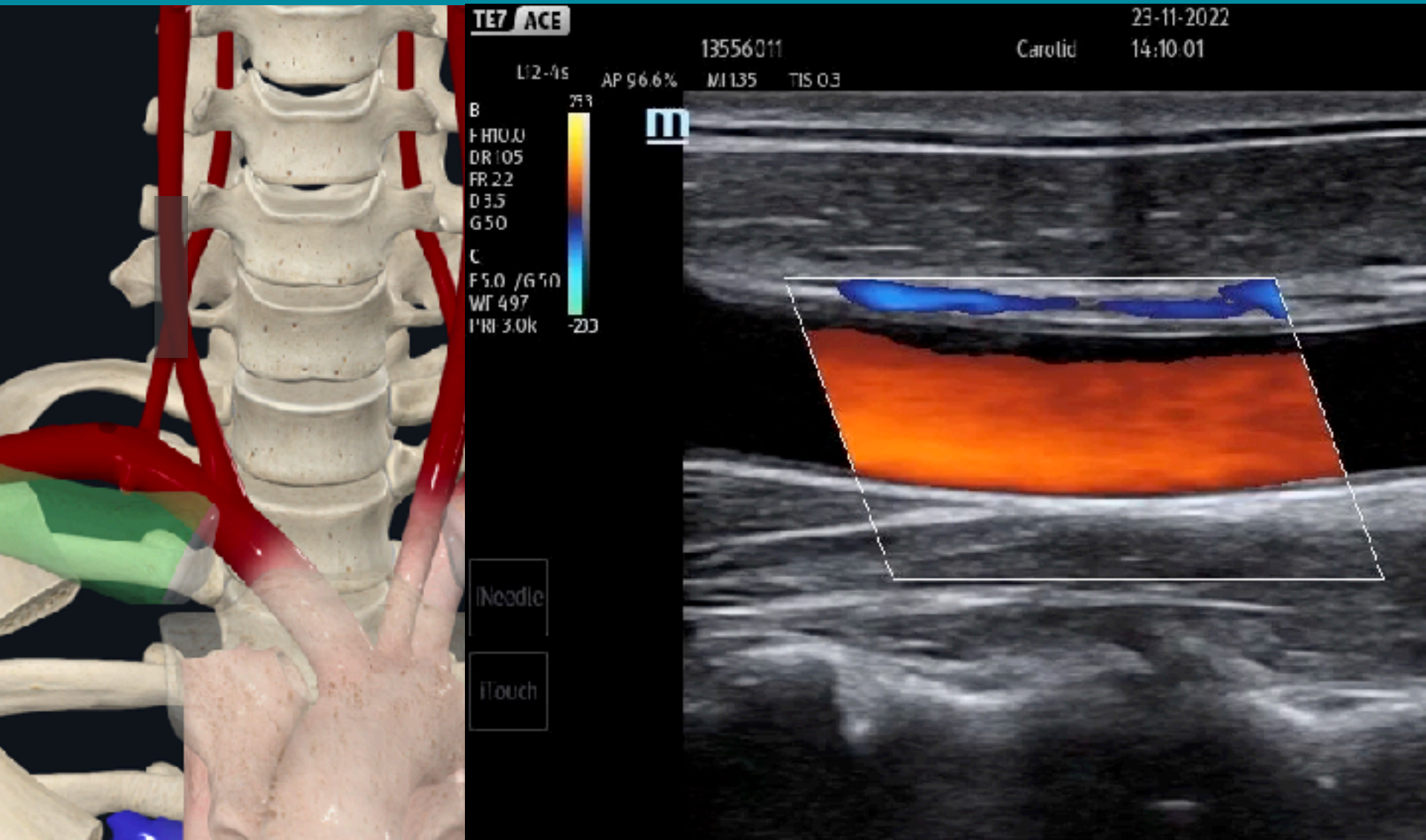

TE7 ACE
CHEN
13556011
24-11-2022
Carotid
15:27:08
L12-4s
AP 96.6%
MI 1.35
TIS 0.2
B
F H10.0
DR 105
FR 40
D 3.5
G 50
iNeedle
iTouch
CCA to ICA (post) & ECA (ant)


TE7 ACE
CHEN
13556011
24-11-2022
Carotid
15:27:21
L12-4s
AP 96.6%
MI 1.35
TIS 0.3
B
FH 10.0
DR 105
FR 22
D 3.5
G 50
C
F 5.0 /G 50
WF 497
PRF 3.0k
233
-233
iNeedle
iTouch

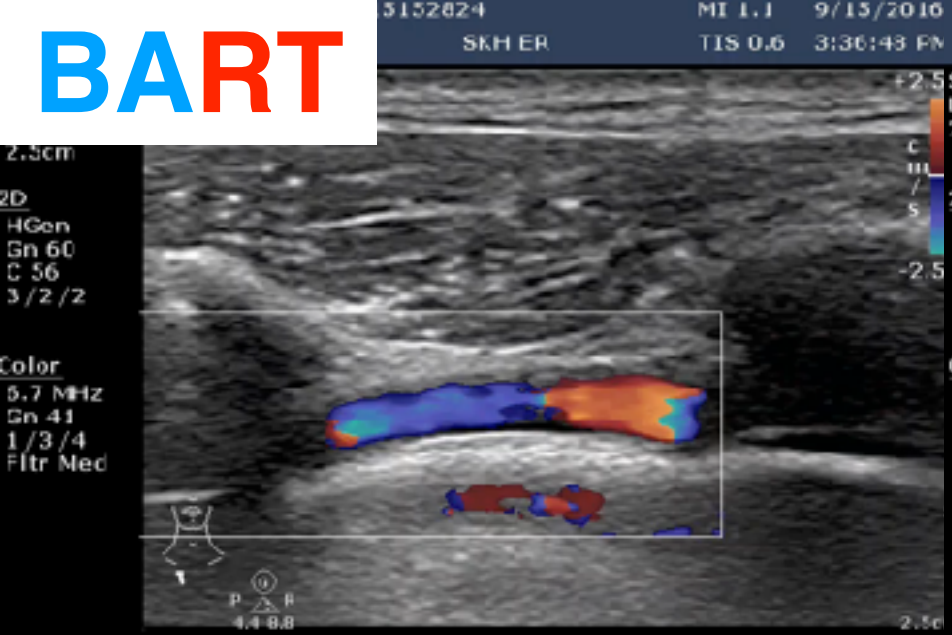
COMMON CAROTID ARTERY



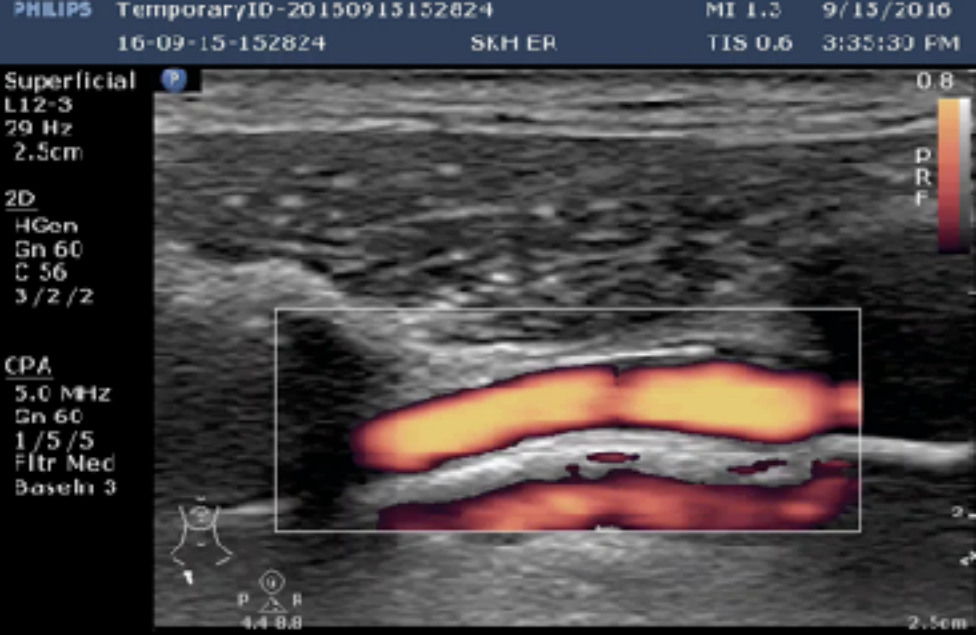
CCA WITH CD


TE7 ACE
23-11-2022
13556011
Carotid
14:10:01
AP 96.6%
MI 1.35
TIS 0.3
B
C
Needle
Touch

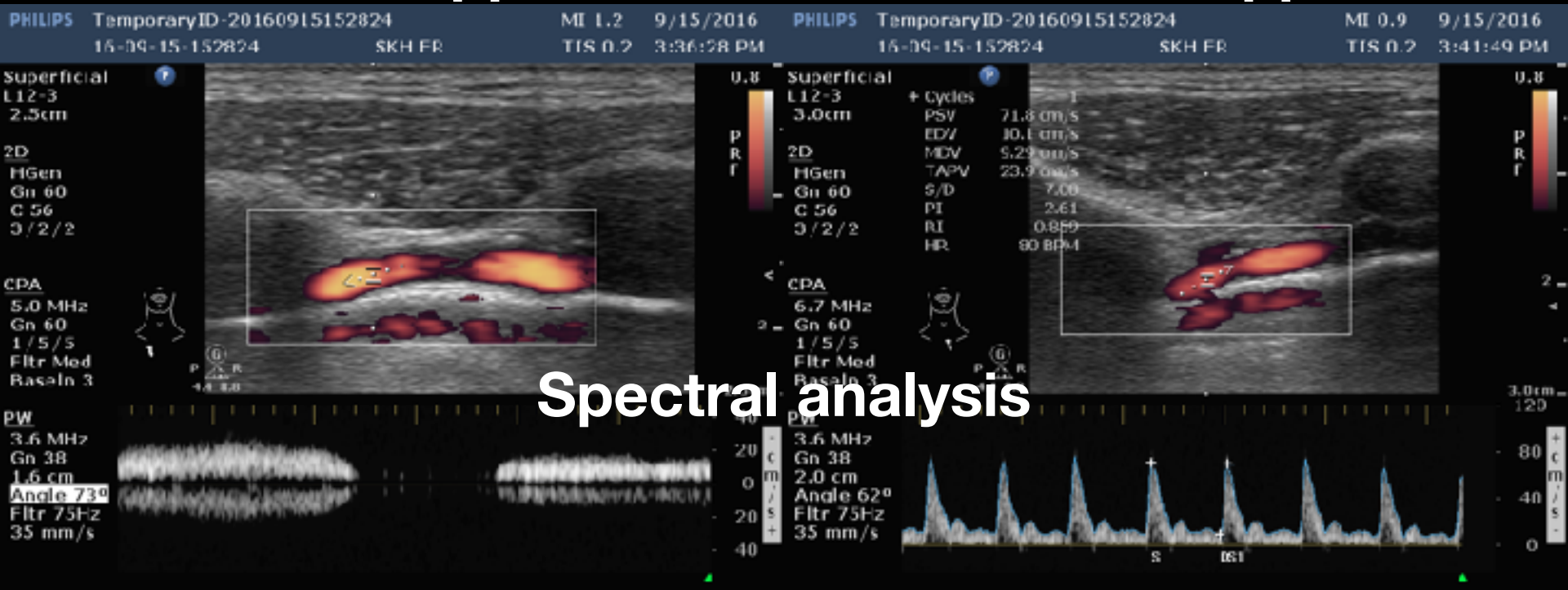
BART



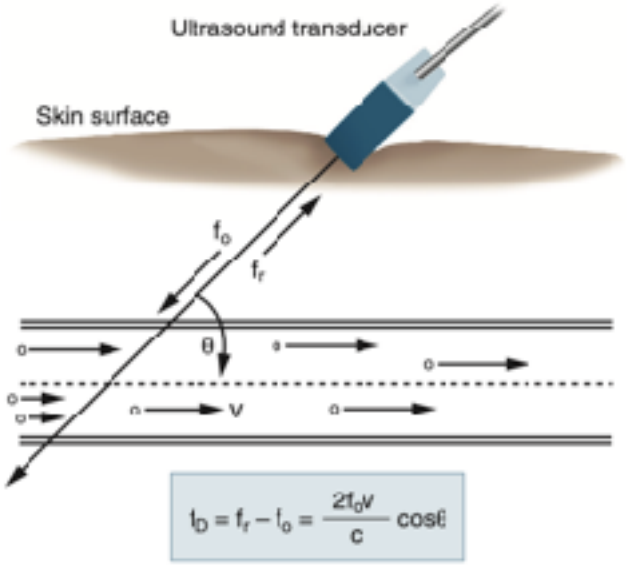
Color Doppler

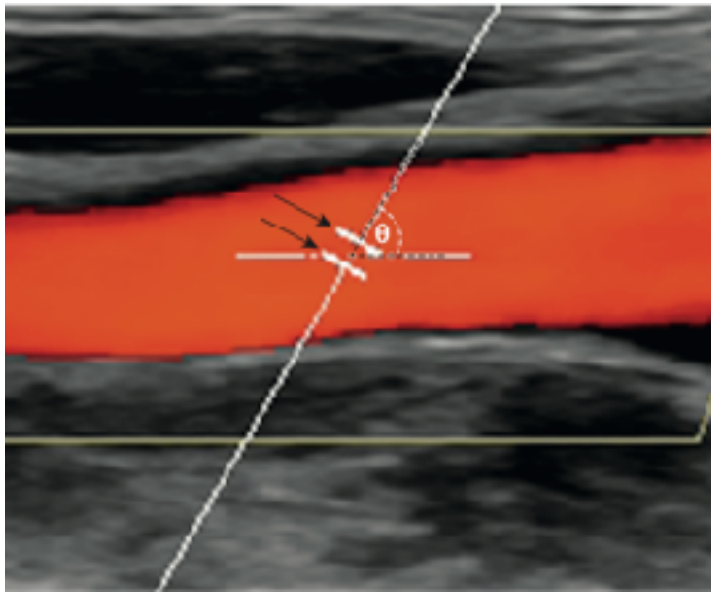


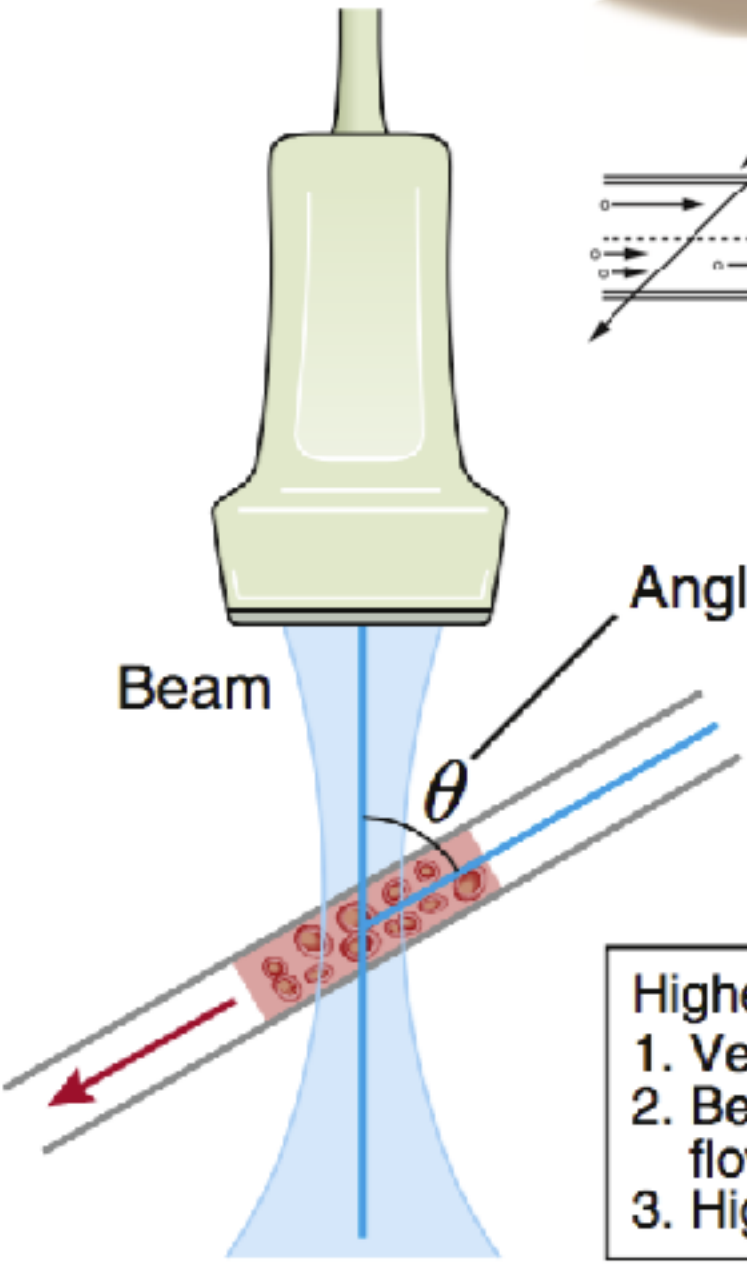
Power Doppler



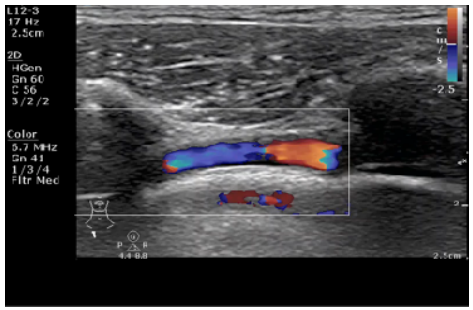
Spectral analysis







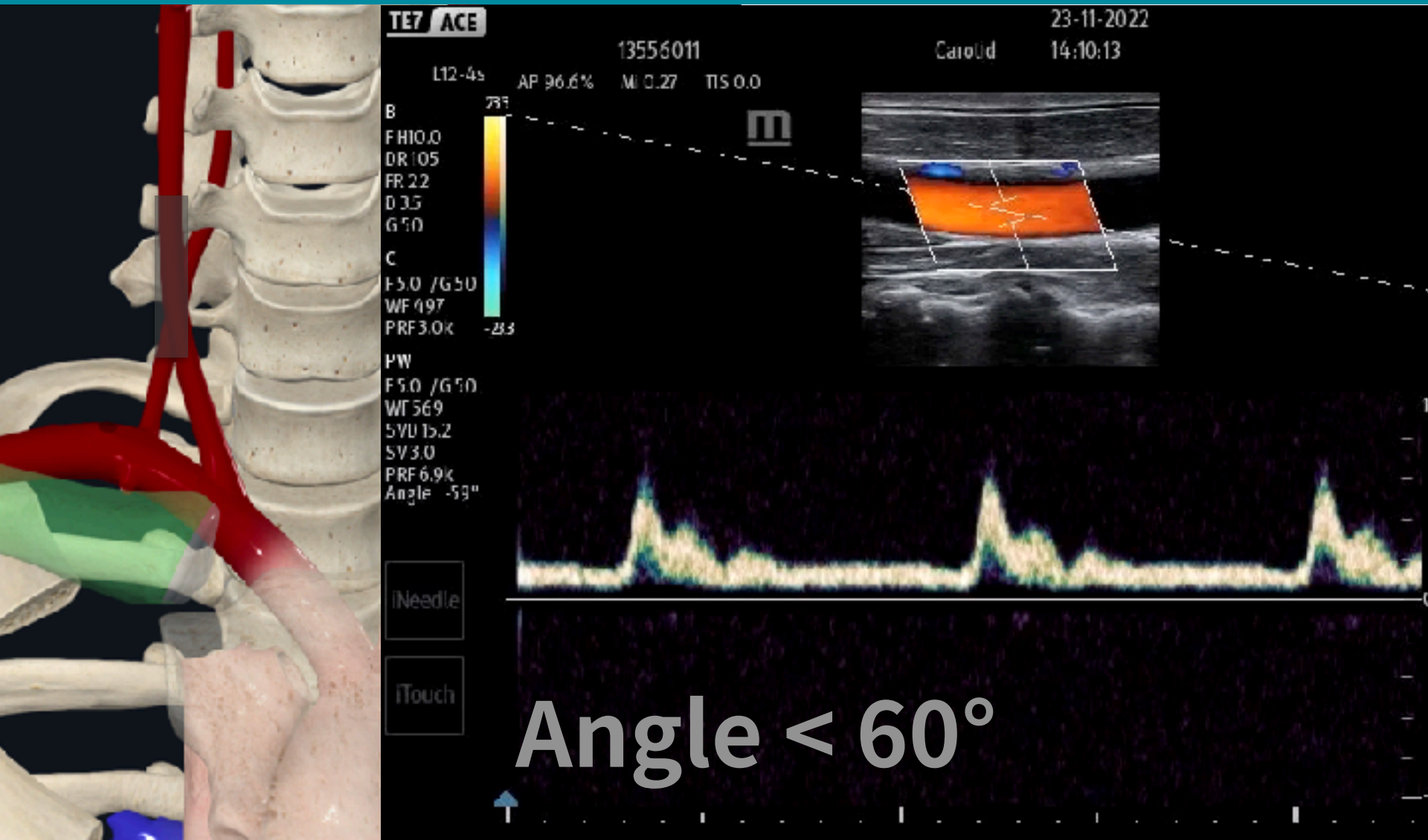
30 ~ 60°

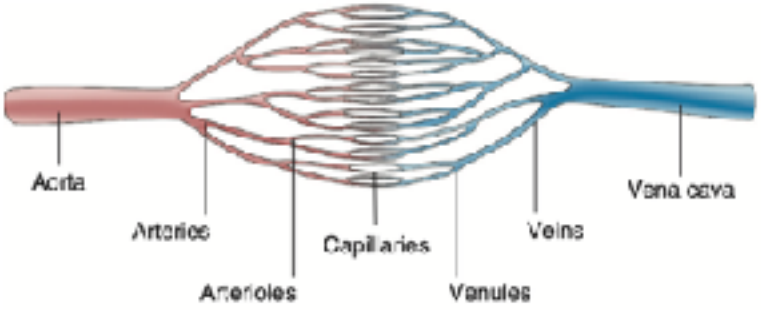


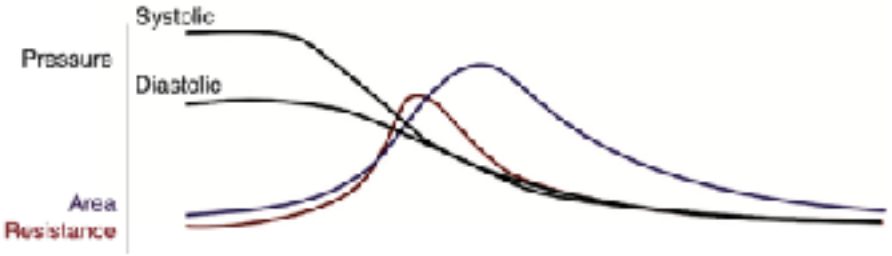
Higher Doppler frequency obtained if:

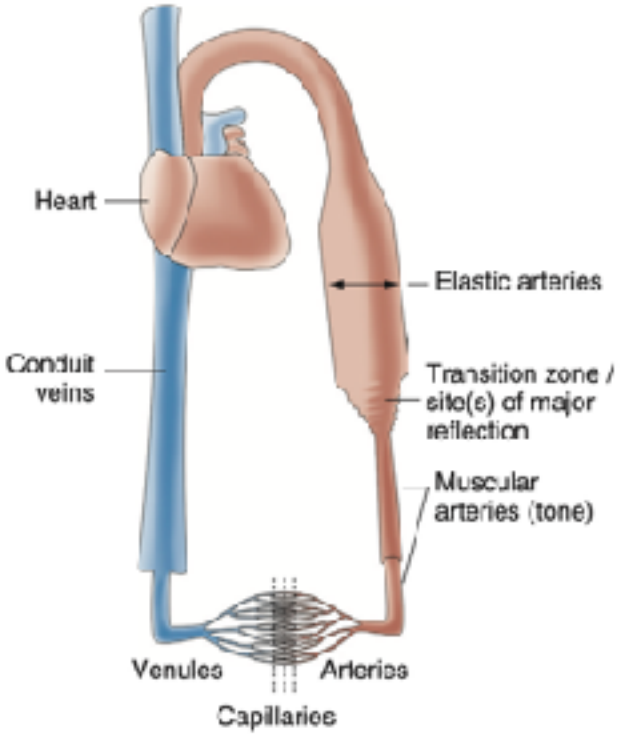
1. Velocity is increased
2. Beam is aligned parallel to flow direction
3. Higher frequency is used

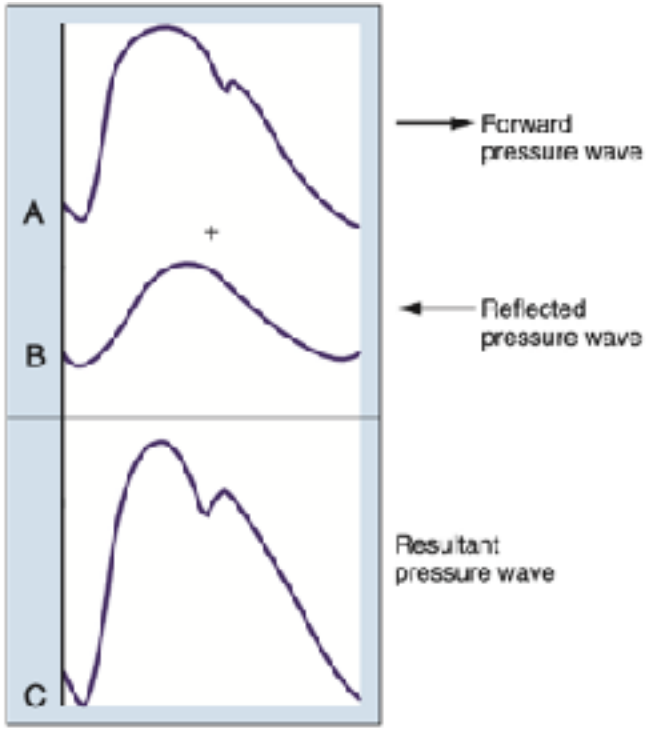
CCA WITH PW

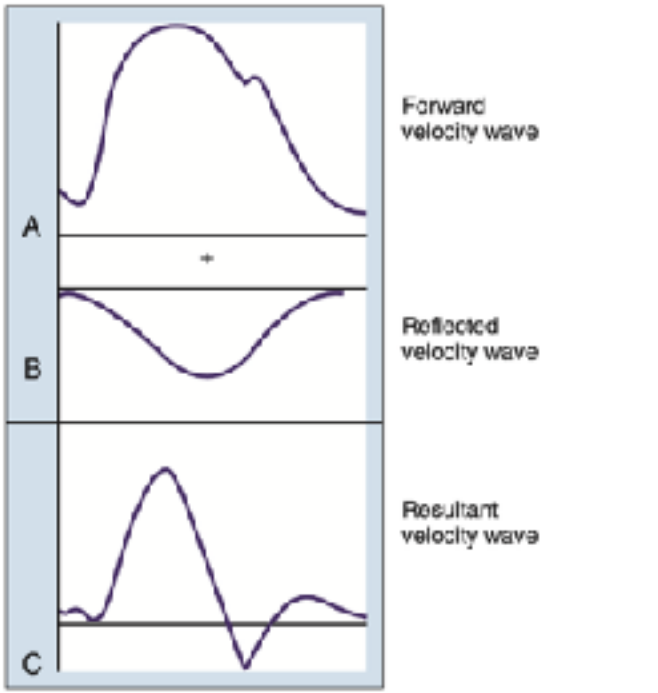

TE7 ACE
23-11-2022
14:10:13
13556011
CaroUd
L12-4s
AP 96.6%
MI 0.27
TIS 0.0
B
FH10.0
DR105
FR22
D35
G50
C
F5.0 /G50
WF497
PRF3.0k
-88
PW
F5.0 /G50
WF569
SVD 5.2
SV3.0
PRF6.9k
Angle -59°
iNeedle
iTouch
Angle < 60°











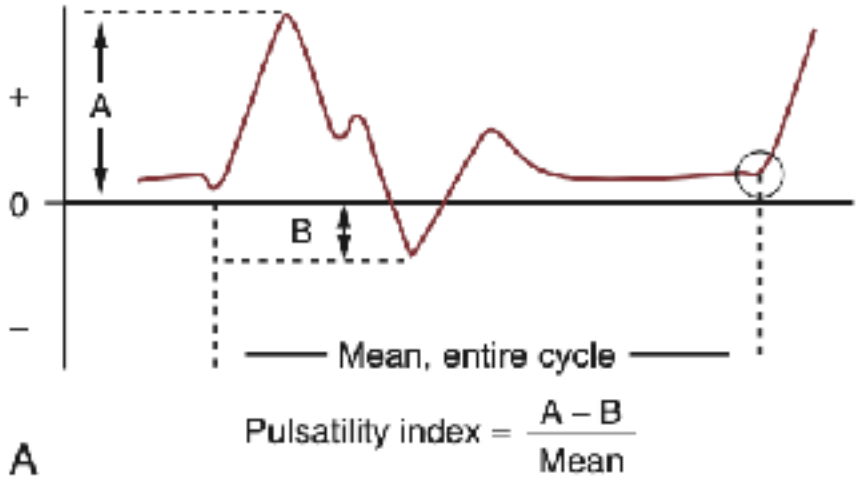
Introduction to vascular sonography_7th ed.

Pulsatility Measurement

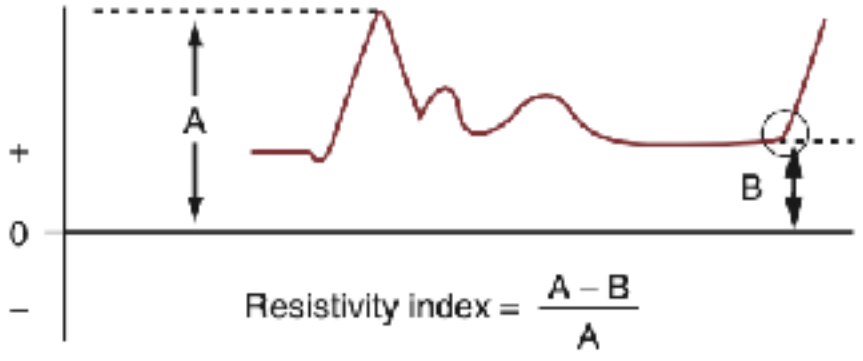
正常波形分析

生理狀態變異

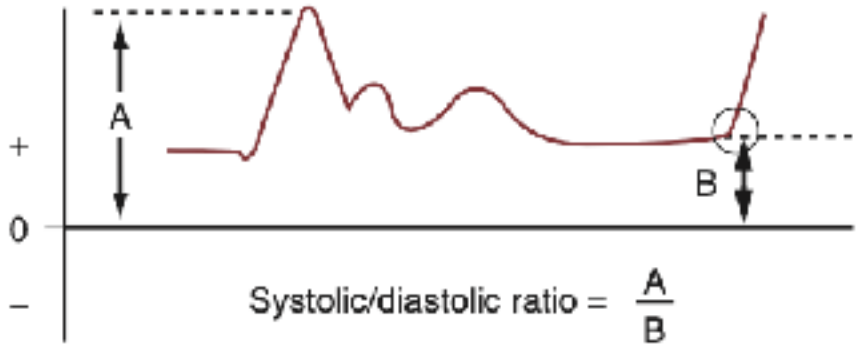
心臟功能影響



A



B

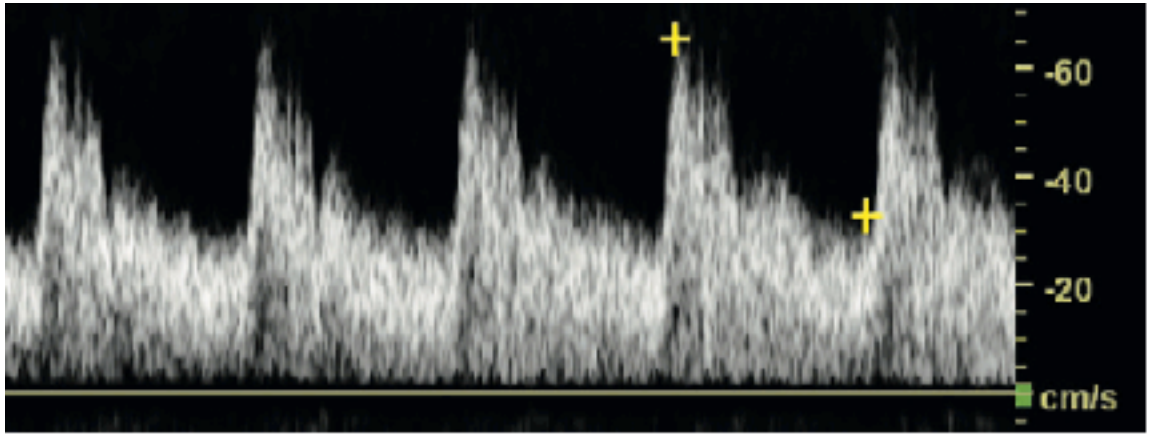


C

Introduction to vascular sonography_7th ed.

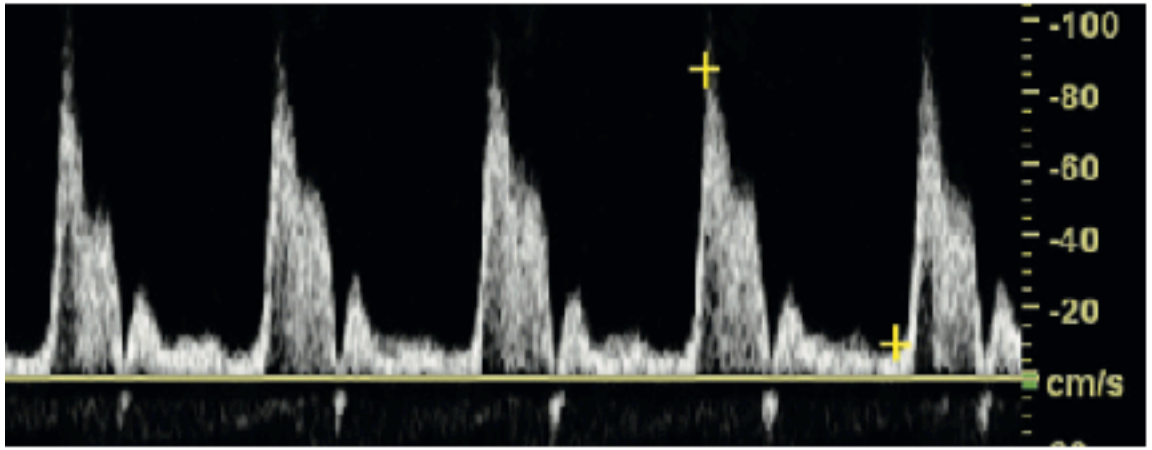
Pulsatility

低



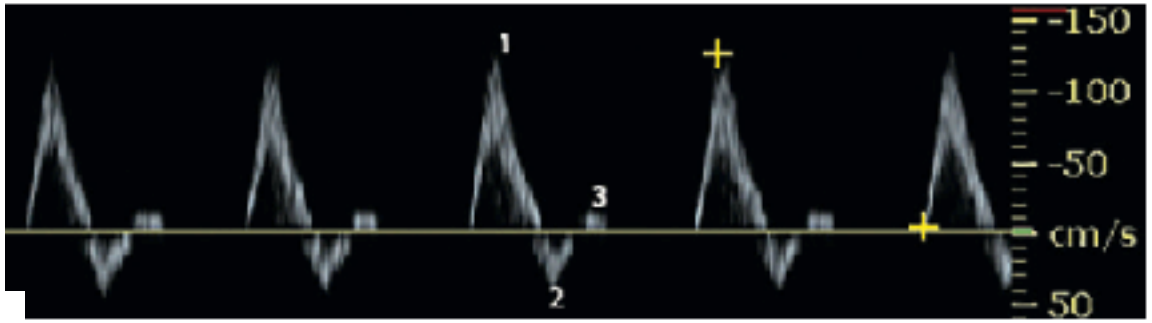
A

中



B

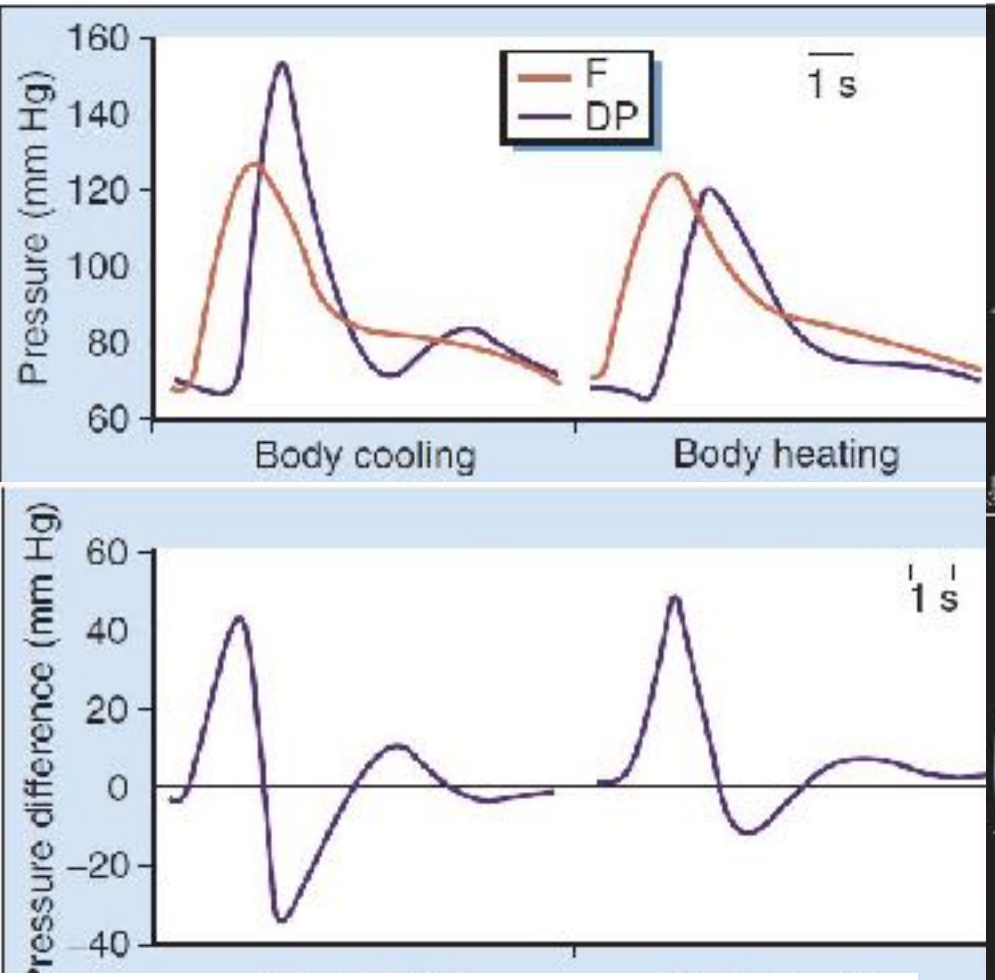
高

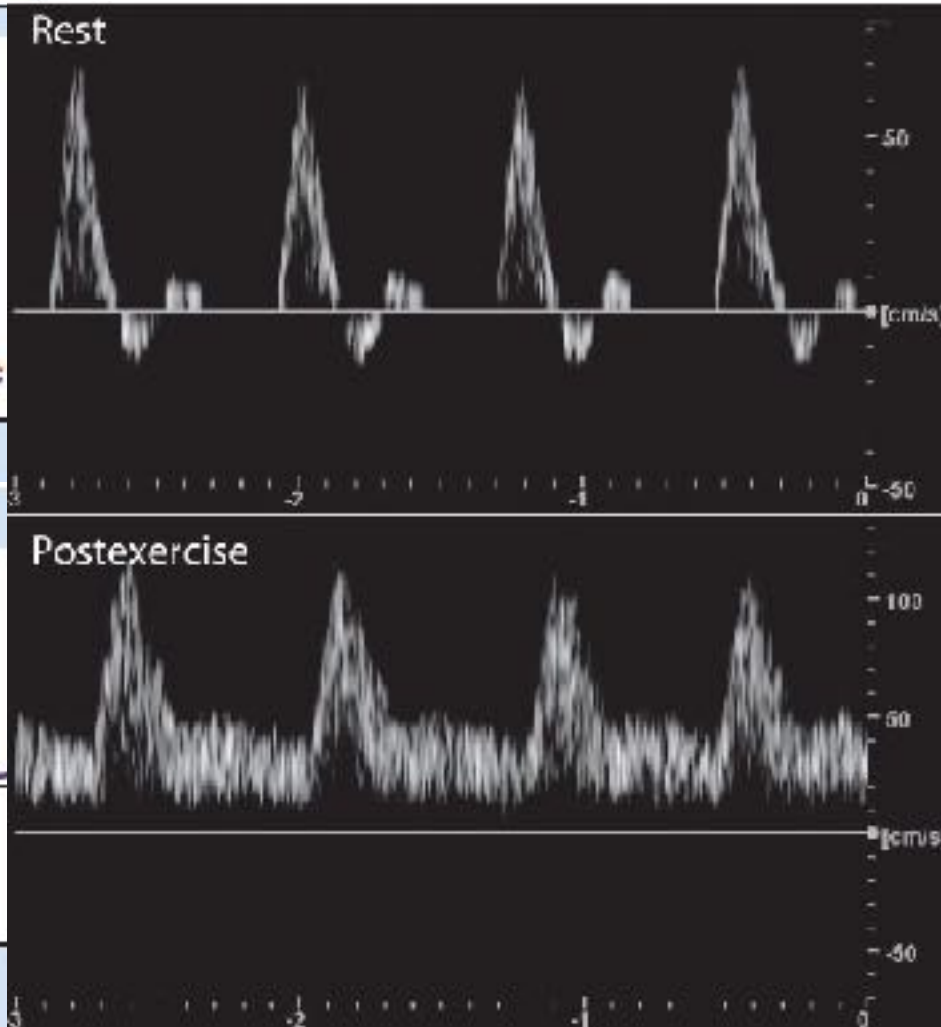


Introduction to vascular sonography_7th ed.

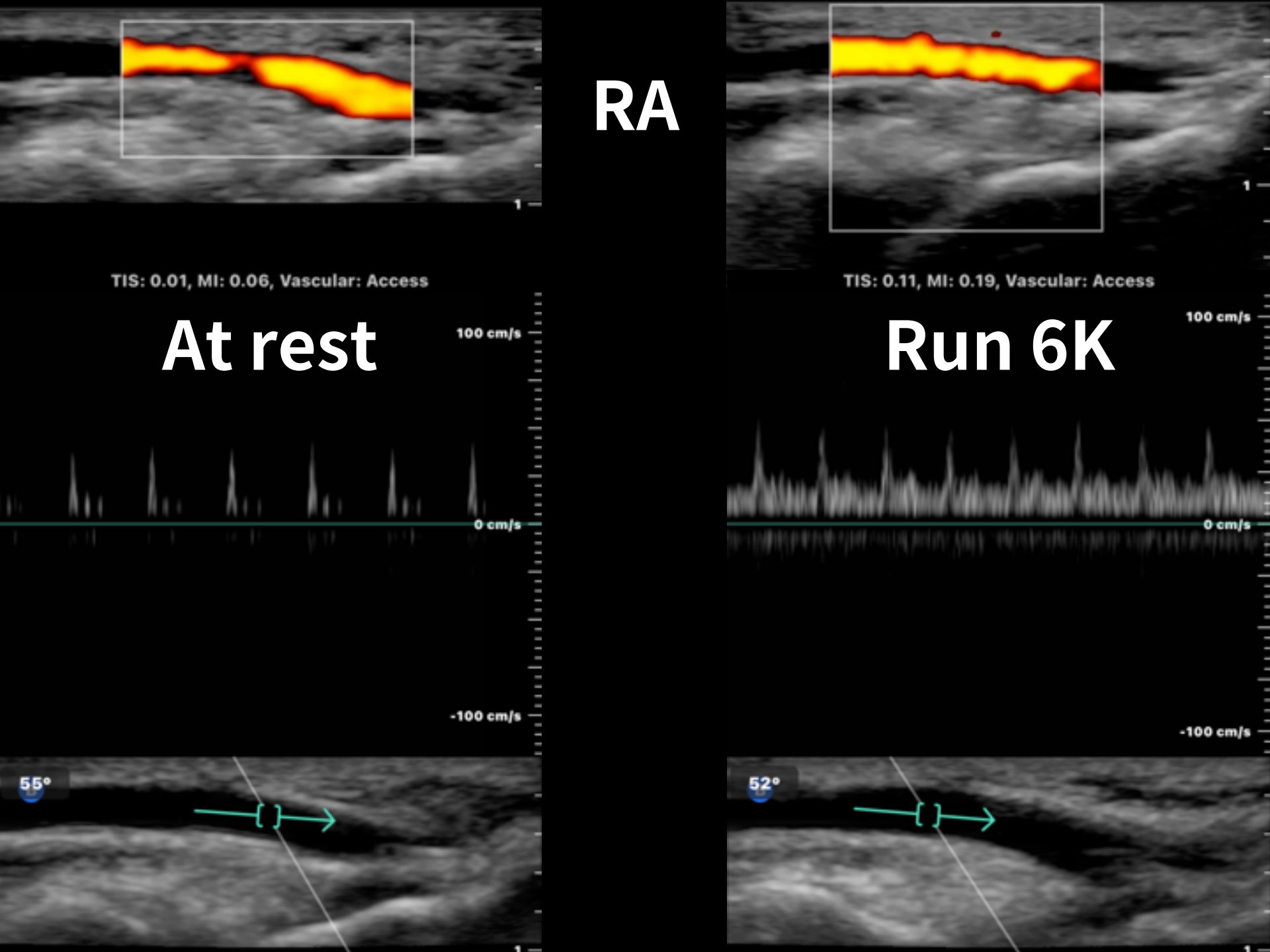
生理狀態的影響

溫度上升，阻力下降，血流增加

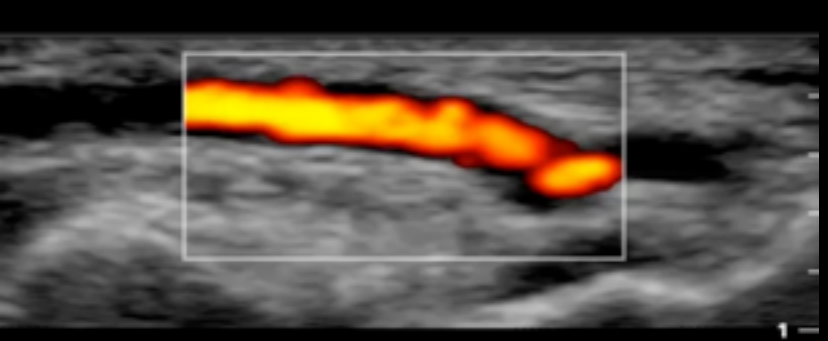


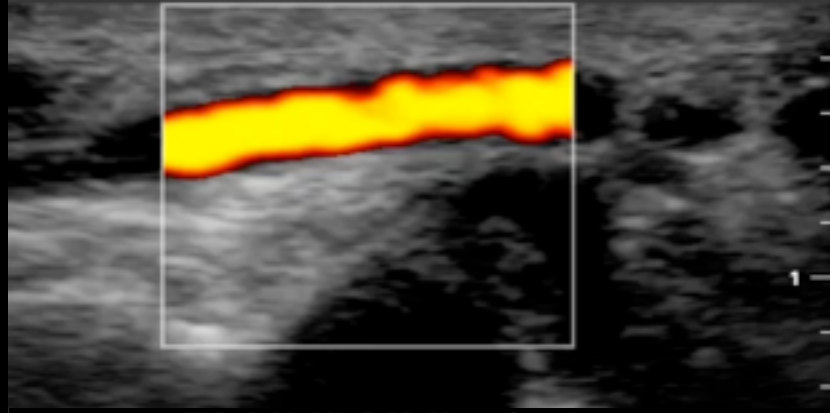


Introduction to vascular sonography_7th ed.


RA
TIS: 0.01, MI: 0.06, Vascular: Access
At rest
100 cm/s
0 cm/s
-100 cm/s
55°
TIS: 0.11, MI: 0.19, Vascular: Access
Run 6K
100 cm/s
0 cm/s
-100 cm/s
52°

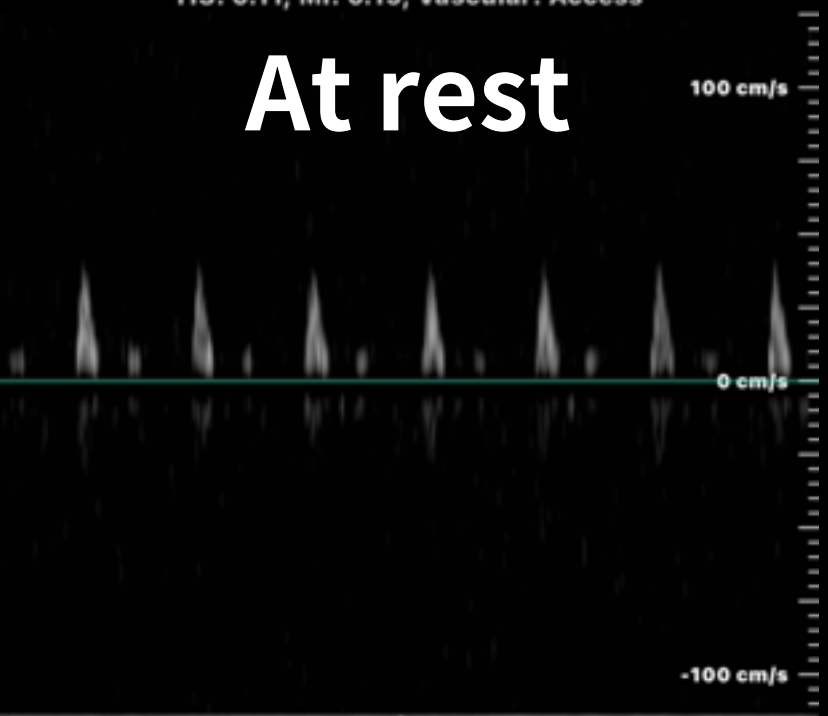
DPA

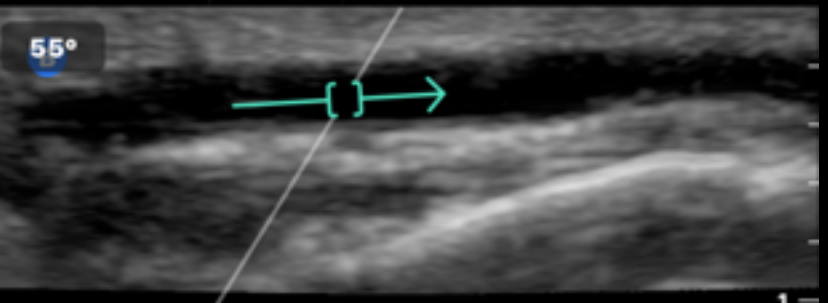




TIS: 0.11, MI: 0.19, Vascular: Access

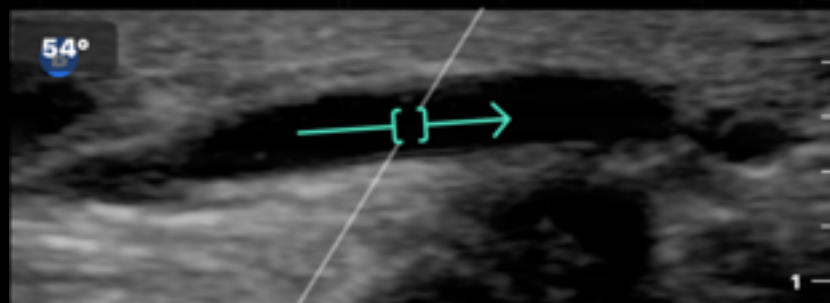
At rest



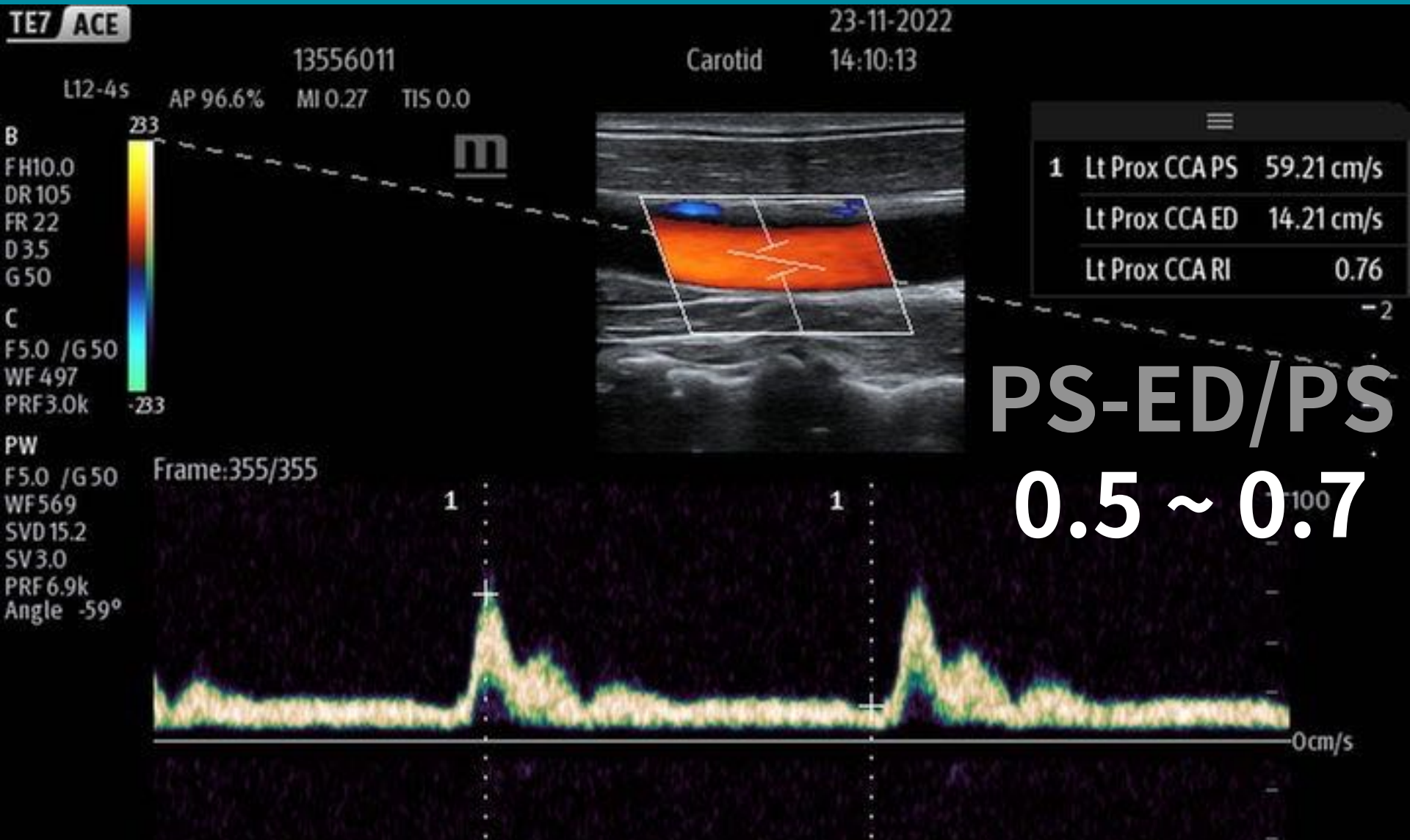


TIS: 0.11, MI: 0.19, Vascular: Access

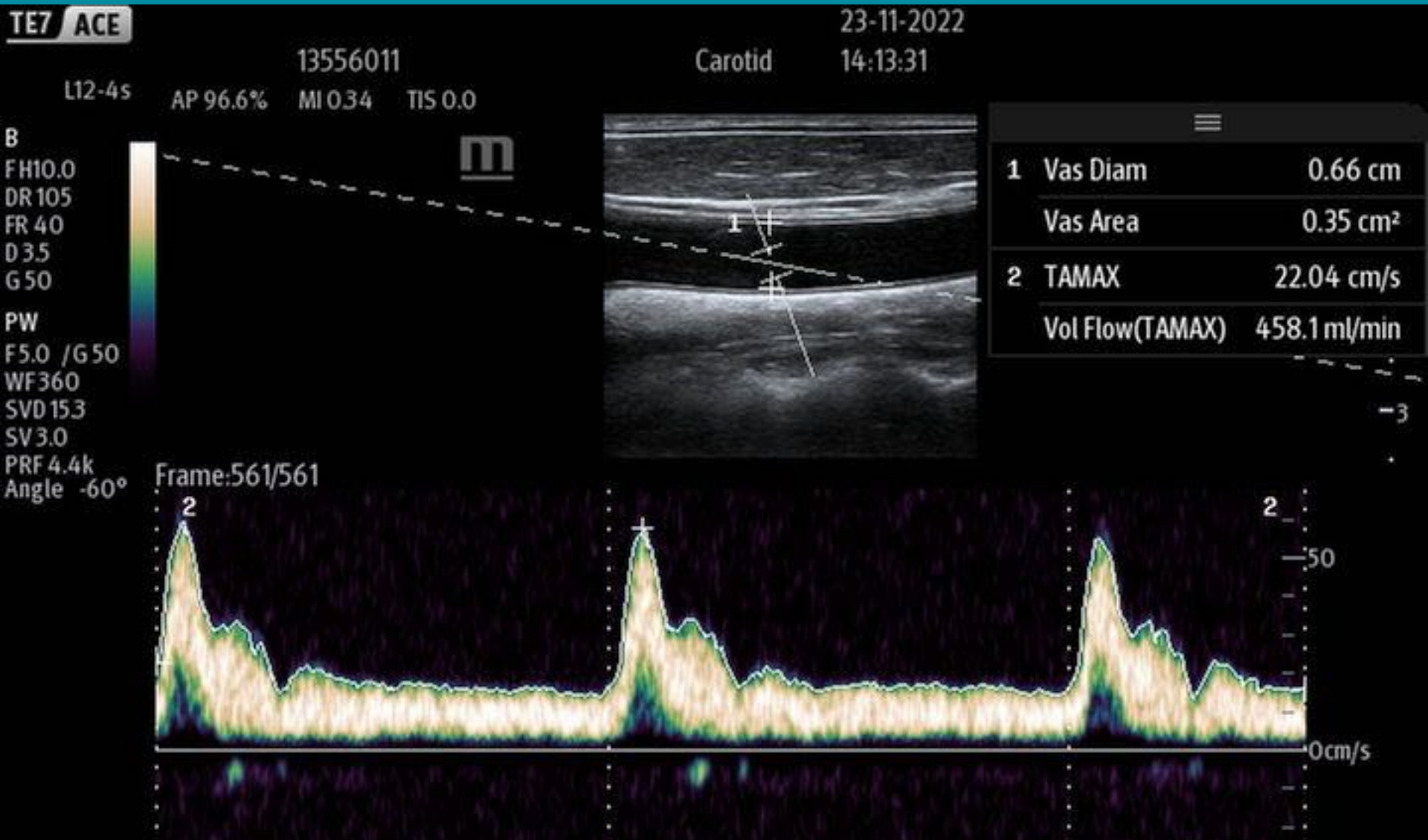
Run 6K



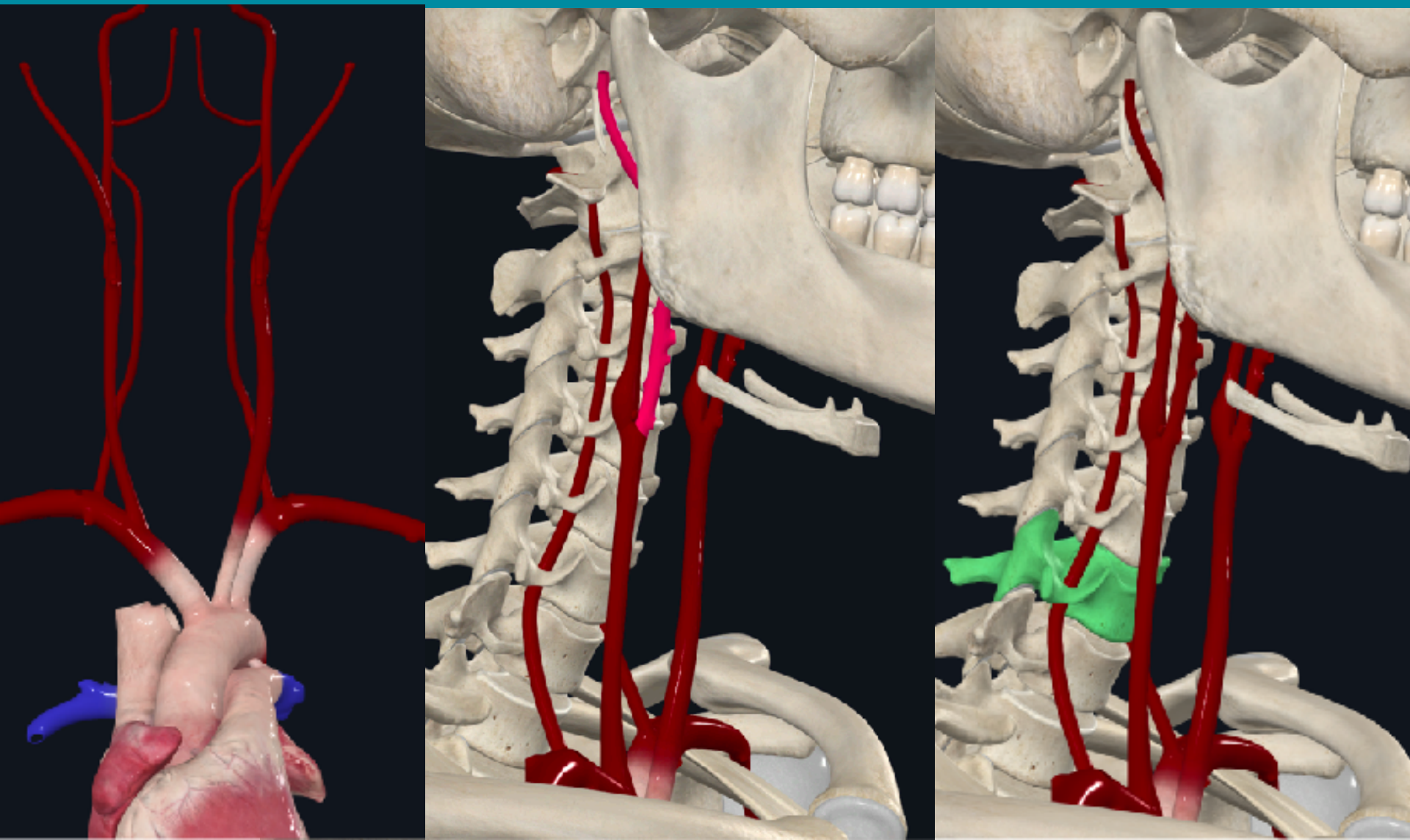
RESISTANCE INDEX (阻力係數)



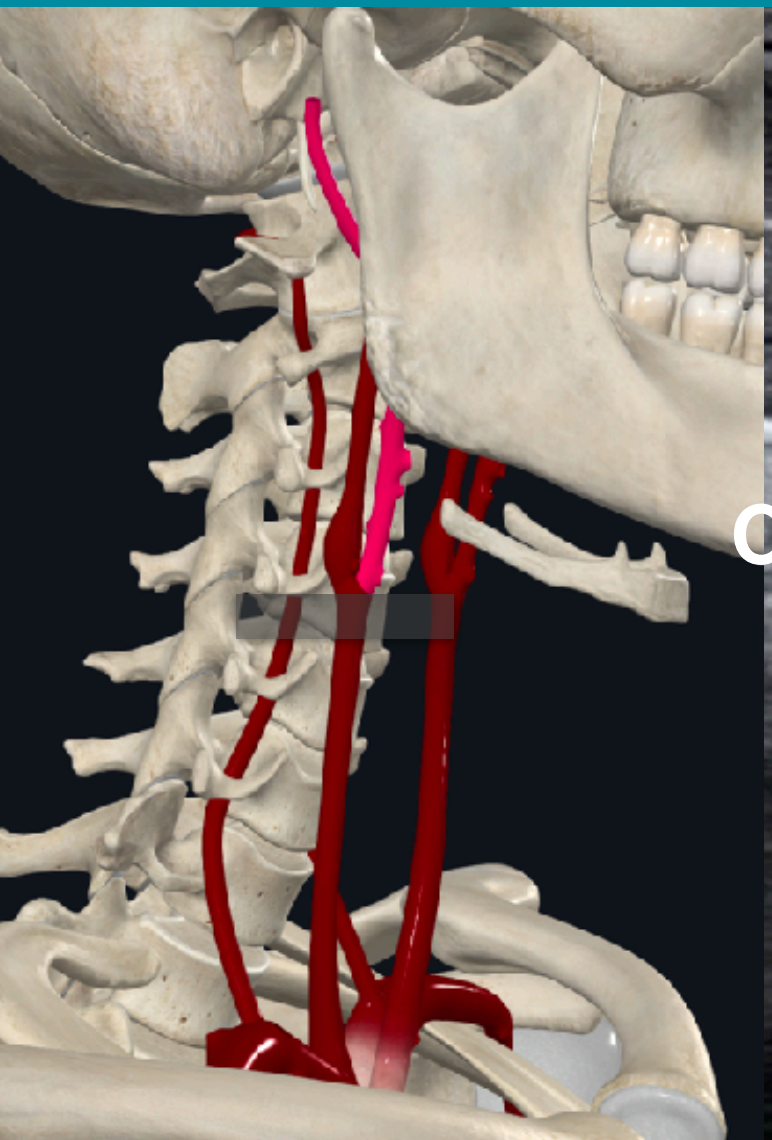
CCA FLOW


TE7 ACE
13556011
23-11-2022
Carotid
14:13:31
L12-4s
AP 96.6%
MI 0.34
TIS 0.0
B
FH10.0
DR 105
FR 40
D 3.5
G 50
PW
F 5.0 /G 50
WF 360
SVD 153
SV 3.0
PRF 4.4k
Angle -60°
1 Vas Diam 0.66 cm
Vas Area 0.35 cm²
2 TAMAX 22.04 cm/s
Vol Flow(TAMAX) 458.1 ml/min
Frame:561/561
50
0cm/s

CCA TO ICA & ECA

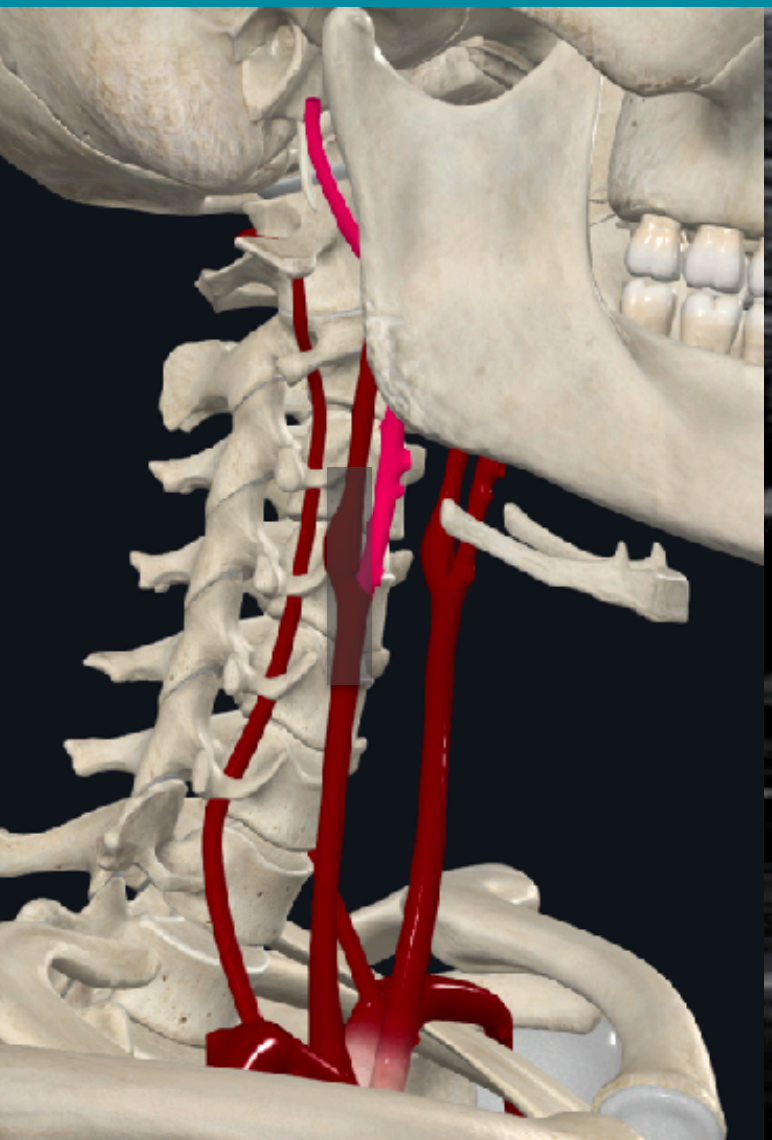


CCA TO ICA & ECA

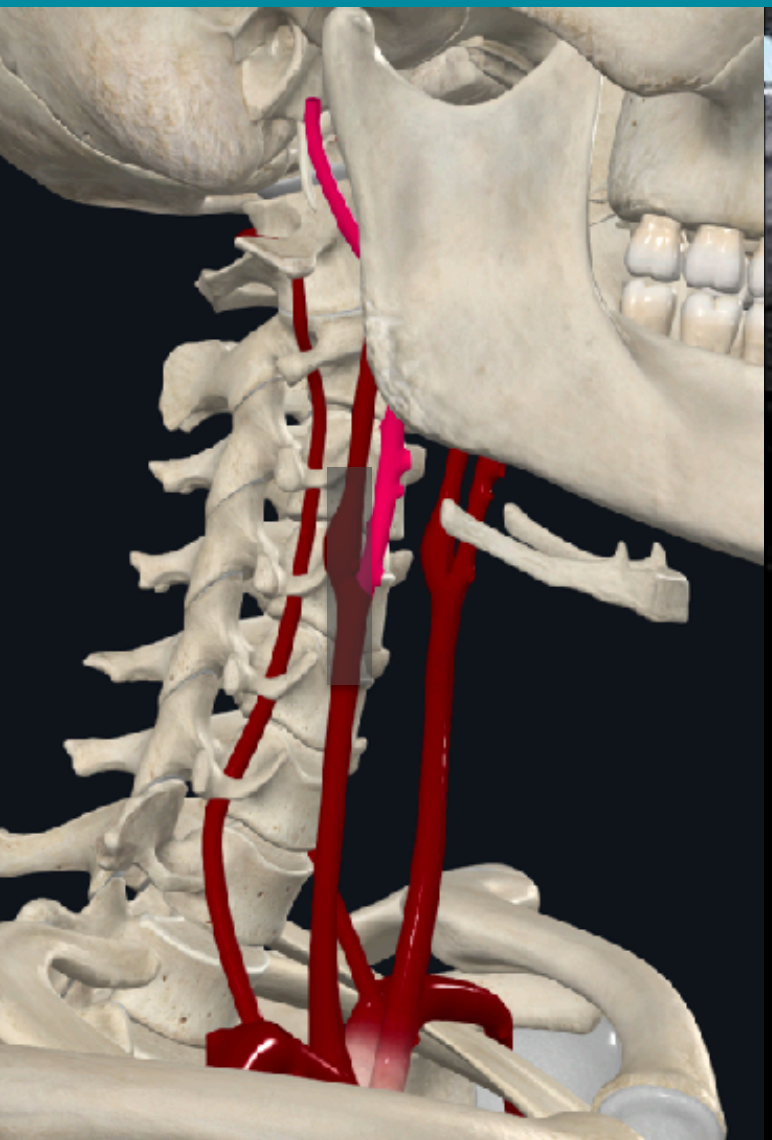


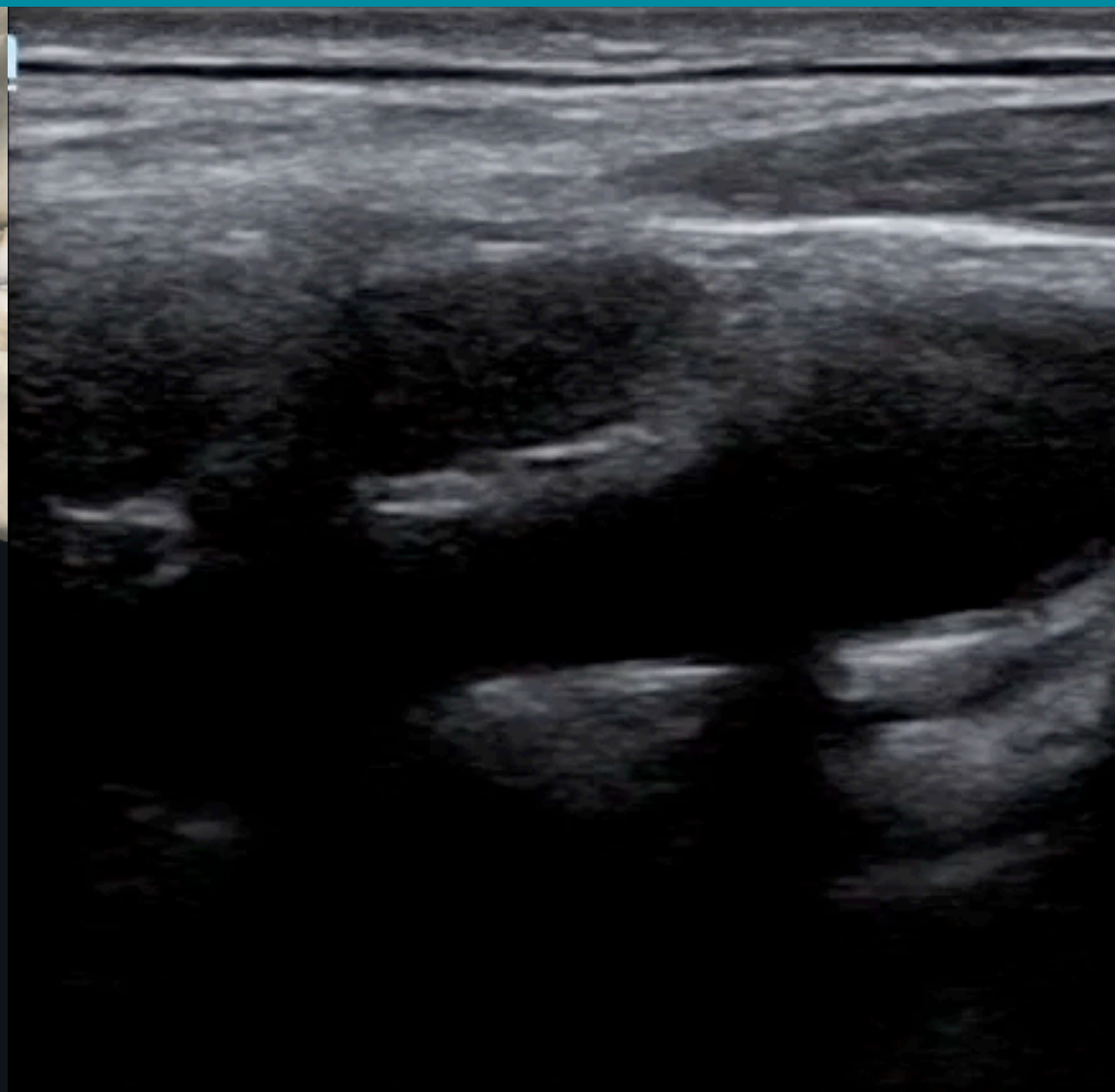
CCA to ICA (post) & ECA (ant)

CCA TO ECA (ANT TILT)

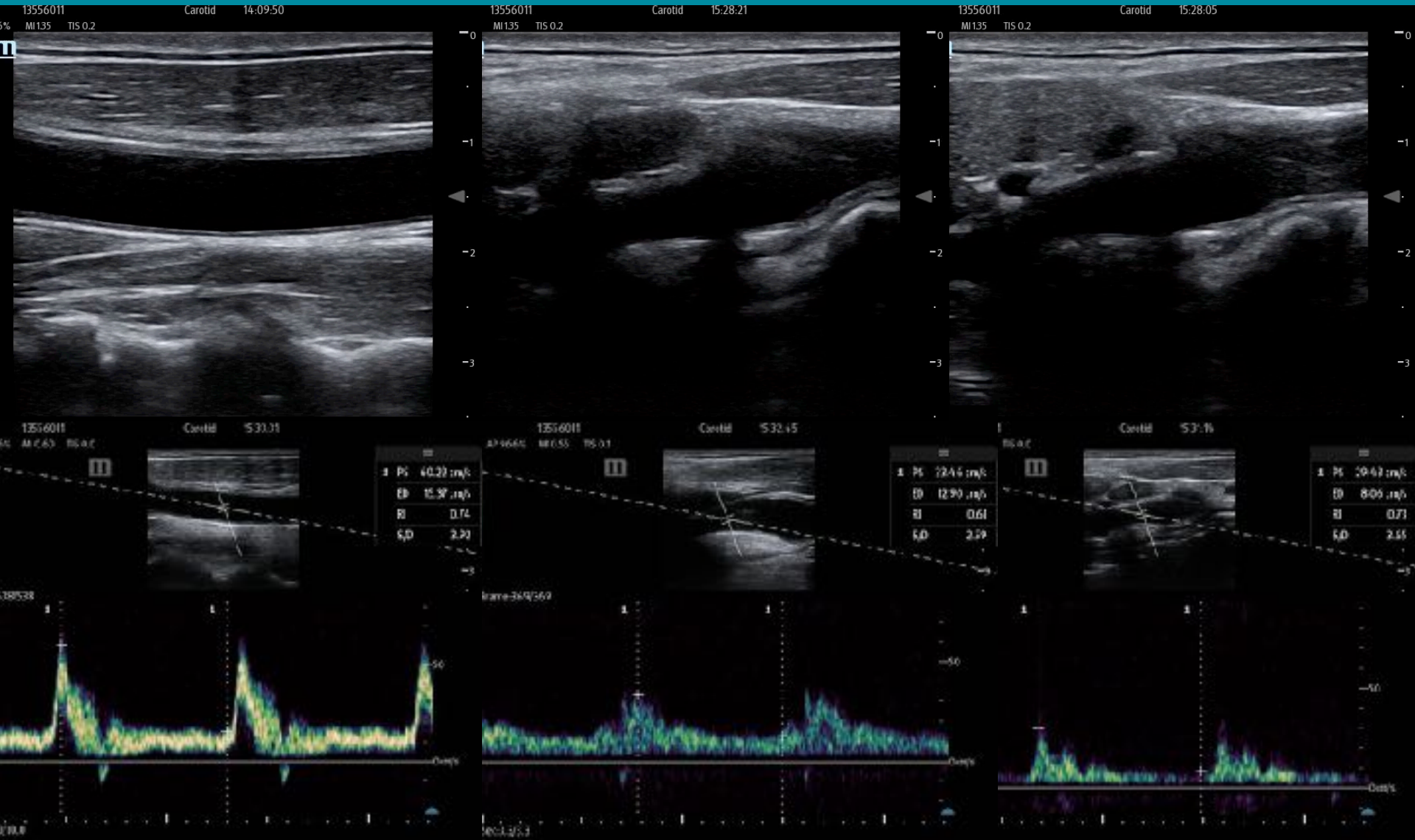


CCA TO ICA (POST TILT)

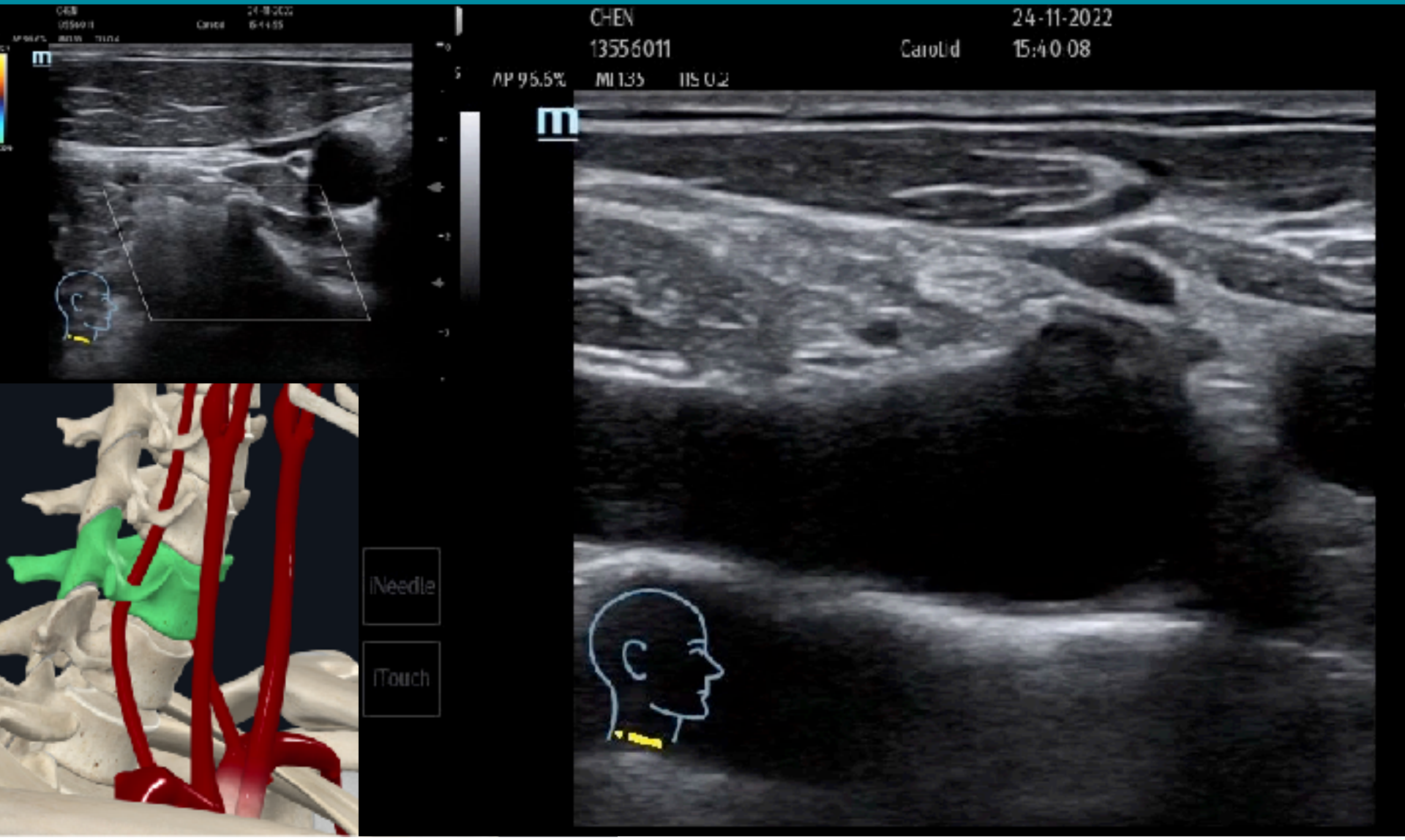




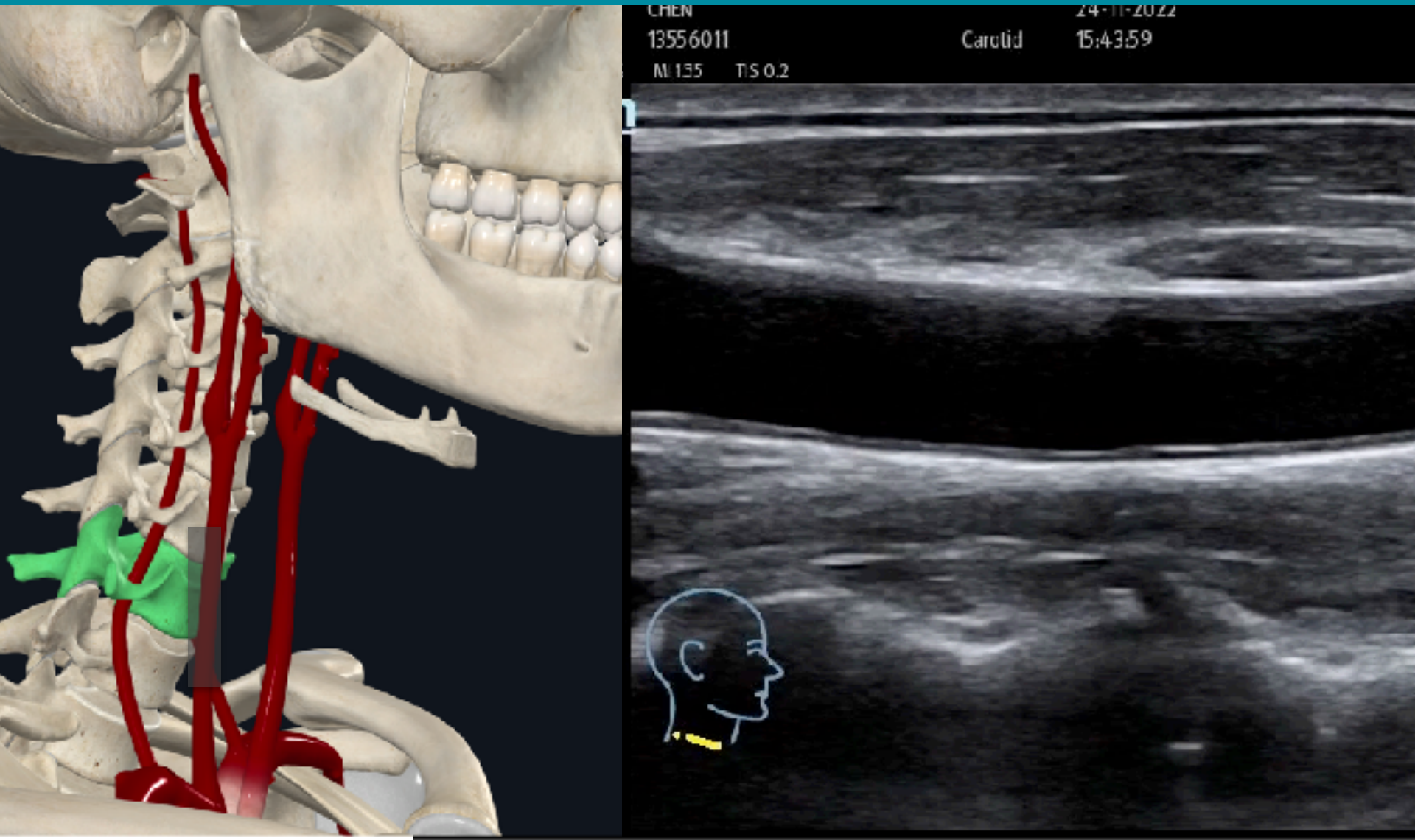
CCA - ICA - ECA


13556011
Carotid
14:09:50
MI 1.35
TIS 0.2
13556011
Carotid
15:28:21
MI 1.35
TIS 0.2
13556011
Carotid
15:28:05
MI 1.35
TIS 0.2

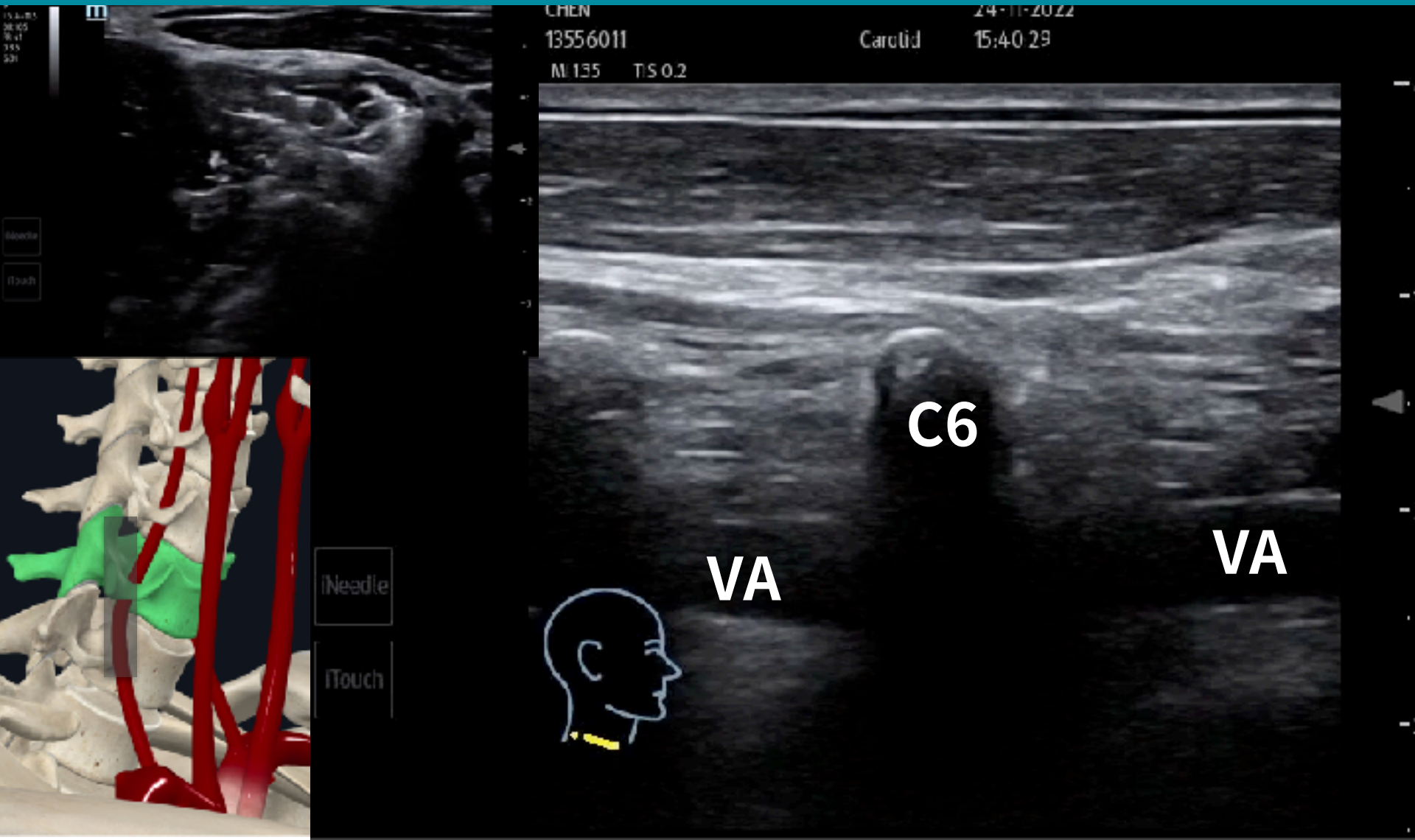
VA (FROM SUBCLAVIAN A)



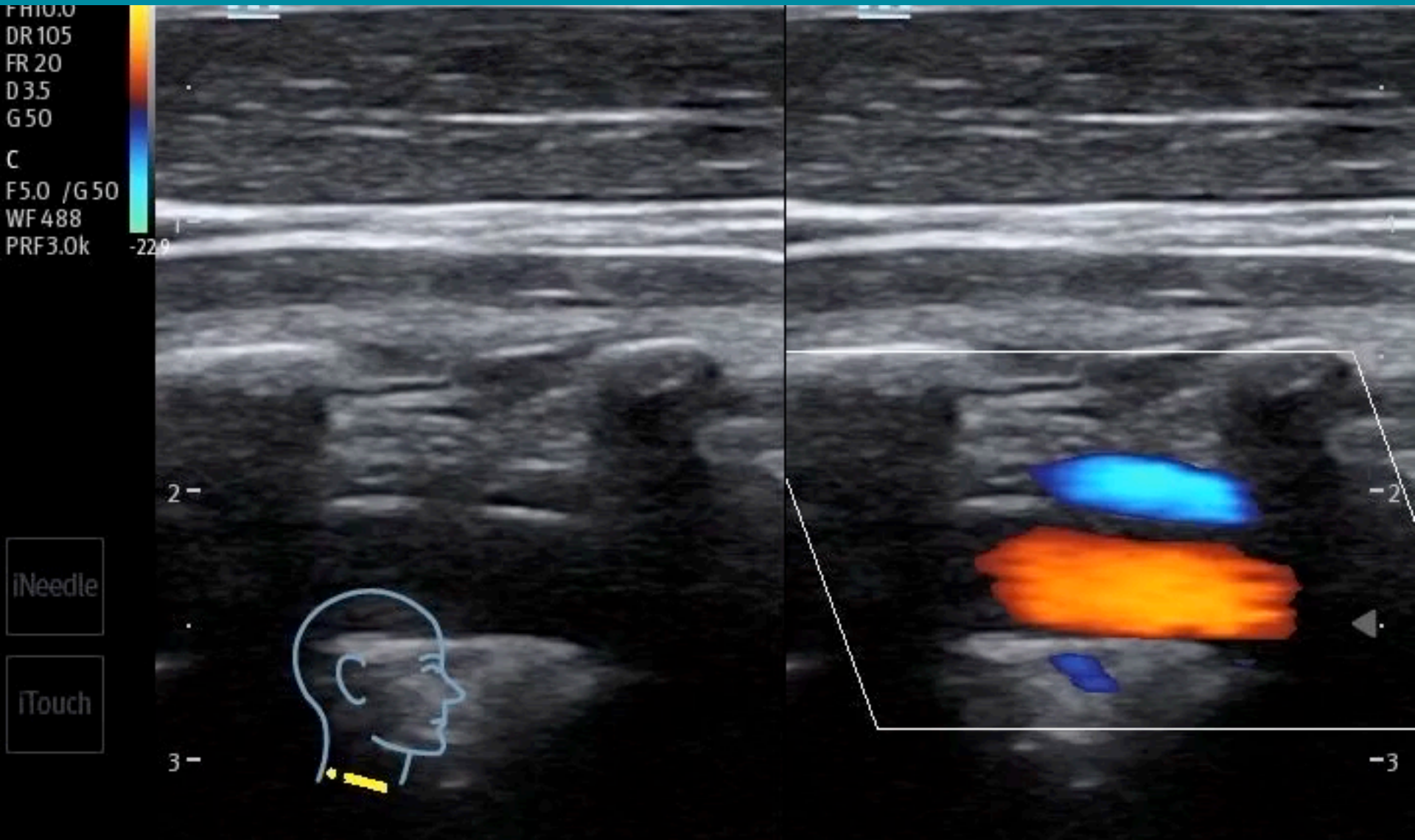
CCA TO VA (TILT):建議的手法

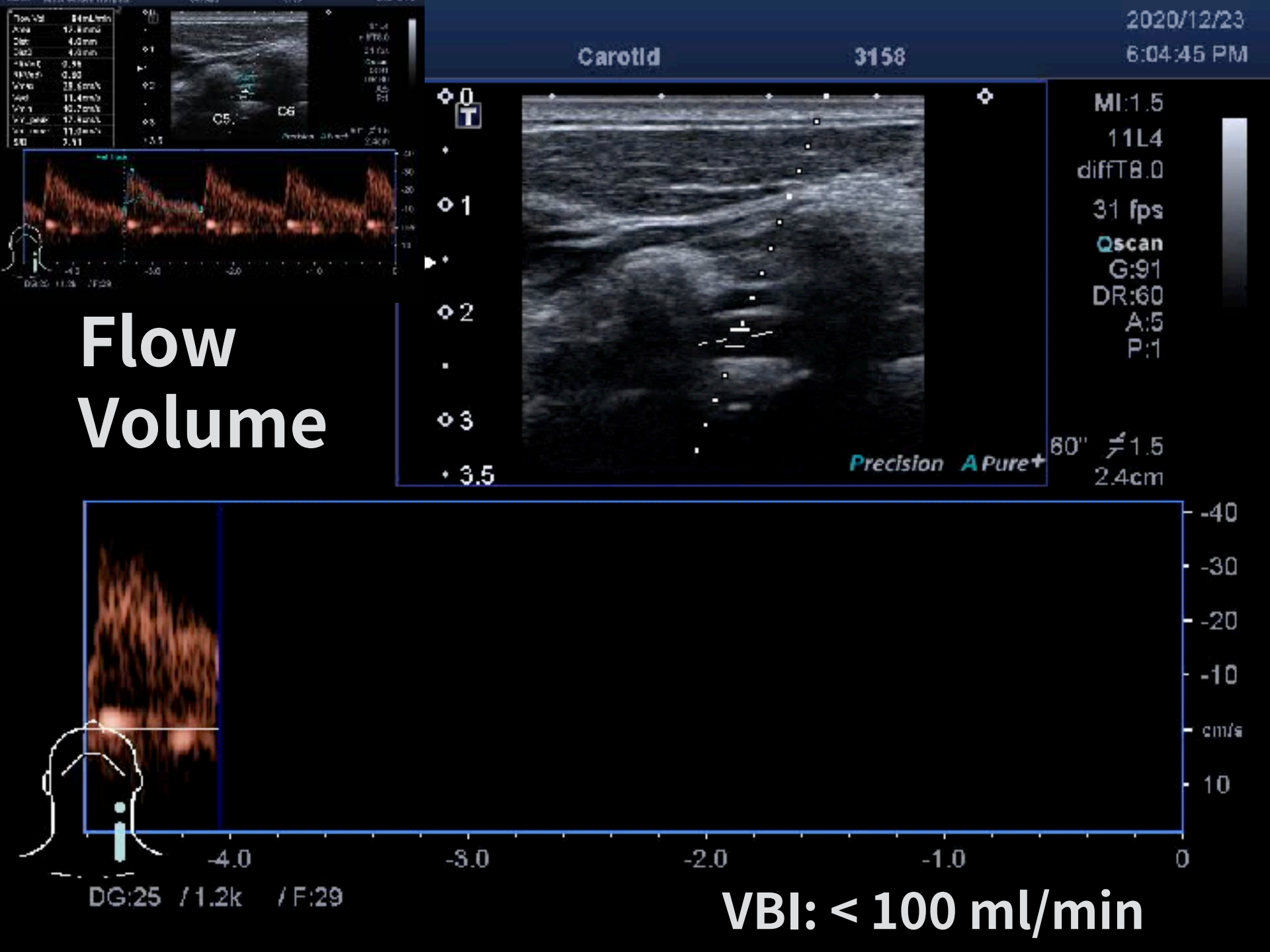


VA (C6)


CHEN
13556011
Carotid
15:40:29
M: 135 TIS 0.2
C6
VA
VA
iNeedle
iTouch

VA

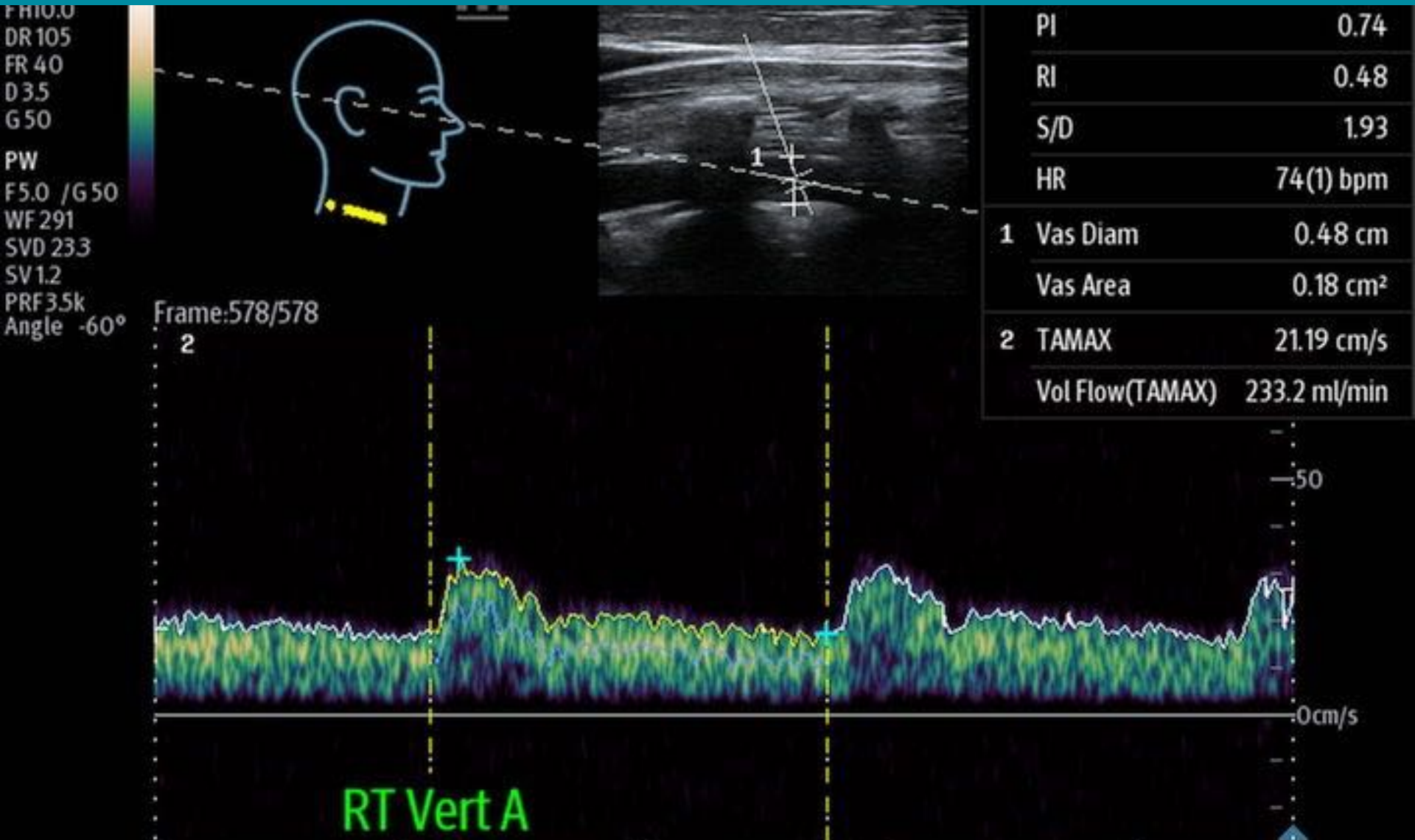




Flow Volume

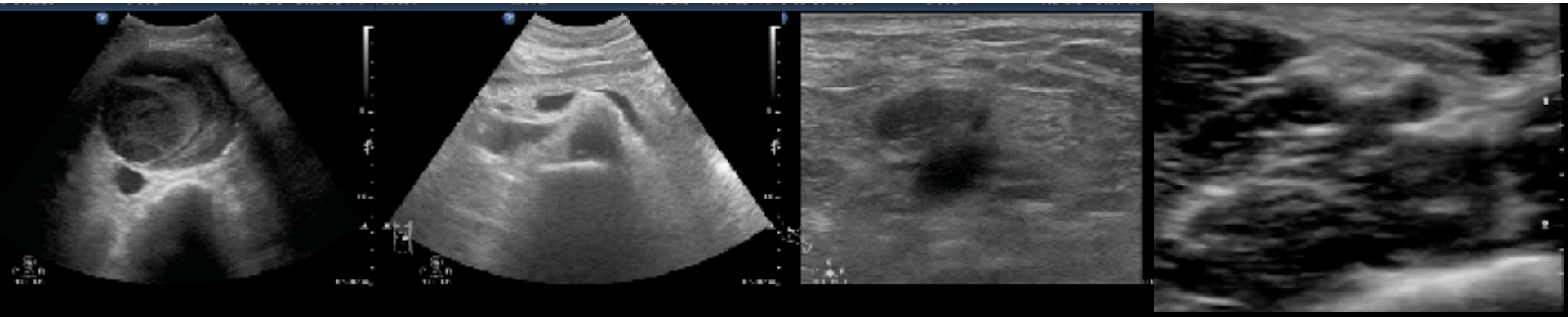
VBI: < 100 ml/min

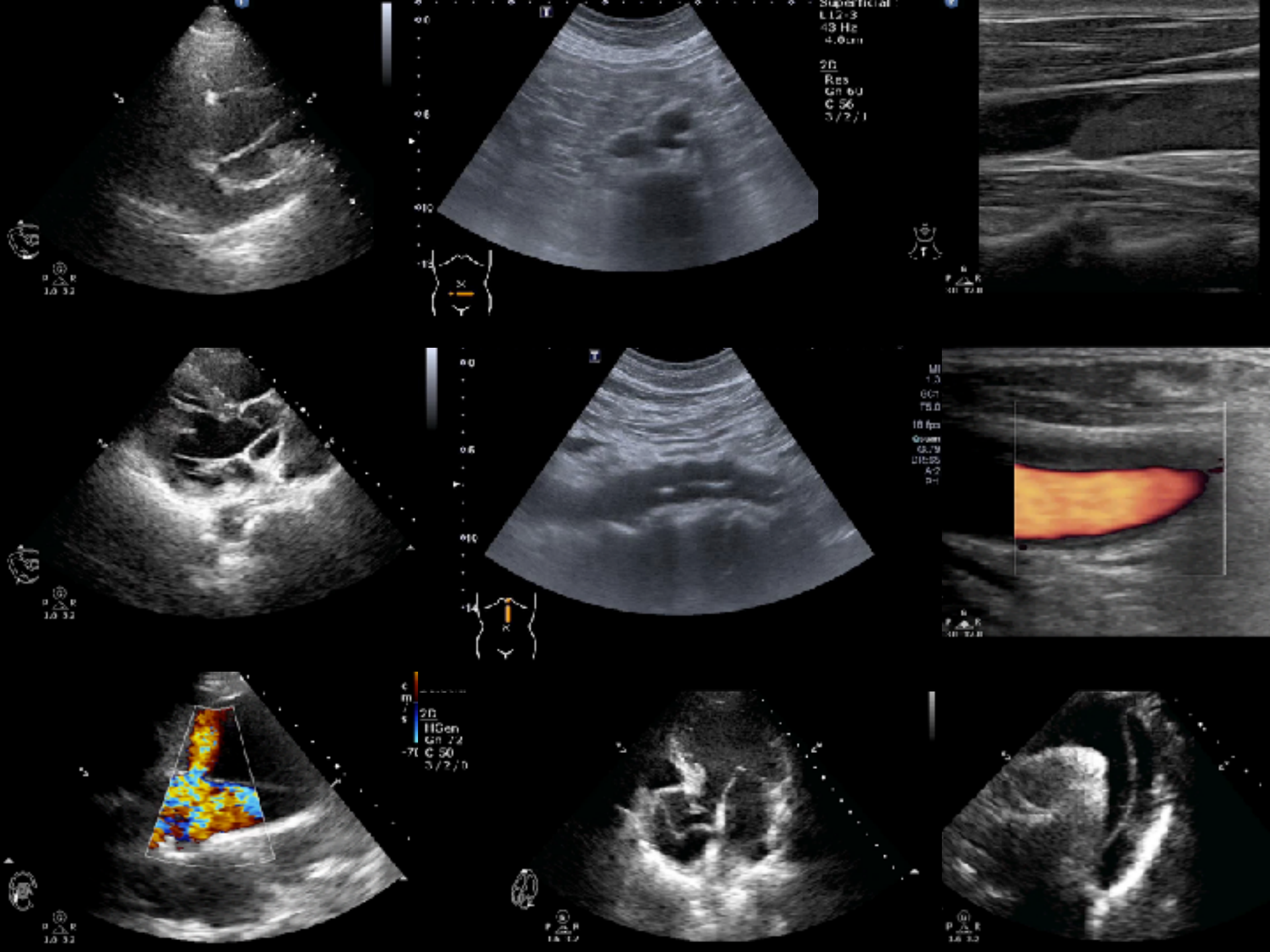
VA FLOW MEASUREMENT



Vascular POCUS

AAA AD DVT Line





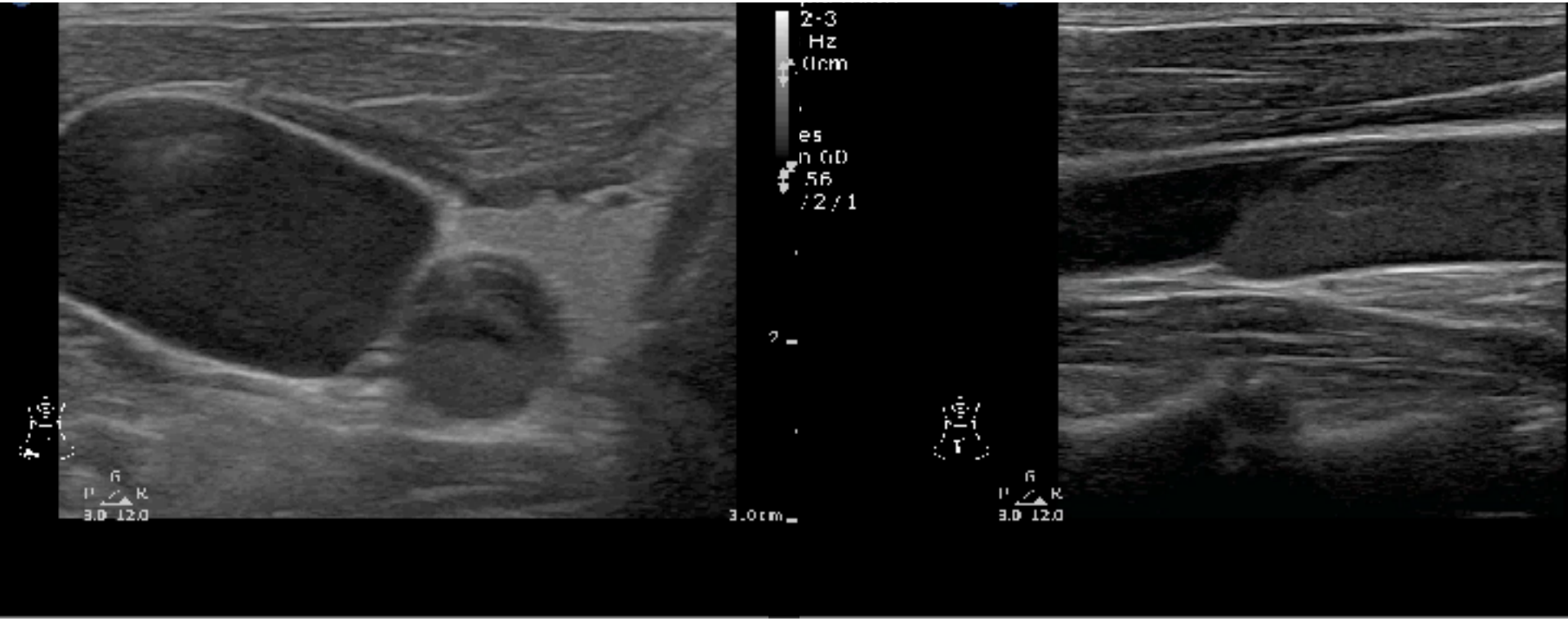
懷疑AD時的POCUS:PAC

CTA仍是最重要的檢查

Pericardium　　ABD Aorta　　CCA

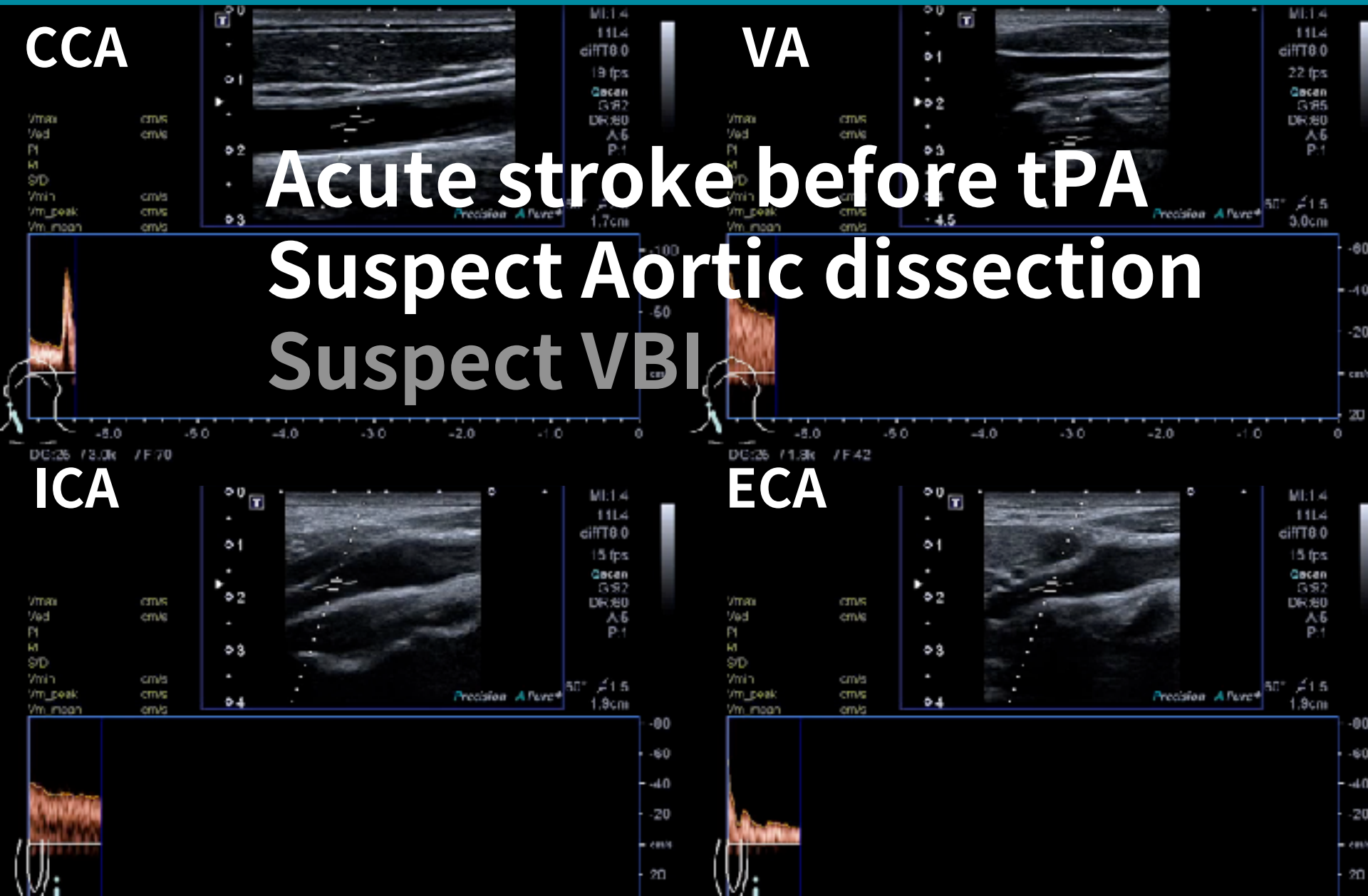
Acute stroke prior to tPA

Bil CCA是最重要的檢查



Occlusion or Flap ==> CTA來排除AD

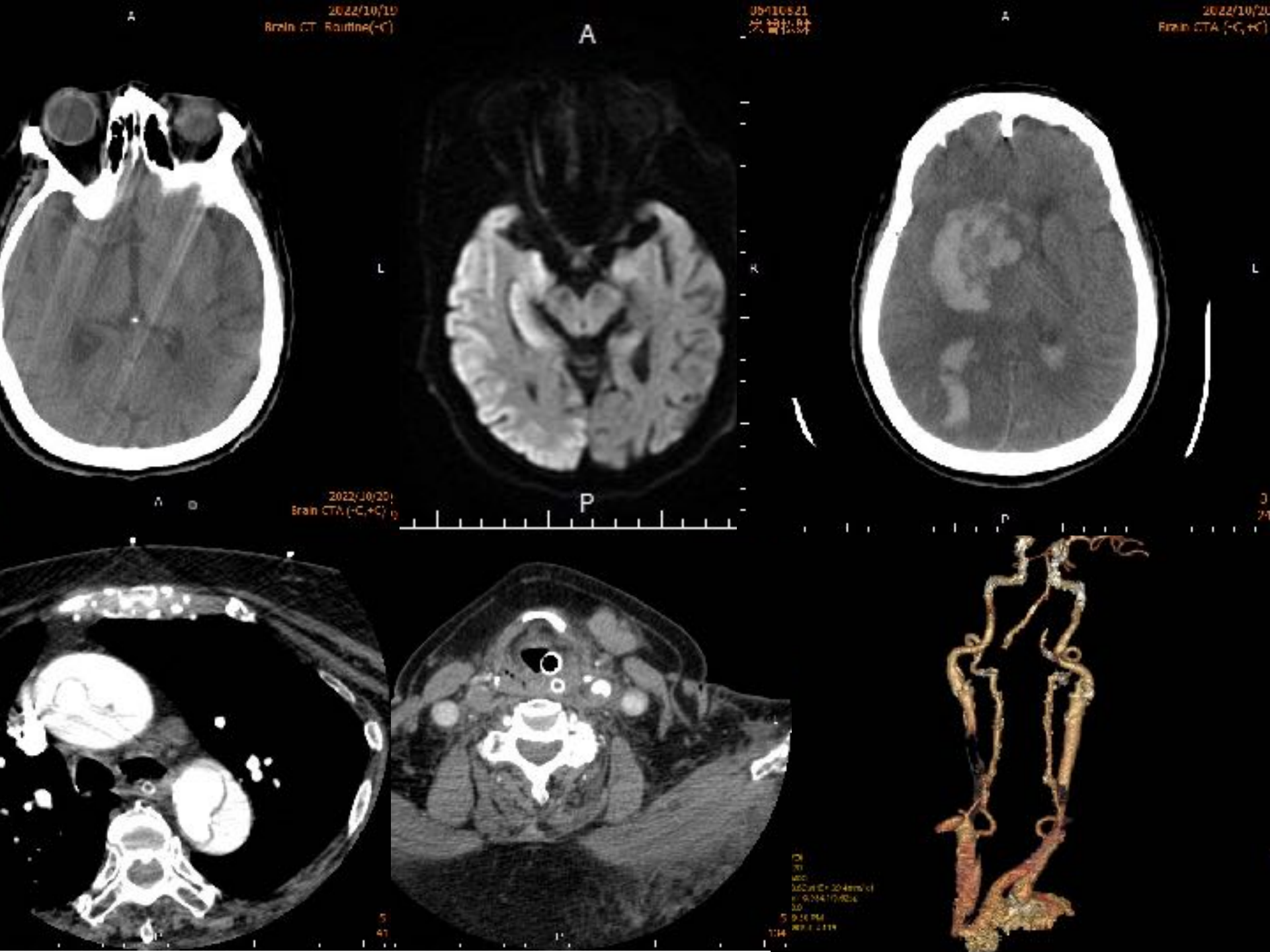
ECD in ER

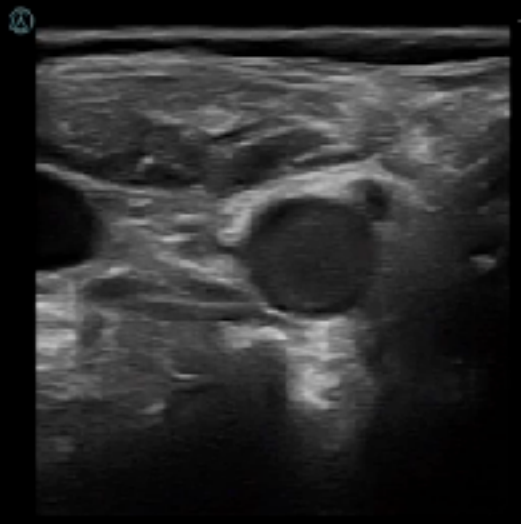
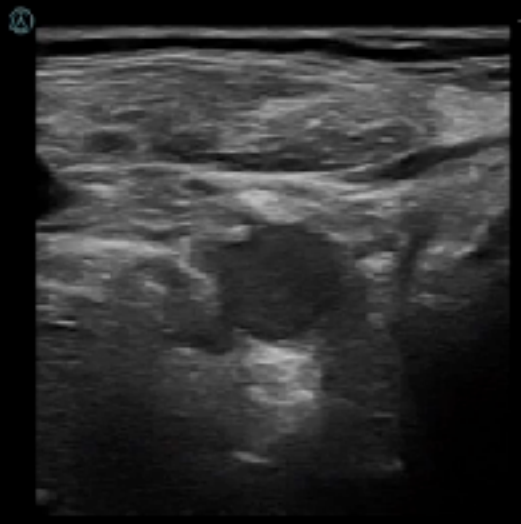
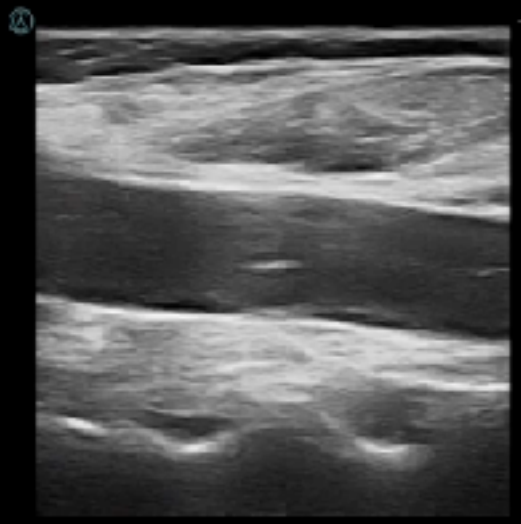
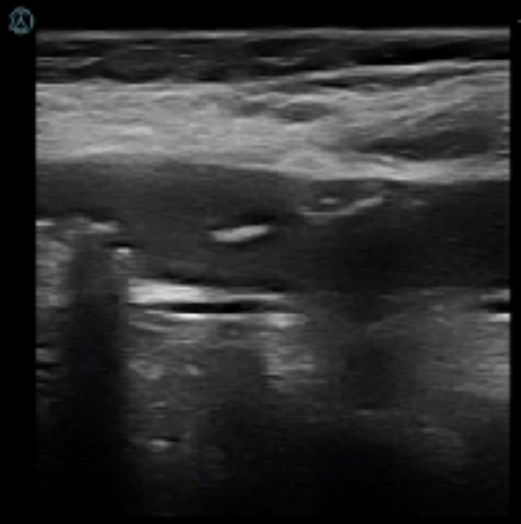

CCA
VA
ICA
ECA
Acute stroke before tPA
Suspect Aortic dissection
Suspect VBI

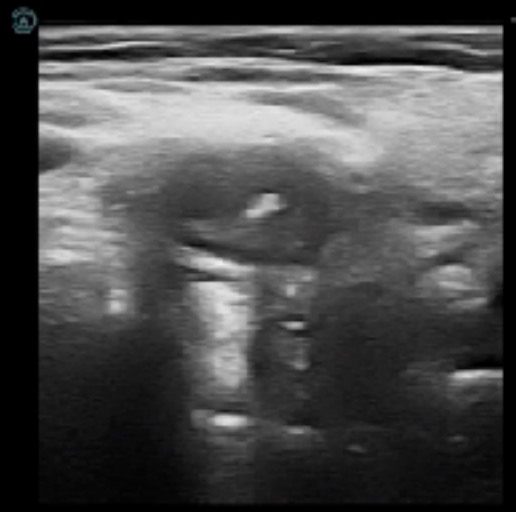
85F, AMS, L weak, eye to R

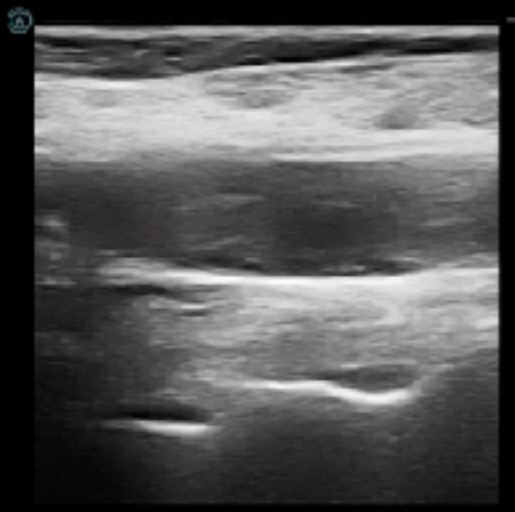
20181203

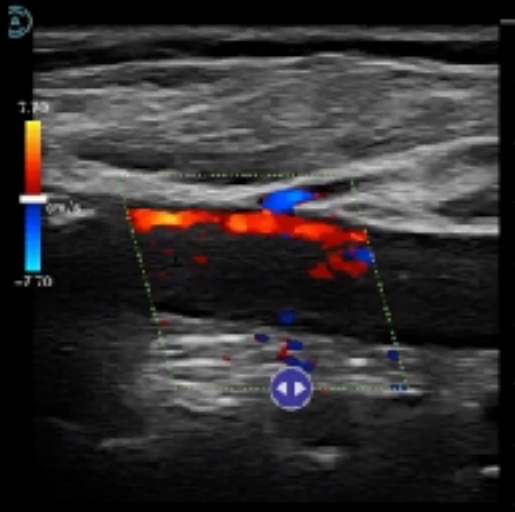
20221019


2022/10/19
Brain CT Routine(-C)
A
2022/10/20
Brain CTA (-C,+C)
P
2022/10/20
Brain CTA (-C,+C)

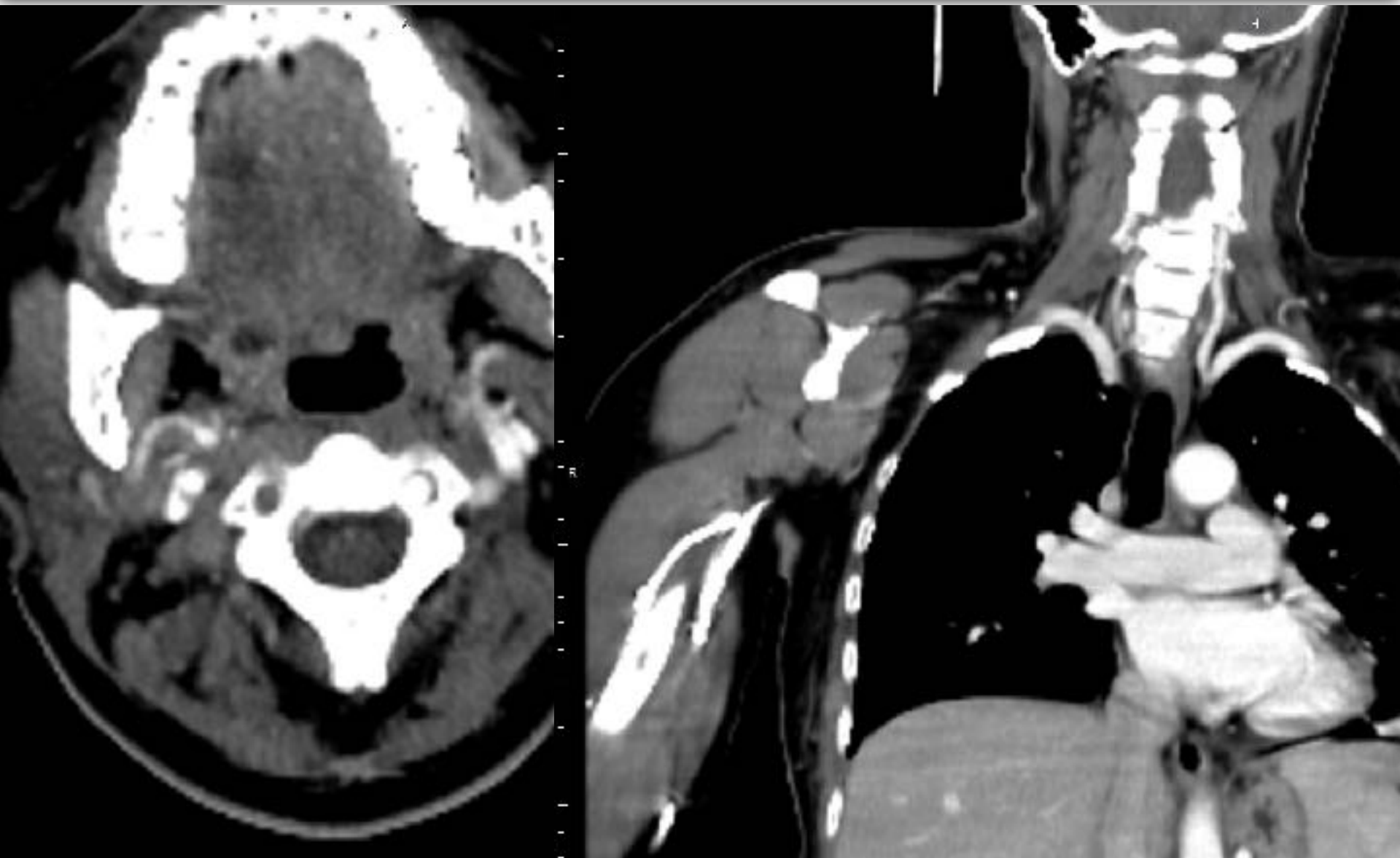





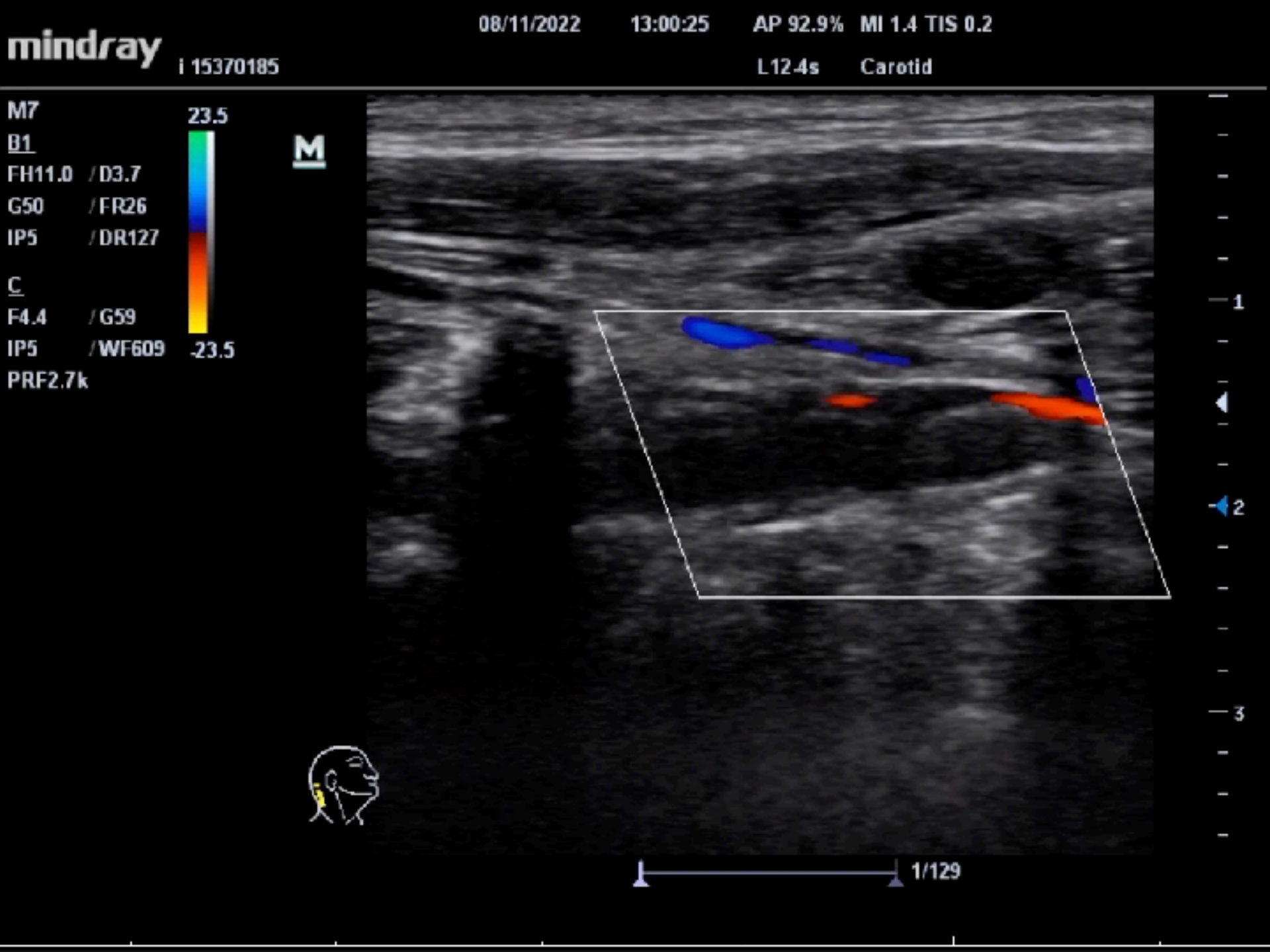


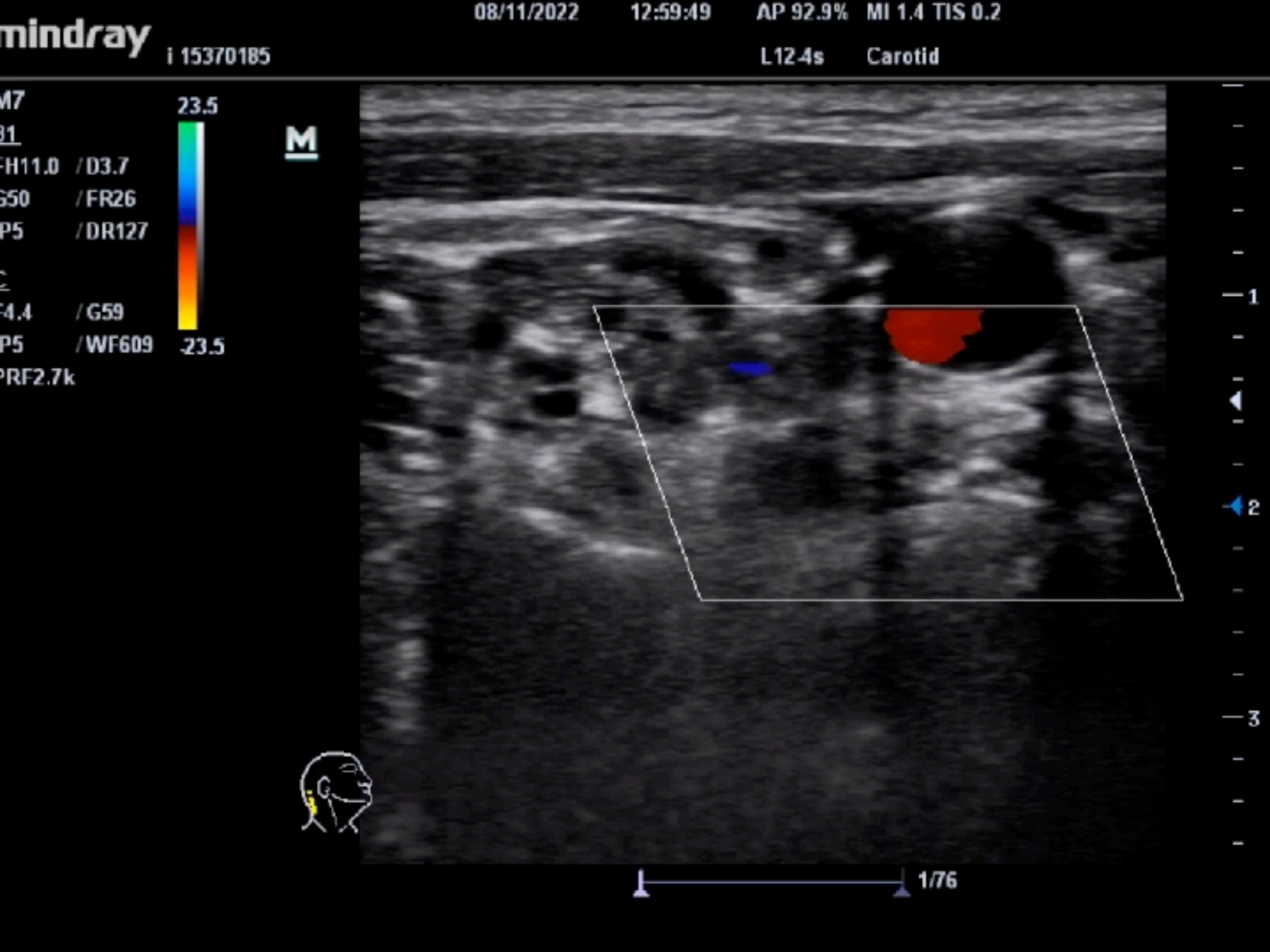




44F, persistent dizziness
(L hand weak & neck pain 1d)




mindray
i 15370185
08/11/2022
13:00:25
AP 92.9% MI 1.4 TIS 0.2
L12-4s
Carotid
M7
B1
FH11.0 / D3.7
G50 / FR26
IP5 / DR127
C
F4.4 / G59
IP5 / WF609
PRF2.7k
23.5
-23.5
M
1
2
3
1/129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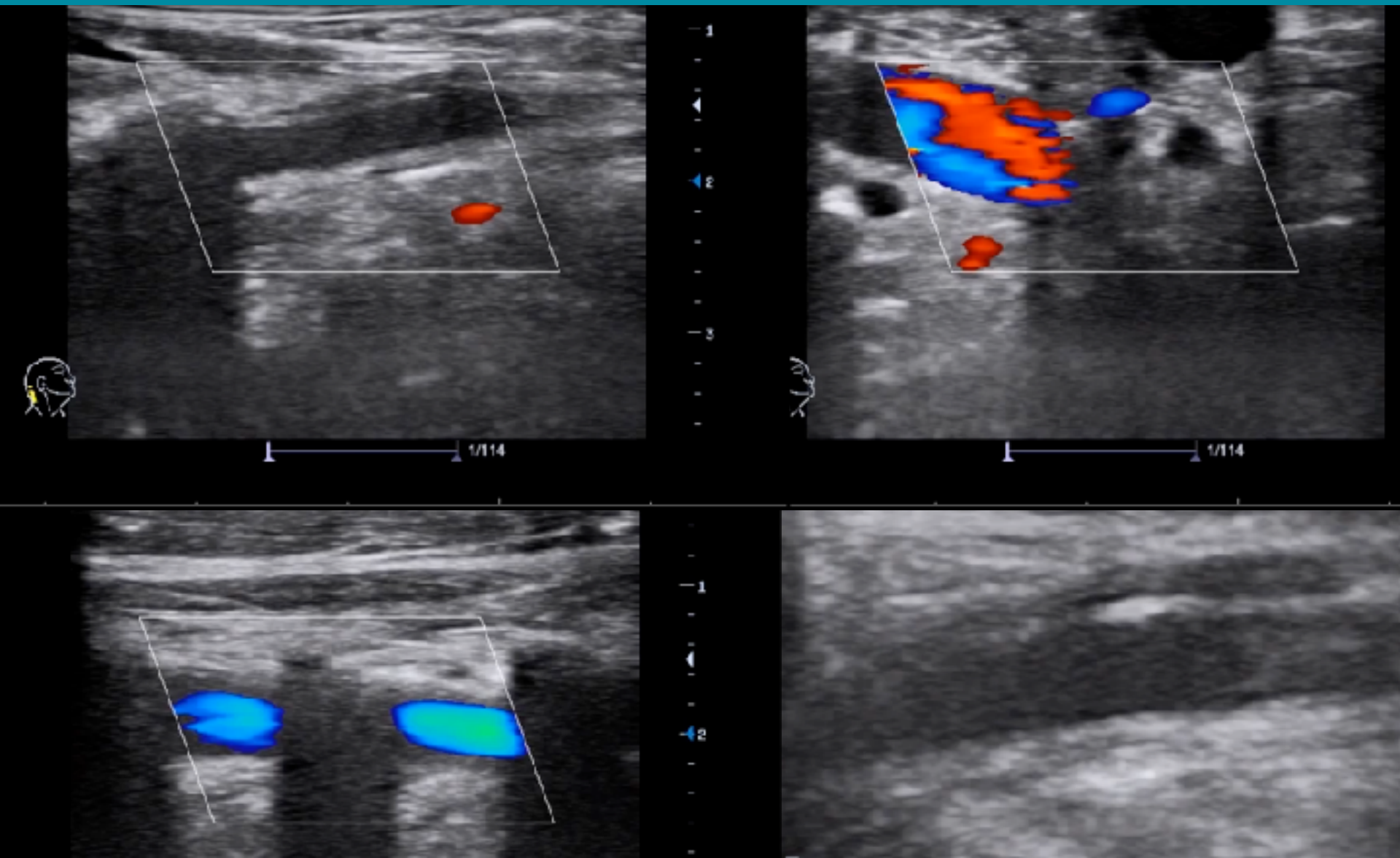
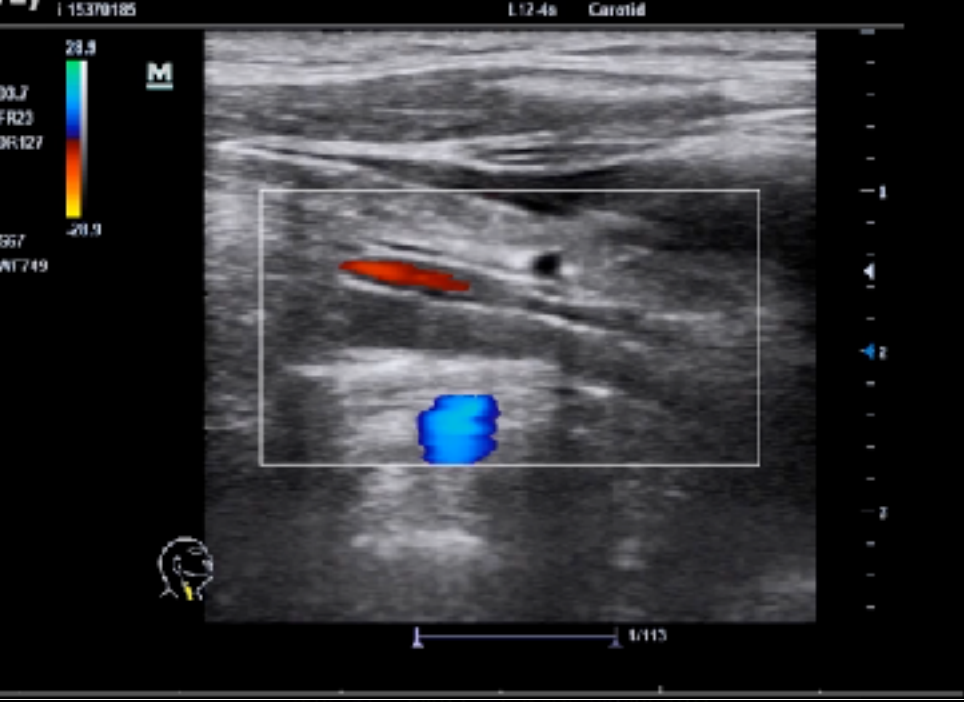
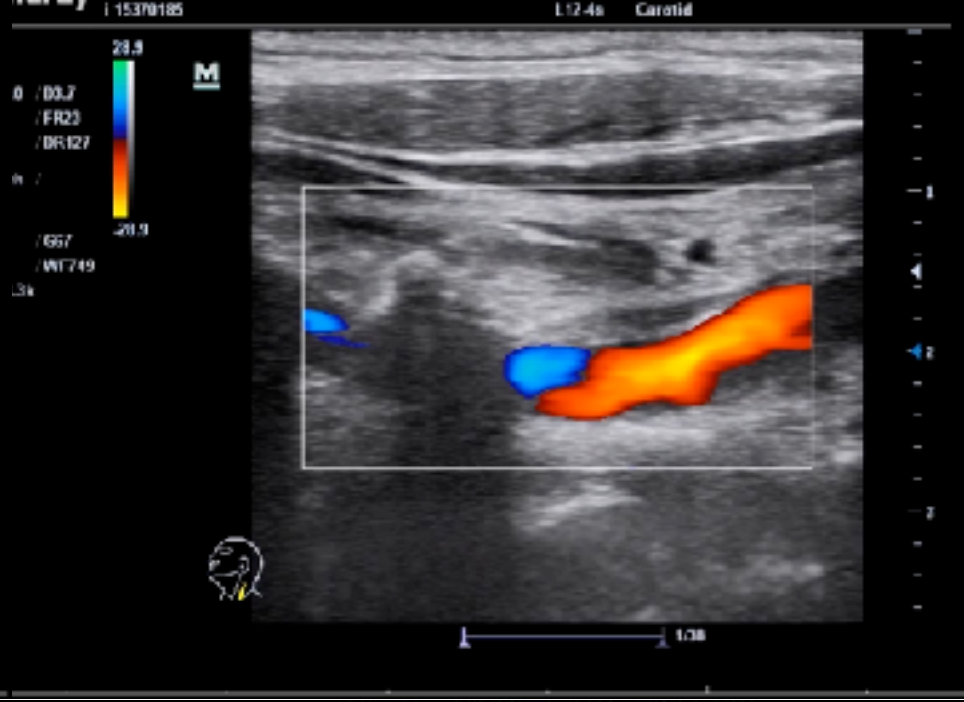
MI 1.4 TIS 0.2
L12-4s
Carotid
M7
31
FH11.0 /D3.7
G50 /FR26
P5 /DR127
F4.4 /G59
P5 /WF609
PRF2.7k
23.5
-23.5
M
1
2
3
1/76

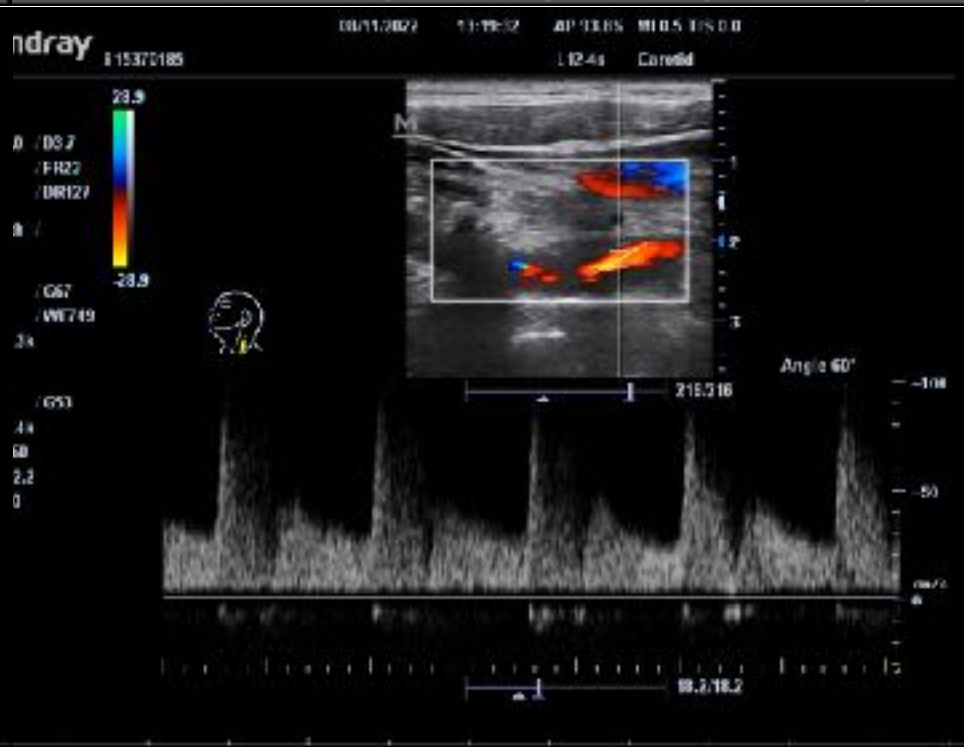
VA



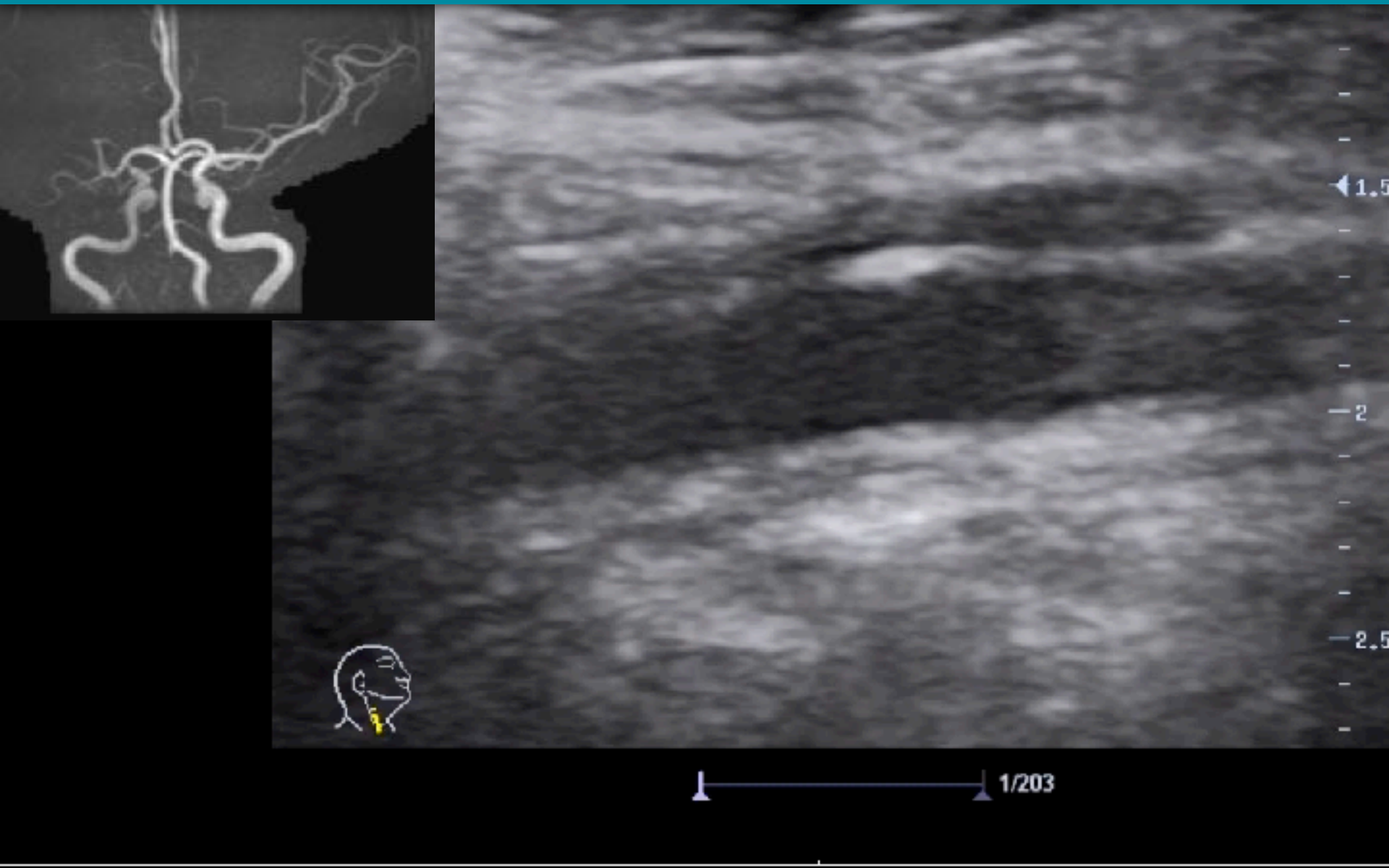

Carotid


Carotid

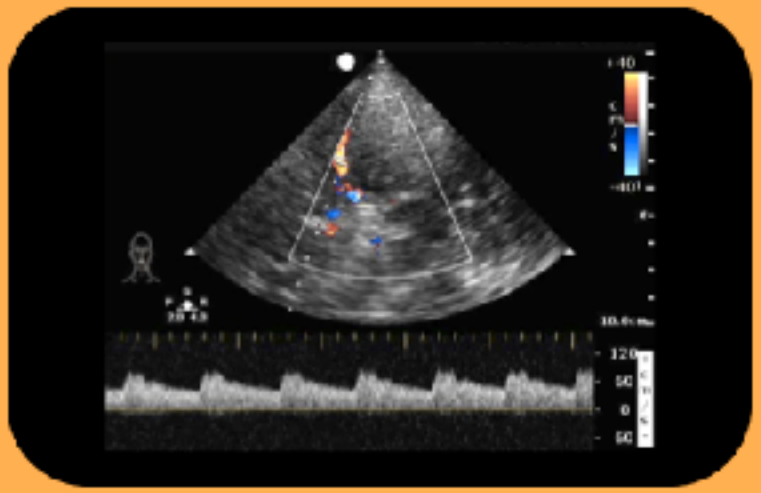

Carotid
Angle 60°


Carotid
Angle 60°

VA dissection



TCD IN TBI



Questions:

Can transcranial doppler (TCD) screen for changes in cerebral blood flow in early traumatic brain injury (TBI)? Do these changes predict neurologic outcomes?

Methods:

Prospective observational study of head trauma patients admitted to ICU. TCD soon after admission. Compared mild-moderate TBI to severe TBI for the incidence of abnormal TCD findings. 2° outcome of finding factors associated with poor outcomes.

N = 66

Results

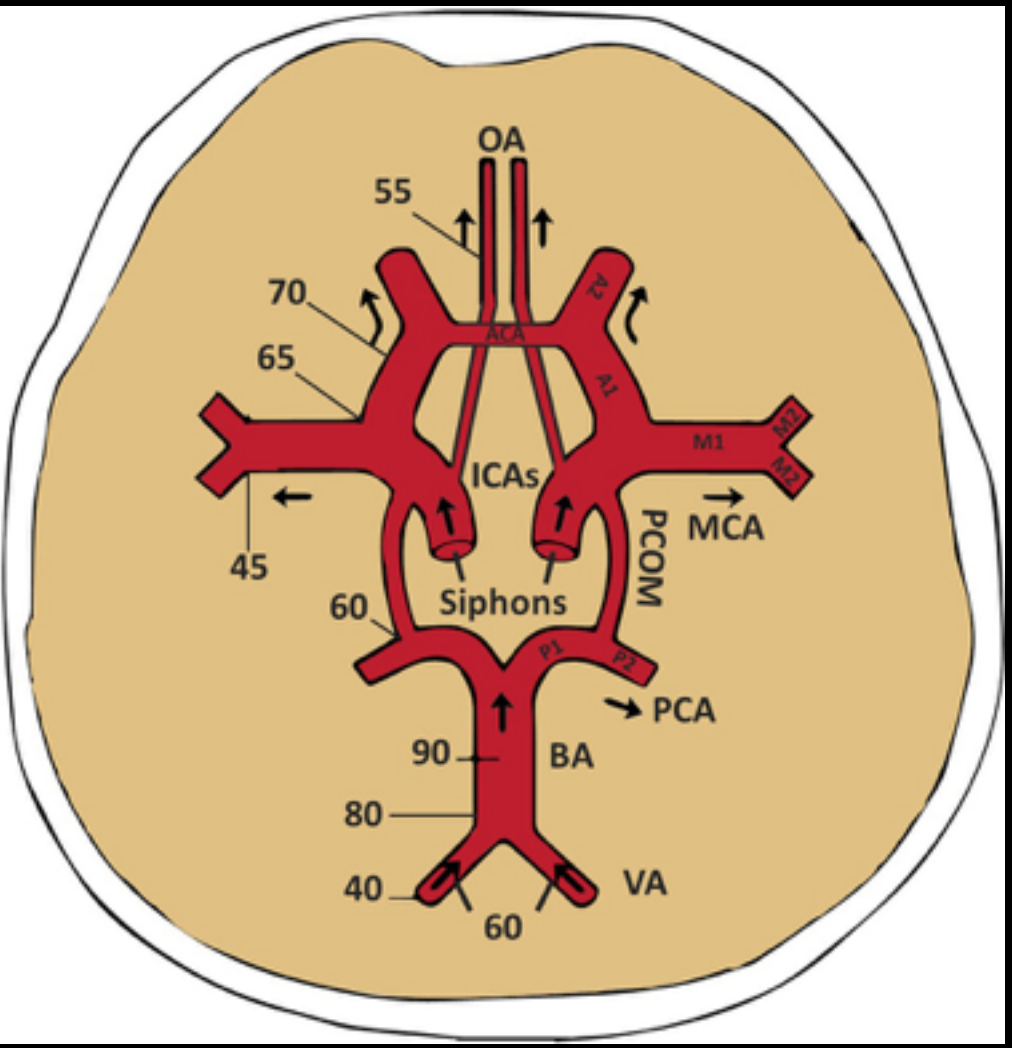
	GCS >8 (%)	GCS ≤8 (%)
Low EDV (<25 cm/s)	11.1	46.7
High PI (>1.3)	16.7	46.7

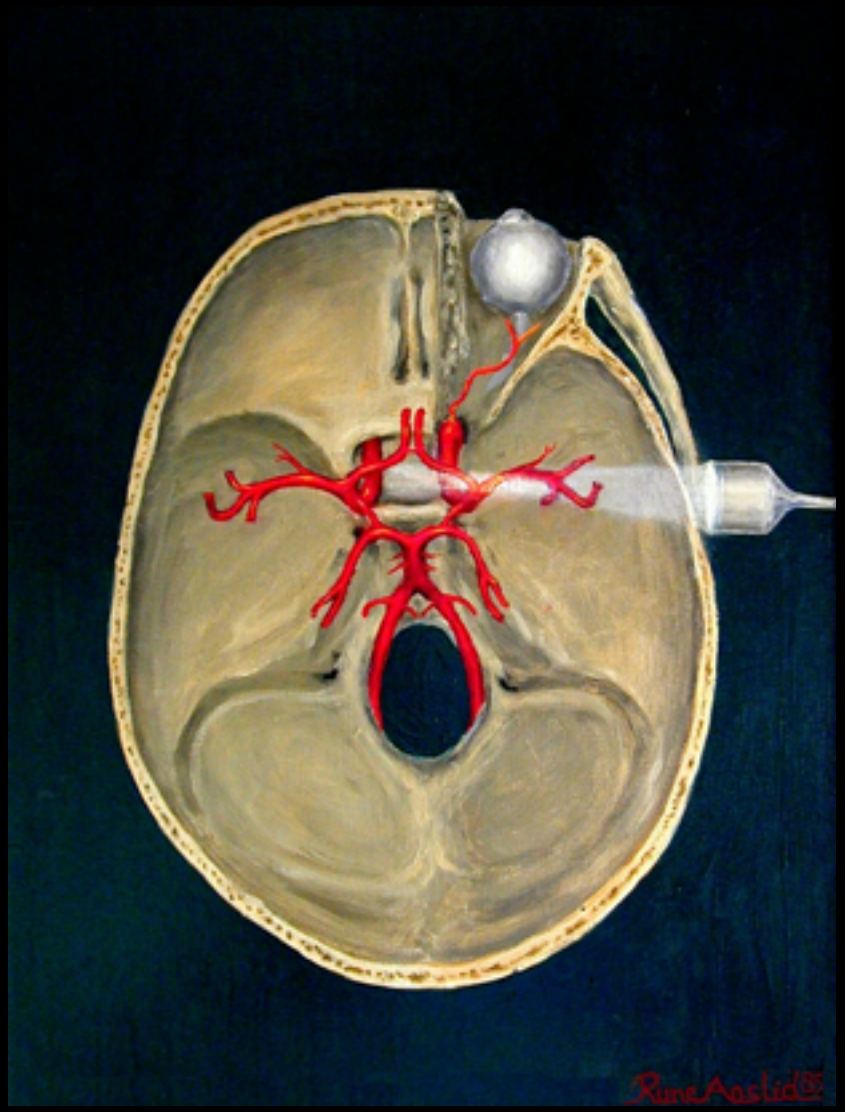
EDV = End diastolic velocity. PI = pulsatility index

Correlation with Glasgow Outcome Score: EDV r 0.52, PI r 0.55

High PI had 91% sens, 89% spec for poor outcome

Aly AA, Farmawy MS. Transcranial Doppler to detect early abnormalities in cerebral hemodynamics following traumatic brain injury in adult patients. Research and Opinion in Anesthesia and Intensive Care. 2020;7:274-81





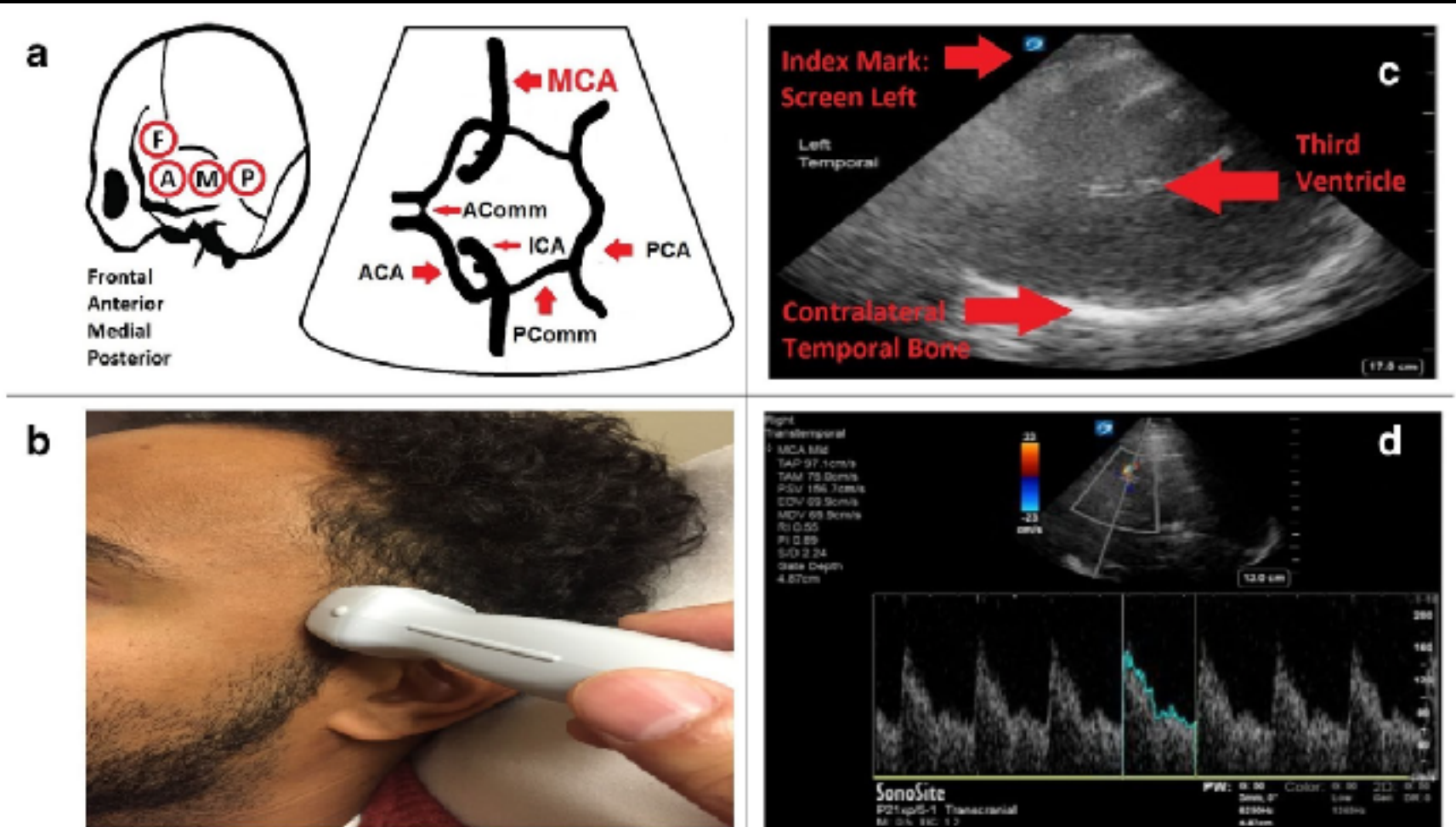
Montrief, T., et al. (2019). Incorporation of Transcranial Doppler into the emergency department for the neurocritical care patient. American Journal of Emergency Medicine 37(6): 1144-1152

Summary of vessel identification criteria

Artery	Window	Depth (mm)	Direction of flow (relative to transducer)	Relation to TICA/MCA/ACA junction	Velocity (cm/sec)	Response to carotid compression
MCA	TT	45-65	Toward	Anterior	45-86	,0
MCA/ACA bifurcation	TT	60-65	Bidirectional	Anterior	-	,0
ACA	TT	60-75	Away	Anterosuperior	41-70	,0
PCA (P1)	TT	60-75	Toward	Posteroinferior	33-54	,0
PCA (P2)	TT	60-75	Away	Posteroinferior	33-54	0
TICA	TT	60-75	Toward	Inferior	30-48	0, reserved
Ophthalmic A.	TO	45-60	Toward	-	21-49	0
CS, Supraclinoid	TO	60-75	Away	-	50-80	0, reserved
CS, Genu	TO	60-75	Bidirectional	-	-	0, reserved
CS, Paraseller	TO	60-75	Toward	-	50-80	0, reserved
Vertebral A.	TF	65-85	Away	-	27-55	-
Basilar A.	TF	90-120	Away	-	30-57	-

Montrief, T., et al. (2019). Incorporation of Transcranial Doppler into the emergency department for the neurocritical care patient. American Journal of Emergency Medicine 37(6): 1144-1152

Trans-temporal TCD

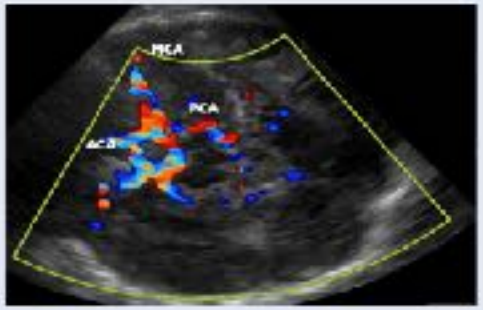


Step 1:

Midbrain identification

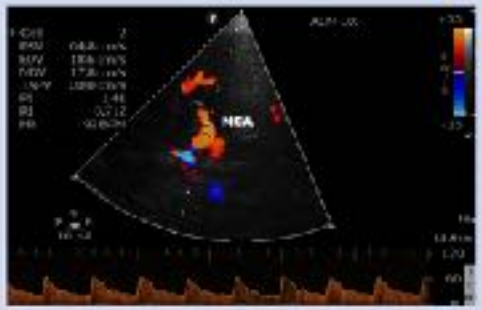
Step 2:

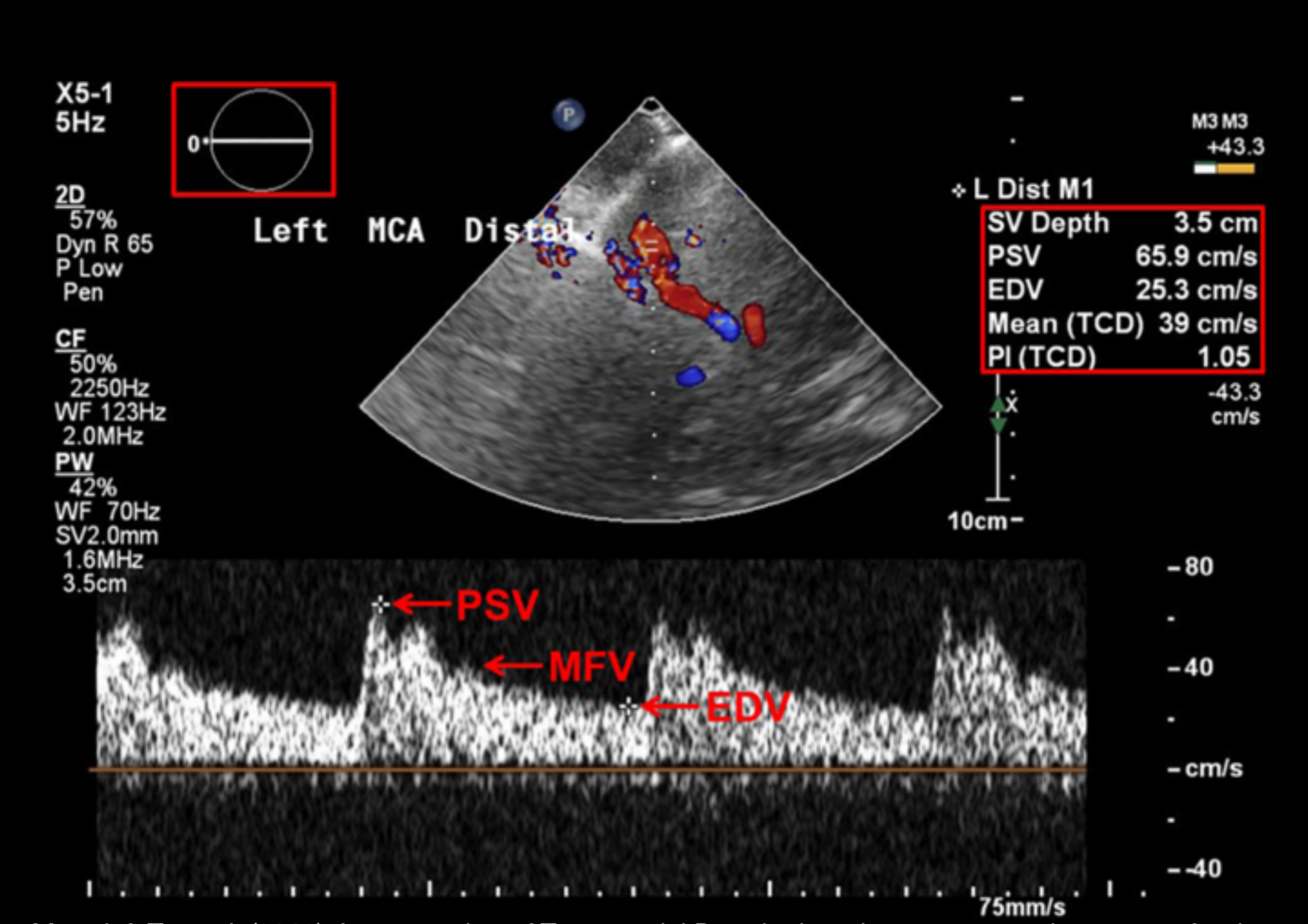
Color Doppler of vessels identification



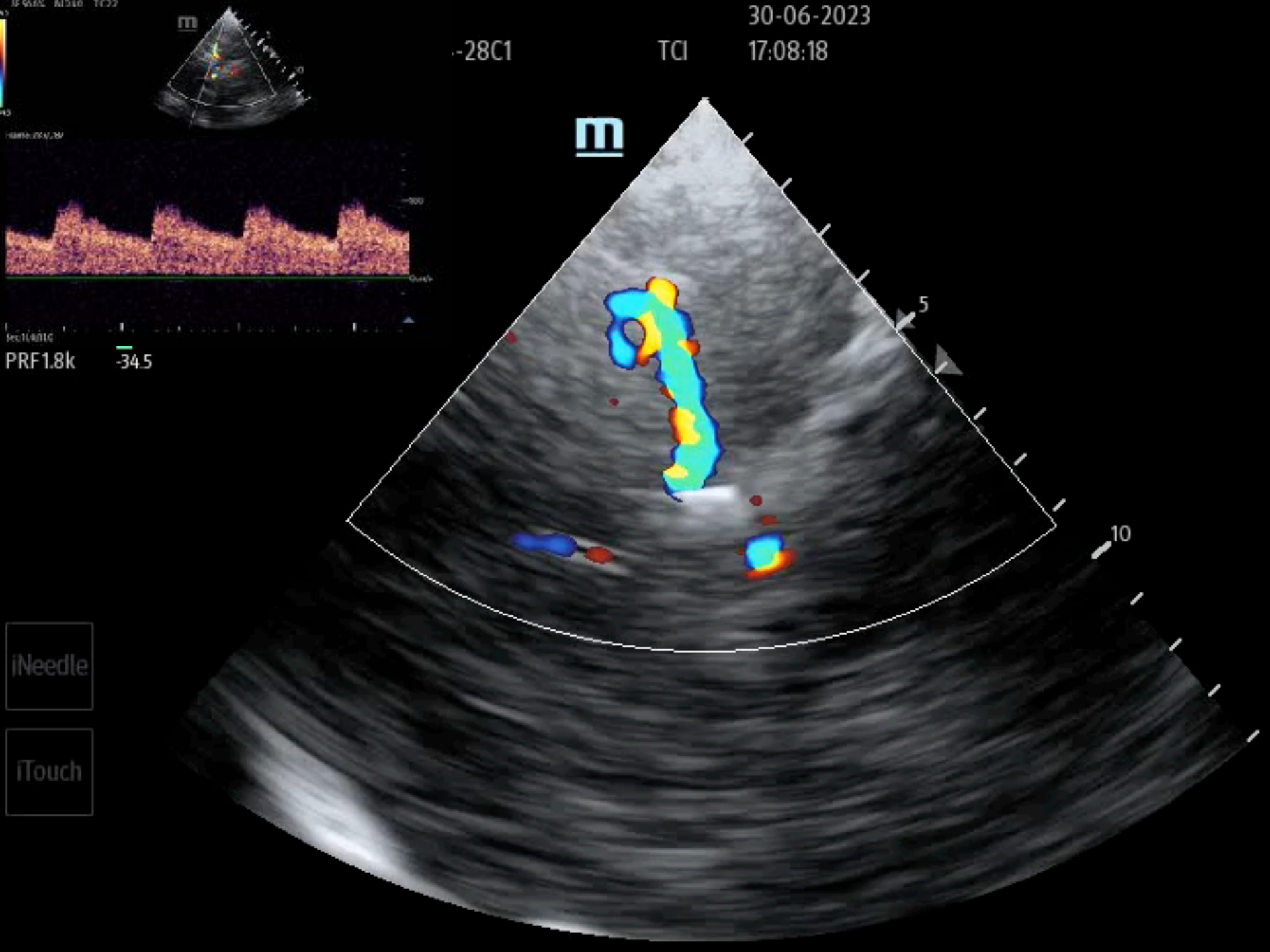
Step 3:

spectral Doppler waveforms can be obtained through pulse Doppler





Montrief, T., et al. (2019). Incorporation of Transcranial Doppler into the emergency department for the neurocritical care patient. American Journal of Emergency Medicine 37(6): 1144-1152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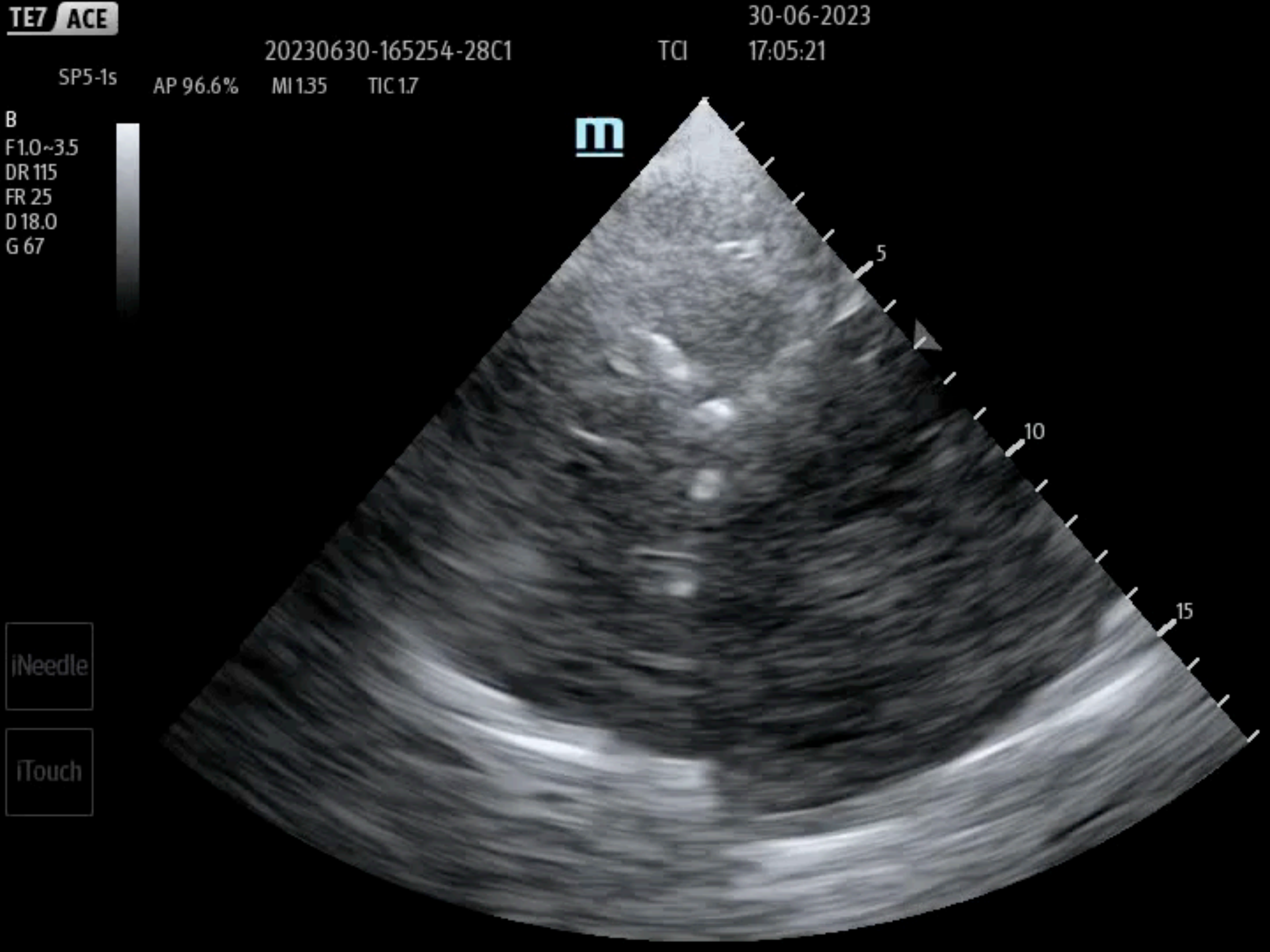
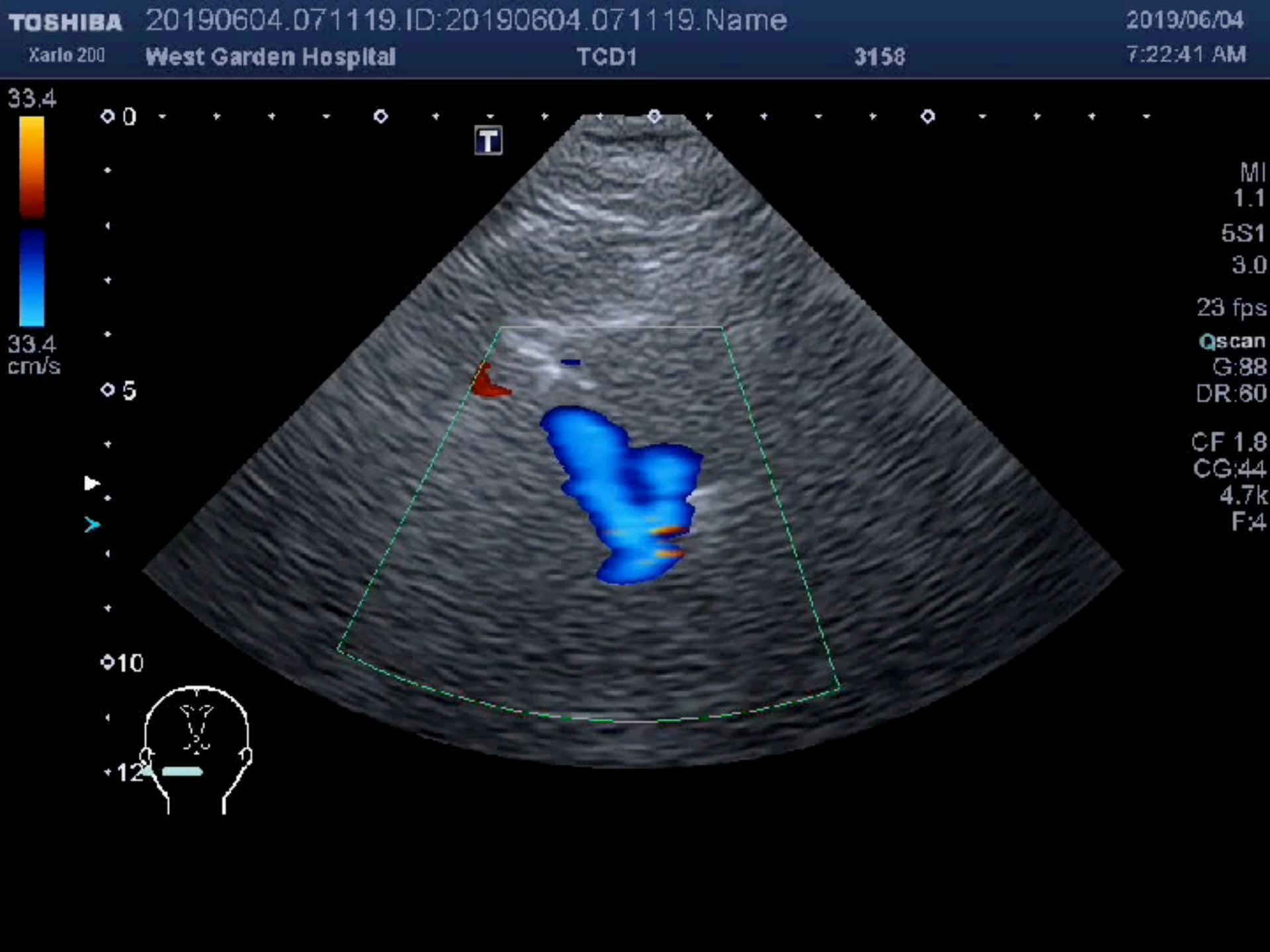
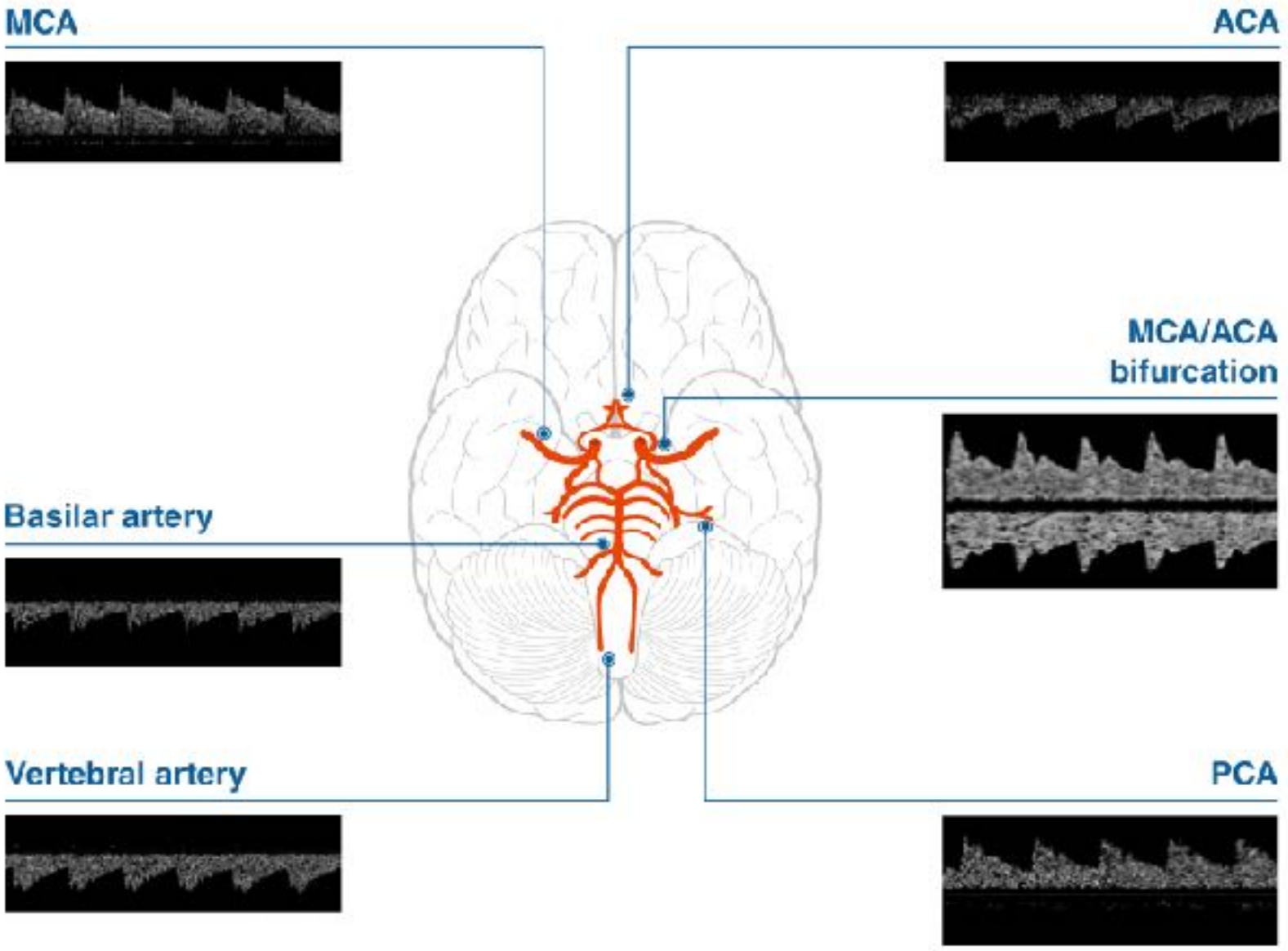
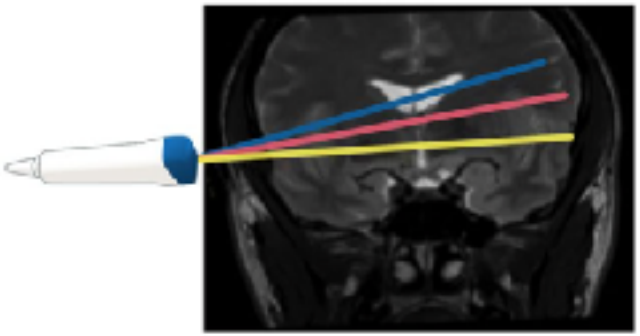
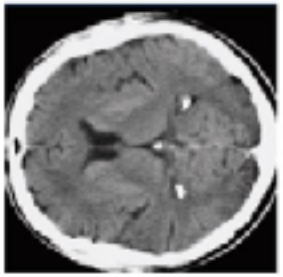
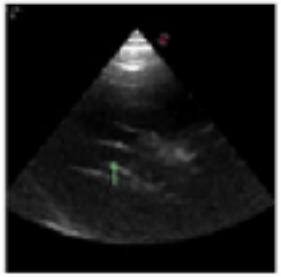
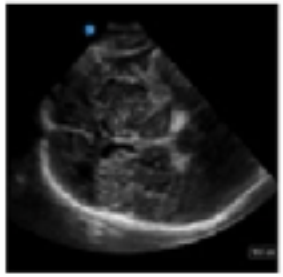
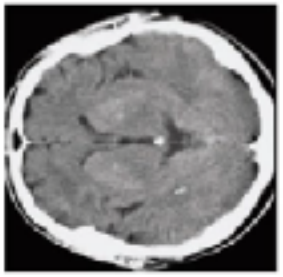
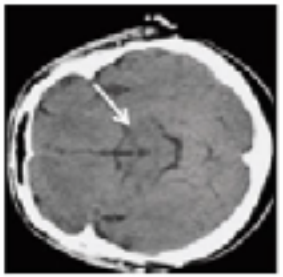
-28C1
TCI
17:08:18
5
10
PRF1.8k
-34.5
iNeedle
iTouch


TE7 ACE
30-06-2023
20230630-165254-28C1
TCI
17:05:21
SP5-1s
AP 96.6%
MI 1.35
TIC 1.7
B
F 1.0~3.5
DR 115
FR 25
D 18.0
G 67
5
10
15
iNeedle
iTouch


TOSHIBA
20190604.071119.ID:20190604.071119.Name
2019/06/04
Xario 200
West Garden Hospital
TCD1
3158
7:22:41 AM
33.4
0
5
10
12
33.4
cm/s
MI
1.1
5S1
3.0
23 fps
Qscan
G:88
DR:60
CF 1.8
CG:44
4.7k
F:4


MCA
ACA
MCA/ACA
bifurcation
Basilar artery
Vertebral artery
PCA



CT	Non-decompressed brain	DC
		
Ventricular plane		
		
Diencephalic or III ventricle plane		
		
Mesencephalic plane		

Peak Systolic Velocity (PSV in cm/s)	Initial peak on TCD waveform during each cardiac cycle	Rapid upstroke indicates lack of severe stenotic or occlusive lesion between observed cerebral artery and heart
End Diastolic Velocity (EDV in cm/s)	Should be between 20% and 50% of PSV value	Indicates low resistance intracranial arterial flow, a normal finding
Mean Flow Velocity (MFV in cm/s)	MFV = EDV + .33 (PSV – EDV)	MCA should have highest MFV in all cerebral arteries observed
Pulsatility index (PI)	PI = (PSV-EDV)/MFV	Used to measure resistance to intra-arterial flow. Value **>1.2** represents high resistance to flow
Resistance Index (RI)	RI = (PSV-EDV)/PSV	Another measurement of flow resistance, this time **distal** to the area insonated. Normal **<0.75**
Lindegaard Ratio (LR)	LR = ipsilateral MCA MFV/ipsilateral	Ratio used to detect cerebral vasospasm. Ratios of **3-6** indicate mild to moderate vasospasm. **>6** = severe vasospasm[21]

Indication	Technique	Clinical Application
Rule-In Vasospasm	- Measure MFV (>200 cm/s is severe; <80cm/s is normal)[29]	- Serial measurements to monitor for post-SAH vasospasm - screen for post-SAH vasospasm
Midline shift	- Measure distance from temporal bone to third ventricle on ipsilateral and contralateral side and divide by 2. - If difference is **positive**, MLS is towards the ipsilateral side. - If difference is **negative**, MLS is towards the contralateral side.	- serial monitoring in patients with subdural or other form of chronic intracranial bleed - reliable measurement of worsening neurologic status and useful when CT is not immediately available (patient unstable, repairs,CT in use, rural or interactional medicine).
MCA occlusion	- measure signal coming from MCA using doppler ultrasound. Similar to DVT or arterial occlusions, decreased or absent signal could indicate occlusion.	- primarily useful for rapid identification of MCA occlusion when CT is unavailable. - potential use for ultrasound enhanced thrombectomy to improve recanalization
Pediatrics	- multiple techniques depending on specific indication	- evaluation of skull fracture, fetal anemia, intracranial and intraventricular hemorrhage, and ischemic stroke

Lau and Arntfield *Crit Ultrasound J* (2017) 9:21
DOI 10.1186/s13089-017-0077-9

Critical Ultrasound Journal

REVIEW Open Access

Point-of-care transcranial Doppler by intensivists

Vincent Issac Lau[1,2*] and Robert Thomas Arntfield[1,2]

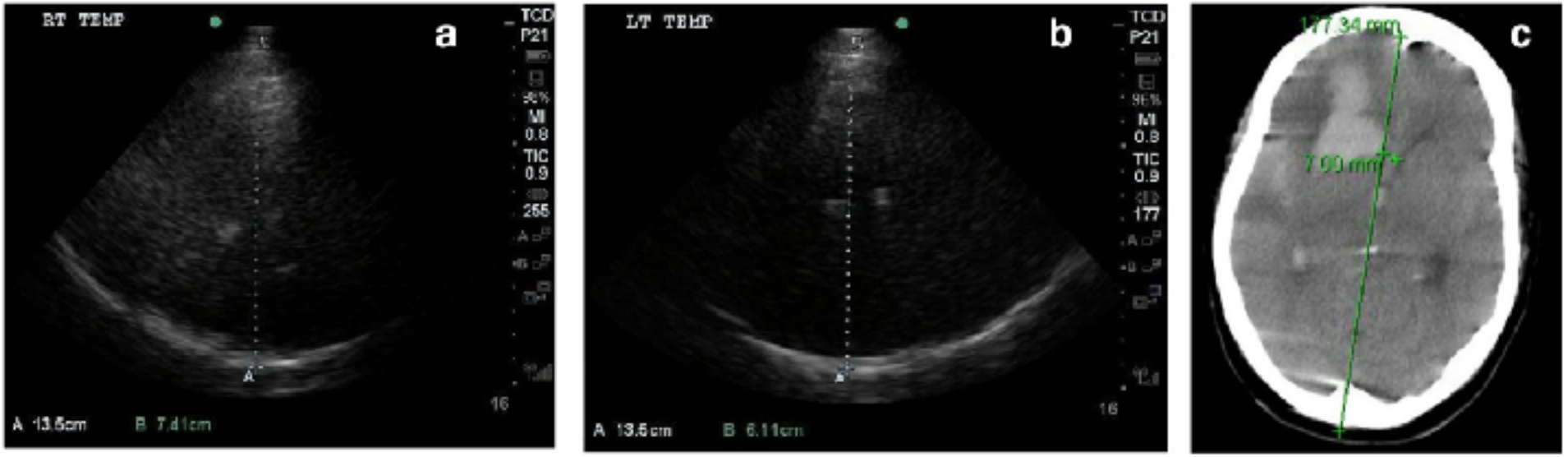
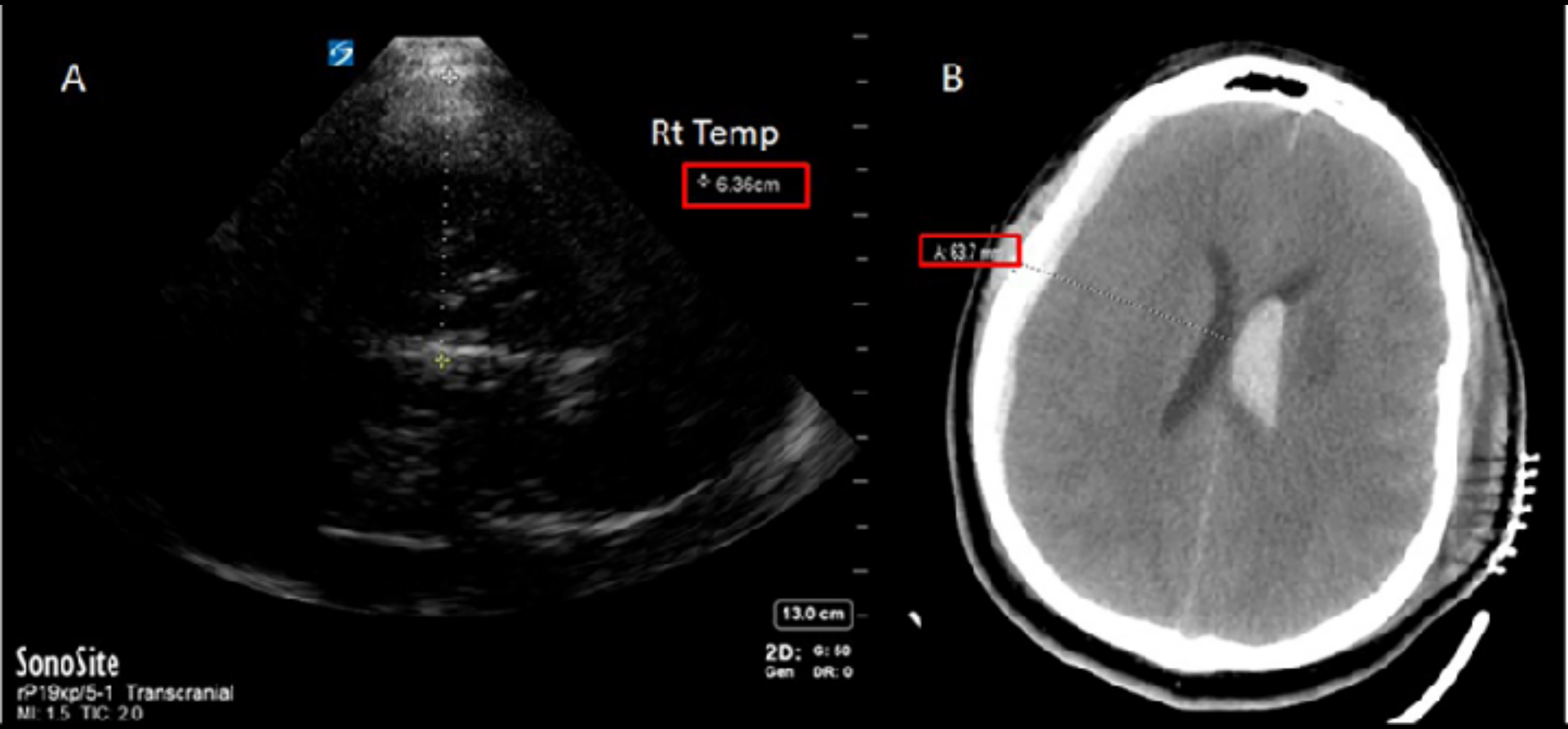


Fig. 1 Transcranial imaging for midline shift. **a** Insonation from right temporal bone to third ventricle, representing distance A (7.41 cm). **b** Insonation from left temporal bone to third ventricle, representing distance B (6.11 cm). **c** Follow-up CT scan post TCD which reveals midline shift to be 7 mm

Midline shift (MLS)

Midline shift = (distance A - distance B)/2; > 0.5 cm = poor outcome



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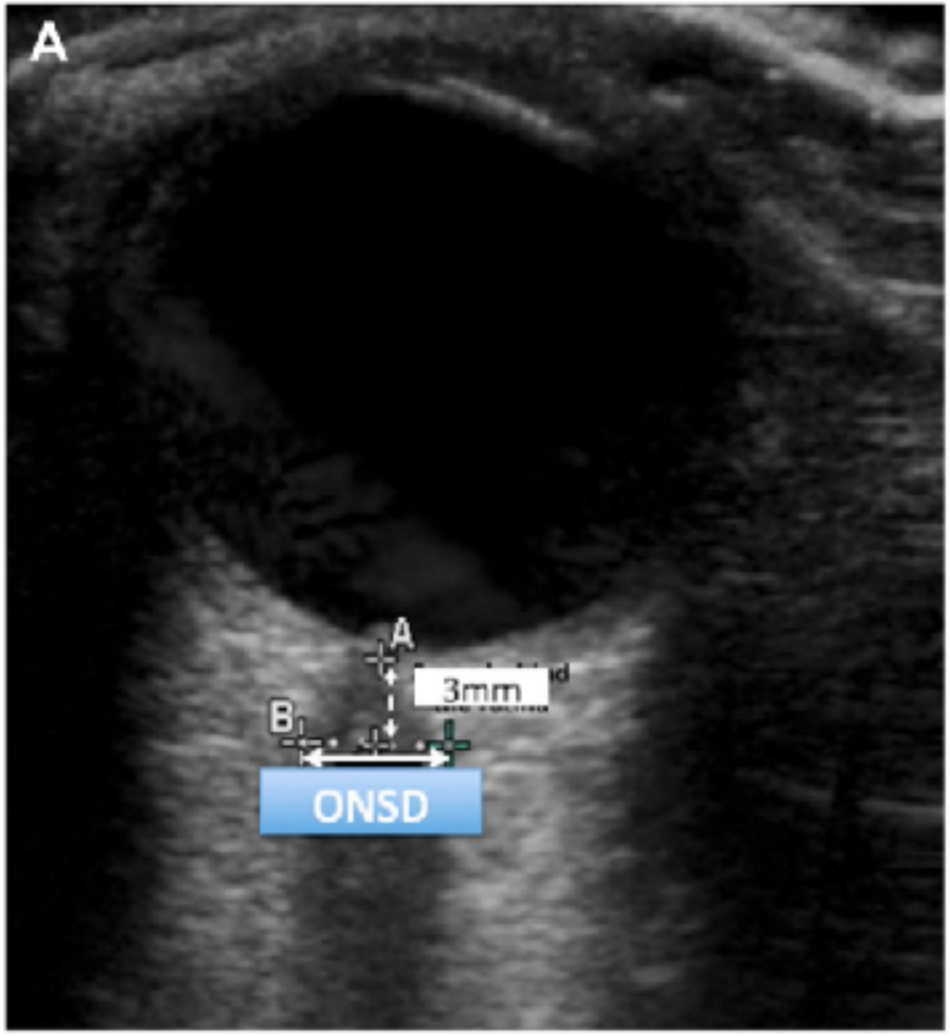
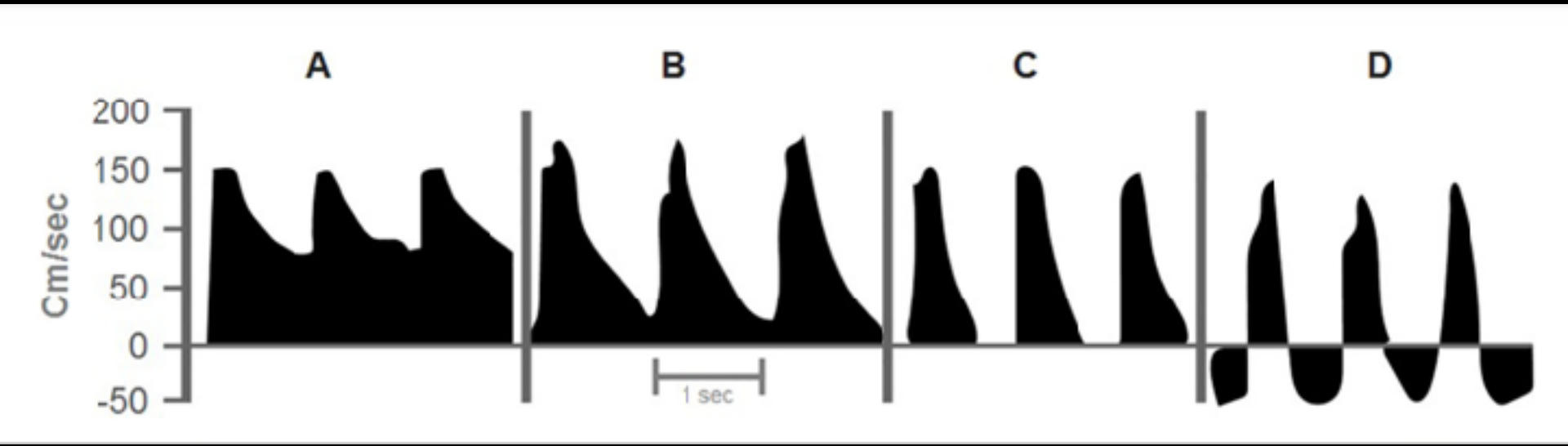
ONSD for ICP



ICP measurement



ICP measurement

Normal PI < 1.2 ~ ICP 12 mmHg

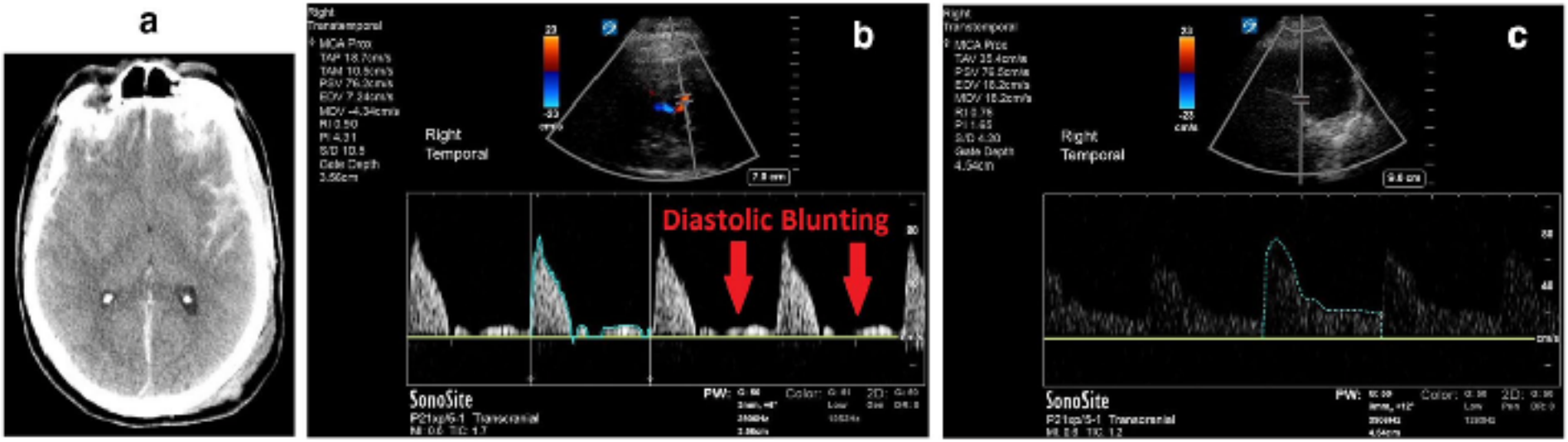


Fig. 3 Raised intra-cranial pressure by spectral Doppler on TCD, as calculated by pulsatility index. **a** Diffuse subarachnoid hemorrhage on CT head. **b** Spectral Doppler of MCA, demonstrating diastolic blunting secondary to raised ICP (pulsatility index = 4.31, ICP = 46 mmHg). **c** Following interventions to reduce ICP, there was normalization of diastolic flow in the MCA, and resolution of high ICP (pulsatility index = 1.65, ICP = 17 mmHg)

PI > 2.13 ~ ICP > 22 mmHg

Vasospasm

Time Averaged Mean (TAM)

Normal	< 80 cm/sec
Mild Vasospasm	>120 cm/sec
Moderate Vasospasm	> 160 cm/sec
Severe Vasospasm	> 200 cm/sec

CORE ULTRASOUND

Vasospasm

Lindegaard Ratio

Hyperemia	< 3
Mild Vasospasm	> 3
Moderate Vasospasm	> 4.5
Severe Vasospasm	> 6

egaard Ratio: MCA mean velocity / ICA (extracranial) mean velocity
PMID:2683600

Vasospasm

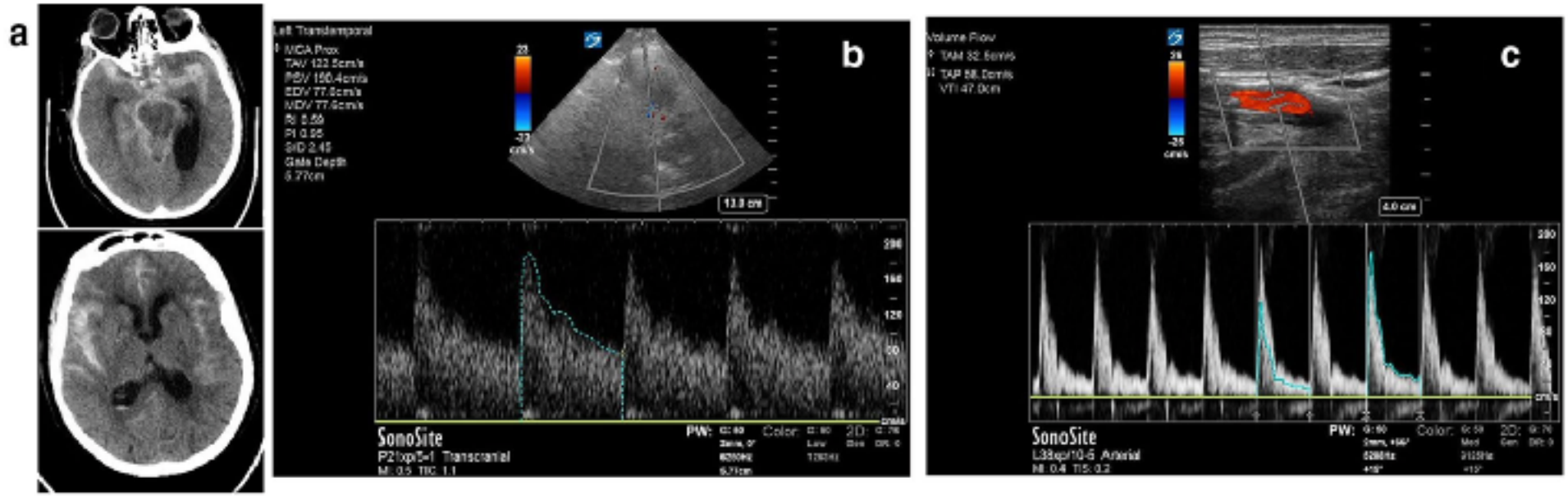
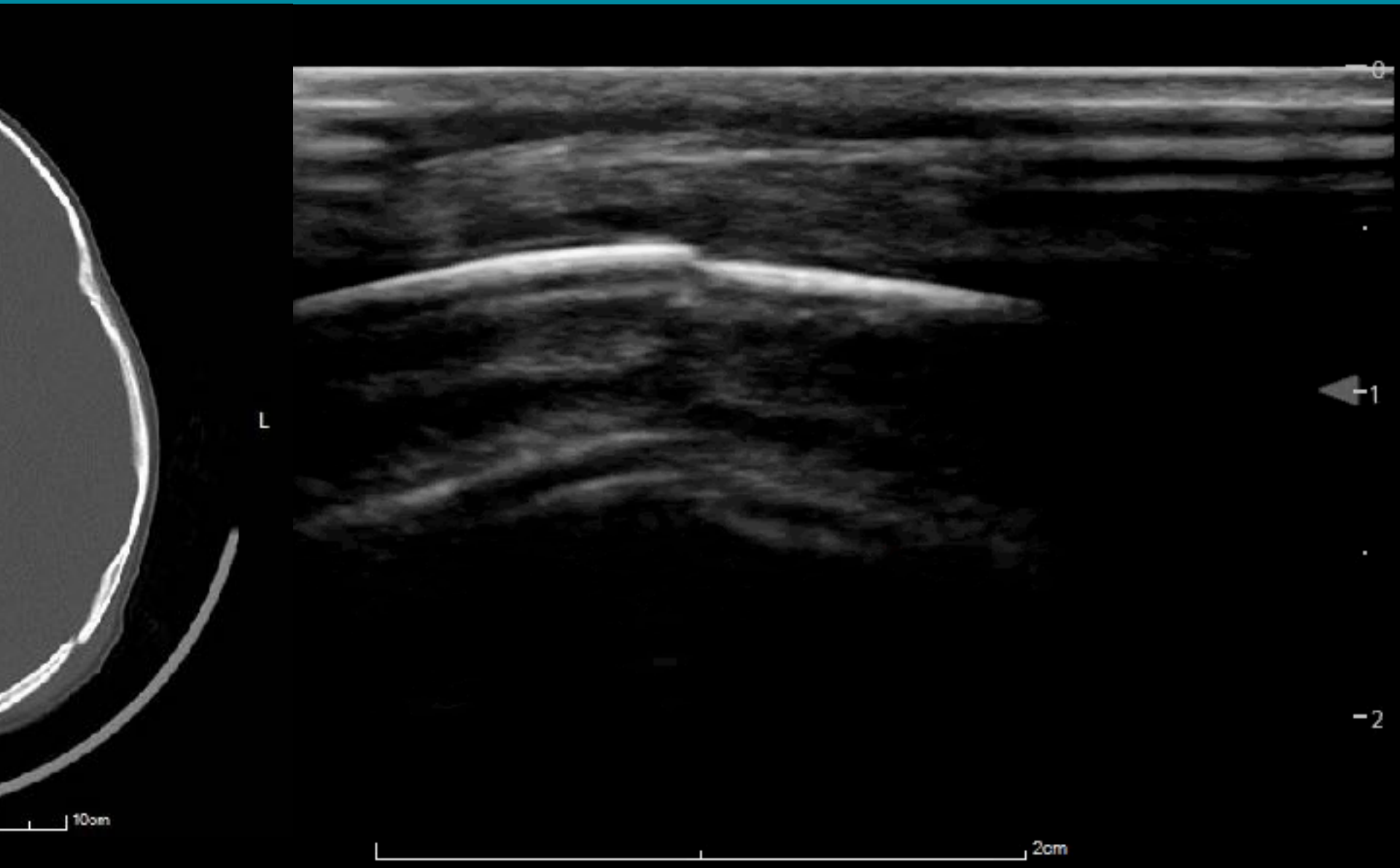
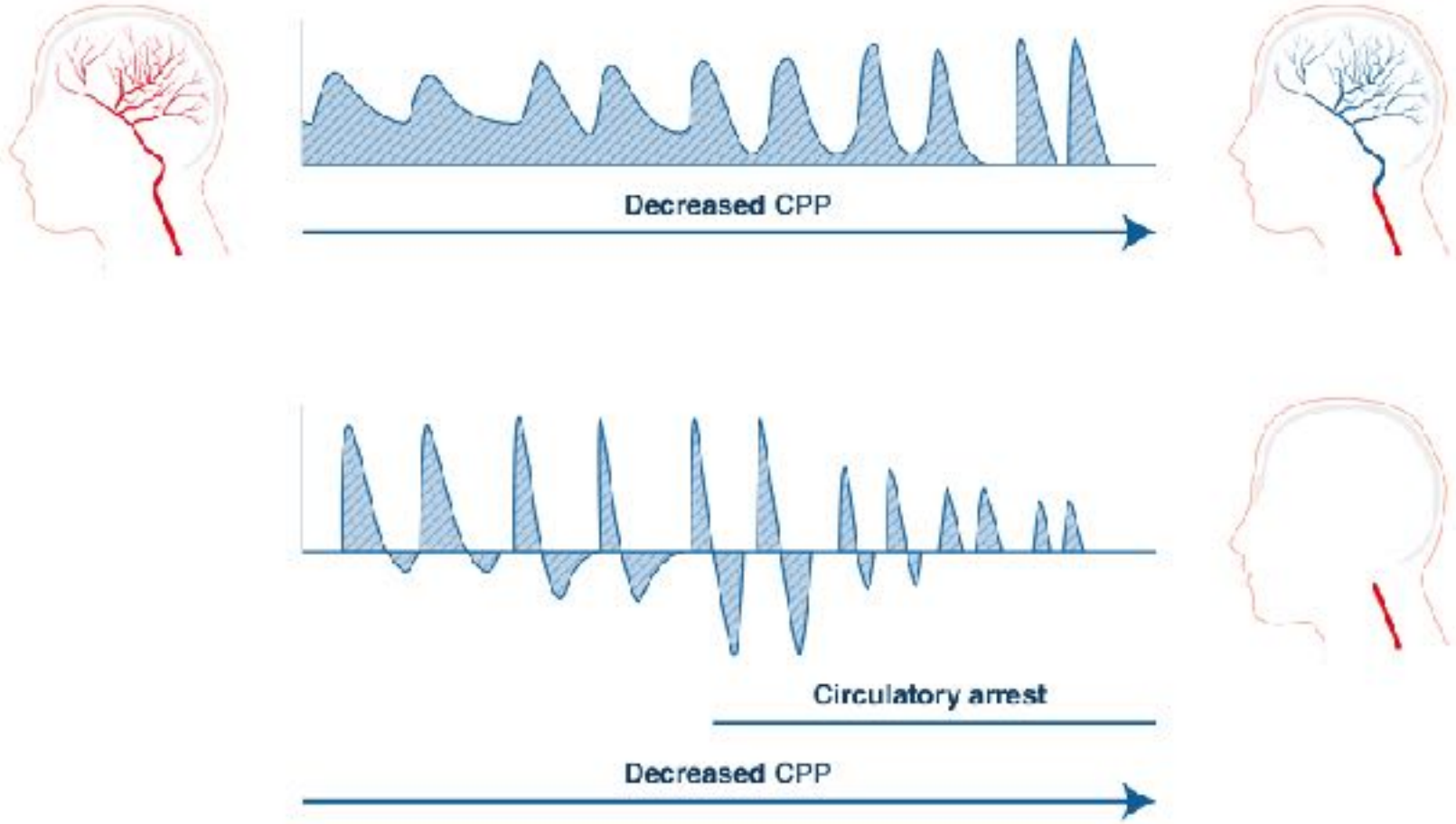


Fig. 2 Transcranial Doppler for vasospasm following subarachnoid hemorrhage. **a** CT Head demonstrating diffuse subarachnoid hemorrhage. **b** TCD measurement of left MCA flows, demonstrating a mean MCA velocity of 123 cm/s (in-keeping with mild vasospasm). **c** Measurement of ipsilateral left ICA flows for calculation of Lindegaard ratio of 3.8 (Mean MCA/ICA velocity = 123/32.5 cm/s), which confirmed mild MCA vasospasm

3M, skull bone fracture

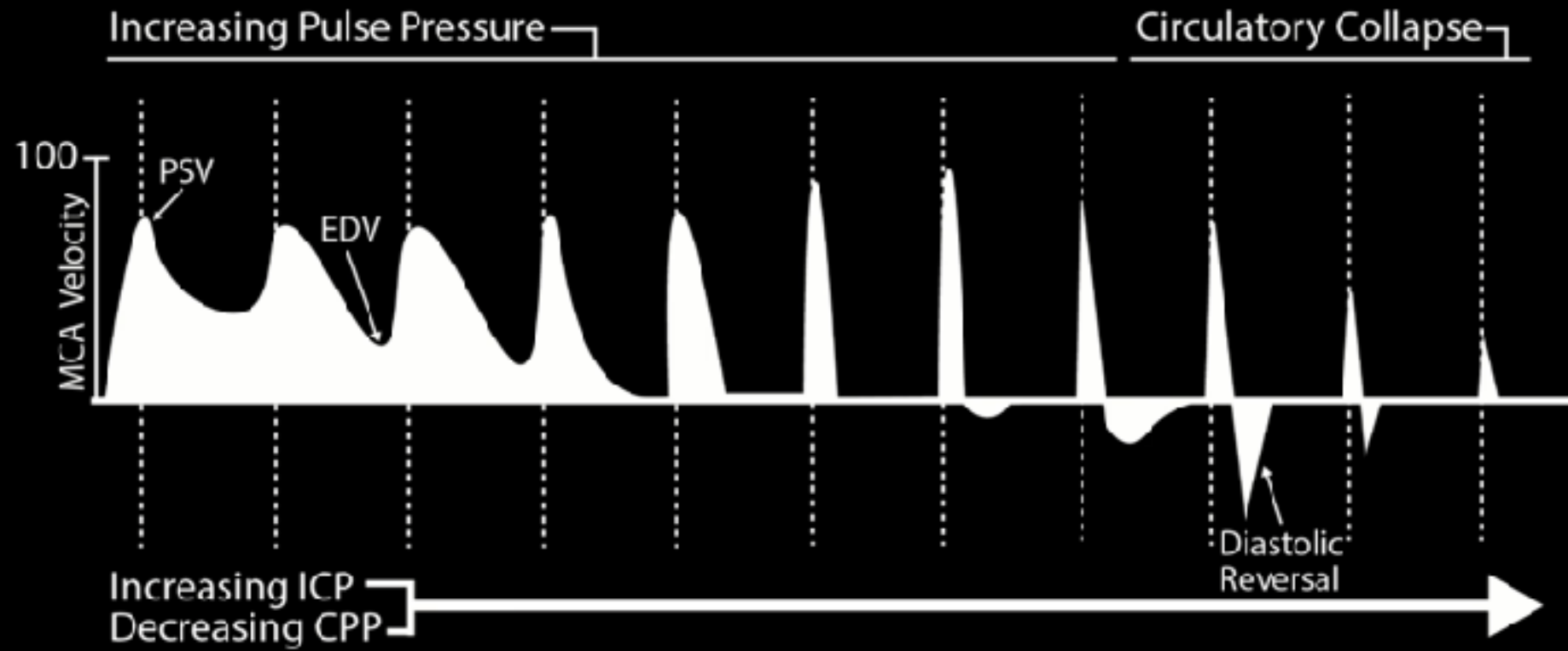


Progressive changes in the waveform morphology of the middle cerebral artery.



(Modified from Hassler W, Steinmetz H, Pirschel J. Transcranial Doppler study of intracranial circulatory arrest. J Neurosurg 1989; 71(2):195 – 201).

Cerebral Circulatory Arrest



Adapted from: Hassler W, Steinmetz H, Pischel J. Transcranial Doppler study of intracranial circulatory arrest. J Neurosurg 1989; 71(2):195-201.

CORE ULTRASOUND

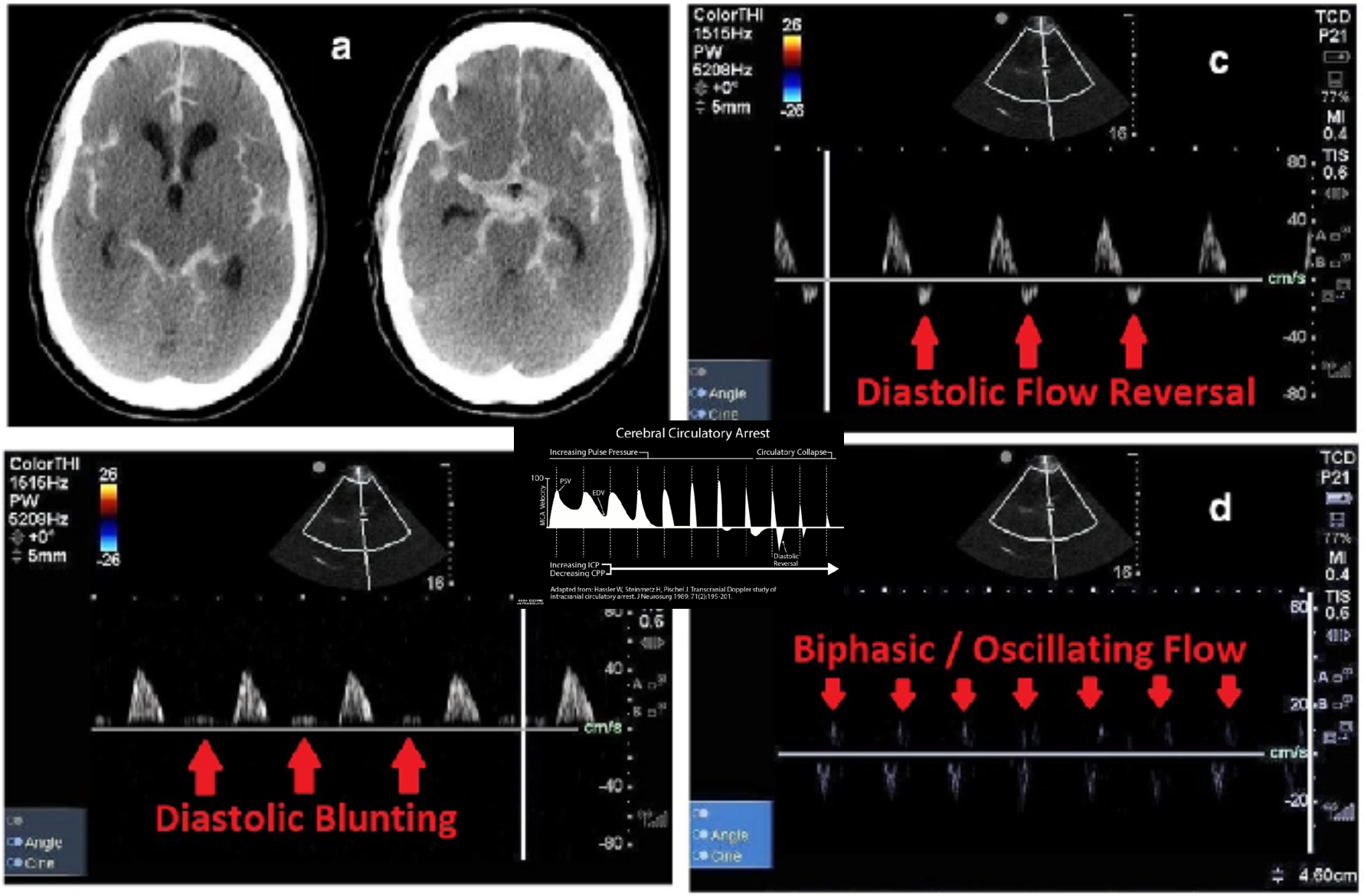
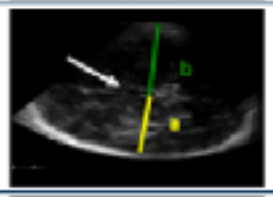
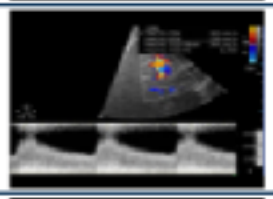
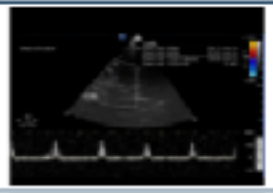
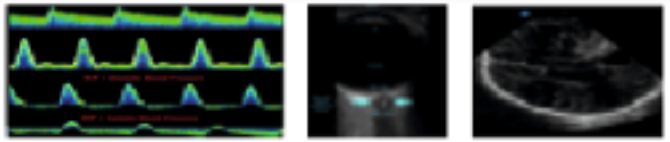
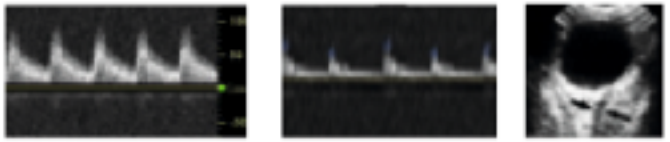
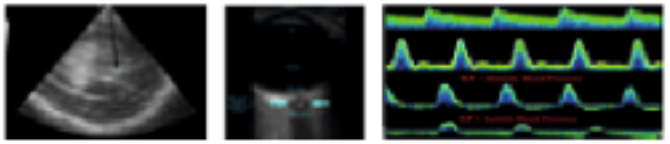
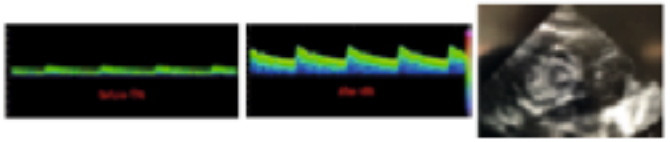


Fig. 4 Step-wise progression of cerebral circulatory arrest. **a** CT Head demonstrating diffuse subarachnoid hemorrhage. **b** Evidence of raised ICI causing decreased diastolic flow as evidenced by blunting of the spectral Doppler signal. **c** Further progression with diastolic flow reversal as rai ICP prevents forward flow in MCA, and even induces backwards flow. **d** Biphasic and oscillating flow as evidenced by net zero flow (where systo and diastolic flow are near equal to each other), indicating the first TCD stage of cerebral circulatory arrest

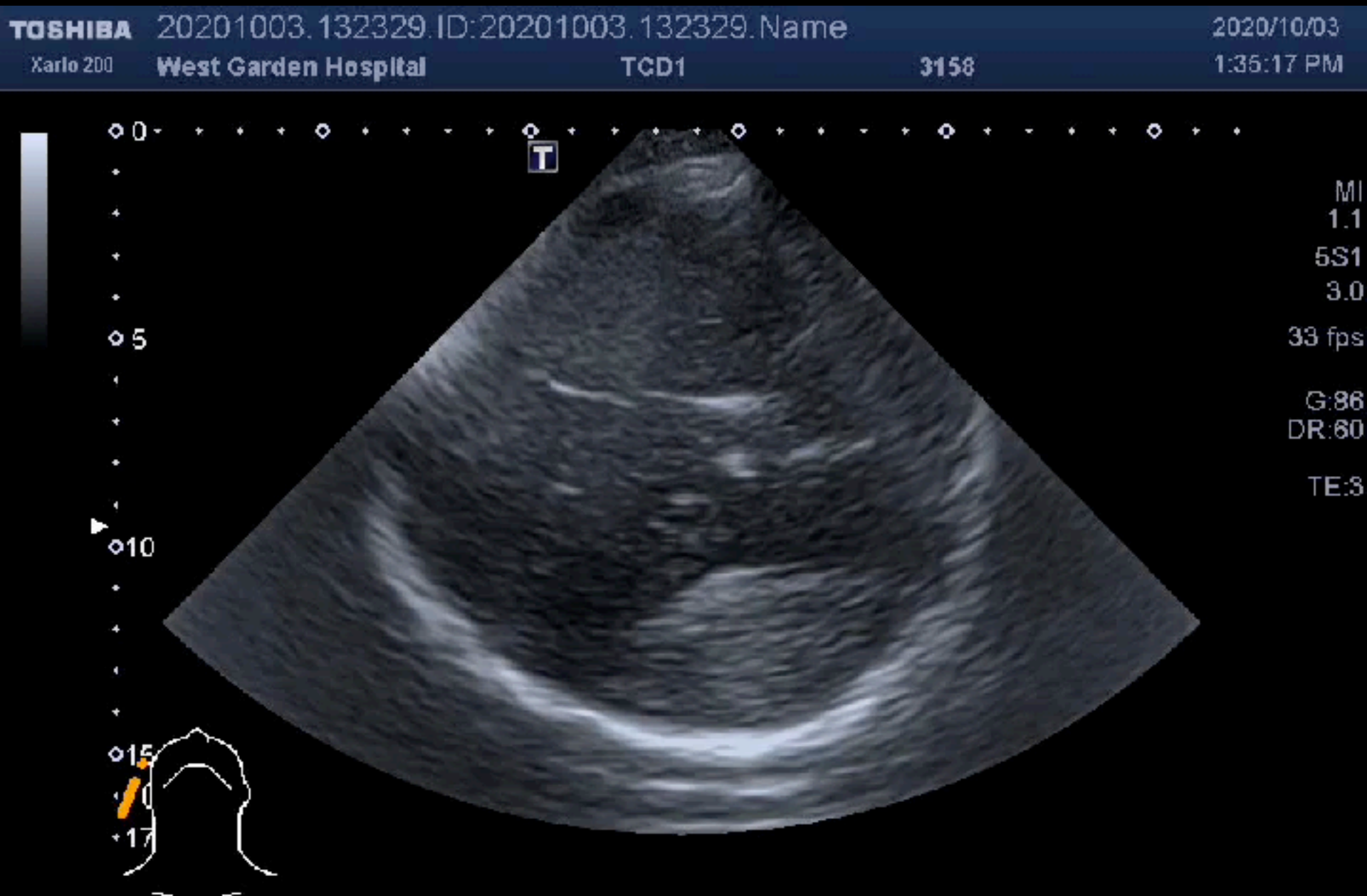
TCD for neurocritical care

Hydrocephalus		Marked dilated third (white line) and lateral ventricles (green lines)
Subdural haemorrhage		Subdural temporal hyperechoic collection (white arrow) in patient with TBI and neurological deterioration
Intracranial haemorrhage		Right-sided intracranial hyperechoic area consistent with haemorrhage (white arrow) in patient with decompressive craniectomy
Midline shift		Diencephalic plane showing the typical appearance of the third ventricle; midline shift can be estimated by measuring the distances between homolateral and contralateral temporal bone with third ventricle [(a-b)/2]
Vasospasm		Increased MCA flow velocities, in a patient with Lindegaard ratio = 6, suggesting cerebral vasospam
Brain death		TCD flow pattern characteristic of severe intracranial hypertension leading to cerebral circulatory arrest
Central nervous system infections		Dilated ventricles with presence of endo-ventricular bacterial vegetations and the posterior horns of the lateral ventricles in patient with post-traumatic meningoencephalitis.

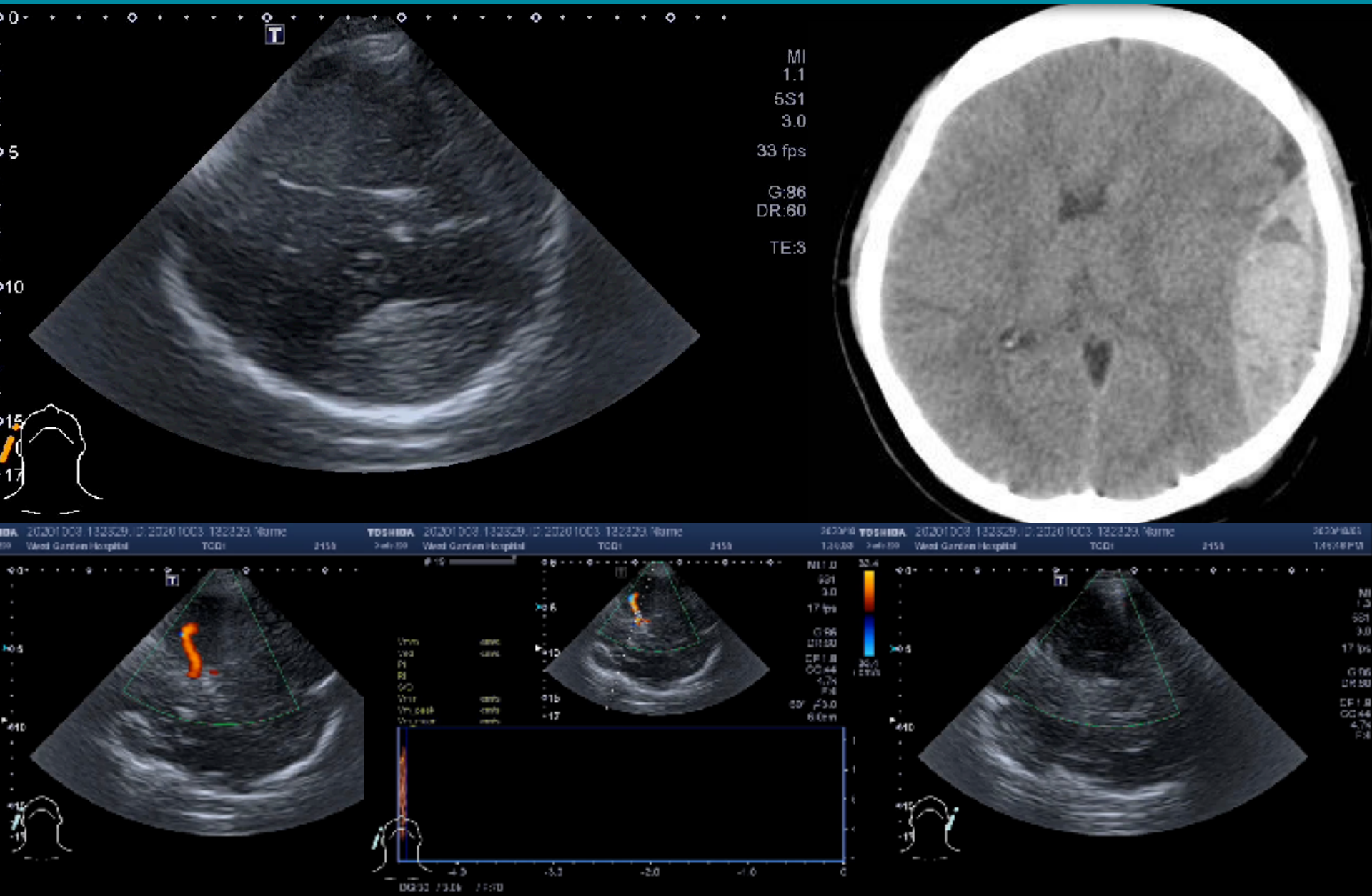
TCD for general ICU & ED

Liver failure		Intracranial hypertension, haemorragic complications, flow pattern
Post-cardiac arrest syndrome		Intracranial hypertension, flow pattern evolution during and after CPR
Severe respiratory Failure-ECMO		Intracranial hypertension, bleeding flow pattern
Polytrauma		Intracranial hypertension, bleeding flow pattern evolution, intracerebral bleeding
Stroke		Flow pattern evolution during reperfusion, intracerebral bleeding
Sepsis		Flow pattern changes predictive for septic encephalopathy, cerebral oedema
Paediatric population		Intracranical bleeding, cerebral masses, intracranial hypertension
Pregnancy		Intracranical bleeding, hypertension, neurological complications related to eclampsia

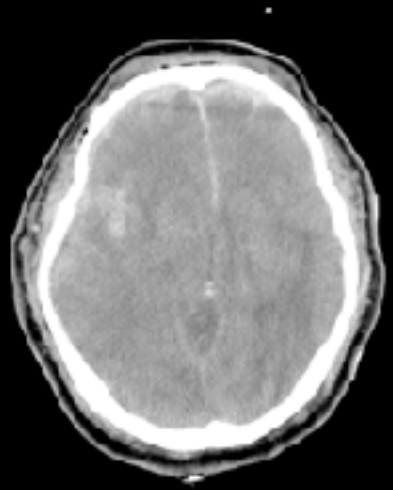
44F, 在廚房跌倒撞到後腦



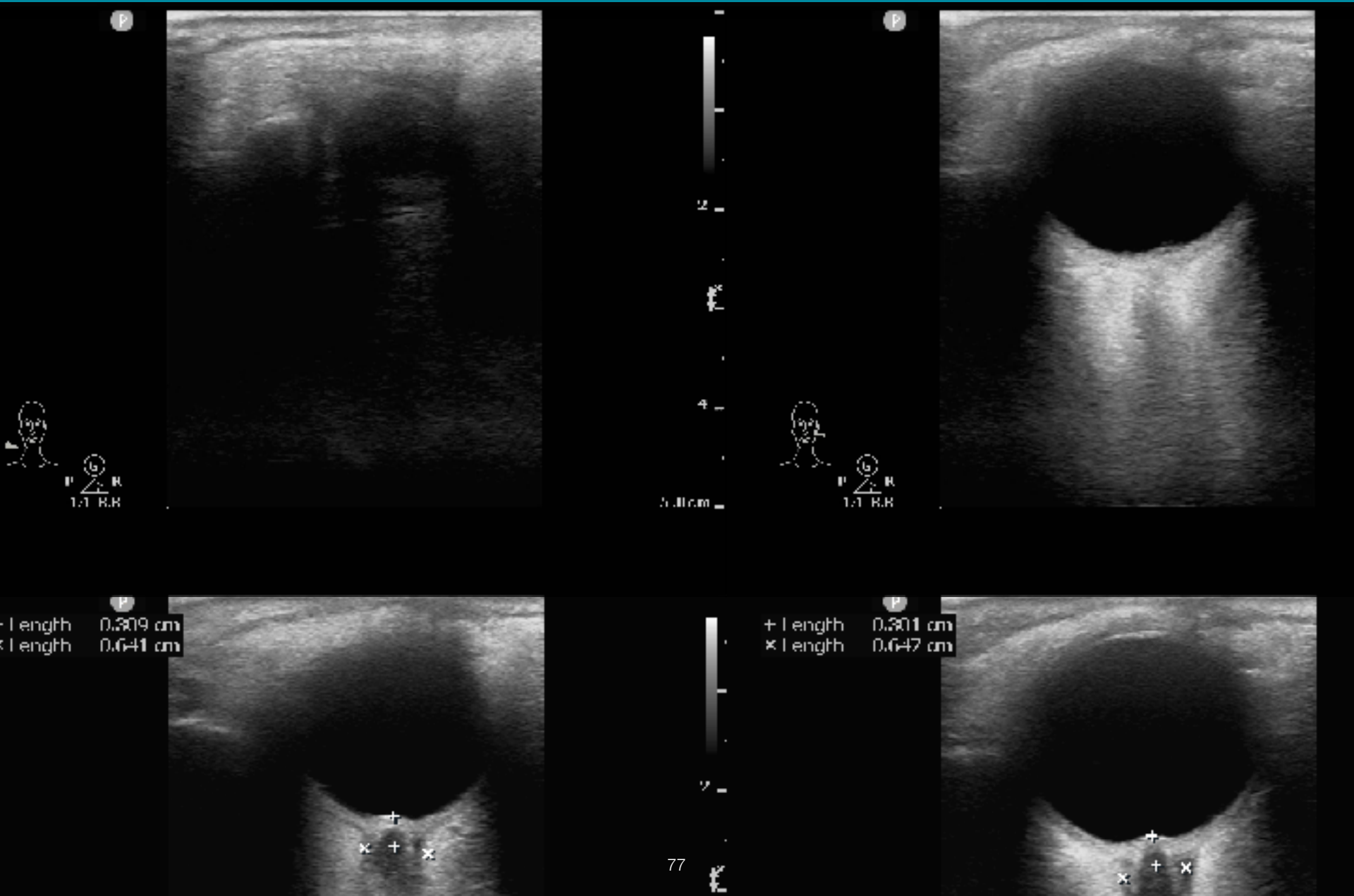
44F, 在廚房跌倒撞到後腦



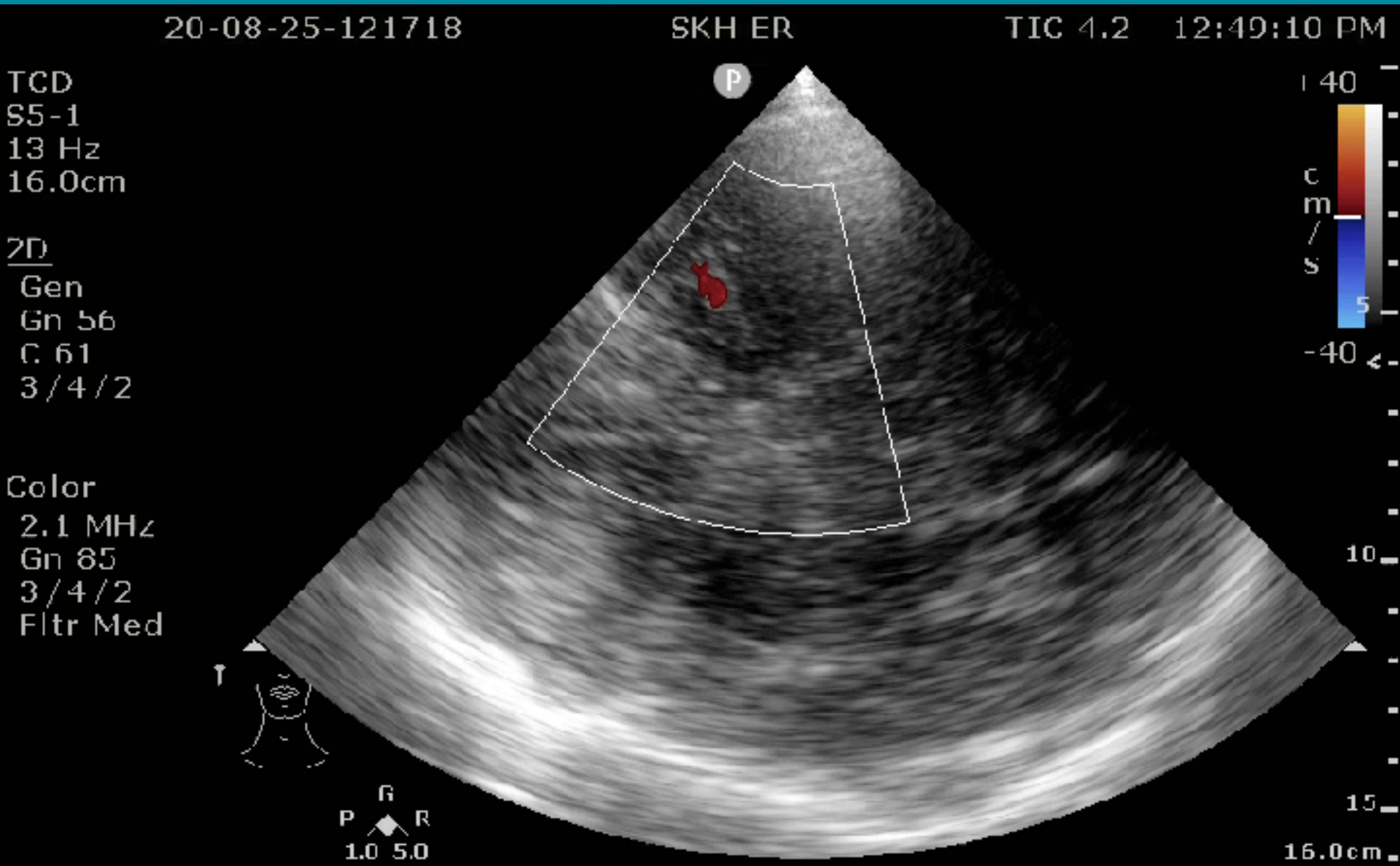
62M, Skull fx & traumatic ICH/ SAH



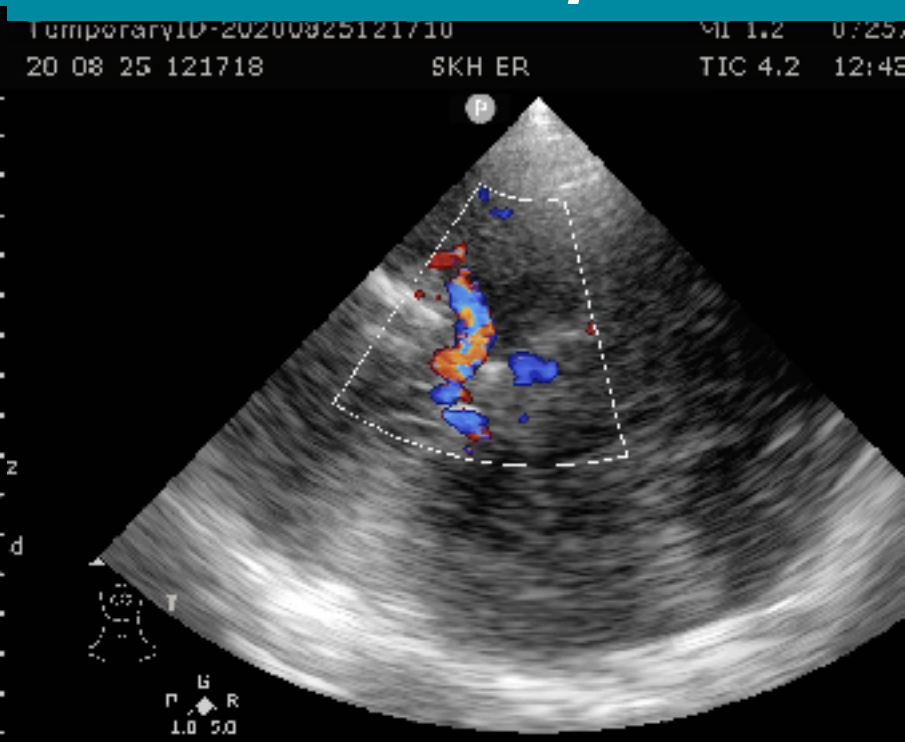
62M, Skull fx & traumatic ICH/ SAH

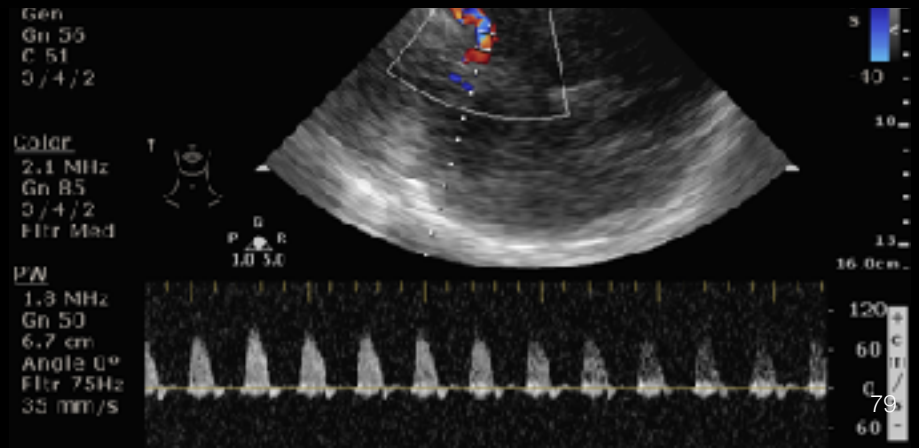


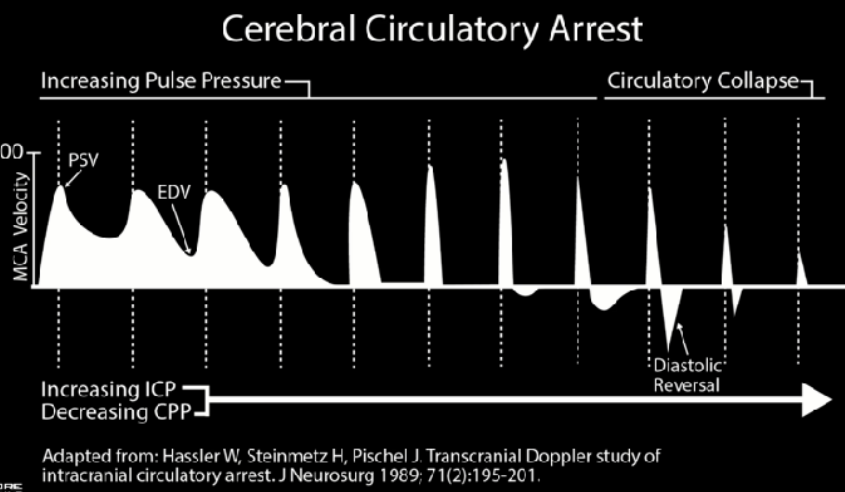
62M, Skull fx & traumatic ICH/ SAH



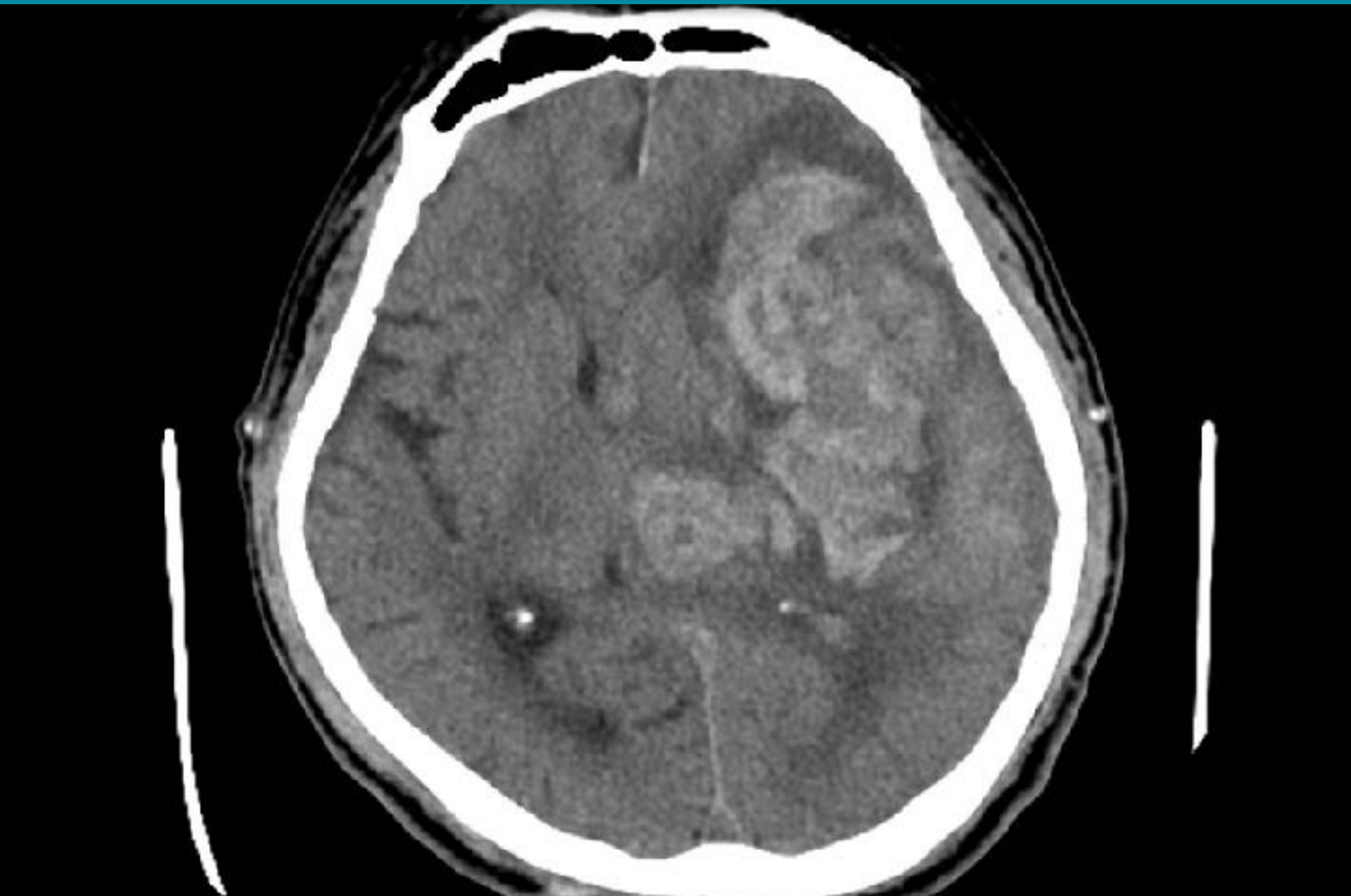
62M, Skull fx & traumatic ICH/ SAH







57M, AMS, 管理員發現倒在地下室



57M, AMS, 管理員發現倒在地下室

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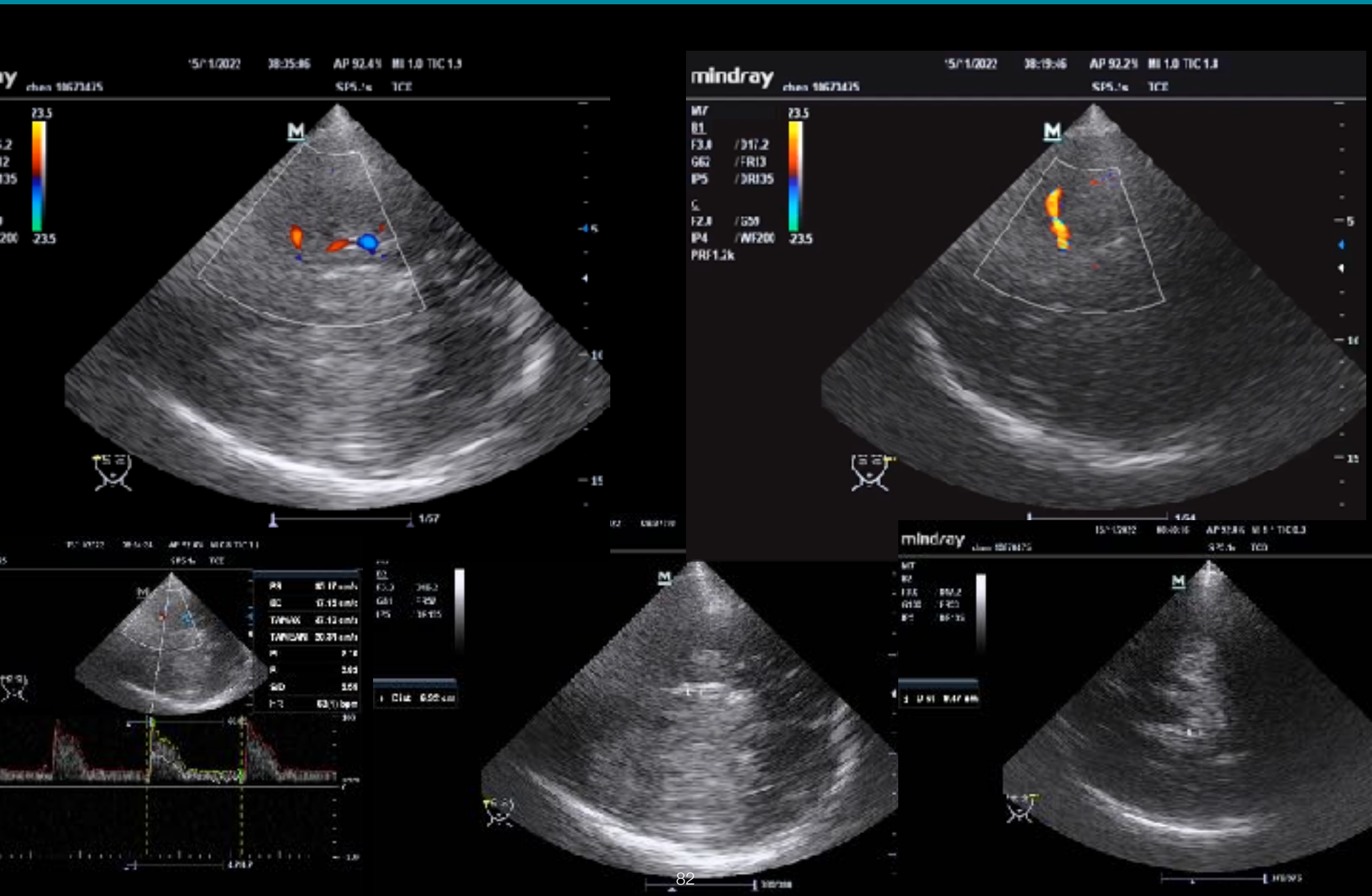
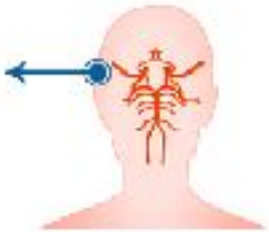
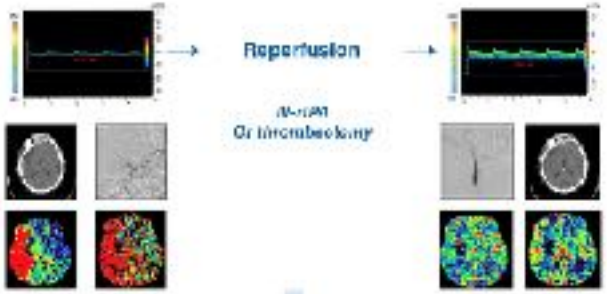


BUS in STROKE

TCD: diagnosis of arterial stenosis
- Reduced CBF velocities
- Changing flow patterns and velocities in contralateral arteries



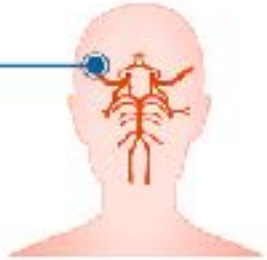
TCD: during peri-procedural thrombolysis with intravenous recombinant tissue plasminogen activator (IV-tPA) < 4.5 hrs of symptom onset monitoring recanalization after thrombolysis and thrombectomy



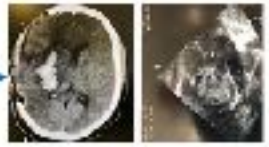
MONITORING OF COMPLICATIONS OF REPERFUSION

Complications:
- Haemorrhagic infarction
- Brain swelling

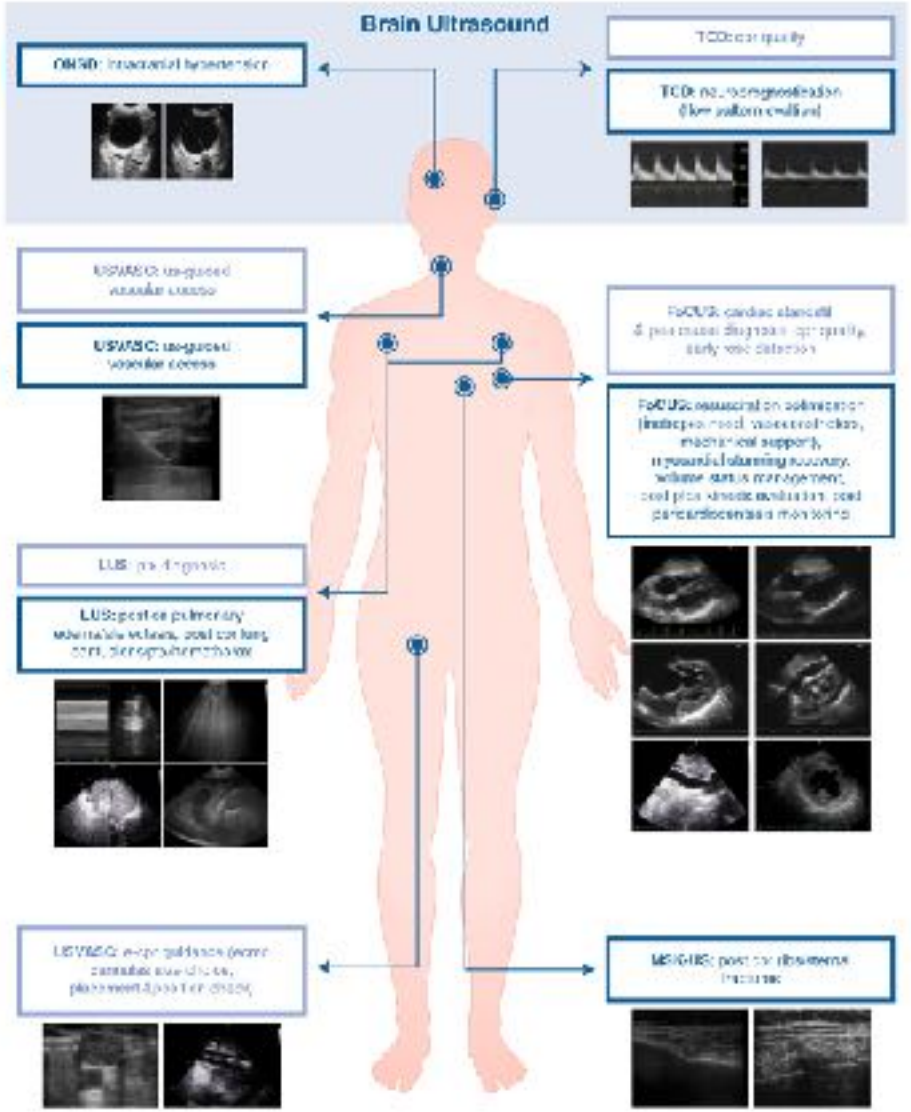
BUS: diagnosis of
- Midline shift
- Intracerebral haemorrhage complication of IV-tPA treatment for ischemic stroke



BUS: BUS guided therapy
BUS is useful in evaluating efficacy of both medical and surgical treatment of intracerebral haemorrhage and intracranial hypertension



PoCUS in CARDIAC ARREST
(Resuscitation guidance, Post-Arrest Syndrome management)



PoCUS in MULTIPLE TRAUMA

Brain Ultrasound: ICP and Cerebral Blood Flow

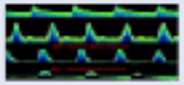
ONSD: raised ICP screening
Intracranial haemorrhage, hydrocephalus
MLS: midline shift detection

PI: pulsatility index
eCCP: Estimated CPP formula

$$PI = \frac{\text{peak systolic velocity} - \text{end diastolic velocity}}{\text{mean flow velocity}}$$

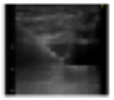
eCPP = (FVd/FVm)*mABP+14

TCD (flow pattern evolution)

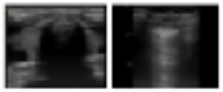


US/VASC: US-guided vascular access

US/VASC: US-guided vascular access

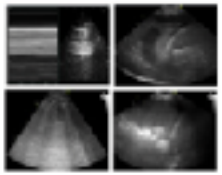


AIRWAY US: intubation check, correct tube position-emergency cricothirotomy



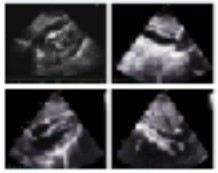
LUS: PTX/hemothorax diagnosis - chest drainage

LUS: PTX/hemothorax monitoring, lung contusions/atelectasis



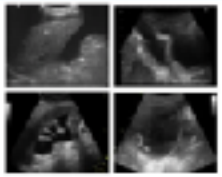
FoCUS: tamponade, severe hypovolemia, myocardial contusion-pericardiocentesis, fluid infusion, inotropes

FoCUS: hemodynamic optimization (persistent hypovolemia, pericardiocentesis monitoring)

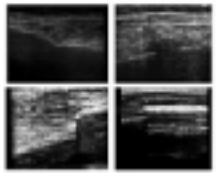


AAST US: free abdominal fluid

ADD: liver/spleen hematoma, kidney rupture, pneumoperitoneum, urinary catheter



MSK-US: Ribs/sternal fractures - long bones fractures- soft tissues hematomas



PRIMARY SURVEY

SECONDARY SURVEY