ASN 2021 VIRTUAL ANNUAL MEETING

Advanced Neurosonology: Emerging Applications of Neurological Ultrasound

Aarti Sarwal, MD, FNCS, FAAN, FCCM
Medical Director/Section Chief, Neurocritical Care
Wake Forest School of Medicine
Winston Salem, NC

Course Objectives

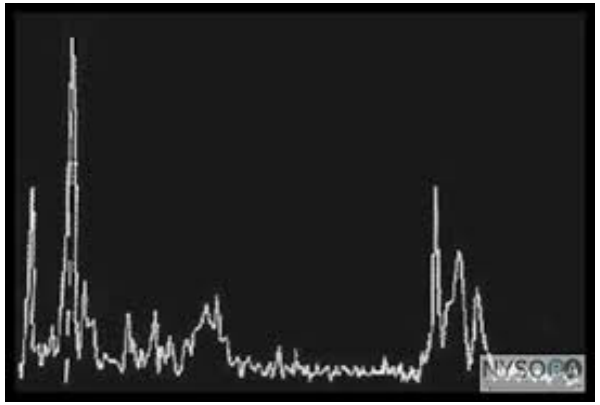
1. To define and discuss neurosonology applications in the intensive care unit setting
2. To define and discuss emerging clinical applications of neurological ultrasound.

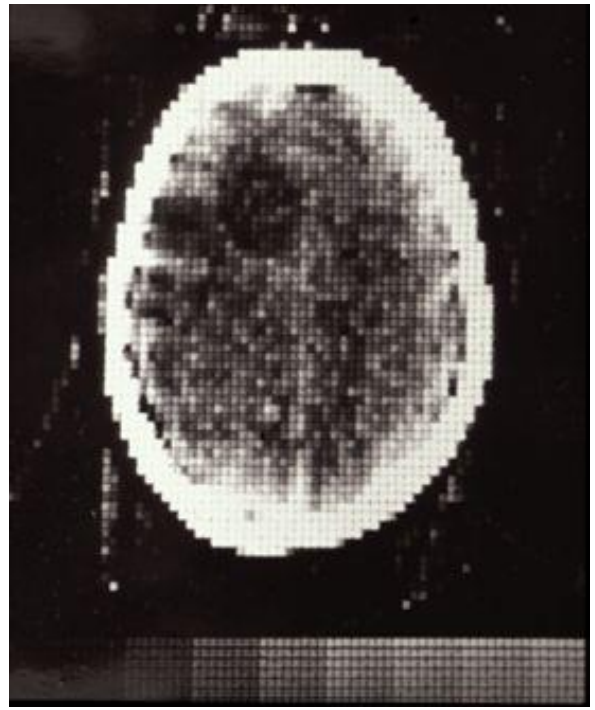
Disclosures

- Honorarium and travel compensation for participation in continuing medical education courses offered by Society of Critical Care Medicine and Neurocritical Care Society

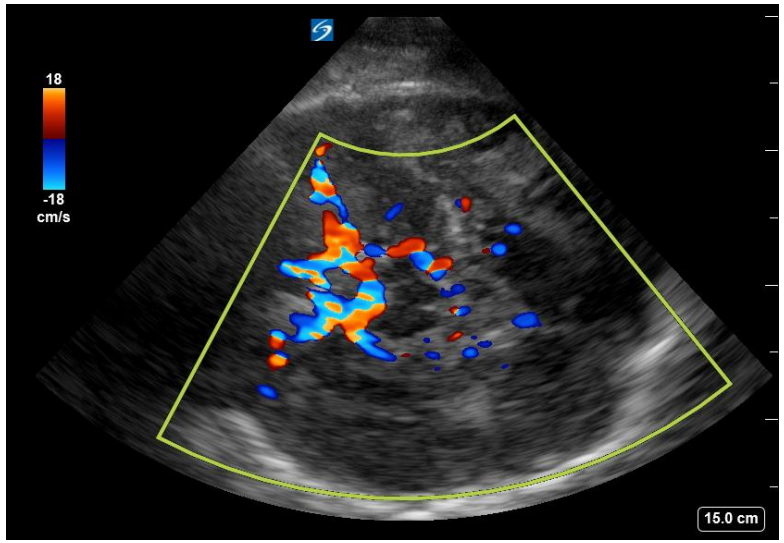
- No other relevant disclosures

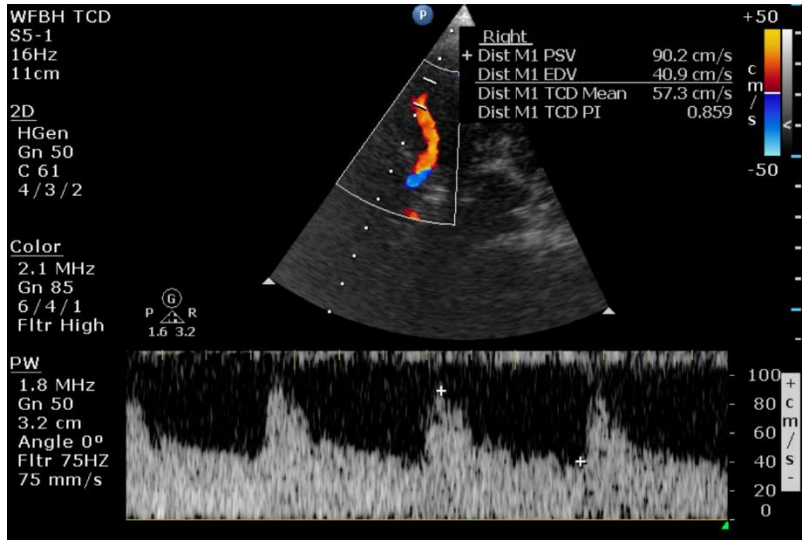
The original point of care study

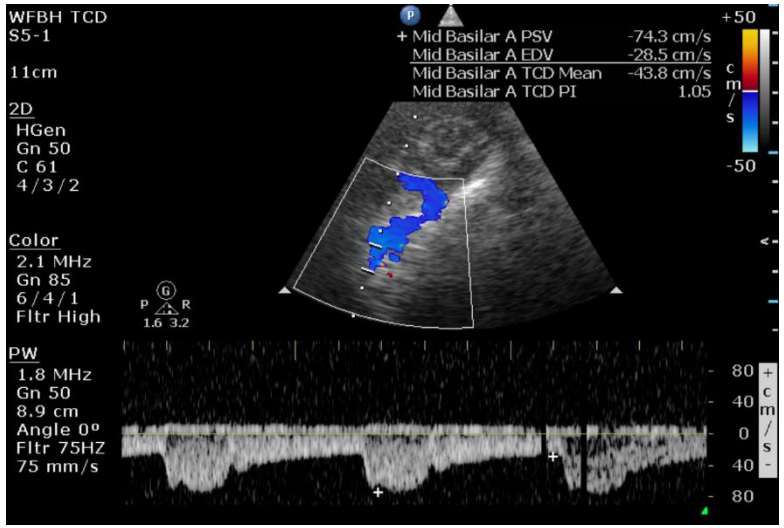


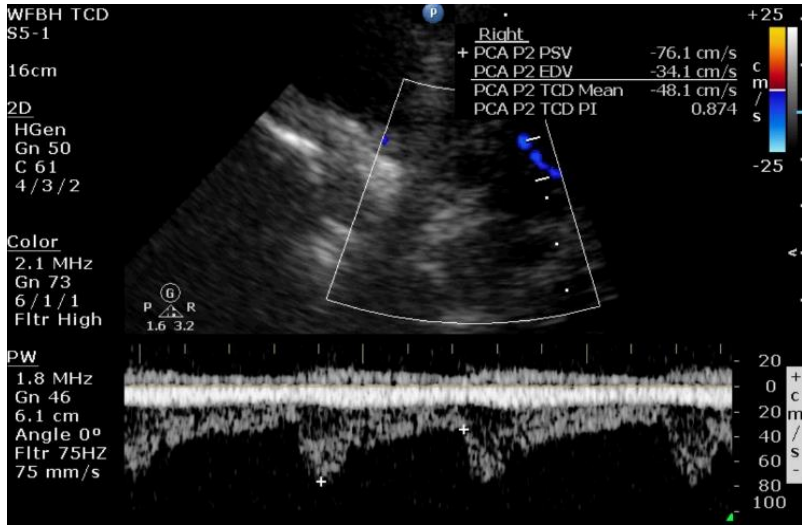


NeuroUltrasound

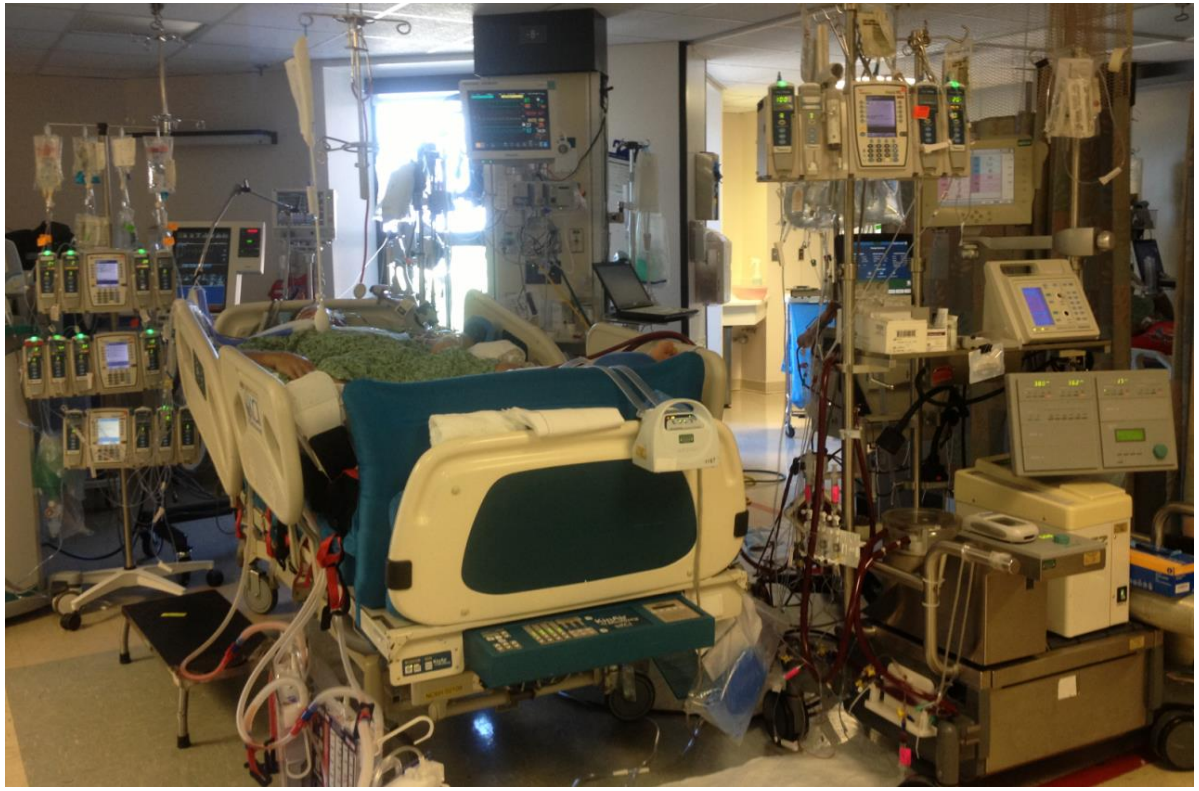








Ultrasound as a tool for CPP



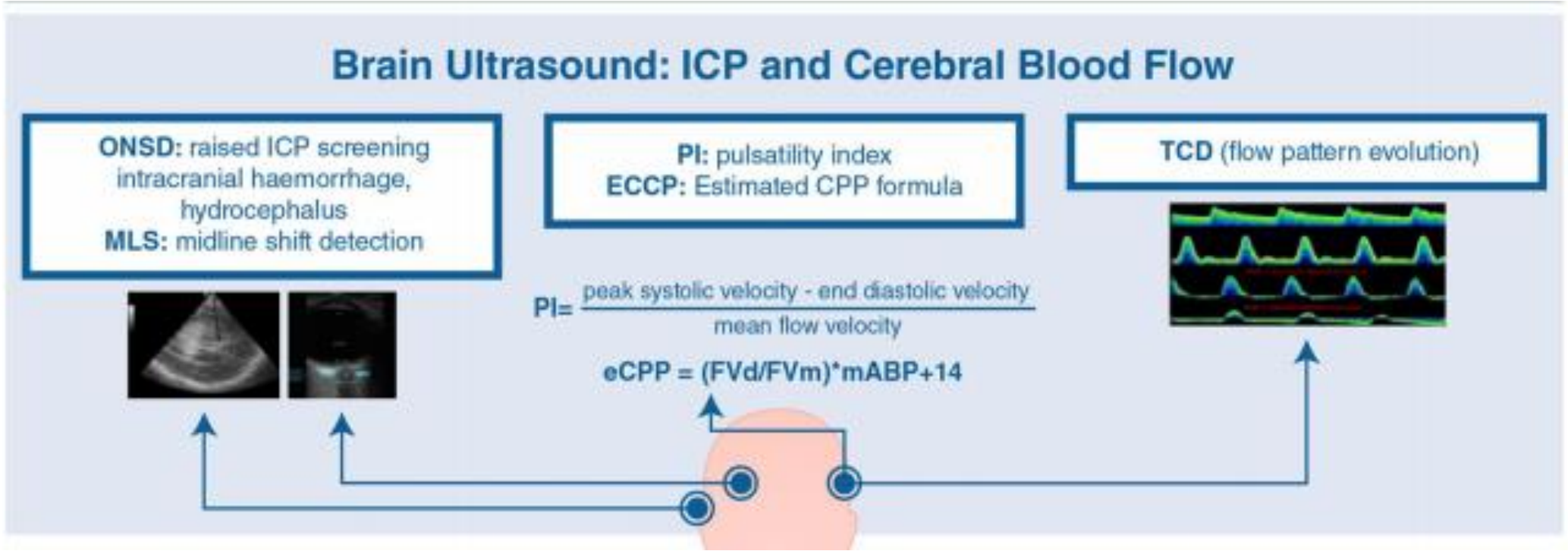
Austere or resource limited environments

Patients on therapeutic anticoagulation or significant coagulopathy/thrombocytopenia

- Cerebral venous sinus thrombosis
- Hepatic encephalopathy
- Neurotoxicity related to chemotherapeutic agents

Difficult to transport patients

- High ventilator settings impairing use of transport ventilators
- Systemic instability due to high need of vasopressors
- ExtraCorporeal Membrane Oxygenation (ECMO)
- High-Frequency Oscillator mechanical ventilation (HFO)
- Intra-Aortic Balloon Pump (IABP)
- Continuous Renal Replacement Therapy



Robba, C., Goffi, A., Geeraerts, T. et al. Intensive Care Med (2019) 45: 913.

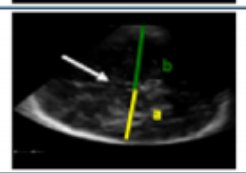
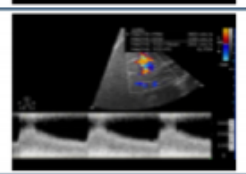
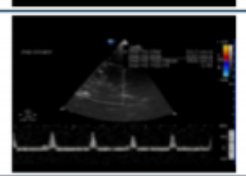
Hydrocephalus		Marked dilated third (white line) and lateral ventricles (green lines)
Subdural haemorrhage		Subdural temporal hyperechoic collection (white arrow) in patient with TBI and neurological deterioration
Intracranial haemorrhage		Right-sided intracranial hyperechoic area consistent with haemorrhage (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.

Fig. 3 Clinical applications of brain ultrasonography in neurocritical care

Robba, C., Goffi, A., Geeraerts, T. et al. Intensive Care Med (2019) 45: 913.

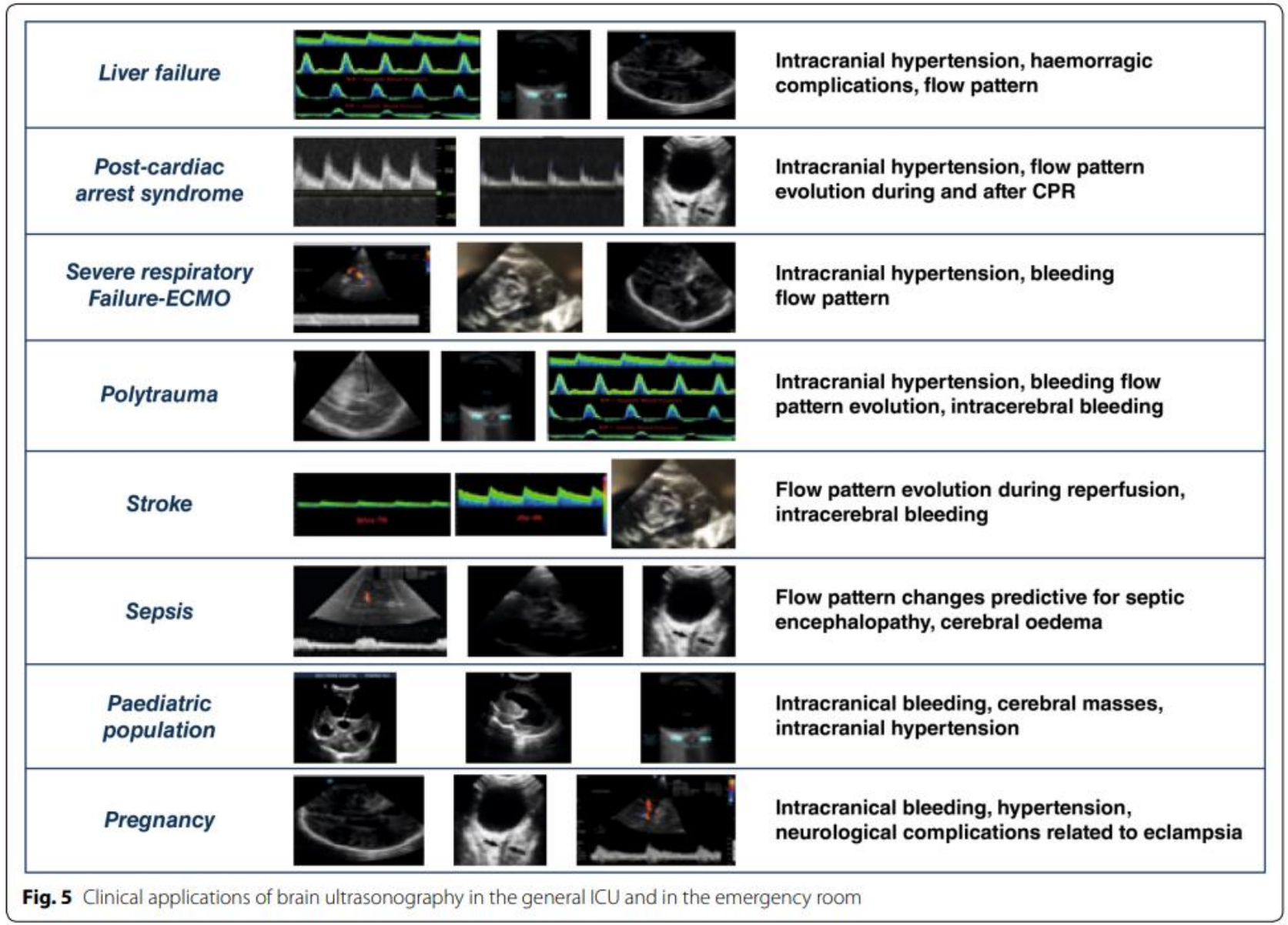
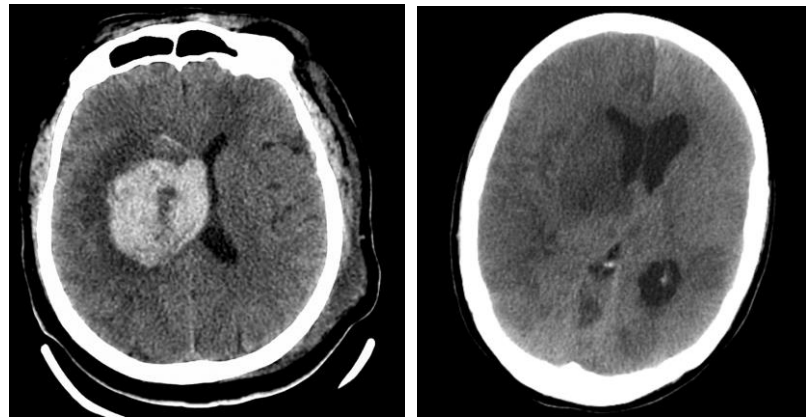


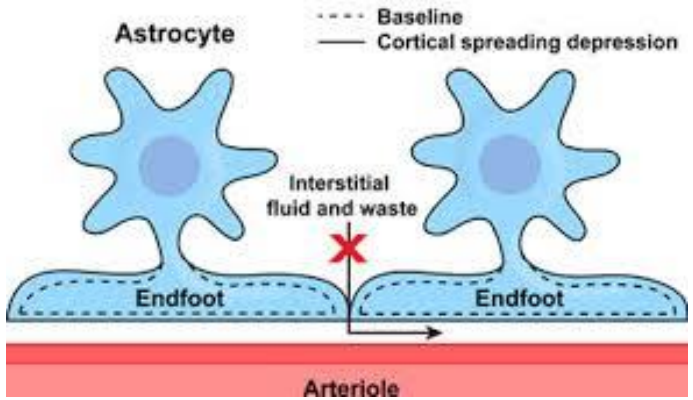
Fig. 5 Clinical applications of brain ultrasonography in the general ICU and in the emergency room

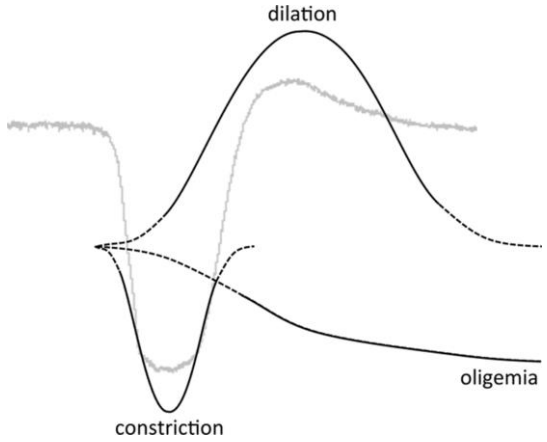
Robba, C., Goffi, A., Geeraerts, T. et al. Intensive Care Med (2019) 45: 913.

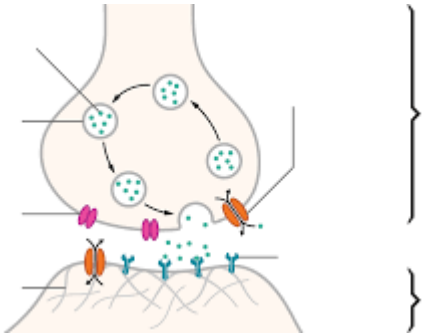
Multimodality assessment

- Electric
- Plumbing
- Chemicals
- Structure

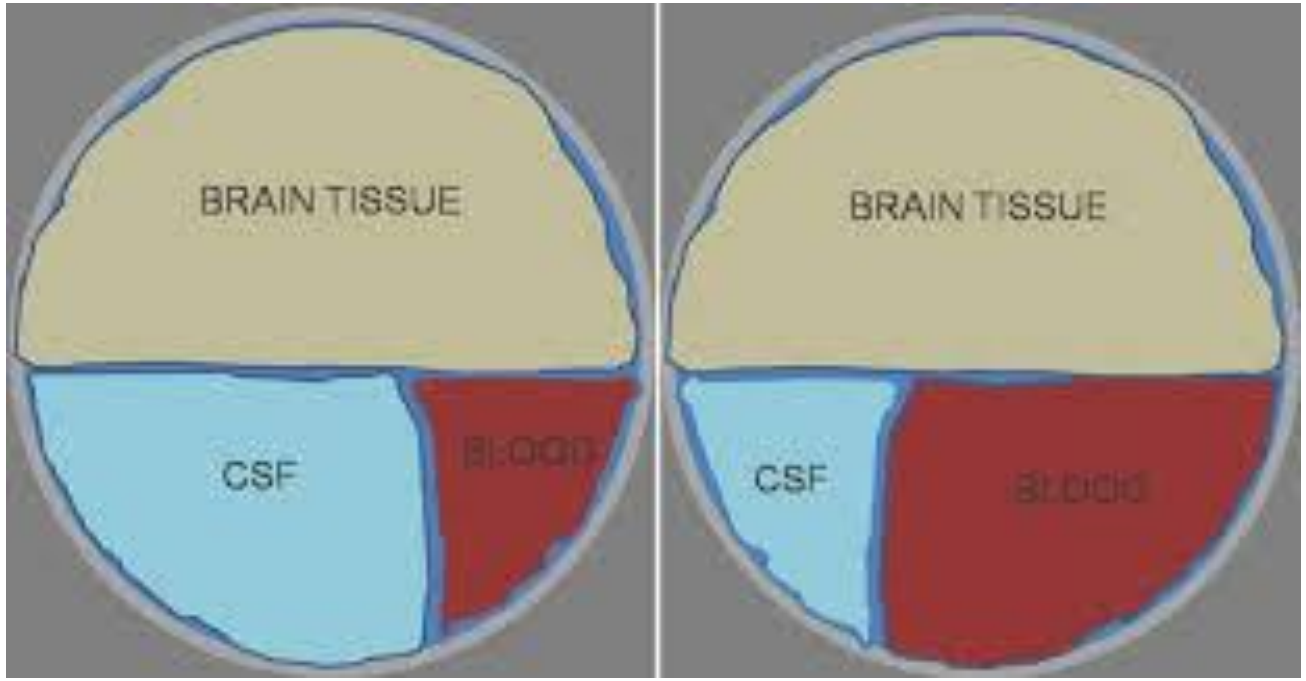




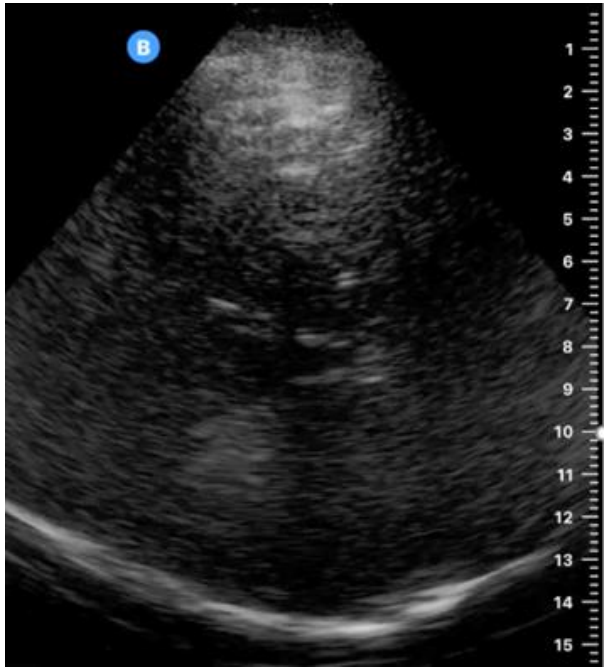


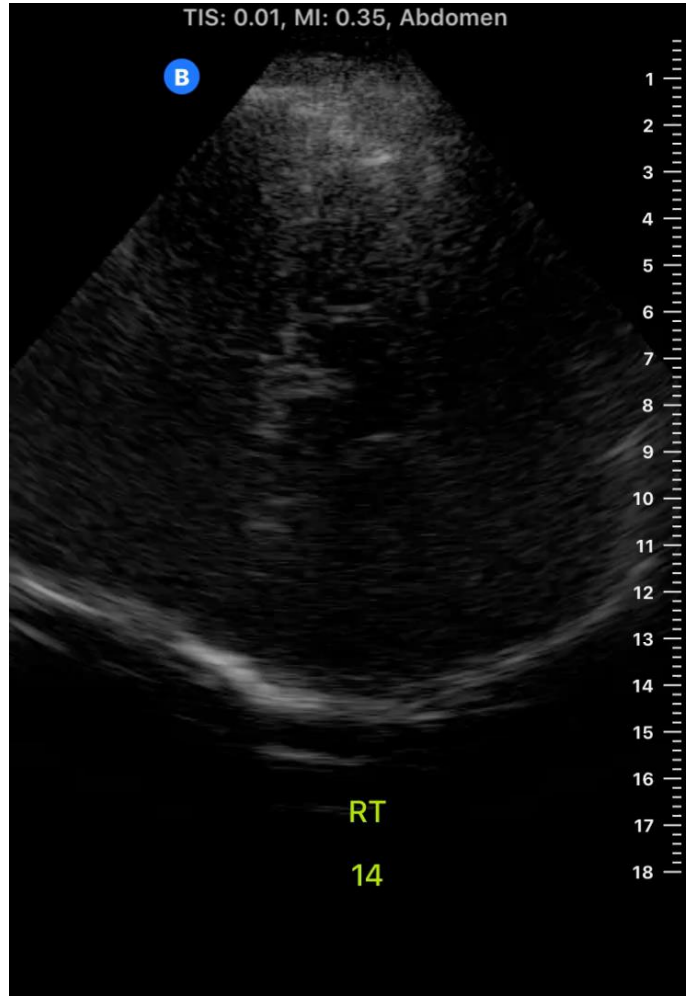


Brain-Monroe Kelly Hypothesis

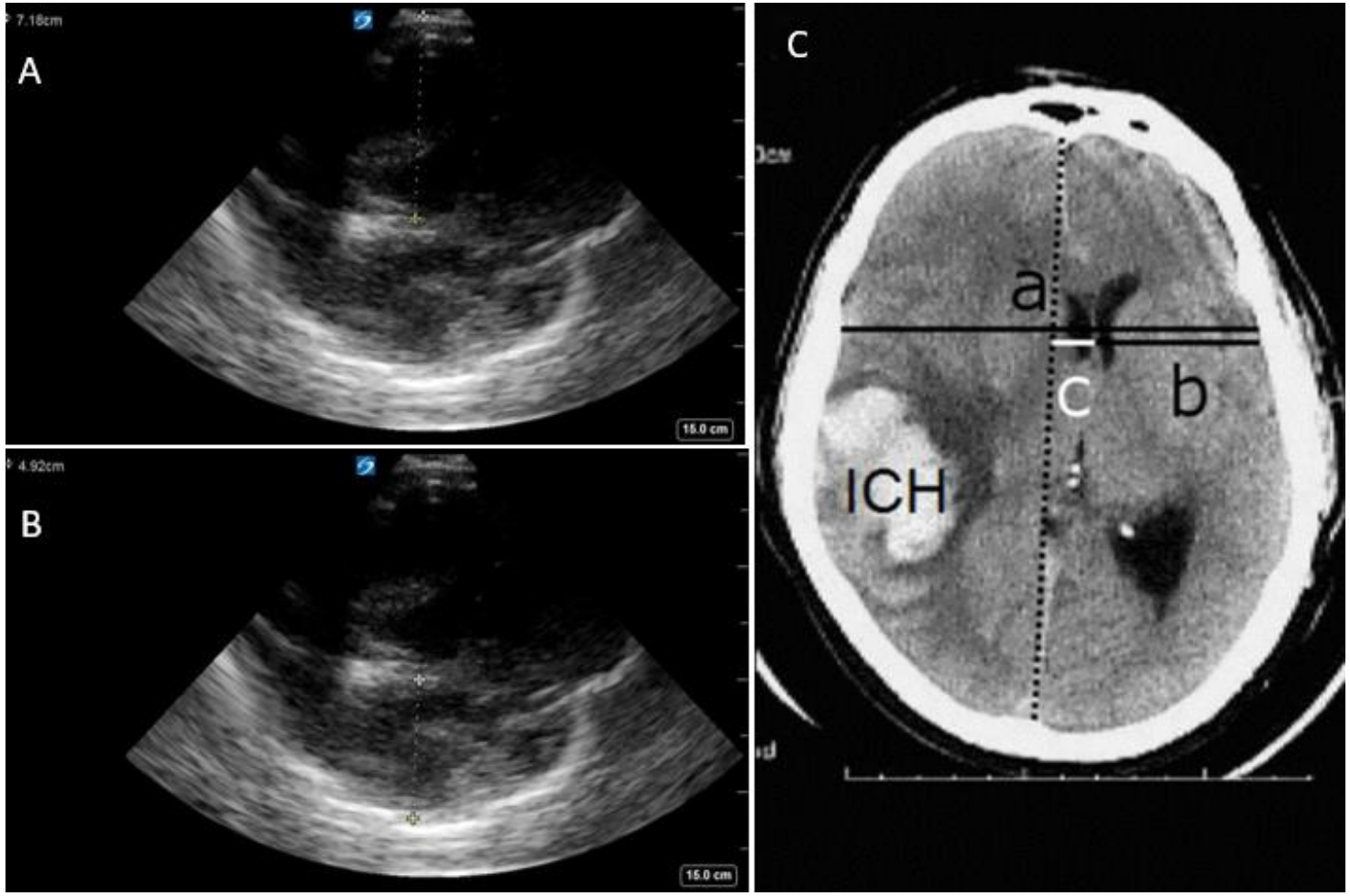


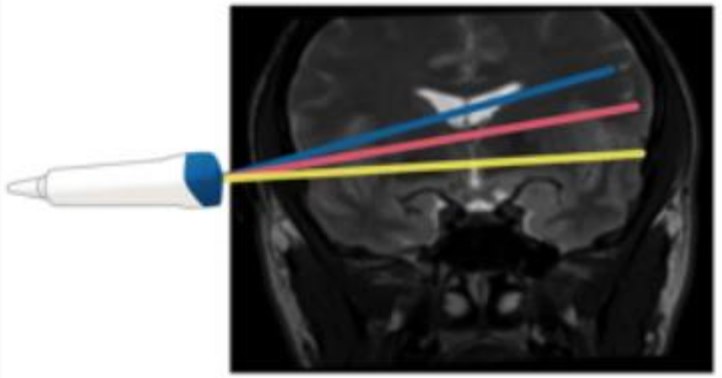
Brain tissue-hemorrhage

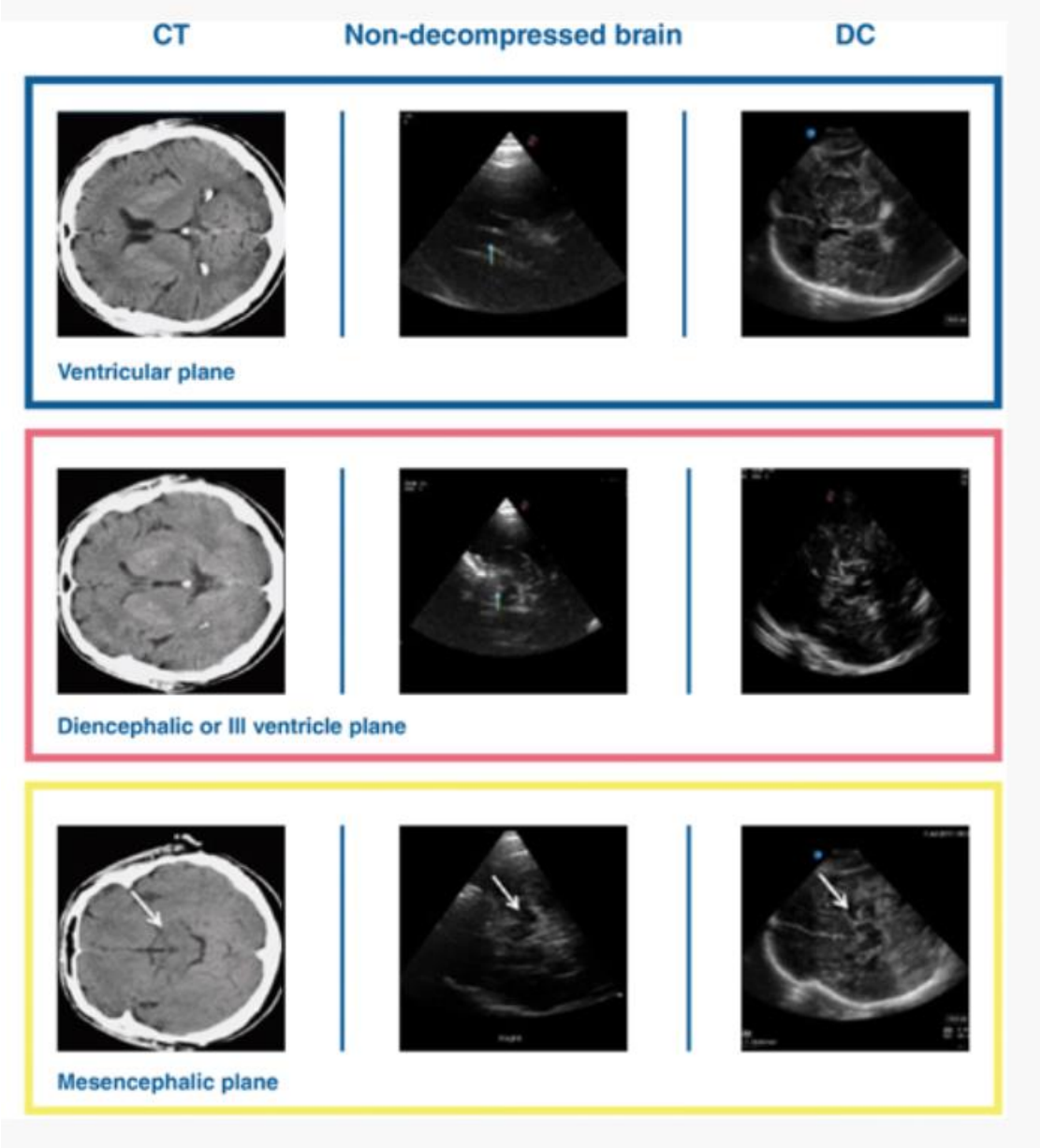




Brain tissue edema-Midline shift

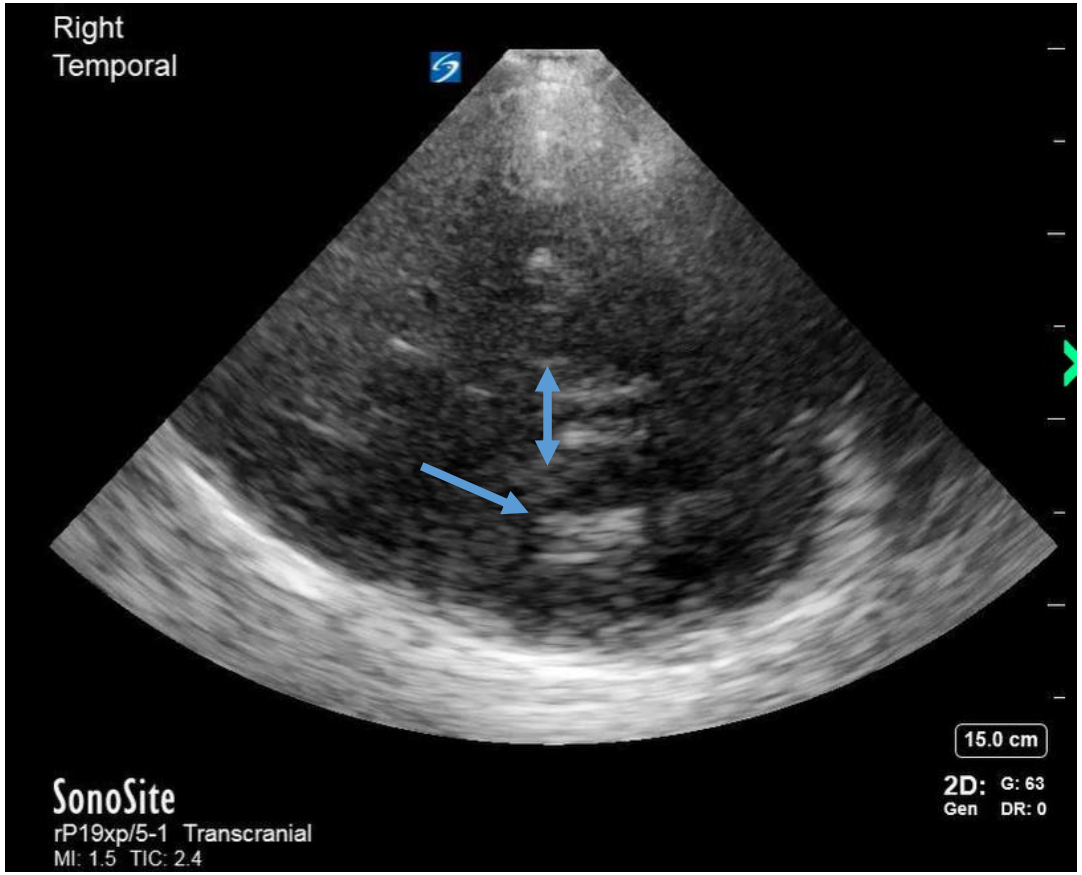






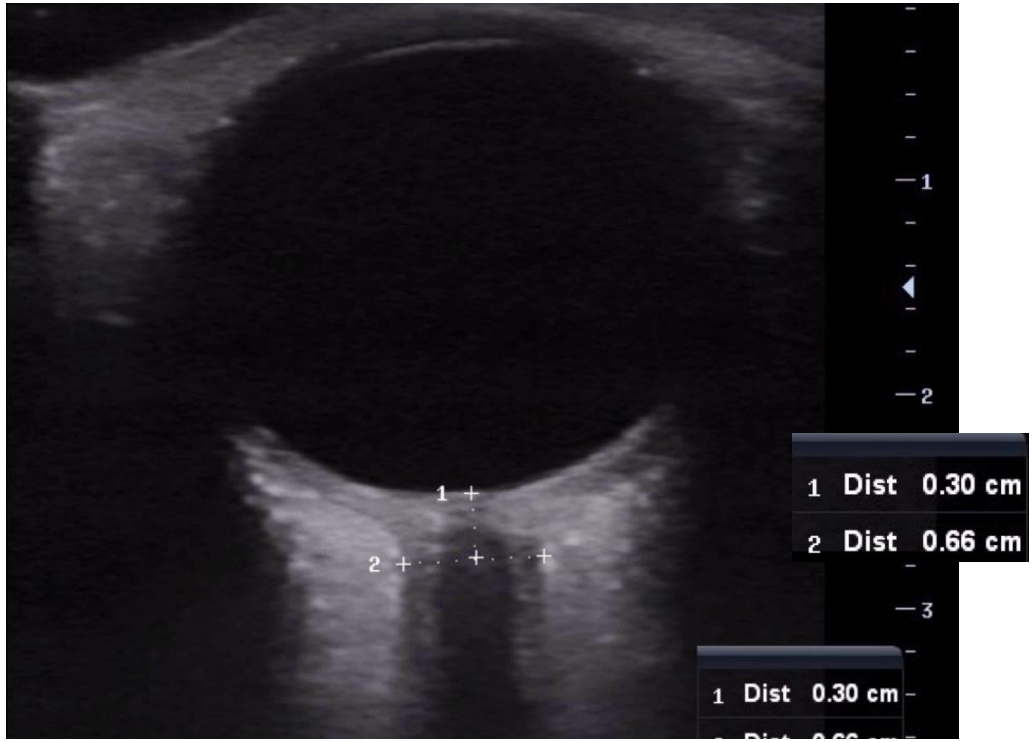
Robba, C., Goffi, A., Geeraerts, T. et al. Intensive Care Med (2019) 45: 913.

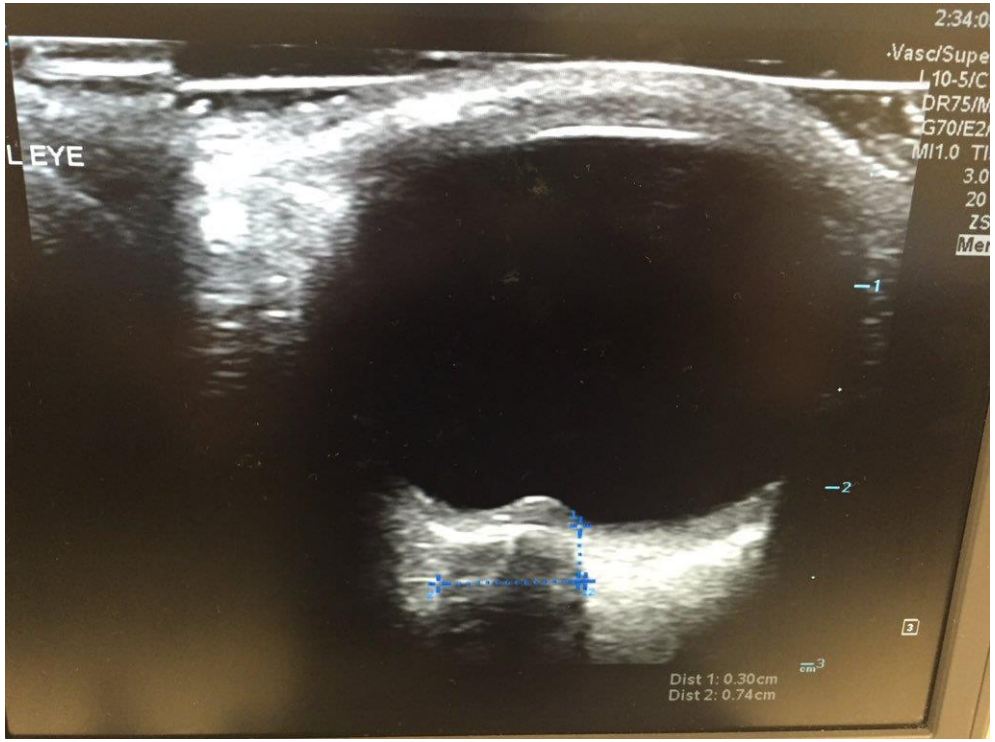
CSF -hydrocephalus



Optic disc bulge-Crescent sign

Dilated Optic Nerve Sheath





Intensive Care Med (2018) 44:1284–1294
https://doi.org/10.1007/s00134-018-5305-7

SYSTEMATIC REVIEW

Optic nerve sheath diameter measured sonographically as non-invasive estimator of intracranial pressure: a systematic review and meta-analysis

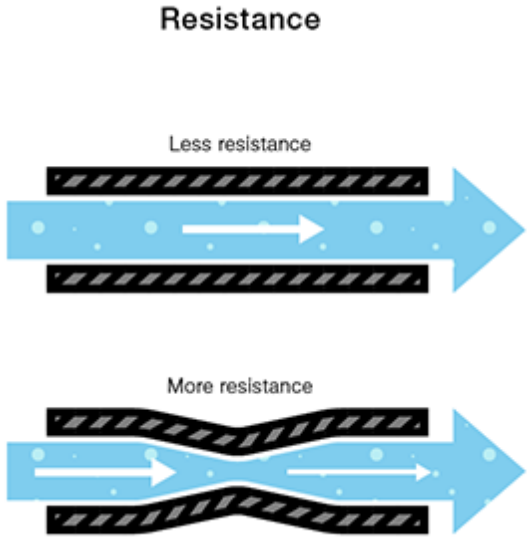
Chiara Robba[1,2*], Gregorio Santori[3], Marek Czosnyka[4,5], Francesco Corradi[6], Nicola Bragazzi[7], Llewellyn Padayachy[8], Fabio Silvio Taccone[9] and Giuseppe Citerio[10]

Study	Description of US for ONSD	Probe	Skills described
Jeon et al. 2017	Temporal part of the closed upper eyelid, with coupling gel, two measurements on each eye in transverse plane	ProSound Alpha 6, Hitachi Medical Corp., Tokyo, Japan 13 MHz US probe	Two investigators with more than 17 examinations
Robba et al. 2017	3 mm behind the retina in both eyes patients in supine position The final ONSD value was calculated by averaging four measured values	11L4, Xario 200; Toshiba; Zoetermeer, The Netherlands 7.5-MHz linear probe	Three experienced operators
del Saz-Saucedo et al. 2016	3 mm behind the lamina cribrosa, patient in supine position, three measurements on each eye	Toshiba AplioXG US system 4.8–11-MHz linear probe	One single operator with 10 years of experience
Rajajee et al. 2011	3 mm behind the retina, three measurements on each eye	Sonosite™ M-Turbo (SonoSite Inc., Bothell, WA, USA) 6–13-MHz linear probe	One operator with 3 years of experience, and one operator with 2 months of experience
Moretti and Pizzi 2009	3 mm behind the globe, patients in supine position, two measurements on each eye	Hitachi EUB 405, Hitachi Medical Corp., Tokyo, Japan 7.5-MHz linear probe	Two experienced operators
Kimberly et al. 2008	3 mm posterior to the orbit, patients in supine position, three measurements on each eye	Sonosite™ Micromax (Sonosite Inc., Bothell, WA, USA) 5–10-MHz linear probe	Two experienced operators
Geeraerts et al. 2007	3 mm behind the globe, supine position, two measurements for each eye (sagittal and transverse planes)	HP Sonos 5550, Hewlett Packard, Les Ulis, France 7.5-MHz linear probe	Two investigators trained in ocular pathology

US ultrasonography, *ONSD* optic nerve sheath diameter

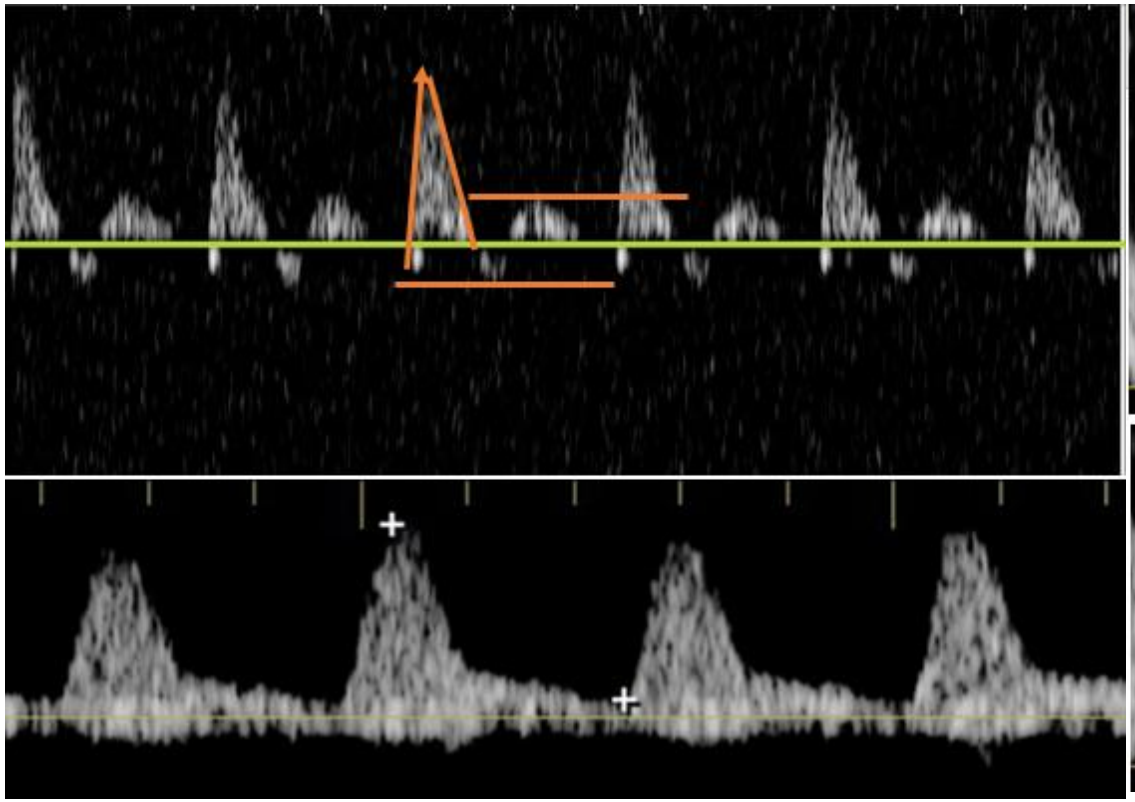
Blood- Resistance

	Resistance of the cerebral vessels	Resistance of the distal vascular bed
Increased	Intracranial stenosis, cerebral vasospasm Vasoconstriction	Increased intracranial pressure Distal atherosclerotic disease.
Decreased	Arteriovenous shunting	Peripheral vasodilatation Hypercarbia, acidosis Reperfusion of ischemic brain

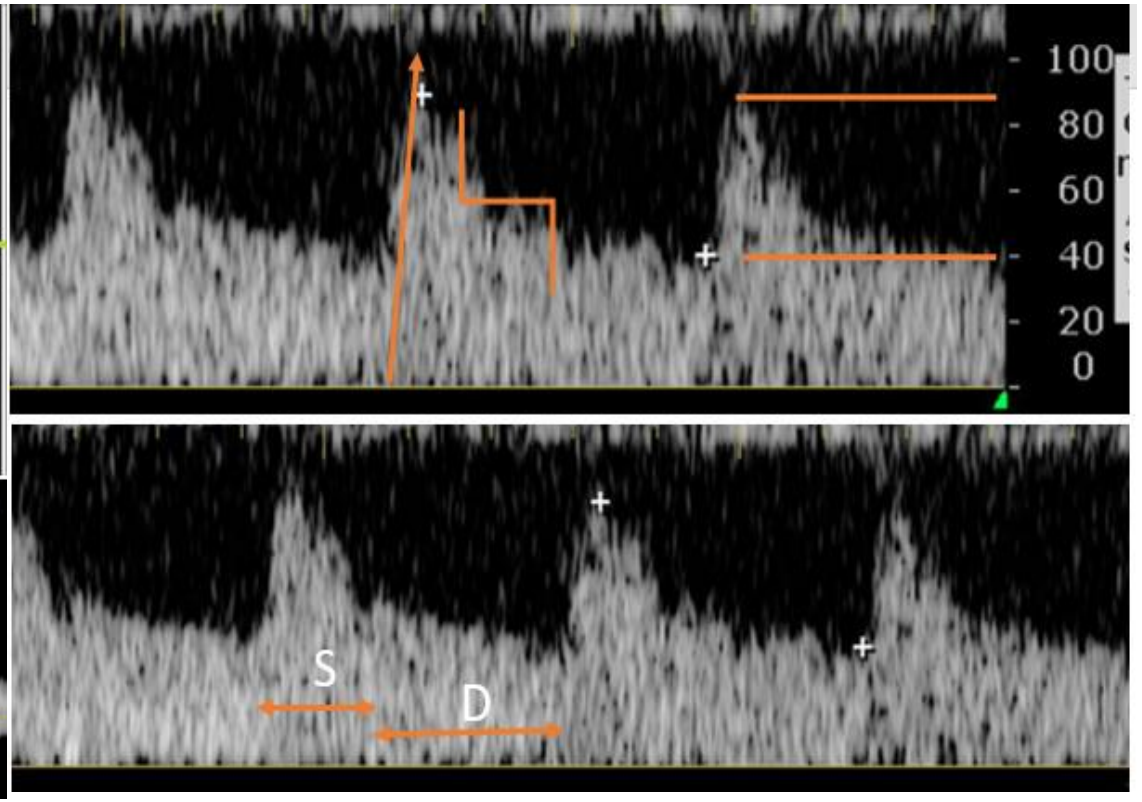


Blood Resistance

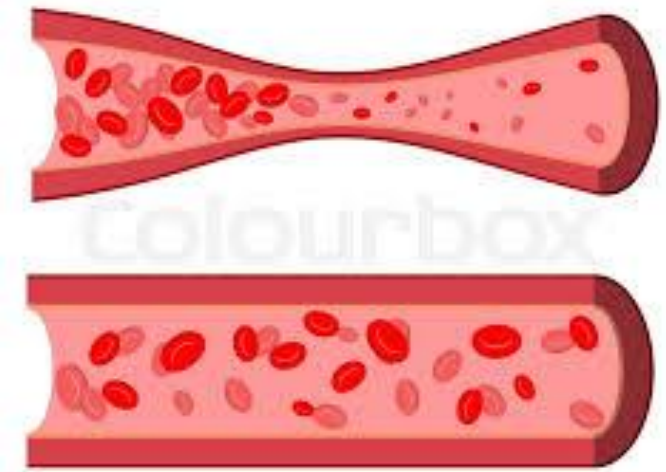
High resistance circulation

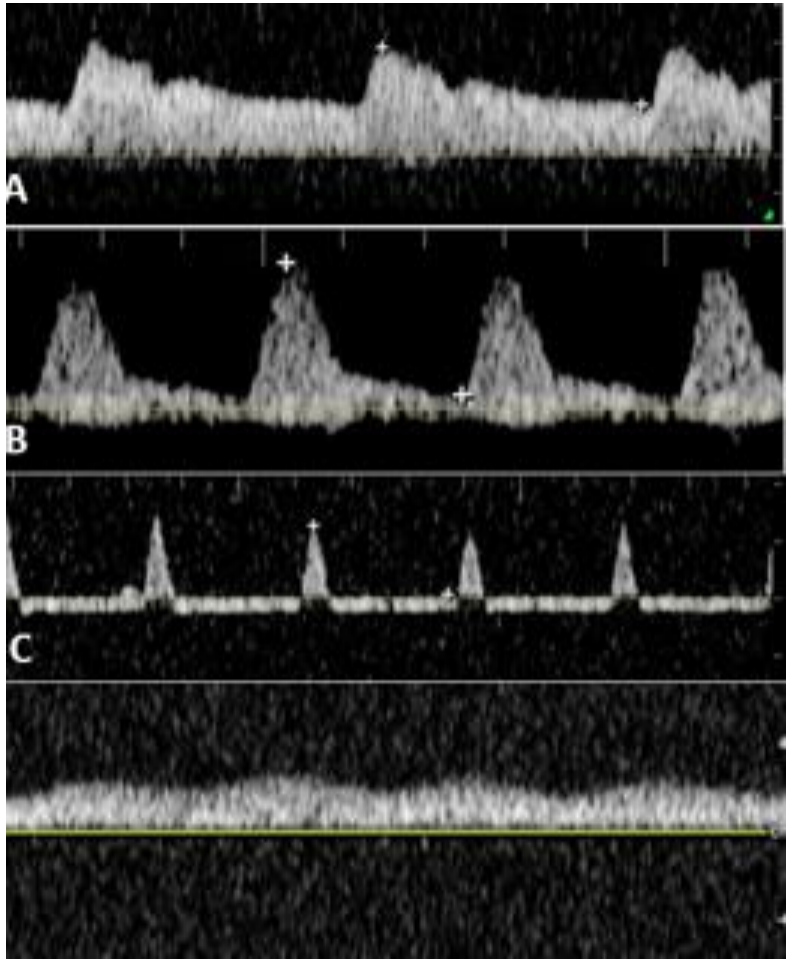


Low resistance circulation



Resistance focal increase





Value despite CTA, MRI in stroke

- 25 of 198 acute stroke patients admitted in 2017 underwent TCD and/or CUS after having CTA head and neck during their hospital admission

The Clinical Contribution of Neurovascular Ultrasonography in Acute Ischemic Stroke

Jonathan R. Gomez, Kyle S. Hobbs, Leilani L. Johnson, Quang D. Vu, John Bennett, Charles Tegeler, Stacey Q. Wolfe, and Aarti Sarwal

Table 3. Results of Review by Two Vascular-Trained Neurologists to Determine Whether Ultrasound added Clinical Information to Management Decisions Despite Having CTA Results

	tPA patients DSA	tPA patients No DSA	No tPA DSA	No tPA No DSA	Totals
Ultrasound changed management after CTA	4	4	2	0	10
No change in management after ultrasound	1	10	3	1	15
Totals	5	14	5	1	

The numbers reflect cases where consensus was reached. A third expert (AS) was used to reach consensus in cases of disagreement using a nominal group process. tPA = tissue plasminogen activator; DSA = digital subtraction angiogram; CTA = computed tomography angiogram.

Table 4. Notable Abnormalities Found on Neurovascular Ultrasound

Most notable abnormalities that were determined to have impacted management

1. Detection of mobile thrombus requiring anticoagulation;
2. Distinguishing carotid near occlusion from occlusion;
3. Confirming hemodynamic significance of intra/extracranial stenosis helping emergent stenting/endarterectomy;
4. Detecting hyperperfusion/hyperperfusion on TCDs inciting workup for noncerebrovascular etiology;
5. Establishing chronicity of carotid stenosis based on collateral flow patterns, especially in patients with no known history or prior medical evaluation.

Most notable abnormalities that did not affect immediate clinical management

1. Anterior circulation velocity asymmetry;
2. Waveform patterns consistent with known CTA findings of intracranial stenosis;
3. Incidental vertebral steal phenomena.

Value despite CTA, MRI in stroke

- 86 patients 2012-2015- CTA, TCD, MRI
- Patients already studied with CTA, TCD during the acute period provide
    - additional useful information in 1 out of 2 patients
    - changes in management are indicated in 1 out of 6 cases.
- The most frequent additional information was
    - **collateral pathways**
    - information related to patency of vessels
    - active microembolization

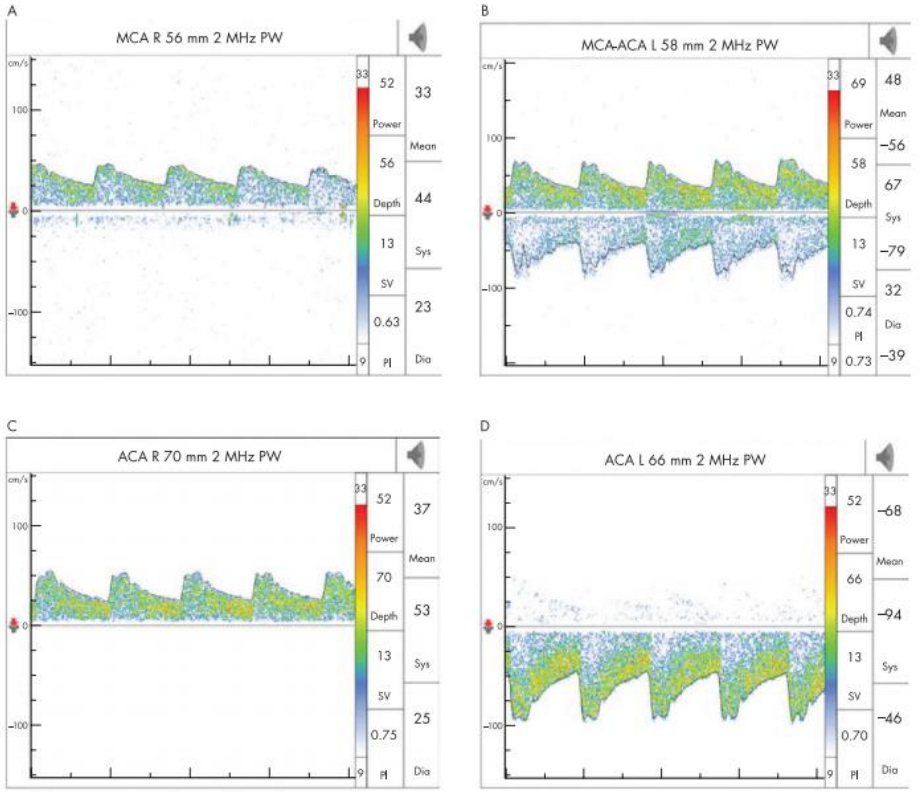
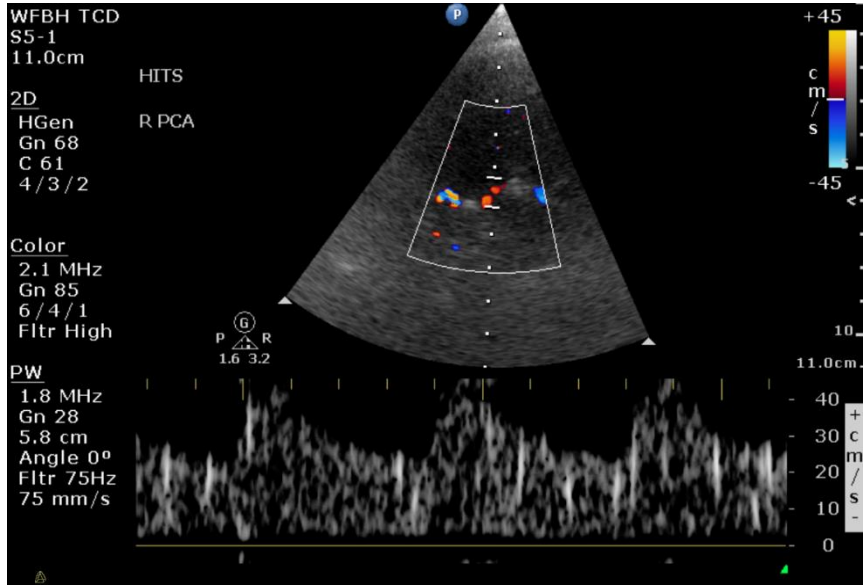


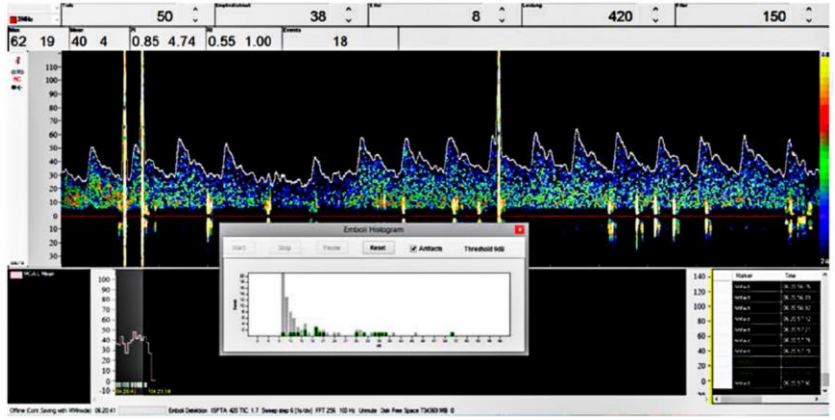
Figure 5 Effect of extracranial internal carotid artery (ICA) stenosis on cerebral haemodynamics (patient had high grade stenosis of proximal right ICA). (A) Decrease in mean flow velocity of right (ipsilateral) middle cerebral artery (MCA). (B) Normal flow in left (contralateral) MCA with increased flow in left (contralateral) anterior cerebral artery (ACA) (due to collateral flow). (C) Reversal of flow in right (ipsilateral) ACA. (D) Increased flow in left (contralateral) ACA.

The Role of TCD in the Evaluation of Acute Stroke. J Neuroimaging 2016;26:420-425.

Emboli monitoring

- Coronary artery bypass
- Carotid endarterectomy
- Cerebral angiograms
- ECMO
- Infective endocarditis





Embolic Signals during Routine Transcranial Doppler Ultrasonography in Aneurysmal Subarachnoid Hemorrhage

Fernando Mendes Paschoal Jr., Karla de Almeida Lins Ronconi, Marcelo de Lima Oliveira, Ricardo de Carvalho Nogueira, Eric Homero Albuquerque Paschoal, Manoel Jacobsen Teixeira, Eberval Gadelha Figueiredo, and Edson Bor-Seng-Shu

Cerebral Microemboli During Coronary Artery Bypass Using Different Cardioplegia Techniques

Andrew J. Baker, MD, Basem Naser, MBBS, Mark Benaroia, and C. David Mazer, MD

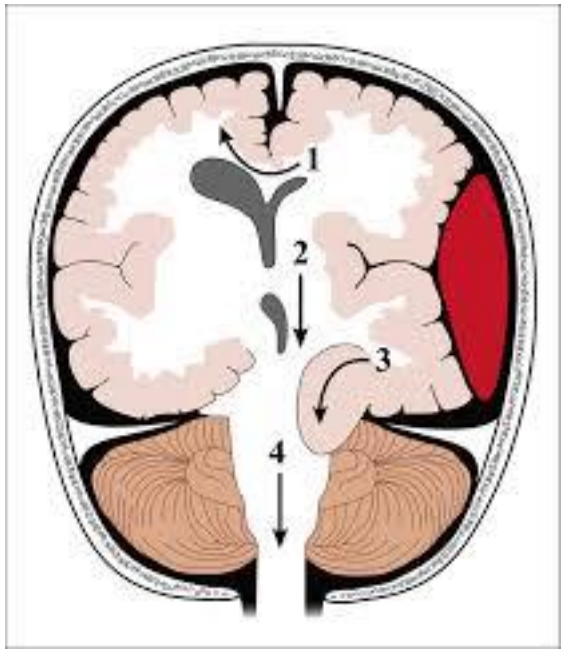
Department of Anaesthesia, St. Michael's Hospital, University of Toronto, Toronto, Ontario, Canada

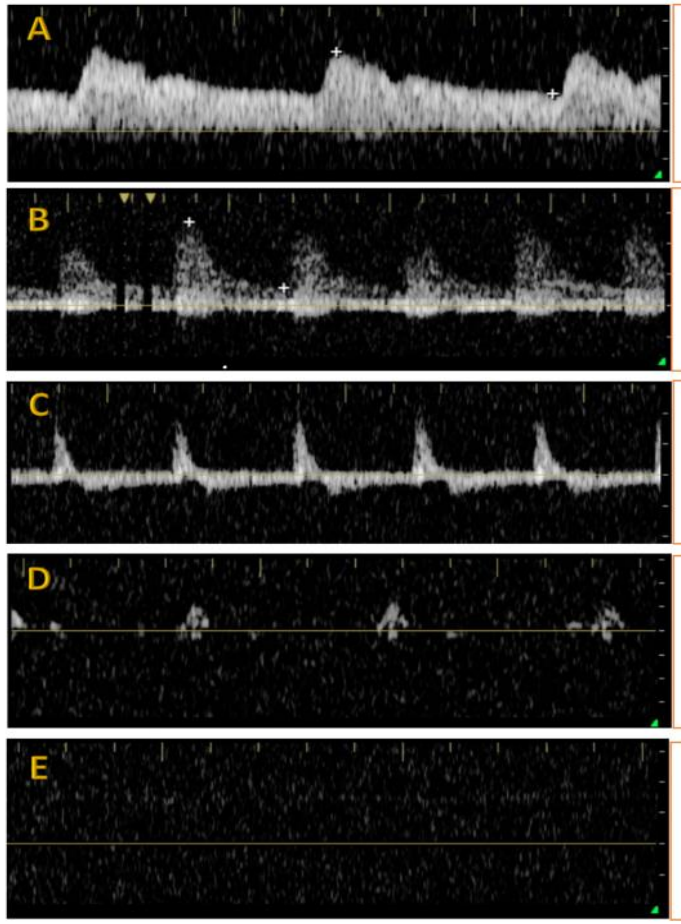
Transcranial Doppler Emboli Monitoring for Infective Endocarditis

Glen Huang, Leilani L. Johnson, James E. Peacock Jr., Charles Tegeler, Kyle Davis, Aarti Sarwal

From the Department of Internal Medicine, University of California Los Angeles, Los Angeles, CA (GH); Department of Neurology, Wake Forest Baptist Medical Center, Winston-Salem, NC (LLJ, CT, AS); Department of Internal Medicine, Wake Forest Baptist Medical Center, Winston-Salem, NC (JJP); and Department of Pharmacy, Wake Forest Baptist Medical Center, Winston-Salem, NC (KD).

Resistance global increase





Normal arterial waveform
ICP significantly lower than diastolic BP

High resistance waveforms
ICP is elevated but lower than diastolic BP

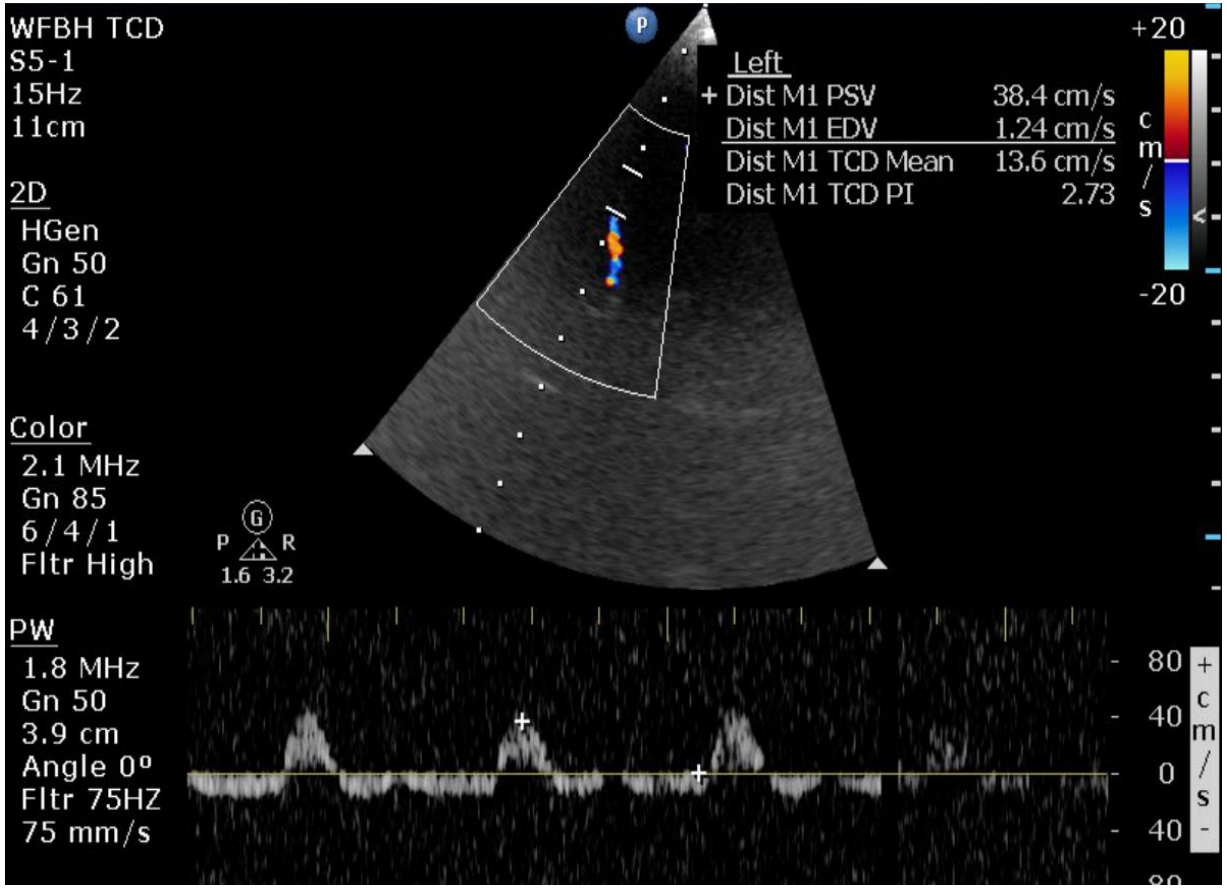
Oscillating waveforms with reversed diastolic flow
ICP is elevated compared to diastolic BP but lower than systolic BP

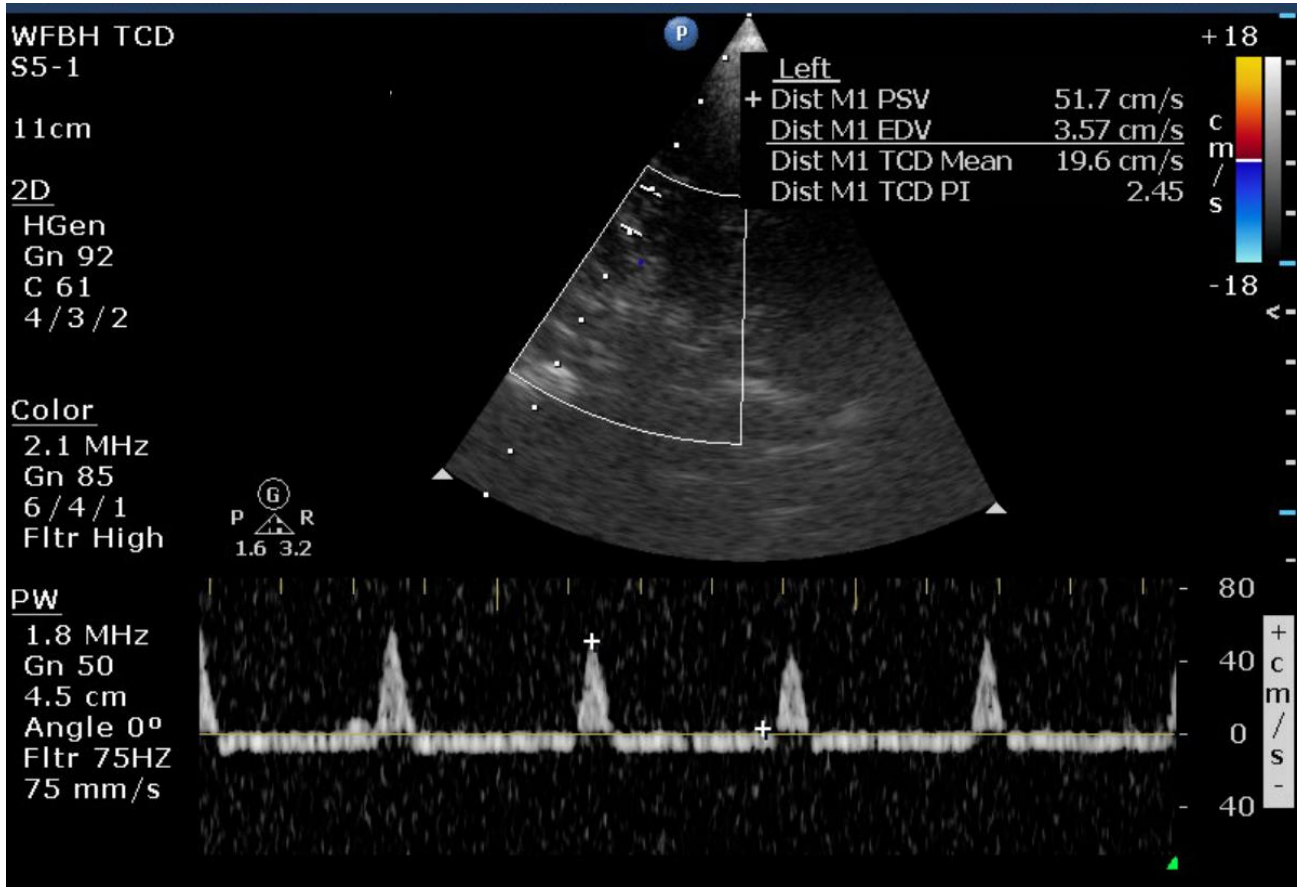
Systolic spikes
ICP is significantly elevated compared to systolic BP

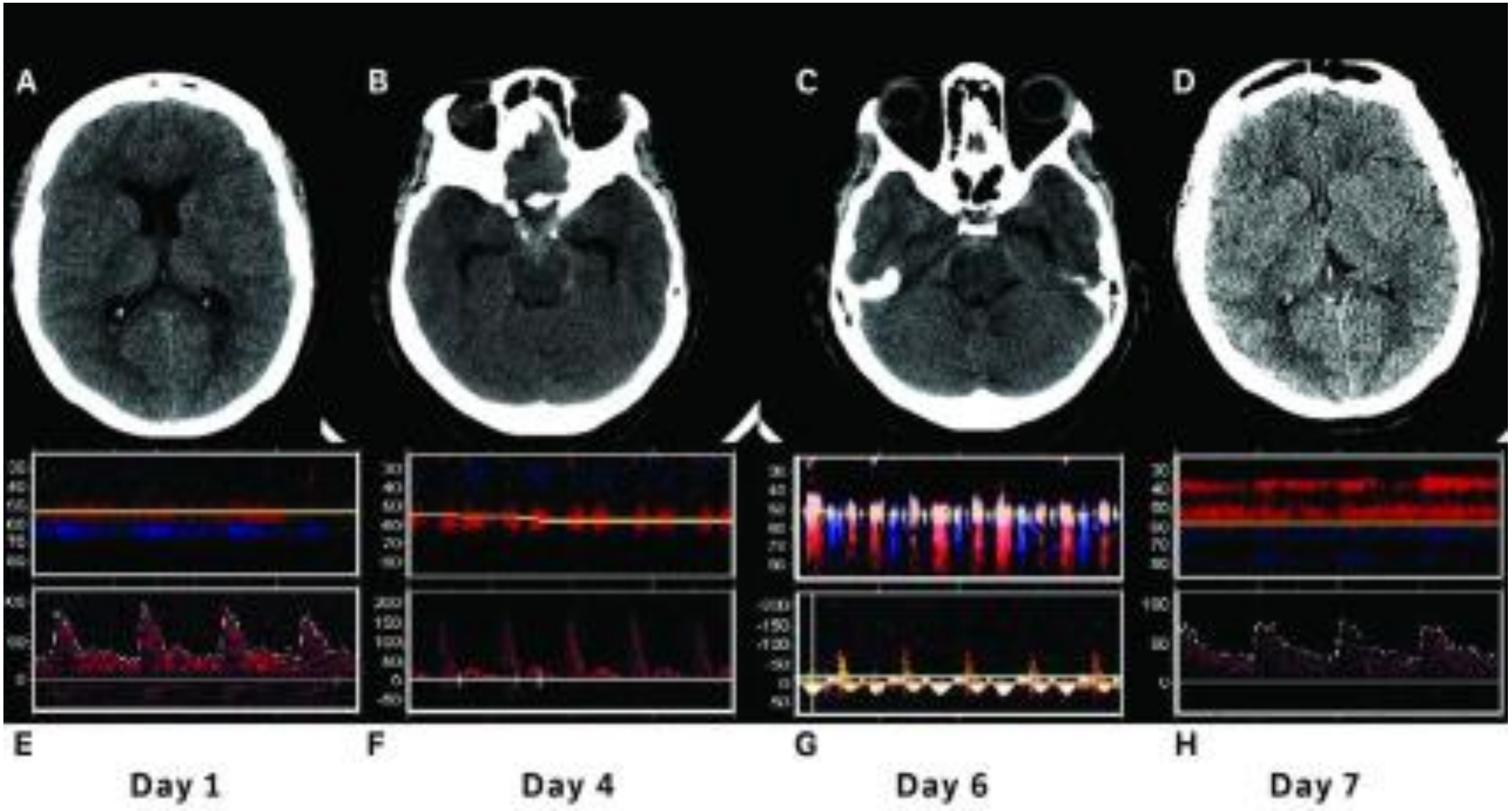
No flow visualized

Progressive increase in intracranial pressure

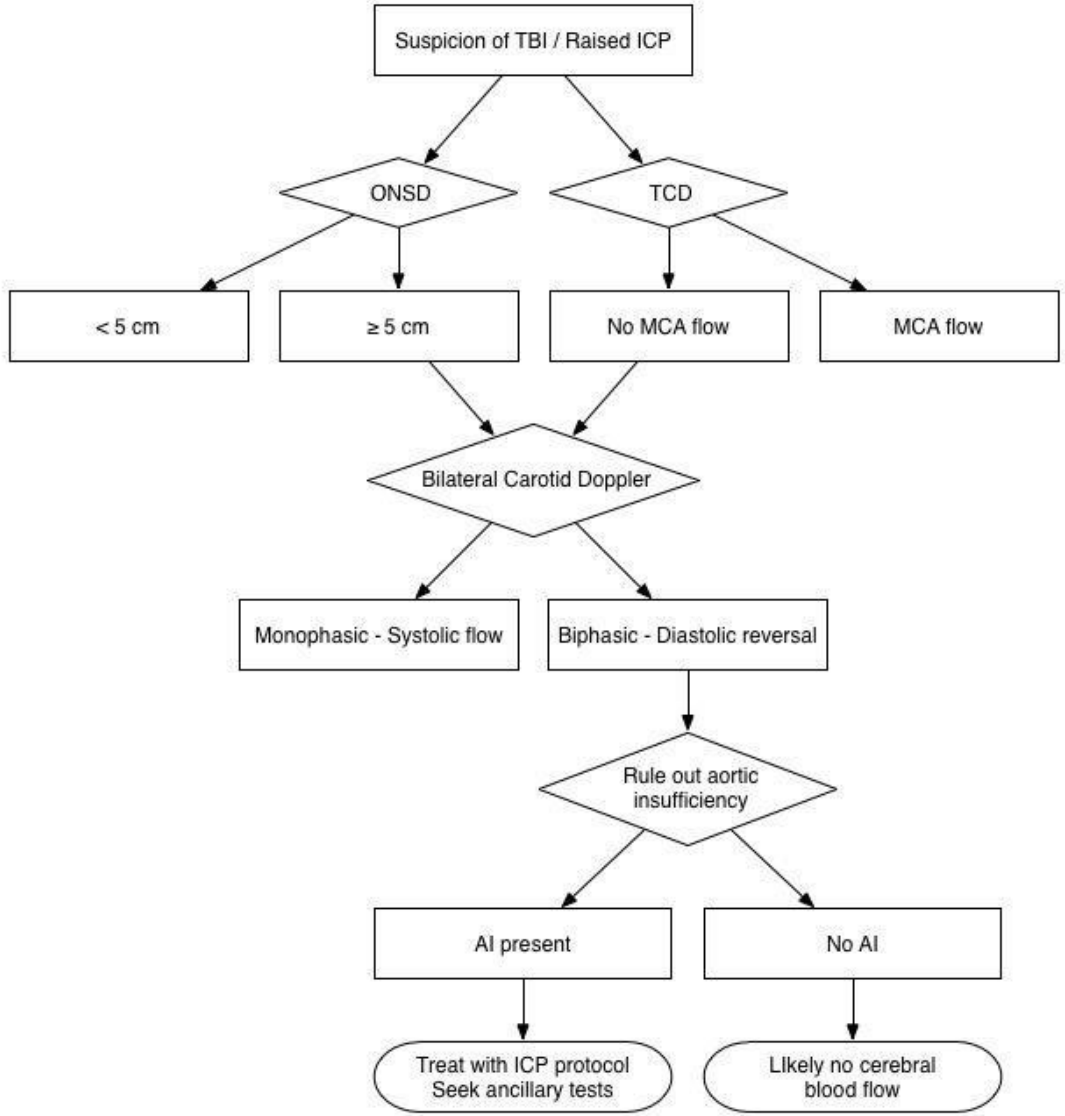
Case study


WFBH TCD
S5-1
15Hz
11cm
2D
HGen
Gn 50
C 61
4/3/2
Color
2.1 MHz
Gn 85
6/4/1
Fltr High
PW
1.8 MHz
Gn 50
3.9 cm
Angle 0°
Fltr 75HZ
75 mm/s
Left
+ Dist M1 PSV 38.4 cm/s
Dist M1 EDV 1.24 cm/s
Dist M1 TCD Mean 13.6 cm/s
Dist M1 TCD PI 2.73
+20
-20
cm/s
80
40
0
40
+ cm/s -


WFBH TCD
S5-1
11cm
2D
HGen
Gn 92
C 61
4/3/2
Color
2.1 MHz
Gn 85
6/4/1
Fltr High
PW
1.8 MHz
Gn 50
4.5 cm
Angle 0°
Fltr 75HZ
75 mm/s
Left
+ Dist M1 PSV 51.7 cm/s
Dist M1 EDV 3.57 cm/s
Dist M1 TCD Mean 19.6 cm/s
Dist M1 TCD PI 2.45
+18
-18
cm/s
80
40
0
40
+ cm/s -



Journal of Ultrasound in Medicine
Volume 34, Issue 8, pages 1345-1350, 1 AUG 2015 DOI: 10.7863/ultra.34.8.1345
http://onlinelibrary.wiley.com/doi/10.7863/ultra.34.8.1345/full#jum20153481345-fig-0002

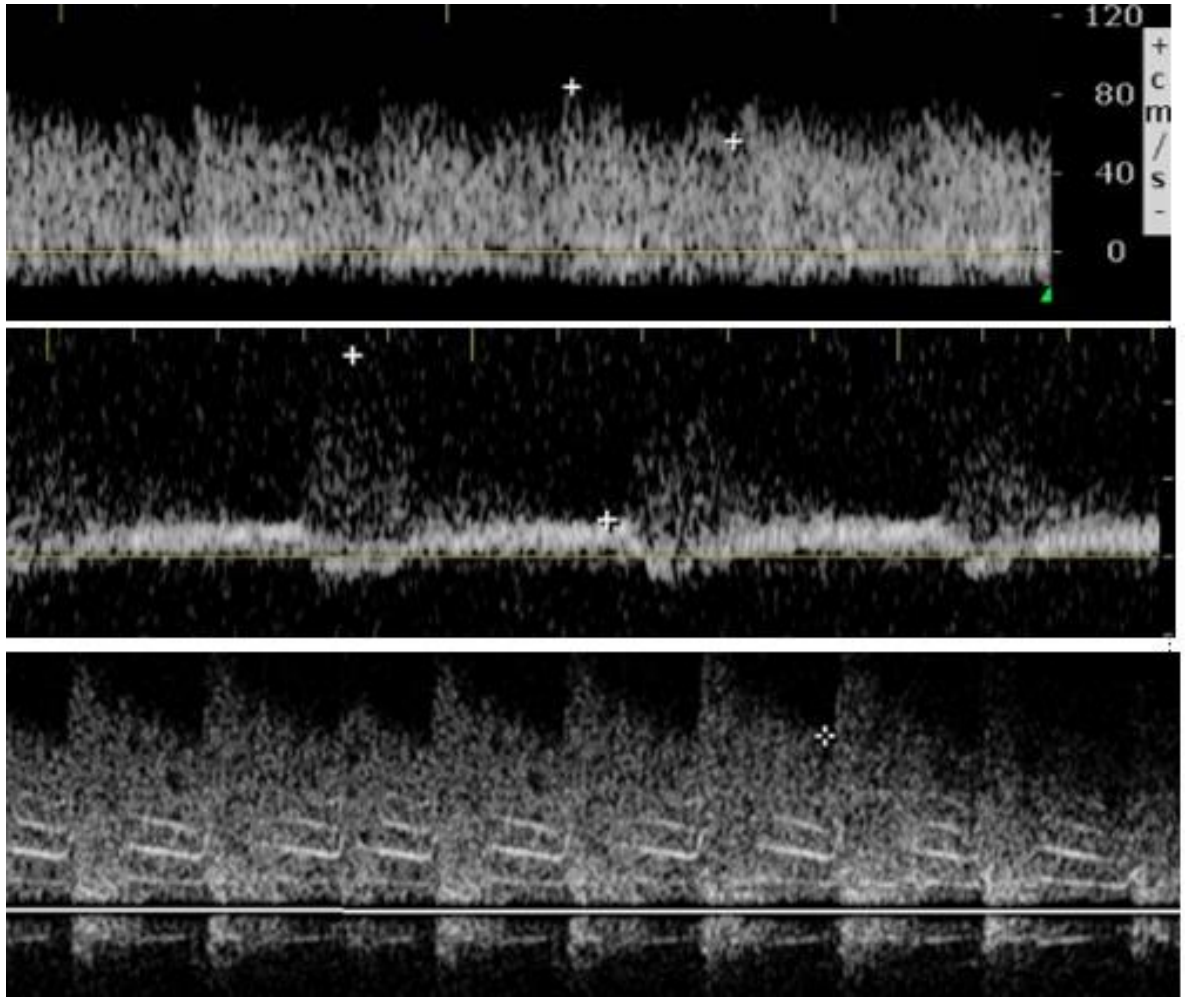


Sample TBI / Raised ICP POCUS Algorithm v 0.1

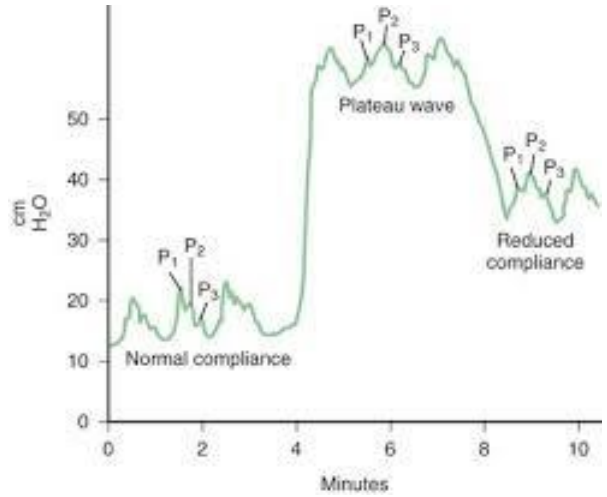
Taylor Zhou

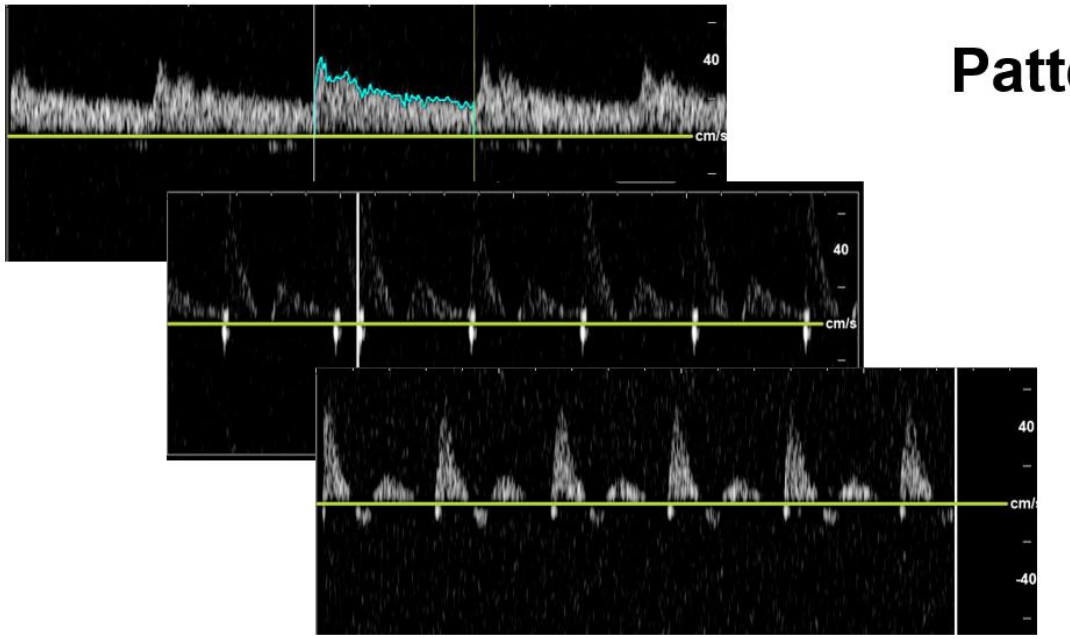
Resistance grades

- Hyperemia vs high resistance
- Post arrest resuscitation
  - presence of a hyperemic TCD pattern is associated with evolution to intracranial hypertension- *Med Intensiva 2010*
  - higher PI resulting from reduced DFV predicted unfavorable outcome- *Resuscitation.* 2019
  - Pollock et al
  - Cohan et al

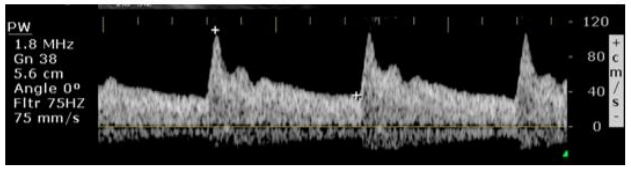


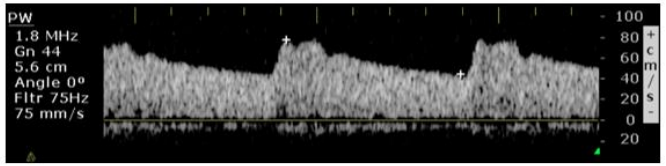
Brain Compliance affecting blood



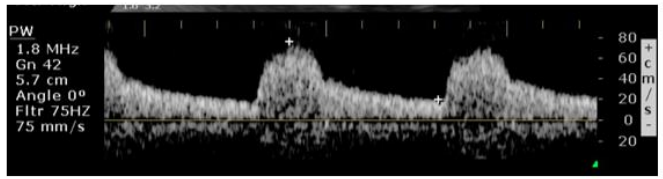


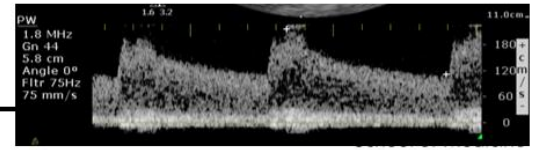
Pattern 1

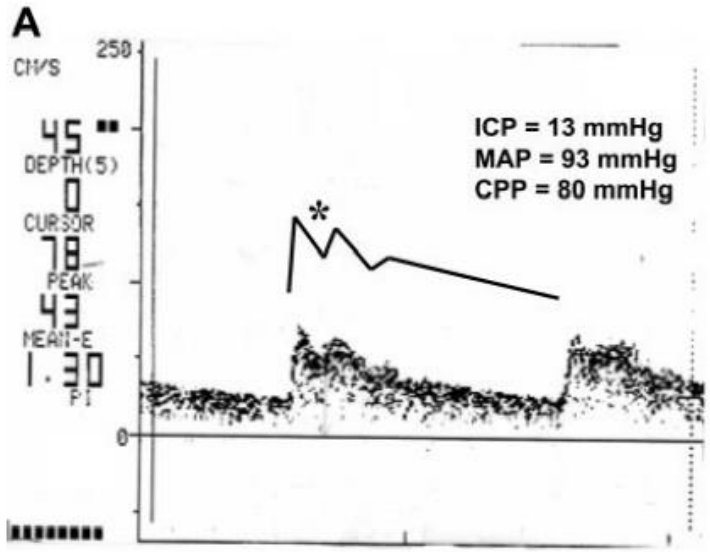


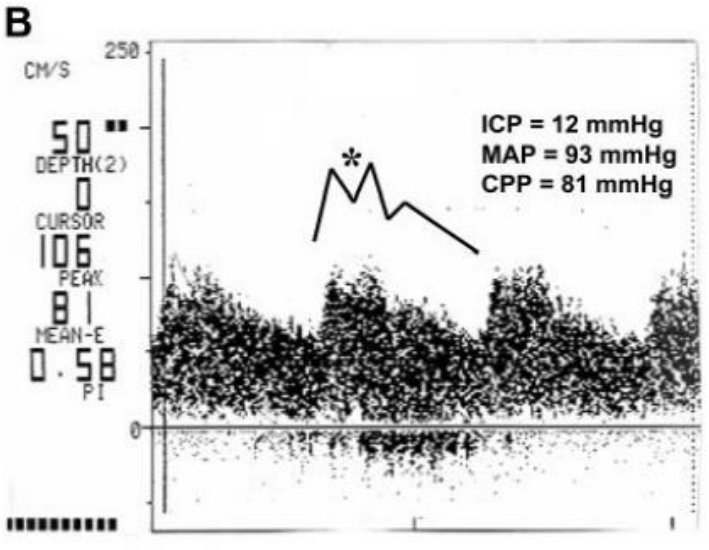


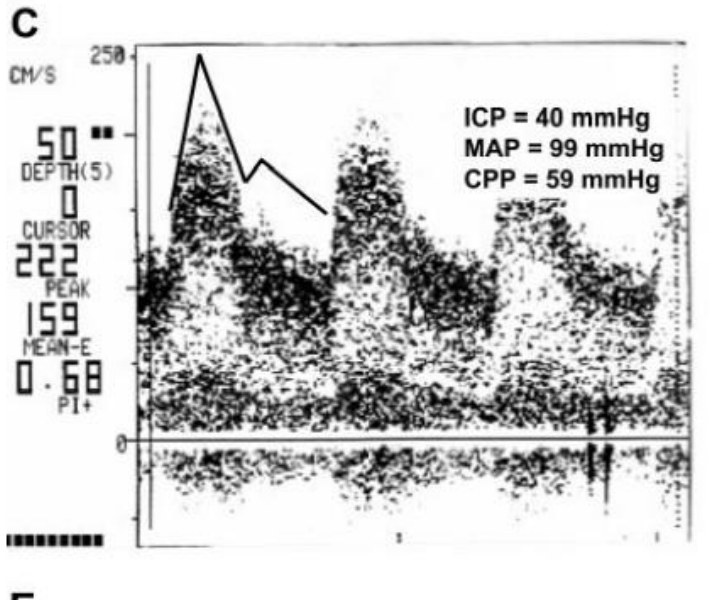
Pattern 2

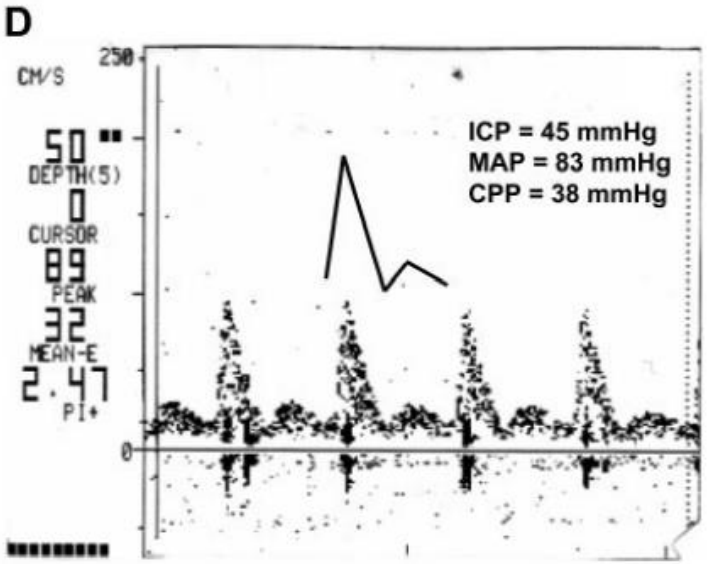


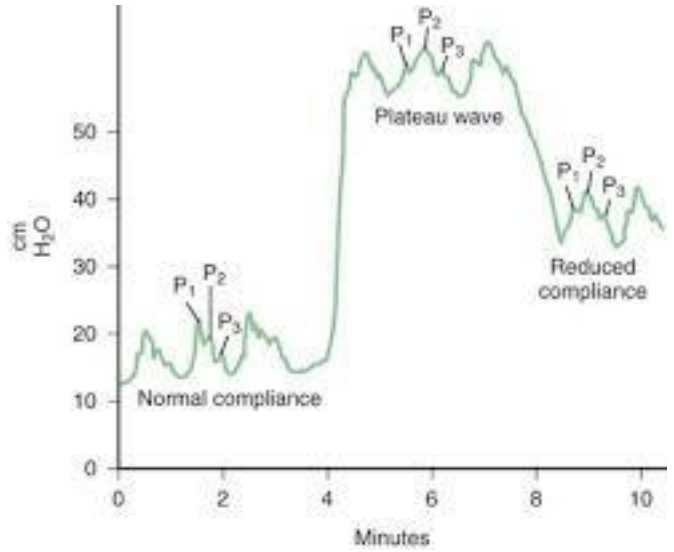


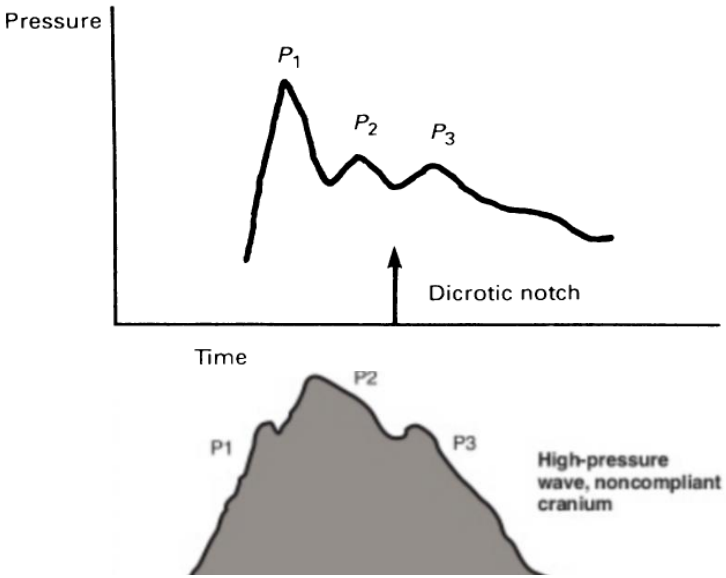












Liver Transpl 14:1048-1057, 2008

Brain Blood Interactions

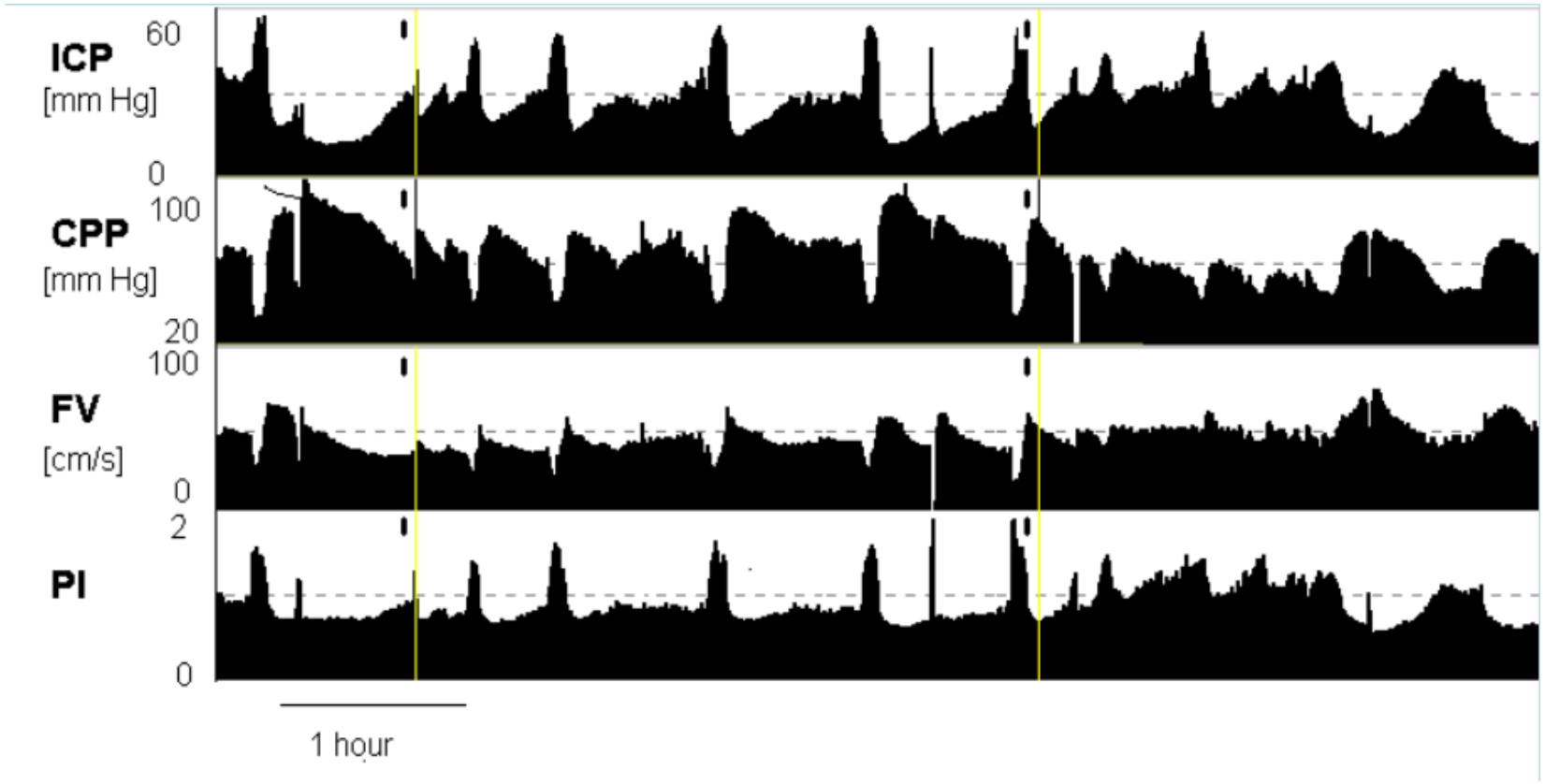
Serial assessment of resistance

Pulsatility index

PSV-EDV

Mean

Prognostic value explored in TBI and post arrest ROSC



CPP estimation from TCD

Bellner
nICP= 10.93*(PI) - 1.28

- nICP_Aaslid

$$\mathrm{nCPP} = \mathrm{FVm} * A/F.$$

- nICP_Schmidt

$$\mathrm{nCPP} = \mathrm{MAP} * \frac{\mathrm{FVd}}{\mathrm{FVm}} + 14\ \mathrm{mmHg}$$

- nICP_Edouard

$$\mathrm{nCPP} = \left(\frac{\mathrm{FVm}}{[\mathrm{FVm} - \mathrm{FVd}]}\right) \times (\mathrm{ABPm} - \mathrm{ABPd})$$

- nICP_ CrCP

$$\mathrm{nCPP} = \mathrm{ABP} \times \left[0.734 - \frac{0.266}{\sqrt{(\mathrm{CVR} \times \mathrm{Ca} \times \mathrm{HR} \times 2\pi)^2 + 1}}\right] - 7.026$$

neurocritical care society Neurocrit Care (2016) 25:473–491
DOI 10.1007/s12028-016-0258-6

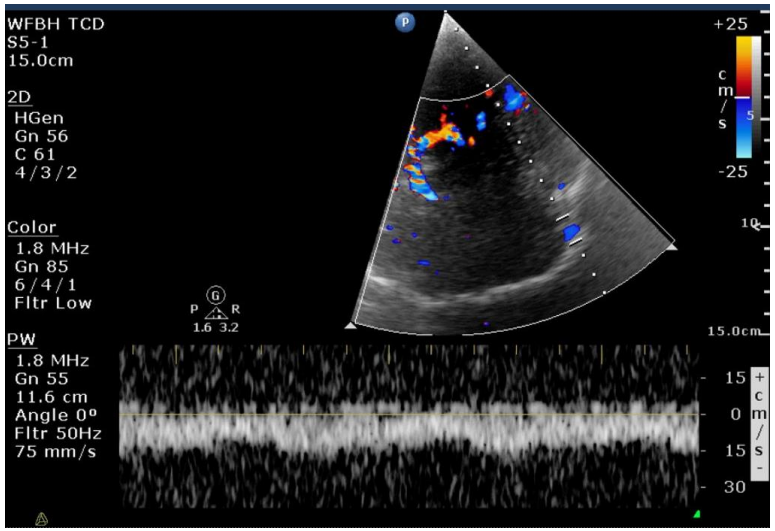
REVIEW ARTICLE

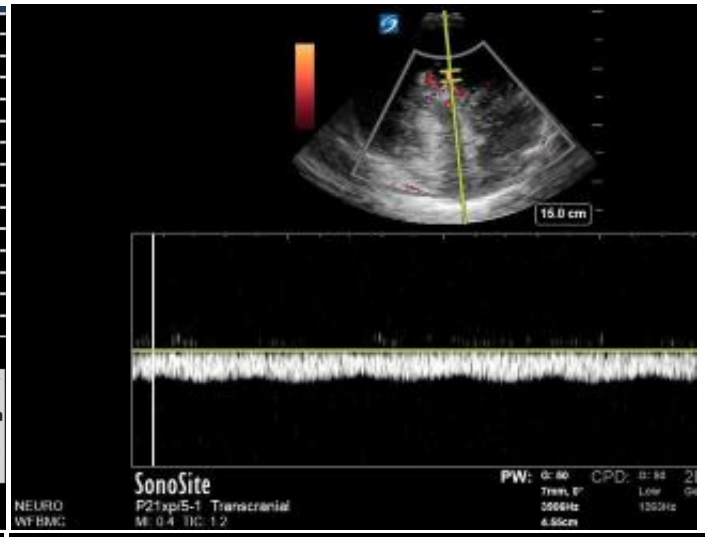
Non-invasive Monitoring of Intracranial Pressure Using Transcranial Doppler Ultrasonography: Is It Possible?

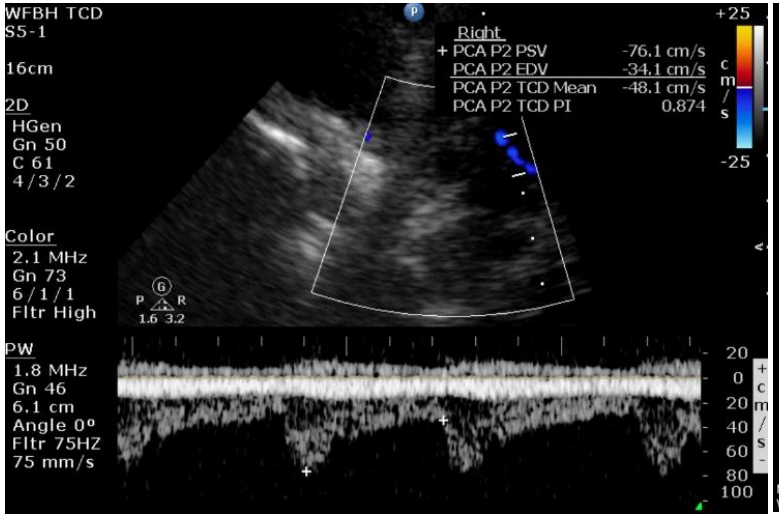
Danilo Cardim[1] · C. Robba[2] · M. Bohdanowicz[3] · J. Donnelly[1] · B. Cabella[1] · X. Liu[1] · M. Cabeleira[1] · P. Smielewski[1] · B. Schmidt[4] · M. Czosnyka[1]

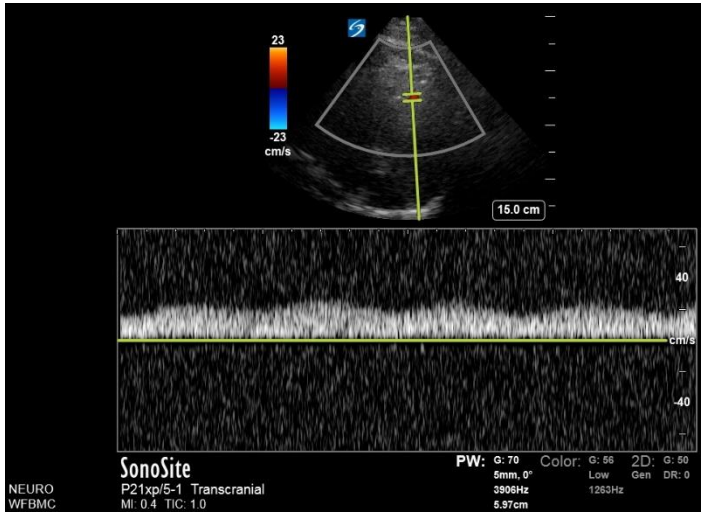
J Neurol Neurosurg Psychiatry 70(2):198–204 Br J Anaesth. 2005;94(2):216–21.

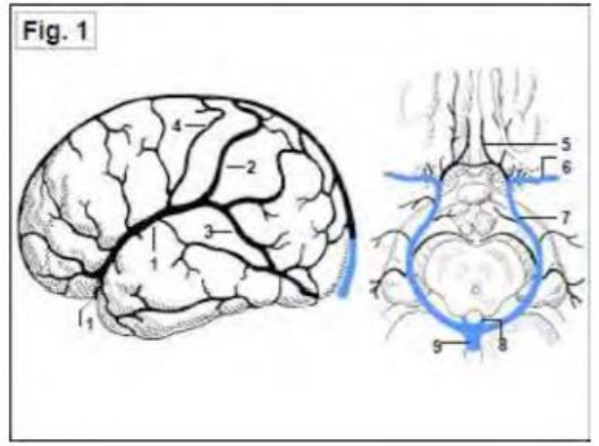
Venous outflow

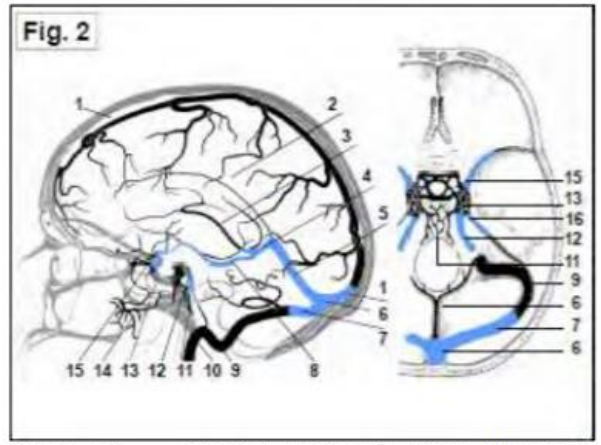






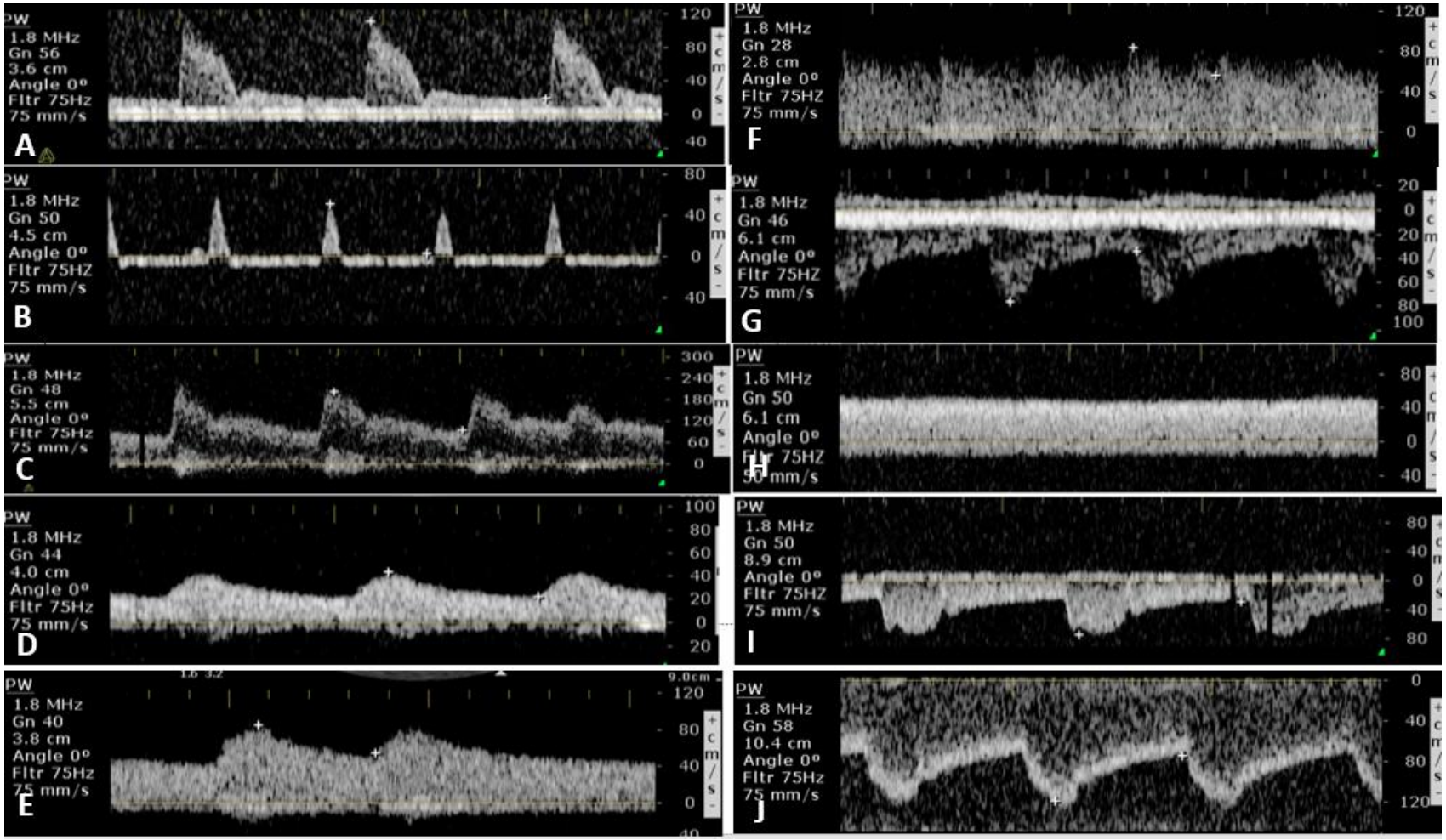




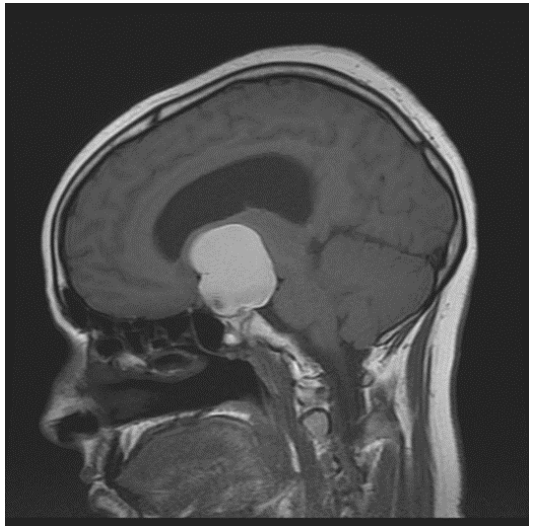


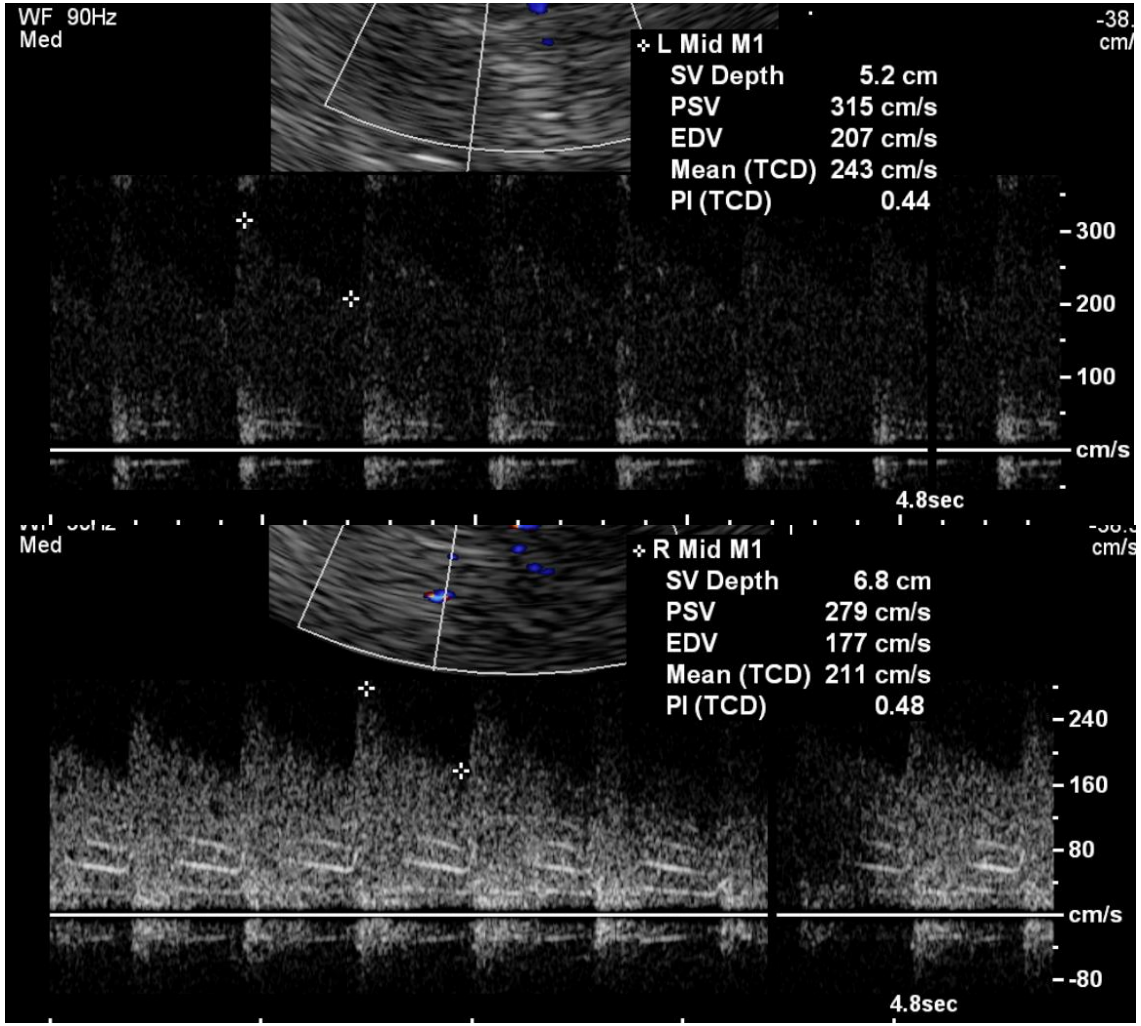
sinus; 16 = superior petrosal sinus. Venous
sonography are shown in blue.

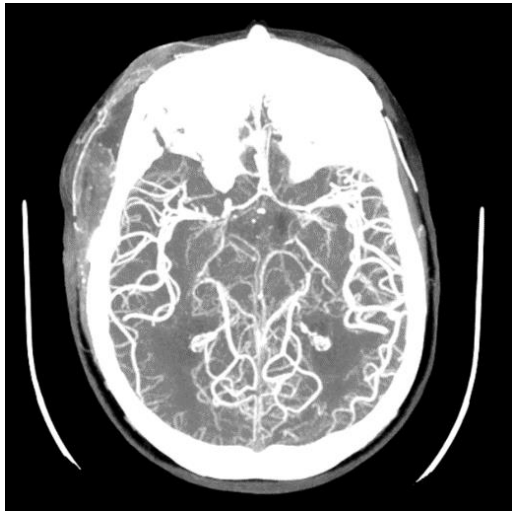
Point of care coma evaluation



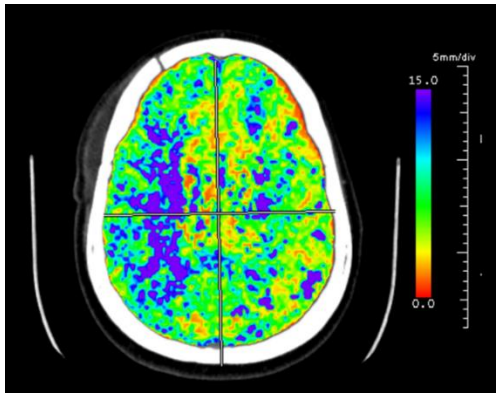
Case study





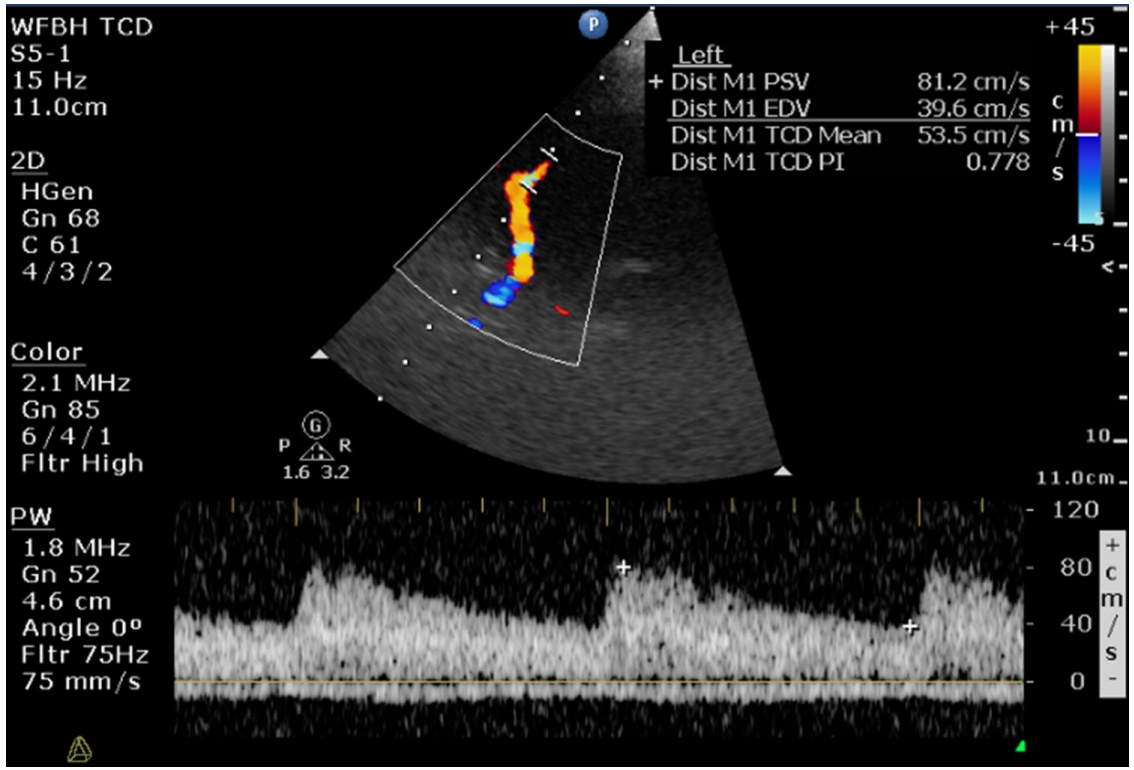


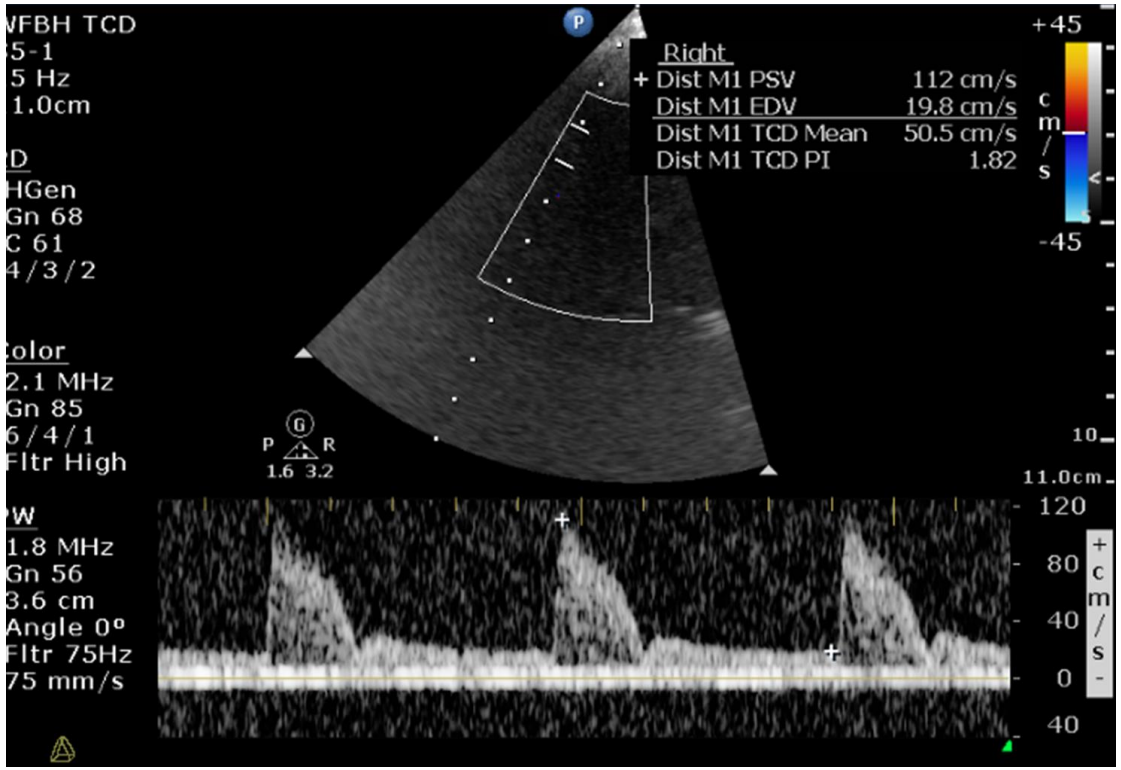
L MCA 243 cm/s
R MCA 211 cm/s



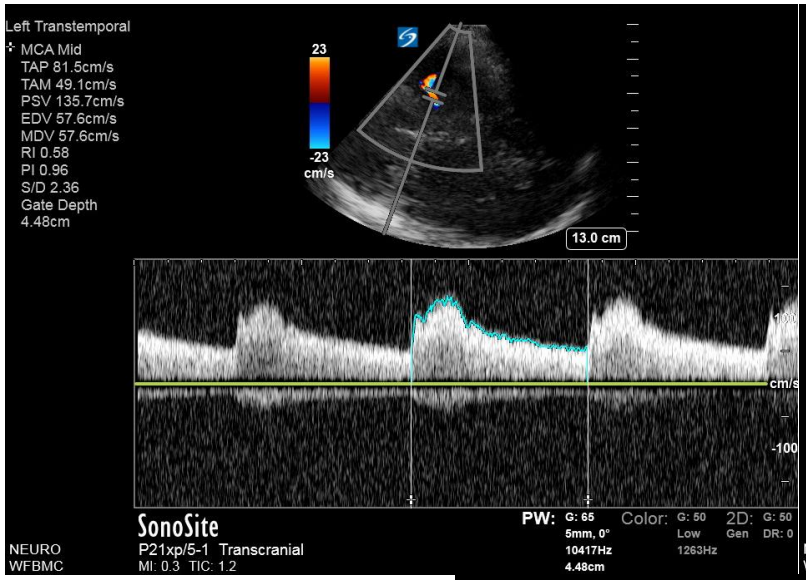
Case study

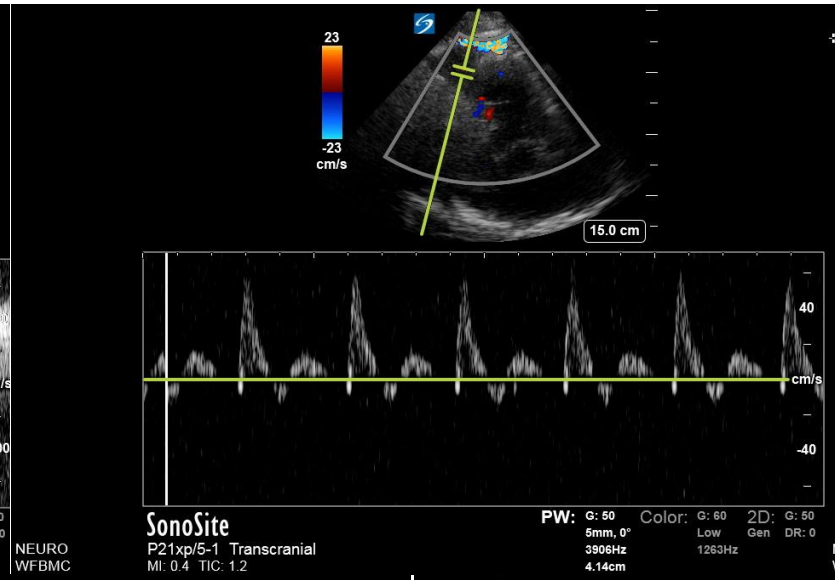
Poor grade SAH monitored for vasospasm



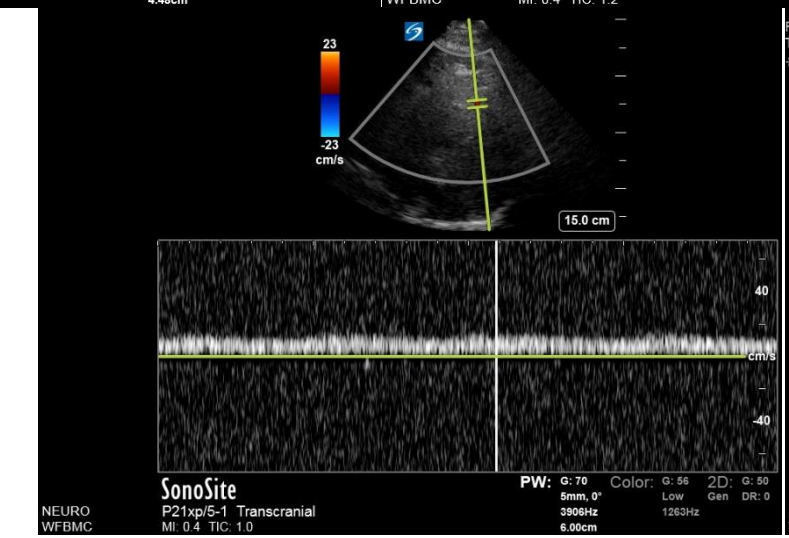


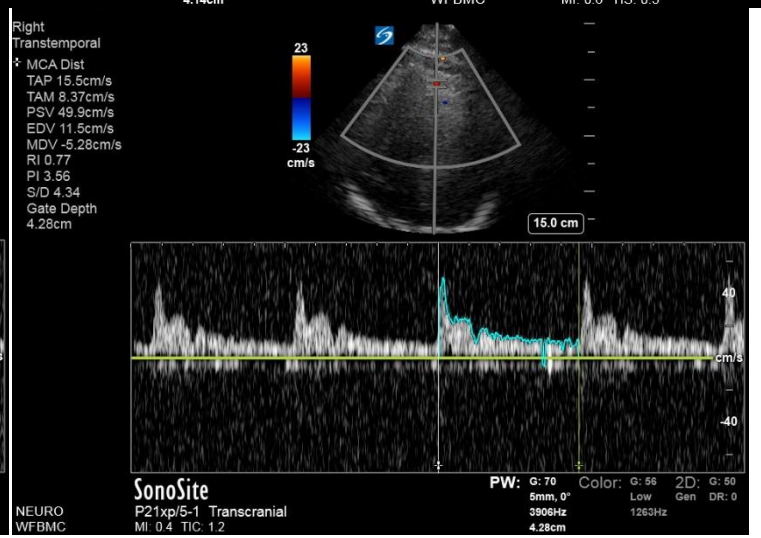
Case study


Left Transtemporal
MCA Mid
TAP 81.5cm/s
TAM 49.1cm/s
PSV 135.7cm/s
EDV 57.6cm/s
MDV 57.6cm/s
RI 0.58
PI 0.96
S/D 2.36
Gate Depth
4.48cm
23
-23
cm/s
13.0 cm
cm/s
SonoSite
NEURO
WFBMC
P21xp/5-1 Transcranial
MI: 0.3 TIC: 1.2
PW: G: 65 5mm, 0° 10417Hz 4.48cm
Color: G: 50 Low 1263Hz
2D: G: 50 Gen DR: 0

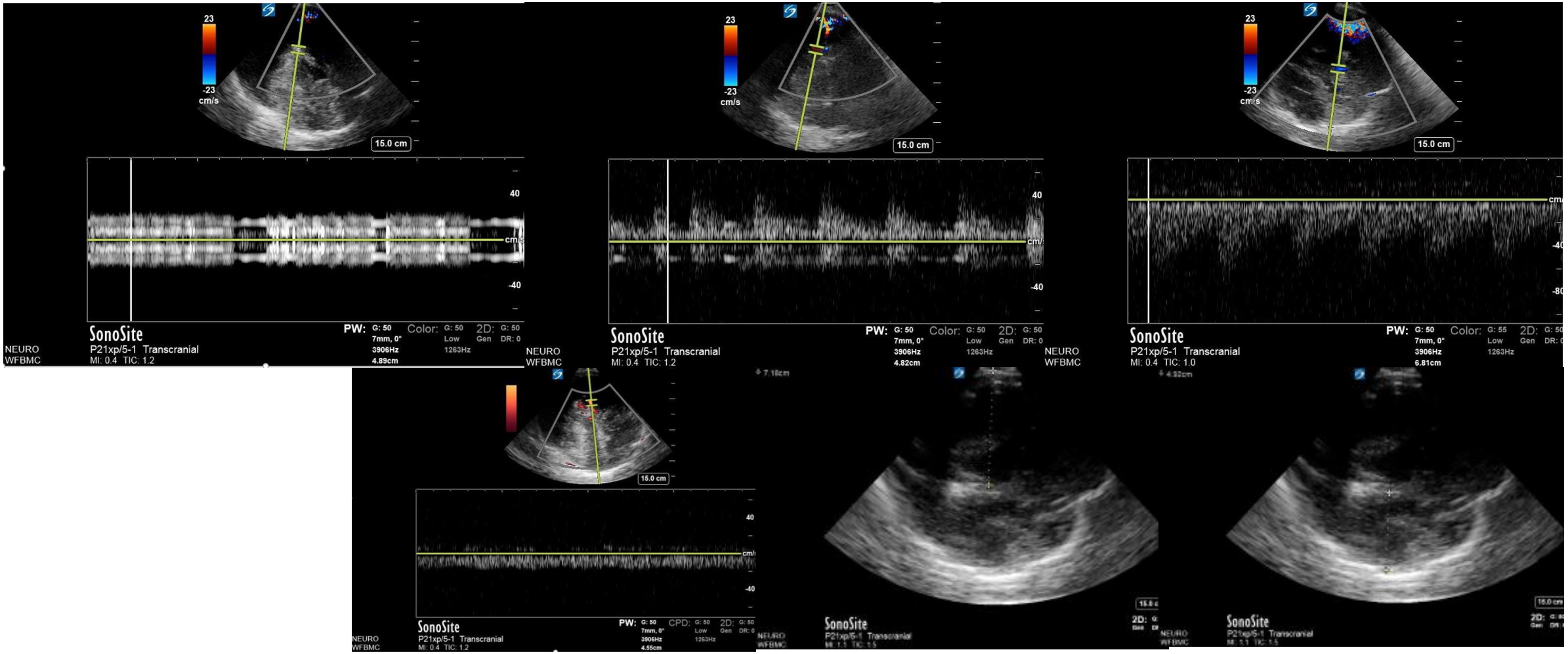

23
-23
cm/s
15.0 cm
40
cm/s
-40
SonoSite
NEURO
WFBMC
P21xp/5-1 Transcranial
MI: 0.4 TIC: 1.2
PW: G: 50 5mm, 0° 3906Hz 4.14cm
Color: G: 60 Low 1263Hz
2D: G: 50 Gen DR: 0


0.64cm
3.5 cm
SonoSite
NEURO
WFBMC
HFL38xp/13-6 Nerve
MI: 0.6 TIS: 0.3
2D: G: 50 Res DR: 0 MB

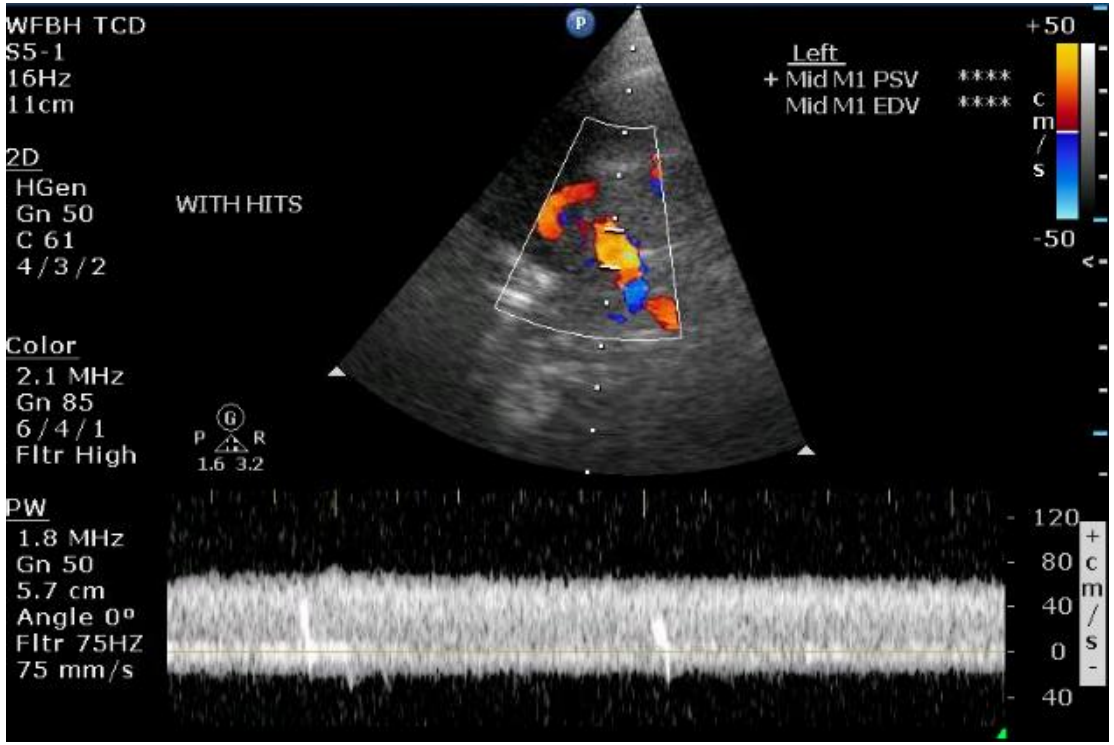

23
-23
cm/s
15.0 cm
40
cm/s
-40
SonoSite
NEURO
WFBMC
P21xp/5-1 Transcranial
MI: 0.4 TIC: 1.0
PW: G: 70 5mm, 0° 3906Hz 6.00cm
Color: G: 56 Low 1263Hz
2D: G: 50 Gen DR: 0

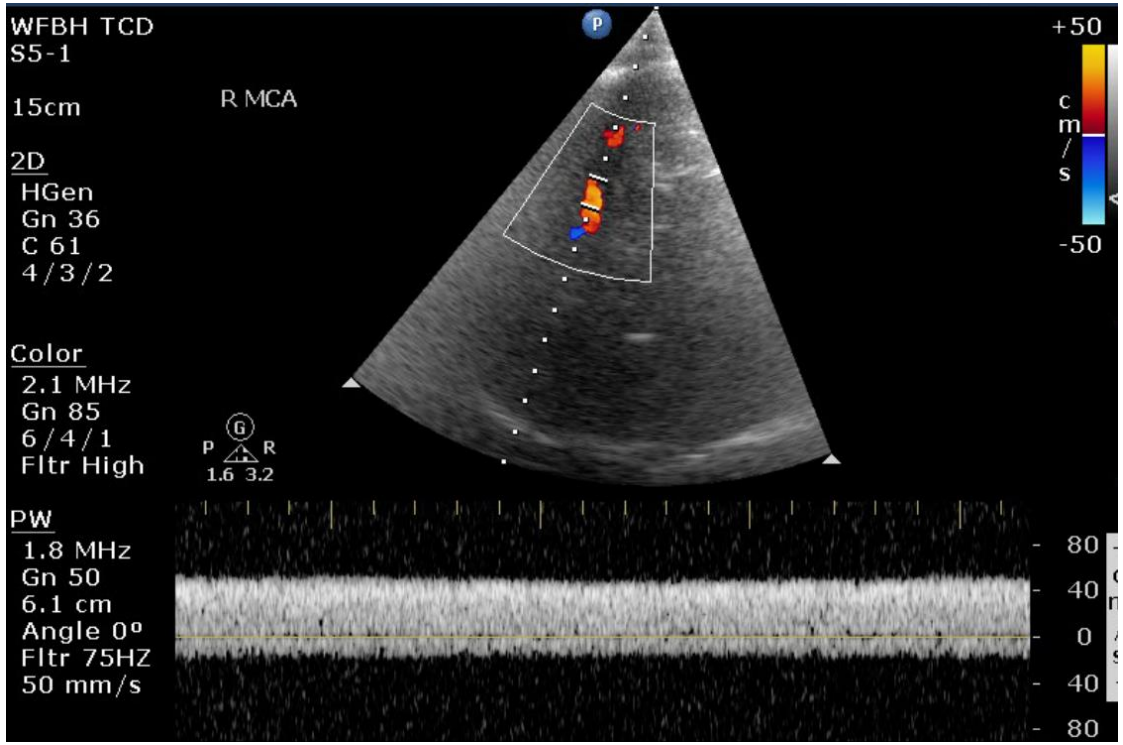

Right
Transtemporal
MCA Dist
TAP 15.5cm/s
TAM 8.37cm/s
PSV 49.9cm/s
EDV 11.5cm/s
MDV -5.28cm/s
RI 0.77
PI 3.56
S/D 4.34
Gate Depth
4.28cm
23
-23
cm/s
15.0 cm
40
cm/s
-40
SonoSite
NEURO
WFBMC
P21xp/5-1 Transcranial
MI: 0.4 TIC: 1.2
PW: G: 70 5mm, 0° 3906Hz 4.28cm
Color: G: 56 Low 1263Hz
2D: G: 50 Gen DR: 0

Case study

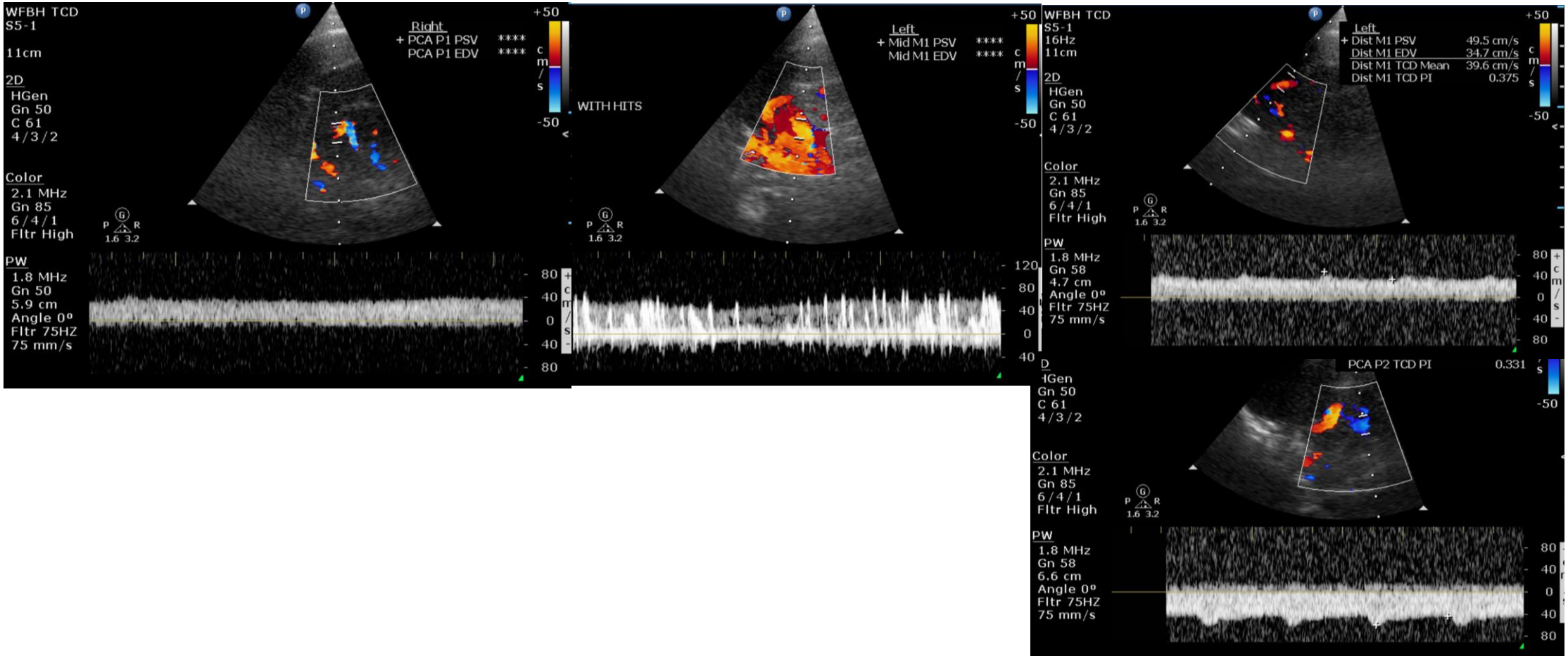

23
-23
cm/s
15.0 cm
40
-40
SonoSite
P21xp/5-1 Transcranial
MI: 0.4 TIC: 1.2
PW: G: 50
7mm, 0°
3906Hz
4.89cm
Color: G: 50 Low 1263Hz
2D: G: 50 Gen DR: 0
NEURO
WFBMC
SonoSite
P21xp/5-1 Transcranial
MI: 0.4 TIC: 1.2
PW: G: 50
7mm, 0°
3906Hz
4.82cm
Color: G: 50 Low 1263Hz
2D: G: 50 Gen DR: 0
NEURO
WFBMC
SonoSite
P21xp/5-1 Transcranial
MI: 0.4 TIC: 1.0
PW: G: 50
7mm, 0°
3906Hz
6.81cm
Color: G: 55 Low 1263Hz
2D: Gen
NEURO
WFBMC
SonoSite
P21xp/5-1 Transcranial
MI: 0.4 TIC: 1.2
PW: G: 50
7mm, 0°
3906Hz
4.55cm
CPD: G: 50 Low 1263Hz
2D: G: 50 Gen DR: 0
NEURO
WFBMC
SonoSite
P21xp/5-1 Transcranial
NEURO
WFBMC
SonoSite
P21xp/5-1 Transcranial
NEURO
WFBMC

Case study


WFBH TCD
S5-1
16Hz
11cm
2D
HGen
Gn 50
C 61
4/3/2
WITH HITS
Color
2.1 MHz
Gn 85
6/4/1
Fltr High
PW
1.8 MHz
Gn 50
5.7 cm
Angle 0°
Fltr 75HZ
75 mm/s
Left
+ Mid M1 PSV ****
Mid M1 EDV ****
+50
cm/s
-50
120
80
40
0
40
1.6 3.2

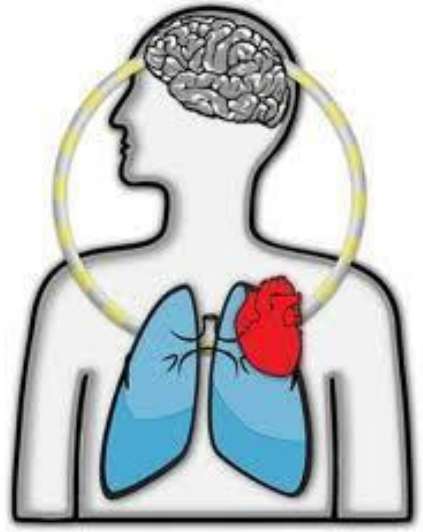

WFBH TCD
S5-1
15cm
R MCA
2D
HGen
Gn 36
C 61
4/3/2
Color
2.1 MHz
Gn 85
6/4/1
Fltr High
PW
1.8 MHz
Gn 50
6.1 cm
Angle 0°
Fltr 75HZ
50 mm/s
+50
cm/s
-50
80
40
0
40
80
1.6 3.2

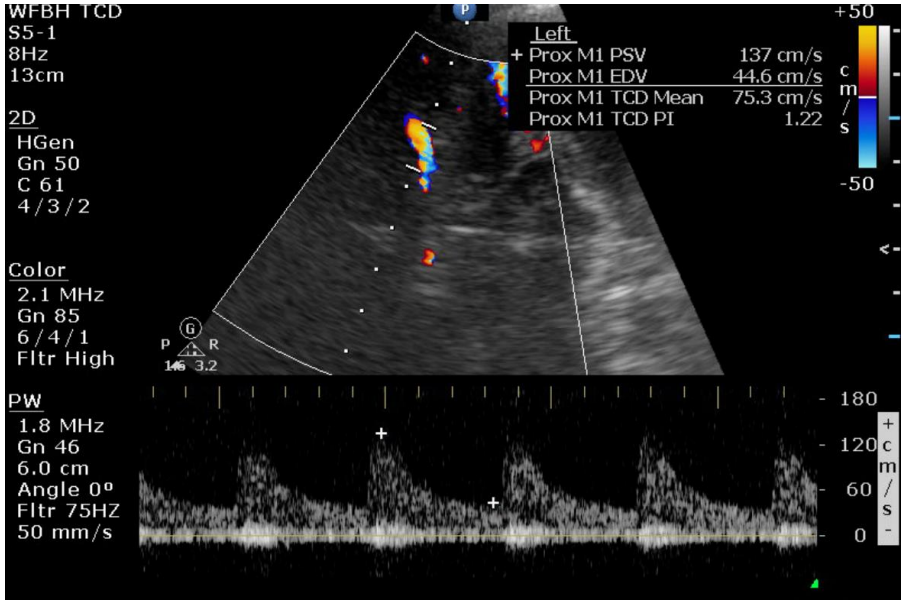
Impella decannulation

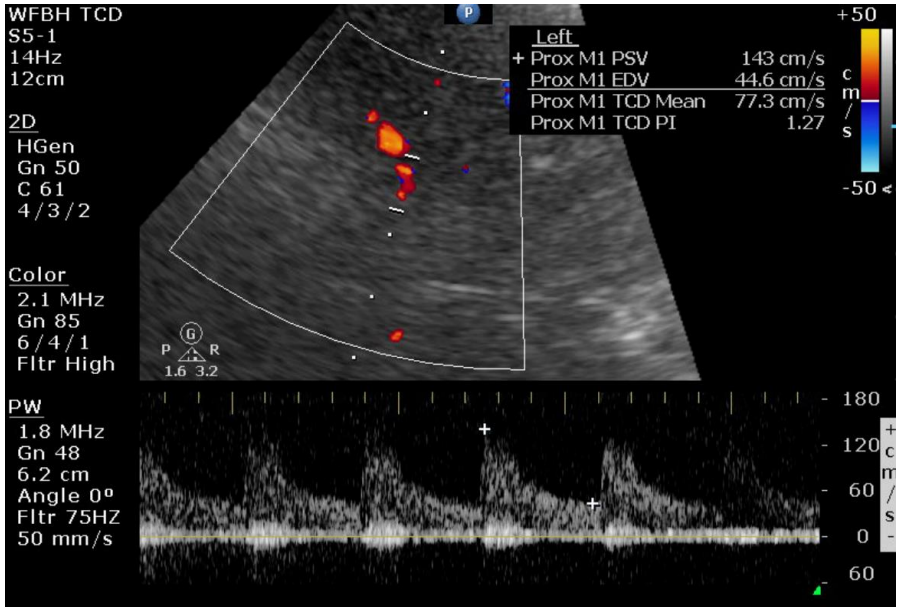


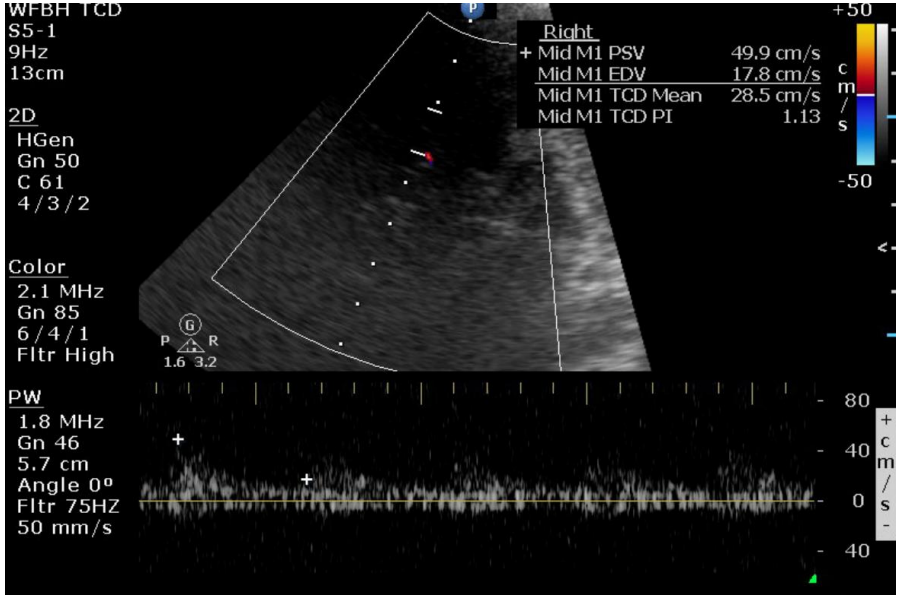
Case study

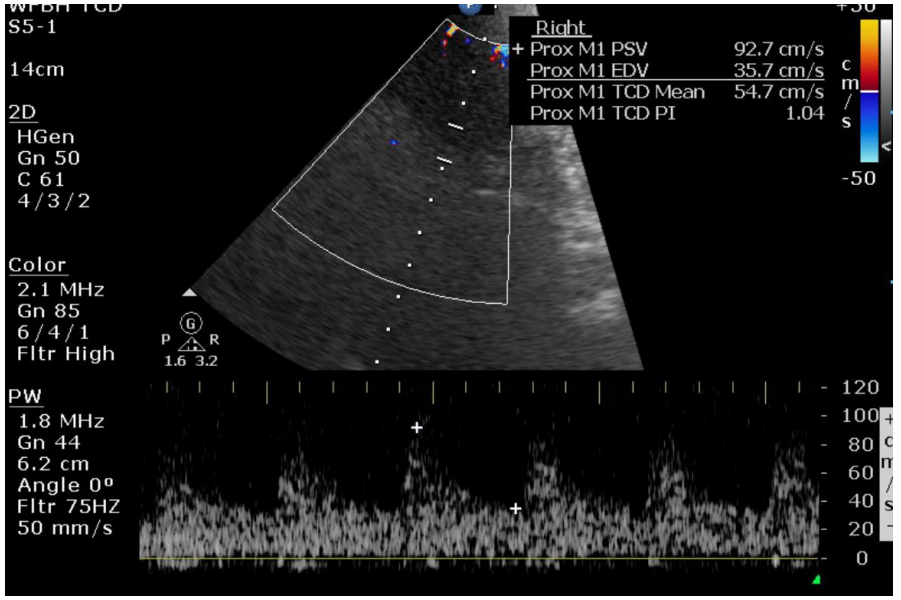
- 68 male presented initially on 12/28 acute onset extremely slurred speech and profound left hemibody weakness. CTA/CTP demonstrated occlusion of right ICA distal to the bifurcation and distal reconstitution of MCA.
- 12/290 2:56 AM S/P mechanical thrombectomy for acute R ICA stroke.TICI 3 achieved.
- 12/29 5:12 AM MRI brain No acute intracranial abnormality.
- 12/29 10:31 AM TCD done , Left hemiparesis
- 12/29 15:49 PM TCD done, Neurologically intact

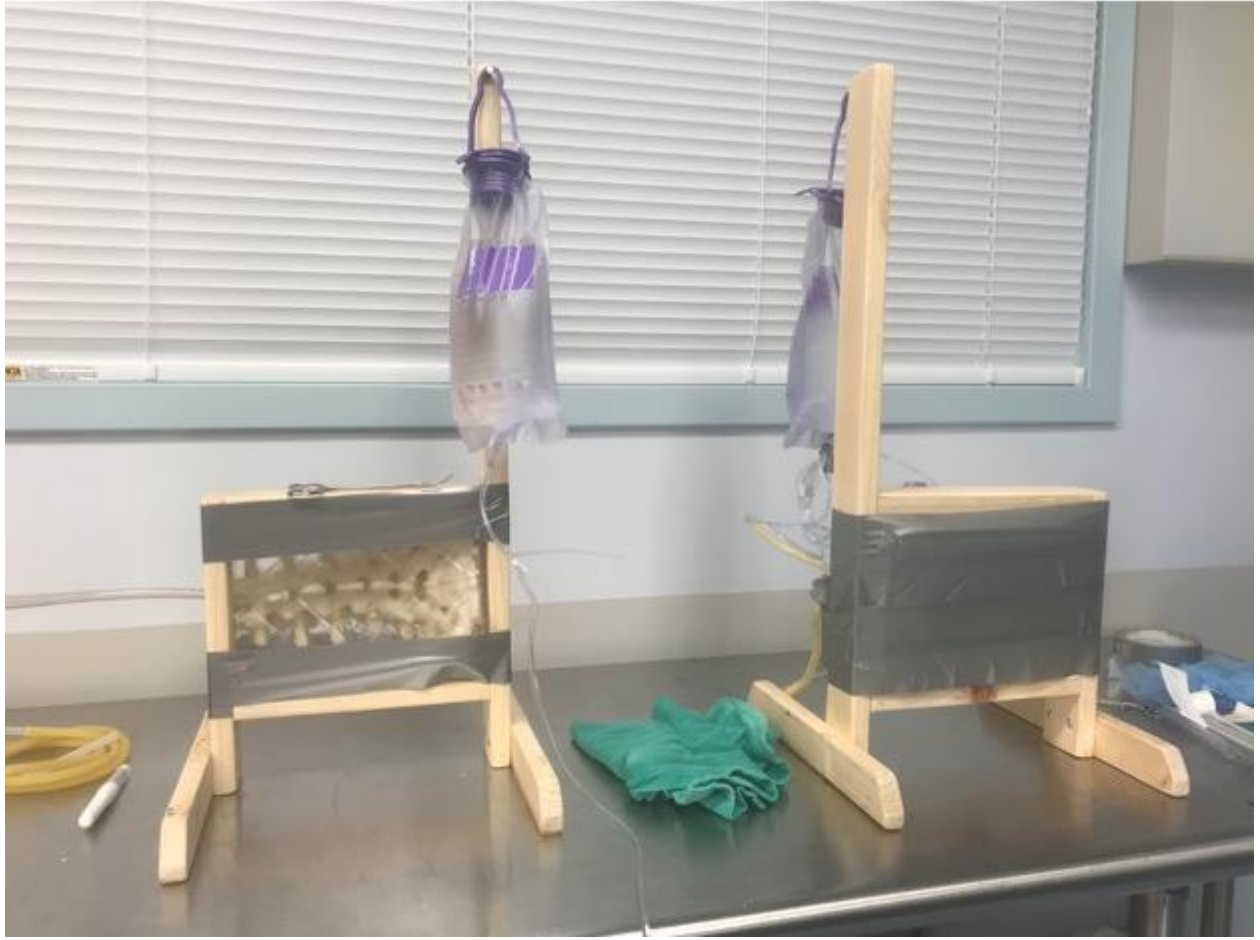


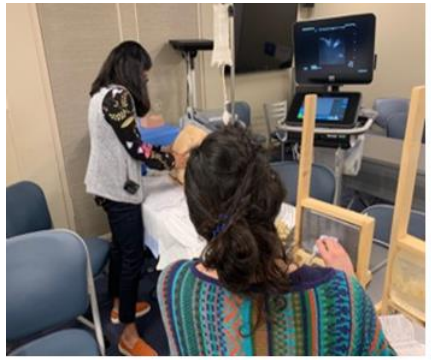

WFBH TCD
S5-1
8Hz
13cm
2D
HGen
Gn 50
C 61
4/3/2
Color
2.1 MHz
Gn 85
6/4/1
Fltr High
PW
1.8 MHz
Gn 46
6.0 cm
Angle 0°
Fltr 75HZ
50 mm/s
Left
Prox M1 PSV 137 cm/s
Prox M1 EDV 44.6 cm/s
Prox M1 TCD Mean 75.3 cm/s
Prox M1 TCD PI 1.22
+50
-50
cm/s
180
120
60
0

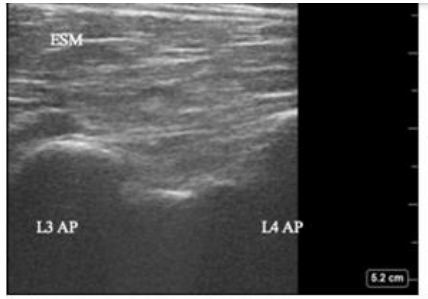

WFBH TCD
S5-1
14Hz
12cm
2D
HGen
Gn 50
C 61
4/3/2
Color
2.1 MHz
Gn 85
6/4/1
Fltr High
PW
1.8 MHz
Gn 48
6.2 cm
Angle 0°
Fltr 75HZ
50 mm/s
Left
Prox M1 PSV 143 cm/s
Prox M1 EDV 44.6 cm/s
Prox M1 TCD Mean 77.3 cm/s
Prox M1 TCD PI 1.27
+50
-50
cm/s
180
120
60
0
60

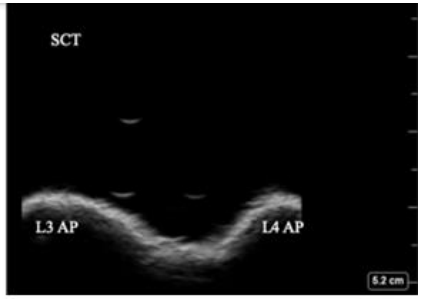

WFBH TCD
S5-1
9Hz
13cm
2D
HGen
Gn 50
C 61
4/3/2
Color
2.1 MHz
Gn 85
6/4/1
Fltr High
PW
1.8 MHz
Gn 46
5.7 cm
Angle 0°
Fltr 75HZ
50 mm/s
Right
Mid M1 PSV 49.9 cm/s
Mid M1 EDV 17.8 cm/s
Mid M1 TCD Mean 28.5 cm/s
Mid M1 TCD PI 1.13
+50
-50
cm/s
80
40
0
40

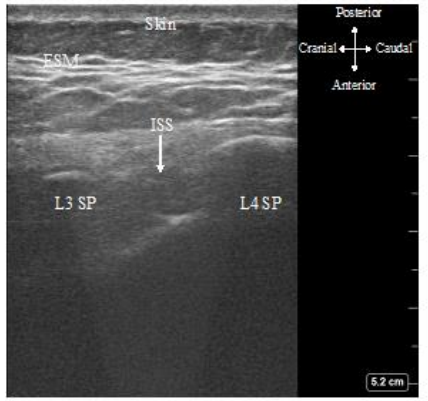

S5-1
14cm
2D
HGen
Gn 50
C 61
4/3/2
Color
2.1 MHz
Gn 85
6/4/1
Fltr High
PW
1.8 MHz
Gn 44
6.2 cm
Angle 0°
Fltr 75HZ
50 mm/s
Right
Prox M1 PSV 92.7 cm/s
Prox M1 EDV 35.7 cm/s
Prox M1 TCD Mean 54.7 cm/s
Prox M1 TCD PI 1.04
-50
cm/s
120
100
80
60
40
20
0

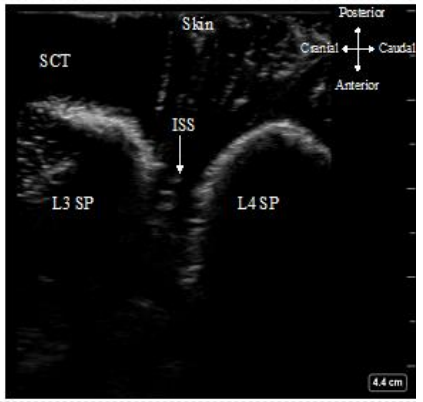


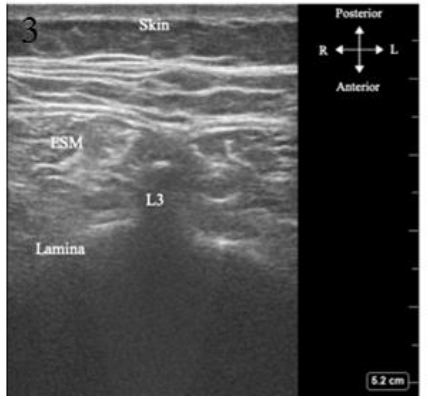


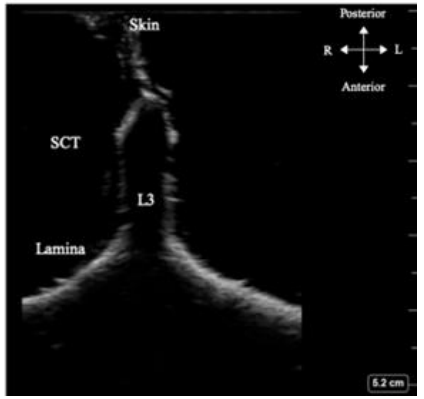

ESM
L3 AP
L4 AP
5.2 cm


SCT
L3 AP
L4 AP
5.2 cm


Skin
ESM
Posterior
Cranial
Caudal
Anterior
ISS
L3 SP
L4 SP
5.2 cm


Skin
SCT
Posterior
Cranial
Caudal
Anterior
ISS
L3 SP
L4 SP
4.4 cm


3
Skin
Posterior
R
L
Anterior
ESM
L3
Lamina
5.2 cm


Skin
Posterior
R
L
Anterior
SCT
L3
Lamina
5.2 cm

B Mode Ultrasound Images Of Thoracic Spine: Case Report

Frenkel M, MD; Gomez J, MD; Carmichael S, MD; Sarwal A, MD
Department of Neurology, Department of Neurosurgery, Department of General Surgery, Wake Forest Baptist Medical Center Winston-Salem, NC

Introduction

- Ultrasound provides the clinician an additional decision-making tool when used at the point-of-care. In the hands of a skilled user, most bodily structures can be visualized distinctly with minimal risk to the patient.
- In patients with extensive hardware after laminectomy, MRI or CT may not help in appropriate visualization to help distinguish intra-spinal or paraspinal pathologies. Most of these patients may have acoustic windows to allow ultrasound visualization otherwise limited by bone landmarks. Exploration of ultrasound as ability to distinguish pathology in post-operative spine cases has not been explored.
- We present a unique case showing the ultrasound appearance of spine captured by imaging the spinal cord of a post thoracic laminectomy patient. In patients with an acoustic window created by lack of bone, US of the spine may be effective in delineating spinal and paraspinal anatomy and pathology

Case report

- 84-year-old male with history of spinal stenosis with multiple prior surgeries and hardware in place (lumbar discectomy L3-L4 PLIF with posterior T10-S1 spinal fusion) presented with worsening back pain. He was found to have T10 Compression fracture with discitis/osteomyelitis T9-T10 with paraspinal and epidural abscess resulting in cord compression and edema.
- T9-T10 laminectomy was done with extension of fusion to T5. Purulent drain was noted around hardware in place

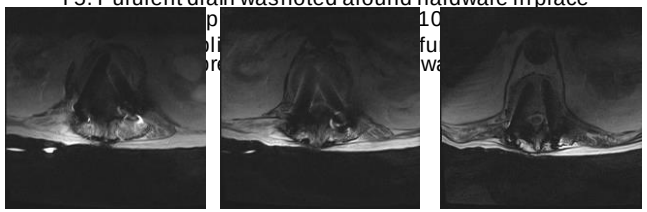


Figure 6. Axial images on MRI Thoracic spine T2 showing limitations of MRI in evaluating spinal and paraspinal pathology due to artifacts created by spinal hardware.

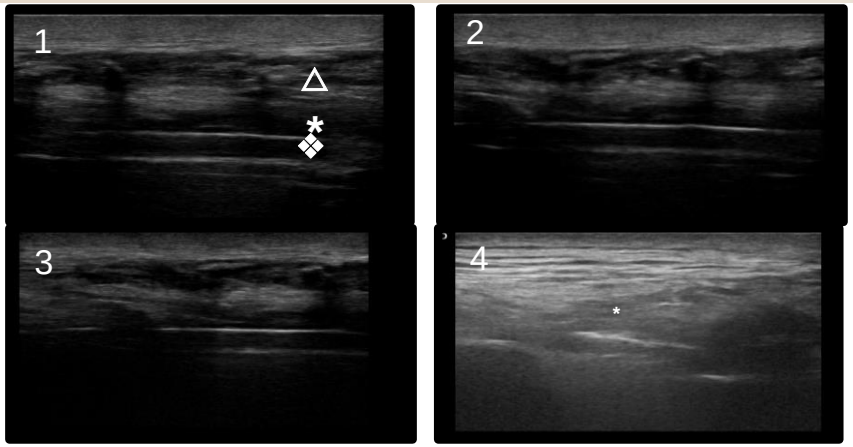


Figure 1-4 (above) Sagittal (1-3) and Parasagittal (4) Images of thoracic spine with a linear probe 6-13 MHz. * Epidural Space △ Subcutaneous Tissue ❖ Spinal Cord

Figure 5 (below) Sagittal images on XR LS spine (right) , thoracic spine (center) and MRI Thoracic spine T2 (left).

Neuroimaging

- Preoperative MRI of thoracic spine concerning for discitis osteomyelitis at T9-T10 with paraspinous and epidural abscesses and pathologic fractures of T9 and T10, with advanced canal stenosis and cord compression resulting in cord edema. (Figure 5, left)
- Preoperative MRI of thoracic spine spinal ultrasound showing (Figure 6) axial images of the thoracic spine
- Preoperative images of the CT T spine (Figure 7) showing T9-10 compression fractures and bony anatomy with hardware.
- Postoperative spinal ultrasound showing (Figures 1-4) the thoracic spine in sagittal longitudinal view with no visible fluid collections in paraspinal or epidural space

Discussion

- During the patient's postoperative course, we attempted visualization of the spinal with point of care ultrasound. US revealed distinct, unobstructed views of the spinal cord due to the lack of the vertebral lamina.
- We present these unique images as proof of the concept to the possible future use of point-of-care ultrasound as a diagnostic tool to examine the epidural space for any residual fluid collections postoperatively.

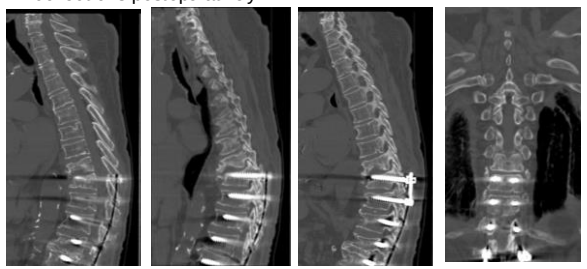


Figure 7. Sagittal images (right three) and Coronal (left) on CT Thoracic spine showing T10 compression fracture with hardware.

Reference
Marshburn, T. H., Hadfield, C. A., Sargsyan, A. E., Garcia, K., Ebert, D., & Dulchavsky, S. A. (2014). New heights in ultrasound: first report of spinal ultrasound from the international space station. *J Emerg Med*, *46*(1), 61-70.

Neurologic Ultrasound in Future of Acute Neuromonitoring evaluation

Role in point of care evaluation during resuscitation and where alternate neuroimaging is inaccessible or not feasible

Role in cerebral hemodynamic assessment to understand pathogenesis of acute bran injury in different diseases

Key component in **MULTIMODALITY GUIDED GOAL DIRECTED THERAPY** post arrest resuscitation, post TBI care, post stroke reperfusion for recanalized vessels, systemic hemodynamic goals in hemorrhage/ECMO

The art of medicine consists of amusing the patient while nature cures the disease….

-

Voltaire

@aartisarwal

asarwal@wakehealth.edu