



Beyond B-mode: Multiparametric Intraoperative Ultrasound in Neurosurgery

Focus on Contrast-Enhanced UltraSound

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Brain Program Advisor | Focused Ultrasound Foundation

Disclosures

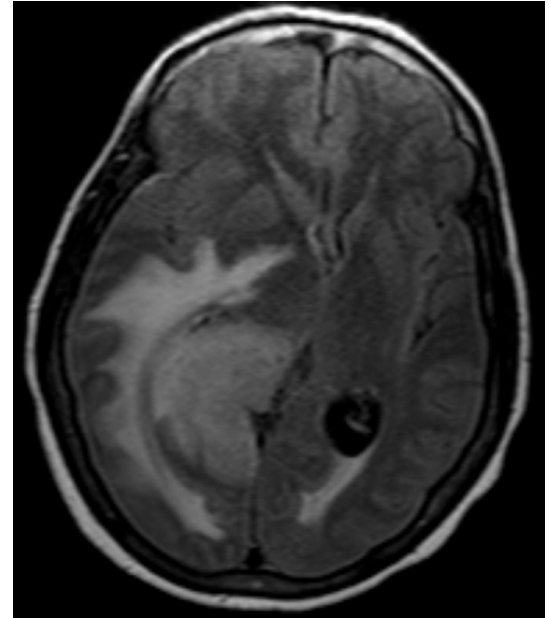
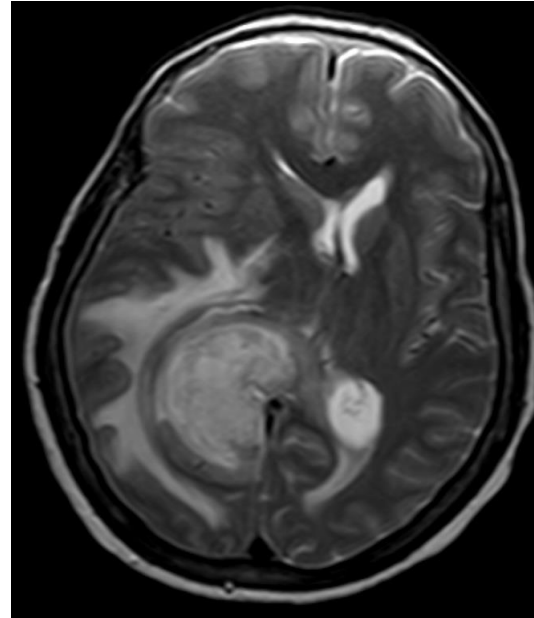
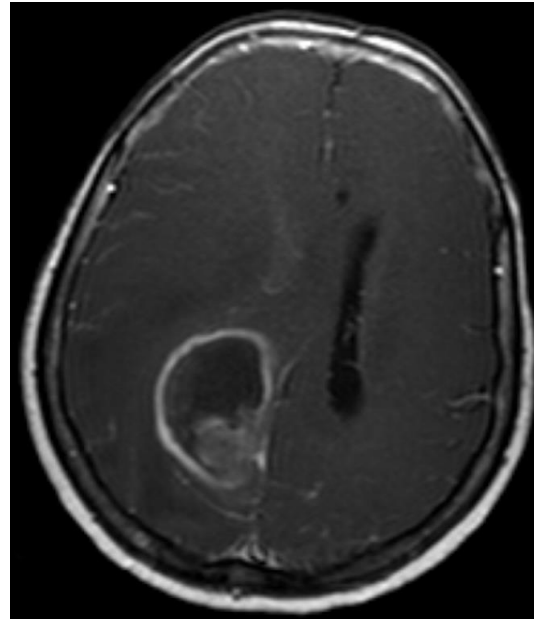
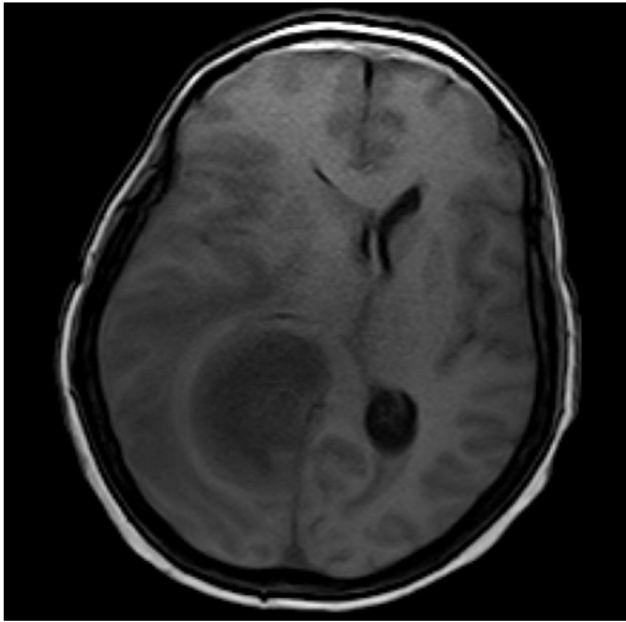
Partnership

- In.Tra.
- Neurostream

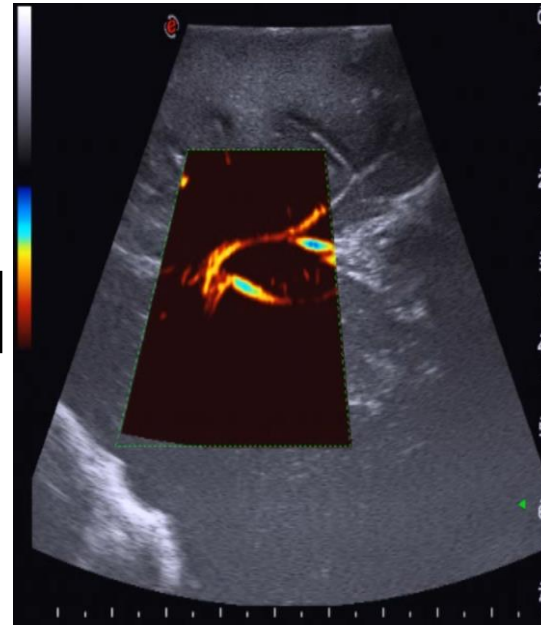
Funding

- Focused Ultrasound Foundation

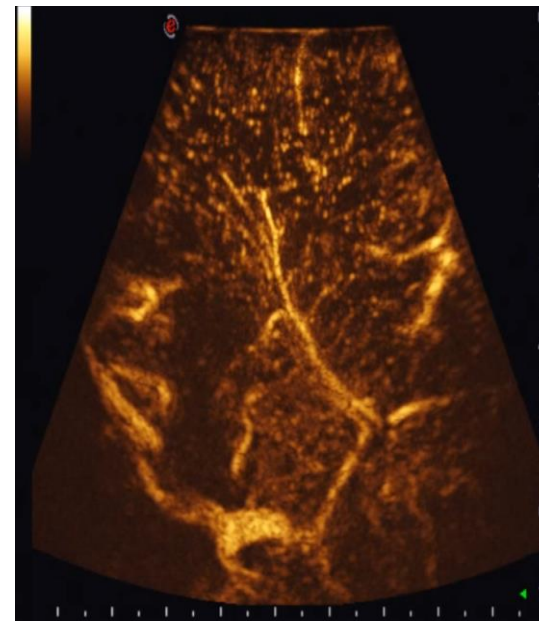
Multiparametric



Multiparametric



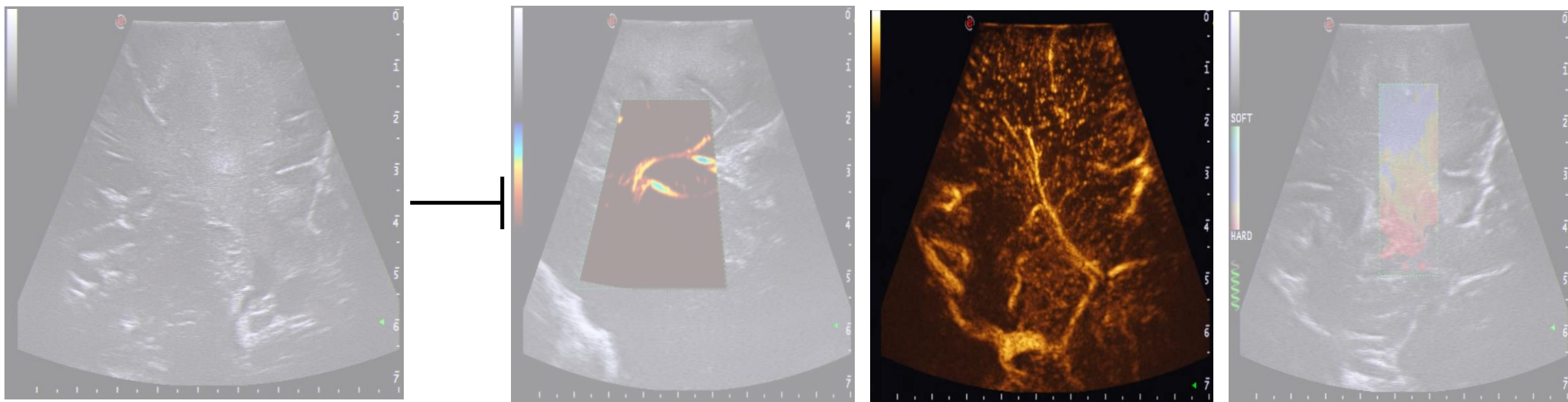
Ultra sensitive Doppler



CEUS



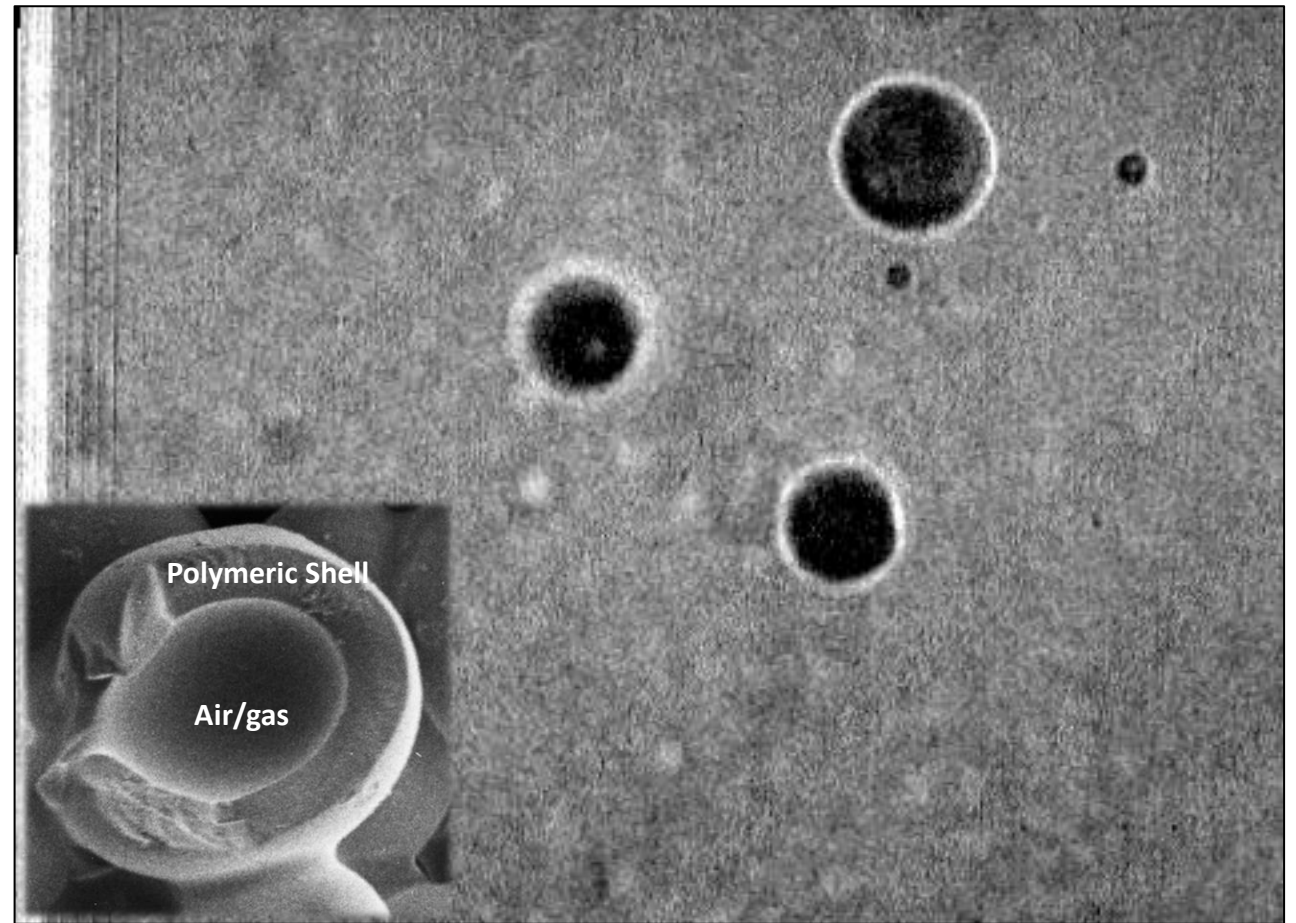
Elasto



CEUS

Microbubbles – since 1980s'

- Encapsulated low-diffusion gasses
 - Same size as an average RBC
 - Purely endovascular medium
 - Resonate at imaging sequences
- Highlight micro- and macro-circulation
- Degree of enhancement is consequence of microvasculature density



How to perform Contrast-Enhanced Ultrasound (CEUS)



Dietrich CF et al. How to perform Contrast-Enhanced ... Ultrasound Int Open 2017; 3: E2–E15

The EFSUMB Guidelines and Recommendations on the Clinical Practice of Contrast Enhanced Ultrasound (CEUS): Update 2011 on non-hepatic applications

Piscaglia F et al. The EFSUMB Guidelines... Ultraschall in Med 2012; 33: 33 – 59

- Widely used for other organs

EFSUMB Guidelines and Recommendations on the Clinical Use of Ultrasound Elastography. Part 1: Basic Principles and Technology

Bamber J et al. EFSUMB Guidelines and... Ultraschall in Med 2013; 34: 169–184

CEUS in neurosurgery

J Neurosurg. 2005 Feb;102(2):295-301.

Intraoperative power Doppler ultrasonography with a contrast-enhancing agent for intracranial tumors.

Kanno H¹, Ozawa Y, Sakata K, Sato H, Tanabe Y, Shimizu N, Yamamoto I.

Ultrasound Med Biol. 2007 Apr;33(4):571-5.

Feasibility of contrast-enhanced sonography during resection of cerebral tumours: initial results of a prospective study.

Engelhardt M¹, Hansen C, Eyding J, Wilkening W, Brenke C, Krogias C, Scholz M, Harders A, Ermert H, Schmieder K.

Neurosurgery. 2007 Apr;60(4 Suppl 2):382-6; discussion 386-7.

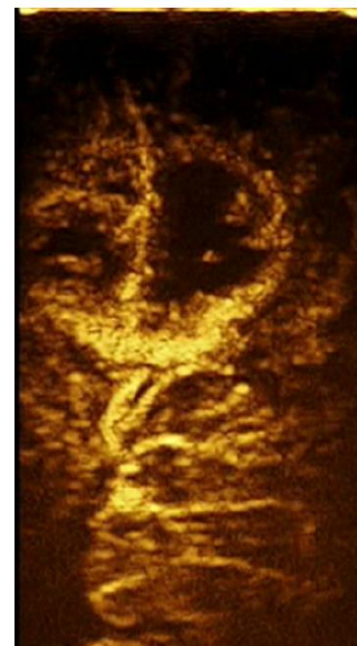
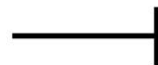
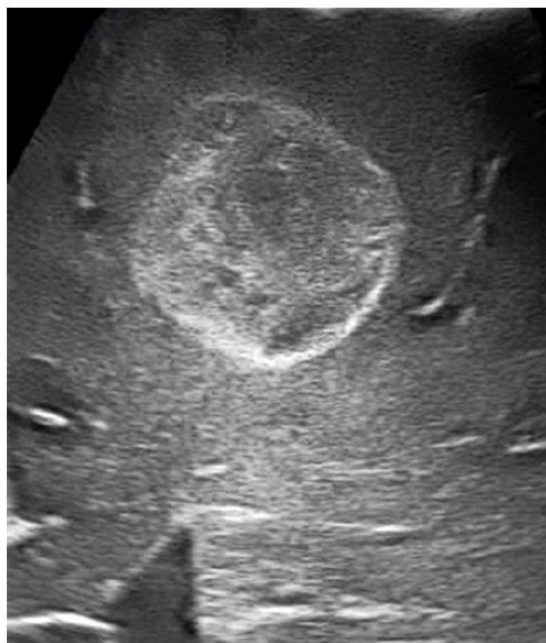
Intraoperative ultrasound using phase inversion harmonic imaging: first experiences.

Hölscher T¹, Ozgur B, Singel S, Wilkening WG, Mattrey RF, Sang H.

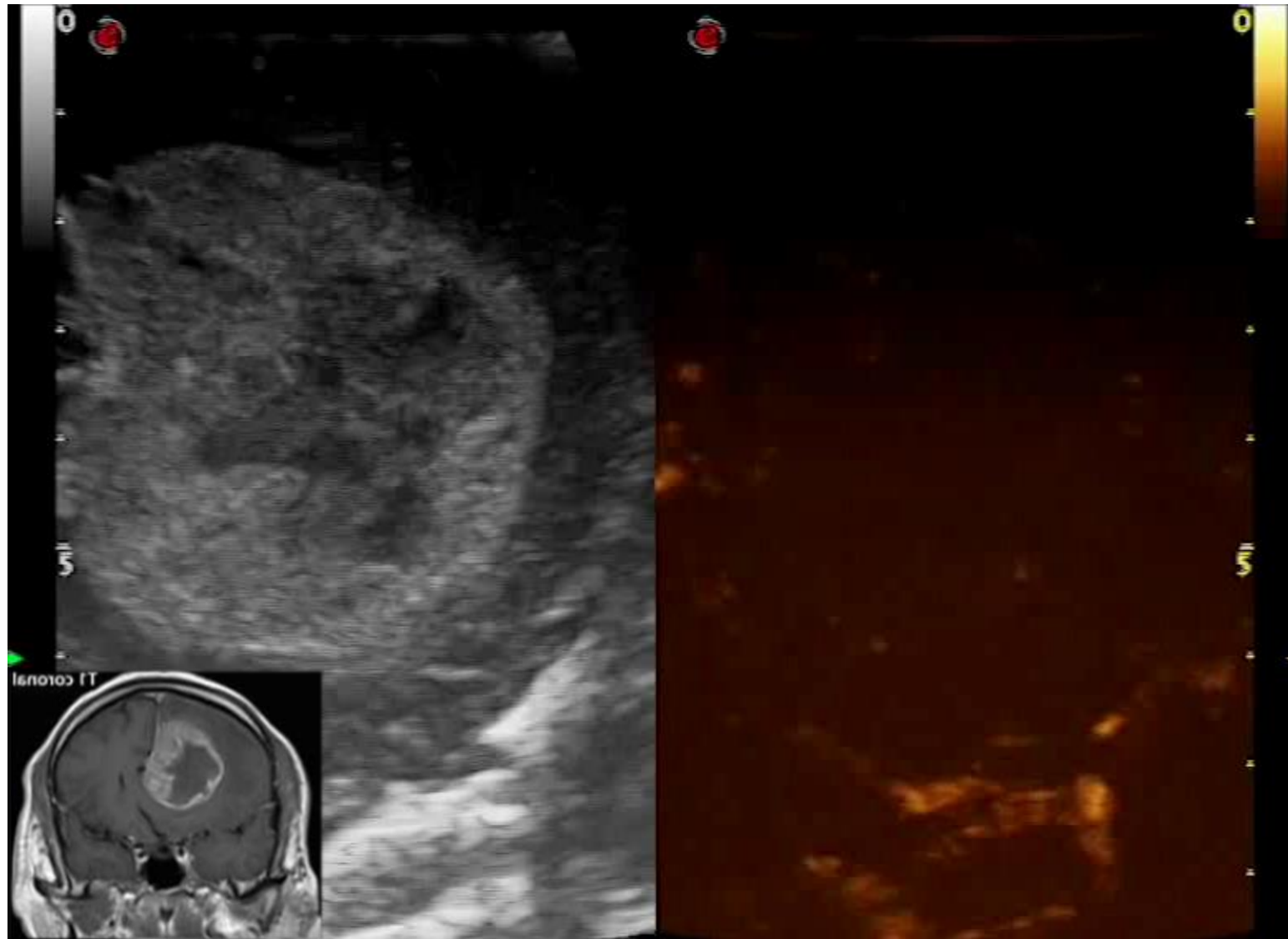
Clin Imaging. 2008 Nov-Dec;32(6):419-24. doi: 10.1016/j.clinimag.2008.05.006.

Intraoperative contrast-enhanced ultrasound for brain tumors.

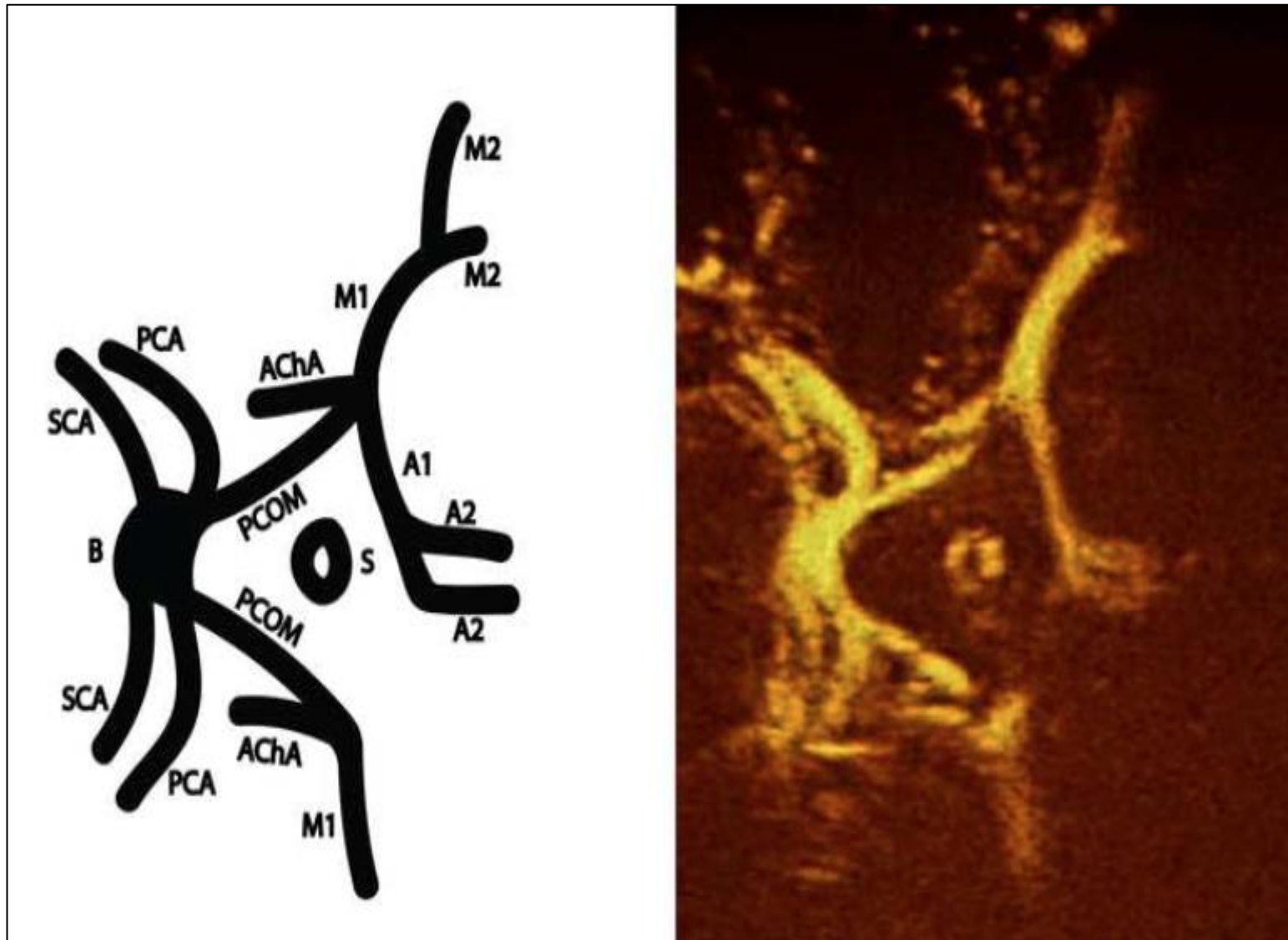
He W¹, Jiang XQ, Wang S, Zhang MZ, Zhao JZ, Liu HZ, Ma J, Xiang DY, Wang LS.



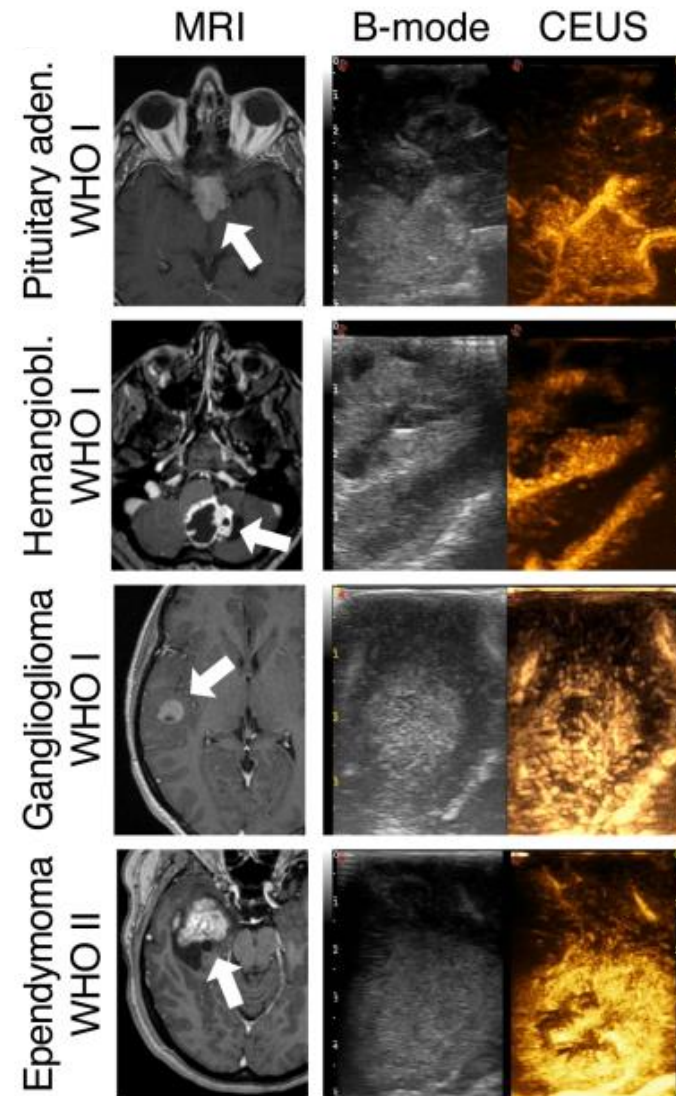
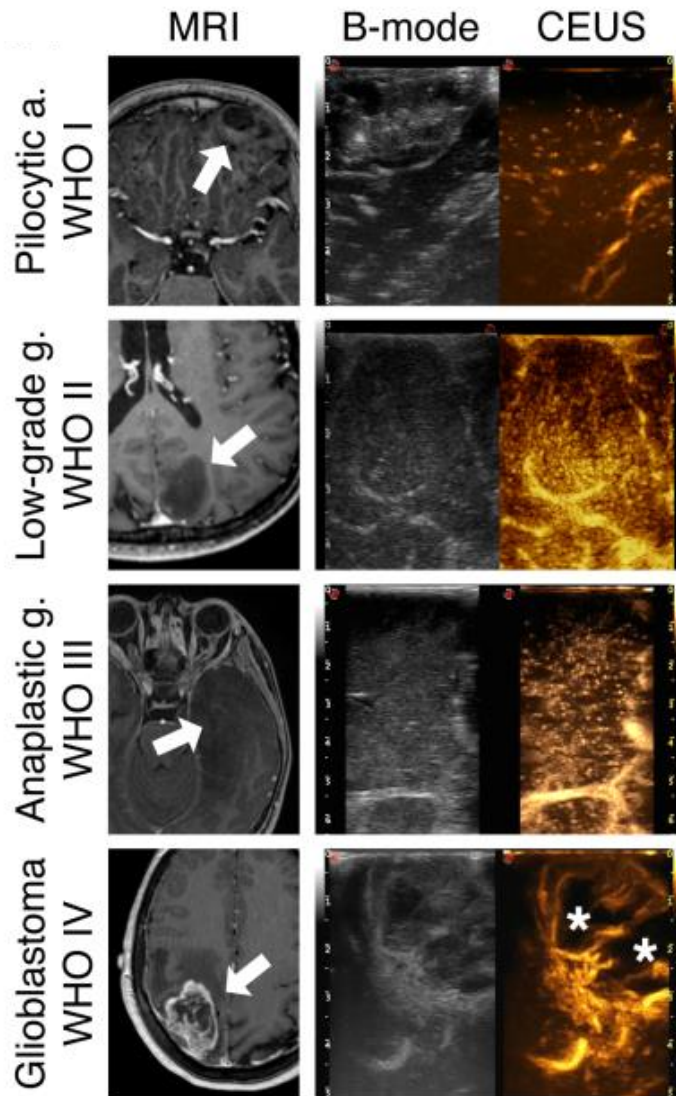
CEUS – from Identification of Structures...



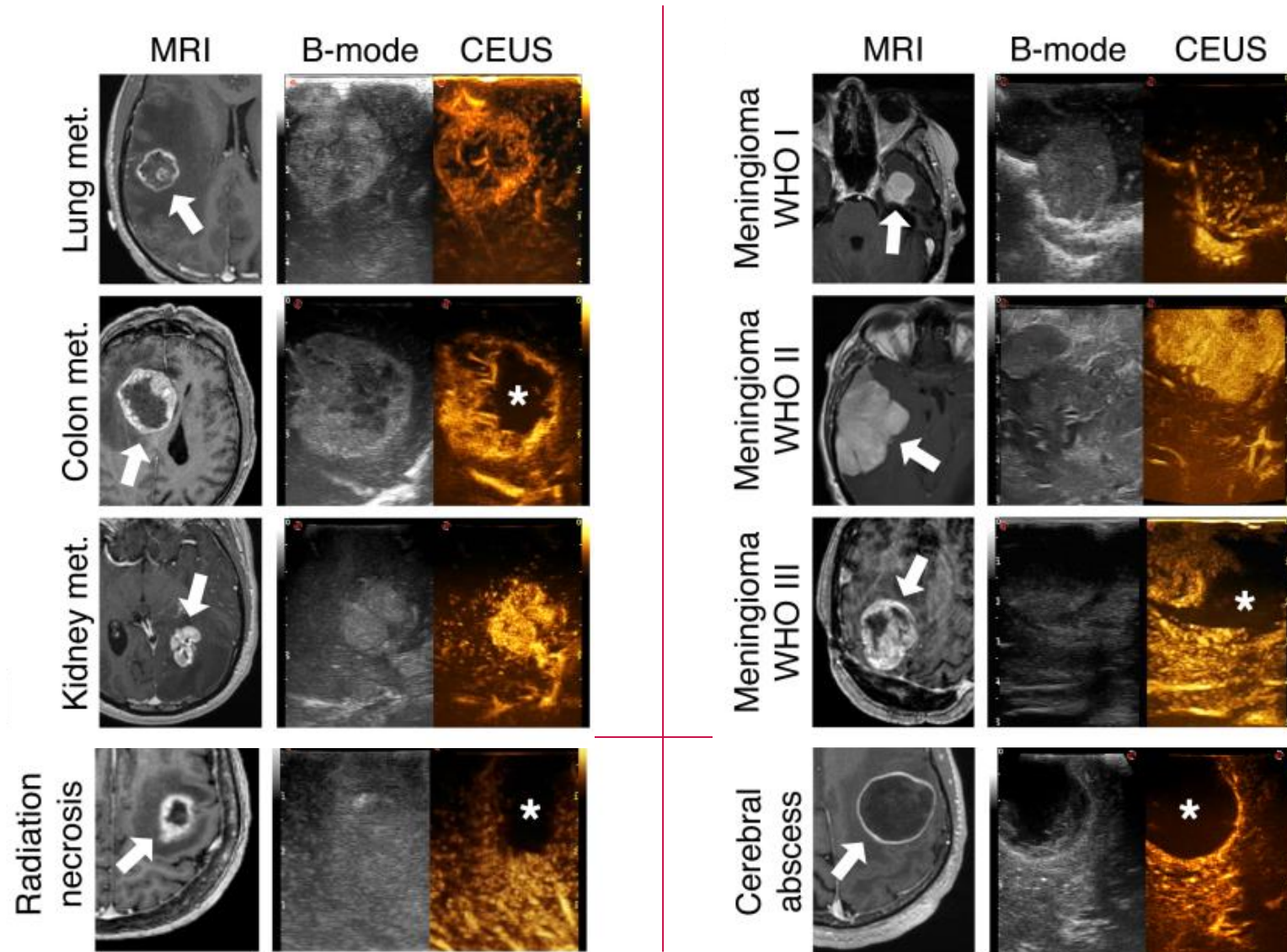
...to Angiosonography



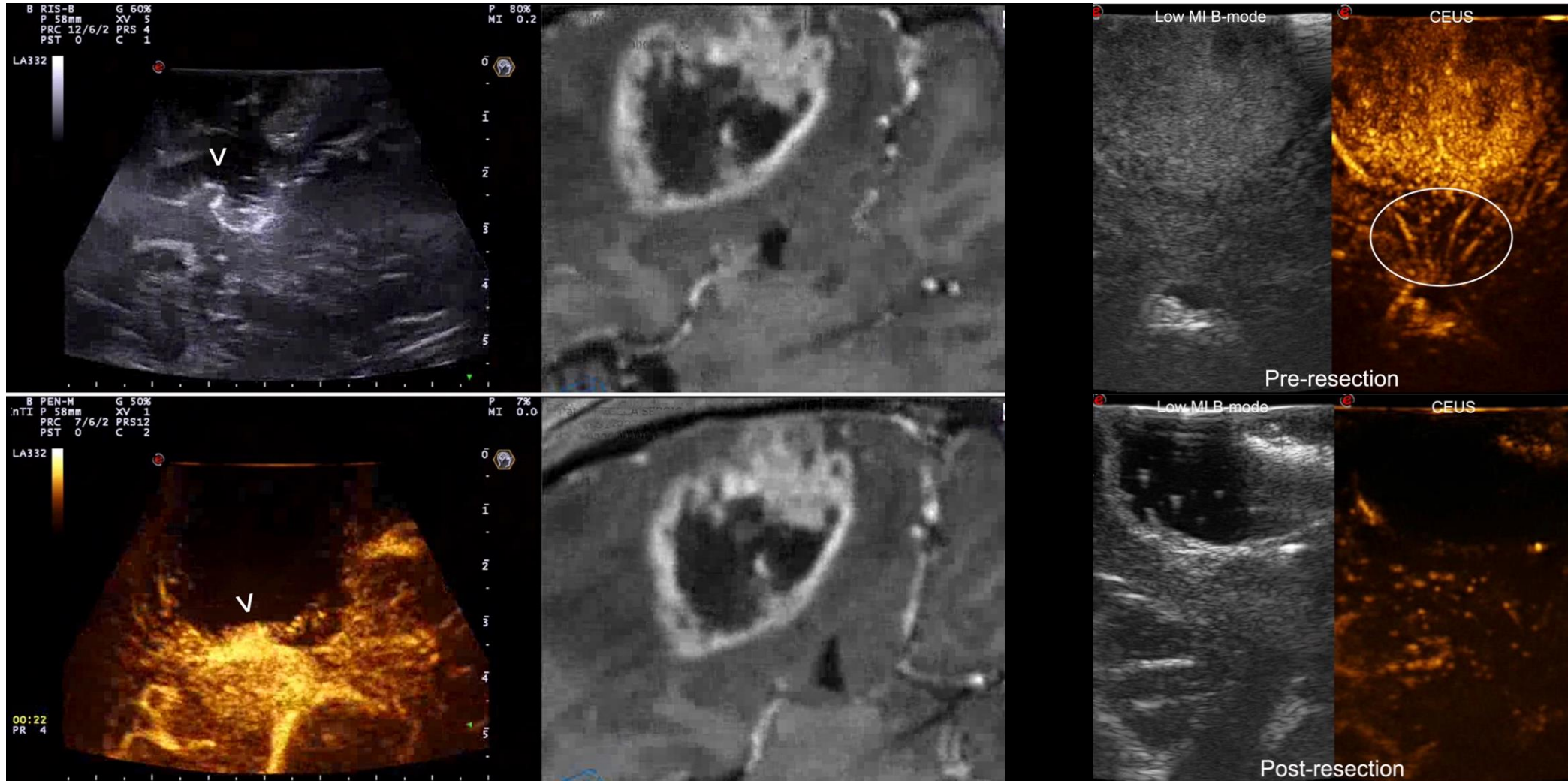
CEUS – From Tumour Visualization...



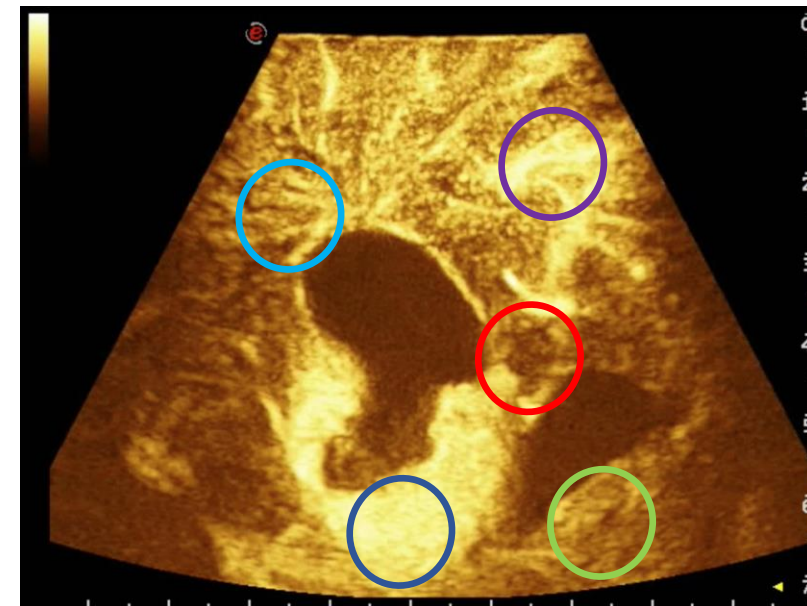
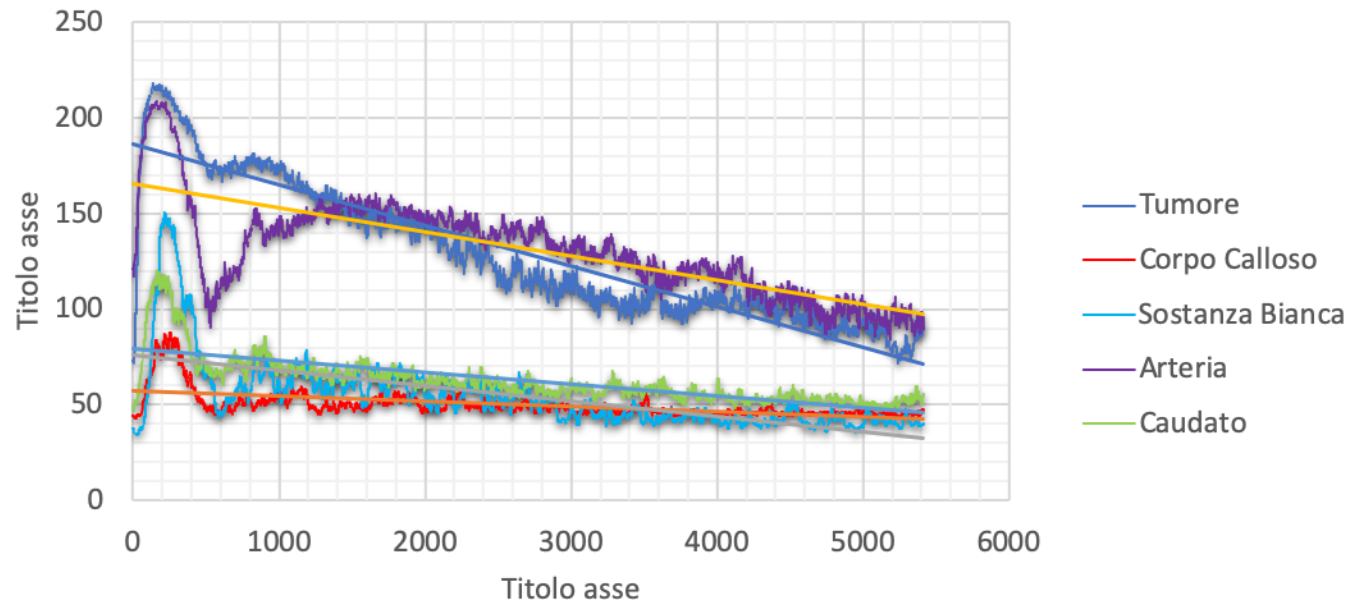
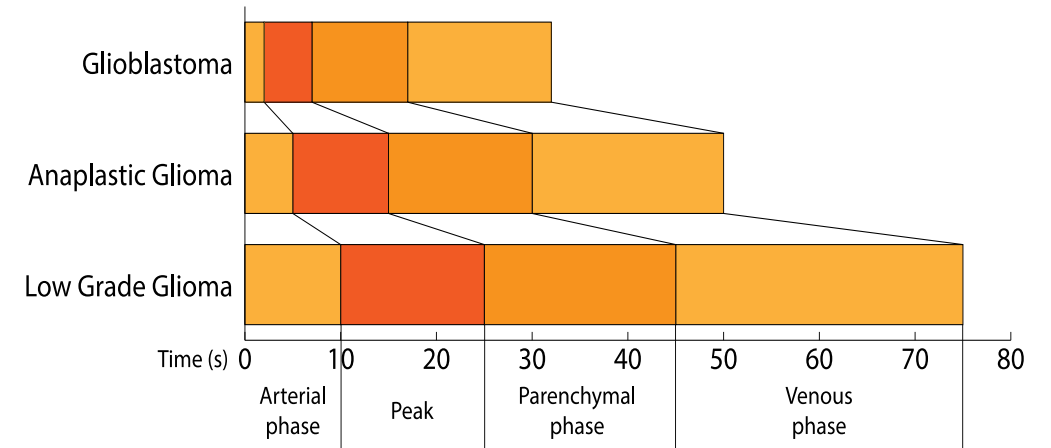
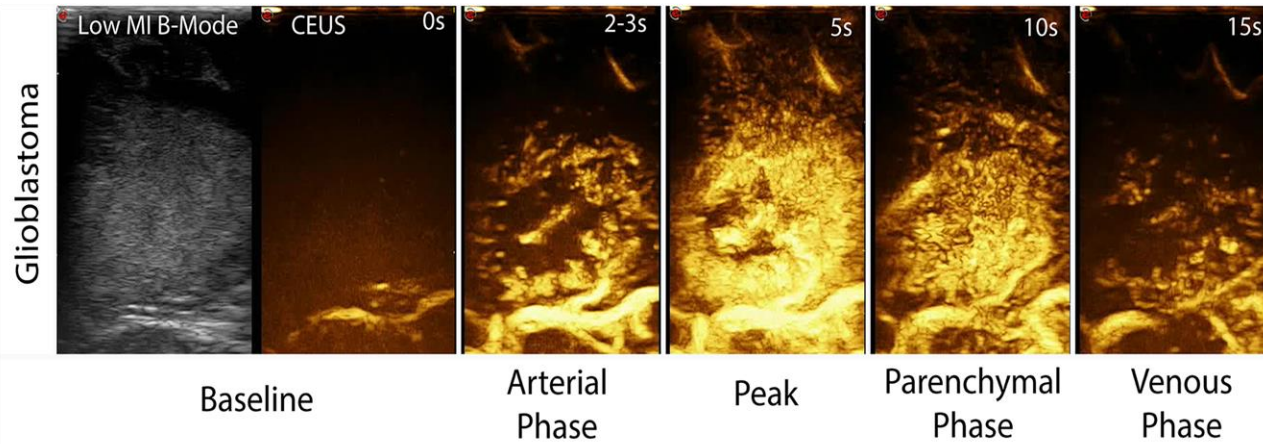
CEUS – From Tumour Visualization...



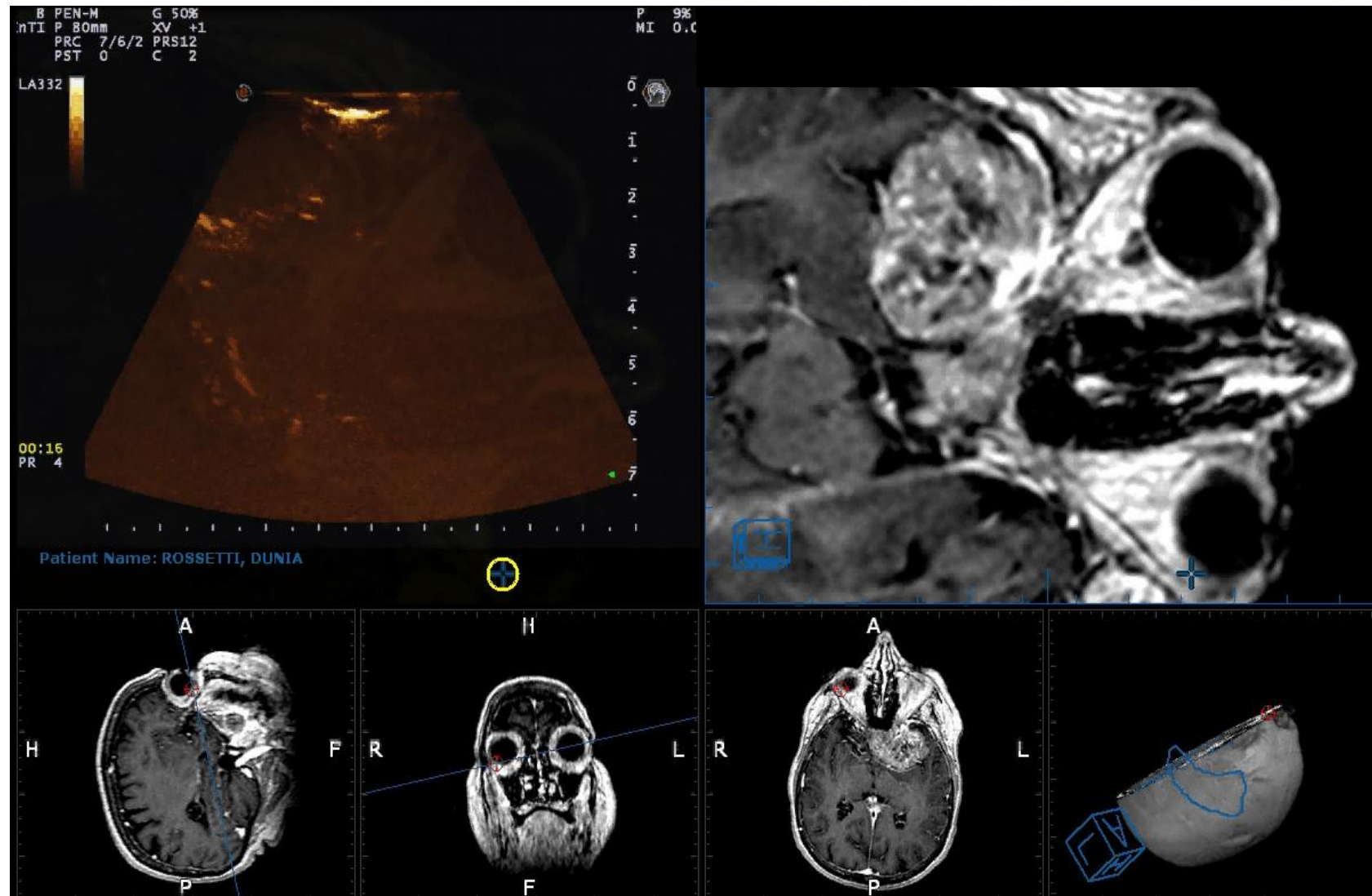
...and Resection Control...



...to Quantitative Characterization and Analysis



Skull base tumors



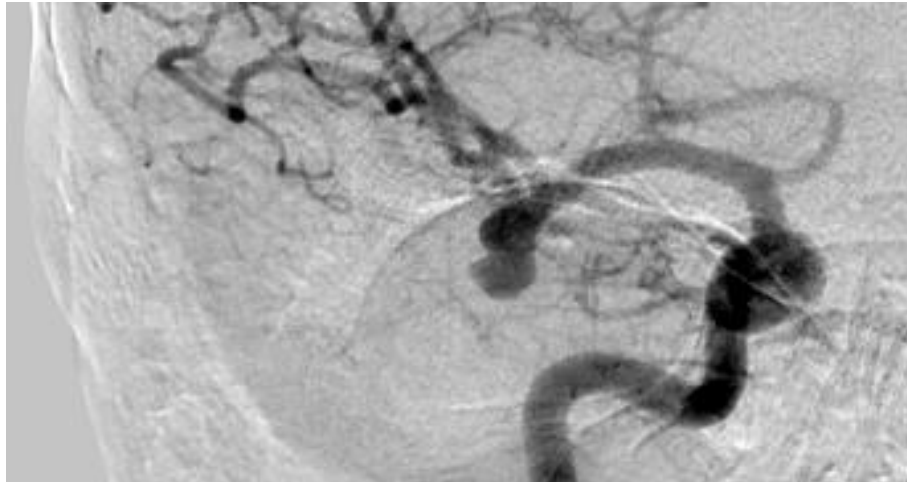
World Neurosurg. 2015 Jul 17. pii: S1878-8750(15)00891-8. doi: 10.1016/j.wneu.2015.07.025. [Epub ahead of print]

Intraoperative Navigated Angiosonography for Skull Base Tumor Surgery.

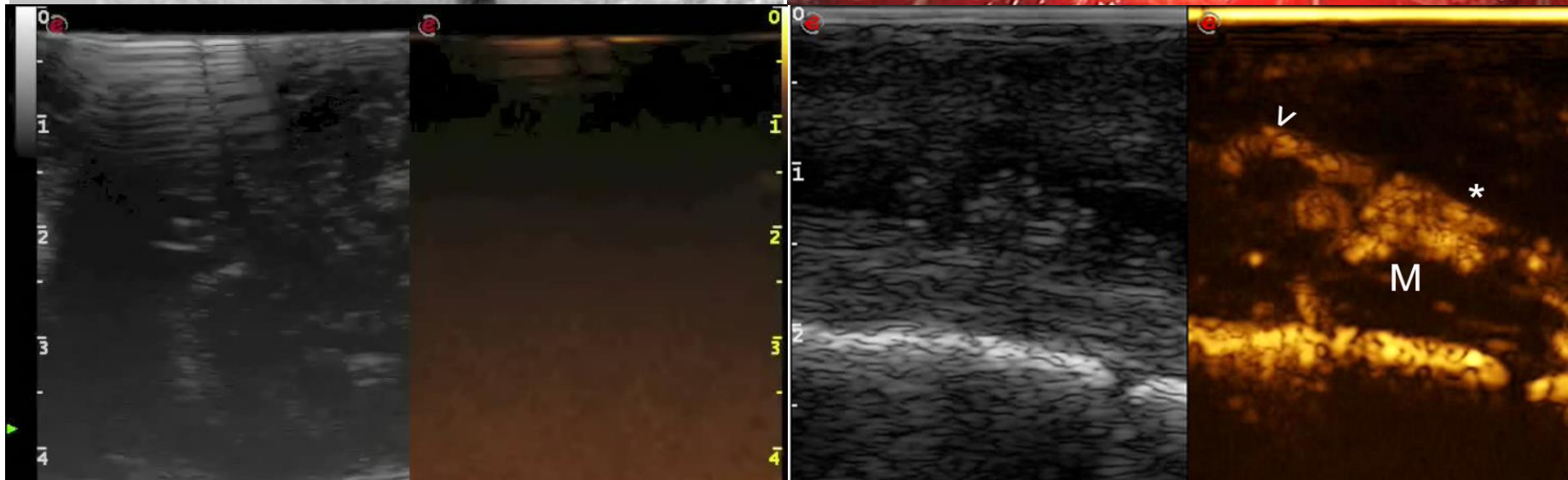
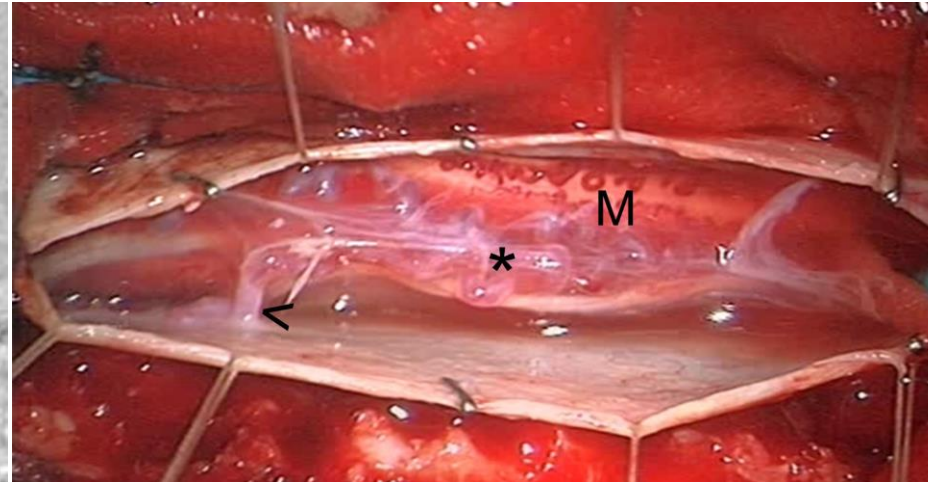
Prada F¹, Bene MD², Casali C², Saladino A², Legnani FG², Perin A², Moiraghi A², Richetta C², Rampini A², Mattei L², Vetrano IG², Fornaro R², Saini M², Martegani A³, DiMeco F⁴.

Vascular Lesions

MCA Aneurysm



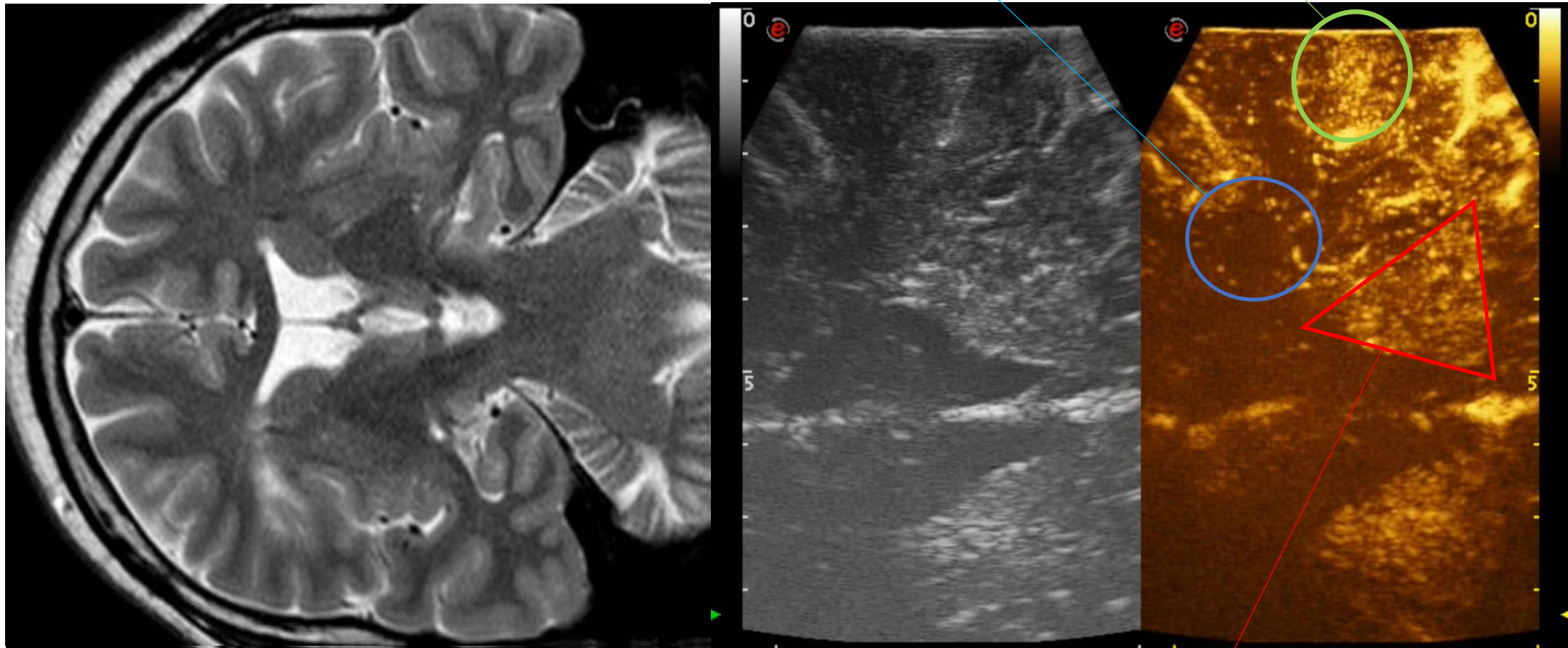
Spinal Arteriovenous Fistula



Epilepsy Surgery

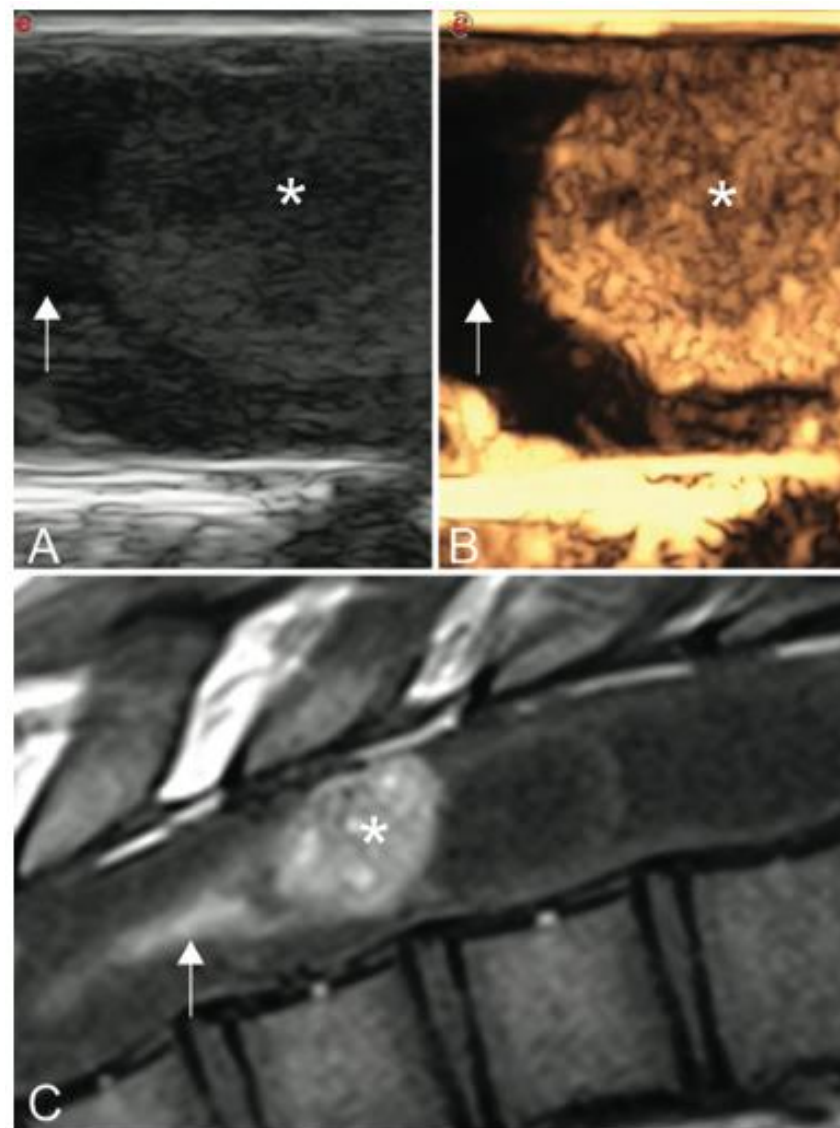
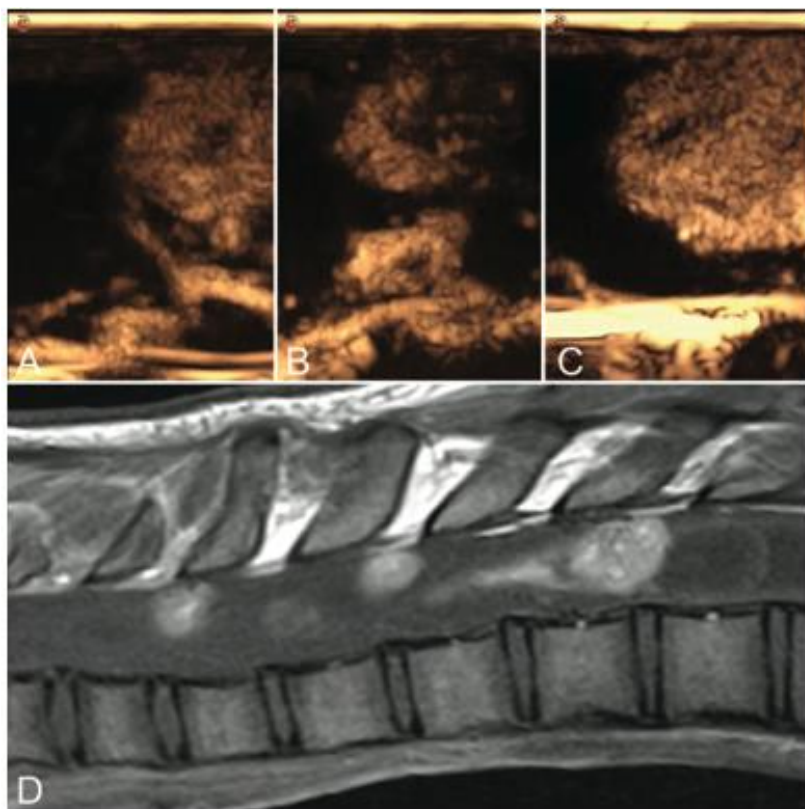
Frontal WM

FCD



Basal ganglia

Spinal tumors

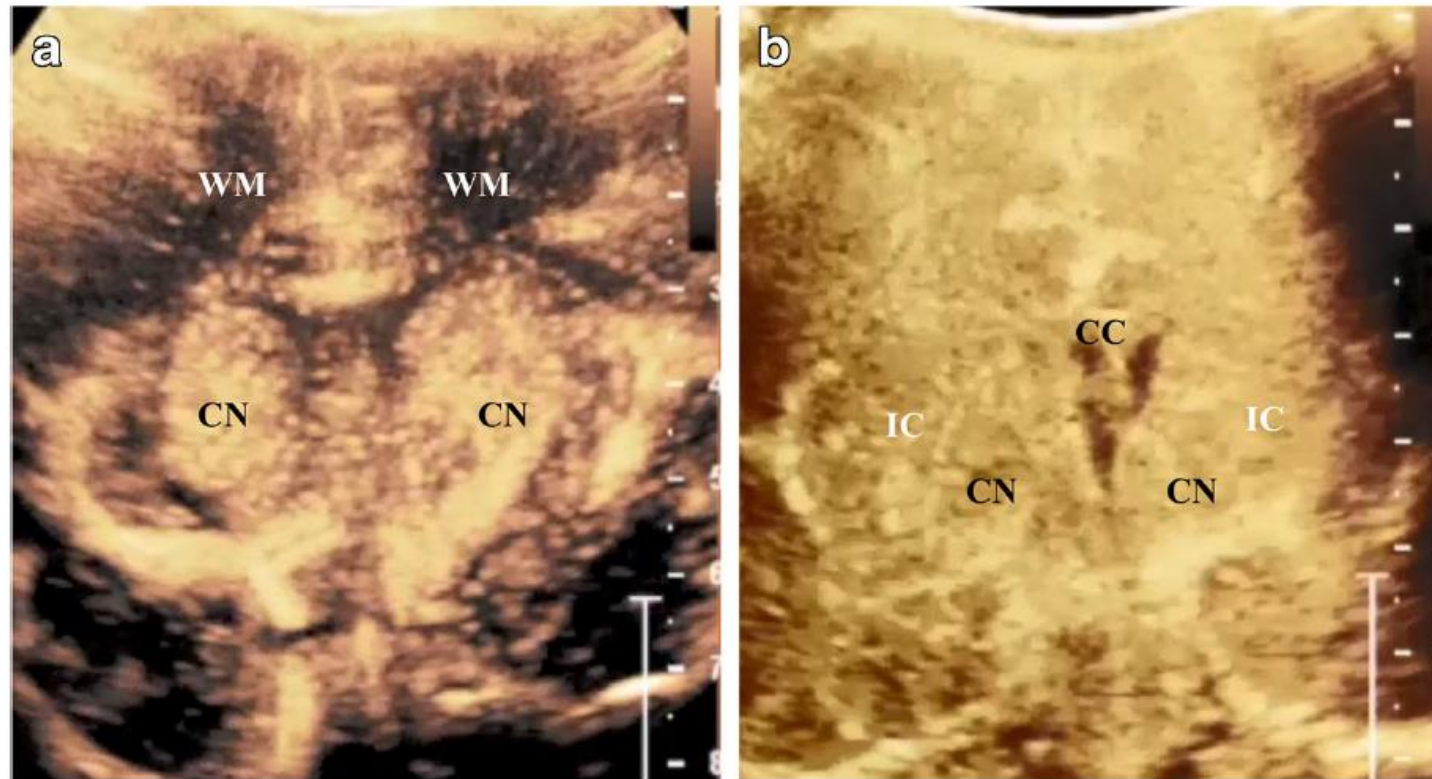


**Discrete or diffuse intramedullary tumor?
Contrast-enhanced intraoperative ultrasound in a case
of intramedullary cervicothoracic hemangioblastomas
mimicking a diffuse infiltrative glioma: technical note
and case report**

Ignazio G. Vetrano, MD,^{1,2} Francesco Prada, MD,¹ Ilaria F. Nataloni, MD,^{2,3}
Massimiliano Del Bene, MD,¹ Francesco DiMeco, MD,^{1,4} and Laura G. Valentini, MD¹

Neurosurg Focus 39 (2):E17, 2015

Pediatric applications



Pediatric Radiology
<https://doi.org/10.1007/s00247-021-04974-4>

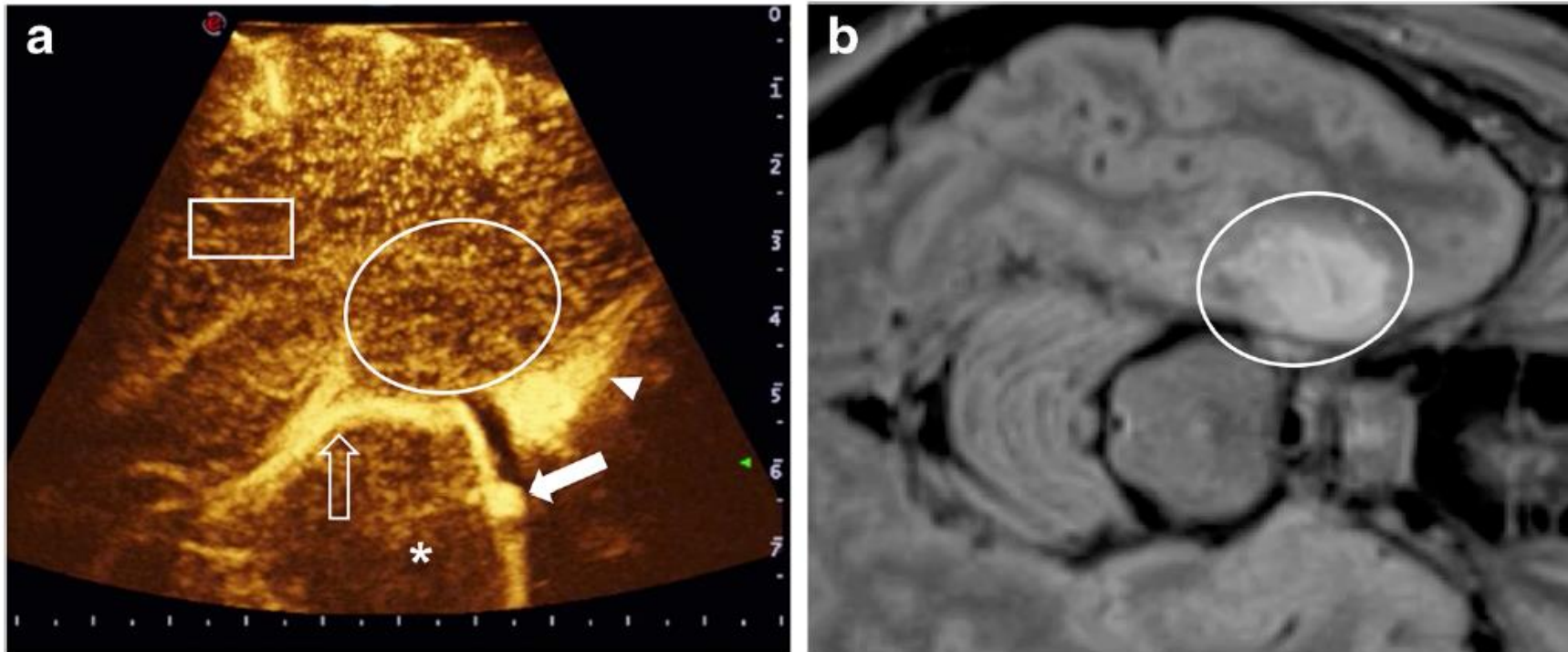
CONTRAST-ENHANCED ULTRASOUND (CEUS) IN CHILDREN



Contrast-enhanced ultrasound of the pediatric brain

Misun Hwang^{1,2} • Carol E. Barnewolt³ • Jörg Jüngert⁴ • Francesco Prada^{5,6,7} • Anush Sridharan¹ • Ryne A. Didier^{1,2}

Pediatric applications




Pediatric Radiology
<https://doi.org/10.1007/s00247-021-04974-4>

CONTRAST-ENHANCED ULTRASOUND (CEUS) IN CHILDREN



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How to Learn/Teach Brain CEUS?



Steep learning curve: requires experience in both acquisition and interpretation



Dedicated hardware/software



Learning US/CEUS physical principles is paramount!



Exposure and First-hand Experience



Specific and Precise Terminology - knobology

Intraoperative Ultrasound - Equipment



Intraoperative Ultrasound - Setting



CEUS Commands - Frequency

Increasing the insonation frequency allows better visualization and contrast of superficial structures.

Lower of the US waves, frequencies allow deeper penetration, although with lower spatial resolution.



Freq.

Focus

CEUS Commands - Focus

The focus should be positioned just deep to the target lesion. Deeper focal zones achieve a more uniform acoustic field, improving sensitivity to the agents and lessens the risk of bubble disruption.



Freq.

Focus

The EFSUMB Guidelines and Recommendations for the Clinical Practice of Contrast-Enhanced Ultrasound (CEUS) in Non-Hepatic Applications: Update 2017 (Short Version)

Authors

Paul S. Sidhu¹, Fabio Piscaglia², Vito Cantisani³, Christoph F. Dietrich⁴, Odd Helge Gilja⁵, Adrian Saftoiu⁶, Eva Bartels⁷, Michele Bertolotto⁸, Fabrizio Calliada⁹, Dirk-André Clevert¹⁰, David Cosgrove¹¹, Annamaria Deganello¹, Mirko D'Onofrio¹², Francesco Maria Drudi¹³, Simon Freeman¹⁴, Christopher Harvey¹⁵, Christian Jenssen¹⁶, Ernst-Michael Jung¹⁷, Andrea Sabine Klauser¹⁸, Nathalie Lassau¹⁹, Maria Meloni²⁰, Edward Leen²¹, Carlos Nicolau²², Christian Nolsoe²³, Francesco Prada²⁴, Helmut Prosch²⁵, Maija Radzina²⁶, Luca Savelli²⁷, Hans-Peter Weskott²⁸, Hessel Wijkstra²⁹

Ultraschall in Medizin 2018

Currently, CEUS is supported by strong consensus among experts while its potential uses and applications are investigate.

Future goal is to gather enough experiences and data to reach LoE 1

RECOMMENDATION 65

Intraoperative CEUS is indicated in neuro-oncological procedures for tumor identification, assessment of boundaries, perfusion pattern and evaluation of residual tumor (LoE 4, GoR C). Strong consensus (19/0/0, 100 %)

RECOMMENDATION 66

Intraoperative CEUS is indicated in angiosonography for neurovascular procedures (LoE 4, GoR C). Strong consensus (19/0/0, 100 %)

RECOMMENDATION 67

Intraoperative CEUS is indicated in traumatic brain surgery to demonstrate tissue viability (LoE 4, GoR C). Strong Consensus (18/0/1, 100 %)

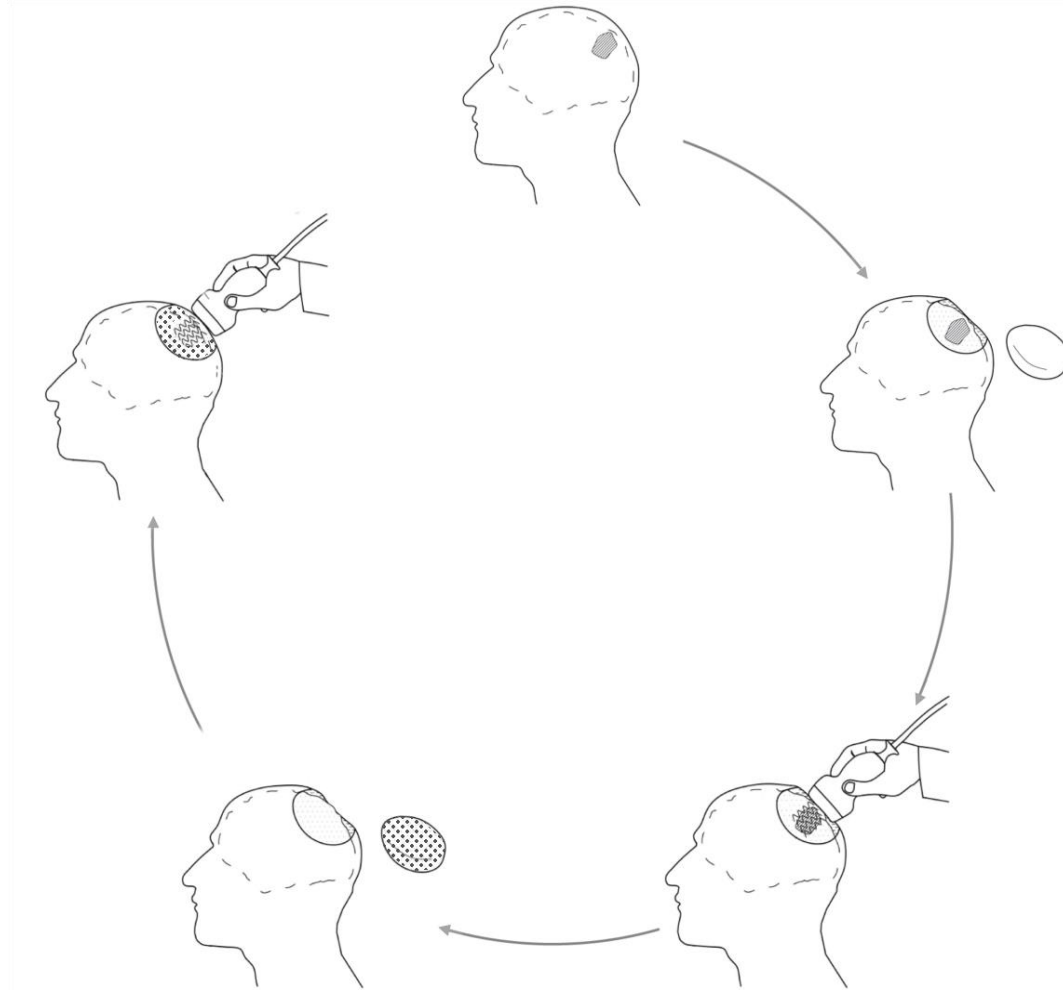
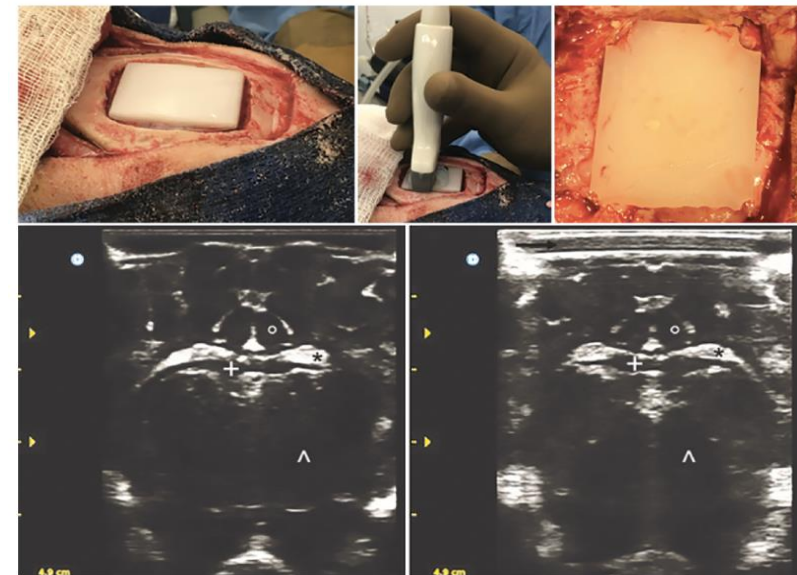
Post-operative Ultrasound

JNS

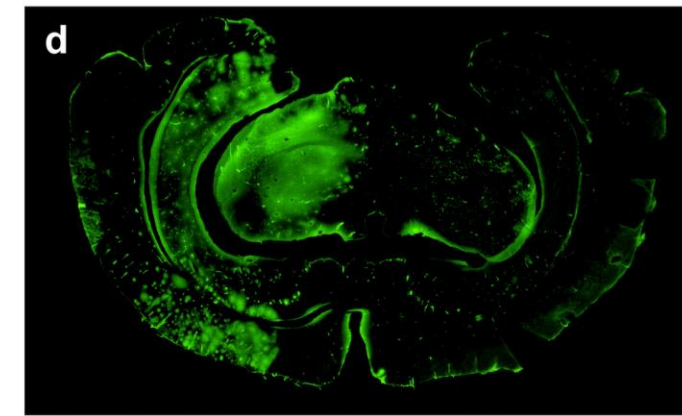
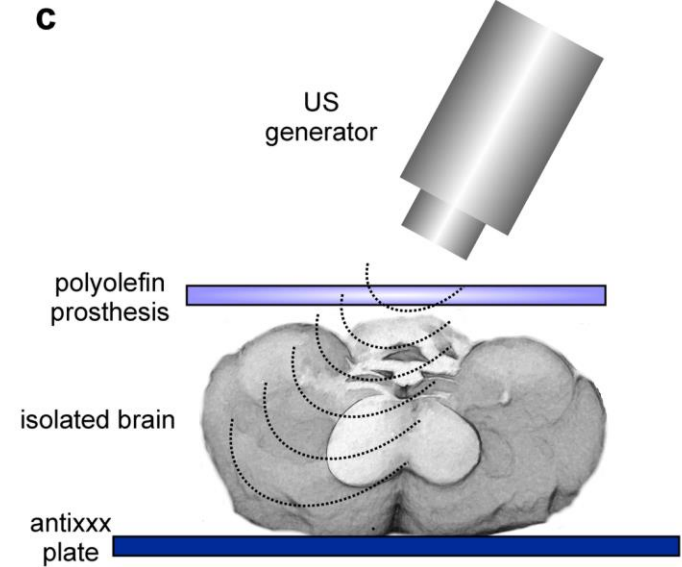
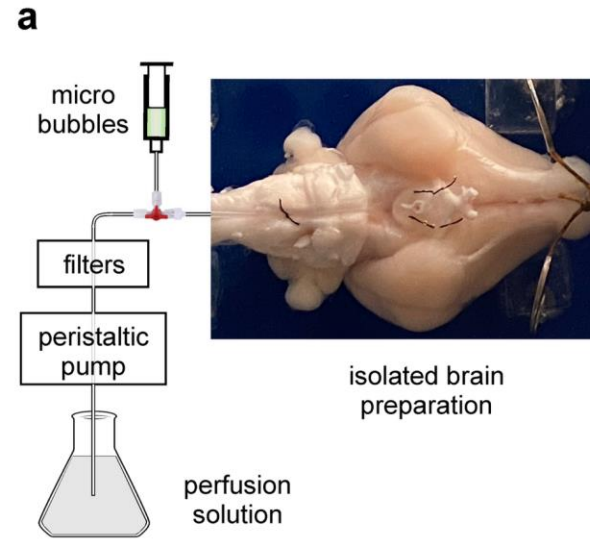
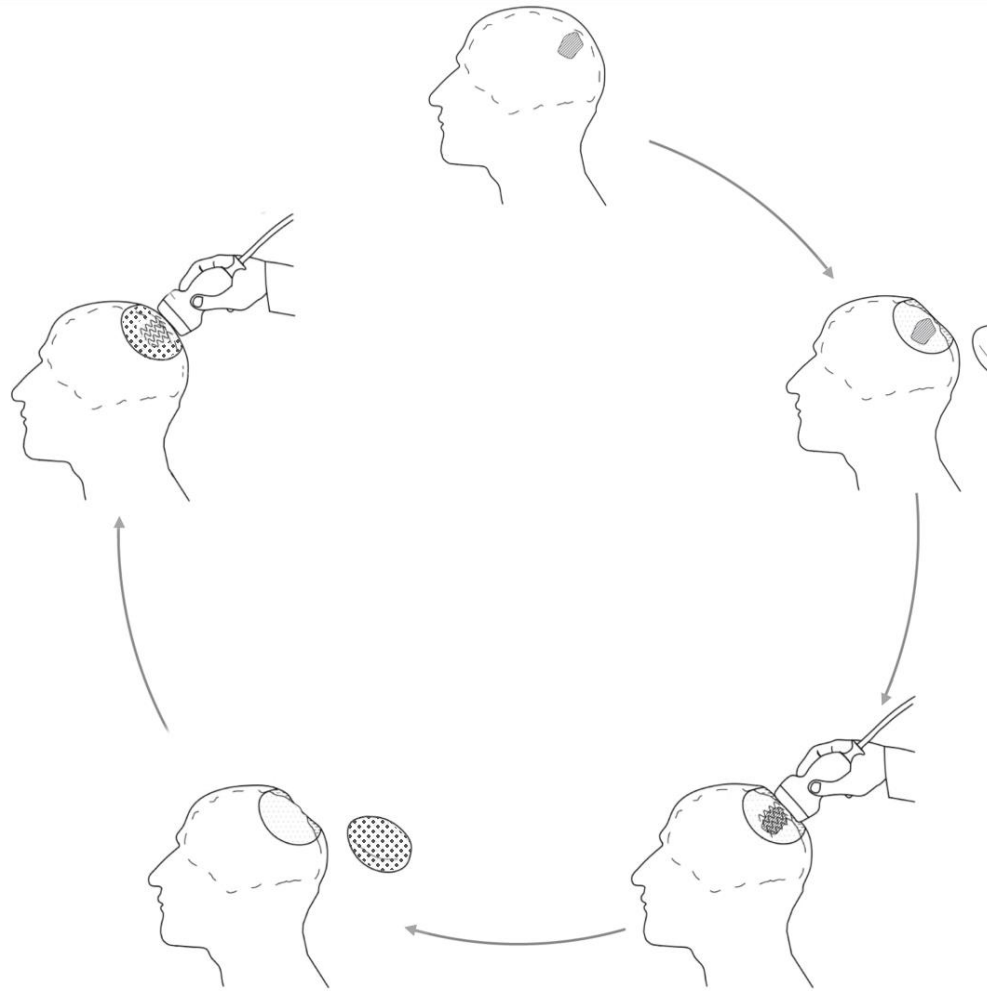
LABORATORY INVESTIGATION

In vitro and in vivo characterization of a cranial window prosthesis for diagnostic and therapeutic cerebral ultrasound

Francesco Prada, MD,¹⁻³ Andrea Franzini, MD,^{1,2} Shayan Moosa, MD,² Frederic Padilla, PhD,³ David Moore, MS,³ Luigi Solbiati, MD,⁴ Francesco DiMeco, MD,^{1,5,6} and Wynn Legon, PhD²



CEUS guided Therapeutic Ultrasound

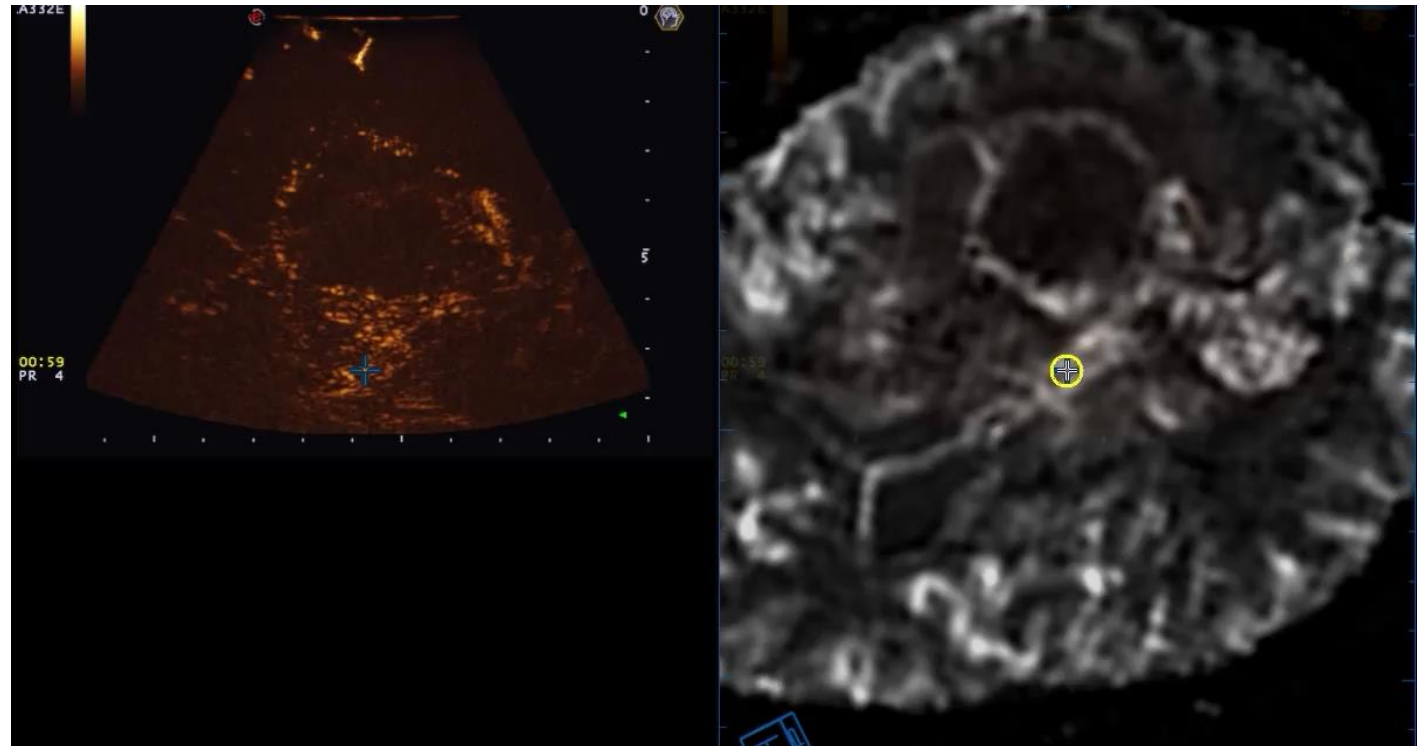


CEUS guided MB mediated follow up and therapy

Conclusions

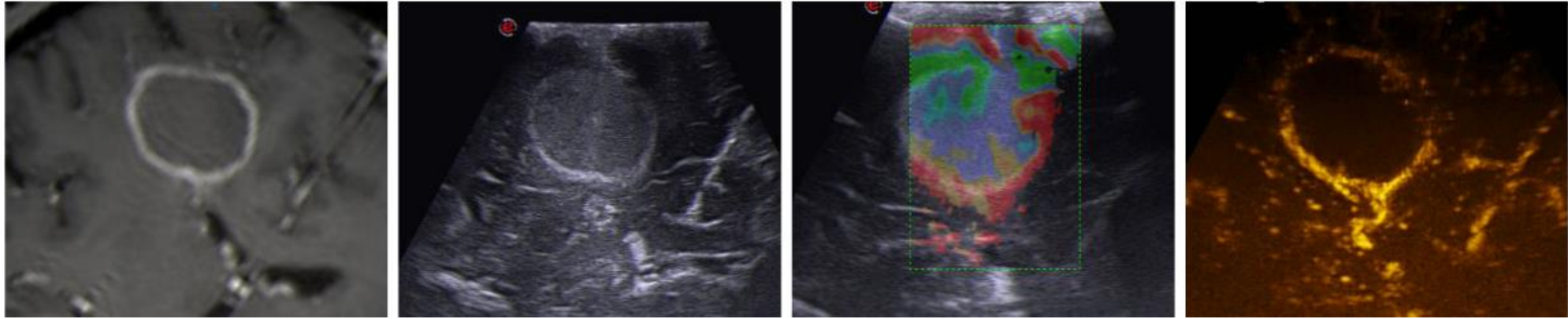
- Contrast-Enhanced Ultrasound provides real time, high-resolution depiction of tumors, vascular structures and perfused parenchyma for multiple surgical needs
- MB potential for follow-up an therapy
- CEUS guided MB mediated therapies

There is more in
ultrasound than
B-mode!!!





FOCUSED
ULTRASOUND
FOUNDATION



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Acoustic Neuroimaging and Therapy Lab

