In Vivo Imaging of Microbubble (MB) Circulation in the Human Brain using Intraoperative Contrast Enhanced Ulstrasound (ICEUS) During Neurosurgical Procedures

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Introduction

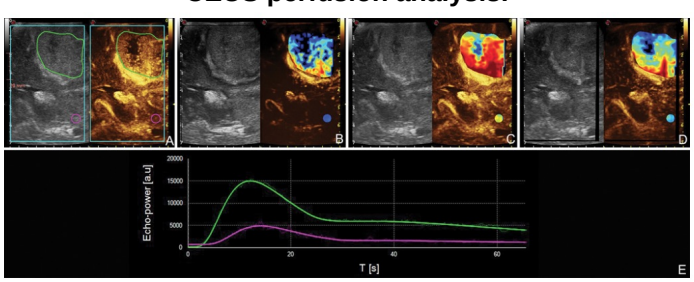
The correlation between MBs circulation and their interaction with focused ultrasound (FUS) in different brain areas has never been specifically investigated, nor the impact of FUS has been correlated with the microbubble distribution in the brain, according to time-intensity curves.
Microbubble concentrations in fact changes in time with different vascular phases (arterial-parenchymal and venous) and showed different concentrations according to vessel density (gray/white matter - basal ganglia), probably also depending on their behaviour.

Methods

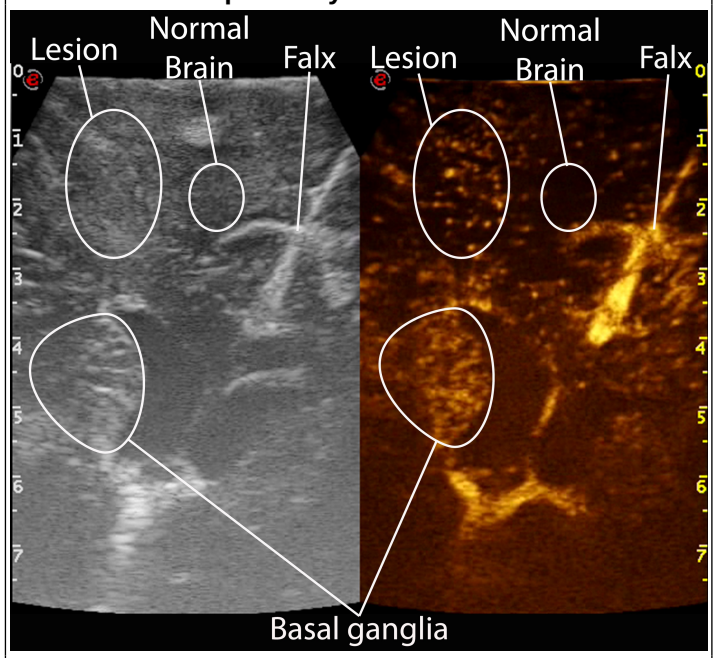
We retrospectively evaluated data regarding a series of > 500 patients who underwent iCEUS imaging in an off-label setting while being operated on for different cerebral tumoral and vascular lesions since 2010.

We analyzed iCEUS imaging obtained after craniotomy, before dural opening, after intravenous injection of ultrasound contrast agent.?A semiquantitative, offline interobserver analysis was performed to visualize each brain lesion and to characterize its perfusion features (timing - degree - patterns of enhancement) . In specific cases a quantitative analysis with dedicated software has been performed.

CEUS perfusion analysis.



Brain parenchyma enhancement.



Coronal CEUS scan in a case of a right frontal low grade glioma. Normal parenchyma does not show any contrast enhancement, while basal ganglia typically show. Lower grade gliomas usually do not demonstrate a strong contrast enhancement.

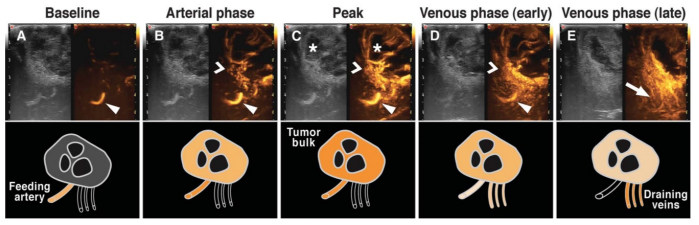
Results

In all cases the lesion and the surrounding parenchyma were visible with iCEUS, permitting perfusion assessment.
MBs highlighted different brain tissues without relying on its echogenicity but on its vascularization.
The degree of contrast enhancement is a consequence of the MBs concentration in time and density of the capillaries. Different lesions show different kinetic and morphologic patterns. Different brain areas and structures show different MBs kinetics and morphologic patterns: large and small vessels > basal ganglia > sulci and gray matter > white matter.

Conclusions

Brain perfusion characteristics, assessed with iCEUS, shed lights on previously unknown features regarding microbubbles distribution in normal and pathological conditions and might have important consequences when dealing with therapeutic US.

CEUS time frame



Glioblastoma right parietal visualized by ultrasound (both B-mode and contrast-enhanced ultrasound; top row), along with a schematic representation of it (bottom row). Note how the microbubble contrast medium allows the neurosurgeon to visualize the feeding artery (full arrowhead; A), the arterial phase, and the tumor parenchyma (B and C; the empty arrowhead points at the secondary arteries, and the star shows the cystic/necrotic areas), followed by the venous phase and the draining veins (arrow) of the lesion (D and E).

Learning Objectives

By the conclusion of this session, participants should familiarize with the fact that microbubbles distribution in normal and pathological conditions could be different and might have important consequences when dealing with therapeutic US

References

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