Intraoperative Contrast Enhanced Ultra-Sound (CEUS) in Brain Tumor Surgery

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Introduction

Contrast-enhanced ultrasound (CEUS) is a dynamic and continuous imaging modality that offers a real-time, direct view of vascularization, flow distribution patterns of different types of lesions. Thanks to second-generation ultrasound-contrast agents, CEUS has become a well-established, live-imaging technique for many organs, but it has never been extensively used for brain imaging, mainly because of bone shielding to ultrasounds. To date, the reported use of intraoperative-CEUS imaging in neurosurgical procedures is very limited. Aim of the study is to provide the first dynamic and continuous intraoperative - CEUS evaluation of different brain lesions. Aim of the study is to provide the first dynamic and continuous intraoperative - CEUS evaluation of different brain lesions.

Methods

All patients included in the study underwent surgery for intracranial tumor with ultrasound guidance. CEUS imaging was obtained before resection of the lesion after microbubble contrast-agent intra-venous injection, using low-acoustic-power contrast -specific modes. A semi-quantitative offline inter-observer analisys had been performed in order to evaluate lesion visualization with CEUS and perfusion characteristics, according to EFSUMB guidelines: timing (arterial/venous phase), degree (comparison with brain parenchyma) and contrast distribution (centripetal/centrifugal pattern, visibility of afferent/efferent vessels, intra-lesion vessels, cystic/necrotic areas). All data were compared both to pre-op MRI and histopathology.

Results

Between December 2010 and May 2013, 71 patients underwent intraoperative-CEUS imaging. In all cases it was possible to visualize the lesion with CEUS. Main findings for glioblastomas and metastasis were: rapid arterious and venous phase (5'-10') with high, heterogeneous contrast enanchement. Low grade glioma: slow arterious phase (10') with persistent parechymal phase and late venous phase, mild dotted enanchement. Meningiomas: rapid arterious phase (5-10') with persistent enhancement. No adverse effects were observed.

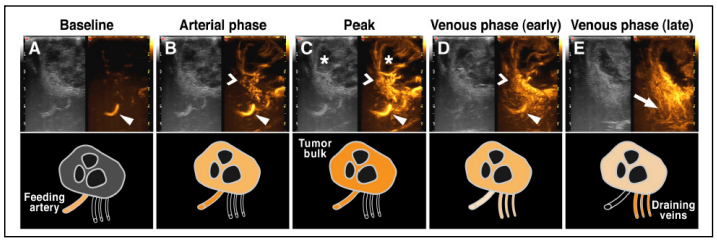

Figure 1 Timeframe of how a glioblastoma is visualized by US (both B-mode and CEUS) (top row), along with a schematic representation of it (bottom row). Note how the microbubble contrast medium allows the neurosurgeon to visualize the feeding artery (full arrowhead) (A), the arterial phase and the tumor parenchyma (B and C – the empty arrowhead point at the secondary arteries, 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 be able to: 1) understand CEUS imaging 2) evaluate its different features in brain tumor visualization 3) discuss CEUS role in tumor resection.

Conclusions

Our study is the first implementation of intraoperative-CEUS in neurosurgery, providing a dynamic and continuous real-time imaging of different brain lesions, through a direct visualization of the lesion, vascularisation pattern, flow distribution of different types of brain lesions.

Figure 2 A comprehensive panel correlating MRI and US appearance (both B-mode and CEUS) of different brain lesions (A: gliomas; B: other tumors; C: meningiomas; D: metastases; E: radiation necrosis; F: cerebral abscess). Every brain lesion is highlighted on a CE-MRI image (arrow); please note how B-mode and CEUS appearances correlate [normal and pathological vessels look orange in CEUS, while non-vascularized/cystic/necrotic areas are black (star)].