

## Residual Tumor Identification with Intra-operative Contrast-enhanced Ultrasound During Glioblastoma Resection

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## Introduction

Our purpose was to assess contrast-enhanced ultrasound (CEUS) capability to identify residual tumor mass during glioblastoma (GBM) surgery, in order to increase the extent of resection.

## Methods

We prospectively evaluated 10 patients who underwent surgery for GBM removal with navigated ultrasound guidance. Navigated Bmode and CEUS were performed prior to resection, during resection and after complete tumor resection. Areas suspected for residual tumors on B-mode and CEUS were localized within the surgical field with navigated ultrasound and sent separately for histopathological analysis to confirm tumor presence.

#### Learning Objectives

To understand CEUS role in identifying residual tumor mass in GBMs' surgery, thus enhancing tumor resection

## Results

In all cases tumor remnants were visualized as hyperechoic areas on Bmode, highlighted as CEUS positive areas and confirmed as tumoral areas on hystopathological analysis. In 1 case only CEUS partially failed to demonstrate residual tumor because the residual hyperehoic area was devascularized prior to ultrasound contrast agent injection. In all cases CEUS enhanced B-mode findings.

Dual-mode scan performed after subtotal resection.



The CEUS scan (right) demonstrates only mild contrast enhancement, but a residual tumor is present and visible as a hyperechoic area on B-mode (left) (circles). Histological analysis confirmed that it was residual tumor. This was probably due to the fact that the area has been devascularized prior to CEUS, leading to an impaired distribution of the UCA in the residue. The B-mode and CEUS scans after subtotal resection in a case of left temporal GBM.



The B-mode (upper panel, left) and CEUS (lower panel, left) images are presented together with the corresponding coplanar preoperative MRI sequences (upper and lower panels, right). In B-mode some hyperechoic artifacts appeared (arrowheads), making it difficult to discern between tumor remnants and edematous brain tissue, whereas in CEUS the area underlying the artifacts is clearly identifiable as

an enhanced component of the tumor located within the navigated surgical volume (arrowheads).

# Examples of residual tumor identification.



left: Dual display of low mechanical index B-mode and corresponding CEUS scans in a case of frontal right GBM. Right: Dual display of low mechanical index B-mode and corresponding CEUS scans ina case of temporoparietooccipital GBM. The artifacts on the surface of the surgical cavity might be misleading when judging the hyperechoic residual tumor mass in B-mode, whereas this is more easily identifiable in CEUS (circles).

## Conclusions

As already shown in other neoplastic lesions in other organs CEUS is extremely specific in the identification of residual tumor. CEUS distinction between tumor and artifacts/normal brain on B-mode is based on its capability to show the vascularization degree and not the echogenicity of the tissues. Therefore, CEUS can play a decisive role in the process of maximizing GBM surgical resection.

## Preresection B-mode and CEUS scans in a case of left temporal GBM.



The B-mode (upper panel, left) and CEUS (lower panel, left) images together with the corresponding coplanar preoperative MRI (upper and lower panels, right). In B-mode it is difficult to discern between tumor and edema (arrowheads), whereas with CEUS the tumor borders are highlighted and superimposable onto preoperative MR images.