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Development of Stereotactic Mass Spectrometry for Brain Tumor Surgery.

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Abstract

BACKGROUND: Surgery remains the first and most important treatment modality for the majority of solid tumors. Across a range of brain tumor types and grades, postoperative residual tumor has a great impact on prognosis. The principal challenge and objective of neurosurgical intervention is therefore to maximize tumor resection, while minimizing potential for neurological deficit by preserving critical tissue.

OBJECTIVE: To introduce the integration of DESI mass spectrometry into surgery for in vivo molecular tissue characterization and intra-operative definition of tumor boundaries, without systemic injection of contrast agents.

METHODS: Using a frameless stereotactic sampling approach and by integrating a 3D navigation system with an ultrasonic surgical probe, image-registered surgical specimens were obtained. The samples were analyzed with ambient desorption/ionization mass spectrometry, and validated against standard histopathology. This new approach will enable neurosurgeons to detect tumor infiltration of the normal brain intraoperatively with mass spectrometry and obtain spatially resolved molecular tissue characterization without any exogenous agent, and with high sensitivity and specificity.

RESULTS: Proof-of-concept is presented in using mass spectrometry intraoperatively for real-time measurement of molecular structure and using that tissue characterization method for the detection of tumor boundaries. Multiple sampling sites within the tumor mass were defined for a patient with a recurrent left frontal oligodendroglioma, W.H.O. grade II with chromosome 1p/19q co-deletion, and mass spectrometry data indicated a correlation between lipid constitution and tumor cell prevalence.

CONCLUSION: The mass spectrometry measurements reflect complex molecular structure and are integrated with frameless stereotaxy and imaging, providing 3D molecular imaging without systemic injection of any agents, which can be implemented for surgical margins delineation of any organ and with a rapidity that allows for real-time analysis.

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