Intraoperative Ultrasound for Brain Tumor Surgery

- Intraoperative Visual Field Assessment in Parietal Glioma Resection and the Role of Virtual Reality Headset-Based Mapping
- High Conductivity Saline Nanodroplets-Enhanced Thermoacoustic Imaging for Brain Tumor Detection
- Volumetric predictors for shunt-dependency in pediatric posterior fossa tumors
- Functional-guided frameless stereotactic biopsy of highly eloquent brain tumors
- Anatomo-functional approach to multimodal motor mapping in diffuse glioma surgery: hierarchical networks
- Advances in minimally invasive surgery for brain metastases
- Tractography in brain tumor surgery: current clinical impact and future challenges
- 5-Aminolevulonic Acid, a New Tumor Contrast Agent: Anesthesia Considerations in Patients Undergoing Craniotomy

Intraoperative ultrasound (IOUS) is an increasingly valuable tool in the surgical management of brain tumors. It provides real-time imaging during surgery, enabling neurosurgeons to localize tumors, monitor resection progress, and identify residual tumor tissue with minimal delay.

Applications in Brain Tumor Surgery

1. **Tumor Localization**:
   - Identifies tumor margins and their relationship to surrounding brain structures.
   - Particularly useful for low-grade gliomas, metastases, and cystic tumors.
2. **Guidance During Resection**:
   - Real-time imaging aids in navigating tumor boundaries, especially in deep-seated or eloquent areas.
   - Facilitates maximal safe resection by distinguishing tumor tissue from normal brain parenchyma.
3. **Assessment of Residual Tumor**:
   - Helps evaluate the extent of resection intraoperatively, reducing the need for postoperative imaging.
4. **Functional Preservation**:
   - In combination with neurophysiological monitoring, IOUS helps avoid damage to critical structures.

Advantages

1. **Real-Time Feedback**:
   - Provides immediate visualization without interrupting surgical flow.
2. **Cost-Effective**:
   - More affordable than alternatives like intraoperative MRI (iMRI) or CT.
3. **Portable and Versatile**:
   - Compact and easy to use, with minimal setup required.
4. **Enhanced Safety**:

- Reduces the likelihood of leaving residual tumor tissue, potentially improving patient outcomes.

5. **Adaptability**:
   - Can be used in conjunction with other technologies like neuronavigation and fluorescein imaging.

Challenges and Limitations

1. **Operator Dependency**:
   - Image acquisition and interpretation require significant experience and training.
2. **Limited Resolution**:
   - IOUS may have difficulty distinguishing between edema, gliosis, and tumor tissue in some cases.
3. **Acoustic Artifacts**:
   - Bone and air can interfere with image quality, necessitating careful positioning and gel application.
4. **Learning Curve**:
   - Surgeons must familiarize themselves with the nuances of IOUS imaging.

Techniques for Optimization

1. **Contrast-Enhanced Ultrasound (CEUS)**:
   - Improves tumor delineation by enhancing vascular structures.
2. **Integration with Neuronavigation**:
   - Enhances accuracy and correlation with preoperative imaging.
3. **Training and Simulation**:
   - Regular use and simulation training can improve proficiency and interpretation skills.

Clinical Evidence

Studies have demonstrated that IOUS significantly improves the extent of resection (EOR) in glioma surgeries. For metastatic tumors, IOUS is effective in identifying small residuals and ensuring completeness of resection.

Future Directions

1. **Advanced Imaging Techniques**:
   - Development of high-frequency probes for better resolution.
   - Integration with 3D reconstruction and artificial intelligence for enhanced interpretation.
2. **Wider Adoption**:
   - As costs decrease and training improves, IOUS may become a standard part of neurosurgical workflows.

Intraoperative ultrasound has revolutionized brain tumor surgery by providing real-time, dynamic imaging. With ongoing advancements in technology and training, its utility and accuracy are likely to continue improving, benefiting patient outcomes worldwide.

Intraoperative ultrasound in intracranial meningioma

Intraoperative ultrasound in intracranial meningioma

Intraoperative ultrasound in glioma surgery

Intraoperative ultrasound in glioma surgery.

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