Glioma surgery

- Molecular and clinical determinants of response to checkpoint inhibitor immunotherapy in glioblastoma
- Serum Autoantibody Titers and Neurofilament Light Chain Levels in CASPR2/LGI1 Encephalitis: A Longitudinal Study
- Coexistence of Congenital Aniridia and Ptosis in a Patient with Neurofibromatosis Type I: A Case Report
- O⁶-Methylguanine-DNA Methyltransferase (MGMT) Promoter Methylation Analysis in Glioblastoma Patients
- An In Vivo Model of Recurrent Glioblastoma
- Growth Dynamics of Brain Tumor Through the Lens of MT-Weighted MRI
- Corrigendum: High-dose fluorescein reveals unusual confocal endomicroscope imaging of low-grade glioma
- Synchronous Occurrence of T-cell Lymphoblastic Lymphoma and High-Grade Glioma in a Pediatric Patient: A Case Report

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Glioma surgery refers to the surgical resection or debulking of a glioma, a type of primary brain tumor arising from glial cells (astrocytes, oligodendrocytes, or ependymal cells).

Classification

Insular glioma surgery.

Occipital lobe glioma surgery.

Thalamic glioma surgery.

Goals

Maximize tumor resection

Preserve neurological function

Obtain tissue for histopathological and molecular diagnosis

Reduce intracranial pressure and improve symptoms

Surgical Strategy

Planning

Positioning

Skin incision

Craniotomy

Extent of resection (EOR) is a key prognostic factor

Gross total resection (GTR)

Subtotal resection

Biopsy (stereotactic or open)

Guided by:

Neuronavigation

Intraoperative magnetic resonance imaging (iMRI)

Fluorescence-guided surgery (5-ALA or fluorescein)

Awake craniotomy for tumors near eloquent cortex

Neurophysiological monitoring (MEP, SSEP, cortical mapping)

Indications

Tumor is accessible and resectable

Clinical or radiological progression

Symptomatic mass effect or intractable seizures

Need for tissue diagnosis

Contraindications

Poor performance status (e.g., Karnofsky < 60)

Deep-seated or non-resectable location (e.g., brainstem)

Diffuse infiltrative pattern without a clear mass

Risks

Neurological deficits (transient or permanent)

Seizures, hemorrhage, infection, CSF leak

Tumor recurrence is common; adjuvant therapy needed

Postoperative Management

MRI within 48–72h to assess EOR

Initiation of adjuvant therapy (radiotherapy ± chemotherapy)

Multidisciplinary evaluation (neuro-oncology, radiotherapy)

Prognosis

Dependent on:

Tumor grade (WHO classification)

Molecular profile (IDH mutation, 1p/19q codeletion, MGMT methylation)

EOR

Age and functional status

Although maximal tumor resection improves survival, this must be balanced with the preservation of neurologic function. Technological advancements have greatly expanded our ability to safely maximize tumor resection and design innovative therapeutic trials that take advantage of intracavitary delivery of therapeutic agents after resection [1].

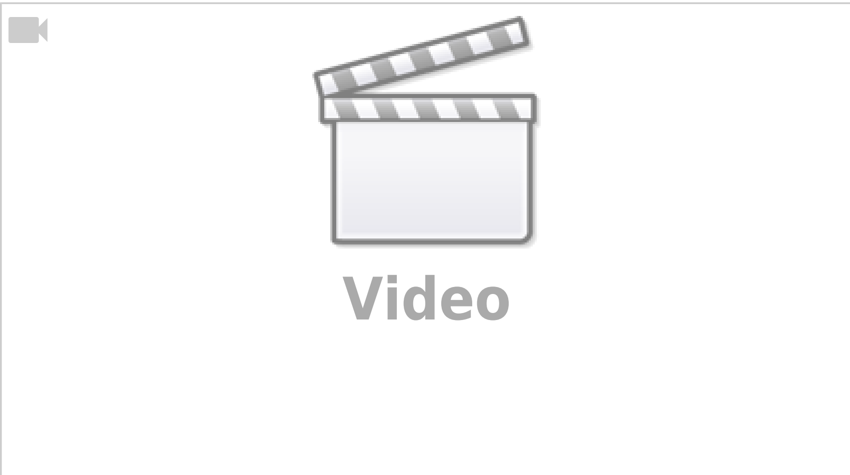
see US National Comprehensive Cancer Network glioma surgery guidelines.

The ideal goal of brain tumor surgery treatment is to maximize the resection of tumor volume, without damaging motion, sensation, language, and other important cognitive functions. The key in this type of surgery is how to identify the positions of brain areas associated with important functions during the surgery accurately and in real-time. Accurate positioning may avoid excessive resection-induced permanent neurological dysfunction, and also avoid incomplete excision due to excessive carefulness, in which situation the desired therapeutic effect would be challenging to achieve [2] [3] [4].

The goal in tumor surgery is to remove the maximum achievable amount of the tumor, preventing damage to “eloquent” brain regions as the amount of brain tumor resection is one of the prognostic factors for time to tumor progression and median survival.

To achieve this goal, a variety of technical advances have been introduced, including an operating microscope in the late 1950s, computer-assisted devices for surgical navigation and more recently, intraoperative imaging to incorporate and correct for brain shift during the resection of the lesion. However, surgically induced contrast enhancement along the rim of the resection cavity hampers interpretation of these intraoperatively acquired magnetic resonance images. To overcome this uncertainty, perfusion techniques dynamic contrast enhanced magnetic resonance imaging (DCE-MRI), Dynamic susceptibility contrast MRI imaging (DSC-MRI)] have been introduced that can differentiate residual tumor from surgically induced changes at the rim of the resection cavity and thus overcome this remaining uncertainty of intraoperative MRI in High-grade glioma resection [5].

Videos



High-grade glioma surgery

see High-grade glioma surgery.

Low-grade glioma surgery

see Low-grade glioma surgery.

The optimal surgical management of gliomas requires a balance between surgical cytoreduction and preservation of neurological function. Preoperative functional neuroimaging, such as functional MRI (fMRI) and diffusion tensor imaging (DTI), has emerged as a possible tool to inform patient selection and surgical planning. However, evidence that preoperative fMRI or DTI improves the extent of resection, limits neurological morbidity, and broadens surgical indications in classically eloquent areas is lacking. In a review, Azad and Duffau described facets of functional neuroimaging techniques that may limit their impact on neurosurgical oncology and critically evaluate the evidence supporting fMRI and DTI for patient selection and operative planning in glioma surgery. The authors also propose alternative applications for functional neuroimaging in the care of glioma patients [6].

Glioma surgery is an essential part of glioma treatment; however, fully achieving the goal of surgery has been uncommon. The goal of surgery is 'maximal safe resection' with the accepted target for maximal being complete resection of the contrast-enhancing tumor. This ideal result was obtained in less than 30% of cases in centers of excellence until a few years ago.

Fluorescence guided surgery (FGS) is a technique used to enhance visualization of tumor margins in order to increase the extent of resection in glioma surgery.

The role of glioma surgery has been debated for decades, as sceptics questioned the rationale of surgery for such an infiltrative disease. However, modern guidelines recommend primary surgical removal for all types of gliomas provided that neurological function is preserved and the tumour appears locally circumscribed on magnetic resonance imaging (MRI).

The benefits of a larger resection, however, must be weighed against the cost of deficits incurred in areas of eloquent cortex, particularly in motor and language areas [7].

Identification of the resection border for gliomas depends on the surgeon's interpretation of visual inspection and touch sensation, and such information depends on the tumor characteristics. One critical factor is the sharpness of the tumor borders as defined on T2-weighted MR images [8].

Because there is a high degree of individual variability in these areas, presurgical localization and intraoperative cortical mapping are often required to optimize the clinical outcome.

White matter tractography is limited by biological variables such as edema, mass effect, and tract infiltration or selection biases related to region of interest or fractional anisotropy values.

An automated tract identification paradigm was developed and evaluated for glioma surgery. A fiber bundle atlas was generated from 6 healthy participants. Fibers of a test set (including 3 healthy participants and 10 patients with brain tumors) were clustered adaptively with this atlas. Reliability of the identified tracts in both groups was assessed by comparison with 2 experts with the Cohen κ used to quantify concurrence. They evaluated 6 major fiber bundles: cingulum bundle, fornix, uncinate fasciculus, arcuate fasciculus, Inferior fronto-occipital fascicle, and inferior longitudinal fasciculus, the last 3 tracts mediating language function.

The automated paradigm demonstrated a reliable and practical method to identify white mater tracts, despite mass effect, edema, and tract infiltration. When the tumor demonstrated significant mass effect or shift, the automated approach was useful for providing an initialization to guide the expert with identification of the specific tract of interest.

Tunç et al., report a reliable paradigm for the automated identification of white matter pathways in patients with gliomas. This approach should enhance the neurosurgical objective of maximal safe resections [9].

Functional magnetic resonance imaging (fMRI) has played an important role in the preoperative assessment of patients with lesions adjacent to eloquent cortex.

Glioma is resistant to the apoptotic effects of chemotherapy and the mechanism underlying its chemoresistance is not currently understood.

Satoer et al. systematically searched the electronical databases Embase, Medline OvidSP, Web of Science, PsychINFO OvidSP, PubMed, Cochrane, Google Scholar, Scirius and Proquest aimed at cognitive performance in glioma patients preoperatively and postoperatively.

They included 17 studies with tests assessing the cognitive domains: language, memory, attention, executive functions and/or visuospatial abilities. Language was the domain most frequently examined. Immediately postoperatively, all studies except one, found deterioration in one or more cognitive domains. In the longer term (3-6/6-12 months postoperatively), the following tests showed both recovery and deterioration compared with the preoperative level: naming and verbal fluency (language), verbal word learning (memory) and Trailmaking B (executive functions).

Cognitive recovery to the preoperative level after surgery is possible to a certain extent; however, the results are too arbitrary to draw definite conclusions and not all studies investigated all cognitive domains. More studies with longer postoperative follow-up with tests for cognitive change are necessary for a better understanding of the conclusive effects of glioma surgery on cognition [10).

5-aminolevulinic-acid fluorescence-guided resection of glioma

5-aminolevulinic-acid fluorescence-guided resection of glioma

Intraoperative direct electrocortical stimulation for glioma surgery

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Awake surgery for glioma

Awake surgery for glioma

Glioma surgery complications

Glioma surgery complications

1)
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