Thalamic glioma surgery approaches

- Primary pineal alveolar rhabdomyosarcoma in an adult patient: a case report and literature review
- Multinodular and vacuolating neuronal tumor in the thalamus: case report and systematic review of literature
- Evaluating the impact of tubular retractors in glioma surgery: A systematic review and meta-analysis
- Transcallosal Retroforniceal Transchoroidal Approach: To the Posterior Third Ventricle and Beyond
- Microsurgical anatomy and approaches to thalamic gliomas. Part 2: Maximal safe resection of thalamic gliomas improves outcomes. A single-center experience
- Microsurgical anatomy and approaches to thalamic gliomas. Part 1: A cartography guide for navigating to the thalamus. Integrating 3D model rendering with anatomical dissections
- Trans-temporal trans-choroidal resection of thalamic and thalamopeduncular tumors: how I do it
- Contralateral interhemispheric transcallosal transchoroidal approach to a thalamic glioma: illustrative case

Surgical approaches depend on the tumor's size, location, and characteristics, as well as the patient's clinical condition.

Approaches

1. Transcortical Approaches

Advantages: Direct access to the tumor; good for larger lesions involving the lateral thalamus or extending into adjacent structures. Techniques: Frontal transcortical: Through the frontal lobe for anteriorly located thalamic lesions. Temporal transcortical: For lesions extending to the mesial temporal structures. Parietal or occipital transcortical: For lesions in the posterior or pulvinar region of the thalamus. Considerations: Risk of cortical injury, seizure development, and motor or sensory deficits.

2. Transcallosal Approaches Advantages: Avoids cortical injury and minimizes seizure risk; excellent for midline tumors or those extending into both thalami (e.g., butterfly gliomas). Techniques: Anterior transcallosal: Access through the corpus callosum for lesions in the anterior thalamus. Posterior transcallosal: For posteriorly located tumors. Considerations: Requires careful handling of the corpus callosum to avoid disconnection syndromes.

3. Subtemporal Approach

Advantages: Direct access to the posterior thalamus and pulvinar region. Indications: Lesions primarily in the posterior or inferior thalamus with minimal lateral extension. Considerations: Risk of damage to the temporal lobe or the venous system.

4. Transsylvian Approach

Advantages: Minimal disruption of the cortex; good visualization of deep structures. Indications: Lesions involving the lateral or anterolateral thalamus, near the Sylvian fissure. Considerations: Technically demanding; risk of damage to the middle cerebral artery or lenticulostriate arteries.

5. Posterior Interhemispheric Parieto-occipital Approach

Advantages: Provides excellent access to the pulvinar and posterior thalamus. Indications: Tumors located in the posterior thalamus and extending to the pineal region. Considerations: Steep learning curve; potential for injury to the occipital lobe and related visual pathways.

6. Endoscopic Approaches Advantages: Minimally invasive; useful for biopsy, cyst decompression, or small lesion resection. Indications: Lesions causing hydrocephalus or located near the ventricular system. Techniques: Endoscopic third ventriculostomy combined with biopsy. Endoscopic transventricular approaches for selected tumors. Considerations: Limited tumor resection capability; primarily used for diagnostic or palliative purposes.

7. Combined Approaches In complex cases, a combination of the above approaches may be employed to achieve maximal safe resection while minimizing risks. Surgical Tools and Technologies Neuronavigation: Enhances surgical precision by mapping the tumor's location relative to critical structures. Intraoperative MRI/CT: Provides real-time imaging to guide resection. Neurophysiological Monitoring: Ensures safety by monitoring motor, sensory, and language pathways during surgery. Awake Craniotomy: May be utilized if the tumor is near eloquent cortical areas. Key Considerations Preoperative Planning: Detailed MRI (including DTI for fiber tractography) and MR spectroscopy to delineate tumor boundaries and assess functional anatomy. Extent of Resection: Strive for maximal safe resection while avoiding morbidity. Thalamic gliomas often require a balance between aggressive resection and functional preservation. Postoperative Care: Adjuvant therapy (radiotherapy or chemotherapy) often follows surgery, depending on the tumor grade and resection extent.

Systematic reviews

Merenzon et al. aimed to systematically review the literature to describe the current surgical outcomes of Adult thalamic glioma (ATG and to provide tools that may improve the decision-making process.

Literature regarding the surgical management of ATG patients was reviewed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines. Four databases were queried and a description of clinical characteristics and survival analysis were performed. An individual patient data analysis was conducted when feasible.

A total of 462 patients were included from 13 studies. The mean age was 39.8 years with a median preoperative Karnofsky performance scale of 70. The lateral approaches were most frequently used (74.9%), followed by the interhemispheric (24.2%). Gross total and subtotal/partial resections were achieved in 81%, and 19% of all cases, respectively. New permanent neurological deficits were observed in 51/433 patients (11.8%). individual patient data was pooled from 5 studies (n = 71). In the multivariate analysis, tumors located within the posterior thalamus had worse median overall survival compared to anterior gliomas (14.5 vs. 27 months, P = 0.003).

Surgical resection of ATGs can increase survival but at the risk of operative morbidity. Knowing which factors impact survival may allow neurosurgeons to propose a more evidence-based treatment to their patients [1)].

Merenzon et al. provide a valuable systematic review that contributes to the understanding of ATG surgical outcomes. Their work underscores the importance of tumor location in survival and calls for a nuanced approach to patient counseling and surgical planning. However, the study's limited individual patient data analysis and lack of practical decision-making tools leave room for further research to fully realize its potential clinical utility.

Cadaveric anatomical studies with a virtual modeling component, integrated with a retrospective clinical analysis

The objective of a study of Martínez Santos et al. was to provide a structured cartography map for neuronavigation for thalamic glioma treatment.

Fifteen formalin-fixed, silicone-injected cadavers (30 sides) were dissected, and 10 adult brain specimens (20 sides) were used to illustrate thalamic microsurgical anatomy using the Klingler fiber dissection technique. Exposures and trajectories for the six most common microsurgical approaches were depicted using MR data from healthy subjects converted into surface-rendered 3D virtual brain models. Additionally, thalamic surfaces exposed with all six approaches were color mapped on the virtual 3D model and compared side-by-side in 360° views with previously reported microsurgical approaches. These 3D models were then used in conjunction with topographic data to guide cadaveric dissection steps.

There are two general surgical routes to thalamic lesions: the subarachnoid transcisternal and transcortical routes. The transcisternal route consists of the following three approaches: 1) anterior interhemispheric transcallosal approach, which exposes the anterior and superior thalamus; 2) posterior interhemispheric transcallosal approach, which exposes the posterosuperior thalamus; and 3) supracerebellar infratentorial approach, which exposes the posteromedial cisternal thalamus and can be extended laterally to approach the posterolateral thalamus by cutting the tentorium. The three transcortical approaches are the 1) superior parietal lobule approach, which exposes the posterosuperior thalamus and is particularly advantageous in the setting of hydrocephalus; 2) transtemporal gyrus approach, which exposes the inferolateral thalamus; and 3) transsylvian transinsular approach, which exposes the lateral thalamus (slightly more superiorly and posteriorly) and is advantageous for pathologies extending laterally into the peduncle, lenticular nucleus, or insula.

Microsurgical approaches to thalamic gliomas continue to be challenging. Nonetheless, safe and effective cisternal, ventricular, and cortical corridors can be developed with thoughtful planning, anatomical understanding, and knowledge of the advantages, risks, and limitations of each approach. In some cases, it is wise to combine these approaches with staged procedures [2)].

A retrospective single-center study was performed on all TG patients from 2006 to 2020. Clinical, imaging, and pathology reports were obtained. Univariate and multivariate analyses were performed to determine prognostic variables. Case examples illustrate various approaches and the rationale for staging resections of more complex TGs.

Results: A total of 42 patients (26 males, 16 females), among them 12 pediatric (29%) cases, were included. Their mean age was 36.0 ± 21.4 (median 30, range 3-73) years. The median maximal tumor diameter was 45 (range 19-70) mm. Eighteen patients (43%) had a prior stereotactic needle tumor biopsy, with the ultimate diagnosis changed for 7 patients (39%) following microsurgical resection. The most common surgical approaches were transtemporal (29%), anterior interhemispheric transcallosal (29%), and superior parietal lobule (25%). Overall, the combined subtotal and gross-total resection rate was 95% (n = 40). Low-grade gliomas (LGGs; grades I and II) comprised one-third of the group, whereas half of the patients had glioblastoma multiforme. There were no operative mortalities. Although temporary postoperative motor deficits were observed in 12 patients (28.6%), all improved during the early postoperative period except 1 (2.4%), who had mild residual hemiparesis. Two patients required CSF diversion for hydrocephalus. The 2-year overall survival rate was 90% for LGG patients and 15% for high-grade glioma (HGG) patients. Multivariate analysis revealed that histological grade, age, and extent of resection were independent prognostic factors associated with survival.

Management of TGs is challenging, with resection avoided by many, if not most, neurosurgeons, especially for HGGs. The results reported here demonstrate improved outcomes with resection, particularly in younger LGG patients. The authors therefore advocate for MSR for a select cohort of TG patients using carefully planned surgical approaches, contemporary intraoperative adjuncts, and meticulous microsurgical techniques [3)].

Martínez Santos et al. address the complex challenge of thalamic glioma surgery (TGs) by creating a structured cartography for guiding microsurgical approaches. Its strengths lie in the integration of anatomical dissections, 3D modeling, and clinical outcomes, providing a comprehensive framework to improve surgical planning. However, several critical aspects merit discussion.

Strengths

Innovative Anatomical Mapping:

The use of 3D virtual brain models to map surgical approaches offers an advanced visualization tool that could significantly enhance preoperative planning. These models provide clarity on the anatomical boundaries and areas exposed by different approaches.

Comprehensive Methodology:

The combination of cadaveric dissections, fiber dissection techniques, and clinical data analysis is robust. It bridges the gap between theoretical anatomical knowledge and practical surgical application.

Clinical Utility:

The study underscores the importance of tailoring surgical strategies based on tumor location and patient-specific factors, emphasizing safe and effective corridors.

Outcome Data:

The inclusion of clinical outcomes for 42 patients offers valuable insights into the efficacy and risks associated with different approaches. The high resection rate (95%) and minimal operative mortality demonstrate the potential benefits of microsurgical resection (MSR) in experienced hands.

Detailed Approach Descriptions:

The clear delineation of six microsurgical approaches and their respective strengths and limitations provides a practical guide for neurosurgeons.

Weaknesses and Limitations

Subjective Nature of Approach Selection:

While the study aims to reduce subjectivity, the final choice of approach remains dependent on the surgeon's experience and judgment. The structured cartography is a step forward but does not fully eliminate this challenge. Small Sample Size for Clinical Outcomes:

The retrospective cohort of 42 patients, including only 12 pediatric cases, limits the generalizability of the clinical findings. Larger, multicenter studies are needed to validate the proposed strategies. Focus on Thalamic Gliomas:

The study's applicability is restricted to TGs, and its findings may not directly translate to other thalamic pathologies. This specificity, while a strength for TG management, limits its broader relevance. Limited Discussion on Intraoperative Challenges:

The study does not extensively discuss intraoperative complications or how contemporary adjuncts (e.g., neuronavigation, intraoperative imaging) were utilized to mitigate risks. Histological Diversity:

While the inclusion of both low-grade gliomas (LGGs) and high-grade gliomas (HGGs) adds depth, the significant difference in prognosis and management strategies between these groups warrants more stratified analysis.

Implications for Clinical Practice

Customized Surgical Strategies:

The study highlights the importance of tailoring surgical approaches to the unique topography of each tumor, advocating for a paradigm shift from reliance on a few standard approaches to a more nuanced, patient-specific strategy.

Integration of 3D Modeling in Training and Planning:

The incorporation of 3D cartography could revolutionize neurosurgical education and preoperative planning, particularly for complex cases like TGs.

Advocacy for MSR:

Despite the challenges, the study makes a compelling case for MSR in appropriately selected patients, particularly those with LGGs and younger age, to improve survival and quality of life.

Conclusion

This study provides a significant contribution to the field of neurooncology by proposing a structured framework for navigating the complexities of TG surgery. While it addresses key challenges and demonstrates promising outcomes, the reliance on subjective expertise and limited sample size necessitate further validation. Future studies should aim to refine these approaches, explore their applicability to other thalamic pathologies, and incorporate advancements in surgical technology to maximize patient safety and outcomes.

Retrospective cohort studies

A study aimed to investigate the selection, safety, and prognosis of medial (transcorpus callosal) and lateral (translateral brain gyrus) approaches for adult thalamic glioma resection.

The medical records of adult patients with thalamic glioma between March 2006 and March 2016 in Huashan Hospital were reviewed. The probabilistic map of the gliomas was shown in Montreal Neurological Institute (MNI) space, and a paralleling midline was delineated to decide the approach. The extent of resection, complications, adjuvant treatment, and survival data were analyzed. A literature review was also conducted.

Fifty-three patients with thalamic glioma were enrolled. Eighteen patients received tumor resection by a medial approach and 35 by a lateral approach. The probabilistic map based on 20 patients showed that 9 gliomas with ≥45% located in the medial side were treated medially and the other 11 gliomas were treated laterally. Both approaches achieved adequate extent of resection with similar morbidity. Kaplan-Meier analysis showed no significant difference of overall survival by a transcorpus callosal or translateral brain gyrus approach. Total resection (TR) or subtotal resection (STR) ($P = 0.0003$), radiochemotherapy ($P < 0.0001$), and low-grade glioma ($P = 0.031$) were correlated with better OS. Multivariate Cox regression analysis showed that TR/STR ($P = 0.007$; 95% confidence interval, 1.345-6.287) and radiochemotherapy ($P < 0.0001$; 95% confidence interval, 4.740-71.569) were independent prognostic factors for adult thalamic gliomas.

Both medial and lateral approaches are feasible and adequate for resection of thalamic gliomas. The paramidline paralleling midline crossing the genu of the internal capsule could help make the choice. TR/STR, radiochemotherapy, and low-grade glioma could benefit the prognosis [4)]

The retrospective design, limited sample size, and lack of detailed neurological outcomes highlight the need for further research. Future studies should aim to refine surgical decision-making and optimize patient outcomes through prospective designs, standardized treatment protocols, and comprehensive outcome assessments.

1)
Merenzon M, Levy AS, Bhatia S, Eatz T, Morell AA, Daggubati L, Berry K, Eichberg DG, Chandar J, Shah AH, Luther E, Lu VM, Komotar RJ, Ivan ME. Surgical Approaches to Thalamic Gliomas: A Systematic Review. World Neurosurg. 2023 Mar;171:25-34. doi: 10.1016/j.wneu.2022.12.043. Epub 2022 Dec 14. PMID: 36528315.
2)
Martínez Santos JL, Aljuboori Z, Richardson AM, Hanalioglu S, Peker HO, Aydin I, Al-Sharshahi ZF, Tunc O, Karatas D, Avci E, Baskaya MK. Microsurgical anatomy and approaches to thalamic gliomas. Part 1: A cartography guide for navigating to the thalamus. Integrating 3D model rendering with anatomical dissections. J Neurosurg. 2024 Jul 19;141(6):1457-1471. doi: 10.3171/2024.3.JNS232049. PMID: 39029125.
3)
Martínez Santos JL, Aljuboori Z, Richardson AM, Hanalioglu S, Peker HO, Sahin B, Al-Sharshahi ZF, Sahin OS, Kina H, Ammanuel SG, Iskandar BJ, Baskaya MK. Microsurgical anatomy and approaches to thalamic gliomas. Part 2: Maximal safe resection of thalamic gliomas improves outcomes. A single-center experience. J Neurosurg. 2024 Jul 19;141(6):1472-1483. doi: 10.3171/2024.3.JNS232067. PMID: 39029116.

4)

Qinglong G, Wei H, Biwu W, Zhiqi L, Yikui L, Pin S, Dongxiao Z, Tianming Q, Yi Z. Lateral or Medial Surgical Approaches for Thalamic Gliomas Resection? World Neurosurg. 2020 Apr;136:e90-e107. doi: 10.1016/j.wneu.2019.11.108. Epub 2019 Nov 27. PMID: 31785434.