Chapter

Perspective Chapter: Glioblastoma of the Corpus Callosum

Daulat Singh Kunwar, Ved Prakash Maurya, Balachandar Deivasigamani, Rakesh Mishra and Amit Agrawal

Abstract

Glioma is the most common malignant tumour of the brain, in which glioblastoma (GBM) is the most aggressive form which infiltrates through the white fibre tracts. Corpus callosum (CC) is most invaded by GBM, it carries poor prognosis as mostly these tumours are not touched upon due to the belief of post operative cognitive decline, or there is incomplete resection leading to tumour recurrence. However current advancement in technology, operative techniques and better understanding of nature of CC-GBM, maximal safe resection is being carried out with better outcomes in comparison with the GBM without infiltration of CC.

Keywords: butterfly glioma, butterfly glioblastoma, corpus callosum, glioma, glioblastoma, surgical resection, survival

1. Introduction

Glioblastoma multiforme originates in the cerebral white matter, accounts for 12–15% of all intracranial neoplasms and is the most common primary intra-axial malignancies [1]. Corpus callosum is the largest interhemispheric commissure connecting two identical cortical areas, and it acts as a white matter bridge between two hemispheres for tumour cells to migrate [2]. These are often reported arising from frontal and parietal lobes. Butterfly gliomas involving the corpus callosum characteristically appear as "butterfly" on imaging as the tumour has contiguous extension through the corpus callosum into both the cerebral hemispheres [1, 3, 4]. The incidence of butterfly glioma ranges from 3 to 14% of all high-grade gliomas [5, 6], and the isolated corpus callosum GBM is a relatively unusual variant of butterfly glioblastoma and account for 3% of all GBM [7]. The butterfly GBM of the corpus callosum can be anterior involving genu or less commonly can be posterior involving splenium [1]. Involvement of the corpus callosum can be on one side or either side involving both cerebral hemispheres (butterfly GBM) [8, 9]. Involvement of the corpus callosum makes the resection difficult and carries a poorer prognosis [10]. In this chapter, we discuss the pathology, clinical and imaging characteristics of glioblastomas involving the corpus callosum and review the management and outcome of these subgroup of tumours.

2. Clinical features

Glioblastoma of the corpus callosum is characterised by a rapidly progressive deteriorating clinical course [11]. Progressive tumour growth in CC causes mass effect and white matter network connectivity changes (due to oedema or direct infiltration) [12]. Because of its location corpus callosum, glioblastomas involve the highly eloquent area of the brain, leading to impaired higher mental function, severe neurological deterioration and features of raised intracranial pressure (headache, vomiting and altered sensorium) [11, 13]. The myriad of symptoms of corpus callosum involvement includes non-specific headaches, paresis, seizures, depression, mutism, ataxia, behavioural abnormalities and Cotard's syndrome [14–16]. Tumours involving the splenium can lead to memory and cognitive function as several associative pathways pass through this area making the outcome further poorer [17].

3. Imaging

CT scan with contrast administration can be used as screening tool; however, post-contrast MRI is the investigation of choice for detail evaluation and

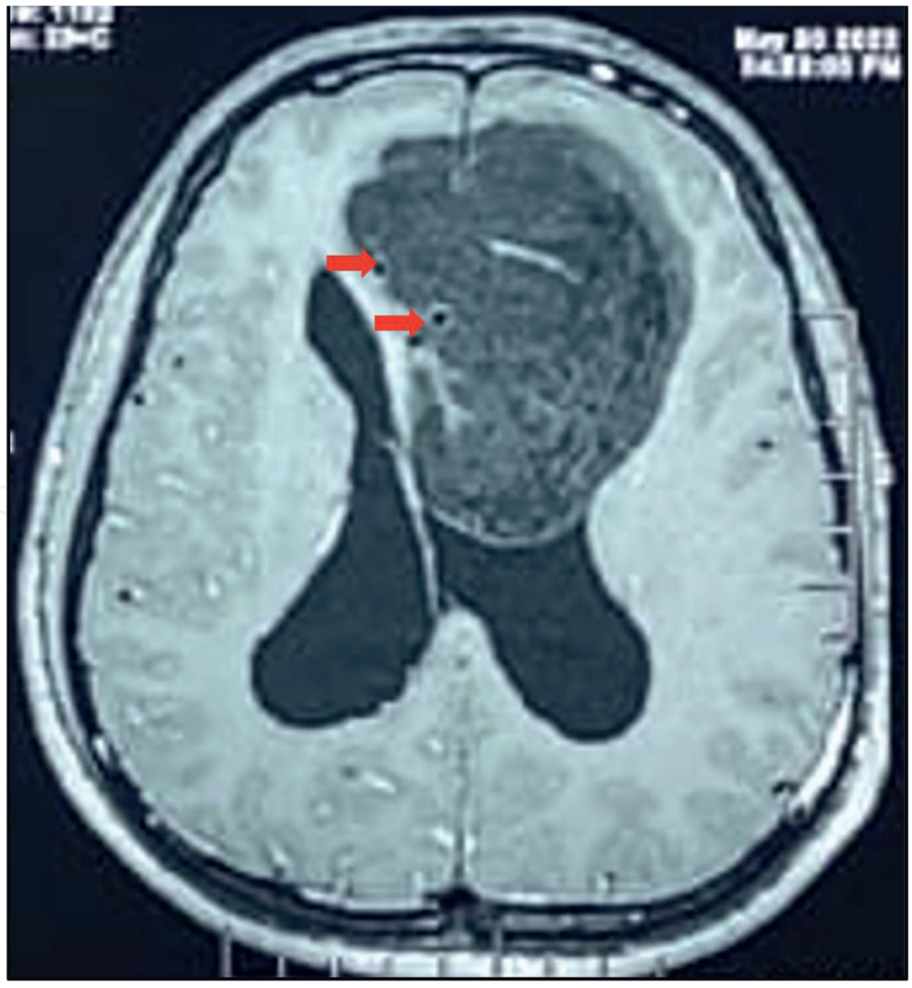

Figure 1.
Axial T1WI with contrast showing lesion involving the corpus callosum (at the genu) with main bulk towards the left side and crossing the midline to invade the right frontal lobe. The red arrows indicate the pushed anterior cerebral arteries towards the right side due to mass effect.

management including surgical planning [7, 18, 19]. Typically, corpus callosal GBM appears as a butterfly-shaped lesion with heterogeneous enhancement with areas of necrosis and haemorrhages with irregular postcontrast peripheral enhancement (**Figure 1**) [7, 18]. Coronal as well as sagittal fluid-attenuated inversion recovery images shall help in delineating the lesion and their relationship with surrounding structures better, [18] and diffusion tensor imaging shall help for the identification of white fibre tracts [20]. Pre-operative planning of tumour removal based on connectomics (machine learning-based algorithm which incorporates DTI and important cerebral network) is also available now [21].

4. Differential diagnosis

A number of pathologies those involve corpus callosum can mimic butterfly glioblastomas including other lesser grade variants of gliomas involving corpus callosum, [22–25] lymphoma, metastasis, [26] toxoplasmosis, [27] demyelinating butterfly pseudo glioma, [28] and neuronal ceroid-lipofuscinosis (Kufs' disease) [29] because of its multiplanar capability, MRI with contrast enhancement and FLAIR sequence [7, 18] can help to differentiate these lesions from each other; however, in doubtful cases the biopsy shall help to make the diagnosis.

5. Management

The aim of management is to improve patient's functionality and quality of life by relieving the symptoms and minimising the complications. Even though there are advances in immunotherapy, targeted therapy and oncolytic viral therapy most patients with CC-GBM suffer from limited survival. Currently, maximal safe resection with adjuvant chemo-radiotherapy remains gold standard [30–32]. Recent advances in the management of brain tumours have made resection of the corpus callosum glioblastomas preferred, possible and safe [33, 34]. Surgery improves overall survival, and it is superior to biopsy [4, 35, 36]. Surgical approaches help in reducing the tumour burden [11, 35, 37, 38] and also provide tissue sample for pathologic and molecular characterisation of the tumour (IDH 1/2 mutation or MGMT promoter methylation or both), thus guiding the further adjuvant management approaches [35]. Surgical resection can also be facilitated by intraoperative magnetic resonance imaging MRI-guided laser interstitial thermal therapy (LITT) techniques as this will increase the efficacy and safety of the procedure [37, 39–41]. Evidence suggests that preoperative KPS score, adjuvant radio chemotherapy and extent of surgical resection (EoR) have impact on survival besides patient's age. In a systematic review done by Palmisciano *et al.* [12], they say that resection of glioma infiltrating the corpus callosum has no significant changes in the post operative complications. Gross total resection of the tumour increases overall survival. Foster *et al.* [42] say that many patients with glioma infiltrating the corpus callosum rarely undergo surgical removal in fear of the post op neuropsychological sequelae. Authors hypothesise that the neuropsychological deficits are mainly due to tumour. Removing tumour reduces the mass effect and improves the microenvironment of the surrounding neurons; this may improve the neurocognitive and neurological function. In a prospective analysis done by them in 21 patients, they found that the neurocognitive decline post operatively was present in 75% of patients who presented with a median KPS of 100%.

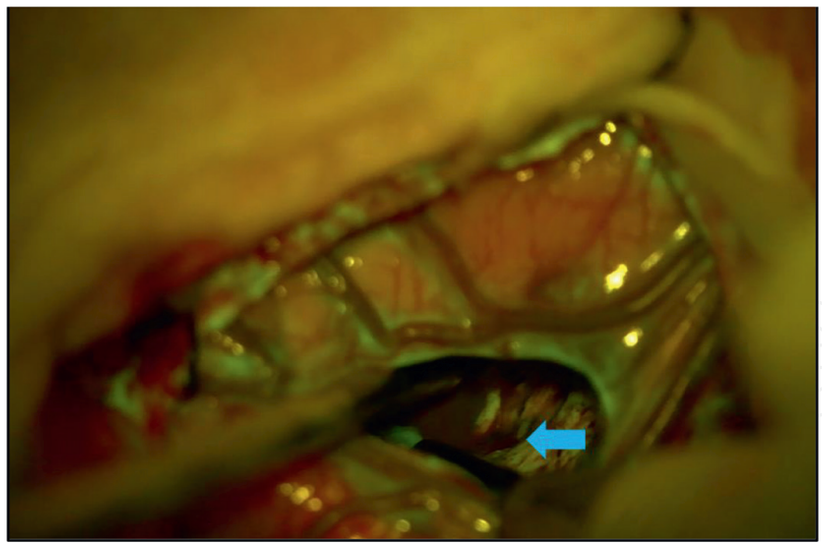

Figure 2.
Intraoperative photograph of tumour resection with the use of sodium fluorescence dye. The blue arrow indicates the plane of tumour-brain interface which was obvious after sodium fluorescence dye administration and facilitated the tumour decompression.

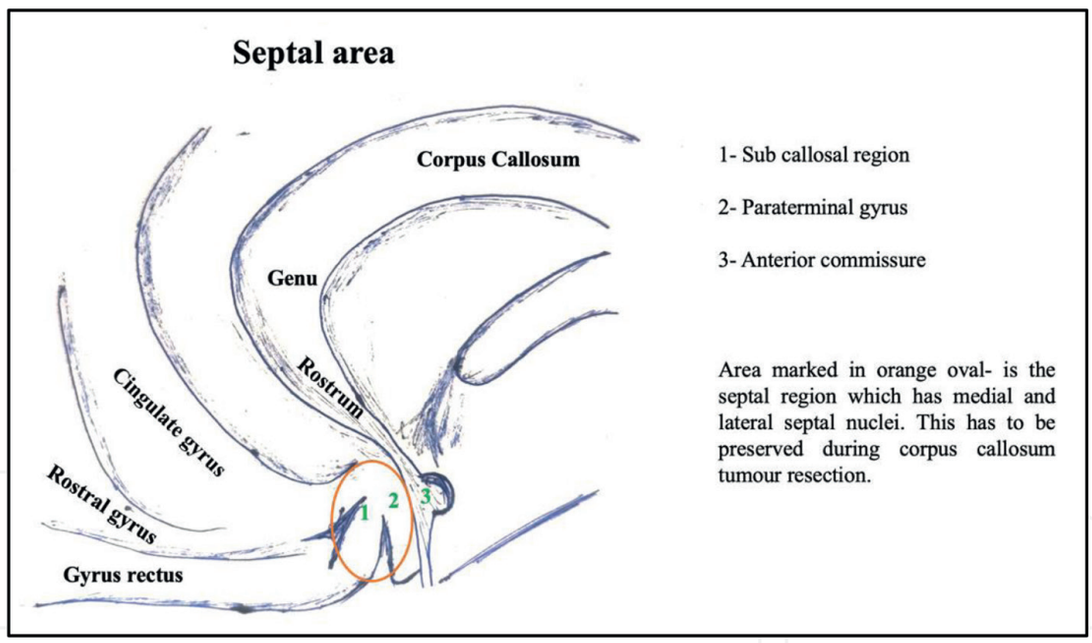

Figure 3.
Representative sketch depicting the corpus callosum and related neuroanatomical structures encountered during surgical resection. The septal nuclei (under orange oval area) need to be preserved during tumour decompression.

But surprisingly after 6 months a very few had impairment in attention, executive functioning, memory and depression. Authors strongly suggest that surgical resection of tumour might outweigh morbidity. Complications like motor deficits, cognitive decline post operatively is due to manipulation of the white fibres of CC and post operative edema (**Figure 2**) [36, 43].

Photo dynamic tumour visualisation technology is very helpful in achieving maximal extent of resection (i.e. supra marginal resection) which is the only modifiable factor linked with overall survival of the patients. Sodium fluorescein (**Figure 2**) and 5-Aminolevulinic acid (5-ALA) are the agents currently being used. In a recent study

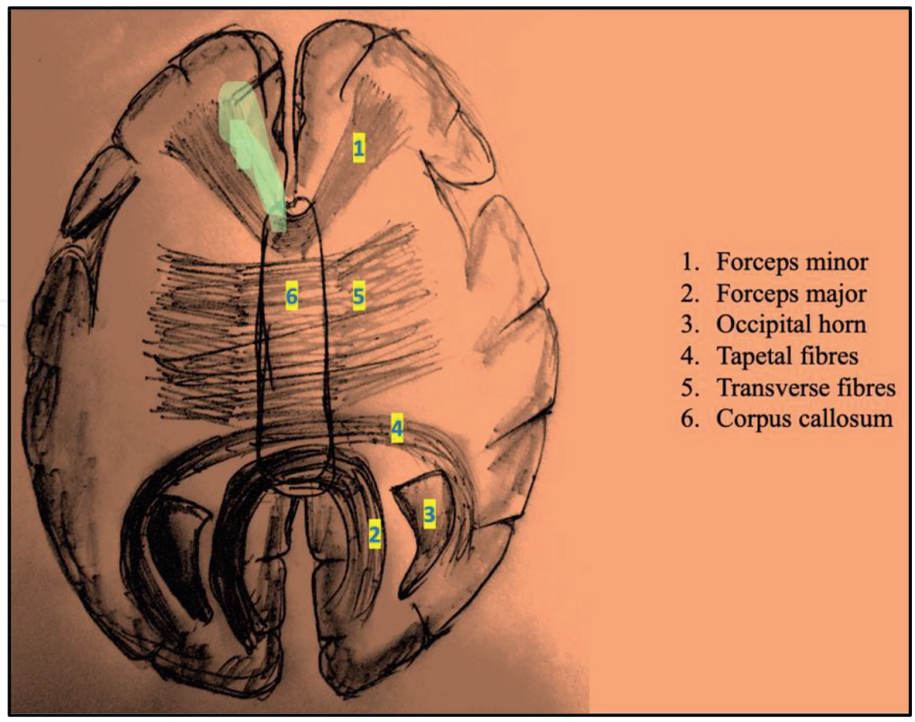

Figure 4.
Figure demonstrating white fibres through which tumour cells from one part of the brain reaching corpus callosum and travels to other side. The light green colour lesion is representing a lesion in the right frontal lobe infiltrating the forceps minor and traversing towards the opposite side.

done on peritumoral region, they found that 5-ALA staining extends beyond the sodium fluorescein-stained areas, even then there are tumour positive cells beyond this region [44]. Combining both fluorescein sodium and 5-ALA gives very good background information of the glioma cells and is more effective in supra marginal resection [33, 45, 46] current understanding is that fluorescein and 5-ALA should be supplemented with supplemented with intra-operative neurophysiological monitoring for better clinical outcome as well as overall survival [44].

In cases of glioma infiltrating the genu and rostrum of the corpus callosum, one should be careful not to enter the subcallosal region (contains septal nucleus) during resection (**Figures 3** and **4**). As this may cause psychiatric disturbances along with cognitive decline, this has been pointed out by Sughrue *et al.* [34].

However, because of its unique location and spread, in comparison with other GBMs, the conservative resection of corpus callosum is possible, thus reducing the chances of overall survival [9–12]. Temozolomide alone or in combination has been shown as a safer alternative in elderly population [26, 28, 42, 43].

6. Outcome

In spite of advances in maximal safe surgical resection techniques, availability of adjuvant radiotherapy and temozolomide chemotherapy, as for other glioblastomas the prognosis in cases of corpus callosal glioblastomas is dismal [3, 4, 19, 25, 35, 39, 47]. In literature, the overall survival in cases of butterfly glioblastomas is in weeks to months, and the median survival of 3 months and a six-month survival is only 38% [3, 19, 22, 24]. Median overall survival of a CC infiltrated glioblastomas is 10.7 months, whereas it is 13.2 months in a non-CC infiltrated glioblastoma [36]. In a series of 215 patients where

the corpus callosum was involved, overall survival was less than <6 months [48]. It is also observed that there are higher rates of recurrence in whom the infiltrated part of tumour in corpus callosum was not removed [36, 49]. However, their isolated case of long-term survival, in a report the patient survived the disease for 5 years and 2 months after the initial diagnosis [50].

7. Conclusion

Glioblastoma infiltrating the corpus callosum is rare yet highly invasive. With the improved intra-operative adjuncts, surgical techniques and concepts, there is higher tumour resection rates with minimal complications. While managing corpus callosal tumours, one should always aim for safe maximal resection with multimodal approach if the situation permits. However, in spite of the advances in the diagnosis and management techniques, there is not much improvement in the overall outcome of these patients.

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References

[1] Kiely F, Twomey F. Butterfly glioma involving splenium of corpus callosum. IJCMI. 2015;**2015**:1000277. DOI: 10.4172/2376-0249.1000277

[2] Mickevicius NJ, Carle AB, Bluemel T, Santarriaga S, Schloemer F, Shumate D, et al. Location of brain tumor intersecting white matter tracts predicts patient prognosis. Journal of Neuro-Oncology. 2015;**125**:393-400

[3] Dayani F, Young JS, Bonte A, Chang EF, Theodosopoulos P, McDermott MW, et al. Safety and outcomes of resection of butterfly glioblastoma. Neurosurgical Focus. 2018;**44**:E4

[4] Chaichana KL, Jusue-Torres I, Lemos AM, Gokaslan A, Cabrera-Aldana EE, Ashary A, et al. The butterfly effect on glioblastoma: Is volumetric extent of resection more effective than biopsy for these tumors? Journal of Neuro-Oncology. 2014;**120**:625-634

[5] Balana C, Capellades J, Teixidor P, Roussos I, Ballester R, Cuello M, et al. Clinical course of high-grade glioma patients with a "biopsy-only" surgical approach: A need for individualised treatment. Clinical and Translational Oncology. 2007;**9**:797-803

[6] Dziurzynski K, Blas-Boria D, Suki D, Cahill DP, Prabhu SS, Puduvalli V, et al. Butterfly glioblastomas: A retrospective review and qualitative assessment of outcomes. Journal of Neuro-Oncology. 2012;**109**:555-563

[7] Sharma R, Tiwari T, Goyal S. Classical imaging finding in callosal glioblastoma multiforme. BMJ Case Reports. 2021;**14**

[8] Nazem-Zadeh M-R, Saksena S, Babajani-Fermi A, Jiang Q, Soltanian-Zadeh H, Rosenblum M, et al. Segmentation of corpus callosum using diffusion tensor imaging: Validation in patients with glioblastoma. BMC Medical Imaging. 2012;**12**:1-16

[9] Kallenberg K, Goldmann T, Menke J, Strik H, Bock HC, Stockhammer F, et al. Glioma infiltration of the corpus callosum: Early signs detected by DTI. Journal of Neuro-Oncology. 2013;**112**:217-222

[10] Talos I-F, Zou KH, Ohno-Machado L, Bhagwat JG, Kikinis R, Black PM, et al. Supratentorial low-grade glioma resectability: Statistical predictive analysis based on anatomic MR features and tumor characteristics. Radiology. 2006;**239**:506

[11] Franco P, Delev D, Cipriani D, et al. Surgery for IDH1/2 wild-type glioma invading the corpus callosum. Acta Neurochirurgica. 2021;**163**:937-945

[12] Palmisciano P, Ferini G, Watanabe G, et al. Gliomas infiltrating the Corpus callosum: A systematic review of the literature. Cancers. 2022;**14**:2507

[13] Witoonpanich P, Bamrungrak K, Jinawath A, Wongwaisayawan S, Phudhichareonrat S, Witoonpanich R. Glioblastoma multiforme at the corpus callosum with spinal leptomeningeal metastasis. Clinical Neurology and Neurosurgery. 2011;**113**:407-410

[14] Zhang J, Xing S, Li J, Chen L, Chen H, Dang C, et al. Isolated astasia manifested by acute infarct of the anterior corpus callosum and cingulate gyrus. Journal of Clinical Neuroscience. 2015;**22**:763-764

[15] Yapıcı-Eser H, Onay A, Öztop-Çakmak Ö, Egemen E,

Vanlı-Yavuz EN, Solaroğlu İ. Rare case of glioblastoma multiforme located in posterior corpus callosum presenting with depressive symptoms and visual memory deficits. Case Reports. 2016;**2016**:bcr2016

[16] Boaro A, Harary M, Chukwueke U, Valdes Quevedo P, Smith TR. The neurocognitive evaluation in the butterfly glioma patient. A systematic review. Interdisciplinary Neurosurgery. 2019;**18**:100512

[17] Sammler D, Kotz SA, Eckstein K, Ott DV, Friederici AD. Prosody meets syntax: The role of the corpus callosum. Brain. 2010;**133**:2643-2655

[18] Uchino A, Takase Y, Nomiyama K, Egashira R, Kudo S. Acquired lesions of the corpus callosum: MR imaging. European Radiology. 2006;**16**:905-914

[19] Agrawal A. Butterfly glioma of the corpus callosum. Journal of Cancer Research Therapy. 2009;**5**:43

[20] Tench C, Morgan P, Wilson M, Blumhardt L. White matter mapping using diffusion tensor MRI. Magnetic Resonance in Medicine: An Official Journal of the International Society for Magnetic Resonance in Medicine. 2002;**47**:967-972

[21] Yeung JT, Taylor HM, Nicholas PJ, Young IM, Jiang I, Doyen S, et al. Using quicktome for intracerebral surgery: Early retrospective study and proof of concept. World Neurosurgery. 2021;**154**:e734-e742

[22] Zakrzewska M, Szybka M, Zakrzewski K, Biernat W, Kordek R, Rieske P, et al. Diverse molecular pattern in a bihemispheric glioblastoma (butterfly glioma) in a 16-year-old boy. Cancer Genetics and Cytogenetics. 2007;**177**:125-130

[23] Kappos L. What is your diagnosis? Butterfly glioma originating from the corpus callosum. Schweizerische Rundschau fur Medizin Praxis= Revue Suisse de Medecine Praxis. 1992;**81**:785-786

[24] Arora M, Praharaj SK. Butterfly glioma of corpus callosum presenting as catatonia. The World Journal of Biological Psychiatry. 2007;**8**:54-55

[25] Bourekas EC, Varakis K, Bruns D, Christoforidis GA, Baujan M, Slone HW, et al. Lesions of the corpus callosum: MR imaging and differential considerations in adults and children. American Journal of Roentgenology. 2002;**179**:251-257

[26] Garber ST, Khoury L, Bell D, Schomer DF, Janku F, McCutcheon IE. Metastatic adenoid cystic carcinoma mimicking butterfly glioblastoma: A rare presentation in the splenium of the Corpus callosum. World Neurosurgery. 2016;**95**(621):e13-e19

[27] Lee H-J, Williams R, Kalnin A. Toxoplasmosis of the corpus callosum: Another butterfly. American Journal of Roentgenology. 1976;**166**:1280-1281

[28] Scozzafava J, Johnson E, Blevins G. Demyelinating butterfly pseudo-glioma. Journal of Neurology, Neurosurgery & Psychiatry. 2008;**79**:12-13

[29] Hammersen S, Brock M, Cervós-Navarro J. Adult neuronal ceroid lipofuscinosis with clinical findings consistent with a butterfly glioma: Case report. Journal of Neurosurgery. 1998;**88**:314-318

[30] Brown TJ, Brennan MC, Li M, Church EW, Brandmeir NJ, Rakszawski KL, et al. Association of the extent of resection with survival in glioblastoma: A systematic review

and meta-analysis. JAMA Oncology. 2016;**2**:1460-1469

[31] Sanai N, Berger MS. Surgical oncology for gliomas: The state of the art. Nature Reviews Clinical Oncology. 2018;**15**:112-125

[32] Bi J, Chowdhry S, Wu S, Zhang W, Masui K, Mischel PS. Altered cellular metabolism in gliomas—An emerging landscape of actionable co-dependency targets. Nature Reviews Cancer. 2020;**20**:57-70

[33] Coburger J, Engelke J, Scheuerle A, Thal DR, Hlavac M, Wirtz CR, et al. Tumor detection with 5-aminolevulinic acid fluorescence and Gd-DTPA–enhanced intraoperative MRI at the border of contrast-enhancing lesions: A prospective study based on histopathological assessment. Neurosurgical Focus. 2014;**36**:E3

[34] Sughrue ME. The Glioma Book. Leipzig, Germany: Georg Thieme Verlag; 2020

[35] Opoku-Darko M, Amuah JE, Kelly JJ. Surgical resection of anterior and posterior butterfly glioblastoma. World Neurosurgery. 2018;**110**:e612-e620

[36] Boaro A, Kavouridis VK, Siddi F, Mezzalira E, Harary M, Iorgulescu JB, et al. Improved outcomes associated with maximal extent of resection for butterfly glioblastoma: Insights from institutional and national data. Acta Neurochirurgica. 2021;**163**:1883-1894

[37] Beaumont TL, Mohammadi AM, Kim AH, Barnett GH, Leuthardt EC. Magnetic resonance imaging-guided laser interstitial thermal therapy for glioblastoma of the corpus callosum. Neurosurgery. 2018;**83**:556-565

[38] Stupp R, Mason WP, Van Den Bent MJ, Weller M, Fisher B, Taphoorn MJ, et al. Radiotherapy plus concomitant and adjuvant temozolomide for glioblastoma. New England Journal of Medicine. 2005;**352**:987-996

[39] Cui M, Chen H, Sun G, Liu J, Zhang M, Lin H, et al. Combined use of multimodal techniques for the resection of glioblastoma involving corpus callosum. Acta Neurochirurgica. 2022;**164**:689-702

[40] Mohammadi AM, Hawasli AH, Rodriguez A, Schroeder JL, Laxton AW, Elson P, et al. The role of laser interstitial thermal therapy in enhancing progression-free survival of difficult-to-access high-grade gliomas: A multicenter study. Cancer Medicine. 2014;**3**:971-979

[41] Hawasli AH, Bagade S, Shimony JS, Miller-Thomas M, Leuthardt EC. Magnetic resonance imaging-guided focused laser interstitial thermal therapy for intracranial lesions: Single-institution series. Neurosurgery. 2013;**73**:1007-1017

[42] Forster M-T, Behrens M, Lortz I, Conradi N, Senft C, Voss M, et al. Benefits of glioma resection in the corpus callosum. Scientific Reports. 2020;**10**:16630

[43] Dadario NB, Zaman A, Pandya M, Dlouhy BJ, Gunawardena MP, Sughrue ME, et al. Endoscopic-assisted surgical approach for butterfly glioma surgery. Journal of Neuro-Oncology. 2022;**156**:635-644

[44] Yano H, Nakayama N, Ohe N, Miwa K, Shinoda J, Iwama T. Pathological analysis of the surgical margins of resected glioblastomas excised using photodynamic visualization with both 5-aminolevulinic acid and fluorescein sodium. Journal of Neuro-Oncology. 2017;**133**:389-397

[45] Molina ES, Wölfer J, Ewelt C, Ehrhardt A, Brokinkel B, Stummer W. Dual-labeling with 5–aminolevulinic acid and fluorescein for fluorescence-guided resection of high-grade gliomas: Technical note. Journal of Neurosurgery. 2017;**128**:399-405

[46] Della Puppa A, Munari M, Gardiman MP, Volpin F. Combined fluorescence using 5-aminolevulinic acid and fluorescein sodium at glioblastoma border: Intraoperative findings and histopathologic data about 3 newly diagnosed consecutive cases. World Neurosurgery. 2019;**122**:e856-e863

[47] Chen K-T, Wu T-WE, Chuang C-C, Hsu Y-H, Hsu P-W, Huang Y-C, et al. Corpus callosum involvement and postoperative outcomes of patients with gliomas. Journal of Neuro-Oncology. 2015;**124**:207-214

[48] Fyllingen EH, Bø LE, Reinertsen I, Jakola AS, Sagberg LM, Berntsen EM, et al. Survival of glioblastoma in relation to tumor location: A statistical tumor atlas of a population-based cohort. Acta Neurochirurgica. 2021;**163**:1895-1905

[49] Duffau H, Khalil I, Gatignol P, Denvil D, Capelle L. Surgical removal of corpus callosum infiltrated by low-grade glioma: Functional outcome and oncological considerations. Journal of Neurosurgery. 2004;**100**:431-437

[50] Finneran M, Marotta DA, Altenburger D, Nardone E. Long-term survival in a patient with butterfly glioblastoma: A case report. Cureus. 2020;**2020**:e6914. DOI: 10.7759/cureus.6914