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HOW I DO IT - TUMOR - GLIOMA

How I do it? Anatomical multifocal high-grade glioma resection

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Abstract

Background If an awake surgery is somehow not available for gliomas at the language area, understanding the anatomy and well-designed surgical strategy are important.

Method We present a case with left hemispheric multifocal high-grade gliomas located deeply at the left temporal pole, the Wernicke's area, and mesial temporal region. Because the patient could not endure the awake surgery and obtain practicable functional magnetic resonance imaging (MRI) for eloquent cortex evaluation, we removed the lesions following the anatomical resection strategy guided by diffusion tensor imaging (DTI).

Conclusion This case demonstrates the value of DTI and the importance of anatomical resection strategies in glioma surgeries.

Keywords Anatomy · Glioma · High-grade glioma · Resection

Introduction and relevant surgical anatomy

Awake surgery with brain mapping is first choice in gliomas at the language area [1]. Theoretically, neurological function preservation can be achieved by the brain mapping with subcortical stimulation in a fully cooperated awake surgery. However, if the patient could not cooperate or tolerate the prolonged awake surgery, general anesthesia may be a rational option. However, under general anesthesia, the surgical outcome largely depended on the surgeon's experience and understanding of the anatomy. Here, we present a case of multifocal high-grade glioma affecting the language area, which was successfully treated by anatomical resection in a non-awake surgery.

A 62-year-old male suffered from slurred speech for 4 months; he also developed right lower extremity weakness 2 days before admission. The physical examination revealed both motor and sensory aphasia. The muscle strength of right lower limb was grade II. The preoperative magnetic resonance imaging (MRI) revealed multiple lesions located in the left hemisphere, including the temporal pole, mesial temporal region, and deep inside the inferior parietal lobe (Fig. 1). The multifocal high-grade glioma was highly suspected, and a treatment strategy of maximal safe resection with language function preservation was made. Therefore, the eloquent cortex and speech-related white matter tracks are the key anatomical structures to be preserved during the operation [2, 3]. Besides, we need to secure the en passage arteries to the language area which may also supply the tumor.

In this case, the Wernicke's area, superior longitudinal fasciculus, arcuate fasciculus, and the inferior fronto-occipital fasciculus are the most important anatomic structures worthy of attention. However, he could not cooperate with the preoperative training and assessment for awake surgery due to the aphasia, and also failed to achieve practicable task functional and resting MRI (fMRI) for eloquent cortex evaluation. Although peritumoral edema, intraoperative brain shift, and differences in real-world white matter tract diameter compared to voxel size are the major limitations of diffusion tensor imaging (DTI) application, it still augments surgical plans, especially safe approach design, for removing highly invasive gliomas by analyzing the relationship between the tumor and white matter tracts, due to the high concordance between DTI representation of the white matter tracts and subcortical mapping [4, 5]. The DTI of this case showed that the superior longitudinal fasciculus and the arcuate fasciculus were closed

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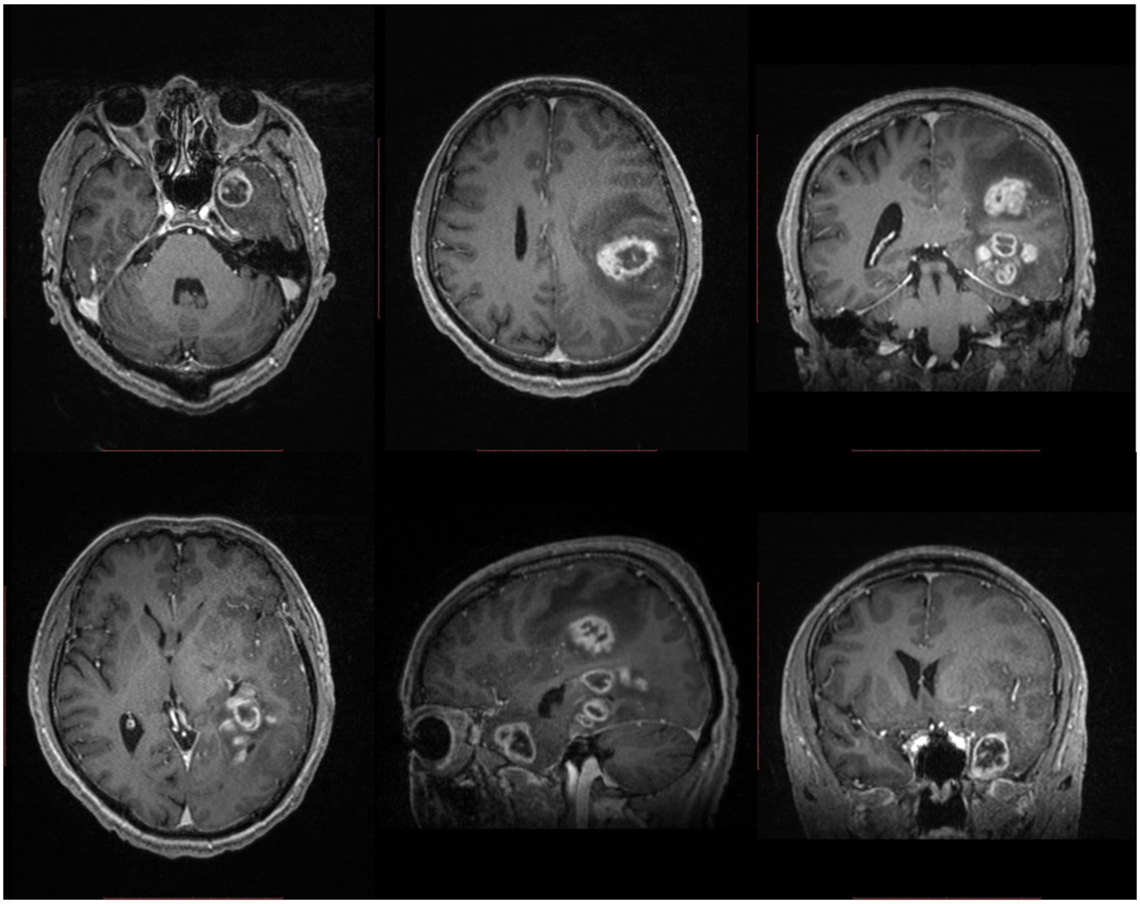

Fig. 1 Preoperative MRI related to the patient in the illustrative video

to the tumor and compressed (Fig. 2). The inferior fronto-occipital fasciculus coursed between the lesions located in the inferior parietal lobe and mesial temporal region. These findings of the DTI could be navigated during surgery.

Considering the already-existed aphasia, and the risk of intolerance of prolonged awake surgery duration due to the multifocal nature of the tumor, this patient was scheduled to be operated under general anesthesia.

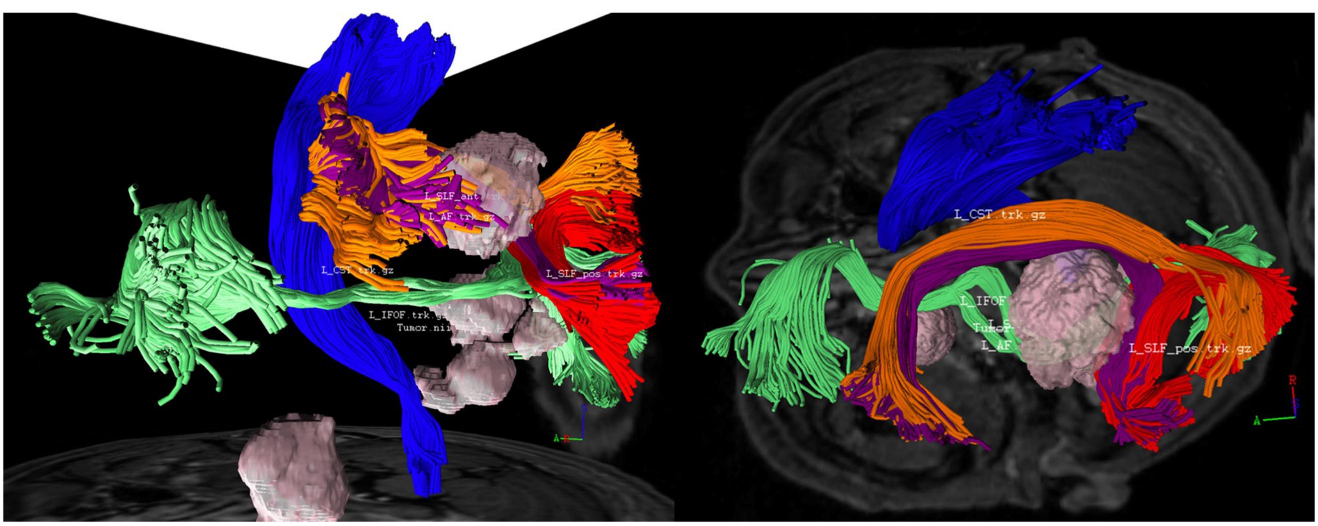

Fig. 2 Preoperative DTI related to the patient in the illustrative video. Blue fiber: corticospinal tract; orange fiber: superior longitudinal fasciculus (anterior brachium); red fiber: superior longitudinal fasciculus (posterior brachium); purple fiber: arcuate fasciculus; green fiber: inferior frontal occipital tract; gray mass: tumor

Description of the technique

During the operation, the patient was placed supine with the head turned to 75 degrees to the right. A "?" (question mark) incision covering all the lesions was planned. After the frontotemporal craniotomy and dura opening, a strip electrode was placed to determine the location of the motor strip by phase reversal, and then used to monitor the electrocorticography. The first step of the operation was to remove the temporal pole with the deep-seated tumor. A quick temporal pole resection was performed and the deeply seated tumor was exposed. We used suction and bipolar forceps to dissect the tumor within the surrounding edematous gliosis. We removed the temporal pole lesion until the edge of the tentorium and Sylvain fissure met.

Then, we started to remove the tumor deep to the Wernicke's area, and finally the lesion located at the mesial temporal region. Because there was no practicable task functional or resting magnetic resonance image for the eloquent cortex evaluation, DTI was important to plan safe approaches. In this case, because the inferior fronto-occipital fasciculus coursed between the tumors, we planned a transcortical approach to expose these lesions instead of trans-white matter methods. We removed a small portion of the posterior temporal cortex under the guidance of neuronavigation to expose the tumor, and attack the parietal tumor from an inferior to superior trajectory to keep the Wernicke's area free. The posterior temporal branch was felt to be the feeding artery of the tumor located deeply in the parietal lobe. The lower portion of the parietal lobe was carefully retracted, and an inferior to superior trajectory was utilized to preserve the Wernicke's area. We carefully skeletonized the feeding artery using low power electrocautery. This lesion was fully devascularized and exposed at this stage. We could easily dissect the lesion within its boundary until the nearby sulci, while sparing the white matter tracts as much as possible. We removed the tumor piecemeal carefully to leave the underneath superior longitudinal fasciculus and the arcuate fasciculus safe. After that, we transected some inferior temporal cortex to expose the remaining tumor located mainly in the fusiform gyrus and parahippocampal gyrus. Again, although we removed the remaining tumor in a piecemeal fashion, we still tried to locate the en passage artery, then skeletonized it to devascularize the tumor. After that, we could remove the tumor in pieces with minimum blood loss. The dissection plane was kept under the white matter and below the choroidal plexus, which are the anatomy landmark of not entering the inferior fronto-occipital fasciculus and thalamus. We removed the lesion in a subpial and piecemeal fashion, until the arachnoid membrane of the ambient cistern and the tentorial edge was met. At this point, we believed that all visible tumors in the MRI should have been resected. We checked the surgical field, obtained thorough hemostasis, and confirmed all the en passage arteries well preserved. The intraoperative transcortical motor evoked potentials showed no changes. The estimated blood loss was less than 400 ml, and no transfusion was needed.

The histological pathology confirmed the diagnosis of glioblastoma, IDH wild type. The MRI scan on day 7 showed complete resection of all tumors, and well preservation of the speech-related white matter fiber tracts (Fig. 3). After 1

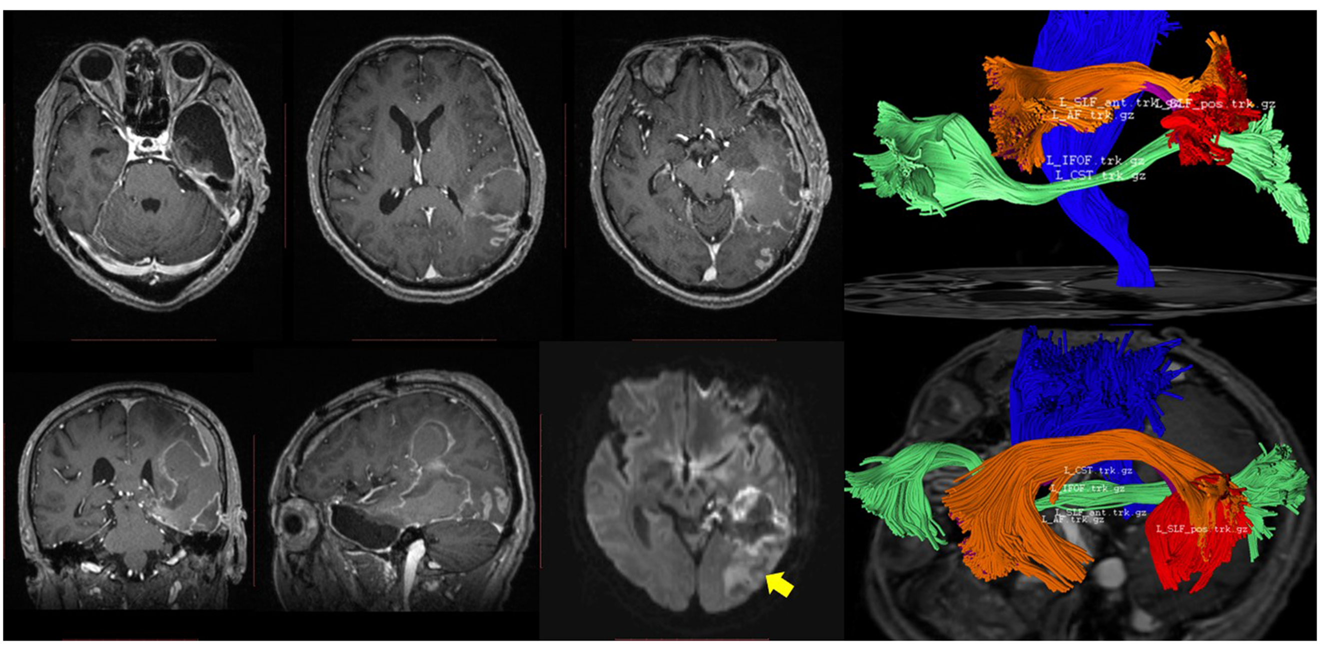

Fig. 3 Postoperative MRI and DTI showing complete resection, and preservation of the speech-related white matter fiber tracts. However, some infarction was found in the posterior temporal lobe (arrow). Blue fiber: corticospinal tract; orange fiber: superior longitudinal fasciculus (anterior brachium); red fiber: superior longitudinal fasciculus (posterior brachium); purple fiber: arcuate fasciculus; green fiber: inferior frontal occipital tract

month, he could communicate fluently in daily life, but with mild anomic aphasia.

Indications

Multifocal glioma is a relatively uncommon tumor with unfavorable prognosis, and the glioblastoma is the most common histotype [6]. The multifocal glioma may impinge white matter tracts by compression or encasement. Currently there is no clear guideline regarding the optimal management of the multifocal glioma. As for the glioblastoma treatment, the standard of care includes resection as feasible or biopsy, adjacent radiotherapy, and chemotherapy [7, 8]. The surgical resection may intuitively delay disease recurrence by cytoreduction, and the relief of mass effect may improve functional status, then might prolong survival and life-quality in symptomatic patients [9]. Therefore, in this case, maximal safe resection was planned after carefully studying the pre-operative radiological imaging.

Limitations

Although we follow the rule of anatomical resection, the usage of ancillary technique, such as intra-operative ultrasound or MRI, should be considered and may be helpful for better confirmation of maximal tumor removal.

How to avoid complications and specific perioperative considerations

We did learn a lesson from this case. The patient experienced a transient deterioration period post-operatively. And we believed the reason might be the vasospasm. After the treatment of nimodipine and adequate intravenous rehydration, on day 7, his muscle strength of right lower limb improved to grade 5-/5 and he was able to ambulate under assistance. His language function improved as well; he could understand and could speak simple words. However, some infarction was also found in the posterior temporal lobe due to the previous vasospasm (Fig. 3). Now with more experience, we advocate that the usage of ultrasonic aspirator may lower the risk of vasospasm.

Specific information to give to the patient about surgery and potential risks

The patient should be fully informed about the risks and benefits about awake and general anesthesia, and particular concern of this case includes the risk of tumor residue, visual field defect, hemiplegia, and the difficulty of fully preservation of language function.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s00701-020-04637-7.

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Compliance with ethical standards

Patient consent It represents a video of a surgical case. The next of kin of the patient gave approval for this publication

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Key points

1. For high-grade gliomas, the goal of the surgery should be maximal safe resection with function preservation.
2. General anesthesia may be a rational option, if the patient cannot cooperate or tolerate the prolonged awake surgery with already-existed aphasia.
3. If an awake surgery is not available for glioma affecting language area, understanding the anatomy and well-designed surgical strategy are important.
4. A detailed preoperative neurological and neuroimaging evaluation is mandatory.
5. DTI is important to evaluate the speech-related white matter tracks and surgical approach planning.
6. The superior longitudinal fasciculus, arcuate fasciculus, and the inferior fronto-occipital fasciculus are the most important speech-related white matter tracks.
7. Anatomical resection rule is important in glioma surgeries.
8. Use transcortical approach for better deep-seated tumor exposure and subcortical neurofiber tracks preservation instead of trans-white matter methods.
9. Securing the en passage arteries before piecemeal tumor resection is the key step for tumor bleeding control.
10. Intra- and post-operative vasospasm of the en passage arteries may occur and should not be neglected.