Magnetic resonance imaging for preoperative identification of the lenticulostriate arteries in insular glioma surgery

Technical note

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A ggressive resection of insular tumors is possible using a meticulous surgical approach based on the regional insular anatomy, with high rates of gross-total resection and low rates of permanent neurological deficits. However, the risk of postoperative morbidities remains high, often caused by disruption of the vascular supply to the surrounding eloquent structures, especially the lenticulostriate arteries (LSAs) that supply the internal capsule. Three-dimensional 3-T time-of-flight (TOF) MR imaging was performed pre- and postoperatively in patients with insuloopercular gliomas. This 3D 3-T TOF MR imaging clearly visualized the LSAs and the relationships with the tumor margins. These findings were confirmed intraoperatively. Three-dimensional 3-T TOF MR imaging of the LSAs in patients with insuloopercular gliomas can help to maximize the extent of resection without neurological complications, preserve the LSAs during surgery, and assist in patient selection. (DOI: 10.3171/2008.11.JNS08858)

KEY WORDS • insuloopercular glioma • lenticulostriate artery • magnetic resonance angiography • time-of-flight magnetic resonance imaging

Abbreviations used in this article: GBM = glioblastoma multiforme; LSA = lenticulostriate artery; MCA = middle cerebral artery; TOF = time-of-flight.
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sequence with contrast medium administration (0.2 ml/kg) at the following parameters: TR 35 msec, TE 1.7 msec, flip angle 25°, field of view 18 × 18 cm, matrix 512 × 256, slice thickness 0.8 mm, and 232 total slices. The data were transferred to a personal computer and transformed into cine images (QuickTime, Apple Inc.). High-intensity spots in the deep white matter, considered to represent the LSAs, were identified visually in cine mode.

Illustrative Cases

Case 1

This 33-year-old male lost consciousness for about 5 minutes without apparent convulsion. A diagnosis of left insuloopercular tumor was established at a local hospital, and he was referred to our hospital for treatment (Fig. 1A). On admission, he exhibited mild right hemiparesis. Preoperative 3-T MR imaging detected the LSAs at the medial border of the tumor (Fig. 1C and D). Gross-total resection was performed with preservation of these vessels (Fig. 1B). A day after surgery, his mild right hemiparesis disappeared. The histological diagnosis of the tumor was an anaplastic ganglioglioma. After adjuvant chemoradiation therapy, he has continued his daily life as before without tumor recurrence for 25 months.

Case 2

This 30-year-old male, who was previously treated at another hospital for multicentric gliomas, was referred to our hospital because of tumor recurrence. On admission, he exhibited mild aphasia, mild right hemiparesis, and bilateral papilledema. Magnetic resonance imaging detected a large tumor in the left insuloopercular region, associated with uncal herniation and midline shift due to the mass effect of the tumor (Fig. 2A). After gross-total removal of the tumor, his hemiparesis disappeared without additional neurological deficits (Fig. 2B). Postoperative 3-T MR imaging revealed preservation of the LSAs at the medial aspect of the resection cavity (Fig. 2C and D). After intensive chemoradiation therapy, he has continued his life as before for 5 years.

Case 3

This 68-year-old male with a GBM of the left insuloopercular region was referred to our hospital for surgical treatment (Fig. 3A). Preoperative 3-T MR imaging detected the LSAs at the anteromedial aspect of the tumor (Fig. 3C). Although previous reports indicated that resection of a GBM in elderly patients carries little benefit, a distinct tumor-brain border without encasement of the LSAs found in this patient prompted us to perform aggressive surgical intervention. Gross-total removal of the tumor was performed with preservation of the LSAs (Fig. 3B and D). After adjuvant chemoradiation therapy, he has continued to live with a Karnofsky Performance Scale score of 100% and without tumor recurrence for 18 months.

Discussion

Neurological deficits may result from resection of insular tumors because specific functions reside within the insula, but avoidable complications are more related to disruption of the surrounding structures and their vascular supply. Direct injury to the vulnerable internal capsule at the superior aspect of the insula where the motor fibers pass over the basal ganglia, compression of the surrounding structures during opercular retraction, damage to the branches and/or vasospasm of the MCA during dissection of the MCA often encased in the tumor, and interruption of the perforating LSAs and long insular arteries arising from M2 can cause damage to the surrounding eloquent structures.

In a study, most of a series of 22 patients who underwent resection of intrinsic insular tumors presented with seizures and 11 patients harbored low-grade tumors. Re-
Immediate neurological dysfunction, primarily dysphasia, and/or hemiparesis occurred in 8 patients, and permanent neurological deficits occurred in 2 patients. The causes of the permanent neurological deficits were interruption of the LSAs in 1 patient and the long perforating artery arising from the M2 vessels in 1 patient. Similarly, coagulation of the LSAs was a major cause of postoperative hemiplegia in previous patient series. Therefore, preservation of the perforating arteries is of utmost importance during resection of insular tumors.

Improving the extent of resection and reducing the risk of neurological complications are important goals in the treatment of insular tumors. Improved understanding of the surgical anatomy, application of adjunctive methods such as motor tract mapping by intermittent electrical cortical-subcortical stimulations, and the availability of awake surgery are important developments. However, patient selection is also an important aspect of risk reduction. For example, it was previously reported that resection of an insular GBM in an elderly patient carries little benefit, whereas resection of a low-grade glioma is potentially beneficial. It was also reported that patients with tumor margins that appeared diffuse on T2-weighted MR imaging tended to have <75% resection, and a progressive increase in patient survival was found with incremental increases in the extent of resection, suggesting that the optimal surgical candidates are patients with distinct tumor margins on T2-weighted MR imaging. Avoidable complications are often related to disruption of the vascular supply to the surrounding eloquent structures, so preoperative detection of LSAs may also help to identify optimal surgical candidates. Three-dimensional 3-T TOF MR imaging with contrast medium admin-

![Fig. 2. Case 2. Preoperative (A) and postoperative (B–D) contrast-enhanced MR images. A and B: Axial T1-weighted images showing the recurrent tumor in the left insuloopercular region associated with uncal herniation and midline shift due to the mass effect of the tumor. C and D: Axial (C) and coronal (D) 3D 3-T TOF images revealing preservation of the LSAs at the medial aspect of the resection cavity. Black arrows = first perforators; white arrows = second perforators; black arrowheads = third perforators; white arrowheads = fourth perforators.](image)

![Fig. 3. Case 3. Preoperative (A and C) and postoperative (B and D) contrast-enhanced MR images. A and B: Axial T1-weighted images showing a left insuloopercular GBM. C and D: Coronal (left) and sagittal (right) views of 3D 3-T TOF images clearly showing the LSAs at the anteromedial aspect of the tumor. Black arrows = first perforators; white arrows = second perforators; white arrowheads = third perforators.](image)
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istration clearly demonstrated the LSAs preoperatively in Cases 1 and 3 in this study. The LSAs were detected at the medial aspect of the tumor in Case 1, and at the anteromedial aspect of the tumor in Case 3. The relatively distinct margin of the tumor-brain interface together with precise information about the LSAs enabled complete resection with preservation of these vessels. The present study and other previous reports suggest that a distinct tumor-brain border without encasement of the LSAs is a prerequisite for gross-total removal of insuloopercular tumors. Therefore, using preoperative 3-T MR imaging to investigate the relationship between the tumor border and LSAs will provide valuable information to achieve maximum resection of tumors involving insuloopercular regions without neurological complications. Even with an invasive tumor with poorly defined margins, this technique may enable complete resection in cases in which the LSAs remain intact preoperatively, although more studies will be needed to address this issue definitively.

Avoiding injury to the LSAs that supply the internal capsule is one of the most challenging aspects of insular surgery. The LSAs can be preserved by identifying the most lateral LSA early in the operation, by dissecting the MCA proximally until the first LSA is reached before removing the tumor bulk. Preoperative identification of LSAs and evaluation of the relationship with the tumor provides additional information to further improve the extent of resection. More experience is required to evaluate how this technology contributes to reducing complication rates from vessel injury during the complete removal of insuloopercular gliomas. Use of intraoperative MR imaging, if possible, may enable one to apply this method to intraoperative detection of LSAs.

Conclusions

Surgical indications for insular gliomas should be based on multiple factors, including the relationship of the tumor with eloquent brain regions such as language areas and with the vessels supplying the surrounding eloquent brain structures. Preservation of the LSAs is one of the most important factors for avoidance of complications. Three-dimensional 3-T TOF MR imaging with contrast medium administration can visualize the route of the LSAs, thus contributing to improvement of the extent of resection and reduction of neurological risk.

Disclaimer

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

References