Insulo-opercular Gliomas: Four Different Natural Progression Patterns and Implications for Surgical Indications

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Abstract

The insular cortex is circumscribed with three limiting sulci, so progression patterns of insulo-opercular gliomas can be categorized into tumor progression limited to the insular cortex, tumor progression via the anterior limiting sulcus, tumor progression via the inferior limiting sulcus, and tumor progression via the superior limiting sulcus. Recent improvements in clinical accessibility and imaging devices have identified more patients harboring small tumors in the insulo-opercular regions. Therefore, the natural progression patterns of insulo-opercular gliomas and the implications for surgical indications are important. Among 36 patients who suffered glioma at insulo-opercular regions and underwent radical resection at our institute between February 2002 and August 2008, cases that showed four different development patterns were retrospectively reviewed. In our series of patients, 7 patients were followed up for more than 100 days after detection of the diseases until surgery. Among these patients, there existed cases that represent four different progression patterns of insulo-opercular gliomas. Surgical complications associated with insulo-opercular gliomas often result from damage to surrounding structures, especially the perforating arteries. Resection of tumors invading medially to the putamen can result in damage to the lenticulostriate arteries, and resection higher than the superior limiting sulcus can result in injury to the long insular arteries. Consequently, the surgical indications for insulo-opercular gliomas should be limited to small tumors within the insular cortex or progressing via the anterior or inferior limiting sulcus. Tumors that progress via the superior limiting sulcus carry a high risk of injuring the long insular arteries. 

Key words: insulo-opercular glioma, surgical indication, lenticulostriate artery, long insular artery, progression

Introduction

Aggressive resection of insular tumors recently became possible using a meticulous surgical approach based on the regional insular anatomy, which has achieved high rates of gross total resection and fewer permanent neurological deficits. However, gross total resection is sometimes impossible with large tumors or tumors invading the surrounding eloquent structures. Moreover, gross total resection still carries a high risk of postoperative morbidities, often related to disruption of the vascular supply to surrounding eloquent structures, such as interruption of perforating vessels, the lenticulostriate arteries (LSAs), and long insular arteries arising from M2 vessels, which is a major cause of permanent morbidities including hemiplegia. Therefore, the surgical indications are one of the most important factors in the management of patients with insulo-opercular gliomas.

The surgical indicators for radical resection include sharpness of the tumor margin, which largely depends on the pathological phenotype of the tumor, and absence of involvement of the LSAs or long insular arteries. However, tumors with invasive margin may still be a candidate if the tumor is still small. Recent improvements in clinical accessibility, and the wide availability of imaging devices including magnetic resonance (MR) imaging have identified more and more patients harboring small tumors in the insulo-opercular regions for follow up at outpatient departments. Therefore, understanding of the developmental pattern of insulo-opercular gliomas is very important to establish the surgical indications and avoid delay in treatment.
Insular gliomas can be categorized into three types based on the patterns of development: insula only, frontal opercular-insular, and temporal opercular-insular, but these developmental patterns have been rarely discussed. The insular cortex is circumscribed by the anterior, superior, and inferior limiting sulci. Therefore, development patterns of insulo-opercular gliomas can be categorized into four groups: tumor progression limited to the insular cortex, tumor progression via the anterior limiting sulcus, tumor progression via the inferior limiting sulcus, and tumor progression via the superior limiting sulcus. Of course, cases may develop from insular cortex and progress via one of the limiting sulci, but the clinical picture should be similar to those with progression into the insular cortex. The present study describes representative cases of these four patterns.

Materials and Methods

Thirty-six patients who underwent surgery for insulo-opercular gliomas at our institute between February 2002 and August 2008 were retrospectively reviewed to prove that development patterns of insulo-opercular gliomas could be categorized into the proposed four groups. Among these cases, seven cases were observed for more than 100 days. Representative cases that demonstrate the proposed four different progression patterns were identified. Cases that represent each different pattern are presented to identify important differences regarding surgical indications.

Results

Six cases were identified as representative cases: Two cases demonstrated tumor progression limited to the insular cortex, one case via the anterior limiting sulcus, two cases via the inferior limiting sulcus, and one case via the superior limiting sulcus. The following case illustrations demonstrate each of the four progression patterns.

Case 1, tumor progression limited to the insular cortex: A 61-year-old female underwent an annual brain check-up examination in November 2002, during which computed tomography identified a new low density area in the left insula (Fig. 1A, B). She was referred to a local hospital in January 2003 and treated with anti-platelet agents under a diagnosis of asymptomatic infarction (Fig. 1C). However, she suffered onset of dysarthria and mild motor aphasia in late August. MR imaging revealed a left insular tumor in September 2003, so she was referred to our institute (Fig. 1D). Her symptoms rapidly deteriorated during the week after referral. She developed aphasia and right hemiparesis. Gross total removal of the tumor was performed, with a subsequent diagnosis of glioblastoma (Fig. 1E). Her symptoms gradually improved afterward, and after adjuvant chemoradiation therapy, she was discharged home with almost full activity of daily living.

Case 2, tumor progression via the anterior limiting sulcus: A 58-year-old male was referred to our institute with a diagnosis of insulo-opercular glioma in June 2008. He had suffered onset of polymyositis at age 43 years. MR imaging had revealed a tumor in the left frontal lobe at that time. Since then, he had been followed up at local hospital (Fig. 2A). MR imaging showed some progression in April 2004 (Fig. 2B), but follow up was discontinued until he transiently lost consciousness in February 2008. MR imaging revealed enlargement of the tumor and invasion into the insular cortex in April 2008 (Fig. 2C). Gross total resection was performed with awake craniotomy in July 2008, and the histological diagnosis was oligodendroglioma (Fig. 2D). He developed no neurological deficit after surgery.

Case 3, tumor progression via the inferior limiting sulcus: A 58-year-old male was referred to our institute with a diagnosis of insulo-opercular glioma in June 2008. He had suffered onset of polymyositis at age 43 years. MR imaging had revealed a tumor in the left frontal lobe at that time. Since then, he had been followed up at local hospital (Fig. 2A). MR imaging showed some progression in April 2004 (Fig. 2B), but follow up was discontinued until he transiently lost consciousness in February 2008. MR imaging revealed enlargement of the tumor and invasion into the insular cortex in April 2008 (Fig. 2C). Gross total resection was performed with awake craniotomy in July 2008, and the histological diagnosis was oligodendroglioma (Fig. 2D). He developed no neurological deficit after surgery.

Fig. 1 Case 1 illustrating glioblastoma progression limited to the insular cortex. Brain computed tomography scans acquired in July 2001 (A), November 2002 (B), and January 2003 (C). Preoperative axial T1-weighted magnetic resonance (MR) image with contrast enhancement obtained in September 2003 (D). Postoperative axial T1-weighted MR image with contrast enhancement (E). Figures B, C, and D were previously published as Figures 7A, B, and C in ref. 6: Saito R, Kumabe T, Tominaga T: [Stroke as initial misdiagnosis of glioma]. No Shinkei Geka Journal 15: 121–127, 2006 (Jpn). Reproduced with kind permission of the Japanese Congress of Neurological Surgeons.
sulcus: A 37-year-old male developed headache in November 2005. MR imaging at a local hospital revealed a mass in the left temporal lobe, so he was referred to our hospital (Fig. 3A). However, he refused to visit our hospital until February 2007. MR imaging obtained in February 2007 revealed a non-enhanced tumor mass infiltrating from the left temporal lobe to the left insular lobe (Fig. 3B, C). Gross total removal was performed in March 2007, which led to a diagnosis of anaplastic ganglioglioma (Fig. 3D). After adjuvant chemoradiation therapy, he was discharged home and is still doing well with full Karnofsky performance status score.

Case 4, tumor progression via the superior limiting sulcus: A 36-year-old male suffered seizure in April 2002 and admitted to a local hospital (Fig. 4A). MR imaging revealed a tumor in the left frontal lobe. However, he refused further treatment at this time, and was followed up at the outpatient department. He suffered several similar seizures and finally accepted surgical treatment. He was referred to our hospital in June 2003 (Fig. 4B). Partial resection was performed with awake craniotomy (Fig. 4C). No neurological deficit was detected after surgery. The histological diagnosis was anaplastic oligoden-
droglioma. After adjuvant chemoradiation therapy, he was discharged home without neurological deficits.

Discussion

The presented cases of insulo-opercular gliomas illustrate the four possible progression patterns. Understanding these patterns of development is quite important in the management of insulo-opercular gliomas. Since resection of tumors invading medially from the insula can result in damage to the LSAs, and resection beyond the superior limiting sulcus can result in injury to the long insular arteries supplying the corona radiata, surgical intervention for insulo-opercular glioma must occur in the early stages, when the tumor is still small and limited to the insular cortex or has progressed locally via the anterior or inferior limiting sulcus laterally to the LSAs but without encasement of these vessels, thus allowing gross total removal without disturbing the LSAs or long insular arteries (Fig. 5)\textsuperscript{2,4,9}

Recently, our group demonstrated preoperative detection of LSAs in patients with insulo-opercular gliomas using 3-tesla three-dimensional time-of-flight MR imaging.\textsuperscript{5} However, precise localization of the long insular arteries is still not possible. Detailed study of the arteries of the insula has shown that the long insular arteries arising from M\textsubscript{2} vessels mostly run through the posterior region of the insula and provide critical blood supply to the corona radiata.\textsuperscript{9} To make matters worse, the arcuate fasciculus that connects Wernicke’s area and Broca’s area in the dominant hemisphere is located near the superior limiting sulcus. Therefore, gross total resection of insulo-opercular tumor that progresses via the superior limiting sulcus is very difficult to achieve.

To adequately treat the patients before progression, it is important to diagnose the lesion earlier. Among 36 patients treated at our institute from February 2002 to August 2008, one patient was referred to our institute for the treatment of recurrent tumor, so 35 patients underwent their first surgery. Thirty-two of these 35 patients suffered some symptoms including seizure, motor weakness, or language disturbances. Median interval between onset of initial symptoms and diagnosis was 20 days (0–543 days). Patients who developed seizure as an initial symptom were likely to be diagnosed earlier when compared to patients whose initial symptom was other than seizure; the median interval was 0 days (0–543 days) and 25 days (0–236 days), respectively. There were non-symptomatic patients, such as Case 1, with tumors detected during the annual brain check-up study. However, the small lesions found in the early stage tended to be misdiagnosed as infarction. Therefore, it is important to keep gliomas in mind when we find small infarction-like lesions in the insulo-opercular regions. Meticulous follow up may lead to successful removal of the tumor without any delay. It is also important to know that the tumor may start to enlarge after a certain amount of time as in Case 2. On the other hand, the median interval between diagnosis and initial surgery was 25 days (0–5319 days). In some cases, symptoms were still mild and so the surgical indication was difficult to determine. However, treatment was delayed in other cases after detection of the disease like Case 4. The reasons for delay were misdiag-
nosis or patient’s refusal (Case 4). Resolutions of these problems are also important in the management of insulo-opercular gliomas.

Insulo-opercular glioma can be classified into four different patterns of development. Resection of tumors progressing medially from the insula can damage the LSAs, and resection beyond the superior limiting sulcus can result in injury to the long insular arteries, so the surgical indications for insulo-opercular gliomas should be limited to small tumors within the insular cortex or progressing locally via the anterior or inferior limiting sulcus laterally to the LSAs without encaissement of these vessels. Tumors that progress via the superior limiting sulcus cannot be treated because of the high risk of injuring the long insular arteries and the arcuate fasciculus in the dominant hemisphere. Therefore, these developmental patterns are quite important in the management of insulo-opercular gliomas.

References


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Commentary

For many years, neurosurgeons have been reluctant to remove insular gliomas due to fear of severe neurological deficits. In the landmark work published in the early 1990s, Yaşargil described the anatomical location of the limbic and paralimbic tumors and their specific ways of extension. Since then, more neurosurgeons have started to remove insular gliomas microsurgically and achieved better outcomes. But even now, surgical treatment of insular gliomas remains a great challenge due to proximity to lenticulostriate vessels and the internal capsule. In this article, the authors categorized the insulo-opercular gliomas into four groups: tumors limited to the insular cortex, tumors progressing via the anterior, inferior, and superior limiting sulci. It is interesting and easy to understand the tumor extension on a plane limited by three sulci. This proposal provided us a new viewpoint to describe insular gliomas and to facilitate preoperative risk assessment.

However, in the real world, it seems difficult to delineate insular gliomas according to this classification. Because of the aggressive characteristic, the tumor will not grow along some specific direction we defined, but to some undefined direction or several directions simultaneously. Moreover, dynamically, the tumor limited in insular cortex may grow superiorly, inferiorly, or anteriorly in a long enough time. So it is questionable to consider the tumor limited in insular cortex as a sole progression pattern.

The authors conclude that the surgical indications for insulo-opercular gliomas should be limited to small tumors within the insular cortex or progressing via the anterior or inferior limiting. This kind of insular gliomas, in my opinion, is the best indication for surgery. But, maximizing the extent of insular glioma resection and minimizing the post-operative morbidity should be considered or at least attempted in all cases. Advances in neuroimaging have allowed the detection of smaller lesions and intra-operative image guidance makes maximal resection possible, so the surgery for insular gliomas is expected to achieve better outcomes.

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