Two-staged Resection of a Left Frontal Astrocytoma Involving the Operculum and Insula Using Intraoperative Neurophysiological Monitoring

—Case Report—

Toshihiro KUMABE, Nobukazu NAKASATO, Kyoko SUZUKI*, Kiyotaka SATO**, Yukihiro SONODA, Jun KAWAGISHI, and Takashi YOSHIMOTO

Department of Neurosurgery and *Section of Neuropsychology, Division of Disability Science, Tohoku University School of Medicine, Sendai; **Department of Neuroanesthesiology, Kohnan Hospital, Sendai

Abstract

A 29-year-old right-handed male with a 12-year education presented with a 2-month history of generalized epileptic activity. Neuroradiological imaging demonstrated a large lesion in the left frontal lobe involving the insulooperculum and in the temporal tip. Neurological and neuropsychological examination revealed no abnormality. Two-staged total resection of a left frontal large astrocytoma involving the insulooperculum was achieved, with preservation of the speech and motor functions. The prefrontal area was resected en bloc under general anesthesia. To avoid vascular damage including the lenticulostriate arteries, the sylvian and the interhemispheric fissures were thoroughly opened. The tumor was apparently located in the anatomical Broca's area. Eighteen days later, the residual tumor was totally resected with no language deficit after identifying the motor-speech cortex, which was displaced from the usual location, by direct cortical stimulation under local anesthesia. The medially extended insular tumor was then resected stepwise with frequent neurological monitoring with the patient awake. Surgery for intraaxial insuloopercular lesions in the dominant hemisphere carries a high risk of speech and motor deficit. This staged operation enables maximum tumor resection of dominant-side large frontal gliomas involving the insuloopercular region, with preservation of both motor and speech functions.

Key words: awake craniotomy, brain mapping, glioma, insulooperculum, staged operation

Introduction

More aggressive surgical resection for gliomas has been proposed to potentiate the effects of adjuvant therapy and to achieve longer overall survival.²⁾ The major limitation to maximal tumor resection is involvement of the eloquent brain regions, including the sensorimotor pathways and language cortex. Surgical management of such lesions carries a significant risk of functional morbidity. Therefore, accurate localization of these critical regions is essential to achieve maximum tumor resection.

The technique of direct stimulation mapping of the cortex to identify regions of language representation and sensorimotor cortex and subcortical stimulation of the descending motor pathways can

minimize the risk of postoperative deficits and maximize the extent of the resection.¹⁻⁴⁾ However, there are few reports of successful surgery for intraaxial insular lesions in the dominant hemisphere, probably due to the high risk of language and motor deficits.^{5,9,10)} The feasibility of surgical treatment for these lesions was demonstrated in 240 patients with limbic and paralimbic tumors, via the trans-sylvian approach, and preservation of the middle cerebral artery (MCA), including both main trunks and small branches, was emphasized to minimize postoperative complications.⁹⁾ Intraoperative functional brain mapping in an awake patient under local anesthesia should be considered for treating dominant-side insular gliomas to reduce the risk of aphasic complications.¹⁰⁾ Experiences of surgical management with intraoperative mapping techniques for circumscribed low grade astrocytomas in the dominant opercular

and insular region have been reported.⁵⁾ Due to possible vascular damage of the lenticulostriate arteries, only biopsy was recommended for large insular or opercular-insular tumors in the dominant hemisphere.⁵⁾

Here we describe a case of a large dominant frontal anaplastic astrocytoma involving the insulooperculum which was treated by a two-staged operation. The first operation under general anesthesia was a frontal lobectomy with control of the entire vascular structure involving the M₁ to M₃ segments of the MCA with the lenticulostriate arteries. The second operation was a craniotomy performed in the awake patient with direct cortical stimulation mapping to achieve maximum tumor resection while preserving the speech and motor functions.

Case Report

A 29-year-old right-handed male with a 12-year education presented with a 2-month history of generalized epileptic activity. T₁-weighted magnetic resonance (MR) imaging demonstrated a large hypointense lesion in the left frontal lobe, involving the insulooperculum, and in the temporal tip. Administration of contrast medium caused slight heterogeneous enhancement (Fig. 1 left column). However, neurological and neuropsychological examination revealed no abnormality.

The patient underwent a two-staged operation. The first stage was a frontotemporoparietal craniotomy performed under general anesthesia on February 27, 1997. The tumor involved Broca's area according to standard anatomical criteria.⁸⁾ The sylvian fissure was opened from the internal carotid artery (ICA) bifurcation in the distal direction to con-

Fig. 1 Axial (upper row) and coronal (lower row) gadolinium-enhanced magnetic resonance (MR) images. Preoperative MR images revealing a heterogeneously enhanced lesion in the left frontal lobe involving the insulooperculum and in the temporal tip (left column). MR images after the first operation revealing the residual tumor in the frontal operculum and insula (middle column). MR images after the second operation revealing gross total resection of the tumor (right column).

trol the entire M₁, M₂, and M₃ segments as they divide on the surface of the insula. Further dissection of the MCA branches was then performed to differentiate tumor-supplying vessels from the lenticulostriate arteries. The interhemispheric fissure was opened from the distal to the proximal portion, so that the entire courses of the bilateral anterior cerebral arteries (ACAs) were visible. The left callosomarginal artery, bilateral pericallosal arteries, bilateral A₂ and left A₁ segments of the ACA, and the left Heubner's artery were identified. The left frontal lobe was resected en bloc anterior to the plane formed by the genu of the corpus callosum, bilateral A₂, left A₁, M₁, M₂, and anterior horn of the lateral ventricle. These major arteries and the lenticulostriate arteries were carefully preserved. The anterior mesial tip of the left temporal lobe was also resected. The inferolateral frontal lobe, although involved by the tumor, was not resected at this first surgery. Histological examination of the tumor specimen revealed an anaplastic astrocytoma. The postoperative course was uneventful. No speech or motor dysfunction was noted. Postoperative MR imaging revealed residual tumor in the frontal operculum and insula (Fig. 1 middle column).

The second operation was performed with the patient awake on March 17, 1997. Cortical mapping was performed using electric stimuli of 2.3–12 mA to identify the sensorimotor and language cortices,

by the method described by Berger et al.¹⁻⁴⁾ Primary speech cortex was identified by speech arrest or speech hesitation due to stimulation during counting or object naming by the patient. Speech arrest was caused exclusively by stimulation of an area rostral to the tumor (Fig. 2). Cortical stimulation in this opercular region evoked no speech disturbance or positive symptoms. Therefore, the left frontal operculum was resected. The medial extension of the insular tumor was then resected stepwise using the Cavitron ultrasonic surgical aspirator with frequent neurological monitoring. Throughout the procedure, the patient was extremely cooperative and reported no problems. After the second surgery, no neurological deficit was observed and MR imaging indicated gross total resection of the tumor (Fig. 1 right column). Neuropsychological examination revealed no aphasia, apraxia, or agnosia. His Aphasia Quotient in the Western Aphasia Battery was 97.8. However, the Wechsler Adult Intelligent Scale-Revised (WAIS-R) indicated minor but significant deficits in his verbal function with verbal intelligence quotient (IQ) of 69 and performance IQ of 109. Abstract thinking and verbal expression of complex material were impaired. The patient returned to work after postoperative irradiation and adjuvant chemotherapy.

Fig. 2 Intraoperative photograph at the first operation (left) and schematic drawing of functional brain mapping with resection areas at each operation (right). The lightly shaded area was resected at the first operation under general anesthesia. The heavily shaded area was resected with the patient awake at the second operation. Arrowheads, sylvian fissure; arrows, central sulcus; open circles, no speech arrest during direct cortical stimuli; solid circles, speech arrest during direct cortical stimuli; solid triangles, tingling sensation of the tongue (To), face (F), and thumb (Th).

Discussion

The problem in the present case was to achieve maximum tumor resection of a large dominant frontal glioma involving the operculum and insula with minimum functional deficit after the surgery. We designed a two-staged operation intended to achieve the following: Preservation of the important vascular structures of the ICA, ACA, and MCA territories; preservation of the speech cortex; and preservation of the primary motor cortex and descending motor pathways. Frontal lobectomy with thorough dissection of the sylvian and interhemispheric fissures was performed under general anesthesia for the first purpose. Then, stepwise resection with intraoperative functional brain mapping was performed with the patient awake for the second and third purposes.

The frontal lobectomy required control of the ICA, A₁, anterior communicating artery, bilateral A₂, A₃, M₁, M₂, M₃, and their perforating arteries to prevent damage to the vascular structures which supply the normal brain. The skin flap should be reflexed until the orbital rim is exposed to approach though the frontal base, and the sylvian and interhemispheric fissures should be separated first. General anesthesia is recommended because the above procedures mediate pain due to the rich distribution of pain fibers in these structures. Also, the patient must be placed in a neutral position with tracheal intubation to separate the interhemispheric fissure. The skin flap and head position of this first procedure are not suitable for the language test with the patient awake. Thus, the patient underwent a two-staged operation.

In the present case, the tumor involved Broca's area according to the standard anatomical criteria.⁶⁾ Therefore, the residual tumor after the first operation could not be resected with only anatomical localization. Cortical mapping during the second surgery revealed that the opercular region was not functionally related to verbal output. There is considerable variation in localization of language cortex among individuals,^{6,7)} so we assumed that the main language area had escaped from the lesion. Thus, the tumor could be resected without devastating language dysfunction postoperatively. However, the postoperative WAIS-R revealed minor deficits in verbal function. Intraoperative cortical stimulation mapping for the identification of essential language sites is indispensable for maximizing the extent of tumor resection and minimizing permanent language deficits, although not all verbal function can be mapped.

Subcortical mapping can also identify the deep motor pathways traveling toward the internal capsule during tumor resection.^{1,4)} In our patient, we could

not obtain stimulation-induced motor movements using stimulation currents as high as 12 mA. Stimulation mapping using greater currents evoked after-discharges and resulted in focal seizure activity. Subcortical stimulation of the descending motor pathway and/or frequent clinical examinations during resection of the medial borders of tumor adjacent to the pyramidal tract can decrease the risk of postoperative motor dysfunction.

The surgical success in this case might be due to the relatively good demarcation and expansive growth characteristics of anaplastic astrocytoma, which resulted in displacement of the eloquent brain area. However, our experience suggests that staged operation with functional brain mapping techniques in the awake patient can be effective for treating dominant-side large frontal gliomas involving the insuloopercular region.

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Address reprint requests to: T. Kumabe, M.D., Department of Neurosurgery, Tohoku University School of Medicine, 1-1 Seiryō-machi, Aoba-ku, Sendai 980-8574, Japan.