Language Areas Involving the Inferior Temporal Cortex on Intraoperative Mapping in a Bilingual Patient With Glioblastoma

—Case Report—

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Abstract

A 40-year-old bilingual man underwent removal of glioblastoma multiforme with intraoperative language mapping, mainly using the picture-naming and auditory responsive-naming tasks under cortical stimulation. Multiple language areas were identified, including one located in the middle of the inferior temporal cortex (ITC). Individual mapping for glioma patients must be performed because language areas might be located in various and unexpected regions, including the ITC.

Key words: intraoperative mapping, awake surgery, language area, inferior temporal cortex, high-grade glioma

Introduction

Intraoperative mapping of the language areas is a useful method for the safe removal of gliomas near the language areas.⁶⁾ The language areas are located in the frontal and temporal cortices with individual variability in both monolingual patients and bilingual patients.^{5,7,12,13)} Furthermore, the presence of a language area in the inferior temporal cortex (ITC) is not usually detected by intraoperative mapping for glioma surgery as well as during the removal of other tumors and in epilepsy surgery.^{10,12)} We report a patient with unique language areas identified by intraoperative mapping.

Case Report

A 40-year-old business man had a 2-month history of headaches with nausea. He became transiently speechless when making an overseas phone call to his wife 3 weeks before admission. On admission, his symptoms included worsened headaches with nausea and very mild attention disturbance. Magnetic resonance (MR) imaging revealed a small ring-enhanced mass with surrounding abnormal intensity in the left temporal lobe (Fig. 1). He was right-handed and a bilingual speaker with Japanese as the early-acquired and daily-spoken language, and English as a late-acquired language, mainly after the age of 25 years for frequent business trips. Mini-mental state examination score was 29 of 30 points, frontal assessment battery score

Fig. 1 Upper row: T₁-weighted magnetic resonance (MR) images with gadolinium showing a small ring-enhanced mass in the left superior temporal lobe. Lower row: T₂-weighted MR images revealing the presence of a hyperintense area in the temporal lobe measuring 6 cm in maximal diameter.

was 16 of 18 points, and standard language test of aphasia (SLTA) for Japanese language score was 10 of 10 points in the aphasia severity rating. Subscores of the SLTA showed 10 of 10 in auditory comprehension (a), 18 of 20 in naming (b), 5 of 5 in sentence repetition (c), 5 of 5 in reading aloud short sentences (d), 10 of 10 in reading comprehension (e), 10 of 10 in dictation of Kana letters (f), and 5 of 5 in dicta-

Fig. 2 Intraoperative language mapping (left) and its scheme on magnetic resonance (MR) image (right) for detecting language areas. The cerebral cortices exposed surgically were stimulated with 5-mm bipolar electrodes with 8-mA current on the temporal lobe (gray line) and 4–6 mA on the frontal lobe (oval regions; stimulated areas on the temporal cortex). Both Japanese language areas (blue areas) and English language areas (red areas) were located on the frontal and temporal cortices. Apparent discrepancy was found between Japanese and English language areas in the temporal cortex. One of the Japanese language areas was located in the middle of the inferior temporal cortex. Dotted yellow line indicates the hyperintense lesion on T₂-weighted MR image; dotted red line, a region removed surgically after the language mapping; dark yellow line, superior temporal cortex (T1); white line, middle temporal cortex (T2); red line, inferior temporal cortex (T3); yellow area, enhanced mass on T₁-weighted MR image with gadolinium.

tion of short sentences (g).

He underwent tumor removal via a fronto-temporal craniotomy. Cortical stimulation during intraoperative language mapping consisted of 0.5-msec biphasic square-wave pulses delivered from a constant current stimulator in 4-second trains at 50 Hz across 5-mm bipolar electrodes. The largest current (ranging from 4 to 8 mA), which did not evoke after-discharges, was used for the stimulation. For intraoperative language mapping, the picture-naming task (for example, 'kutsu' in Japanese and 'shoes' in English) and the auditory responsive-naming task (for example, Query, 'What animal has a very long nose?'; Answer, 'zou' in Japanese and 'elephant' in English) under cortical stimulation was performed for all regions of the exposed cortex, and we defined the stimulated region as a language area if the stimulation reproducibly induced speech arrest. These investigations revealed the presence of language areas in the frontal and temporal cortices (Fig. 2). There was an apparent discrepancy between Japanese and English language areas in the temporal lobe, and one of the Japanese language areas was located in the middle of the ITC (MITC). In this MITC region, cortical stimulation induced typical speech arrest both in Japanese picture-naming and auditory responsive-naming tasks. The stimulation also induced similar speech arrest during these tasks in the English language area in the superior temporal cortex (STC), and induced speech disturbance with paraphasia and sporadic speech arrest during the auditory responsive-naming task in another Japanese language area in the STC.

The hyperintense lesion on T₂-weighted images was removed except for language areas while the patient was awake, guided by the MR imaging navigation system and

Fig. 3 Magnetic resonance images showing that the enhanced mass on T₁-weighted images with gadolinium was removed (upper row), and the hyperintense lesion on T₂-weighted images was partially removed (lower row).

photodynamic diagnosis using 5-aminolevulinic acid. The subscore of the SLTA one week after the surgery showed slightly decreased scores with sensory aphasia pattern, 6 points in subscore (a), 15 in (b), 3 in (c), 5 in (d), 9 in (e), 10 in (f), and 3 in (g), although the aphasia severity rating remained at 10 points. No obvious deficit in his bilingual speech or any other neurological symptoms was detected 3 weeks after the surgery. MR imaging showed that the enhanced lesion was gross totally removed, and the surrounding abnormal intensity lesion was partially removed to preserve the temporal language areas (Fig. 3). Histological examination revealed a typical glioblastoma (World Health Organization [WHO] grade IV, no deletion in 1p36 or 19q13) with elevated MIB-1 index (20.3%) surrounded by diffuse astrocytoma components (WHO grade II) with MIB-1 index of less than 5%.

Discussion

Intraoperative mapping was useful for the detection of language areas in the present bilingual patient with glioblastoma multiforme. The mapping showed apparent discrepancies between the Japanese and English language areas in the temporal cortex. The MITC Japanese language area was probably more dominant than the STC Japanese language area near the English language area, because cortical stimulation induced more typical speech arrest in the former. Previous studies of language areas in bilingual patients have found the cortical areas for multiple languages were located in the temporo-parietal cortex and in the frontal cortex with individual variability.^{5,6,12,13)}

In the present patient, one of the language areas was located in the MITC. In various case series, naming sites in the temporal lobe were predominantly found in the superior and middle temporal gyri.^{3,10,12,14)} For example, there was no language region of the ITC in 57 patients with one or more temporal lobe language sites.¹⁴⁾ Verb

generation was disrupted by ITC stimulation in only one of 14 cases.¹⁰⁾ In a large case series mainly of brain tumors, cortical dysplasia, and epilepsy, the language areas were located in the anterior ITC in no patient (by naming task) and MITC in 2 (by reading task) of 28 patients.¹²⁾ The basal temporal regions induce certain language dysfunction using a systematic battery of language tests.¹⁾ Especially in transcription and mental recall tasks of Japanese 'kanji' morphograms, functional MR imaging showed lateralized activation of the basal temporal regions including the left posterior ITC. In contrast, neither oral reading nor semantic judgment produced similar activation of this area.⁹⁾ Therefore, we think that the typical speech arrest by cortical stimulation of MITC shown in the present case is a minor event. Furthermore, the responses were evaluated mainly by the picture-naming and auditory responsive-naming tasks without using 'kanji' or other morphograms.

As a limitation of the electrical stimulation in our case, the reason for the speech arrest area located in the ITC remains uncertain, but can be explained as a redistribution or reorganization of functional neural networks for motor function. Functional MR imaging study before surgery for patients with brain tumors involving the motor cortex showed that two or more exceptional activation sites were demonstrated in the majority of patients,⁴⁾ probably due to the reorganization of the motor cortex. Language functions are likely to become reorganized in patients with slow growing tumors including low grade gliomas^{11,17)} as well as congenital anomalies in the left hemisphere.^{2,16)} In our case, the lesion probably had a long growth interval, allowing the language areas to shift into the intact area in the ITC. However, we cannot prove this speculation due to lack of information about the language areas in the early stage of the present case. Another explanation is the possibility of indirect stimulation into the inferior longitudinal fasciculus (ILF). In some cases, deficits in the left ILF resulted in impairments in object naming.¹⁵⁾ However, in another case, the ILF was not indispensable for language semantic pathways because subcortical stimulation never elicited any language disturbances when performed at the level of the ILF.⁸⁾

We recommend individual mapping under the awake condition for glioma patients, because the language areas might be located in various and unexpected regions, including the ITC.

Conflicts of Interest Disclosure

No conflict of interest exists. All authors who are members of The Japan Neurosurgical Society (JNS) have registered online Self-reported COI Disclosure Statement Forms through the website for JNS members.

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