

Abnormal Configuration of Broca's Area: Relationship To Frontal Lobe Tumors

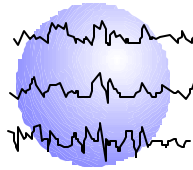
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ABSTRACT

BACKGROUND

Paul Broca first defined the expressive classical language area in 1861, located in the posterior portion of the inferior 3rd convolution of the left frontal lobe. Space-occupying lesions in the frontal lobe can invade this area, however, the effect of frontal tumors on the language area has rarely been studied¹.

OBJECTIVES

We report cases of splitting and displacement of Broca's area by left frontal gliomas.

METHODS

10 patients with primary frontal tumors near the classic motor speech area underwent electrocortical stimulation (ECS) for language mapping. These patients first presented with a seizure disorder and were subsequently found to have primary frontal tumors, Grade II-IV gliomas. Language dominance in these patients was defined based on the results of the intracarotid amobarbital procedure performed during preoperative assessment.

RESULTS

The language maps showed abnormal configuration of Broca's area by the tumor in 6 of 10 patients (60%). Three patients had splitting of Broca's area into two parts and the remaining three had displacement of this area. In splitting cases, one split segment was found located in the superior frontal convolution and the other segment in the inferior frontal convolution. In the displaced cases, Broca's area was found displaced superiorly either in the superior frontal convolution (2 cases) or the middle frontal convolution (1 case).

CONCLUSION

Growing and invading frontal tumors located in close proximity to Broca's area may lead to splitting and displacement of language cortex. We suggest that careful language mapping is necessary in order to achieve a safe surgical resection.

INTRODUCTION

The frontal lobe consists of two classical language areas known worldwide. These areas were fully described by the pioneering works of Penfield and associates using the technique of ECS for brain mapping²: the expressive Broca's area and the supplementary motor area. Currently, while noninvasive mapping techniques like magnetoencephalography and functional MRI are rapidly gaining credibility. ECS remains the most reliable method of identifying and establishing the margins of functional language cortex.

In this retrospective study, we describe the effect of invading and growing frontal gliomas on Broca's area in 10 patients, evaluated with ECS.

METHODS

10 patients with primary left frontal gliomas who underwent brain language mapping between January 1996 and January 2001 at Minnesota Epilepsy Group were retrospectively reviewed. Data collected from their medical records included: age at presentation, gender, handedness, hemispheric language dominance based on IAP, clinical presentation, MRI findings, surgical procedures and pathological results.

Demographic information is shown in Table 1. ECS in our center is performed according to the technique of Luders and his associates³. A subdural electrode array (SEA) was surgically implanted over the tumor and the patient returned to his/her hospital room. Language mapping was then conducted on the epilepsy unit by two different epileptologists and one neuropsychologist over several days. The language protocol included the assessment of different modalities: tasks of automatic speech (counting), confrontation naming in response to drawings of common objects, auditory comprehension (following one-step commands), repetition (short phrase) and reading (single words). This protocol was performed in at least two stimulation sessions at multiple electrode sites.

The mapping results were carefully reviewed and compared to colored photographs of brain before and after SEA placement to clearly identify the location of the essential functional areas in relation to the tumor.

RESULTS

Of the 10 patients reviewed, 4 were found to have a classical localization of Broca's area while 6 had an abnormal configuration of Broca's area. 3 of these 6 patients had split Broca's and the remaining 3 had superiorly displaced Broca's (Figure 1). In splitting cases, one split segment was found located in the superior frontal gyrus and the other segment in the inferior frontal convolution. In the displaced cases, Broca's area was found displaced superiorly in the superior frontal gyrus. A comparison of the variables for patients with classical versus atypical Broca's areas is presented in Table 2. All patients underwent total surgical resection of their tumors except one patient who had a subtotal resection. They were subsequently treated with chemotherapy and/ or radiation therapy (Table 1).

DISCUSSION

These results are based on a small number of patients identified in a retrospective analysis and thus our power in predicting this occurrence or its relationship to other patient variables is limited. Nonetheless, comparison of the patients with this abnormal Broca's configuration to patients who did not demonstrate the finding led us to the following speculations:

1. 4 of the 6 patients with abnormal Broca's area were females whereas all patients with classical standard Broca's area were males. This suggests that the female brain may have more potential for reorganization.
2. 2 of 6 patients with atypical Broca's area were found to have bilateral language, while all cases with the standard classical Broca's were exclusively left hemispheric dominant for language. The possibility that bilateral language might be associated with the potential for neuronal reorganization should be considered.
3. All tumors in patients with the standard Broca's configuration were located in the middle frontal lobe whereas tumor locations in those with abnormal Broca's areas were mainly in the anterior or posterior frontal lobe. This suggests a possible anatomical influence of the location of the frontal tumor on the relocation of Broca's area.
4. 4 of 6 patients with split and displaced Broca's were found to have high-grade primary frontal gliomas, compared to 1 of 4 cases with a traditional Broca's area, suggesting that a deformed Broca's area might be more likely to occur with rapidly growing and infiltrating frontal tumors.

CONCLUSIONS

1. A confirmatory prospective analysis is needed to further assess the characteristics of this abnormal representation of Broca's area and to determine factors that may trigger this occurrence.
2. We recommend careful assessment of the expressive language area in patients with primary frontal tumors prior to surgical resection in this region.
3. ECS for language mapping should include all three frontal convolutions to define accurately the surgical margins.

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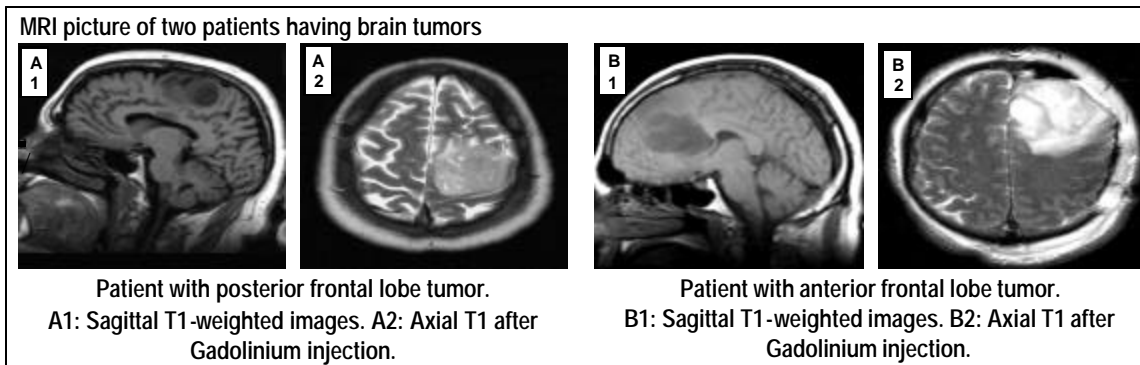
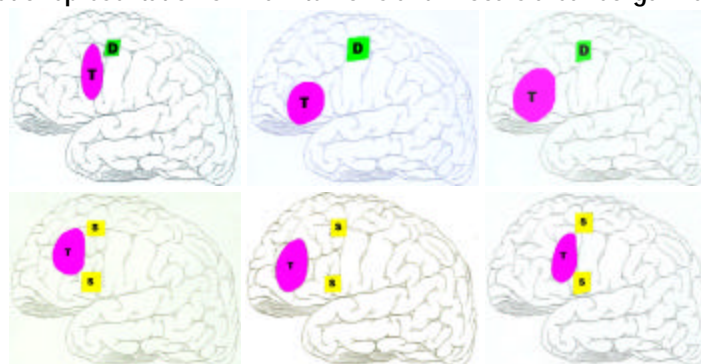


Table 1.
Demographic patient's data, Clinical presentation, MRI features, Pathology results and surgical procedures.

| Patient | Age | Gender | Handedness | IAP | Presentation | MRI Features | Pathology |
|---------|------|--------|------------|-----|--------------|----------------------------------|-----------------------|
| 1 | 38 y | M | R | LD | SPS | 4.5x2.8x3.4 cm L post frontal | Grade IV glioblastoma |
| 2 | 51 y | M | R | LD | GTC | 5.6x5.6x6.5 cm L mid frontal | Grade III glioma |
| 3 | 32 y | F | R | LD | GTC | 3.0x3.4x3.1 cm L post frontal | Grade III glioma |
| 4 | 47 y | FM | R | LD | CPS | 6.2x4.6x5.7 cm L mid frontal | Grade II glioma |
| 5 | 28 y | FF | R | LD | Headache | 5.4x4.9x5.5 cm L ant frontal | Grade IV glioma |
| 6 | 25 y | M | L | LD | CPS | 2.5x2.7x2.6 cm L mid frontal | Grade II glioma |
| 7 | 34 y | M | R | LD | GTC | 4.5x4.6x4.7 cm L mid frontal | Grade II glioma |
| 8 | 49 y | M | R | LD | GTC | 5.4x3.6x3.9 cm L mid frontal | Grade III glioma |
| 9 | 43 y | F | L | BD | GTC | 3.5x2.6x2.6 cm L ant frontal | Grade II glioma |
| 10 | 28 y | F | R | BD | GTC | 4.5x4.5x5.5 cm L ant frontal | Grade II glioma |

IAP=Intracarotid Amitobarbital Procedure, y=years, M=male, F=female, R=right, L=left, LD=left language dominance, BL=bilateral language, SPS=simple partial seizure, GTC=generalized tonic-clonic seizures, CPS=complex partial seizures, post=posterior, mid=middle, ant=anterior.

Figure 1
Schematic representation of Brain tumor's and Broca's area reorganization.



T= tumor, S= split, D=displaced

Table 2.

Comparison demographic data between patients with frontal tumors who have classical Broca's and those with split or displaced Broca's area (Abnormal Broca's).

| Patient's Variables | Classical Broca's | Abnormal Broca's |
|---|--------------------------|-------------------------|
| Number of Patients: | 4 | 6 |
| Mean age yrs (SD) | 38.75 (11.32) | 36.67 (9.15) |
| Gender: M/F Ratio | 4/0 | 2/4 |
| Handedness: R/L | 3/1 | 5/1 |
| IAP: LD/BL | 4/0 | 4/2 |
| Clinical Presentation: Seizure/Headache | 4/0 | 5/1 |
| Tumor Location: Ant/Mid/Post (Based on MRI) | 0/4/0 | 3/1/2 |
| Pathology Results: Low Grade/High Grade | 2/2 | 2/4 |

Yrs=years, SD=standard deviation, M=male, F=female, L=left, IAP=intracarotid amobarbital injection, LD=left language dominance, BL=bilateral language, Ant=anterior, Mid=middle, Post=posterior