The use of computerized tomography (CT) and magnetic resonance (MR)–guided stereotactic techniques has resulted in a dramatic reduction in the morbidity and mortality rates associated with biopsy of brain tumors. Complication rates following supratentorial brain biopsy for tumors range between 3% and 10%.1,12,14 In general, these complications occur as a result of hemorrhage at the biopsy site; nonetheless, most iatrogenic clinical deficits resolve quickly.14 Although dysphasia occurs in approximately 50% of patients with dominant-hemisphere tumors,6,10 there has been no prospective or retrospective study that contained an objective evaluation of the effects of image-guided stereotactic biopsy of nonpolar tumors in the dominant hemisphere on speech and language functions. This study was therefore designed to evaluate this question prospectively. It was hypothesized that CT-guided stereotactic biopsy of nonpolar brain tumors in the dominant hemisphere would not impair language function.

Clinical Material and Methods

Patient Selection

Patients with dominant-hemisphere brain tumors who were considered unsuitable for cytoreductive surgery on the basis of CT or MR images, but in whom tissue diagnosis was required, were selected for the study. Cerebral dominance was determined using the Handedness Inventory.2 Patients were excluded if their first language was not English, if they had suffered previous significant head injury or other brain disease (including psychiatric disorder), or if they had impairments of vision or hearing that could not be corrected by corrective lenses or hearing aids, respectively. The study was approved by the regional hospital ethics committee.

Language Testing

The patients were started on dexamethasone therapy if there were signs and symptoms of raised intracranial pressure or focal neurological dysfunction. Within 24 to 48 hours of starting the course of dexamethasone, language function was assessed using both the Western Aphasia Battery (WAB) and the Boston Naming Test (BNT). The BNT is a short test of anomia and the WAB is composed of a series of tests used to evaluate comprehension and expressive language functions. Two summary scores are derived from groups of test scores. The Aphasia Quotient (AQ) provides a measure of the severity of dysphasia: an AQ of 93.8 or higher (maximum AQ = 100) indicates normal language function, whereas an AQ less than 93.8 indi-
cates dysphasia. The Language Quotient (LQ), which also reflects the reading and writing subtests, demonstrates competence across all language modalities. Assessment was performed by a qualified speech therapist in a quiet room on the day before the biopsy specimen was obtained and was repeated 3 to 5 days after stereotactic biopsy. The time taken to perform the WAB was also documented.

**Stereotactic Biopsy**

After general anesthesia had been induced in the patient, stereotactic biopsy was performed using the Brown-Roberts-Wells (Radionics Inc., Burlington, MA) stereotactic system and CT imaging (model 8800CT; General Electric Medical Systems, Milwaukee, WI). The cranial entry point was either a burr hole placed on the coronal suture for more anteriorly placed lesions or a posterior or parietal burr hole for more posteriorly placed lesions. The trajectory of the biopsy cannula was not plotted using multiplanar reconstruction of the CT scan. Three to five biopsies were taken, using a Sedan–Nashold side-biting biopsy cannula (Radionics, Inc.), from one or two designated target points. The neuropathological diagnosis was recorded for each patient.

**Statistical Analysis**

Paired t-tests were performed on the first versus the second AQs, LQs, and BNT scores. A probability level of less than 0.05 was taken to indicate significance. All raw score distributions were skewed in the same direction. The t-test is robust under such conditions and was preferred to nonparametric alternatives for its greater statistical power.

**Results**

There were 16 patients in the study ranging in age from 26 to 73 years with a median age of 49.5 years. All patients were right handed according to the Handedness Inventory and presumed to be left hemisphere dominant. Seven patients had malignant glioma (glioblastoma multiforme or anaplastic astrocytoma), six had lower grade tumors (oligodendroglioma, astrocytoma, or mixed oligoastrocytoma), and three had metastases. Each patient had a solitary cerebral lesion. The tumors were either extensively deep, central hemispheric lesions (gliomas) or more localized lesions involving the thalamocapsular-basal ganglia-insular regions (gliomas and metastases). All the biopsy targets were directed at these regions because none of the lesions was predominantly located in the temporal, frontal, or occipital poles. Most patients received dexamethasone therapy 2 to 5 days before the biopsy, and in most of these cases the dosage of dexamethasone was reduced serially prior to the second language assessment (Table 1).

**Western Aphasia Battery**

Eleven (69%) of the 16 patients had an AQ within normal limits before biopsy, whereas five were dysphasic (AQ < 93.8). Group data showed there was a small but insignificant decrease after biopsy in both the AQ and the time taken to perform the WAB (Table 1). There was also a marginal, insignificant decline (p = 0.49) in the group LQ from 83.8 preoperatively to 82.2 postoperatively. The LQ could not be recorded in three patients because their dysphasia was so severe that not all WAB subtests could be performed.

The language function of four of the five dysphasic patients deteriorated after biopsy despite continuation of dexamethasone therapy, as demonstrated by the lower postoperative AQs (Table 1). The other patient who was borderline dysphasic before biopsy (Case 12) improved slightly and obtained an AQ just within normal limits postoperatively. One of the dysphasic patients (Case 14), who had an AQ of 54 after biopsy, later made a complete recovery (AQ = 97) after radiotherapy for a diffuse oligoastrocytoma. The other three patients with dysphasia deteriorated and remained profoundly dysphasic prior to death. Postoperative CT scans were obtained in all patients who deteriorated and, except for punctate hematoma at the biopsy site, there were no changes from the corresponding preoperative studies.

Of the 11 patients whose preoperative AQs and LQs were within normal limits, 10 still had normal language function at postoperative assessment and dexamethasone therapy had been stopped in all but one by this time (Table 1). The one patient whose AQ was significantly worse (Case 10) was a medical doctor who had a lesion in Wernicke’s area; this lesion caused a very minor impairment in his ability to dictate patient notes. He declined any steroid therapy, both before and following biopsy, diagnosis of glioblastoma multiforme, despite having pronounced iatrogenic dysphasia. A postoperative CT scan did not show any hemorrhage to account for the deterioration in WAB scores. The patient refused any active treatment and died 5 weeks after biopsy.

**Boston Naming Test**

Group analysis of paired data, that is, data only for patients who took pre- and postoperative BNTs, showed a small but significant improvement in the BNT score following biopsy (Table 1). This paradoxical finding occurred partly because the three dysphasic patients (Cases 14–16) whose WAB language scores were worse after biopsy were unable to complete the BNT postoperatively. However, nine of the 10 patients who showed a change in their BNT score showed improvement after biopsy, and in three patients whose AQ was greater than 93.2, this improvement ranged from 7 to 12 points.

**Discussion**

Image-guided stereotactic biopsy of brain lesions is a very commonly performed procedure. The morbidity and mortality rates associated with this operation have been well documented in several series, but no previous studies have addressed the issue of whether biopsy impairs language function. This is an important question because many patients undergoing stereotactic biopsy have lesions that straddle or involve large regions of the dominant hemisphere that subserve receptive and oral and written expressive language. In patients undergoing surgery to resect lesions in these regions, language function is often thoroughly assessed and intraoperative stimulation and mapping are also used. Because the latter tech-
Effects of stereotactic biopsy on language functions

### TABLE 1
Clinical characteristics and scores of language functions in 16 patients who underwent image-guided stereotactic biopsy for nonpolar tumors in the dominant hemisphere

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Tumor Neopathology</th>
<th>Preop Steroid Dosage (mg/day)</th>
<th>Postop Steroid Dosage (mg/day)</th>
<th>Preop AQ</th>
<th>Postop AQ</th>
<th>Preop WAB Test Time (min)</th>
<th>Postop WAB Test Time (min)</th>
<th>Preop BNT Score</th>
<th>Postop BNT Score</th>
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<tr>
<td>1</td>
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<td>8</td>
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<td>43</td>
<td>54</td>
<td>56</td>
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<tr>
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<td>0</td>
<td>99.6</td>
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<td>35</td>
<td>59</td>
<td>59</td>
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<td>42</td>
<td>45</td>
<td>48</td>
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<td>0</td>
<td>99.2</td>
<td>99.6</td>
<td>48</td>
<td>64</td>
<td>57</td>
<td>58</td>
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<td>8</td>
<td>8</td>
<td>99</td>
<td>100</td>
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<td>0</td>
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<td>0</td>
<td>97.2</td>
<td>69.4</td>
<td>—</td>
<td>—</td>
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<tr>
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<td>6</td>
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<td>120</td>
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<tr>
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<td>glioblastoma multiforme</td>
<td>16</td>
<td>6</td>
<td>43.4</td>
<td>37.8</td>
<td>—</td>
<td>—</td>
<td>10</td>
<td>—</td>
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<tr>
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<td>anaplastic astrocytoma</td>
<td>16</td>
<td>16</td>
<td>25</td>
<td>19</td>
<td>100</td>
<td>—</td>
<td>—</td>
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</table>

**Mean**
- 7.7 ± 3.0
- 87.4 ± 84.3
- 59.7 ± 57.7
- 47.6 ± 51.9

**Standard deviation**
- 6.3 ± 4.8
- 22.4 ± 25.8
- 30 ± 31.4
- 9.6 ± 9.1

**Significance level**
- 0.008
- 0.136
- 0.631
- 0.016

*The maximum AQ is 100 and the maximum score for the BNT is 60. The numbers of patients refer to matched pairs and not to the total number of scores. Significance levels were derived from a paired t-test. — = test not taken or completed.

The study was designed to address the specific issue of morbidity in language function caused by image-guided stereotactic biopsy of nonresectable, nonpolar brain tumors in the dominant hemisphere. Although the cohort is small, the comprehensive assessment paradigms have enabled identification of two definite trends. First, if the patient has a nonpolar lesion in the dominant hemisphere that is not causing dysphasia as assessed on the WAB, there is a low risk using conventional surgical biopsy practice that the patient will be rendered dysphasic by the biopsy regardless of the tumor diagnosis. The absolute risk of iatrogenic dysphasia in this series was 9% with a 95% confidence interval of 0 to 26%. Only a large study cohort would enable better assessment of this risk and of whether certain categories of brain tumor predispose to this complication. One possible explanation for this relatively low risk is that the tumor and biopsy trajectory might not anatomically straddle those parts of the dominant hemisphere subserving vital language functions. Another possibility is that mild dysphasia that has resolved with steroid therapy prior to both testing and biopsy might indicate that the language regions of the brain were dysfunctional because of the pathophysiological, not directly anatomical, effects of the tumor. In either case, uncomplicated biopsy would seem to pose a low risk to language function. A slight problem with both these explanations arises when one focuses on Case 10. This patient had normal language functions on the WAB and BNT preoperatively, yet after an uncomplicated biopsy of his glioblastoma multiforme, he developed severe dysphasia. Although the lesion was in Wernicke’s area, the postoperative CT scan appeared unchanged from the preoperative study and excluded a biopsy site hematoma. The patient declined steroid therapy, both pre- and postoperatively, and remained dysphasic until his death.

Second, it seems that if a patient has significant dysphasia preoperatively the biopsy is likely to aggravate the deficit. This phenomenon was seen in four of the five dysphasic patients. The explanation for this finding is probably related to further compromise, by the biopsy procedure, of fragile cerebral “reserve” underlying speech and language functions. In the dysphasic patient in whom deterioration did not occur, the AQ was initially borderline (93.2) and improved to within normal limits at the postoperative assessment. In the one patient whose AQ deteriorated following biopsy of a low-grade tumor (oligoastrocytoma), there was almost complete restoration of language function 3 months after completing radiothera-
This event would suggest that the neoplastic oligodendrocytes and astrocytes had caused a functional depression of neurons and axons subserving language functions and, once this neurodepressant effect was removed, the infiltrated brain was able to function normally.

From the neurolinguistic viewpoint, the 31% incidence of dysphasia in a nonpolar dominant-hemisphere brain tumor cohort is at the lower limit of reported incidence of language dysfunction. This may reflect either the beneficial effects of steroid medications in rectifying dysfunction prior to assessment, or the small size of the cohort. The former is undoubtedly a factor because all but one of the patients whose AQ was normal at the postoperative assessment had completely discontinued steroid medications, yet none showed any deterioration in postoperative BNT score. Indeed, the overall improvement in the BNT score after biopsy can only be attributed to steroid medication–mediated improvement in peritumoral brain function because there is little or no practice effect with the BNT. The criteria by which language dysfunctions are determined or defined are also important; for example, the BNT is a more sensitive test for anomia than the WAB. Because anomia, but not necessarily more severe dysphasia, is a common sequela of brain tumors, regardless of tumor location within the dominant hemisphere, the reported incidence of language dysfunction depends heavily on test type. These observations and findings would indicate that all patients with tumors in the dominant hemisphere should have objective, quantitative language assessments performed before either resective surgery or diagnostic biopsy. Because many of these patients have tumors with a poor prognosis both for survival and for preservation of focal neurological integrity, it is incumbent on surgeons to be aware of which patients are at high risk of subsequent speech and language dysfunction before the performance of stereotactic biopsy.

References


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