Neurosurgical forum
Letter to the editor

Language Representation


Abstract

Dissociated language functions are largely invalidated by standard techniques such as the amobarbital test and cortical stimulation. Language studies in which magnetoencephalography (MEG) and functional magnetic resonance (fMR) imaging are used to record data while the patient performs lexicosemantic tasks have enabled researchers to perform independent brain mapping for temporal and frontal language functions (MEG is used for temporal and fMR imaging for frontal functions). In this case report, the authors describe a right-handed patient in whom a right-sided insular glioma was diagnosed. The patient had a right-lateralized receptive language area, but expressive language function was identified in the left hemisphere on fMR imaging and MEG-based mapping. Examinations were performed in 20 right-handed patients with low-grade gliomas (control group) for careful comparison with and interpretation of this patient’s results. In these tests, all patients were asked to generate verbs related to acoustically presented nouns (verb generation) for fMR imaging, and to categorize as abstract or concrete a set of visually presented words consisting of three Japanese letters for fMR imaging and MEG.

The most prominent display of fMR imaging activation by the verb-generation task was observed in the left inferior and middle frontal gyri in all participants, including the patient presented here. Estimated dipoles identified with the abstract/concrete categorization task were concentrated in the superior temporal and supramarginal gyri in the left hemisphere in all control patients. In this patient, however, the right superior temporal region demonstrated significantly stronger activations on MEG and fMR imaging with the abstract/concrete categorization task. Suspected dissociation of the language functions was successfully mapped with these two imaging modalities and was validated by the modified amobarbital test and the postoperative neurological status. The authors describe detailed functional profiles obtained in this patient and review the cases of four previously described patients in whom dissociated language functions were found.

Kamada and colleagues present the case of a right-handed patient with a right frontotemporal glioma and dissociated left frontal and right temporoparietal language functions. They review the literature on fMR imaging and list four other patients with dissociated language function. We would like to add three previously described epilepsy patients with right frontal and left temporoparietal language areas, bringing the total number of cases in the literature to eight.

In their paper, Kamada and associates advocate the use of MEG in addition to fMR imaging because “little neural activity is detected in Wernicke areas on fMR imaging–based imaging mapping, and a more reliable method is required.” We agree that the use of fMR imaging for identification of language areas is not yet trusted in a clinical setting, and that findings on fMR imaging are not always consistent when compared with the findings in other studies or with other functional techniques. However, we feel that with carefully chosen and validated protocols, fMR imaging is already a valuable clinical tool that can be used for reliable identification of typical patients (for example, patients with left-hemisphere dominance) and atypical patients (such as patients with right-hemisphere dominance or bilateral language representation). We currently use fMR imaging as an adjunct to the Wada test and/or electrocortical stimulation. Given the limitations of the two latter (gold standard) techniques, we have found that a convergence of results from different techniques is very helpful for surgical planning. As is true of most of our colleagues, we do not have access to MEG, and we argue that with the use of multiple-task protocols in fMR imaging the added value of MEG is limited.

In general, results of studies in the literature indicate a high but not perfect agreement (90–95%) between fMR imaging and the results of the Wada test for typical patients. In patients with bilateral language representation, on the other hand, agreement is found in less than 50%. This low predictive value hinders current clinical application of fMR imaging because in neurosurgical practice it is of utmost importance to selectively identify the one atypical patient among the larger population of typical patients. An important drawback of the majority of studies that have correlated fMR imaging and Wada test findings is that only a single fMR imaging task has been used (most often a word generation or letter generation task). In these studies, temporoparietal activity is usually sparse and not very reliable, and clinical decision making is consequently limited to the frontal region. However, detection power for both frontal and temporoparietal language activity can be significantly increased when multiple fMR imaging tasks are used. A simultaneous analysis of these multiple tasks (focusing on areas that are commonly used in different cognitive tasks) has the additional advantage of increasing the reliability of results. Indeed, multiple-task fMR imaging studies yielded better agreement between Wada test and fMR imaging results than single fMR imaging tasks. In our experience this is particularly true in patients with bilateral language representation. In a previous study we found agreement with the Wada test in three of four cases (compared with agreement in none or one case with the single tasks). Remarkably, three patients in the bilateral group had a dissociation of right frontal and left temporoparietal language areas that was not observed in any of the patients with unilateral representation. Calculation of a global lateralization index in these cases (that is, a lateralization index that is based on the total amount of activity) can be potentially misleading, as other authors have suggested. Another rather remarkable finding in our study was that the average amount of fMR imaging activity in the bilateral group was significantly lower than in the unilateral group—either left-hemisphere (11 patients) or right-hemisphere (three patients) dominant. Although the bilateral group was small, limiting generalization of results, language-related activity
may be more difficult to detect in patients in the bilateral group. This implies that the statistical power may have been too low for reliable detection of language areas in patients with bilateral language representation in some of the studies in the literature, in particular when only single fMR imaging tasks were used.

With the advent of noninvasive functional neuroimaging techniques, it has become clear that the traditional clinical language model with its static epicenters of Broca and Wernicke is a crude oversimplification of language representation. Functional neuroimaging studies have demonstrated great variability among patients as well as healthy volunteers, and consequently language areas have been found outside the classical areas in both the left and right hemispheres. As a result of this finding, some authors have proposed a fundamentally different view on language representation and suggest that language dominance might be a continuous property of both hemispheres.11,12 This concept of a more graded language distribution explains several observations from both functional neuroimaging and Wada test or lesion studies.2 Although part of the fMR imaging activity that is generally found in the so-called nondominant hemisphere is undoubtedly related to methodological and statistical procedures, it is probably not correct to assume that this activity always reflects noncritical language processes. It is now well-recognized that right hemisphere damage can impair the language abilities known as discourse and prosody.7 These language aspects are not thoroughly tested with the Wada test and are usually not appreciated in surgical outcome studies. Nathoo et al.6 confirmed prosody-related right temporal language areas with electrocortical stimulation on fMR imaging in a patient with left hemisphere dominance. Furthermore, there is concern that the Wada test, being the gold standard, underestimates the incidence of bilateral language dominance, as inconsistencies have been reported in clinical outcome3 and in the findings of electrocortical stimulation.5,11

In conclusion, we agree with the authors that presurgical language fMR imaging studies have limitations and should be used in addition to other functional techniques. It should be noted, however, that with dedicated multiple-task protocols, fMR imaging can be a valuable and unique neurosurgical tool, particularly for distinguishing typical from atypical patients. Of course, replacement of existing techniques requires extensive testing and validation in large groups of patients. This not only requires comparison to results of the Wada test (that in itself can be disputed on methodological and practical grounds), but in particular to the true gold standard: patient outcome. To date, this has rarely been done with the more advanced modern language tests.10

Clearly, the number of atypical patients who have been studied is too small to calculate predictive values for any of the noninvasive functional neuroimaging techniques. Future studies should therefore include standardized fMR imaging experiments for comparison and pooling of results across institutions, and for a more objective use in neurosurgical practice.

References

Response: We thank Dr. Rutten for his comments and his interest in our recent publication in which we describe details of the dissociated language functions over both hemispheres using fMR imaging and MEG. We have read the manuscript he mentions in his letter and found that there were an additional three patients with the dissociated frontal and temporal language functions. This does indeed bring the total number of reported cases to eight. We nevertheless believe that the increased number of cases does not