PRESURGICAL LOCALIZATION OF LANGUAGE: A PRELIMINARY COMPARISON OF MULTIPLE TECHNIQUES

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REVISED ABSTRACT

RATIONALE: The intracarotid amobarbital procedure (IAP) has historically been the gold standard for lateralization in language function. Localization of language cortex has previously been performed through cortical stimulation studies and more recently with functional neuroimaging procedures. Good concordance has been reported in lateralizing language. Systematic comparison of techniques that localize language cortex has been limited. The current study reports our preliminary experience comparing fMRI, magnetoencephalography (MEG) and electrocortical stimulation in patients with language dominance established by IAP.

METHODS: The subjects were 13 patients who were candidates for epilepsy surgery (8 M; 5 F). Ages ranged from 7 to 47 yrs. Eleven patients were right-handed, one was left-handed and one was ambidextrous. Eleven of the patients were left-hemisphere dominant by IAP and two were undetermined. Eight patients underwent fMRI with language testing in multiple modalities and also underwent cortical stimulation mapping using subdural electrode array. Four patients underwent mapping with MEG and cortical stimulation. One patient underwent all procedures. Anatomical localization of language cortex was compared between techniques.

RESULTS: Eleven patients demonstrated left hemisphere language lateralization on all procedures. One patient yielded discordant data, with the IAP undetermined, fMRI suggesting right dominance, and stimulation identifying expressive language in the left hemisphere. For the remaining patient, language lateralization was undetermined on IAP, but clearly left on fMRI and cortical stimulation. When the localization of language areas was compared across techniques, fMRI activation suggested larger areas of language cortex compared to results of stimulation mapping for a majority of cases. In contrast, MEG appeared to under-represent language cortex compared to stimulation mapping in one of four patients. Language areas appeared more consistent in the remaining three cases. The patient who underwent all procedures demonstrated consistent localization of language areas.

CONCLUSION: Reliance on functional neuroimaging alone to guide surgical resection remains uncertain. Continued language mapping using electrocortical stimulation is essential to the application and interpretation of function neuroimaging.

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Introduction:

The intracarotid amobarbital procedure (IAP) has historically been the gold standard for lateralization in language function. Localization of language cortex has previously been performed through cortical stimulation studies and more recently with functional neuroimaging procedures. Good concordance has been reported in lateralizing language[1]. Systematic comparison of techniques that localize language cortex has been limited[5]. The current study reports our preliminary experience comparing fMRI, magnetoencephalography (MEG)/ magnetic source imaging (MSI) and electrocortical stimulation in patients with language dominance established by IAP.

Methods:

The subjects consisted of 13 patients (8 males; 5 females) who were candidates for epilepsy/lesional surgery at Minnesota Epilepsy Group, PA. Ages ranged from 7-47 years. Eleven patients were right-handed, one was left-handed and one was ambidextrous. Eleven of the patients were left hemisphere dominant for language by IAP, one bilateral, and one was undetermined. Eight patients underwent fMRI from August 2001 to December 2003 at the NIH in Bethesda, Maryland with language testing in multiple modalities. Four patients underwent language mapping with MEG at the University of Texas, Memorial Hermann Hospital in Houston, Texas from June 2003 to January 2004. One patient underwent all procedures. Cortical stimulation studies utilizing subdural electrode array were performed with language protocols on all patients prior to resective surgery while hospitalized at United/Children's Hospital in St. Paul, Minnesota. Anatomical localization was compared between techniques (Table 1).

Results:

Eleven patients demonstrated left hemisphere language lateralization on all procedures. One patient (patient 1) yielded discordant data with the IAP suggesting left dominance, FMRI revealed right dominance and cortical stimulation studies identified expressive language in the left hemisphere. It is noted this patient had previously undergone a left anterior topectomy at an outside institution with a documented language decline in the postoperative period. An FMRI was performed in preparation for additional epilepsy surgery. No language decline was documented following this second resective surgery.

For the remaining patient (patient 8), language lateralization was undetermined on IAP, but clearly left dominant on FMRI and cortical stimulation.

Patient 12 yielded bilateral language on IAP with greatest contribution from the left hemisphere. Via cortical stimulation studies, expressive language was identified in the left hemisphere. Resection of brain tumor anterior to language was performed without documented language decline. With increased tumor growth over a 5 year period, a MEG was obtained confirming language localized on previous cortical stimulation studies.

The MEG was concordant with IAP and cortical stimulation results in all 5 cases. The patient who underwent all procedures (patient 9) demonstrated consistent localization of language (Table 1).

Discussion:

When localization of language was compared across techniques, FMRI suggested larger areas of language cortex activation compared to results of cortical stimulation mapping for a majority of the cases. This has been previously described[2] and a variety of explanations have been proposed[3]. This includes analysis thresholds for FMRI language signals and changes in spatial extent. Additionally, blood oxygen level-dependent (BOLD) effect may disrupt normal vascular response in tumor/lesional patients. Additional discrepancies have been sited to include attention to tasks, age of subject, and patient deficits.

Although accurately correlated, MSI appeared to depict more discrete language areas compared to cortical stimulation mapping1. This may be due to single equivalent current dipole modeling the center of gravity of evoked magnetic fields as projected on the patient's MRI. Additionally, MSI maps neuronal firing in the sulcus rather than the gyrus (Figure 2), while cortical stimulation studies interrupt language function by providing electrical current to cortical surfaces (Figure 3).

Conclusions:

1. Based on our limited number of cases reliance on functional neuroimaging to solely guide resective surgery remains uncertain[3].
2. FMRI may provide more spatial functional information though clinical correlation to eloquent cortex for determining surgical margins[3,5].
3. MEG/MSI provides unique information directly mapping neuronal activity and is not vulnerable to vascular phenomena.
4. Both procedures are non invasive and may provide useful information during pre-surgical evaluation.
5. Additional studies are required to verify reliability, reproducibility and validity of results in conjunction with clinical utility[5].

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Demographic Information

Patient	Sex	Age (yrs.)	Handedness	IAP	fMRI (Expressive/Receptive)	MEG (Expressive/Receptive)	STIM	Clinical History
1	M	11	A	LD	R IFG/MFG R MTG/STG		L MFG	Neuronal Disgenesis
2	M	12	R	LD	L MFG/IFG L STG/MTG		L IFG	MTS
3	F	15 ½	L	LD	L MFG L MTG/STG		L IFG	Tumor
4	M	16	R	LD	L MFG/IFG L STG/MTG		L MG/IFG L STG/AG	Hamartoma
5	F	15	R	LD	L MFG L STG		L IFG L STG	MTS
6	M	11	R	LD	L MFG L STG/MTG		L IFG	MTS
7	M	42	R	LD	L MFG/IFG L STG/MTG		L MFG L STG	Tumor
8	F	10	R	Unclear	L MFG L STG		L MFG L STG	Gliosis
9	F	15	R	LD	L MFG/IFG L STG/MTG	L MFG L STG/MTG	N/A L STG/MTG	Gliosis
10	M	47	R	LD		L MFG/IFG L STG	L MG/IFG L STG	Tumor
11	M	14	R	LD		L IFG N/A	L IFG N/A	MTS
12	F	11	R	Bilateral		L MFG/IFG L STG/R STG	L MFG	Tumor
13	M	32	R	LD		L STG	L STG/MTG	Tumor

M=male, F=female, A=ambidextrous, R=right, L=left, LD=left dominant, IFG=inferior frontal gyrus, MFG=middle frontal gyrus, STG=superior temporal gyrus, MTG=middle temporal gyrus, AG=angular gyrus, N/A=not available, MTS=mesial temporal sclerosis

Figure 1

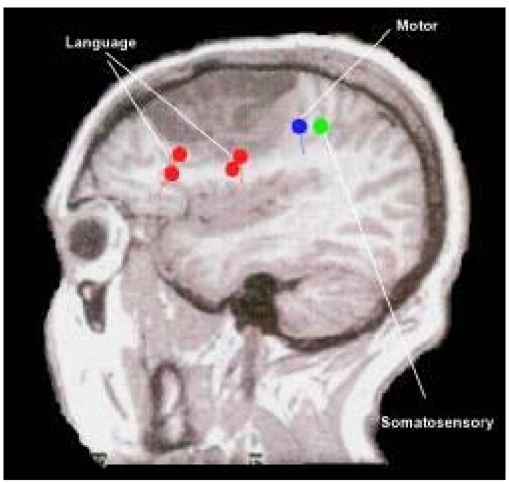

Figure 2