**Poster: 2-1 Clinical MEG: Presurgical evaluation of functional mapping**

2-1-1: Comparison of Functional Localization with MEG Somatosensory Evoked Field and Intraoperative or Extracoperative SEP

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For surgical treatment of medically intractable epilepsy it is important to localize motor functional area in the brain to avoid involving this area during the resection of seizure onset or epileptogenic zones in order to avoid any impairment of motor function after the surgery. Intraoperative visual identification of the central sulcus may be difficult. For this reason, the median nerve somatosensory evoked potential (SEP) recorded from a cortical grid array has been used to demonstrate the characteristic phase reversal on the central sulcus. However, intraoperative median nerve SEP can be often time consuming. Functional localization with magnetoencephalography (MEG) and whole head magnetometers has shown increasing usefulness and accuracy with new source analysis algorithms. We recorded 8 children, who underwent surgery, with either intraoperative or extracoperative median nerve SEP and median nerve somatosensory evoked field (SEF) with CTF 275-channel MEG system. For the SEF electrical stimuli were given to left and right median nerve alternately with 200μs duration, 3.9 Hz rate, and 500 repetitions with intensity to produce a clearly visible muscle twitch causing abduction of thumb. The source localizations were done with either single equivalent current dipole fit or SAM, or both. Those two modalities were compared with 3D brain images created by co-registration of each patient's MRI and CT with subdural grid with CURRY6 and compared with intraoperative images of grid, dipole fit or SAM peak and brain surface topography. We found good accuracy for MEG central sulcus localization. This methodology may reduce time needed to verify precentral motor gyrus intraoperatively.

2-1-2: Measures of Resting-state Connectivity and Disruptions Due to Focal Brain Lesions

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The resting-state functional connectivity between brain regions and the disruption of these networks due to focal brain lesions are poorly understood. In this study we investigate two metrics of functional connectivity, imaginary coherence (IC) and phase-lag index (PLI) in order to uncover resting-state connectivity in healthy subjects and in patients with focal brain lesions. We recorded spontaneous cortical activity in MEG for 15 patients and 14 healthy subjects. The voxel time courses were reconstructed using an adaptive spatial filter. One confound of using MEG for assessing connectivity is that there is zero-time lag blur across sensors, creating spurious connections between voxels. Both IC and PLI address the problem of volume conduction by eliminating zero-time lag effects in the reconstruction time courses. IC looks at only the imaginary part of the coherence, which is immune to effects of volume conduction. PLI is a measure of the asymmetry of the distribution of phase differences between two signals. We filtered the reconstructions for each individual's alpha-band and calculated both IC and PLI in a pairwise fashion between all the voxels. In the healthy subjects, we were able to uncover a network in the alpha band. In order to assess brain lesion induced changes, we performed two types of analyses. First we compared each patient to the control population to draw conclusions about the number of voxels with decreased functional connectivity and their relative spatial distribution with respect to the area of lesion. Second, we compared the affected hemisphere to the unaffected hemisphere for each individual patient to draw conclusions about the effect of brain lesions on connectivity in the hemisphere of lesion. These methods are effective in uncovering the interactions of brain areas in both healthy subjects and in patients with brain lesions.

2-1-3: Preoperative mapping of eloquent cortex using MEG-based imaging

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Reliable and accurate, noninvasive methods of mapping brain networks involved in speech and language, referred to as eloquent cortex, are needed to reduce the dependence on invasive methods such as the Wada test, electrocorticography (ECoG) and electro-cortical stimulation (ECS). In this study, patients with brain tumor, AVM, or epilepsy were referred clinically for functional brain imaging using magnetoencephalography (MEG). MEG data was obtained while subjects...
participated in somatosensory, motor and language tasks. Specific language tasks included overt picture naming and auditory verb generation. A subset of patients had a Wada test in preparation for surgery. Anatomical distances between locations of somatosensory cortex and peaks of activations obtained during language tasks were calculated in both affected and unaffected hemispheres. Lateralization of language tasks was also assessed and compared with Wada results for patients with those results. Peak of activation obtained during picture naming during 600 ms prior to speech onset, between 15-30 Hz, was significantly anterior (p<0.00001) to lip somatosensory cortex and both significantly anterior (p<0.00001) and inferior (p<0.00001) to index finger somatosensory dipoles. There were no differences between the affected and unaffected hemispheres. Verb generation localizations 600 ms prior to overt speech production for the same frequency range were similar to picture naming. For data between 15-30 Hz as well as for other frequency bands, peaks were seen in other locations including prefrontal and parietal cortex. The consistent relationship between speech task and lip somatosensory localizations and the distinct peaks in the 15-30 Hz range suggest that this method should reveal mouth motor cortex. Lateralization comparisons with Wada will be presented at the poster.

2-1-4: Analysis of temporal language function by MEG for preoperative mapping: Comparison MEG with electrocortical stimulation

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(Purpose) Electrical cortical stimulation (ECS) with subdural electrodes has been a gold standard for preoperative mapping of cortical function in epilepsy patient. However, ECS is an invasive method and required implantation of subdural electrodes that has the limited coverage over brain. We routinely investigated reading-task MEG for identification of language dominance. To evaluate the utility of a source estimation using single dipole model and distributed source model (Minimum norm), we compared the results of MEG analysis with electrical stimulation mapping. (Patients and Methods) MEG recordings were obtained in two intractable epilepsy patients who underwent implantation of subdural electrodes for preoperative evaluation of seizure onset. We used reading-task MEG to detect semantic responses to Japanese letters, and their MEG data were analyzed by single dipole model and distributed source model. After implantation of subdural electrodes, we performed ECS for cortical mapping. Their language dominance was validated by the Wada test.(Results) Case1 was right-handed, 40 year-old man, and Case 2 was right-handed, 33 year-old female. Reading-task MEG showed dipole cluster on the left superior temporal gyrus and left middle temporal sulcus, respectively. Reading-task MEG showed dipole cluster, and Minimum norm Estimation showed signal sources on almost the same region. Cortical mapping of temporal language function with MEG was validated by ECS, which caused disturbances of picture naming.(Discussion) In reading-task MEG, we obtained almost the same results in source estimation using single dipole methods and distributed source model. In addition, the source localization of temporal language function was confirmed by ECS. MEG is a useful method in preoperative mapping of temporal language function.

2-1-5: Assessment of Hemispheric Dominance for Language Based on Independent Component Analysis of MEG Evoked Activity

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Analysis of magnetoencephalographic (MEG) activity has been recently employed to determine hemispheric dominance for language during the presurgical evaluation of neurosurgery patients. The accuracy of the MEG-based method is approaching the lateralization accuracy of the traditional invasive procedure known as Wada, and it is now used as a reliable, adjust, and noninvasive clinical tool. In some cases, however, there are discrepancies in lateralization and exact location of the language specific cortex. In an effort to further improve the accuracy of the MEG-based procedure, we employed our newly developed independent component analysis methodology to analyze single-trial evoked responses (ERs) obtained from a series of epilepsy patients, who underwent complete preoperative evaluation, including Wada.

In this study we report preliminary results from ten subjects. A continuous recognition memory task for spoken words was employed, whereby stimuli had a duration between 300-750 ms and were delivered binaurally to the patients in a random order, with an interstimulus interval between 2.5 and 3.5 sec. Approximately 300 ERs were recorded, each consisting of 200 msec prestimulus and 800 msec poststimulus activity. Single-trial MEG responses were processed separately in four nonoverlapping time windows centered approximately at 100, 300, 400, and 550 msec poststimulus, corresponding roughly to four distinct component peaks visible in the ensemble average ERs of all subjects. After processing, several laterality indexes were computed in each window based on the normalized difference of activity characteristics recorded in each hemisphere, including peak latency, power,
Abstract / Poster: 2-2 Clinical MEG: Epilepsy (1)

frequency content, and signal-to-noise ratio. Overall, this methodology yielded an 83% success rate in assessing language laterality, a value very close to the 87% success rate provided by the current MEG procedures that are based on dipole localization.

2-1-6: Shunt effectiveness in patients with iNPH predicted by MEG changes before and after lumbar tap test

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iNPH (idiopathic normal pressure hydrocephalus) is a syndrome that is characterized by a classic triad of symptoms including dementia and urinary incontinence, gait disturbance. Although iNPH is often defined as "treatable dementia" which symptoms can be reversed by ventriculoperitoneal (VP) shunting, it is so common that the patients with iNPH incorrectly diagnosed as degenerative dementia disorders such as Alzheimers disease (AD) and treated as probable AD by drugs, which are not effective for iNPH. Although VP shunting is now a common neurosurgical procedure, it is associated with risks and complications, which makes evaluation of "shunt-responsiveness" essential. Lumbar tap test (LTT) is most common to evaluate shunt-responsiveness before neurosurgical operation, whereas this test involves the withdrawal of CSF by means of lumbar puncture, which is not non-invasive. The purpose of this study is to investigate whether MEG measurements made it possible to predict successful outcomes of shunt operations. We measured MEG in six iNPH patients before and after LTT and compared with the symptom changes and MEG findings. Four out of six patients showed the improvement of the triad symptoms and evaluated that VP shunting would be effective. All of these four patients showed the improvements of MEG findings, such as slow wave reduction, faster basic rhythm and better alpha blocking. Three out of four patients had VP shunting and showed the improvement of the triad symptoms (one refused to be operated). There were no MEG changes in two patients who showed no improvements by LTT. We suggested that MEG might be useful for the evaluation of shunt-responsiveness.

Poster: 2-2 Clinical MEG: Epilepsy

2-2-1: Musicogenic Seizures: Ictal MEG and Simultaneous EEG with functional MRI (SEM)

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Localization of the ictal onset zone is crucial in patients with medically refractory partial seizures. Ictal onsets are often marred by muscle artefact but the significance of pre-ictal MEG dipoles is unknown. We present a patient with musicogenic seizures that had both ictal MEG and ictal SEM recordings. We were able to compare the spatiotemporal propagation of both these studies. The ictal MEG demonstrated a right mesio-temporal dipole pattern approximately 2 seconds prior to the clinical onset, with dipole propagation to the right superior temporal region. The ictal SEM demonstrated functional changes broadly over the right frontal and temporal regions 10 seconds prior to the seizure with changes over the right lateral and superior temporal lobe during the first 10 seconds following ictal onset. The intracital MEG propagation pattern localized to the fronto-central regions over the right. The localization of the ictal MEG and ictal SEM studies was confirmed by invasive electrodes and a post-surgical seizure-free outcome. These findings support MEG dipoles captured before the behavioral or EEG onset of seizures as ictal as SEM changes are demonstrated during this period. The patterns of SEM and MEG ictal propagation could represent complementary information relating to the pathophysiology of ictal propagation.

2-2-2: Should MEG be always performed in the care of epileptic patients?

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1NINDS

Introduction: Research application of MEG has been continuously expanding. However, its clinical application is still limited to the field of epilepsy. The ability of MEG to localize epileptic spikes as well as the complementary function between EEG and MEG has been well established. MEG may shed a light on the ambiguity of EEG. However, these capabilities entirely depend on the presence of spikes in EEG and/or MEG. Thus, we evaluated the presence or absence of spikes in epileptic patients who were referred to NIH. Reasons for patient referral to NIH included self-referral,