Abstracts from the 5th International Symposium on Navigated Brain Stimulation in Neurosurgery

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5th International Symposium on Navigated Brain Stimulation in Neurosurgery (pub. June 2014)
Introduction

This 5th International Symposium on Navigated Brain Stimulation (NBS) allowed experts in functional mapping and imaging to continue to share their experiences with this emerging standard for non-invasive cortical mapping. This year there was also a focus on pediatric use and the potential therapeutic use of NBS in post-stroke recovery. Many of the Symposium presentations contained previously unpublished data and we are grateful to the authors for their permission to publish abstracts for colleagues unable to attend in person.

Last year, 2013 there were eleven peer-reviewed papers published on the use of NBS mapping in neurosurgery and neurosurgical planning. Eight of these papers dealt with mapping of the motor cortex. A noteworthy paper, authored by Takahashi et al., combined the results of all the 11 reports herto published on the accuracy of NBS. In a meta-analysis, the author found good agreement between NBS and DCS mapping across all published studies with a mean difference of 6.2 mm between the two methods. The repeatability of motor area localization by NBS was shown by three publications in 2013, all confirming good inter- and intra-observer repeatability. The clinical usefulness of NBS in recurrent surgery for glioma was shown in a paper by Krieg et al.; NBS offers a notable advantage over imaging-based methods here since NBS is not compromised by surgically-modified hemodynamics. Vitikainen et al. showed that nTMS is accurate enough for locating the primary motor cortex when evaluating patients for epilepsy surgery – a step forward in the search for less invasive techniques to help this largely pediatric patient population.

Of particular note was the publication of the first study showing that the introduction of nTMS has made a positive difference to neurological outcomes. Earlier, several papers have shown that NBS results help in neurosurgical workflow. In October 2013, a paper authored by Picht & Schultz et al. showed that adopting presurgical NBS motor mapping has correlated with a significant outcome benefit for patients.

In 2013, a record number of papers were also published on language mapping by NBS using navigated, repetitive TMS. The originally published mapping protocol was shown to offer good sensitivity with low specificity by Picht et al. A follow-up study with a modified protocol by Tarapore et al. achieved excellent sensitivity and good specificity. This rapid development in the technical performance of NBS language mapping holds a great deal of promise for the method in the future. In 2013, both Rösler et al. and Krieg et al. used an NBS System to document a shift of language function to the right hemisphere in patients with language-eloquent brain tumors. Although these are preliminary observations, NBS language mapping could fundamentally change our surgical approach in patients with perisylvian tumors if the findings are confirmed in larger patient populations.

Professor Turo Nurmikko presented early findings from his team’s work on using inter-hemispheric asymmetry of corticomotor areas to guide therapeutic rTMS in neuropathic pain and followed-up with further detail and final results in the enclosed abstract. Navigated TMS has exciting potential application in neurotherapy and it was gratifying to note the interest of the neurosurgical community in recent advances in the use of NBS for stroke rehabilitation and tinnitus, as well as neuropathic pain.

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Presurgical Functional Mapping in Children Using NBS

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Functional mapping techniques available at University of Tennessee/Le Bonheur facilities include functional MRI (fMRI) and navigated TMS (nTMS), as well as magnetoencephalography (MEG) single-dipole mapping for localization of interictal epileptiform discharges, sensory mapping from tactile stimulation, receptive language mapping by word recognition tasks and expressive language mapping by covert naming. The nTMS mapping methods we employ are single-pulse TMS, for eliciting motor function, and 5 Hz repetitive TMS for expressive language mapping. nTMS is performed using an NBS System (Nexstim Oy, Helsinki, Finland), which was installed in mid-2012. We currently perform approximately 70 nTMS studies annually (2013 = 71), with approximately 85% of the studies performed on children. So far, the youngest patient undergoing motor mapping was aged 21 months, while the youngest patient undergoing speech mapping was an 11-year-old. In total, the department has performed 46 expressive language mapping studies using nTMS.

nTMS is a valuable addition to other established functional mapping techniques because it supports the maxim of “maximal lesion resection with minimal functional deficit”. For patients, multimodal imaging and image integration enable minimizing the use of invasive procedures, such as the intracarotid amobarbital test (Wada test) and mapping by direct electrocortical stimulation, where possible.

Case: Presurgical multi-modal imaging in 14-year-old epilepsy patient

A previously healthy, 14-year-old male presented with a single, 20-min seizure episode. The patient had symptoms of speech deficits, including word-finding difficulties and apraxia. MRI revealed a left-sided opercular glioma (Figure 1). Due to the language-eloquent location of the tumor, directly in Broca’s area, the patient underwent multi-modal motor and language mapping with nTMS, MEG and fMRI, in addition to tractography and spectroscopy. The nTMS and MEG investigations were successful, but due to the highly vascularized nature of the tumor, the fMRI results were not useful.

The tumor was resected in an interventional MRI suite using image-guided microsurgical dissection techniques and intraoperative ultrasound. The tumor pathology was consistent with low-grade glioma. Post-operative language mapping by nTMS and MEG revealed expressive language-positive areas in locations around the resected lesion area, very consistent with the pre-operative mapping results (Figure 2). The patient made a full and successful recovery with no long-term speech or language deficits.

Discussion

Multimodal imaging is important to enable successful preoperative investigations in situations where one specific modality fails in an individual patient. Additionally, the concordance of results between independent methods validates a completely non-invasive investigation. In an epilepsy center, nTMS has a significant advantage compared to the other available techniques because it is important that mapping can also be performed on patients with implanted vagal nerve stimulation (VNS) devices and leads, or other metal from dental work, for example. Additionally, nTMS mapping is not influenced by scarring or adhesions from earlier surgical interventions. For a children’s hospital, in particular, it is essential that functional mapping can be performed in patients who cannot lie still and cannot be expected to comply with detailed instructions. Unlike with MEG, nTMS never requires sedation in order to perform mapping. Additionally, nTMS mapping is not influenced by neurovascular uncoupling and therefore can be performed in the vicinity of vascular tumors and arteriovenous malformations (AVMs) where fMRI has been shown to be prone to false-positive results.
Figure 1: Results of presurgical imaging and mapping in 14-year-old male (case patient).

Top left - Axial FLAIR MR-image revealed a tumor in a language-eloquent location.

Bottom left - nTMS mapping of the primary motor cortex areas showed that the lesion was quite remote from the motor cortices.

Bottom right - Preoperative nTMS language mapping revealed positive expressive language areas directly behind the lesion.
Post-operative language mapping results were very consistent with the pre-operative language mapping results.