Magnetoencephalographic and fMRI Examination of the Effects of VC/VS DBS on Post-stroke Pain

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Introduction

Post-stroke pain syndrome (PSPS) is an intractable disorder characterized by unrelenting chronic pain and hemiparesis. While traditional analgesic approaches largely fail to provide long-term relief, integrative approaches targeting affective-cognitive spheres are promising. Recently, we demonstrated1 that deep brain stimulation (DBS) of the VC/VS, significantly improved pain affect and quality of life in PSPS patients. Here, we explore if this clinical improvement was reflected in magnetoencephalography (MEG) and functional magnetic resonance imaging (fMRI) correlates that could serve as objective signatures.

Methods

We performed MEG and fMRI on 10 PSPS patients in the baseline, DBS-OFF and DBS-ON states. MEG: Visual cues evoked anticipation as patients awaited a painful (PS) or non-painful (NPS) stimulus to their non-affected or affected extremity. Whole brain event-related responses were examined. fMRI: We used a simple block paradigm. After initial preprocessing, the difference of fMRI z-map between ON-vs-OFF were generated on the MNI template in Talairach space for each patient and averaged as the final results.

Results

There were no significant difference between PS-vs-NPS before surgery or in the DBS-OFF condition, suggesting a loss of salience in the untreated pain state. DBS significantly modulated the N1 (parietal/prefrontal) component of NPS anticipation, restoring discrimination capacity (Fig-1a). DBS enhanced the anterior N1 (anterior cingulate ACC) among treatment responders, reflecting emotional regulation (Fig-1b). fMRI: Comparing DBS ON-vs-OFF, we observed (Fig-2) stronger activation of 1. medial parietal and frontal lobes on the non-affected side. 2. ACC contralateral to pain for both extremities.

Conclusions

DBS-induced changes in MEG correlates reflect treatment effects and could potentially serve as biomarkers for clinical outcomes. fMRI findings further corroborate MEG data showing modulation of behavioral and associative areas including ACC and fronto-parietal cortices. Overall, VC/VS DBS modulated the affective component of pain, as evidenced in clinical metrics, and greater involvement of associative-limbic structures during pain and pain anticipation.

Learning Objectives

By the conclusion of this session, participants should be able to: 1) characterize spatio-temporal activations of pain affect. 2) identify the functional correlates of VC/VS DBS modulation. 3) Understand fMRI and MEG objective signatures of pain affect.

References

1. Lempka SF, Malone DA, Hu B, Baker KB, Wyant A, Ozinga J, Plow EB, Pandya M, Kubu CS, Ford PJ, and Machado AG. Randomized clinical trial of deep brain stimulation for post-stroke pain. Annals of neurology 2017.

Fig-1

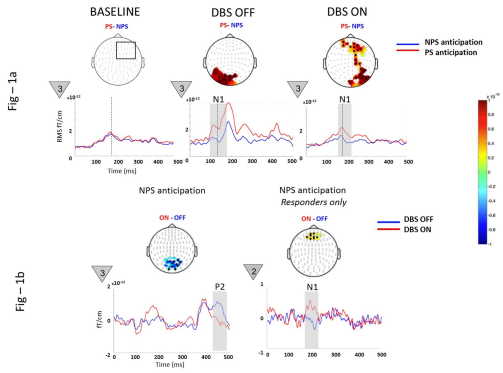

Fig-1: (a) Difference between anticipation pain and a non-painful stimulus (PS – NPS) at pre-op baseline (left), DBS-OFF (center) and DBS-ON (right) states. (b) Difference between DBS ON and OFF states (ON – OFF) during NPS anticipation in all patients (left) and only in responders (right).

Fig-2

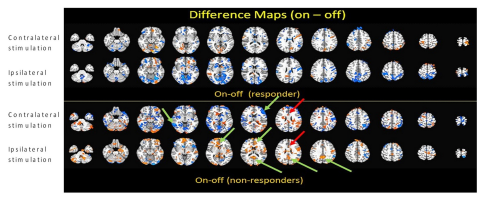

Fig-2: Maps of significant difference between activation observed with DBS ON and DBS OFF. Orange (blue) regions indicate regions where activation response to pain stimuli was greater (lesser) with DBS ON than with the DBS OFF. Green arrows indicate stronger activation of medial parietal and frontal lobes. Red arrows indicate stronger activation of ACC. Right side of the figure corresponds to the brain hemisphere contralateral to the affected side.