Anterior Thalamic Deep Brain Stimulation: BOLD Activation Patterns in a Large Animal Model

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Introduction

The Electrical Stimulation of the Anterior Thalamus for Epilepsy (SANTE) trial has provided randomized data that deep brain stimulation (DBS) of the anterior thalamic nucleus (ATN) has clinical efficacy for the treatment of medically refractory complex partial seizures. While the mechanism of action underlying ATN DBS remains poorly understood, the therapy clearly exerts its effect distantly from the seizure onset zone by modulation of neural networks. Here we investigate the activation patterns induced by ATN DBS in a large animal model by monitoring the blood oxygenation level-dependent (BOLD) response on fMRI.

Methods

We performed DBS in anesthetized swine, targeting the left ATN (n = 3), and applied stimulation parameters which replicate the median values used in the SANTE trial (145 Hz, 5V, 90 us; 1 minute on, 5 minutes off) as well as brief stimulation (6 seconds on, 1 minute off) and measured the resulting BOLD activation patterns with 3T fMRI.

Results

We found that ATN DBS resulted in widespread ipsilateral activation of cortical areas, most robustly in the temporal lobe, but also in the premotor cortex, primary motor and somatosensory cortices, cingulate cortex, and insula. Varying DBS voltage and frequency, we found that the cluster size of BOLD activation increased. Notably, stimulation at 8 V and 60 Hz, we observed bilateral temporal and frontal activation patterns.

Conclusions

These results show that ATN DBS is capable of inducing activation in a wide variety of cortical structures, and that the size of activation areas is strongly amplitude- and stimulation time-dependent. Therefore, this treatment may hold untapped promise for the treatment of seizures with both intra- and extratemporal foci, and the mapping of the DBS circuitry effect in relation to these foci with fMRI may prove clinically useful in the future.

Learning Objectives

Here we demonstrate that ATN DBS in a porcine model resulted in widespread activation of both temporal and extratemporal cortical areas.

References