An integrated solution to predict the stimulation parameters after STN DBS for PD

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Introduction

Deep brain stimulation (DBS) titration is experience-dependent and time-consuming. It is expected to be more challenging with the wider use of directional DBS leads. Connectivity-based methods for stimulation titration are required. We hypothesized that stimulation parameters can be estimated based on the cortical connections of the DBS electrodes.

Methods

Twenty-four Parkinson's (PD) patients with subthalamic nucleus (STN) DBS were included. All patients had preoperative 3Tesla diffusion imaging (60 directions) and one-year follow-up after DBS. We recorded parameters associated with stimulation-induced acute clinical effects (ACE) during DBS programming. We classified them into improvement (rigidity, bradykinesia, and tremor), and side effects (paresthesia, motor contractions, visual disturbances). Using probabilistic tractography, we identified the cortical voxels uniquely associated with each ACE category. A prediction algorithm, based on support-vector-machines (SVM) with repeated cross-validation, was trained on the unique features of cortical connectivity. This algorithm was then used to estimate the optimal contact and stimulation amplitude combination for each DBS contact in both hemispheres. A blinded comparison with actual stimulation parameters was done using sensitivity analysis. We also tested the classifier on another independent cohort of 14 PD patients with STN DBS.

Results

Clusters in premotor and SMA (area 6) were significantly associated with therapeutic stimulation. At one year, 42 of the 47 stimulation electrodes were accurately estimated as 'efficacious' and the therapeutic window calculated to be =3 volts in 31(66%) and between 2-2.9 volts in 11(24%) respectively. The SVM algorithm had excellent sensitivity (area under curve = 0.8506, 95% CI 0.7026 – 0.9987). Its sensitivity was maintained in the validation cohort.

Conclusions

The optimal stimulation settings after DBS can be estimated from the pattern of cortical connections of each electrode. Prospective validation in a larger cohort may help test the prediction accuracy of this approach.

Learning Objectives

By the conclusion of this session, participants should be able to: 1) Understand that each' stimulation-linked effect has a different pattern of connectivity, 2) The unique features of connectivity may be used to train a classifier with the ability to predict a range of optimal settings of stimulation to use.

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