Use of quantitative measures of brain MRI to predict cognitive outcomes after Subthalamic nucleus Deep Brain Stimulation in Parkinson’s disease

Laura J Weinkle BA,1,2 Olga Klepitskaya MD,2 Stefan Sillau PhD, Justin Honce MD, Jody Tanabe MD, John A. Thompson PhD, Brian Hoyt PhD

1 Modern Human Anatomy Program, University of Colorado School of Medicine; 2 Department of Neurology, University of Colorado School of Medicine; 3 Department of Neurosurgery, University of Colorado School of Medicine; 3 Department of Radiology, University of Colorado School of Medicine

Background/Rationale

- Deep Brain Stimulation (DBS) of the Subthalamic nucleus (STN) is a standard treatment for the motor symptoms of idiopathic Parkinson’s disease (iPD).
- Studies evaluating cognitive outcomes following STN-DBS report significant declines in domains such as executive function, verbal fluency, and attention.
- Few studies have assessed predictors of cognitive decline in PD patients treated with STN-DBS.
- Identification of pre-surgical MRI predictors might provide an important clinical tool for better risk-to-benefit assessment.

Objective

- The aim of this study is to explore whether pre-surgical white matter lesion volume (WML), forebrain parenchyma atrophy, or hippocampus volume, measured quantitatively on brain MR images, is predictive of cognitive outcomes following STN-DBS for iPD.

Hypothesis

- Patients with increased burden of pre-surgical WMLs will experience a greater decline in performance on neuropsychological (NP) tests post-DBS surgery than those with a lower burden of or absence of WMLs. Patients with more forebrain parenchyma or hippocampus atrophy will experience greater post-STN-DBS declines in performance of NP tests.

Methods

Fig 2 Flow Chart of Population Identification and MRI analysis

Study Population: 43 patients

NP data *See inset
Pre-surgical MRI
Clinical data

Correlation to quantitative measures of brain MRI

Inclusion criteria:
- Idiopathic PD
- Had STN-DBS between 01/2011 ~ 06/2016
- Pre-op and ≥ 6 month post-op NP testing

Covariates:
- Age at baseline
- Education
- Number of vascular comorbidities

WML volumes:
- Lesion Prediction Algorithm (LPA)
- Bilateral brain region volumes:
  - Forebrain parenchyma
  - Hippocampus

Results

Fig 3 Pre-surgical T2-FLAIR MRI pre-LPA processing (a, c) and post-LPA processing (b, d) showing “light” (b) and “heavy” (d) burden of pre-surgical WML.

Fig 4 Pre-surgical 3D T1-weighted MRI with segmented brain regions, showing forebrain parenchyma in red, and hippocampi in yellow. From left to right, axial, coronal, and sagittal sections.

Fig 5 Mean pre- and post-surgical group neuropsychological evaluation scores by domain.

* Significant change in performance on cognitive test.

Fig 6 Increased burden of pre-surgical lesions was significantly correlated with impaired pre/post performance on block-design, a visuospatial task.

Fig 7 Less pre-surgical left forebrain parenchyma atrophy was significantly correlated with better pre/post change in performance on the Brief test of attention (BTA).

Conclusions

- Significant correlation between greater burden of pre-surgical WML volume and impaired performance on a visuospatial task, and less bilateral forebrain parenchyma atrophy and better performance on an attention task.
- Beyond any clinical predictors, pre-surgical WML and brain region volumes, do not put STN-DBS candidates at an increased risk for post-surgical cognitive impairments.

Future Directions

- Correlate cognitive outcomes with lesion burden in specific cortical regions (e.g. frontal, parietal)
- Stratify patients according to pre/post change in cognitive status

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