Using Structural Connectivity Graph Analysis to Predict Cognitive Decline in Patients After Carotid Endarterectomy

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Target Audience: Researchers and clinicians who are interested in applications of structural connectivity for predicting clinical outcomes.

Introduction: While Carotid endarterectomy (CEA) has been noted to reduce the risk of future stroke in patients with high-grade stenosis, approximately 25% of CEA patients experience decline in postoperative neurocognitive function as measured on neuropsychological testing [1]. However, no imaging biomarkers have been established for identifying these patients. **This work demonstrates the application of structural connectivity graph analysis to identify patients at increased risk for cognitive decline after CEA using only preoperative T1 and DTI.**

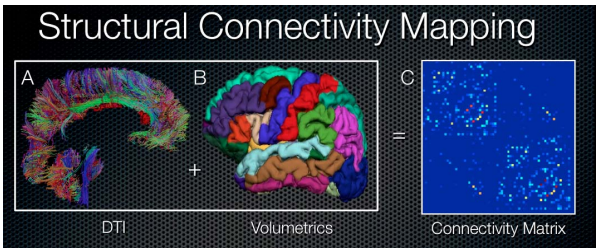

Figure 1: Whole brain HARDI tractography results from DTK were combined with whole brain segmentation results from FreeSurfer 5.3. The resulting connectivity matrix was then converted into a graph, which was analyzed using the Brain Connectivity Toolbox.

Methods: Subjects: twenty eight patients were scanned with IRB approved written consent using a GE 750 Signa 3.0T scanner as part of their presurgical evaluation. Acquisitions: Each subject underwent structural 3D FSPGR (TE Min Full, Flip angle 11, dimensions 1.2mm isotropic, TI 400, FOV 27, NEX 1, Matrix 256x256), DTI (30 directions, 5 B0, B=1000, FOV 24, slice thickness 2.5, Matrix 96x96, dimensions 0.96x0.96x2.5mm, TR=6600, TE Minimum) in addition to our department standard CEA preoperative imaging protocol using the GE 8 Channel HNS NVHead coil. Neuropsychological Testing: Patients underwent a battery of neuropsychological tests during preoperative evaluation and again 1 month after surgery. The testing battery included the Rey-AVLT and MMSE. Decline was determined by evaluating decreased performance on the Rey-AVLT on 1 month follow up. Processing: the FSPGR images were processed using FreeSurfer 5.3 (FS)[2]. The resulting segmentations were reviewed and edited as needed under the supervision of a neuroradiologist. The DTI images underwent FSL eddy current and motion correction [3]. Whole brain tractography was then performed using Diffusion Toolkit (DTK) and the results were inspected using TrackVis[4]. Connectivity matrices were generated from the FS segmentation and DTK fiber tracking using MATLAB. Multiple graph metrics were then computed using the Brain Connectivity Toolbox[5].

Results: The graph analysis methods "weighted optimal community structure" & "binary component sizes" metrics both predicted patients that would experience cognitive decline with 81% sensitivity 83% and specificity (FDR .05). These two measures were computed at 10 proportion edge thresholds from .1 to 1 at intervals of .1 in weighted and binary networks respectively.

Discussion: These results suggest that structural connectivity analysis may be able to serve as a biomarker for underlying biological processes responsible for those patients that experience cognitive decline after CEA. They also demonstrate that preoperative imaging analyzed in this manner may help risk stratify patients for cognitive decline prior to CEA or other carotid revascularization intervention. Identifying these patients offers clinicians the ability to target specific therapies to these at risk patients, including altering surgical technique and post-operative therapies, as well provide tools for patient and family counseling regarding potential post surgical deficits.

Conclusion: Applying structural connectivity analysis may be capable of identifying patients at increased risk for post surgical cognitive decline, and can serve as powerful tool to both help guide therapy and provide patients' families guidance regarding prognosis.

References: [1] Mocco et al. Neurosurgery, 2006; 58(5): 844–850, [2] Dale et al. Neuroimage 1999; 9, 179-194, [3] Jenkinson et al. NeuroImage, 62:782-90, 2012, [4] Wang et al. Proc. Intl. Soc. Mag. Reson. Med. 15 (2007) 3720, [5] Rubinov et al. NeuroImage, vol. 52, no. 3, pp. 1059–1069, 2010.

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