Outcomes After Temporal Lobe Epilepsy Surgery as a Function of Graph Theory Metrics

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Introduction

Despite appropriate localization and resection of seizure-onset zones, only about 60% of epilepsy surgery patients achieve seizure freedom at one year postoperatively.(Ref 1) Graph theory provides mathematical tools to better understand connectivity in complex systems and has been extensively used to study EEG signals in various neurologic pathologies. (Ref 2)The goal of our study is to use graph theory metrics to predict post-epilepsy surgery outcomes.

Methods

15 consecutive temporal lobe epilepsy patients from January 2013 to February 2014 who received a two-stage surgery by a single surgeon (WKD) were selected for analysis. Five second samples of their intracranial EEG were analyzed from periods remote from seizure activity, immediately before seizure onset, immediately after seizure onset, at the half-way point of the seizure, immediately prior to seizure termination, and immediately after seizure termination. These samples were used to calculate correlation matrices between the EEG channels. After thresholding, connection graphs were constructed and graph theory metrics were calculated for each node in the graph and for the largest connected element of the graph. The patient's medical records were reviewed for outcomes at 1 year postoperatively. Using the patients' post-implantation and post-resection MRI scans, the authors determined resection volumes relative to the implanted electrode contacts.

Results

41 seizures were analyzed. 9 patients were completely seizure free at 1 year (Engel Ia). The small world index in the immediate post-seizure state was significantly larger (p=0.022) in patients who were seizure free. Synchronizability was significantly lower in the mid-seizure (p=0.032) and late seizure (p=0.021) time-points in seizure-free patients. Seizure free patients were more likely to have nodes with larger measure of hub characteristics resected than patients who had persistent seizures (OR 8.05).

Conclusions

Graph theoretical metrics of intracranial EEG were associated with post-epilepsy surgery outcomes. Larger studies may better define their utility in surgical planning.

Learning Objectives

By the conclusion of this session, participants should be able to

1) Identify several important graph theory metrics

2) Recognize the potential of graph theory metrics to improve epilepsy surgery resection planning

References

1) Long-term seizure outcome after resective surgery in patients evaluated with intracranial electrodes. Bulacio et al. Epilepsia. 53(10). 1722-30. 2012.

2) Networks of the Brain. Olaf Sporns. Cambrige. 2011.