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Utility of SPM in Quantitative Analysis of Neuroimaging in Epilepsy Surgery

Study Purpose and Rationale

Neuroimaging, specifically high resolution MRI, ictal and inter-ictal SPECT, and FDP-PET, is a crucial diagnostic tool in exploring the underlying cause of epilepsy in the pediatric population. All three imaging modalities provide insight into the pathogenesis and molecular mechanisms of seizures and the combination of these imaging techniques allows for the detection of focal epileptic areas (Kim et al., 2009). Currently, MRI, SPECT, and PET imaging, along with the clinical history and neuropsychological assessment is part of the standard pre-operative care for patients undergoing epilepsy surgery at the Columbia University Medical Center. These imaging modalities are interpreted visually - however, visual interpretation can vary among readers.

Statistical parametric mapping (SPM) is a technique developed by the Wellcome Trust Center for Neuroimaging at University College London and has been used to provide an objective quantitative analysis to supplement visual interpretation of images (Lee et al., 2005)(Akman et al., 2015). The software pre-processes and smooths imaging data to reduce noise and converts the image into a map consisting of voxels, which represents the properties of a particular coordinate in 3D space. As all patients' brains are slightly different, the images then undergo spatial normalization to line up the superficial brain structures with a template image, which are generally adult control images. Studies have shown that an adult template can be successfully used in spatial normalization in the pediatric population for children over age 6. However, significant artifact was seen in applying an adult template in children less than 6 years old (Muzik, Chugani, Juhász, Shen, & Chugani, 2000). Because of the difficulty obtaining control pediatric images, there have been few studies focusing on the use of SPM in pediatric epilepsy.

This study aims to expand on prior studies in the pediatric population to establish SPM as a quantitative approach to identifying epileptogenic foci using SPM.

Study Design

This study will be both a retrospective and a prospective study of patients undergoing epilepsy surgery workup at our institution. Patients will be identified retrospectively from the Columbia University Medical Center epilepsy neurosurgery database who have high resolution MRI, ictal and inter-ictal SPECT, and FDG-PET data over an eight-year period (2010-2017). In addition, patients with epilepsy who are candidates for surgical resection will be identified and recruited for prospective analysis.

The imaging data will be analyzed using statistical parametric mapping (SPM) software to quantitatively detect common focal epileptic areas and to identify remote cortical regions with functional abnormality distant from the epileptic focus. The SPM analysis will also be correlated with the patient's clinical presentation and neuropsychological assessment scores, and with qualitative visual interpretation of the images. The standard SPM control is adult images – however, we will also use normal MRI, SPECT, and PET imaging data from our migraine database as controls.

Statistical Analysis

SPM uses a general linear model to identify clusters of voxels with significant difference between the patient image and the control template. Voxels with a p-value of <0.05 are considered statistically significant regions of interest.

The output of the software will be compared to the gold standard of the neuroradiologist read to assess the accuracy of SPM. We will also investigate the specificity and sensitivity of SPM. If we assume that the software will have an accuracy of 95%, but we will accept an accuracy of 85%, we will need 80 subjects to power the study.

Confidentiality

Imaging data will be obtained in the form of CDs, which will be stored in a locked filing cabinet. A password-protected computer will be used to code the data so that only the person with the link to the code can identify from whom the data was collected. The data will be stored in an encrypted drive. Another password-protected computer will be used for analysis of the coded images. Only personnel involved in the research will have access to the computers, the filing cabinet, and the room the computers and filing cabinet are in.

Recruitment

Participants for prospective analysis will be identified by the medical team, which consists of the resident, fellow, and attending physician taking care of the patient during their hospitalization for workup of epilepsy. The team will reach out to one of the researchers who will approach the potential participant with more information and consent them if they agree to participate

Potential Risks

There are no additional risks other than potential loss of confidentiality to participants enrolled in this study as MRI, SPECT, and FDP-PET imaging are an established part of the pre-operation protocol for epilepsy surgery

Potential Benefits

Benefits include the establishment of a quantitative method of image analysis that will streamline the identification of epileptogenic foci with potential for surgical resection. In addition, this study seeks to identify cortical areas distant from the epileptogenic focus that might be missed in qualitative, or visual, interpretation of the imaging, which can provide insight into both the pathways of epilepsy and potential additional areas for resection.

References

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