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Mapping Affected Brain Areas in Epilepsy by Non-Invasive Optical Detection of Cerebral Blood Flow

Epilepsy is a neurological disorder that alters brain activity and causes frequent seizures. It can result from physical injury, an anatomical abnormality, or any disease that produces inflammation and malfunction of brain cells. Evidence supports a significant basis for a hereditary component, as well. Epilepsy affects about 470,000 children in the US and is the most common chronic neurological condition for those younger than 18 years of age. Medications are the first choice of treatment but sadly, one third of affected children are refractory and require surgical resection of the affected area to achieve relief. While seizure freedom or a progressive decrease in seizure frequency is attainable after resective surgery, there is inherent risk in damaging or removing essential brain tissue associated with sensorimotor function, including language, imagination, and memory skills. Successful surgery depends in part on precise localization of the affected brain area and accurate mapping of eloquent cortex that must be saved. Mapping the safest path into the brain, however, can be quite challenging, as abnormalities in brain development may produce atypical organization of cognitive function and make it difficult to predict where certain skills are localized. The standard method to pinpoint affected cortex is direct brain stimulation with invasive electrodes under general anesthesia. To minimize the risk of complications in creating a 3D map of affected brain areas, functional magnetic resonance imaging (fMRI) has proven to be a reliable non-invasive alternative. Typically, the epilepsy patient during fMRI undergoes a series of active tasks that require significant patient cooperation and movement restrictions that makes it unsuitable for children younger than about 10 years of age. To address the need for an effective means of pre-surgical planning in vulnerable young children affected by epilepsy, Roarke proposes a non-invasive optical approach based upon parallelized diffuse correlation spectroscopy (PDCS) that will localize key brain areas by measuring the backscatter of harmless light directed into the child's head. In effect, a single-photon avalanche diode array sensor will detect the back-scattered light of moving red blood cells, which he has confirmed in adults corresponds to variation of blood flow within specific areas of the brain cerebral cortex. Like fMRI, the technique is sensitive to small fluctuations, has extremely high temporal resolution and thus, can provide a spatial map of hemodynamic activity within the brain that reflects underlying neuronal activity. Unlike fMRI, the proposed PDCS device will be portable, inexpensive, and sit comfortably atop the patient's head at bedside, with minimal patient cooperation and without regard for restless moving about by a child. If Roarke is successful, improving epilepsy pre-surgical planning will enable earlier resective surgery in those children severely affected by the disorder and who most need seizure freedom or a progressive decrease in seizure frequency.