【Grant-in-Aid for Scientific Research (S)】

Integrated Disciplines (Complex Systems)

Title of Project : Evaluation and Control of Epilepsy Dynamics Based on Multimodal Brain Signals and Thermal Neuromodulation Using Focal Brain Cooling

Michiyasu Suzuki
(Yamaguchi University, Graduate School of Medicine, Professor)

Research Project Number : 15H05719 Researcher Number : 80196873
Research Area : Neurosurgery
Keyword : Thermal neuromodulation, Epilepsy, Low-invasive implantable devices

【Purpose and Background of the Research】

Epilepsy is a common chronic neurological disorder characterized by recurrent unprovoked seizures. The condition is usually treated with medication, but even the best agents do not provide seizure control in over 30% of patients with epilepsy. Surgical treatment is performed for such patients, but is not always successful because of proximity to eloquent areas.

Electrical stimulation of the brain has been proposed as a replacement for surgical resection such as VNS and RNS. However, the role of electrical stimulation in treatment of epilepsy is still unclear and several clinical studies have not achieved satisfactory results.

Focal cooling of the epileptogenic region of the brain is an attractive and nondestructive approach for treatment of patients with epilepsy. Focal brain cooling (FBC) was proposed approximately 50 years ago as an effective method for treatment of impaired brain conditions and recent research has shown suppression of abnormal electrical brain activity (epileptic discharges) using FBC. In the first clinical study performed worldwide, we showed that FBC has neuroprotective and anticonvulsant effects in patients intraoperatively.

Improved measurement methods have suggested that both EEG and other kinds of brain activity are related to the pathology of epilepsy Therefore, we have developed a thermal neuromodulation system based on focal brain cooling using epilepsy dynamics analysis of multimodal brain signals, in collaboration with a medical and engineering team.

【Research Methods】

The research plan is divided into three parts, with the goal of development of a low-invasive implantable thermal neuromodulation system. In part A, a novel implantable sensor will be developed for detection of multimodal brain signals such as EEG, brain temperature, NIRS signal, intracranial pressure, and head motion, using flexible printed circuit technology. In part B, the pathological brain dynamics of epilepsy will be examined using statistical analysis and mathematical neural modeling. In part C, we will develop a FBC apparatus that can modulate the pathologic brain on demand under a minute power load.

【Expected Research Achievements and Scientific Significance】

Surgery is effective for treatment of some patients with epilepsy, but other patients are not candidates for resection and many are refractory to treatment. These patients experience physical or mental disabilities in their lives that compromise social interactions, employment, and overall health and quality of life.

In the near future, it is likely that our research will open new horizons in neuromodulation devices. These new devices will have important roles in treatment of epilepsy and stroke. This treatment will be transformative for patients who currently cannot be treated effectively.

【Publications Relevant to the Project】

・Nomura S, Inoue T, Maruta Y, Imoto H, Suzuki M. Changes in glutamate concentration, glucose metabolism, and cerebral blood flow during focal brain cooling of the epileptogenic cortex in humans. Epilepsia, 2014;55(5):770-776
・Yamakawa T, Inoue T, Suzuki M, Niwayama M. Development of an Implantable Flexible Probe for Simultaneous Near-Infrared Spectroscopy and Electrocorticography. IEEE Transaction on Biomedical Engineering, 2014;61(2):388-395

【Term of Project】 FY2015-2019

【Budget Allocation】 152,600 Thousand Yen

【Homepage Address and Other Contact Information】

http://ds.cc.yamaguchi-u.ac.jp/~neuro-w1/
neurosur@yamaguchi-u.ac.jp