Stereoelectroencephalography to Help Treat Refractory Epilepsy

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Abstract—In recent years, stereoelectroencephalography (SEEG) has been a new alternative in pre-surgical evaluations to determine and map out epileptogenic zones in patients’ brains. This deeper brain imaging helps surgeons more effectively treat refractory epilepsy and reduce or eliminate seizures.

I. INTRODUCTION

REFRACTORY epilepsy is a form of epilepsy in which medication cannot control the patient’s seizures. If a patient tries two different medications to reduce and control seizures with no results, then they are considered to have refractory epilepsy. While there is still dispute over how drug-resistant epilepsy is diagnosed, it is believed that 20-40 percent of patients with epilepsy are refractory. If diagnosed with refractory epilepsy, patients can undergo surgery to remove their epileptogenic zone (EZ), given that it is deemed safe to do so. While epilepsy surgery is given based on the patient’s decision, it has been shown to control seizures with success rates varying from 50-90% [1]. While it was first developed in the late 1900s, stereoelectroencephalography (SEEG) has gained popularity for pre-surgical imaging of the brain in recent years due to the introduction of high resolution imaging and robotic systems.

II. METHODS

SEEG is a method of brain imaging in which multiple electrodes are implanted deep inside of the cerebral tissue. Before this can be done, doctors first use magnetic resonance imaging (MRI) to map out a 3D image of the patient’s brain. With this 3D image, the paths for the electrodes can be evaluated in stereotactic planning software. This picture shows screenshots of stereotactic planning software, where the trajectory of an electrode (yellow lines) is visible on multiple planes [2]. This allows doctors to determine where electrodes can be inserted to avoid arteries and minimize risk of brain hemorrhaging. After the placement of the electrodes has been determined in the stereotactic planning software, the patient is moved to the operating room to have the electrodes implanted. A robot, such as NeuroMate, helps surgeons to fix guiding screws into the skull. After creating holes through the skull, surgeons place hollow screws into the hole to allow a pathway for the electrodes.

Surgeons implanting depth electrodes into a patient with the help of NeuroMate [3].

Depth electrodes are then threaded through the pathway and implanted in the brain. Brain imaging can be done during or after the surgery to confirm proper locations of electrodes. The electrodes are tested immediately after surgery to ensure that they are working, allowing quick replacement in case of some electrodes not working. These electrodes are thin wires (about 1-2 mm) with multiple metal electrodes down the length of the wire. These depth electrodes allow monitoring of brain activity in deeper areas that subdural grid electrodes have trouble observing. The electrodes then collect data of brain activity over 3-15 days, allowing doctors to detect the epileptogenic zone and determine which procedure should be done to remove or disconnect the EZ. Surgical procedures include thermal lesions or microsurgical removal of gray matter.

IV. DISCUSSION

The use of SEEG to detect epileptogenic zones has greatly improved treatment methods of refractory epilepsy. SEEG depth electrodes are much less invasive than subdermal grid electrodes, which require an open surgery to implant. SEEG also allows “direct recording from every cerebral structure, including depth of sulci and white matter”, which is advantageous to subdural electrode grids, though subdural grids are superior for cortical mapping [2]. Several research studies show that implantation of SEEG electrodes is generally safe, with fewer complications than other methods. Complications with cerebral tissue are very serious, such as hemorrhages in the brain. One study showed only 5 intracranial bleedings that required surgical treatment out of 419 procedures and a total of 19 complications of 419 procedures (4.5%) [3]. While SEEG is still in its infancy, this shows hope for a safer method of detecting epileptogenic zones when noninvasive brain imaging cannot.

REFERENCES