NATIONAL DIALOGUE FOR Healthcare Innovation

MEDICAL INNOVATION: ELECTROENCEPHALOGRAM (EEG) (MEDICAL DEVICE: DIAGNOSTIC)

Physician: Hans Berger, William Grey Walter
Institutions: University of Jena, Burden Neurological Institute

Situation

Two million Americans suffer from epilepsy

Epilepsy is a chronic neurological condition characterized by persistent seizures stemming from abnormal electrical activity in the brain. The seizures can vary in frequency and severity, and cause involuntary changes in body movement or function, sensation, awareness, or behavior. Epilepsy can either be inherited, or caused by trauma such as a brain injury or stroke.

The Centers for Disease Control and Prevention (CDC) estimates that two million Americans suffer from a form of epilepsy, and that some 140,000 new cases are diagnosed each year. The condition costs the American economy $15.5 billion annually by way of expenses related to medical treatment, as well in lost wages and productivity.

Physician-Industry Collaboration

Discovering the link between brain waves and seizures

Early in the twentieth century, very little was known about epilepsy and other brain disorders, principally because there was no way to analyze brain activity for abnormalities. While the newly-discovered X-ray helped diagnose ailments in many areas of the body, no technology existed for measuring and identifying conditions related to brain waves and function. The existence of electrical waves in the brain had only recently been discovered, in 1875, by an English physician named Richard Caton.

Building on Caton's work, a German physician named Hans Berger at the University of Jena, with a specialty in studying the physiology of the brain, began working on ways to measure brain electricity to better understand mental processes. Unfortunately, the thickness of skull bones prevented him from being able to pick up any measurements directly from the brain. Berger then had an idea of putting electrodes under the skin of patients who had part of their skull removed surgically and trying to detect electrical signals from the brain through soft tissue.

Beginning with animals, and then working his way to humans as testing subjects, Berger in 1924 was able to use a simple electricity-monitoring device to measure brain activity in such a patient and record it on graph paper for the first time ever. Now that he knew that brain waves could be measured through soft tissue, he used rudimentary radio technology to amplify the signal so it could measure the waves through the skull. The era of the so-called "electroencephalogram," or EEG, had begun.

According to the World Health Organization, "This led rapidly to the confirmation that seizures were the result of electrical discharges in the brain," including by Dr. William Grey Walter in Great Britain, who used delta waves to identify tumors and lesions that cause seizures. After World War II, Walter further refined EEG technology by developing an imaging technique using 22 devices attached all around a patient's skull, producing a rich, so-called "topograph" of the brain in three dimensions, measuring four different kinds of electrical waves.

Innovation Benefits

An almost real-time snapshot of brain activity

While other imaging technologies such as computerized axial tomography (CAT) and magnetic resonance imaging (MRI) have subsequently been developed, EEGs remain the standard and most important non-invasive device for diagnosing epilepsy, and they are used for detecting and analyzing many other brain conditions such and tumors and strokes. Modern computing power has given EEG devices the ability to pinpoint precise locations of brain abnormalities that cause epileptic seizures.

The chief brain mapping initiative of the National Institutes of Health (NIH) points out that, "Unlike a MRI, the speed and fidelity of the EEG…can break down brain activity to the millisecond, providing an almost 'real-time' snapshot." As a result, physicians are now able to diagnose epileptic conditions with remarkable accuracy, and make well-informed recommendations on appropriate therapies, including medication and surgery.

Patient Benefits

"The EEG helped me figure out what was wrong"

Jim T., a healthy 38-year old in Washington, was on a run when he began to experience a severe tingling and numbness that shot through his body, accompanied by a strange smell and a feeling of "déjà-vu," as if he knew what his running partner was going to say before he said it. The feeling was so powerful, that he had to stop and grab a nearby fence to steady himself. The whole episode lasted only around 10 seconds, and felt to Jim almost like a mild shock.

Jim felt fine for the rest of the day, but had another such episode the next morning, as he was about to get up. Then he was fine. Six weeks passed, and then Jim had a recurrence of the event, followed by several more the next two days.

When the same pattern occurred two months later, Jim told his general practitioner, who referred him to a neurologist at George Washington University. The neurologist said it sounded like a possible seizure, but ordered an EEG to help in the diagnosis. Jim had a crown of electrodes attached to his scalp, with wires linked to a computer to measure his brain waves. The whole procedure lasted less than 30 minutes.

The test came back inconclusive for epilepsy. However, the neurologist told Jim if the episodes came back again to let him know right away, and he would arrange for a new procedure known as an ambulatory EEG that would allow Jim to be analyzed for up to 72 hours, using a battery pack attached to the crown of electrodes on his scalp.

Another six weeks went by and Jim felt the same sensations. He was given the ambulatory EEG right away, and sure enough, he had several of the events over the succeeding days. The EEG was downloaded to a computer, and Jim's neurologist made a quick diagnosis – he suffered from a mild form of epilepsy known as "simple partial seizure disorder."

The neurologist recommended a new medication that now has Jim living with his epilepsy controlled. He is back to running and working everyday without having to deal with regular episodes of seizures. "The EEG helped me figure out what was wrong, and now I'm better," Jim said.