Perspective

Small sensors for special surgery

Abstract

The brain is a living miracle. There are so many tasks to be done at once, so many neurons that need to talk with each other, integrate and interact to perform perfection in one part of one synaptic or non-synaptic action and within femtoseconds. We understand that the diseased brain that is compromised need not be thought of as a damaged brain. It is simply one that needs to be and can be fixed, in fact, with brilliant technologies that are at our fingertips. We believe that the brain is an electronic and chemical device that matches in temporal and spatial synchrony our first- class small sensor for surgery trademarked, the BRODERICK PROBE® series of nanoprobes and circuits. It is said to be one of the latest extraordinary feats in the surgical world and it is named affectionately after the author's father, Paddy Broderick, from County Clare, Ireland.

Thus, we think of brain and spinal cord disease as a mismatched connection, some connection that is wrong-just not right- as the fabulous network of dendrites work as do our internet cables, in this case, insulated from the extracellular space and as these dendrites impinge on an axon at the terminal synapses, neuronal and glial decisions are made and so our tethered telemetry and fiber optic sensors soar sweetly through the milieu of cerebral matter to allow us to see, to image online and in real time and in vivo, what the brain is feeling or doing at any precise sub-second during intraoperative brain surgery. This is the true story of how the announcement of this amazing discovery is credited for repurpose. With gratitude to Medcrave, we share the original work and the intricate know-how with surgeons worldwide.

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Illustration: The Nanoprobe

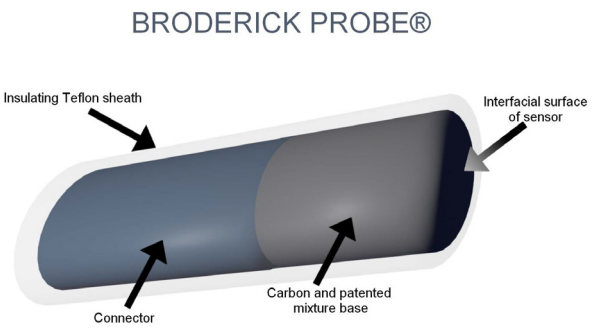

Figure 1 introduces the BRODERICK PROBE® PEA/BSA biochip, the BRODERICK PROBE® PEA biochip and the BRODERICK PROBE® BSA biochip in 3D. Credit for Art work: Aisha Hashmi, CCNY student of Dr. Broderick in Neurobiology Class, Medical 10000, Fall, 2021. The artwork appears for the first time in this article for Medcrave.

Introduction: The Clinical Trial

[The discovery is announced in the originally published abstract below:

"A Clinical Trial of an Advanced Diagnostic Biomedical Device for Epilepsy Patients" 2008;18(1):50.

Introduction

We are developing an advanced biomedical device for the diagnosis of epilepsy in patients during surgery. This micronanotechnologic device represents a significant advance in biomedical engineering and bioimaging. For the first time, the neurochemistry underlying normal and pathologic neuronal function in the intact brain of the epilepsy patient is studied *in vivo* in NYU Tisch Hospital under Internal Review Board approval, with unique biosensors patented by CUNY and NYU. Using semiderivative voltammetric circuits, neuromolecular imaging (NMI), with the Broderick probe biosensor, selective detection of specific neurotransmitters in discrete parts of intact brain is imaged within a temporal resolution of seconds. Our studies begin with presurgical evaluation of the patient with EEG monitoring wherein the site of cortical resection is delineated and subdural grid and strip electrodes are placed on the surface of the brain to identify the epileptogenic cortex. Then, biosensors, with a diameter five times less than epilepsy depth electrodes for invasive EEG, are placed by direct visualization in the exposed cortical region with and without epileptic spike activity in regions destined for resection. About 10 recordings with [X]-irradiated (11.6−12.7 kGy) laminar biocompatible carbon-based laurate biosensors are taken at cortical depths of microns to less than 2 mm for a 20−30 min time period. In our first anterior temporal lobe epilepsy patient, results showed that dopamine (DA), homovanillic acid (HVA) (metabolite of DA), serotonin (5-HT), L-tryptophan (L-TP) (precursor to 5-HT), and peptides (dynorphin and somatostatin) were present in the patient's neocortex (current resolution: nanoamperes). Intraoperative images were verified by comparison with our 14 year empirical database on epilepsy (Br. Res., 2000,2001; Bioimaging in Neurodegeneration, Springer, Humana Press, NJ, 2005; Clinical U.S. Patent, #7,112,319,2006; Clinical & Preclinical U.S. Patent, Pending, 2009). Future studies involve the prolonged use of biosensors in patients undergoing intracranial EEG studies in the NYU Tisch Intensive Care Unit. The present studies chart a course for safe and cutting-edge opportunities to characterize neurochemical profiles for epilepsy patients with partial seizures. The studies also provide discovery of novel surgical and pharmacologic strategies to alleviate the burden of seizures in our epilepsy patients.[1–5]

Below is the Link for "A Clinical Trial of an Advanced Diagnostic Biomedical Device for Epilepsy Patients"

https://www.dl.begellhouse.com/journals/1bef42082d7a0fdf,2c6be4517b8ab096,6e3123256c563d78.html#

The event was announced at the Polytechnic Institute at the Conference on The Long Term Effects of Medical Implants, April 3-5, vol. 19, pp.103-111, 2009. NYU posted a press release in 2010 and the Folio Journal of the CUNY Graduate Center published the event as follows:

"The surgeon fixes the probe's tip safely into place, and, in these cutting-edge human trials of the device, data light up a computer screen on a desk a few feet away. As the probe lightly brushes against the brain, information flows through an analyzer to the computer, tracing the traffic of neurotransmitter chemicals along the brain's pathways, revealing the crucial dance of synapse-to-synapse, signals that keep us alive. In an instant, it's clear where the brain is functioning normally and where transmissions along chemical pathways have gone awry". (Quote about the BRODERICK PROBE® written by Paul Karr, for the Folio Journal, the CUNY Graduate School, 2011).

Background of the author

I began this journey as a neuroscientist and transformed spectrometry into spectral analysis in the form of live electrochemistry using carbon allotropes in lipid matrices. Then, the journey led me into videotracking with Neuromolecular Imaging and now into Voltaic Photonics, using protein neuroprobes in dual photodiode/fiber optics. The nanobiosensor operates by detecting current at potential differences, experimentally specific for each neurotransmitter. Several neuromolecules are imaged selectively within sub-seconds in real time, in vivo, in vitro and in situ.

What we have here, in one example, is a miniature biocompatible, photosensitive, electroactive polymeric sensing neuroprobe that operates by converting photonic energy into electrochemical energy, generating a photocurrent in the brain via ion channels in skull without opening the brain and/or opening the brain minimally. The output is provided in units of voltage. Laser diodes encompassing fiber optic proteins enable the electrochemical waveform to be seen as an electrochemical image. The photocurrent provides an imaging profile of neurochemicals derived from sensing the brain. Thus, our original BRODERICK PROBE® polymer, a Nano Biotechnology that sees inside the brain is further enabled by quantum mechanics inventive art for advanced nanomedicine and nanosurgical sensing devices in the BRODERICK PROBE®. This photoelectrochemical conductance device provides another novel series of nanobiosensors for Nano Biotechnology, nano-diagnostics, nanotherapies.

Discussion

The outstanding event was launched at the Conference at the Polytechnic Inst. Intraoperative surgery was successfully done and surgeon Dr. Werner Doyle announced that "this day will go down in history as the proof of concept for a new extraordinary technology for epilepsy surgery for patients." Drs. Kolodny and Pacia wrote testimonials in the NYU press release and Dr. Kuzniecky applauded the clarity of the data with great aplomb.

The Speech

The original Speech in power point is attached here to share with the surgeons worldwide. The file is entitled, Copy of Polytechnic-FINAL-2009.

Below is the Link for our Abstract to the Clinical Trial for the BRODERICK PROBE® biosensor and circuits used clinically for the first time in the brain of the epilepsy patient intraoperatively during resection surgery LIVE in the clinical setting.

https://www.dl.begellhouse.com/journals/1bef42082d7a0fdf,2c6be4517b8ab096,6e3123256c563d78.html#

With impressive Eurasian funding to manufacture and market the probe, the prioritizing of the inventive art by the upper management/administration at the City University of New York, the digitizing of the probe with our cutting- edge patents, books, publications, videos, cameos, podcasts, awards and our new You Tube Channel, Eazysense Nanotechnology, the resurgence of the tiny probe is fulfilling. We wish to show the surgeons the new way to see inside the brain during surgery.

Take home message

The nanotechnology is amenable to breakthrough robotic innovations for the surgeon and the patient. The BRODERICK PROBE® is a series of nanobiosensors that are smaller than one human hair. The Unexpected Happening in Boston at the time of the Meeting of the American Epilepsy Society, December 4th, 2009 at 7PM Eastern.

Patricia suffered a near fatal accident wherein Patricia lost her sight and a spinal cord injury caused the loss of her mobility to walk. The surgeons were fascinated with her recovery and they were fascinated with the nanoprobe; the surgeons visited the Broderick Laboratory on her swift return to discuss the use of the nanoprobe in surgery and then, back to the research enterprise!

Development

Broderick PA et al. Identification, Diagnosis, and Treatment of Neuropathologies, Neurotoxicities, Tumors, and Brain and Spinal Cord Injuries Using Electrodes with Microvoltammetry. US Patent Serial No. 10,980,460, Issued. 2021.

Broderick PA. Noninvasive Electroactive Photonic Protein Sensor with Polymer Photovoltaic Optics for Memory Transduction using Organic and Inorganic Elements as Platforms. US Non-Provisional Patent. International Application Patent # PCT/US16/68879. US Serial No. 11,197,615, B2, December 14th, 2021, Issued. 2021.

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Conclusion

From spectral analysis to Neuromolecular Imaging to Voltaic Photonics, we have cautiously made our way, step by step to the novel growth of the BRODERICK PROBE® enterprise to enter into but not limited to the biomedical market. Before these steps, the Broderick Brain Foundation was founded; this is the "non-profit" arm of the "for profit" Company, Eazysense Nanotechnologies Incorporated in New York, USA.

Acknowledgments

The author wishes to thank the Broderick Brain Foundation, the F.M. Kirby Foundation, the Center for Advanced Technology, CUNY, and the MacKenzie Foundation, each for partial support of our laboratory and students during these studies. It is important to note that since this body of work, the development and pioneering of Neuromolecular Imaging and the BRODERICK PROBE® has taken place diligently for many years. Other grants include the National Institute of Health, National Institute on Drug Abuse, The Lowenstein Foundation, the FACES and PACE Foundations for Epilepsy, The NYU Comprehensive Epilepsy Center, Dept. Neurology, Drs. Doyle, Kuzniecky, Devinsky, Pacia and Kolodny in addition to NYU Dept. Anesthesiology, Drs. Becker, Haile, Quartermaine, Blanck and Li and as well as Dr. Piercey, Upjohn Pharmacia Company, now Pfizer, deserve honorable mention. Dr. John P. Morgan, MD, Chairperson, Dept. Pharmacology, CUNY Medical School (prior to 1986-2000), Bridget Teresa O'Sullivan, OP, MA, Drs. Doris Clouet and Nathan Kline receive thanks. Website: Eazysense: https:www.eazysensenanotechnology.com

Conflicts of interest

The author declares there is no conflict of interest.

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