Invasive Neurostimulation: Advantages and Disadvantages for Managing and Monitoring of Epilepsy

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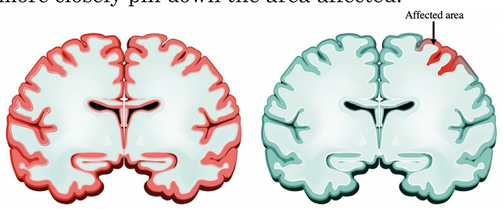
Epilepsy in the Population

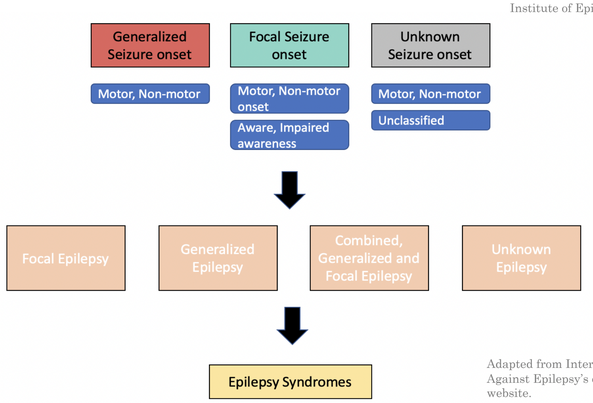
Epilepsy is one of the most common brain disorders and is characterized by the recurrence of unprovoked seizures. It affects over **70 million** people worldwide, **3.4 million** in the U.S. alone, and it is estimated **1 in 26 people** in the U.S. will develop the disease at some point in their lifetime (Epilepsy Foundation).

Classification

- Classification of Epilepsy requires a complex diagnosis with no gold standard method. It is based on epilepsy type, seizure type and syndrome.
- The 3 main seizure types include: **Focal (60%)**, **Generalized (40%)** or **Unknown**.
  - Unknown is a result of the combination of both focal and generalized seizures, or symptom presentation without evidence of focal or generalized onset.
- Digital EEGs are used for automated seizure event detection. While an event is occurring, intracranial EEG recordings can rapidly detect spikes to more closely pin down the area affected.



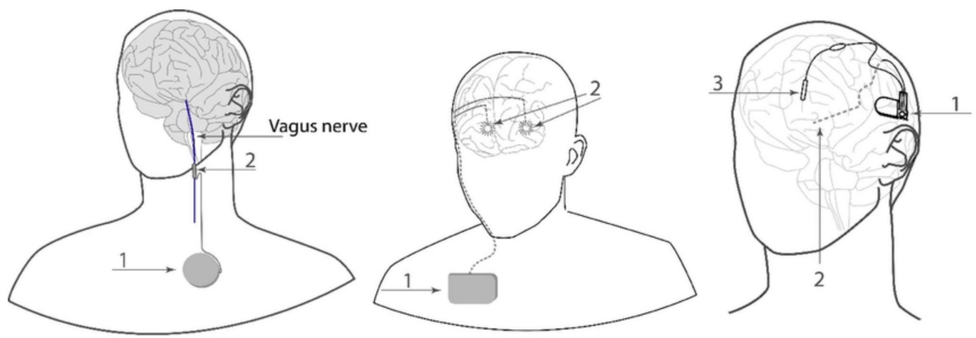
Adapted from CHI Neurological Institute of Epilepsy's website



Adapted from International League Against Epilepsy's educational website.

Current Neurostimulatory Devices

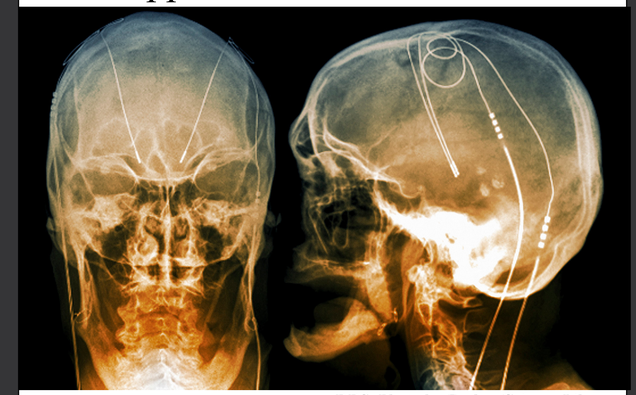
- The current need for further intervention in Epilepsy treatment is made clear by the amount of refractory cases to pharmacological management. With 2/3 of epilepsy able to be properly managed with treatment, **1/3 is considered drug resistant (DRE)**. DRE is associated with higher morbidity and mortality and can have a significant negative impact on a patients quality of life.
- The 3 major neurostimulatory devices on the market today:
  - **Vagus Nerve Stimulation (VNS)** – *focal and refractory seizures*
  - **Brain-responsive Neurostimulation (RNS)** – *focal and refractory seizures*
  - **Deep Brain Stimulator (DBS)** – *focal and refractory seizures*



Alexander N Pisarchik, PhD

	VNS	DBS	RNS
Mode of Action	**Open loop system** (AspireSR®) Surgically implanted near the collarbone and wire is run to the Vagus nerve. **Pre-programmed**: electrical impulses programmed by physician on a set interval	Open loop system (NeuroPace®) Surgically implanted near the collarbone and wire is run to the Vagus nerve. **Pre-programmed**: electrical impulses programmed by physician on a set interval	**Closed loop system** Sits on focal area on top of the brain where seizures begin. **Responsive Stimulation**: can give small impulses in response to abnormal seizure activity
Side Effects	- Hoarseness, cough - Local infection	- Infection - Intracranial hemorrhage - +/- Worsening memory	- Infection - Intracranial hemorrhage
Long Term Efficiency	Seizure reduction: 1 year: 26.21% 5 years: 55.8%	Seizure reduction: 1 year: 43% 5 years: 68%	Seizure reduction: 1 year: 44% 2 years: 53%

Application to Patients



DBS. Photo by Zephyr/Science Library

The use of an implantable device in the treatment of epilepsy is found to be beneficial for three major reasons:

1. Understanding the onset of seizures for preventative care, and as a means to better control and respond to future seizures
2. Lack of side effects
3. Effective treatment for drug-resistant patients

Future direction

- **Closed-loop systems (i.e. RNS)**: With real life data being sent to physicians directly, it allows for better communication between parties to improve effects and provide a base to build upon for further research.
- **Advanced neuroimaging technologies and Brain Mapping**: Creating views of a patient's individual anatomical and physiological brain circuitry to improve the current systems and decrease the outside neural interference with these devices.

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