Epilepsy & Functional Neurosurgery

An Introduction

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• What is a seizure?
  - continuous firing of neurons in unison; depending upon the function of those neurons in specific parts of brain, the seizure will manifest as a motor, sensory, or other type of seizure

• The different types of seizure: Basic classification
  - Simple vs. Complex: No change in level of consciousness vs. change
  - Partial vs. Generalized: Involve part of brain vs. whole brain
Medically Intractable Epilepsy

- If a patient has failed two medications (i.e. continues to have seizures), then adding or substituting a third medication has a less than 6% chance of curing the patient.

- Patients with uncontrolled epilepsy are at increased risk for sudden death (e.g. drowning, traumatic brain injury)

- Surgery now offers up to 85% cure rate with minimal risk, for properly chosen candidates

- Although most patients are determined by many to have “medically intractable epilepsy” after 2 years on medications, the average time to surgery is 18 years, resulting in many of these patients dying from epilepsy
What surgical options are available for epilepsy?

• **Temporal lobectomy:**
  Most common form of partial complex epilepsy arises from the mesial temporal lobe (hippocampus, uncus, and entorhinal cortex regions) – removal of this region can now be done with minimal morbidity, with over 85-90% of patients being SEIZURE-FREE forever thereafter – this is superior to continued medical therapy, according to a recent randomized trial (Wiebe et al, New England Journal of Medicine, 2003)

• To reduce risk of damaging language and memory, patients can undergo a “WADA” test which temporarily “paralyzes” that half of the brain into which it is injected; patients are shown flashcards, and stop talking or remembering when the sodium amytal (paralysis) sets in, indicating that hemisphere is involved with language or memory function.
The WADA Test

- Inject fast acting anesthetic
- Patient is moving fingers and counting
- Opposite fingers stop
- If language also on that side, patient stops counting

Figure courtesy of Dr. Pinkston
Surgical Treatment of Epilepsy: Other Options

• Hemispherectomy
  - Some patients have significant cortical dysplasia which involves the entire hemisphere on one side; others have status epilepticus (continuous seizures) from one hemisphere of the brain only – the goal is to functionally disconnect this hemisphere from the other

• 75% of patients are seizure-free following this procedure; if done before 2 years old, many patients can move bilaterally post-operatively
Some patients have more than 100 seizures a day on medications, and have unresectable locations of the brain from which seizures begin

- A “palliative” treatment is vagal nerve stimulation

- A “pacemaker” sends electrical current every five minutes up the LEFT vagus nerve (since the right sided nerve may be associated with cardiac dysrhythmia because of the SA node innervation) - helps reduces seizures 30-60%, but rarely cures anyone

- Other “palliative” options include corpus callosotomy for disconnecting the hemispheres of the brain and preventing seizure spread, or subpial transections of eloquent cortex which interrupt the “U” fibers and prevent seizure spread while retaining important function
How do you know which surgical treatment to use?

- Step 1: Know where the seizure is coming from

  - Normally, the scalp EEG reveals the general location;
  - If only one location is the “focus” of the seizure each time, and it’s in a resectable part of the brain (i.e. not motor cortex, speech, memory, vision, etc.-related) then it can be generally resected safely
  - If scalp electrodes are ambiguous, then intracranial electrodes (e.g. epidural, subdural, or intraparenchymal depth electrodes) may be inserted to help localize the exact region of the seizures
  - If multiple regions are “foci” then surgery is not as likely to cure the patient
  - Generally, temporal lobe-originating seizures respond best to surgery; extra-temporal locations (e.g. frontal lobe seizures) do not respond as well to surgical resection resulting in seizure freedom
Monitoring Patients

- Many patients are monitored for at least 24 hours to "catch" enough seizures for analysis.
- Some patients have "pseudoseizures" which are behavioral seizures and not electrographic seizures.
- Video-EEG allows simultaneous recording of patients' behavior and EEG findings, to differentiate real seizures vs. "pseudoseizures".
- Patients are not always aware of "faking a pseudoseizure"; also, 10% of patients with pseudoseizures also have real seizures, so they must be taken seriously enough.
- Most seizures occur during sleep, so a sleep EEG study is a vital part of recording.
The EEG: normal waves, spikes, and seizures

- Normal waves: Delta (1-3 Hz); Theta (4-<7 Hz); Alpha 7-12 Hz; Beta (>13 Hz)

- Spikes – may indicate the location of seizures; often seen in interictal period when isolated

- Seizures
  - Continuous spike and wave in generalized seizures (as seen); may vary in other seizures (e.g. 3 Hz seen in absences seizures)

http://www.epilepsiemuseum.de/english/diagnostik/eeg.html
Case Scenario

- Somebody just had an event at a store where people found this person down on the ground. The person is now coherent, and isn’t sure what happened. Nobody witnessed a seizure. Is there any utility to getting an EEG now, since the likelihood of having a seizure (if that’s what happened) during an EEG will be extremely low?

- What do you think?

  - **Answer**: The EEG may not show another seizure unless the patient has one during the EEG, but it can reflect “spikes” which suggest an epileptogenic focus – so it is of utility to get an EEG.
Status Epilepticus: An Emergency

- **Definition**
  - A seizure ongoing for 30 minutes without stopping, or multiple seizures in succession without sensorium returning to normal between them

- **Proper Treatment**
  - Fast-acting Benzodiazepine (e.g. lorazepam aka Ativan) in escalating doses - for adults, 2 mg q 2 min. until seizure stops
  - Add phenytoin or valproic acid (loading dose)
  - If seizure still does not stop, then intubate and administer general anesthesia
19 y.o. female with complex partial seizures associated with dyslexia.

Detailed History: Above-average intelligence, no problems in school except occasional dyslexia. Over past several years, developed seizures involving flashing lights.

Physical Exam: Normal

Extraoperative monitoring: A grid was placed to exactly localize her epilepsy, which was between the reading area and visual area.

Resection: A focus was identified between the reading and visual area – this was resected.

Post-operative condition: Seizure-free, without neurological deficit.
Intraoperative Case Presentation (continued)

Intraoperative photograph schematic

Courtesy UCLA Epilepsy - Dr. Itzhak Fried
Results (total procedure time 7 hours)
- S1 strip - lateral inferior temporal - language disruption at points 8-9, 7-8, 5-6, 3-4, 1-2 (entire region)
- S2 strip - basal temporal region - language disruption at 1-2, 2-3, 4-5, 6-7, 8-9
- G1 main lateral grid
- No language effects (in absence of AD) -- 3-4, 4-5, 15-16, 28-29, 37-38, 39-40
- Inconsistent responses at 5-6, 23-24
- Reading disrupted at 45-46
- Occipital strips -- medial contacts at 1-2, 3-4 showed right visual field phosphenes

Conclusion:
Language points closely anterior and superior to lesion; reading areas posterior to lesion -- No disruption of language or reading directly over the lesion
Functional Neurosurgery
Functional Neurosurgery

• Goal: To increase function via neurosurgery, in the least invasive method possible

• Main indications
  – Movement disorders
    • Parkinson’s disease
    • Essential tremor
    • Dystonia
  – Pain
Functional Neurosurgery

- Types of Procedures:
  - Deep brain stimulation (globus pallidum interna, thalamus ventral inferomedial nucleus, subthalamic nucleus) – a reversible procedure, whereupon a thin electrode is placed at the brain site, connected to the “pacemaker” like stimulator implanted in the chest wall
  - Motor cortex stimulation for pain
  - Epidural stimulator placement for back pain
  - Baclofen pump placement for spasticity
  - Selective dorsal rhizotomy for spasticity
Schematic diagram of deep brain stimulator

- An electrode is placed at the target in brain, and is connected to a pacemaker-like device implanted in the chest wall, as shown in this picture.

http://www.medtronic.com/UK/patients/neuro/brain_stimulation.html
Choice of targets: The rationale

- **Main symptoms:**
  - Dyskinesia, rigidity $\rightarrow$ Subthalamic nucleus (STN) or Globus pallidum interna (GPi)
  - Tremor $\rightarrow$ Thalamus (Vim nucleus)
  - Pain in body $\rightarrow$ Sensory thalamus (Vpl/Vpm regions, depending on distribution of pain)
  - Pain in back; arms/legs without a structural lesion $\rightarrow$ epidural steroid injection for temporary relief, epidural stimulator for longer relief
  - Spasticity $\rightarrow$ Baclofen intrathecal pump or Selective dorsal rhizotomy
  - Cancer pain $\rightarrow$ Morphine intrathecal pump
Image guidance system

- Image-guided neurosurgery allows a “GPS-like” pre-registered means of navigating in the brain.

- MRI scans taken pre-operatively are “co-registered” with a patient’s head in the operating room using landmarks such as the tip of the nose, tragus, canthi, etc. and this allows us to find the most direct approach to the tumor inside the brain.

http://www.stealthstation.com/physician/neuro/library/tria.jsp
Case Scenario: Thalamotomy

72 y.o. F with multiple medical problems had worsening tremor which impaired writing and feeding activities of daily living.

A lesion was made at the left thalamus (see MRI), which resulted in tremor & writing ability improvement (above).
Pain: Neurosurgical Treatment Options

Brain
- Deep brain stimulation of thalamus, peri-ventricular gray, or peri-acqueductal gray
- Motor cortex stimulation

Spine
- Epidural stimulation in distribution of pain
- Intrathecal drug delivery (morphine; baclofen for spasticity & spasticity-related pain)

http://www.medtronic.com/
The End