Epilepsy Surgery: Indications and Outcomes

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Epilepsy Surgery

- What is Epilepsy?
- Role of Epilepsy Surgery
- Pre-operative Evaluation
- Surgical Procedures
- Future Strategies
EEG: Seizure
EEG: Seizure Initiation
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Definitions

• Seizure:
  the clinical manifestation of an abnormal and excessive excitation of a population of cortical neurons

• Epilepsy:
  a tendency toward recurrent seizures unprovoked by systemic or neurologic insults
Incidence of Seizures and Epilepsy

• Seizures
  – Approximately 9% of the population will have a seizure in their lifetime.
  – About 5% will have febrile convulsions in early childhood.
  – The great majority of seizures do not lead to epilepsy.

• Epilepsy
  – Incidence: ~45/100,000 per year
  – Point prevalence: 0.5-1%
Surgical Treatment of Epilepsy

- 0.5 – 1% of the U.S.A. population (2.5M)
  - ~ 30-40% medically refractory (700K)
    - ¼ - ½ are potential surgical candidates (~ 100K)
- Only 2% of patients that would benefit from surgery receive operations

- Surgical Candidacy
  - Medically refractory
  - Anatomic epileptic focus

Epilepsy Surgery

• What is Epilepsy?
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Indications for Epilepsy Surgery

• Clear anatomic etiology suggesting potential surgical cure.

• Persistent seizures despite optimal anti-epileptic drug (AED) trials.

• Severe seizure disorders needing palliative seizure reduction.
Medical Intractability

• Anti-seizure Drugs (AEDs) show declining utility with successive treatment failures.
  – Failure of 1 first-line AED, < 50% success with 2\textsuperscript{nd}
  – Failure of 2 first-line AED, < 20% success with 3\textsuperscript{rd}
  – Failure of 3 first-line AED, < 5% success with 4\textsuperscript{th}

• Although newer medications may be better tolerated, their efficacy has not proven substantially superior.

Epilepsy Surgery

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Pre-operative Evaluation

• Goal: Define the anatomic epileptic focus.
• Studies:
  – Semiology
  – Video EEG study
  – MRI: to show lesion or sclerosis
  – PET: interictal hypometabolism
  – Neuro-psychological evaluation
    • Lateralizing, localizing and prognostic
  – Wada test
    • Lateralizes language and memory dominance
Pre-op Evaluation: Video EEG

- Patient’s undergo video EEG for an extended period.
- Medications are withheld.
- Seizures are recorded to determine point of origin.
Pre-op Evaluation: Imaging

- MRI scan may show regions of dysplasia, a benign tumor, or scarring of the hippocampus.

- PET scans show areas of decreased metabolism suggesting a focal brain abnormality.

- Other Imaging modalities may be used in specific circumstances.
Pre-op Evaluation: Wada Test

- In Wada test an anesthetic agent is infused to each brain hemisphere sequentially to evaluate the location of language and memory.
- Injection of the epileptogenic side without deficit predicts surgical safety.
Epilepsy Surgery

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Epilepsy Surgery Procedures

• Lesionectomy
• Temporal lobe epilepsy
• Non-temporal epilepsies
• Disconnection surgeries
• Vagal nerve stimulation
Lesionectomy

- Clear lesion associated with seizure type.
- Resection of lesion and peri-lesional tissue.
Temporal Lobe Epilepsy

- Most common intractable epilepsy syndrome
- 60-70% associated with Mesial Temporal Sclerosis
- Semiology – Complex partial seizures
  - Auras
    - Epigastric, nausea, palpitations
  - Early ipsilateral head version w/ contralateral dystonia
    - 97% predictive of lateralization
  - Late contralateral head version w/ contralateral dystonia and contralateral mouth deviation
    - 90% predictive of lateralization
Temporal Lobe Epilepsy

- **EEG findings**
  - Sharp waves in mesial structures without extratemporal activity

- **MRI**
  - Hippocampal atrophy
    - Seen on T1
    - Signal change
      - Seen on T2 or Flair

- **PET**
  - Interictal hypometabolism
Standard Anterior Temporal Lobectomy
Mesial Temporal Lobe Epilepsy

- Mesial Temporal Sclerosis

7. Figure from Blumcke, I, Beck H, Lie AA, Wiestler, OD. Epilepsy Res. 1999 Sep;36(2-3):205-23.
Standard Anterior Temporal Lobectomy

- Resected tissue
  - Antero-lateral temporal lobe
    - **LEFT** Superior (2-3 cm), middle and inferior (4-6 cm) temporal gyri
    - **RIGHT** 4-6 cm resection from tip
  - Mesial structures
    - Amygdala, hippocampus and parahippocampal gyrus

- Seizure control ranges from 60-80% seizure free

- At Vanderbilt, performed if dysplasia or lesion in lateral cortex.
Seizure Outcomes

Engel Classification

I. Free from disabling seizures
   A. Completely free
   B. Non-disabling simple partial only
   C. Some disabling after surgery, but non-disabling for >2 yrs
   D. Generalized w/ AEDs stopped

II. Rare disabling
   A. Initially free, but still rare
   B. Rare disabling seizures
   C. Occasional disabling since surgery, but rare for last 2 yrs

III. Worthwhile improvement

IV. No Worthwhile improvement

Selective Amydalo-hippocampectomy

Approach corridor
Transcortical Transventricular Technique

- **Incision**
  - Starting at zygoma
  - Curves posteriorly
  - Temporalis split

- **Craniotomy**
  - 2.5 - 3 cm diameter
  - Centered over middle temporal gyrus
Transcortical Transventricular Technique
Transcortical Transventricular Technique
Transcortical Transventricular Technique

- **Extent of resection**
  - Medial amygdala
  - Hippocampus
    - 3-3.5 cm
    - Post to cerebral peduncle
  - Parahippocampal gyrus
Seizure Outcomes

• Outcomes for selective AH vs. ATL
  – Equivalent regardless of surgery or approach
    • Wieser: >10yr follow-up transsylvian
      – 71% Engel I
    • Lutz: Randomized, prospective trial
      – Transcortical (77%); transsylvian (73%)
  – Subtemporal approach: 80% Engel I or II
  – Reduction in AEDs
    • 74% of Engel Class Ia patients stopped AEDs by post-op year 5

Non-temporal Epilepsy

- Seizures originating in other parts of the brain are more difficult to pinpoint and treat.
- Non-temporal epilepsies typically require placement of subdural or deep electrodes to pinpoint seizure activity.
- Once focus is identified a second surgery is performed to remove that brain area.
- Great care is taken to identify regions of “eloquent” cortex.
  - Mapping from subdural grids.
  - fMRI or Wada Testing
  - Awake procedures to map cortex
Non-temporal Epilepsy

- Epilepsy grid implantation.
Depth Electrodes

- Intraventricular electrode monitoring
Non-temporal Epilepsy

• Resection based on information from grid.
Functional Anatomy: Multiple Sub-pial Transection

- When seizure is located in motor or language cortex, excision is not possible.
- Fibers between neurons can be interrupted in the MST procedure.
Other Epilepsy Procedures:
## Epilepsy Surgery Outcomes

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<th>Temporal</th>
<th>Extra-Temporal</th>
<th>Lesional</th>
<th>Hemispherectomy</th>
<th>Callosotomy</th>
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<td>35</td>
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<td>35</td>
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<td>20</td>
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<tr>
<td><strong>Total</strong></td>
<td>100</td>
<td>100</td>
<td>100</td>
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</tbody>
</table>

- Results expressed as % of total
Vagus Nerve Stimulation

- **Historical Data:**
  - 1980’s: Desynchronization of EEG by VNS in animals
  - 1990’s: Device concept and pilot testing
  - 1997: FDA approval for patients with medically refractory CPSz and generalized seizures

- **Selection Criteria:**
  - > 6 szrs / month
  - Medically refractory (appropriate neurologist evaluation)
  - EEG demonstrating non-focal epilepsy
Vagus Nerve Stimulation

- **Surgery:**
  - 2 hour outpatient surgery

- **Stimulation:**
  - Cycling: 30s on / 5 min off
  - Option of patient-triggered stimulation

- **Adverse effects** local, related to stimulus (hoarseness, throat discomfort, dyspnea)
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Deep Brain Stimulation

• Outcomes:
  – 50% reduction in seizures
  – Anecdotal case reports of < 5 cases per report
  – Essentially similar results as VNS but no mood effects

• Disadvantages:
  – Not FDA approved
  – Targeting debated
  – Open Loop design
Deep Brain Stimulation

• Advantages:
  – More targeted control at seizure spread
  – Known surgical technique

• Disadvantages:
  – Not FDA approved
  – Targeting unclear
  – Open Loop design
Preemptive Brain Stimulation

- **Surgical Concepts:**
  - Focus of seizure activity is restricted
  - Localized detecting electrodes feed signals to control circuitry
  - HF Stim applied to region of ictal focus within 2 sec of seizure onset

Seizure Focus: Detection of electrical discharges

Processing signal: Electrical therapy Yes or No?

Stimulus delivered To area of interest Within 2 sec's
Preemptive Brain Stimulation

• Surgical Concepts:
  – Neuropace™ study
  – Electrodes implanted:
    • Cortical strip
    • DBS
  – Generator: embedded in cranial vault
  – Software loadable algorithms for detection and therapy
Preemptive Brain Stimulation

• Advantages:
  – Addresses non-resectable, focal seizure D/O
  – Allows much control of therapy
  – Open ended architecture

• Disadvantages:
  – Non-FDA approved, but IDE granted in 2003
  – Major surgery needed for implant
  – Outcomes unclear
Neurology
• Bassel Abou-Khalil, MD, Director
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• Amir Arain, MD
• Nabil Azar, MD
• Christine Dong, M.D.
• Martin Gallagher, MD, PhD
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