Intracranial EEG Recording

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Faculty/Presenter Disclosure

- Faculty: Dr Richard S McLachlan
- Relationships with financial sponsors:
  - None currently that I know of.
  - Lots in the past.

Objectives

Discuss:
- reasons for intracranial recordings
- SEEG vs subdural recording
- advantages and disadvantages of intracranial recording
- efficacy and safety of intracranial recording

General Themes

- Invasive recording should address a specific hypothesis
- Accurate coverage of the area of interest can be a challenge
- Use of depth vs subdural electrode recording is changing

Why invasive recordings?

1. Seizures lateralized but not localized
2. Seizures localized but not lateralized
3. Seizures neither localized or lateralized
4. Seizures from “hidden” location
5. Seizure location discrepant with other data
6. Seizure localization in eloquent area
7. Seizure localization related to lesion
8. Failed epilepsy surgery

Advantages of Intracranial Recording

1. Increased spatial and temporal resolution
   - no attenuation by scalp and skull
   - selective electrode positioning
2. Can record from “hidden” cortex
   - mesial temporal, mesial frontal, orbital frontal, insula, calcarine
3. No muscle/ cardiac artifact
4. Stimulation mapping of function

Watch out for 1. “fishing expeditions”
2. “shooting fish in a barrel”

Jayakar P et al. Diagnostic utility of invasive EEG. Epilepsia 2016; 57:1735-47
Types of Invasive Recording

- Depth (SEEG) 2018
- Subdural strips/grids Going (2015)
- Intraoperative (ECoG) Going (2000)
- Sphenoidal, nasopharyngeal, epidural pegs, foramen ovale Gone (1990)

Reif PS et al. The history of invasive EEG. Seizure 2016; 41:395-5

Subdural Placement LHSC

Subdural vs SEEG

Epilepsy Surgery at LHSC

Invasive recordings as percent of all epilepsy surgeries

- 1980s      10%
- 1990s      30%
- 2000s      50%

Why the transition from subdural to depth electrodes?
1. Surgeon preference
   - stereotaxic technology improved
   - less OR time
   - less radiation exposure
2. Cases are different
   - fewer temporal lobe cases
   - more insula cases
   - more MCD

Stereotaxic EEG (SEEG)

Robot

“Slicer Imaging”

Thermocoagulation after SEEG
26yo woman
Seizures onset age 20 Risk factors: none

**Daily:** perioral/bimanual tingling plus cephalic sensation, with retained awareness.

**Weekly:** progress to loss of awareness, staring, swearing, laughter, dystonic posture left more than right, bimanual automatisms greater right.

Occasional secondary generalization.
- Normal exam, MRI and PET
- Previous right temporal lobectomy based on EEG findings of right temporal originating seizures
- No improvement
- Now EEG shows bitemporal seizures

**Disadvantages**
1. Risk of sampling error if cortex not adequately covered
2. Generalized or widely synchronous signals poorly recorded
3. Risk of complications (low)
4. Patient discomfort (esp with subdurals)
5. Brain damage (all SEEG, some subdural)
6. Epileptogenic?

**Solid Angle Theorem**
(Burneo et al 2006, Al-Otaibi et al 2010)
- N=132
- Mean duration 12 days up to 1 month
- Complication= 3%
- Infection, hemorrhage, aseptic meningitis, status epilepticus, edema
- Headache= 100%

**Safety Subdural Strips**
(Clinically silent 25-35%)
- N=132
- Mean duration 12 days up to 1 month
- Complication= 3%
- Infection, hemorrhage, aseptic meningitis, status epilepticus, edema
- Headache= 100%
Iatrogenic seizures

Grids are bad news!

Is SEEG safe? A systematic review.
Epilepsia 2016; 57:386-401

- N= 2624 patients (30 reports)
- Complications 1.3%
- Permanent neurologic deficit 0.6%
- Mortality 0.3%
- Mainly hemorrhage, infection

Brain Damage

Memory after SEEG in TLE

- No change:

- Maybe (after lobectomy):
  - Ljung et al Epilepsia. 2017;58:2143–52
  - Helmstaedter et al. Epilepsia 2018

Comparison IEEG

<table>
<thead>
<tr>
<th></th>
<th>Subdural</th>
<th>SEEG</th>
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<tbody>
<tr>
<td>Cortex convexity</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Deep “hidden” cortex</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Patient comfort</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Safety</td>
<td>same</td>
<td></td>
</tr>
<tr>
<td>Functional mapping</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>OR time</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Instrumentation/cost</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Spatial resolution</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Research application</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>EEG reading</td>
<td>+</td>
<td>-</td>
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<tr>
<td>Lesioning</td>
<td>-</td>
<td>+</td>
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Outcome after Invasive Recording  
(LHSC 2009&2016)

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<tbody>
<tr>
<td>All (n=130)</td>
<td>47%</td>
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<tr>
<td>TLE (n=139)</td>
<td>53%</td>
</tr>
<tr>
<td>&lt; Age 40 yrs</td>
<td>58%</td>
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<tr>
<td>&gt; Age 40 yrs</td>
<td>40%</td>
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Some remaining questions

- How long is it safe to record?
- How many seizures do we need?
- How to limit need for additional electrodes?
- Referential vs bipolar montages?
- Iatrogenic spikes and seizures?
- When should resection be done after recording?

The End