Intraoperative Monitoring: Role in Epilepsy Based Tumor Surgery

December 2, 2012

Aatif M. Husain, M.D.
Duke University and Veterans Affairs Medical Centers, Durham, NC
## Disclosures

<table>
<thead>
<tr>
<th>Name of Commercial Interest</th>
<th>Type of Financial Relationship</th>
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<tbody>
<tr>
<td>UCB Pharma</td>
<td>Research, consultation, speaker bureau</td>
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<td>Upsher Smith Laboratories</td>
<td>Research, consultation</td>
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<td>Jazz Pharma</td>
<td>Consultation, speaker bureau</td>
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<td>Demos Medical Publishing</td>
<td>Royalties</td>
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American Epilepsy Society | Annual Meeting 2012
Learning Objectives

• Understand technique and utility of language mapping
• Understand techniques used for motor cortex localization
• Compare various techniques used for motor mapping and monitoring
Overview

• Language mapping and monitoring
• Central sulcus/motor cortex localization
• Motor pathway monitoring

• Intraoperative ECoG
Language Mapping

• Rationale
  – Localization of language areas very variable
  – Resection in “eloquent” area may be possible
  – Identifies clinical function of neural tissue

• Cautions
  – Mapping may result in seizures
  – After discharges must be monitored
  – Awake patient
Language Mapping – Technique

• Cortical areas stimulated with bipolar constant-current stimulator (Penfield technique)
  – 60 Hz trains of biphasic pulses
  – Each pulse 1 ms. (2-10 mA per pulse)
  – Train duration 3 – 5 seconds
• ECoG obtained with strip electrode(s)
• After discharge threshold identified
• Mapping performed with stimulation intensity 2 mA less than AD threshold
• Naming task performed
Patient 1: 24 year old, right-handed woman started having CPS 6 months prior to referral to epilepsy center. Seizure have continued despite treatment with LEV and LCM.
Patient 1: After Discharge
Patient 1: 24 year old, right-handed woman started having CPS 6 months prior to referral to epilepsy center. Seizure have continued despite treatment with LEV and LCM.

Slide courtesy Sandra Serafini, Ph.D.
Patient 1: 24 year old, right-handed woman started having CPS 6 months prior to referral to epilepsy center. Seizure have continued despite treatment with LEV and LCM.

- Broca’s area (Tag 10)
- Tongue motor (Tag 1)
- Tongue sensory (Tag 2)
- Auditory naming (Tag 30)
- Tumor (Tag 21)

1, 10 = PreCen Gyrus
2 = PostCen Gyrus
20, 22, 24, 26 = STG
21, 23, 25 = MTG
30 = Ant Supramarginal
1cm ruler at bottom right

Slide courtesy Sandra Serafini, Ph.D.
ARS Question

Should language mapping be performed in all cases of dominant hemisphere fronto-temporal-parietal tumor/epilepsy surgery?

A. Yes
B. No
C. No opinion
N=29 #raw sites=204
2V, 10VA, 17VAS
#SpArr=29
Language Monitoring

- Resection rule: resect > 1 cm. from essential site to avoid functional deficit
  - Visual naming task
- Monitor language function during resection
  - Testing during resection
  - Testing with electrical stimulation
- 7 patients with LGG in Broca’s area – resection with language mapping and monitoring
- Stimulation during resection caused language deficits
  - White matter between anterior insula and pars orbitalis (anterior margin)
  - Fibers from ventral premotor cortex (posterior margin)
  - Anterior part of arcuate fasciculus (depth)
  - Head of caudate nucleus
- Postoperatively transient language worsening but no permanent deficits


Patient 2: 15 year old male with ganglioglioma and epilepsy refractory to medications; undergoing tumor resective surgery.

- Pre-resection: No errors in 6 stim trials
- Post-resection: Hesitations w/ resection

Slide courtesy Sandra Serafini, Ph.D.
Central Sulcus/Motor Cortex Localization

• Rationale
  – Location of central sulcus not visually obvious, especially in cases of tumors
  – Resection in “eloquent” area may be possible
  – Identifies clinical function of neural tissue

• Cautions
  – Mapping may result in seizures
  – Injury to white matter fiber tracts can cause complications

• Techniques
  – Median (? tibial) SEP
  – Electrical stimulation (Penfield technique)
  – Direct cortical stimulation
Median SEP “N20 Phase Reversal”


Median SEP Technique

• Stimulation of median nerve
• Recording from exposed cortex with strip/grid electrode
• “Referential recording” with distant reference
• Largest amplitude N20 over somatosensory cortex
• Anterior-posterior phase reversal marks central sulcus
• Electrode position must be moved to check for variations, especially when lesions present
Patient 2: 5 year old male with tuberous sclerosis and multiple cortical tubers with medically refractory epilepsy – undergoing surgery to resect left parietal lesion.
Patient 2: 5 year old male with tuberous sclerosis and multiple cortical tubers with medically refractory epilepsy – undergoing surgery to resect left parietal lesion.
Electrical Stimulation Technique

- Cortical areas stimulated with bipolar constant-current stimulator (Penfield technique)
- ECoG obtained with strip electrode(s)
- After discharges monitored
- Observation of face/limbs
- EMG monitoring of face/limbs
- Clinical seizures common
EMG Recording

- EMG recording from face, limbs increased sensitivity of motor mapping
- 24% of patients had clinical or subclinical seizures during mapping
- Mapping method less likely to produce seizures

I use electrical stimulation (Penfield method) for motor cortex localization during tumor surgery for epilepsy.

A. True
B. False
C. Uncertain
Direct Cortical Stimulation Technique

- Stimulation (anode) with strip electrode placed on cortex; same electrode used for median SEP
- Cathode placed distally
- Monopolar stimulator can be used
- Standard stimulator with 0.05 ms pulse width
- 5 pulse train, 2.1-4 ms ISI
- Stimulation intensity up to 20 mA/60 V
  - Some report intensities up to 25 mA/110 V*
- EMG recording electrodes in face, limbs

Direct Cortical Stimulation

### Mapping
- Nonrecurrent pulse trains used
- Subdural strip placed perpendicular to central sulcus
- Various contacts on subdural strip sequentially stimulated
- Hand-held bipolar or monopolar stimulator can be used
- Site of lowest intensity stimulus evoking MEP response is over motor cortex

### Monitoring
- Strip electrode rotated to lie parallel to central sulcus
- Lowest stimulus intensity that evokes MEP used
- MEP recorded from restricted group of muscles
- Multiples sites may need to be stimulated to evoke hand/leg responses
- Hand and foot sites stimulated with monopolar or bipolar derivation
- Repeated throughout surgery

Patient 2: 5 year old male with tuberous sclerosis and multiple cortical tubers with medically refractory epilepsy – undergoing surgery to resect left parietal lesion.
Electrical vs. Direct Cortical Stimulation

**Electrical Stimulation**
- Incidence of seizures: 9.5%
- Movement with stimulation
- Activates cortical neurons
- Cannot be done continuously during surgery
- No/light anesthesia
- Higher total charge delivery
- FDA approved

**Direct Cortical Stimulation**
- Incidence of seizures: 1.2%
- No movement with stimulation
- Activates cortical neurons
- To be used continuously during surgery
- General anesthesia
- Much lower charge density
- Not FDA approved (yet)

Transcranial vs. Direct Cortical Stimulation

**Transcranial Stimulation**
- 75 µs pw, 9 pulses, 2 ms ISI, 330 V

**Direct Cortical Stimulation**
- 75 µs pw, 7 pulses, 2 ms ISI, 40 V


tceMEP can activate subcortical pathways
Subcortical Mapping with Intraoperative Imaging

• 42 patients with corticospinal tract tractography co-registered to surgical navigation-derived images

• Direct subcortical stimulation with monopolar stimulator, 0.1-25 mA intensity; recording from muscles

• Intraoperative ultrasound during stimulation; compared to tractography based neuronavigation

• Stimulation thresholds compared to distance to corticospinal tracts

Subcortical Mapping - Tractography

- Stimulation threshold increases approximately 1 mA/mm of distance from CST
- Subcortical MEP threshold of 3 mA is cutoff for new CST deficits

Motor cortex mapping and monitoring reduces morbidity.

A. True
B. False
C. Uncertain
Review of Motor Mapping/Monitoring

Mapping
- 70 patients with brain tumors underwent motor mapping with SEP and motor cortex stimulation
- Localization of central sulcus with SEP in 100%
- DCS elicited MEP in 95.7%
- DCS stimulation intensity 6.1-11.5 mA in precentral gyrus, 6.2-25 mA in other areas
- No complications observed

Monitoring

<table>
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<tr>
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<th>N=25</th>
<th>No new deficit (%)</th>
<th>Temporary new deficit (%)</th>
<th>Permanent new deficit (%)</th>
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<tbody>
<tr>
<td>No changes (n=10)</td>
<td></td>
<td>9 (90)</td>
<td></td>
<td>1 (10)</td>
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<tr>
<td>Temporary MEP loss (n=9)</td>
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<td>1 (12)</td>
<td>4 (44)</td>
<td>4 (44)</td>
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<td>Permanent MEP loss (n=5+1)</td>
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<td>0</td>
<td>0</td>
<td>5 (100)</td>
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- MEP amplitudes vary widely
- Lack of comparable series – uncertain if monitoring reduces morbidity

Conclusions

• Distribution of language sites variable – mapping important to avoid damage
• Motor cortex localization/mapping done with many different techniques
• New mapping techniques have advantages over older methods
• Motor monitoring during tumor dissection may prevent injury to CST