Anesthesia for Spine Surgery:

**Impact of Neuromonitoring on our Practice**

Jeremy A. Lieberman, MD
Chief, Spine Anesthesia
Dept. Anesthesia & Perioperative Care
UCSF

---

**Major Spine Surgery -- 1992**

- Congenital Disease
  - Idiopathic Adolescent Scoliosis
- Thoraco-Lumbar
- Neuro-Protection:
  - No electrophysiology
  - Wake-Up Test

---

**1990 - 2000's**

- New Implant technology
- Lumbar Interbody Fusion (LIF)s
  - Posterior
  - Anterior
  - Lateral
- Minimally Invasive Techniques

---

**Trends in Procedures**

- Thoracic
- Lumbar
- Cervical

_Cowan Neurosurgery 2006_
Trends in Spinal Surgery

- Fusions:

![Graph showing trends in spinal surgeries]

Weinstein Spine 2006, Deyo, NEJM 2010

Other Changes...

- Surgical training

![Bar chart showing fellowship vs. non-fellowship]

Magit, J Spinal Disord Tech, 2007

Availability

- EMG – early 1990s
- SSEP – late 90’s
- MEP – mid 00’s

![Image of various diagnostic equipment]

Spine Surgery -- 2012

- Degenerative Spine Deformity
- Older population with co-morbidities
- Neurophysiologic monitoring

![Image of elderly patient with spine deformity]

X-ray Lumbar Scoliosis
Objectives

- Review neuromonitoring modalities
- Describe Anesthetic options
- Other factors that affect NM responses

Neural Injury

Spinal Cord vs. Nerve Roots

<table>
<thead>
<tr>
<th>Spinal cord ends ~ L1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cord</td>
</tr>
<tr>
<td>Roots</td>
</tr>
<tr>
<td>Both</td>
</tr>
</tbody>
</table>

Neurologic Injury

- Spinal Cord Injury:
  - Rare
  - Devastating
  - Motor > Sensory

- Spinal Nerve Root Injury: *(radiculopathy)*
  - Common
  - Rarely permanent - days to months
  - Both motor and sensory
Nerve Root Injury

The Efficacy of Motor Evoked Potentials in Fixed Sagittal Imbalance Deformity Correction Surgery
Jeremy A. Lieberman, MD,* Russ Lichy, MS, DABNM,† John Feiner, MD,* Sarona S. Ho, MD, and Sigurd H. Beren, MD

Overall Nerve Root Injury:
29%

Serious Nerve Injury:
Motor grade ≤ 3/5:
11%

Electromyography

- Electrodes placed near muscles
- Mechanical stimulation of Lower Motor Neuron causes muscle activation
- Electrodes detect currents in muscles that are activated:
  - “Free-Run EMG”

Advantages of EMG

- Detect trauma to specific nerve roots
- Real-time monitor
- Any Anesthetic agent OK-
  - avoid muscle relaxation
- SSEP and dermatomal SSEP of limited utility for nerve root monitoring
- MEP still being evaluated

Sensitivity and Specificity

- Overly sensitive 100%
- Not specific 23% (abundant false positives)
- Positive Predictive Value 8%


Gunnarsson Spine 2004
**Evoked EMG**

- Confirm Pedicle Screw placement
  - Monopolar stimulating electrode

**Medial Wall Breach**

**Somatosensory Evoked Potentials (SSEP)**

- Monitor of sensory tracts
- Will detect global spinal cord ischemia
- Technically simple:
  - Simple stimulation technique
  - Look for changes to latency or amplitude

**SSEP Limitations**

- May miss isolated Motor injury
- Poor at detecting Nerve Root injury
- Affected by Anesthetics:
  - Relaxants OK

**MEP Techniques**

- Stimulation Site:
  - Trans-cranial: Motor cortex - (scalp)
  - Spinal Cord: Near or inside canal
- Response Site:
  - Myogenic: Muscles (EMG)
  - Neurogenic: Peripheral nerve
  - Spinal cord: Epidural space
    - if distal to the surgical site
Most Prevalent “TcMEP”

- Trans-Cranial Stimulation
  - Electric
  - “Threshold”
  - Multiple Pulses - 2 to 9
- Myogenic Response

NO False Negative !!!


Growth of MEP Use

- 2002 -
  - 57 Spine centers
    - 68%: MEPs were used
  - Survey of anesthesiologists (SNACC)
    - 50%: MEPs available
    - 25%: MEPs used for spine cases
- 2003 - FDA “approval” for clinical use


Does It Make a Difference?

- Multimodal monitoring - High Sens. and Spec.
- Little Evidence:
  - Intervention reduces injury rate
  - Specific intervention indicated

Fehlings Spine 2010

Anesthetics and Evoked Resp.

High: Volatile Agents
- N₂O
- Propofol
- Dexmedetomidine
- Narcotics
- Ketamine
- Etomidate
- Lidocaine

Medium: Low:

High: Medium: Low:
Loose Guidelines

- Limit Volatile (< 0.3 MAC) or avoid
- Propofol:
  - Dose: 50 - 150 µg/kg/min
  - Serum level: 2 - 5 µg/mL
- Narcotic
- Consider:
  - Ketamine (3 -10 mcg/kg/min)
  - Lidocaine (1.5 mg/kg/hr)
  - Dexmedetomidine (0.1-0.3 mcg/kg/mn)
- Avoid N₂O - mainly for SSEP

Options

- Anesthetic Goals – more than just to enable SSEPs & MEPs
- Vapor vs. TIVA:
  “Give Me TIVA !!! ”

Cocktails:

- Desflurane (< 0.3 MAC), propofol, fentanyl, lidocaine, ± ketamine
- Propofol, remifentanil, dexmedetomidine
- Etomidate, sufentanil
- Dexmedetomidine, remifentanil
- Ketamine, N₂O

Muscle Relaxants

- Interfere with MEP, EMG responses
- Frequently used
  - Infusion is essential
    - Keep 2-3 twitches out of the TOF
      or 50% of Baseline twitch height

*We prefer to avoid them*
“I’m Giving TIVA…

…..My Work is done”

“Anesthetic Fade”

- MEP (and SSEP) responses decline over time despite consistent anesthetic drug levels or anesthetic depth

- Options:
  - Shorten the case – staging
  - Switch to more favorable agents


“Hemodynamic Fade”

- Altered Physiologic parameters affect SSEP and MEP responses:

Physiologic Factors

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Goal:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood Pressure</td>
<td>MAP &gt; 65 - 70 mmHg</td>
</tr>
<tr>
<td>Hematocrit</td>
<td>&gt; 21% (Hgb &gt;7 gm/dL)</td>
</tr>
<tr>
<td>Temperature</td>
<td>Normal</td>
</tr>
<tr>
<td>Volume</td>
<td>Euvolemia</td>
</tr>
<tr>
<td>Cardiac Output</td>
<td>Maintain – do not simply drive up BP</td>
</tr>
</tbody>
</table>
Challenging Patients

- Age - < 6
- Preexisting Weakness
  - MEPs are harder to obtain
  - Sensitive to anesthetics
    - Avoid volatile agents
    - Accelerated “fade”
- Opiate Tolerant
  - Ketamine, Lidocaine, Dexmedetomidine

Lyon et al. J. Neurosurg Anes 2005

Normal MEP Tracings

Surgeon Sinking A Screw

Recovery of MEPs
**Loss of MEP Responses 2**

15:48: Bolus of Propofol 50mg...

---

**OOOPS!!....Anesthetic Bolus**

15:48: SBP drops by 40mmHg

---

**All Better**

Gave fluids and decreased anesthetic levels....

Surgeon waited until MEPs improving before continuing

---

**Example 3**
What Happened?

- Surgeon: “I didn’t do anything!!!”
- Anesthesia: “I didn’t change anything!!!”
- Cell-Saver technician: “My reservoir is getting full”

- CVP - dropped from 10 to 6
- MAP - dropped 20 mmHg
- Hgb - now 7.4 (last was 9.0)

After Resuscitation...

Note The Similarity

Summary

- Demand for monitoring is increasing
- Anesthetic choices must try to be compatible with monitoring
- Continued vigilance to maintain:
  - Favorable anesthetic levels
  - Hemodynamic homeostasis