Anesthesia Challenges: Intraoperative Neurophysiologic Monitoring and Anesthesia
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12 March 2011

Our role with neurophysiologic monitoring
- Patients at risk for hypoxia and ischemia to vital neurological structures
- Intraoperative neurophysiologic monitoring improves patient outcome through early detection and early intervention
- Our objectives:
  - Understand the basic physiology behind neurophysiologic monitoring
  - Discuss how our anesthetics interact and affect the monitoring
  - Apply our knowledge of physiology and pharmacology to develop an anesthesia plan that optimizes patient outcome

Intraoperative Neurophysiologic Monitoring (IONM)
- IONM or surgical neurophysiology is a growing allied health field in which surgical neurophysiologists works closely with the surgeons and anesthesia providers to monitor the nervous system during certain surgical procedures.
- IONM reduces complications such as paralysis, hearing loss and stroke by detecting injury in time to prevent it.
- Overall incidence of neurological complications after spine surgery (including scoliosis surgery) - 4%
- Typical monitoring cases include spine surgeries and some vascular surgeries i.e. carotid endarterectomies and thoracic-abdominal aortic aneurysms.
A Word About POVL
(post operative vision loss)

- Incidence 1% or less
- Ischemic optic neuropathy (ION) was the most common (89%) cause of POVL after spine surgery in the prone position.
- At least one of the following was present along with prone position:
  - > 1000 ML EBL
  - > 6 hours of anesthetic duration
  - Foam Pillow used in 77% of cases
  - 50% recovery rate
- Central Retinal Artery Occlusion - 0% recovery rate


Case Presentation

- 42 y/o male ASA II with C5-C7 cervical stenosis from DJD scheduled for minimally invasive cervical laminectomy and microdiscectomy with spinal fusion.
- HTN, Hyperlipidemia
- NKDA
- Ht: 172.5cm   Wt: 104kg   BMI: 36
- Hg: 14.8, other labs unremarkable

Neurological manifestations

- With 90 degree flexion of neck, parathesias are elicited into the index and middle finger bilaterally.
- "neck" considered stable by neurosurgeon.
- Scheduled for SSEP, EMG and TcMEP IONM
- Surgical neurophysiologist requests:
  - NO N2O or muscle relaxation and less than 0.5 MAC of volatile agent.
In the 1970s, following the development of commercial evoked potential equipment, SSEP was used to prevent paralysis in scoliosis surgeries. SSEP monitoring has become the standard of care for a wide variety of spinal and other surgeries.

In the 1980s, the development of transcranial motor evoked potential (TcMEP) monitoring led to multimodal spinal cord monitoring capabilities. Multimodal spinal cord monitoring has become the gold standard of care and is the preferred method for detection and reduction in intraoperative spinal cord injury.

**IONM Modalities**

- **Somatosensory Evoked Potentials (SSEP)**
  - Records the response from the brain or spinal cord after an electrical stimulation from a peripheral nerve. Monitors the integrity of the dorsal columns of the spinal cord including posterior spinal arteries ischemia. Any decrease in amplitude and increase in latency could indicate nerve injury.

- **Transcranial Electrical Motor Evoked Potentials (TcMEP)**
  - An electrical stimulus is applied to the motor cortex of the brain. A response is recorded from the spinal cord or from limb muscles. Monitors function of the anterior, ascending motor tracts of the spinal cord.

- **Brainstem Auditory Evoked Potentials (BAEP)**
  - An electrical brainstem response to an auditory stimulus, usually a click delivered through small-in-the-ear earphones. Used to monitor brainstem function and to help preserve hearing in acoustic neuromas and brainstem tumor cases. Least affected by our anesthetics.

- **Electromyography (EMG)**
  - Evoked EMG, using an electrical stimulus delivered through hand-held probes used by the surgeon, is used to identify and test spinal nerve roots, cranial nerves and peripheral nerves.

- **Pedicle Screw Stimulation**
  - An evoked EMG obtained by stimulating a screw placed in pedicle. Since a nerve root lies immediately beneath each pedicle, a response indicates a breach in the pedicle.

- **Electroencephalogram (EEG)**
  - Records spontaneous brain activity of the cerebral cortex.
**Multimodal IONM**

- Reduces neural risk
- Improves surgical decision making
- Affected by our choice and management of anesthetic agents

**What else can affect IONM responses?**

- Surgical nerve injury
  - Trauma
- Irrigation
- Direct injury
- Anesthetic management
- Anesthetic agents
- Patient physiologic factors and temperature
- Technical difficulties
  - Lead placement
  - Amplifier
  - Stimulator

**Anesthetic Considerations**

- Develop a plan that optimizes IONM and patient outcome
- Three key components of our plan
  - Anesthetic choice and management
  - Management of patient’s physiologic parameters which supports neural functioning
  - Pharmacological management of muscle relaxation
How Does Anesthesia Affect Intraoperative Neurophysiologic Monitoring for Spine Surgery?

Effects of Anesthetic Agents

- Most volatile anesthetics cause a dose-dependent depression of amplitude and a dose-dependent increase in latency.
- Changes start to occur at 0.5% MAC for SSEP.
- Changes start to occur at 0.2% MAC for MEP.
- Effects of low% MAC overcome by high frequency transcranial stimulation (toeMEP).
- Recommendation: Avoid inhalational agents for optimal MEP monitoring.


Nitrous Oxide

- Unpredictable additive/synergistic effects with halogenated agents.
- 60-65% N2O has minimal effect on latency but decreases amplitude.
- 50% or less N2O combined with narcotic, etomidate, propofol and ketamine produce reliable monitoring.
- Recommendations with IOMN:
  - Do not use in combination with halogenated agents.
  - Use 50% or less N2O especially when using with propofol.
IV Anesthetic Agents

- **Opioids**
  - Cause a mild decrease in amplitude and increase in latency with both SSEP and MEP monitoring
  - Improves myogenic response with MEP by reducing background motor unit potentials and muscle contractions

Intravenous Anesthetic Agents

- **Propofol**
  - Dose dependent decrease in amplitude for SSEP and MEP monitoring
  - Depresses amplitude completely with an induction dose with a rapid recovery
  - Easy to titrate
  - Popular agent in TIVA

- **Barbiturates and Benzodiazepines**
  - Mild depression of SSEP with quick recovery
  - Prolonged marked depression of MEP at the compound muscle action potential
  - Thiopental and midazolam should be avoided for induction

- **Ketamine**
  - Enhances SSEP and MEP amplitude responses
  - Desirable for IONM
  - Increases in ICP and hallucinations may limit usage
IV Anesthetic Agents

- **Etomidate**
  - Increases cortical SSEP amplitude and latency
  - Associated with myoclonus which suggests increase cortical activity
  - Has a sustained amplitude enhancement with continuous infusion with both SSEP and MEP monitoring

- **Droperidol**
  - Minimal effects when used with fentanyl
  - Concerns with prolonged QT may preclude its usage

IV Anesthetic Agents

- **Dexmedetomidine** (Precedex)
  - Alpha 2 agonist
  - "Cooperative sedation"
  - Anxiolysis, analgesia, amnesia
  - No respiratory depression
  - Has minimal to no effect on SSEP or MEP monitoring
  - Used as an adjunct with a propofol-based TIVA for spine surgery

DEX and POSTOPERATIVE NEURO ASSESSMENT

- DEX offers an advantage for patients who need immediate postoperative neurological evaluation
- Intubated patients are comfortably sedated and easily aroused for sequential neuro checks
- Intubated patients after anteroposterior multi level fusion sedated with DEX vs propofol had more consistent neuro checks performed
- 20 patients studied, 10 on DEX, 10 on propofol
- 3 patients on propofol could not complete their neurological exam
Muscle Relaxants

- Will not effect SSEP monitoring
- May improve SSEP amplitude by reducing background muscle artifact
- Profound NMB will obliterate MEP
- No NMB agent after intubation with MEP
- Partial NMB (2/4 TOFwitches) beneficial in reducing patient movement which accompanies testing
- Can mimic neural injury

Indications for MRs when using MEP monitoring

- Sufficient blockade to attenuate patient movement when stimulation interferes with surgery
- Distractions while using the microscope
- To facilitate surgical manipulations of muscles
- To reduce electromuscular noise in SSEP monitoring

Somatosensory Evoked Potentials

- All volatile agents have a dose dependent increase in latency and a decrease amplitude - a depressant effect.
- Nitrous Oxide have mixed effect on amplitude and latency - more profound with volatile agents.
- Benzodiazepines, barbiturates and propofol produce a dose dependent increase in latency and decrease in amplitude < halogenated agents.
- Etomidate and ketamine minimally decrease latency and increase amplitude - a stimulating effect.
- Opioids and dexmedetomidine does not affect SSEP monitoring.

Muscle relaxants do not affect SSEP

DEX can be used as an adjunct for TIVA
Motor Evoked Potentials (MEP)

- All inhalational agents depress MEP
- Nitrous Oxide depresses to a smaller degree with IV agents
- Benzodiazepines, barbiturates and propofol depress MEP more than SSEP but can be overcome with multi-stimulation.
- Etomidate and ketamine have a mild stimulating affect.
- Opioids and dexmedetomidine does not affect MEP monitoring.
- Muscle relaxants obliterate MEP.

Temperature - changes affect latency more than amplitude
- as core temp decreases, latency increases by slowing conduction velocity
- as core temp increases, latency shortens
- changes in regional temp, can alter EP
- using cold irrigation on the spinal cord

Patient Physiologic Parameters Affecting IONM

- Blood Pressure
  - changes affect amplitude more than latency
  - hypotensive anesthesia may be used to minimize blood loss
  - MAP < 60 starts to show changes in SSEP
  - MAP < 50 could cause absent responses to SSEP
Patient Physiologic Parameters Affecting IONM

- HCT less than 10% to 15% will increase latency and decrease amplitude in SSEP
- Hypoxemia leads to ischemia which leads to neural injury decreasing amplitude
- Hyperventilation causes vasoconstriction, decreasing spinal cord blood flow, causing ischemia (CO2<20mmhg) altering SSEP and, potentially, MEP

Determined first and foremost: what is safe for the patient?
- Preoperative discussion of the case with the surgeon, and anesthesia and monitoring teams
- Monitoring, positioning, lines, anesthetic agents and airway management
- This case included SSEP, tMEP and EMG monitoring
- Standard monitoring plus invasive blood pressure monitoring and BIS

Anesthetic Choice and Management

- 42 y/o male ASA II with C5-C7 cervical stenosis and DJD scheduled for a minimally invasive cervical laminectomy and discectomy with spinal fusion.

Airway Management (Glidescope)

- Cervical spine motion at C2-5 segment was reduced by 50%
- Had a better glottic view compared to DL with same amount of c-spine movement
- Took 62% longer to intubate vs the MAC #3 blade
Anesthetic Options

- <0.5% MAC of volatile agents
  - DES and SEVO preferred due to their insolubility
- < 0.6% MAC of N2O
  - safer when used with IV anesthetic
- Opioids, ketamine, DEX, etomidate have minimal effects
- Propofol, BENZOs and BARBS dose-dependent depression
- Muscle Relaxants - must be well monitored

Anesthetic Plan

42 y/o male ASA II with C5-C7 cervical stenosis scheduled for a cervical laminectomy with spinal fusion.

Induction
- fentanyl, ketamine 20mg IV, Lidocaine, decadron, rocuronium, SEVO

Maintenance
- propofol 120mg/kg/min and remifentanil 0.12mcg/kg/hr, no muscle relaxant and SEVO off - excellent IONM responses
- surgeon used local at the beginning and the end of surgery

Emergence
- wide awake with no c/o surgical site discomfort
- moved all 4 extremities

Trouble Shooting

- Surgeon checks retractors, surgical site for potential nerve impingement
- Technician checks recording electrodes, check filter settings or may increase stimulation rate
- Anesthesia Team
  - eliminate N2O or volatile agent
  - maintain a steady state of physiologic parameters
  - switch to TIVA with remifentanil, DEX, etomidate, ketamine
What are your choices?

- 39 y/o male for L4-L5 lumbar laminectomy and fusion with SSEP and EMG IONM: Anesthetic technique included 0.5% MAC of Isoflurane, sufentanil infusion and vecuronium.

Since multimodal monitoring increases safety and quality of care for spine surgery, our evidenced-based anesthetic will carry on our anesthetic tradition of vigilance.