INTRAOPERATIVE NEUROPHYSIOLOGIC MONITORING IN SPINAL DEFORMITY SURGERY

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DISCLOSURES
RESEARCH: OREF, CSRS, BARNES JEWISH FOUNDATION, FOX FAMILY FOUNDATION, NIH
OVERVIEW

• Why Monitor?
• How to Monitor?
• What to do when IOM alerts?
• Case Examples

WHY MONITOR?

• Provide continuous information concerning the status of “at risk” neural elements during surgery
• Serve as an early warning system to alert the surgeon to changes in neural status in a timely manner
• Assist in providing the patient with an optimal outcome
WHY MONITOR?

• New Neurological Deficits are not UNCOMMON in Spinal Deformity Surgery
  • Nearly 20% in Fox Pediatric and Scoli-Risk-1 Adults
• WashU: 12,375 Monitored cases over 25 years
  • 3.1% Rate of IOM alerts
    • 93% of these cases data recovered
    • 0.12% with permanent deficits
• IOM Will Help Minimize the Risks of New Neurological Deficits
  • Provided we respond appropriately

HOW TO MONITOR?
BASIC COMPONENTS

• Somatosensory Evoked Potentials (SSEP)
• Motor Evoked Potentials (MEP)
• Descending Neurogenic Evoked Potentials (DNEP)
• Triggered and Spontaneous Electromyography (EMG)
• Stagnara Wake-up Test
BASIC COMPONENTS

• Each patient is his or her own control
• Data used as “baselines” are recorded at completion of wound exposure
• Data interpretation is performed by individual electrophysiologists (@ WashU)
• Physician over-sight programs are more common

SOMATOSENSORY EVOKED POTENTIALS

• Obtained via peripheral nerve stimulation
• Ascending signal is carried by the posterolateral tracts of the spinal cord
• Primary information contained in the SSEP is proprioception
• End point of reception is the somatosensory cortex
SOMATOSENSORY EVOKED POTENTIALS

• Signal averaged data, not a “real time” analysis
• Frequency of data collection increases sensitivity to operative events
• Provides information about the entire sensory pathway
• Cortical SSEPs are sensitive to a variety of systemic events

SSEP RECORDING SITES

• Cortical data sensitive to cerebral blood flow issues
• Not sensitive enough to use in isolation and requires multimodal IOM
DESCENDING NEUROGENIC EVOKED POTENTIAL (DNEP)

• Stimulation at the level of the spinal cord
• Response is composed largely of antidromic sensory activity
• NOT a motor evoked potential
• Neurogenic recording eliminates interference due to patient movement

DESCENDING NEUROGENIC EVOKED POTENTIALS

• Regardless of neurophysiologic composition, the DNEP has proven extremely sensitive to spinal cord deficits
• When obtained, DNEP data are very consistent and repeatable
• Only anesthetic requirement is near complete muscle relaxation
DNEP STIMULATION METHODS

- Placement of two needle electrodes into the tips of consecutive spinous processes (SP-DNEP)
- Percutaneous placement of two 50-75mm needle electrodes onto the base of consecutive cervical laminae (PERC-DNEP)
- Insertion of an epidural catheter via a laminotomy within operative spinal levels (EPI-DNEP)
- 1/2 inch needle electrodes into the disc space of two consecutive spinal levels (anterior procedures)

PERCUTANEOUS DNEP
UNTIL BROWN SEQUARD

EPIDURAL DNEP
MOTOR EVOKED POTENTIALS

• True motor evoked potentials are elicited via stimulation of the motor cortex
• Transcranial stimulation is achieved with two methods:
  • Electrical excitation (TCeMEP)
  • Magnetic excitation (TCmMEP)

MOTOR EVOKED POTENTIALS

• Short acting muscle relaxant should be used for intubation to allow MEP data acquisition prior to incision
• Use of relaxant during wound exposure is acceptable and much appreciated by the surgeon
• Minimal or no use of relaxant is optimal. If used, titration to maintain 1/4 or 2/4 twitches is required
MOTOR EVOKED POTENTIALS

- Jaw clenching with stimulus presentation is common. Use of a bite block is necessary.
- Tongue lacerations are the most frequently reported complication when using TCeMEP.
- Use of an oral airway as a bite block is not recommended.

NERVE ROOT MONITORING

- Origins of the technique are in the area of cranial nerve surgical monitoring.
- Advent of segmental spinal instrumentation (pedicle screws) led to the development of spinal nerve root monitoring.
- Nerve root specific information was not available with SSEP and MEP techniques.
NERVE ROOT MONITORING

- EMG recordings may be triggered or spontaneous
- Triggered EMG was developed to objectively assess positioning of pedicle screws
- Pedicle screw placed in bone, without breach, will require greater stimulation to trigger a response from the corresponding spinal nerve root
- Low triggered EMG responses may suggested some breach of bony margins

TRIGGERED EMG

NORMATIVE VALUES

- Thresholds greater than 8.0 mA consistent with intact pedicle walls
- 4.0 to 8.0 mA, possible pedicle wall breach, physical inspection recommended
- Less than 4.0 mA, very strong likelihood of pedicle wall defect
TRIGGERED EMG

SSEP ANESTHETIC CONSIDERATIONS

- Halogenated agents: 0.5 MAC or less
- Nitrous oxide: 50% or less, if at all
- Intravenous anesthetics: drip infusion rather than bolus
- Muscle relaxant: 0/4, but data can be obtained with more activity
MOTOR EVOKED POTENTIALS
ANESTHETIC CONSIDERATIONS

• Cortical stimulation requires specific anesthetic administration
• Inhalational anesthetics depress MEP amplitudes in a dose-dependent manner
  • Prefer Total IV Anesthesia (TIVA)
• Length of surgery and pre-operative neurologic status can compound the effects of inhaled anesthetics
• False warnings to the surgeon minimize effectiveness of intraoperative monitoring
• Loss of intra-op data results in unnecessary wake-up tests

STAGNARA WAKE-UP TEST

• Original form of intraoperative monitoring
• Largely replaced with electrophysiologic techniques
• Remains the “gold standard” for intraoperative motor assessment
• Used to confirm loss of intraoperative data
STAGNARA WAKE-UP TEST

• Advance preparation is necessary, all personnel should be trained to perform a wake-up test
• Patients should be rehearsed repeatedly and informed of this possibility
• Use of the wake-up test is a surgeon’s prerogative

IN THE CASE OF IOM CHANGES

Stephen Lewis, Spine 2013

Type I: Prior to Decompression
Type II: During Decompression/Osteotomy
Type III: After Osteotomy Closure
TYPE I IOM ALERT
PRIOR TO DECOMPRESSION

- Increase MAP
- Remove / Reduce Traction
- Check Implants if in
  - EMG Stimulation
  - Radiographs
  - Remove

TYPE II IOM ALERT
DURING DECOMPRESSION / OSTEOTOMY

- Increase MAP
- Place stabilization rod if not in place
- Remove traction
- Continue / Complete Decompression and Osteotomy
- Close Osteotomy
  - If no improvement, open and reduce reduction
TYPE III IOM ALERT
AFTER OSTEOTOMY CLOSURE

• Raise MAP
• Open Osteotomy and Ensure Adequate Resection
• Reclose with Less Correction/Shortening

EVEN BRIEFER SUMMARY
IN THE CASE OF IOM CHANGES

• Check BP & ↑ if hypotensive (map ≥80 mmHg)
• Consider immediate release of any distractive/correction forces placed on the spinal column via instrumentation/traction
  • Release set screws
  • Actually remove rods
  • Remove implants i.e. hooks, screws, or wires that are potentially impinging on the neural elements
• Check hemoglobin & transfuse if hemoglobin >10
• Order wake-up test
THE “UNMONITORABLE” PATIENT

- Do not go without monitoring!
  1. Following positioning (if at risk)
  2. Following exposure
  3. Following implant (screw) placement
  4. Immediately following correction
  5. Approx. 1H after correction
  6. Prior to leaving operating room

CASE EXAMPLES
13 YEAR OLD, F, PIERRE-ROBIN
13 YO F, KYPHOSING SCOLIOSIS

- PCO T4-T6, T8-T11, with planned apical resection
- DNEP and SSEP data lost during Screw Placement
  - Reversed with increased MAP and Temporary Rod with shortening
  - Data lost AGAIN During Fascial Closure

13YO F, KYPHOSING SCOLIOSIS, LOSS OF IOM

- Loss of Left DNEP/SSEP
- Decrease in Right
- Stagnara = No LLE Motor
HYNDMAN-SCHNEIDER DECOMPRESSION

APICAL PEDICULECTOMY

- Return of Data
- Stagnara Normal
- Surgery Completed 1 week later
18 YO M, SCHEUERMANN WITH SYMPTOMATIC THORACIC HNP

- Plan T3-L3 PSF with T11-T12 Discectomy
- Rods placed, loss of Left, then Right side data
  - Returned with rods removed
- Rods replaced with less correction, Loss of Right data alone, no return with rod removal
MAPPING THE DEFICIT WITH NMEP

- Used epidural catheter to “map” the deficit
  - Data at T11-T12 intact
  - Data at T10-T11 intact
  - No data at T9-T10
- Circumferential decompression performed at T9-T10
  - Data returned to 50% of baseline with normal SSEP
  - Stagnara normal

LOSS OF IOM DURING KYPHOSIS WITH HNP

- Short rods spanning decompressed levels
- Return to OR in one week for PSF without correction
- No deficits
CONCLUSION

• IOM is effective
  • Must be multimodal with SSEP and DNEP/TcMEP
• Proper attention to IOM changes will help minimize new neurological deficits
  • Attention to MAP
  • Adequate decompression
  • Inadequate/Excessive Correction
• IOM Should be used in all spinal deformity surgeries in NA

Thank You