Intraoperative Neurophysiological Monitoring in Spine Surgery

- Use of a Brain Monitor in a Pediatric Scoliosis Spinal Fusion with Instrumentation to Prevent a Full Wake-Up Test: A Case Report
- Intraoperative neurophysiological monitoring and patient-related outcomes in thoracic spinal meningiomas surgery: a single-center retrospective cohort study
- Assessing Surgical Outcomes in Cervical Degenerative Disease: The Role of Intraoperative Neurophysiological Monitoring
- The need for neuromonitoring during growing rod surgical distractions
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- Effect of low-dose volatile anesthetics on intraoperative neurophysiological monitoring during anesthesia with remimazolam

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Introduction

Intraoperative neurophysiological monitoring (IONM) is an essential tool in spine surgery, allowing real-time assessment of the functional integrity of neural structures, including the spinal cord, nerve roots, and peripheral nerves. It plays a crucial role in reducing the risk of neurological injury and improving surgical outcomes.

Modalities Used in IONM for Spine Surgery

Different neurophysiological modalities are used depending on the type of spine surgery and the structures at risk. These include:

Somatosensory Evoked Potentials (SSEPs)

- Monitor sensory pathways in the dorsal columns of the spinal cord.
- Commonly used in surgeries involving the cervical and thoracic spine.
- Reduction in amplitude or increase in latency can indicate ischemia or mechanical compression.

Motor Evoked Potentials (MEPs)

- Assess the functional integrity of the corticospinal tract.

- Useful in procedures where motor pathways are at risk, such as scoliosis correction or spinal tumor resection.
- MEP loss or attenuation signals potential motor pathway compromise.

Electromyography (EMG)

- **Spontaneous EMG** detects nerve root irritation or compression.
- **Triggered EMG** helps identify nerve roots and assess pedicle screw placement.
- Used extensively in lumbosacral procedures to minimize iatrogenic nerve damage.

Dorsal Column Mapping

- Used in intramedullary spinal cord tumor surgeries to delineate sensory pathways and preserve function.

Brainstem Auditory Evoked Potentials (BAEPs)

- Occasionally used in cervical spine surgeries where the brainstem may be at risk.

Clinical Applications of IONM in Spine Surgery

IONM is beneficial in various spinal procedures, including:

- **Scoliosis and Deformity Correction (e.g., AIS, kyphosis)**
  - High risk of spinal cord injury due to deformity correction maneuvers.
  - Combined SSEP and MEP monitoring provides optimal safety.
- **Cervical and Thoracic Myelopathy Surgery**
  - IONM helps prevent iatrogenic spinal cord injury during decompression and instrumentation.
- **Lumbar and Sacral Spine Surgery**
  - EMG monitoring minimizes the risk of nerve root damage during decompression, pedicle screw placement, and interbody fusion procedures.
- **Spinal Tumor Resection**
  - SSEPs, MEPs, and direct spinal cord stimulation help in tumor resection while preserving neurological function.
- **Spinal Cord Injury and Trauma Surgery**
  - IONM provides real-time feedback on spinal cord function to guide surgical intervention.

—- Neuromonitoring in minimally invasive spine surgery (MISS) provides real-time feedback to surgeons and enhances surgical precision for improved patient safety. Since the 1970s, established techniques like somatosensory evoked potentials, motor evoked potentials, and electromyography have been integrated into spine surgeries, significantly reducing the risk of neurological complications. These neuromonitoring modalities have been crucial, particularly in complex

procedures with limited direct visualization. Refinements in these techniques have led to greater confidence in nerve root safety, contributing to the success of MISS. Despite some debate regarding the routine use of neuromonitoring in noncomplex surgeries, its importance in complex cases is well-documented. Studies have demonstrated high sensitivity and specificity rates for these techniques, with multimodal approaches offering the best outcomes. Advancements in mechanomyography and its potential integration into neuromonitoring protocols highlight the continuous improvement in this field. As MISS continues to evolve, adopting next-generation neuromonitoring systems, including artificial intelligence and machine learning, will play a pivotal role in advancing the efficacy and safety of spine surgeries. [1)]

Limitations and Challenges of IONM

- **False Positives/Negatives**: Variability in patient positioning, anesthesia effects, or technical issues can lead to misleading results.
- **Anesthetic Influence**: Certain anesthetics (e.g., inhalational agents) can suppress MEP signals, necessitating the use of total intravenous anesthesia (TIVA).
- **Cost and Availability**: Requires specialized equipment and trained personnel, which may limit its use in some centers.

Conclusion

IONM has become a standard of care in complex spine surgery, providing critical intraoperative feedback to reduce the risk of neurological injury. A multimodal approach using SSEPs, MEPs, and EMG offers the most comprehensive protection for neural structures. However, proper interpretation of IONM signals and integration with surgical decision-making are essential for optimal outcomes.

Systematic literature review

The objective of a systematic literature review was to evaluate if intraoperative neurophysiological monitoring (IONM) can prevent neurological injury during spinal operative surgical procedures.

IONM seems to have presumable positive effects in identifying neurological deficits. However, the role of IONM in the decrease of new neurological deficits remains unclear.

Using the Preferred Reporting Items for Systematic Reviews and MetaAnalyses (PRISMA) guidelines for systematic reviews and Meta-analysis, Daniel et al., from São Paulo, Brazil, reviewed clinical comparative study who evaluate the rate of new neurological events in patients who had a spinal surgery with and without IONM. Studies were then classified according to their level of evidence. Methodological quality was assessed according to methodological index for non-randomized studies instrument.

Six studies were evaluated comparing neurological events with and without IONM use by the random effects model. There was a great statistical heterogeneity. The pooled odds ratio (OR) was 0.72 {0.71; 1.79}, P=0.4584. A specific analysis was done for two studies reporting the results of IONM for spinal surgery of intramedullary lesions. The OR was 0.1993 (0.0384; 1.0350), P=0.0550.

IONM did not result into fewer neurological events with the obtained evidence of the included studies. For intramedullary lesions, there was a trend to fewer neurological events in patients who underwent surgery with IONM. Further prospective randomized studies are necessary to clarify the indications of IONM in spinal surgery [2].

Intraoperative neurophysiological monitoring for anterior cervical discectomy and fusion

Intraoperative neurophysiological monitoring for anterior cervical discectomy and fusion.

Intraoperative neurophysiological monitoring for Lumbar Spinal Instrumentation

Intraoperative neurophysiological monitoring for Lumbar Spinal Instrumentation.

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2)
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