INTRAOPERATIVE NEUROMONITORING — CLINICAL REFERENCE

The MindSync IONM Guide

A technical reference on intraoperative neuromonitoring for spine surgeons, pain-management physicians, neurophysiologists, and surgical facilities.

Prepared by the Mind Sync Clinical Team

Oscar Padilla, Clinical Manager

We specialize in IONM · 2500 Dallas Pkwy, Suite 500, Plano, TX 75093

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1. Clinical rationale & the multimodality approach

Intraoperative neuromonitoring (IONM) provides continuous, real-time assessment of nervous-system function while a patient is anesthetized and unable to report symptoms. Its purpose is to detect an evolving, potentially reversible insult to neural structures early enough that the surgical or anesthetic team can intervene before injury becomes permanent.

No single modality assesses the entire nervous system. Sensory and motor pathways travel in anatomically distinct tracts with different vascular supplies, and each modality has blind spots. A multimodality approach — selected for the specific procedure and structures at risk — provides complementary coverage and reduces the chance that an injury goes undetected.

Why combine modalities

- SSEP monitors the dorsal-column / medial-lemniscus sensory pathway but can miss isolated anterior (motor) cord injury.
- MEP monitors corticospinal motor pathways but is more anesthesia-sensitive and intermittent.
- EMG detects mechanically or thermally provoked nerve-root irritation in real time and guides instrumentation.
- Together they give overlapping sensory, motor, and nerve-root coverage tailored to the case.

2. Monitoring modalities

SSEP — Somatosensory Evoked Potentials

Principle. Peripheral mixed-nerve stimulation (commonly posterior tibial, median, or ulnar) generates a response recorded over the peripheral nerve, spine, and contralateral somatosensory cortex (e.g., CPz/CPc).

What it assesses. Integrity of the dorsal-column / medial-lemniscus pathway and, indirectly, overall spinal-cord and cortical function. Useful for positioning-related plexopathy as well as surgical risk.

Commonly cited alarm criteria

- A ≥50% reduction in cortical amplitude and/or a ≥10% increase in latency from a stable baseline is a widely used warning threshold.
- Trends matter more than a single sweep; confirm reproducibility before alarming.

Anesthetic sensitivity. Relatively robust. Affected by halogenated agents and nitrous oxide in a dose-dependent way; stable anesthesia improves signal consistency.

Limitations. Does not directly assess motor pathways; averaged and therefore not instantaneous; sensitive to limb temperature, ischemia, and technical factors.

MEP — Transcranial Motor Evoked Potentials (TcMEP)

Principle. Transcranial electrical stimulation (a high-voltage pulse train over motor cortex) elicits descending corticospinal volleys recorded as compound muscle action potentials (CMAPs) in target muscles.

What it assesses. Functional integrity of the corticospinal (motor) pathway — the tract most vulnerable in anterior cord ischemia and the one SSEP can miss.

> **Commonly cited alarm criteria**
>
> - Criteria are institution-dependent. Common approaches include all-or-none loss of the muscle response, a significant amplitude reduction (often cited as >50–80%), or an increase in the stimulation threshold (often >100 V).
> - Because muscle MEPs are inherently variable, the chosen criterion should be defined and applied consistently.

Anesthetic sensitivity. Highly anesthesia-sensitive. Total intravenous anesthesia (TIVA) is strongly preferred; halogenated agents and nitrous oxide markedly suppress responses. Muscle MEPs are abolished by neuromuscular blockade.

Limitations. Intermittent (cannot run continuously); contraindications include epilepsy, cortical lesions, implanted stimulators/pacemakers, and skull defects (relative); risk of bite injury and movement.

D-wave (epidural recording)

In intramedullary spinal-cord tumor surgery, a D-wave recorded from an epidural electrode measures the fast corticospinal volley directly. A >50% D-wave amplitude reduction is concerning; preservation of the D-wave correlates with motor recovery even if muscle MEPs are transiently lost, making the two complementary in IMSCT cases.

EMG — Electromyography (free-running & triggered)

Principle. Free-running EMG continuously listens for spontaneous motor-unit activity; triggered (stimulated) EMG applies a known current to instrumentation or tissue and records the evoked muscle response.

What it assesses. Real-time nerve-root irritation (neurotonic discharges) and the proximity of pedicle screws or instrumentation to neural elements.

> **Commonly cited alarm criteria**
>
> - Pedicle-screw stimulation: thresholds below roughly 5–8 mA raise concern for a pedicle breach or screw–nerve proximity; values above ~10–15 mA are generally reassuring.
> - Interpret thresholds in context — chronic compression, osteoporotic bone, current shunting, and CSF can all skew values.

Anesthetic sensitivity. Free-running and triggered EMG are abolished by neuromuscular blockade; avoid paralytics after intubation when EMG is monitored.

Limitations. Sensitive but not specific; absence of activity does not guarantee an intact root; mechanical artifact can mimic discharges.

EEG — Electroencephalography

Principle. Continuous recording of cortical electrical activity from scalp electrodes, interpreted for symmetry, frequency content, and burst-suppression.

What it assesses. Cerebral cortical function, depth of anesthesia, and regional ischemia — most commonly cross-clamp ischemia during carotid endarterectomy.

> **Commonly cited alarm criteria**
>
> - During carotid cross-clamp, attenuation or slowing (especially asymmetric) suggests ischemia and may prompt shunting or blood-pressure augmentation.
> - Always interpret against the patient's own baseline and current anesthetic state.

Anesthetic sensitivity. Strongly modulated by anesthetic agents (burst-suppression at depth); hypothermia and hypotension also alter the trace.

Limitations. Detects cortical, not deep or brainstem, ischemia; artifact-prone in the OR environment.

BAER — Brainstem Auditory Evoked Responses

Principle. Click stimuli delivered to the ear generate a far-field response whose waves reflect sequential activation of the auditory pathway — Wave I (distal CN VIII), Wave III (caudal pons), and Wave V (midbrain / inferior colliculus).

What it assesses. Auditory-nerve and brainstem functional integrity, particularly in posterior-fossa and cerebellopontine-angle procedures.

> **Commonly cited alarm criteria**
>
> - Significant latency prolongation or amplitude loss of Waves I–V relative to baseline is the warning signal; Wave V is the most robust to follow.
> - Wave I loss suggests a peripheral (CN VIII / cochlear) cause rather than central.

Anesthetic sensitivity. Comparatively resistant to anesthetic agents, which makes BAER a stable brainstem monitor.

Limitations. Low amplitude requires extensive averaging (slow to update); pre-existing hearing loss limits utility.

3. Alarm criteria & the signal-change response algorithm

When a monitored signal changes meaningfully, the value of IONM lies in a fast, disciplined response. A structured algorithm separates true neural events from technical or systemic causes and drives timely intervention.

Quick-reference alarm thresholds

SSEP	≥50% amplitude drop and/or ≥10% latency increase from baseline.
Muscle MEP	All-or-none loss, marked amplitude reduction (often >50–80%), or threshold rise (often >100 V) — per institutional criterion.
D-wave	>50% amplitude reduction (intramedullary tumor surgery).
Triggered EMG	Screw-stimulation threshold below ~5–8 mA suggests breach / proximity.
EEG	New or asymmetric attenuation/slowing (e.g., during carotid cross-clamp).
BAER	Significant latency prolongation or amplitude loss of Waves I–V.

Signal-change checklist

When a change occurs

- **Confirm it is real.** Check electrodes, impedances, stimulation, and recording before alarming; verify reproducibility.
- **Rule out systemic causes.** Blood pressure (MAP), temperature, hematocrit, CO2, anesthetic depth, and recent neuromuscular blockade.
- **Communicate immediately.** Notify the surgeon and anesthesia team with the specific finding and timing.
- **Correlate with surgical events.** Distraction, instrumentation, retraction, positioning, or hemostatic maneuvers.
- **Support intervention.** Consider pausing or reversing the recent maneuver, augmenting MAP, releasing distraction, or repositioning.
- **Monitor for recovery and document.** Track the trend back toward baseline and record the event, response, and outcome.

4. Anesthetic & physiologic considerations

Anesthetic technique is integral to a successful IONM case, especially when motor pathways are monitored. Early coordination between the surgeon, anesthesiologist, and monitoring team prevents avoidable signal loss.

- **TIVA is preferred when MEPs are monitored** — typically propofol plus an opioid, sometimes with ketamine or dexmedetomidine as adjuncts to permit lower hypnotic doses.
- **Halogenated agents and nitrous oxide** suppress MEPs (and, to a lesser degree, SSEPs) in a dose-dependent fashion; minimize or avoid them when motor monitoring is required.
- **Neuromuscular blockade** abolishes muscle MEPs and EMG; after intubation, paralytics should be avoided or tightly controlled when these are monitored.
- **Maintain a stable anesthetic plane** — abrupt bolus dosing produces transient signal changes that mimic surgical events.
- **Physiologic factors** — hypotension, hypothermia, anemia, and hypocapnia degrade signals and must be excluded before attributing a change to surgery.

5. Procedure-specific monitoring strategies

Cervical spine	SSEP + MEP for cord-level risk; EMG for nerve-root and positioning monitoring (myelopathy, corpectomy, fusion).
Thoracolumbar fusion	Triggered EMG for pedicle-screw testing; SSEP + MEP where cord or conus is at risk; free-running EMG for root protection.
Deformity / scoliosis	SSEP + MEP are standard given correction-related cord-ischemia risk; respond to distraction-related changes promptly.
Intramedullary tumor	D-wave plus muscle MEP and SSEP; D-wave preservation guides safe resection and predicts recovery.
Peripheral nerve	Free-running and triggered EMG, nerve action potentials, and stimulation to map and protect nerves.
Pain — SCS	EMG and SSEP to confirm midline lead placement and laterality during spinal-cord-stimulator trials and implants.
Vascular — CEA	EEG ± SSEP to detect cross-clamp ischemia and inform shunting and blood-pressure management.

6. The remote oversight model

Mind Sync pairs a credentialed on-site technologist with a remote oversight physician, giving every case two layers of expert attention.

- **On-site technologist (CNIM-certified)** sets up, establishes baselines, manages acquisition, and is the hands at the bedside.
- **Remote oversight physician (board-certified)** reviews the live data over a secure connection and interprets changes in real time.

- **Real-time interpretation loop** — the physician's read is relayed to the technologist and surgical team without waiting for post-hoc review.
- **Redundancy and coverage** — defined escalation, backup connectivity, and scheduling so coverage is dependable on the day of surgery.

7. Quality, credentialing & billing

Selecting a monitoring partner is a clinical, compliance, and operational decision. Mind Sync aligns with the standards of ASNM, ABRET, and ASET, and coordinates facility credentialing in advance.

Billing structure (general overview)

IONM billing distinguishes the **technical component** (acquisition by the technologist) from the **professional component** (physician interpretation), and distinguishes in-OR attendance from remote monitoring. Current coding commonly references continuous in-OR IONM (per-15-minute) and remote/monitoring-outside-the-OR (per-hour) services, alongside the baseline study codes for SSEP, MEP, EEG, and EMG.

Coding and payer coverage change over time and vary by plan; this overview is general and not coding, legal, or reimbursement advice. Mind Sync handles billing transparently and supports facility credentialing and documentation.

8. Working with Mind Sync

To plan coverage for an upcoming spine, neuro, or pain case, contact our team. We will align on the procedure, modalities, anesthetic plan, scheduling, and credentialing so the day of surgery is seamless. Consultations are free.

Email Info@mindsyncmonitoring.com

Web www.mindsyncmonitoring.com

Office 2500 Dallas Pkwy, Suite 500, Plano, TX 75093
