



# The Intraoperative Neuromonitoring (IONM) form: A How-to Guide

#### Introduction

Welcome to the IONM questionnaire/form. Ordinarily, the in-room neuromonitorist fills out this form. Thank you for reviewing this guide and for your participation.

Briefly, transcranial electrical motor evoked potentials (MEPs) are recorded at baseline from at least one muscle from each available limb which is either considered at risk (from surgery, positioning, etc.) or used as a control. "Available" means usable recording/stimulation sites of a limb not congenitally absent/amputated or enclosed by a surgical dressing, immobilizing cast, etc. Somatosensory evoked potentials (SEPs) are recorded at baseline after stimulation of a major sensory or sensorimotor nerve in each available limb. The SEP minimum to qualify for the form is one upper limb for "Upper SEPs" and one lower limb for "Lower SEPs".

This form does not include questions on D waves, electromyography, F waves, or reflexes. Later iterations may include other modalities and/or more exacting MEP/SEP methods questions as well. The form, as it stands, is meant to provide IONM-related evidence in a great many but not all spine surgery pathologies, procedures, settings, and so on... while respecting your contribution of time and effort.

Many questions require one (best) response, identified as "please select" within the dropdown list. Other questions will accept multiple applicable answers. Please complete the form based on what is happening (or just happened) with *your patient*, not the average approach for all patients. Nevertheless, it is understood that questions related to your MEP/SEP alert criterion may be answered based on an historically accepted value or may be tailored to the current case. It is strongly recommended to complete and submit the form by case end.

Please allow up to 15+ minutes the very first time you fill it out. Reading this guide first may help. With experience, it will take much less time. The sections are roughly sequential over the course of a case, starting with **Preliminary Data**. As the case progresses, questions appear on MEPs, SEPs, anesthesia, warning criteria, alarms, signal recovery, and codiagnostics. This How-to Guide is intended to hopefully clarify difficulties a respondent may experience while filling out the form.

There are four sections to the form: **Preliminary Data**, **MEP and SEP Data**, **Warning Criteria Definition and Alarms**, and **Co-diagnostics**. This guide is arranged by the Section Headers to permit quick reference.





# **Preliminary Data**

#### Monitoring Date = Enter

**Neuromonitoring specified as** = In almost all forms, "In-room neuromonitorist independently recorded tests" will be the expected response. The choice, "In-room neuromonitorist independently recorded tests and Surgeon also used hand-held or automated device" may be selected as appropriate. "Surgeon only used hand-held or automated device" applies *only* to cases where the surgeon is self-neuromonitoring with some general staff assistance.

**Operating rooms** = Total number of rooms not just spine surgery; select best response.

University affiliated = Yes or No.

Neurosurgery and/or orthopedic spine fellowship = Yes or No.

**Model of care** = Select best choice from a drop-down list of 10 choices. Note: Choices with "PhD [or MD] neurophysiologist not routinely in operating room but personally and immediately available" imply a technologist or physiologist is doing all the in-room baseline recordings and neuromonitoring but there is an in-house doctorate level consultant if needed. This choice is different from technologist or physiologist either "reporting directly [and only] to the surgeon" or personally assisted by an "in-room PhD [or MD] neurophysiologist part of case" (and supervised the entire case by that doctorate level neurophysiologist).

**Planned maintenance anesthetic** = Select from the drop-down list the maintenance anesthetic that is planned before surgery begins; that is, the "planned" anesthetic may not end up being the actual anesthetic as neuromonitoring signal recordings are attempted.

**Pre-op limb and/or walking neurological deficit** = Yes or No. If No, the deficit queries end; if Yes, answer the queries regarding sensory & motor (select all limb combinations that apply) and walking deficits (select best descriptor).

**High-risk findings on pre-op imaging** = "None" or "Unknown" or select *one or more* highrisk imaging findings from the drop-down list. Typically, absolute or critical stenosis indicates < 10mm AP spine canal diameter. If "Other high-risk finding," these are generally well covered in the surgeon form. Specify other high-risk finding = for example, tumor, spondylolisthesis, etc. Or write "see surgeon form." Also, you should, if needed, consult the surgeon to confirm high-risk imaging findings.





## MEP and SEP Data

MEPs monitored = Yes or No. If No, select best reason from the drop-down list. Please answer the later MEP Alarm(s) queries as "No." If you or your institution do record MEPs on some patients but not this particular patient, please do answer later questions on Major MEP Warning Criterion (WC) Definition: spinal cord and root, plexus. If you or your institution NEVER record MEPs on any spine patient, then, under Major MEP WC Definition: spinal cord and root, plexus select "other" and below that Please specify other by writing "none."

**MEPs monitored** = Yes or No. If Yes, a series of additional queries appear.

Total intravenous anesthesia used during MEP acquisition = Yes or No.

**Partial or complete neuromuscular blockade used during MEP acquisition** = Yes or No. This question DOES NOT pertain to the initial exposure epoch; it DOES pertain to periods of potentially risky surgeon actions like spine decompression, osteotomy, instrument implantation, correction, mass excision, etc.

When first MEP recorded, timing = Select best answer.

**Further optimized anesthesia and/or blood pressure management requested** = Yes or No. If Yes, **Further optimized anesthesia and/or blood pressure management implemented** = Yes or No.

**Before crucial surgical actions, MEPs recorded from all limbs/myotomes at risk** = Yes or No. If Yes, **please select best MEP descriptor**. Note: assuming anesthetic/surgical conditions remain stable, "reproducibility" is a measure of your confidence that the next evoked potential trial will very nearly resemble the last recorded trials in amplitude and latency. If No, **Were the non-elicitable MEPs from weak limb(s**)? = Yes or No. Note: less than full pre-operative strength in ALL muscles where MEP is recorded (or attempted) defines a "weak limb." For example, a limb MEP montage includes the Tibialis Anterior = weak preoperatively and the Abductor Hallucis = normal strength pre-operatively. That is not a "weak limb."

**Estimated Bilateral MEP Frequency** = select best estimate of number/hour. This is an estimate of MEP frequency per hour from end of exposure to the beginning of closure. Concurrent (or nearly concurrent) left and right body recordings = one trial.

**Upper SEPs were monitored** = Yes or No. If No, query thread ends.





**Upper SEPs were monitored** = Yes or No. If Yes, answer queries.

**Recorded before and after positioning =** Yes or No.

**Trial to trial reproducibility BEFORE crucial surgical actions** = select the best answer. Note: assuming anesthetic/surgical conditions remain stable, "reproducibility" is a measure of your confidence that the next evoked potential trial will very nearly resemble the last recorded trials in amplitude and latency.

**Lower SEPs were monitored** = Yes or No. Please follow the same query thread and guidance as **Upper SEPs were monitored**.

If neither Upper SEPs nor Lower SEPs were monitored in this particular patient, please still complete **Major SEP WC Definition** later in the form. Answer the later **SEP Alarm(s)** queries as "No."

## Warning Criteria (WC) Definition and Alarms: MEPs

Major MEP WC Definition: spinal cord and

**Major MEP WC Definition**: root, plexus = Select the best answer from the drop-down list. **If Other, Please specify other** = brief written description of your warning criterion.

Warning Criterion (WC) met? = Yes or No. If No, query thread ends.

Warning Criterion (WC) met? = Yes or No. If Yes, Was the alarm anesthesia and/or technically related? = Yes or No. If Yes, query thread ends. If No, query thread continues as follows:

**Surgeon informed and acknowledged** = Yes or No. If Yes, proceed with further queries. If No, select best reason from the drop-down list and proceed with further queries

**MEP WC: limbs affected** = See drop-down list and select applicable limbs.

**Surgical context** = Select best answer from the drop-down list.

**Intervention** = Select all applicable responses from the drop-down list. Note: "Adjusted or reversed surgeon action" includes all surgeon in-wound maneuvers taken to recover evoked potential loss... for example, reduction of deformity correction, adjustment or removal of a retractor/implant/clip, local application of warm irrigation/vasoactive meds, etc.

**Complete or partial MEP recovery before surgery end** = Yes or No. If Yes, please select Complete (all affected MEPs no longer met WC) or Partial (at least one MEP no longer met WC but one or more MEPs still met WC).





Note: MEP recovery depends on your original definition of the warning criterion. For example, if the spinal cord criterion is "at least 50% amplitude decrease" in a thoracic deformity correction and an alarm in the left and right abductor hallucis is reported, recovery above 50% decreased amplitude in one muscle = "partial recovery"... in both muscles = "complete recovery."

Add another alarm? = Yes or No. If Yes, please know a maximum of three MEP alarms is permitted. Therefore, the alarms with the most clinically significant impact should be included. Repeated reports to the surgeon of an ongoing or progressive alarm status within the same surgical context (positioning, deformity correction, osteotomy closure, retractor opening, etc.) counts as one alarm. Because each alarm based on **anesthesia and/or technically related** problems uses up one of three total MEP alarms, it is advised to use this explanation only when these problems significantly complicate, delay, and disrupt the progress of surgery.

### Warning Criteria (WC) Definition and Alarms: SEPs

**Major SEP WC Definition** = please select from drop-down list. Note: amplitude reduction from recent pre-change values exceeding variability refers to "visually obvious amplitude reduction from recent pre-change values and clearly exceeding variability, particularly when abrupt and focal," per MacDonald et al. Recommendations for intraoperative SEPs, 2019.

If Other, **Please specify other** = brief written description of your warning criterion.

Warning Criterion (WC) met? = Yes or No. If Yes, Was the alarm anesthesia and/or technically related? = Yes or No. If Yes, query thread ends. If No, query thread continues as follows:

**Surgeon informed and acknowledged** = Yes or No. If Yes, proceed. If No, select best reason from the drop-down list.

**SEP WC: limbs affected** = See drop-down list and select applicable limbs.

**Surgical context** = Select best answer from the drop-down list.

**Intervention** = Select all applicable responses from the drop-down list. Note: "Adjusted or reversed surgeon action" includes all surgeon in-wound maneuvers taken to recover evoked potential loss... for example, reduction of deformity correction, adjustment or removal of a retractor/implant/clip, local application of warm irrigation/vasoactive meds, etc.

Complete or partial SEP recovery before surgery end = Yes or No. If Yes, please select Complete (all affected SEPs no longer met WC) or Partial (at least one limb no longer met WC but one or more SEPs still met WC). In general, SEPs include left and right upper and





lower limbs. As examples: one limb SEP meets the warning criterion, then recovers = complete recovery versus two limbs meet the warning criterion and one limb recovers = partial recovery.

Add another alarm? = Yes or No. If Yes, please know a maximum of three SEP alarms is permitted. Therefore, the alarms with the most clinically significant impact should be included. Repeated reports to the surgeon of an ongoing or progressive alarm status within the same surgical context (positioning, deformity correction, osteotomy closure, retractor opening, etc.) counts as one alarm. Because each alarm based on **anesthesia and/or technically related** problems uses up one of three total SEP alarms, it is advised to use this explanation only when these problems significantly complicate, delay, and disrupt the progress of surgery.

#### **Co-diagnostics**

2 dimensional (Conventional C-arm) = Yes or No.

3 dimensional (Isocentric C-arm, O-arm, intraoperative CT, or navigation) = Yes or No.

Robot guided screw implantation or other surgical maneuver = Yes or No.

Surgeon directed/driven hand-held and/or automated neuromonitoring device = Yes or No.

**Stagnara (wake-up) test** = Yes or No. Note: this test may be executed electively or as part of an alarm.