



NATIONAL COMPETENCY SKILL STANDARDS FOR PERFORMING INTRAOPERATIVE NEUROPHYSIOLOGIC MONITORING

Intraoperative Neurophysiologic Monitoring (IONM) Specialists practice in accordance with the facility policy and procedure manual which details every aspect and modality of testing.

ASET – The Neurodiagnostic presents this document to provide national criteria for evaluating competencies for performing intraoperative neurophysiologic monitoring (IONM).

Intraoperative neurophysiologic monitoring is an advanced level of practice in the neurodiagnostic field. Training and education should reflect this advanced level and achievement of recognized professional credentials should be accomplished.

Basic knowledge and technical performance, as well as quality patient care and patient interaction, were considered. The technical components include those defined in the publications of the American Clinical Neurophysiology Society (ACNS) and the American Society of Neurophysiological Monitoring (ASNM). These resources are found on their respective websites: ACNS – www.acns.org; ASNM – www.asnm.org.

Section I: Intraoperative Neurophysiologic Monitoring Core Knowledge

1.1 Pre-surgical preparation

The IONM Specialist:

- confirms procedure orders for surgical monitoring requested
- obtains relevant patient history
- verifies patient identity using at least two patient identifiers according to The Joint Commission Standards
- explains IONM procedure to the patient and/or caregiver
- obtains or verifies informed consent for IONM following facility policy
- reviews all IONM contraindications based on patient history and surgeon orders
- establishes and confirms a HIPAA-compliant connection with the attending neurophysiologist/physician
- determines monitoring and anesthetic preferences of attending neurophysiologist/physician
- ensures proper electrodes/supplies is available depending on monitoring modalities
- initiates pre-surgical communications with anesthesia team regarding these preferences
- converses with the surgeon regarding surgical procedure, approach, structures at risk, modalities to be monitored and documents the conversation
- selects and confirms with the surgeon/attending neurophysiologist/physician montage(s) appropriate for surgical procedure being performed.

1.2 Select the appropriate equipment, instrumentation, and settings

The IONM Specialist:

- maintains equipment in good working order and confirms bi-annual maintenance checks have been performed according to the hospital's biomedical standards and the manufacturer's recommendation following institutional policy
- performs biomed electrical safety check upon each visit to the hospital whenever equipment is transported into a facility
- selects montage(s) appropriate for surgical procedure being performed according to facility

- policy and procedures
- if using preprogrammed templates, ensures that the template for the selected surgery is open before the patient enters the room with appropriate settings and parameters
- ensures stimulator is functioning appropriately
- verifies that all stimulators are delivering expected stimuli to the correct neural structure
- obtains all additional equipment and supplies such as auditory stimulators, monopolar stimulators, etc.
- cleans, disinfects equipment, cables, etc., prior to placing equipment in the operating room following facility policy.

1.3 Operating room environment

The IONM Specialist:

- follows standard precautions for infection control per facility policy and procedures
- understands roles of all healthcare professionals in the operating room
- understands the operation room layout and where sterile field locations begin and end
- avoids contamination of sterile drapes, personnel, instruments, etc.
- requests the nurse in the room pass off sterile electrodes to the surgical personnel in an approved sterile fashion
- places bloody or contaminated items in biohazard containers and needle electrodes in an appropriate sharps container
- follows hazardous material management guidelines
- minimizes travel in/out of the operating room as much as possible
- observes electrical and general safety precautions when connecting the patient to equipment
- arranges cables and equipment to prevent injury
- uses “no-trip” orange cord covers when available

1.4 Intraoperative Neuromonitoring

The IONM Specialist:

- stops all activity and actively participates during the surgical time-out or surgical pause and documents participation
- communicates the IONM preferences of surgeon to the attending neurophysiologist/physician and confirms the appropriateness of modalities to be monitored
- provides feedback from the interpreting neurophysiologist/physician when additional modalities or muscle groups are suggested
- communicates IONM preferences to the anesthesia team and other operating room personnel in a clear, definite, and collegial manner and documents conversations
- before the patient enters the operating room suite:
 - o sets up and confirms proper operation of all equipment
 - o arranges head box, cables, and electrodes for minimization of artifacts and electrical hazards preventing electrodes from being dislodged, or contaminated with fluids
- tests equipment and checks integrity of electrodes by checking and documenting impedances
- obtains initial responses and obligate peaks after induction and prior to incision and sets baselines as appropriate to the procedure; marks waveforms and calculates the absolute latencies, amplitudes, or inter-peak intervals at baseline
- sets or resets baselines as appropriate to the surgical procedure according to the facility policy and procedures or the interpreting neurophysiologist/physician direction
- obtains an interpretation of baselines from the attending neurophysiologist/physician and

- communicates the information to the surgeon
- throughout the surgery, reports to the surgeon any change in data which meets the alarm criteria outlined in the facility policy and procedure manual or at the direction of the attending neurophysiologist/physician
- during the recording, adjusts data collection parameters as needed according to facility policies and procedures, some examples including:
 - adjusting stimulus rate as needed to reduce time-locked artifacts
 - adjusting stimulus intensity to obtain supramaximal stimulation of the peripheral nerve
 - establishing and documenting that stimulating parameter are within safe limits
 - recording from additional electrode derivations in case of technical problems to allow continuous recording
 - using a montage that records obligate peak responses from peripheral nerve, spinal cord, subcortical structures, and the cerebral cortex as appropriate
- maintains appropriate recording electrode impedance, relatively balanced and below 5000 ohms to ensure proper recording and decrease artifact
- at the end of the procedure, removes and discards disposable supplies, especially sharps and contaminated items according to facility policies and procedures, cleans and disinfects equipment, cables, etc.

1.5 During and throughout the procedure

The IONM Specialist documents:

- surgical procedure with levels and laterality as appropriate
- modalities performed
- surgical maneuvers and events
- levels of inhaled anesthetics, dosage of intravenous anesthetics, and use of muscle relaxants
- blood pressure, temperature, and other physiologic parameters as appropriate
- any and all communications or warnings relevant to patient care:
 - with attending surgeon, surgeon replies, and corrective action taken
 - with attending neurophysiologist/physician
 - with anesthesia team and/or other operating room personnel
- all technical problems and corrective troubleshooting steps performed
- saves all data according to the practice of medical records retention in the state in which the surgery was performed
- exact time, obligate waveform labels, latencies, and amplitudes for all printed traces as detailed in facility policy and procedures
- prepares the documentation for the attending neurophysiologist/physician according to facility policy and procedure.

1.6 Intraoperative Communications/Data Analysis

The IONM Specialist:

- recognizes significant changes, according to facility alarm criteria, and alerts the surgeon and attending neurophysiologist/physician as detailed in the facility policy and procedures
 - if needed, notifies surgeon that monitoring is momentarily interrupted for troubleshooting
- prepares technical report of case for the attending neurophysiologist/physician according to facility policy and procedures.

Section II: Knowledge and Skills

2.1 The IONM Specialist understands:

- critical periods during the surgery when iatrogenic injury is most likely to occur and other points in surgery that could cause possible data changes
- blood pressure, hemodynamics, and other physiologic factors
- steps of the surgical procedure being performed
- neurologic structures at risk
- unique surgical instruments and the effects of their use
- effects of corrective forces exerted by implanted instrumentation
- anatomy of monitored pathways, source of blood supply, electrode derivations, and generators of components and obligate waveforms
- pre-operative deficits, intraoperative injuries, and possible post operative outcomes
- waveform changes generated by ischemia, blood pressure, oxygen saturation, core, and limb temperature
- how anesthetic and physiological changes affect desired patient data per modality including:
 - changes in concentration of volatile agents (MAC)
 - interactions between nitrous oxide and potent volatile anesthetics
 - unstable physiological factors such as changes in CO₂, hemo/hemato, blood pressure, and metabolic rates
- how the method of delivering anesthetics (inhalation, infusion, bolus injection, low flow inhalation, total intravenous) affects data
- modalities being performed and how to obtain desired data relative to anesthesia
- operating room etiquette in the following areas:
 - use of collodion, acetone, or other flammable materials when applicable
 - potentially bio-hazardous material
 - use and disposal of sharp electrodes
 - electrical safety issues related to:
 - types of recording and stimulating electrodes
 - cautery units and return grounding pads
 - other instruments that are connected to the patient
 - simultaneous multiple earth grounds and how equipment in the OR can create ground loops
 - use of new equipment in the OR (bio-med checks at individual hospitals)
 - placement of other equipment (blood warmers, microscopes, etc.) effects on the quality of the intraoperative recording
 - placement of power cords relative to other equipment.

2.2 The IONM Specialist maintains and improves knowledge, skills, and professional stature by any or all of the following:

- is certified in Basic Life Support (BLS) and follows facility policy and procedures for respiratory or cardiopulmonary crisis.
- follows facility policy and procedures for infection prevention relevant to the patient and equipment.
- follows HIPAA policy and facility procedures for cybersecurity and safety of electronic records.
- hospital in-service programs, especially post-operative review of monitored surgical cases with attending neurophysiologist/physician
- reading books and journal articles related to IONM
- attending professional meeting, seminars, and online education opportunities
- providing education to staff members

- participating in research activities
- other educational opportunities that become available
- achieving intraoperative neurophysiologic monitoring certification and meeting recertification requirements.

Section III: Modalities

3.1 As detailed in the facility policy and procedure manual, during intraoperative neurophysiologic monitoring, the IONM Specialist:

- is knowledgeable of and follows the ACNS Guideline 11A Recommended Standards for Neurophysiologic Intraoperative Monitoring Principles
- discusses anesthetic recommendations for monitoring, in a definitive but cordial manner, with anesthesia staff
- ensures that the data collection portion of the IONM instrument and stimulators are correctly synchronized
- ensures that all stimulators are correctly delivering expected stimuli to the selected side
- chooses the appropriate stimulus rate and adjusts as needed to reduce time-locked artifacts
- has knowledge of stimulation rate and number of averages to obtain the greatest amount of data in the shortest amount of time
- establishes and documents that stimulating parameters are supra-maximally activating the stimulated neural structure within safe limits
- recognizes, documents, and attempts to eliminate or reduce all artifacts
- establishes baseline values prior to induction of anesthesia and positioning of the patient, if appropriate (as in cases of unstable cervical spine)
- reestablishes baselines accordingly to facility policy and procedures and in consultation with attending neurophysiologist/physician
- performs electrographic measurement of muscle relaxant agents on compound muscle action potentials with techniques used in peer-reviewed scientific literature to ensure that levels are adequate for monitoring motor pathways
- monitors continuously during critical periods of the procedure, documents evoked potential tracings at frequent intervals as directed by facility policy and procedures
- archives data:
 - preserves and archives data based on the facility policy and procedures
 - makes electronic and/or hard copies of data for documentation purposes according to facility policy and procedure
 - even in the absence of significant changes, documents waveforms along with descriptions of surgical events.

3.2 Intraoperative electroencephalography (EEG)

The IONM Specialist:

- selects montage(s) appropriate for surgical procedure being performed according to facility policy and procedures
- selects the appropriate instrumentation settings according to facility policy and procedures and makes instrument changes as appropriate
- recognizes, documents, and attempts to eliminate or reduce all artifacts
- monitors appropriate evoked potential modalities and physiological characteristics appropriate to the EEG monitoring
- understands necessity of recording activity pre-position and post-position of the patient's head
- establishes a preoperative post-anesthetic baseline prior to incision and re-establishes that

- baseline if necessary
- recognizes and documents all EEG patterns during the monitoring and explains the relevance of the underlying patterns to the performance of IONM monitoring
- recognizes significant EEG changes, according to facility alarm criteria, and alerts the surgeon and attending neurophysiologist/physician as detailed in facility policy and procedures
- documents warnings to surgeon and surgeon's response, as well as any corrective action and/or recovery, following facility policy and procedures.

3.3 Spontaneous or evoked electromyography (EMG)

The IONM Specialist:

- has knowledge of anesthetic techniques preventing inhibition of neuromuscular junction transmission
- performs electrographic measurement of muscle relaxant agents on compound muscle action potentials with techniques used in peer-reviewed scientific literature to ensure that levels are adequate for monitoring motor pathways
- selects appropriate recording parameters and montage for EMG
- is aware of the resistance to neuromuscular blockade relative to body location
- is aware of the effects of other non-muscle relaxing agents such as some vancomycin, blood pressure lowering agents, and magnesium
- understands anatomy and physiology of muscles and neural structures at risk of injury relative to surgery performed
- understands the appropriate use and safety issues related to subdermal needle electrodes
- recognizes significant EMG activity and alerts the surgeon and attending neurophysiologist/physician according to facility policy and procedures
- has experience in the audio sound of EMG changes and communicates said changes with surgeon and supervising neurophysiologist/physician
- understands rate of stimulation relative to neuromuscular blockade during evoked EMG
- uses safety precautions with regard to duration and intensity when performing direct nerve stimulation.

3.4 Motor cranial nerve recording

The IONM Specialist:

- selects appropriate recording parameters and montage for EMG
- applies needle, adhesive electrodes, or hook-wire recording electrodes to the appropriate muscles to record spontaneous and evoked EMG responses from the specific nerves
- tests impedance and recording function prior to prepping and draping
- performs electrographic measurement of muscle relaxant agents on compound muscle action potentials with techniques used in peer-reviewed scientific literature to ensure that levels are adequate for monitoring motor pathways
- ensures neuromuscular blockade level complies with facility policy and procedures
- monitors the ongoing EMG through a loud-speaker or earphone or otherwise based on established facility practice which provides continuous auditory feedback
- provides an appropriate sterile stimulating probe according to the surgeon's preference
- selects appropriate stimulus intensity, duration, and polarity to produce an appropriate muscle response from the cranial nerve being stimulated while being cognizant of patient safety issues
- records spontaneous free-running EMG, signal-triggered EMG, and evoked CMAPs
- informs the attending surgeon of spontaneous activity, mechanical stimulation of the nerve

- and results of nerve stimulation
- recognizes significant EMG changes, according to facility alarm criteria, and alerts the surgeon and attending neurophysiologist/physician as detailed in the facility policy and procedures
- documents surgical events, warnings to surgeon, etc., as stated in the facility policy and procedures.

3.5 Spinal Screw and Direct Nerve Stimulation – Threshold Testing

The IONM Specialist:

- selects appropriate recording parameters and montage for EMG
- applies needle, adhesive electrodes, or hook-wire recording electrodes to the appropriate muscles to record spontaneous and evoked EMG responses from the specific nerves
- tests impedance and recording function prior to prepping and draping
- performs electrographic measurement of muscle relaxant agents on compound muscle action potentials with techniques used in peer-reviewed scientific literature to ensure that levels are adequate for monitoring motor pathways
- ensures neuromuscular blockade level complies with facility policy and procedures
- monitors the ongoing EMG through a loudspeaker or earphone or otherwise based on established facility practice which provides continuous auditory feedback
- provides an appropriate sterile stimulating probe according to the surgeon's preference
- selects appropriate stimulus intensity, duration, and polarity to produce an appropriate muscle response from the screw or nerve being stimulated while being cognizant of patient safety issues
- is able to troubleshoot unexpected threshold levels, for example understands:
 - how excessive fluid in the sterile field can cause stimulus shunting and the effect it may have on threshold levels,
 - the effect that the presence of hardware such as rods may have on threshold levels,
 - low bone density will decrease thresholds, screws coated with hydroxyapatite will increase thresholds as will certain metal alloys used,
 - injured nerve roots may also have higher than normal thresholds, etc.
- records spontaneous free-running EMG, signal-triggered EMG, and evoked CMAPs
- informs the attending surgeon of spontaneous activity, mechanical stimulation of the nerve and results of nerve stimulation
- documents surgical events, screw threshold levels, warnings to surgeon, etc., as stated in the facility policy and procedures.

3.6 Intraoperative somatosensory evoked potential (SSEP)

The IONM Specialist:

- is knowledgeable of and follows the ACNS Guideline 11B Recommended Standards for Intraoperative Monitoring of Somatosensory Evoked Potentials
- maintains appropriate stimulating electrode impedance and assures proper stimulation by decreasing stimulus artifact
- uses a montage that records obligate peak responses from peripheral nerve, spinal cord, subcortical structures, and the cerebral cortex as appropriate
- records from electrodes overlying the scalp surface, peripheral sites of mixed nerves, and from electrodes placed in the spinous process or epidural spaces
- marks waveforms and calculates the absolute latencies, amplitudes, and/or inter-peak intervals at baseline and throughout the monitoring procedure
- is prepared to use alternative stimulating or recording paradigms in order to compensate for complex technical or patient-related problems.

3.7 Cortical and subcortical mapping

The IONM Specialist:

- obtains a pre-incision baseline with surface electrodes to confirm function of the somatosensory/motor pathway and approximate latency of obligate-peaks/responses
- records eloquent language cortex mapping and/or electrocorticography (ECoG)
- records direct cortical and subcortical stimulation for motor cortex
- selects appropriate timebase, sensitivity, band pass settings, and understands appropriate stimulator settings appropriate per modality
- selects the appropriate stimulation site (i.e., contralateral median nerve, cortical stimulation)
- uses appropriate electrodes and understands functionality of electrode types placed or manipulated by surgeon
- prepares stimulus site to reduce stimulating electrode impedance per modality
- is knowledgeable of the various types of stimulator probes, i.e., monopolar, bipolar, grid stimulation
- monitors subcortical peripheral nerve site to verify stimulus effect for SSEPs
- uses a referential and bipolar montage that records direct cortical responses and allows identification of “phase reversal” and amplitude gradients for SSEPs
- obtains adequate resolution of the obligate waveform components
- records from multiple cortical sites in order to obtain adequate localization
- prints a hard copy or obtains a digital copy of simultaneous or sequentially recorded SSEPs per facility policy for the purpose of studying the amplitude gradient and polarity of the responses in relation to the location of the gyri.

3.8 Intraoperative brainstem auditory evoked potential (BAEP)

The IONM Specialist:

- is knowledgeable of and follows the ACNS Guideline 11C Recommended Standards for Intraoperative Monitoring of Auditory Evoked Potentials
- establishes hearing threshold and documents any existing hearing loss or condition of ear structures
- uses molded ear speakers or insert transducers to avoid contamination of the surgical field
- uses waterproof adhesive tape, Tegaderm™, and/or bone wax to protect the ear speaker or foam ear insert and ear canal from blood or fluids per departmental policy
- chooses the appropriate montage, timebase, number of stimuli, sensitivity, and band pass settings
- understands use of condensation, rarefaction, and alternating click to obtain best response as appropriate
- uses an appropriate stimulus intensity based on facility policy and procedures and adjusts intensity based on patient hearing assessment
- has knowledge of the adverse effects on peak components that changing the stimulus rate has and can only adjust the stimulus rate according to facility policy and procedures
- uses an appropriate stimulus rate to resolve the most important BAEP components and maintains the same rate throughout that obtains the most data in the shortest amount of time
- understands the effects that drilling, cold irrigation and other surgical factors can have on the BAEP
- obtains adequate resolution of obligate component(s) waves I, III, and V
- measures and calculates the absolute latencies, amplitudes, and inter-peak intervals of obligate peaks at baseline and throughout monitoring
- masks the contralateral ear with appropriate white noise intensity

- continuously monitors the ear ipsilateral to surgical intervention (contralateral ear monitoring is also appropriate for large posterior fossa tumors, or as a control)
- during certain posterior fossa procedures, records direct nerve action potentials from the 8th cranial nerve simultaneously with the BAEPs by:
 - providing the surgeon with a sterile direct nerve electrode for placement on the exposed 8th cranial nerve
 - communicates to the surgeon the correct placement of the recording electrodes
 - using the same auditory clicks to stimulate the ipsilateral ear at the same intensity and stimulus rate as that used with the BAEPs
 - using a montage referencing the direct nerve electrode to the ipsilateral ear
 - selecting appropriate timebase and recording sensitivity to record these high amplitude responses
 - reporting significant changes in morphology, latency and amplitude of these responses as outlined in the facility policy and procedures.

3.9 Intraoperative transcranial electrical motor evoked potentials (TCeMEP) / transcranial electric stimulation (TES-MEP)

The IONM Specialist:

- is knowledgeable of and follows the ACNS Guideline 15 Intraoperative Spinal Monitoring with Somatosensory and Transcranial Electrical Motor Evoked Potentials
- reviews the patient's history/physical checking for medical conditions which may contraindicate the use of TCeMEPs; reviews these findings with the attending neurophysiologist/physician
- chooses the appropriate stimulation sites by measuring the head using the International 10–20 System of electrode placement or in accordance with policy and procedures
- chooses the appropriate muscles to be monitored based on the surgical procedure being performed and understands/elicits D wave recording
- securely applies recording electrodes that are below 5000 ohms and balanced to ensure proper recording of the muscle activity
- collaborates with the anesthesia team to ensure the proper anesthetic regimen for protocol is being used
- collaborates with the anesthesia team to ensure that appropriate mouth and tongue protection is in place according to facility policy and procedures
- chooses the appropriate stimulation parameters including, intensity, duration, and frequency of stimulation delivery
- recognizes significant change, according to facility alarm criteria, and alerts the surgeon and attending neurophysiologist/physician as detailed in the facility policy and procedure manual.

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