

# POLICIES AND PROCEDURES OF THE **MASTERS OF SURGICAL NEUROPHYSIOLOGY PROGRAM**



Last Updated

09/29/2022

This document contains the various policies and procedures created by the IONM program.

# Table of Contents

Criteria for Successful Completion of Each Segment of the Curriculum Master of Science in Surgical Neurophysiology .....	3
Policy on Credits for Experiential Learning Master of Science in Surgical Neurophysiology .....	5
Policies and Procedures for Clinical Practicum Master of Science in Surgical Neurophysiology .....	6
Policies on Advanced Placement Master of Science in Surgical Neurophysiology .....	8
Graduate Competencies for Performing Intraoperative Neurophysiological Monitoring (IONM) .....	9
I.    ENTRY-LEVEL competency is evidenced by the graduate’s knowledge demonstrated in the following areas .....	9
A. <b>Bioelectrical principles</b> .....	9
B. <b>Surgical and anatomic principles</b> .....	10
C. <b>IONM Techniques</b> .....	11
II.   ENTRY-LEVEL competency is evidenced by the graduate’s skills demonstrated in the following areas .....	12
A. <b>Pre-operative phase</b> .....	12
B. <b>Intra-operative phase</b> .....	13
C. <b>Post-operative phase</b> .....	17
D. <b>Ethics, Safety and Professional Principles</b> .....	18
III.  Clinical Cases .....	18

# Criteria for Successful Completion of Each Segment of the Curriculum Master of Science in Surgical Neurophysiology University of Connecticut

The students in the Master of Science in Surgical Neurophysiology complete a condensed 1-year program that include four semesters: Summer Session I, Summer Session II, Fall and Spring. The criteria to pass each segment of the curriculum based on the semester is as follow:

## Summer Session I:

Includes 3 core courses:

PNB 5101 - Anatomy and Physiology for Intraoperative Neuromonitoring - 4 Credits

PNB 5102 - Fundamentals of Intraoperative Neuromonitoring - 3 Credits

PNB 5103 - Applied Intraoperative Neuromonitoring - 2 Credits

## Grading Scale:

Grade	Letter Grade	GPA
93-100	A	4.0
90-92	A-	3.7
87-89	B+	3.3
83-86	B	3.0
80-82	B-	2.7
77-79	C+	2.3
73-76	C	2.0
70-72	C-	1.7
67-69	D+	1.3
63-66	D	1.0
60-62	D-	0.7
<60	F	0.0

*Students need to obtain a cumulative B or higher grade in the three courses (and at least B- or higher in each course individually) to be able to progress to the next semester.*

## Summer Session II:

Includes 1 core course:

PNB 5104 - Clinical Practicum in Intraoperative Neuromonitoring (1) - 3 Credits

*Students need to obtain a B or higher grade to continue in the program.*

## **Fall Semester:**

Includes 2 core courses:

- PNB 5104 - Clinical Practicum in Intraoperative Neuromonitoring (2) - 3 Credits
- PNB 5105 - Seminar in Intraoperative Neuromonitoring (1) - 2 Credits

And 1 or 2 of these elective courses:

- PNB 3251 - Biology of the Brain - 3 Credits
- PNB 4400 - Biology of Nervous System Diseases - 3 Credits
- PNB 5350 - Membrane Transport in Health and Disease - 3 Credits
- PNB 5396 - Principles of Physiology and Neurobiology - 3 Credits
- PNB 6417 - Developmental Neurobiology (offered every other Fall) - 3 Credits
- NURS 3100 - Clinical Science (1) - 3 credits
- SLHS 5322 - Electrophysiology Techniques and Interpretation (1) - 4 credits
- SLHS 5375 - Auditory System: Anatomy and Physiology - 3 credits

*Students need to obtain a cumulative B or higher grade in the courses they take (and at least B- or higher in each course individually) to be able to progress to the next semester.*

## **Spring Semester:**

Includes 3 core courses:

- PNB 5104 - Clinical Practicum in Intraoperative Neuromonitoring (3) - 3 Credits
- PNB 5105 - Seminar in Intraoperative Neuromonitoring (2) - 2 Credits
- PNB 5106 - Advanced Modalities in Intraoperative Neuromonitoring - 4 Credits

And 0 or 1 of these elective courses:

- PNB 6426 - Molecular and Cellular Neurobiology - 3 Credits
- PNB 5107 - Clinical Research Methods in Intraoperative Neuromonitoring - 3 credits
- PNB 3251 - Biology of the Brain - 3 credits
- PNB 5396 - Principles of Physiology and Neurobiology (2) - 3 credits
- PNB 6426 - Molecular and Cellular Neurobiology - 3 credits
- NURS 3110 - Clinical Science (2) - 3 credits
- NURS 3120 - Patient-Centered Health Assessment Across the Lifespan - 3 credits
- PSYC 5228 - Neuropsychopharmacology - 3 credits

*Students need to obtain a cumulative B or higher grade in the courses they take (and at least B- or higher in each course individually) to be able to graduate. Total of 32 credits required for graduation.*



## **Policy on Credits for Experiential Learning Master of Science in Surgical Neurophysiology**

1. The Clinical Practicum is offered over a period of 3 consecutive semesters (Summer Session II, Fall and Spring) to the students. Each semester includes 3 credits over its course.
2. Students will complete close to 250 clinical hours if all three courses (nine credits) of the Clinical Practicum is taken during their enrollment in the program.
3. In addition to these clinical hours, the students need to complete a variety of tasks and assignments including:
  - a. Participation in roundtable format Question and Answer (Q & A) sessions regarding their experience in the first few weeks of starting their clinical practicums.
  - b. Presenting their monitored cases to the class and responding to questions about them.
  - c. Presenting a variety of surgical procedures that utilize IONM. Content include indication for each specific procedure, advantages of the surgical technique utilized, surgical steps involved and a review of potential post operation complications of each surgery.
4. Each student must submit an evaluation report on a weekly basis (or other intervals recommended by the Clinical Director of the program) to report their experience with their clinical training and emphasize on areas in need of improvement (either by them or by their mentors).
5. Each student must submit a monthly “ongoing Assessment Report” to the program Director that provides details of their progress throughout the month and signifies the areas in need of improvement.
6. A comprehensive exam is conducted at the end of each semester that the Clinical practicum is offered. The exam not only tests the students understanding of the concepts related to IONM, but also includes testing the students’ abilities in writing protocols appropriate for modalities tested, placement of electrodes on the mannequin models and offer monitoring plans suited for different types of surgical procedures. The content of the exam will be more expansive towards the end of the program corresponding to students’ progress in the program.
7. Final grading and awarding the credits in each semester is based on successful completion of the assigned tasks, continuous participation in covering assigned surgical cases (no more than one missed day per semester with prior coordination with the Clinical Director of the program), meeting certain competency level evaluated by the mentors and successful completion of the end of the semester exam.



## **Policies and Procedures for Clinical Practicum Master of Science in Surgical Neurophysiology**

1. All students enrolling in Clinical Practicum need to complete Criminal Background Screening, Immunizations, Drug Testing and Physical Exam as required by healthcare affiliated partners and be cleared before they can start their hospital visits.
2. If any student becomes non-compliant with the requirements mentioned at any time during the program, his/her Clinical Practicum will be halted until the requirement is satisfactory met.
3. Students need to follow any specific affiliate healthcare partners individual rules and regulations while on their facilities grounds.
4. Students need to have minimum of two available days during any semester they are enrolled in the Clinical Practicum. The Clinical Director need to be informed by each student before the first day of each semester they are enrolled in the Clinical Practicum of their available days throughout the semester.
5. Students must meet their assigned mentor for the day preferably one hour prior to the start of the procedure.
6. Each student is only allowed one missed clinical day each semester with prior notification to the Clinical Director of the program unless the students is ill and in that case the student with coordination with the Clinical Director will be taken out of the Clinical Practicum until the student has recovered from their illnesses.
7. Late arrival on any assigned case is equivalent to a missed case and will be treated as such.
8. Missing more than one clinical day without coordination with the Clinical Director of the program can result in failing the course and if it continues more than two clinical days, may result in disqualification from continuation of the Clinical Practicum for the semester and all the consecutive semester(s).
9. The University shall withdraw any Student from the Facility at the Facility's request, if the Facility determines that due to health, performance, or other reasons, such Student's continued participation in the Program is detrimental to the Student, the Facility, and/or the Facility's patients or personnel.
10. Students would need to adhere to all the recommendations provided to them by the Clinical Director of the program based on the feedback from mentors and show improvement in the

deficient areas.

11. All the tasks assigned out of the Operating Room including case presentations, paper presentations, etc. need to be completed on the deadlines provided.
12. All students shall complete the program evaluation forms on a frequency recommended by the program's Clinical Director.
13. All mentors shall complete the program evaluation forms on a frequency recommended by the program's Clinical Director.
14. The students must not disclose any confidential material or information connected with the Facility or any of its patients, except as required by federal or State law, including the Connecticut Freedom of Information Act (FOIA). Students are required to comply with the Facility's policy on confidentiality.
15. The students must keep all the proprietary information of the neuromonitoring providers they may be exposed to while with the mentors in the Operating Room environment confidential.
16. The students must also abide with any specific requests by the neuromonitoring providers as it relates to their activity while training under the supervision of assigned mentors by these providers.
17. In case of any needle stick incident, the students shall immediately notify the Circulating Nurse in the operating room and the program Clinical Director so appropriate follow-ups can be completed.
18. Any case of misconduct, harassment, violence, etc. occurring while on the healthcare facilities shall be reported immediately to the Clinical Director of the Program, for HR or any other UConn appropriate bodies be informed and for follow-up measures to be put in place appropriately.



## **Policies on Advanced Placement Master of Science in Surgical Neurophysiology**

1. The program understands that employment opportunities may be offered to the students throughout the program by either neuromonitoring providers or in-house IONM entities. The employment under this circumstance does not disqualify students from participating and completing the program.
2. The employers promise the program that students are allowed to complete a minimum of 8 hours of Clinical Practicum each week during the academic semesters under the supervision of the mentors and the information regarding their case coverage will be provided to the Clinical Director of the program.
3. Students shall not be paid for the weekly 8 hours of Clinical Practicum. Receiving payments during these hours disqualify the students from continuation of their Clinical Practicum.
4. Students are responsible to assure their required clinical hours are completed throughout the week and reported properly to the Clinical Director.
5. A fair interview process will be open to all the students. All students interested can apply to the program.
6. Once employed, the employer will take over the responsibilities of general and professional liabilities of the students along with assuring they are properly credentialed to enter any healthcare facility they are assigned to.
7. Students who are hired and their respective mentors need to continue to submit evaluation reports on the intervals requested by the Clinical Director of the program similar to other students that are not hired (as described in Policies and Procedures for Clinical Practicum).
8. Any corrective measure(s) that are recommended based on the students' progress in the Clinical Practicum, need to be implemented and the evaluation of the students will be monitored by the Clinical Director of the program to assure student's successful progression in the remainder of the program.



## **Graduate Competencies for Performing Intraoperative Neurophysiological Monitoring (IONM)**

The Master of Science in Surgical Neurophysiology Program at the University of Connecticut Department of Physiology and Neurobiology has adopted all the guidelines set forth by the Committee on Accreditation for Education in Neurodiagnostic Technology (CoA-NDT) in Intraoperative Neurophysiological Monitoring (IONM). All the competencies recommended by the committee has been implemented in different program's courses and students are trained throughout the program to meet the level of competencies expected.

### **I. ENTRY-LEVEL competency is evidenced by the graduate's knowledge demonstrated in the following areas:**

#### **A. Bioelectrical principles**

- 1) Demonstrate a historic knowledge of analog NDT technology by:
  - a. Describing how differential amplifiers work;
  - b. Illustrating the grid concept with respect to anode and cathode designation;
  - c. Applying positive/negative and near/far field potentials to the grid; and,
  - d. Explaining the effect of input impedance, common mode rejection, polarity convention and gain,
  - e. Explain the effects of other equipment (fluid warmers, OR table, patient warmers, etc.) on the quality of the intraoperative recording.
  
- 2) Demonstrate the application of current digital principles of electronics and mathematics to recording by:
  - a. Illustrating how differential amplifiers work;
  - b. Determining the amplitude, latency and frequency of waveforms;
  - c. Calculating the duration of waveforms;
  - d. Illustrating the polarity of waveforms;
  - e. Defining impedance;
  - f. Describing analog to digital conversion and the effects of sampling rate (Nyquist);
  - g. Identify vertical resolution limitations as identified by signal clipping;
  - h. Correcting or reporting malfunctions or deviations as appropriate;
  - i. Stating how waveform displays are affected by:
    - i. amplifier and preamplifier integrity;
    - ii. filter settings;
    - iii. amplifier gain/display gain; referential and bipolar montages;
    - iv. digital/smoothing filters;
    - v. electrode types and electrode material composition; and,
    - vi. malfunctioning equipment.
  - j. verifying appropriate filter and sensitivity settings; and,
  - k. verifying proper amplifier function
  
- 3) Analyze the digital spectral array (DSA) by:

- a. identifying the frequency axis of a DSA; and
  - b. explaining how power is represented and plotted as a color.
- 4) Illustrate basic electrical concepts by:
- a. solving for circuit elements using Ohm's law;
  - b. calculating equivalent resistance for Resistors in parallel and series; and
  - c. explaining the proper use of low and high frequency and notch filters for signal processing.

## **B. Surgical and anatomic principles**

- 1) Identify the impact of pre-operative deficits and intraoperative injuries on post-operative outcomes.
- 2) Identify specific surgical maneuvers and tools or implants that can cause intraoperative injury.
- 3) Identify specific anatomic structures in the context of:
  - a. Spinal Surgery
    - i. Illustrate basic spinal anatomy and structure;
    - ii. Identify generally accepted innervation patterns of cervical, lumbar, and sacral nerve roots;
    - iii. Describe the surgical devices and implants used along with their function for spinal procedures;
    - iv. Identify and locate the cauda equina; and,
    - v. Illustrate the organization of the brachial plexus.
  - b. Spinal Cord Surgery
    - i. Illustrate the topographical organization of major sensory and motor pathways in the spinal cord;
    - ii. Differentiate between and locate proprioceptive and nociceptive spinal pathways;
    - iii. Illustrate the functional and topographical perfusion of the spinal cord;
    - iv. Classify spinal cord tumors as extradural, intradural-extramedullary, and intramedullary; and,
    - v. Locate the cell bodies for sensory and motor neurons in the spinal cord.
  - c. Supra- and Infra-tentorial procedures for tumor resection
    - i. Describe the pathways, functions, and innervation patterns of cranial nerves;
    - ii. Identify the topographical organization of the brain, including:
      1. 4 lobes and their primary functions;
      2. Major motor, sensory, and speech/language areas; and,
      3. Brainstem structure and composition
  - d. Neurointerventional Radiology procedures
    - i. Identify major cerebral arteries and their supply to topographical areas;
    - ii. Illustrate and identify the circle of Willis; and,
    - iii. Explain the collateral flow concept.
  - e. Vascular surgery
    - i. Explain cerebral and spinal autoregulation and its limitations in pathologic patients;
    - ii. Explain the benefits and utility of hypothermia for neuroprotection; and,
    - iii. Describe the pattern of spinal cord perfusion from the aorta.
  - f. Otolaryngological surgery
    - i. Identify the muscles innervated by the terminal branches of:
      1. The vagus nerve (CN X)
        - a. Superior laryngeal nerve
        - b. Recurrent laryngeal nerve; and

2. The facial nerve (CN VII)
  - a. Temporal branch
  - b. Zygomatic branch
  - c. Buccal branch
  - d. Marginal mandibular branch

## C. IONM Techniques

### 1) Phase Reversal

- a. Explain how the localization of the sensorimotor cortex is achieved with SSEPs by recognizing how to:
  - i. Confirm somatosensory pathway with pre-incision baselines with scalp electrodes;
  - ii. Adapt time base, sensitivity and bandpass, as needed;
  - iii. Select appropriate stimulation site (typically contralateral median nerve);
  - iv. Record from strip or grid electrodes;
  - v. Prepare stimulus site to reduce stimulating electrode impedance;
  - vi. Monitor peripheral nerve site to verify stimulus effect;
  - vii. How to use a referential or bipolar montage to record direct cortical responses and produce a physiologic “phase reversal”;
  - viii. Obtain adequate resolution of the obligate components; and,
  - ix. Record from multiple cortical sites in order to obtain adequate localization.

### 2) Cranial nerve EMG monitoring.

- a. Explain how motor cranial nerves are monitored and stimulated by recognizing:
  - i. How to apply needle, sticky pads or hookwire recording electrodes to the appropriate muscles to record spontaneous and evoked EMG responses from the specific nerves;
  - ii. Who is qualified to place needles for cranial nerve 3,4,6, 9,10 and 12 per department policy;
  - iii. How to check impedance and recording function prior to prepping and draping;
  - iv. How to provide a sterile stimulating probe when needed and understanding the utility of different types of probes;
  - v. How to select appropriate intensity and duration to produce a moderate muscle twitch of the muscles from the cranial nerve being stimulated being cognizant of patient
  - vi. safety issues and following department protocols; and,
  - vii. How to record spontaneous free-running EMG and evoked CMAPs.
- b. Peripheral nerve mapping
  - i. Describe the benefit of intraoperative mapping for peripheral nerve repair by:
    1. explaining the utility of tripolar stimulation:
      - a. Discussing the concept of axonal regrowth following nerve injury and
      - b. Listing and describing the degrees of nerve injury in the Seddon or Sunderland classification systems.
- c. Electrocochleography.
  - i. Explain how to record direct nerve action potentials from the cochlea or cranial nerve VIII simultaneously with BAEPs during certain tumor cases by recognizing:
    1. How to pass the sterile direct nerve needle electrode;
    2. How to use the same auditory clicks, intensity and stimulus rates as the BAEPs;
    3. How to use a montage referencing the direct nerve electrode to the ipsilateral ear; and,

4. How to select appropriate time base and recording sensitivity to record these high amplitude responses.
- d. Electrocorticography
  - i. Explain electrocorticography (EcoG) and subdural/depth electrode placement/recording by recognizing:
    1. How electrodes are placed and sterile method of transfer of electrodes and cables.
    2. What montages are used to record EcoG.
    3. What settings and sensitivity are needed.
    4. What artifacts are encountered during recording.
    5. What EEG waveforms are consistent with epileptogenic foci in the surgical field.
    6. What cortical stimulation procedures are used.
    7. How to correlate epileptogenic foci with neuroanatomy and clinical behaviors.
    8. Sub-clinical seizure patterns, including:
      - a. post-stimulation direct cortical after discharges
      - b. sub-clinical EMG.
- e. Visual Evoked Potentials.
  - i. Explain the application and limitations of VEPs including:
    1. Ideal anesthetic parameters and montages for intraoperative VEPs;
    2. How to obtain relevant ophthalmologic and neurologic history;
    3. How to assess a patient's ERG;
    4. How to use LED goggle stimuli; and,
    5. The limitations of Flash and LED stimuli.

## II. ENTRY-LEVEL competency is evidenced by the graduate's skills demonstrated in the following areas:

### A. Pre-operative phase

- 1) Apply functional anatomy and physiology as pertains to the underlying disease process and surgical procedure being performed by:
  - a. identifying signs and symptoms of common medical and surgical disorders and
  - b. identifying signs and symptoms of intraoperative neurological complications.
- 2) Demonstrate the importance of effective communication among all involved personnel concerning what is involved in the surgery, what structures are at risk, and documenting
- 3) Appropriate communication with the interpreting physician.
- 4) Recommend criteria for assessing IONM abnormalities and maturation of components based on those established by professional organizations.
- 5) Document preoperative discussions with the neurophysiologist and surgeon in determining a monitoring plan that may include:
  - a. Identifying the structures at risk;
  - b. Modalities offered by the technologist and requested by the surgeon;
  - c. Clear criteria for alarm parameters; and,
  - d. Frequency of modalities.
- 6) Discuss with the anesthesiologist and surgeon the optimal anesthetics and physiologic parameters for each modality being monitored and documenting the outcome of these discussions.
- 7) Identify and discuss contraindications and concerns with specific monitoring techniques with surgeon and anesthesiologist prior to case.

- 8) Develop an anesthetic regimen best for agreed upon monitoring plan.
- 9) Discuss with anesthetist the potential use of IONM data in assessing depth of anesthesia.

## **B. Intra-operative phase**

Intra-operative phase competencies must be achieved and documented. During live cases within the surgical suite.

- 1) Properly set up a surgical case for neuromonitoring by:
  - a. Verifying identity of patient according to the National Patient Safety Standards of the Joint Commission and hospital policies and procedures;
  - b. Documenting the patient history and clinical findings in accordance with hospital policy;
  - c. Documenting the surgery being performed;
  - d. Documenting alternative electrode placement, if any;
  - e. Identifying and maintaining the sterile field;
  - f. Obtaining sterile electrodes and any other sterile supplies before the procedure;
  - g. Passing sterile electrodes and devices to surgical personnel in an appropriate manner;
  - h. Testing electrodes by checking and documenting impedances;
  - i. Measuring, marking and applying electrodes according to commonly accepted national and international standards;
  - j. Tracking an appropriate electrode count before and after the case;
  - k. Arranging headbox, cables, and electrodes for minimization of artifacts, and to prevent electrodes from being dislodged, dried or contaminated with fluids;
  - l. Verifying amplifier function;
  - m. Verifying appropriate filter settings;
  - n. Verifying sensitivity settings; and,
  - o. Cleaning and prepping skin prior to electrode application per department protocols, securing electrodes adequately and disposing properly after use;
- 2) Acquire baseline intraoperative neurophysiological signals that include:
  - a. Pre-incision baseline of all modalities;
  - b. Post-incision optimized baselines that may be necessary related to positioning or changes in the anesthetic regimen;
  - c. Reliably interpretable waveforms which are relatively artifact free and exhibit good replication;
  - d. Appropriate recording and stimulus parameters using supramaximal stimulation techniques where applicable;
  - e. Displaying obligate EP waveforms according to professional guidelines or hospital policy;
  - f. Using appropriate electrode type based on stimulus or recording sites;
  - g. Normal, abnormal, or unobtainable waveforms as related to clinical symptoms and/or diagnosis;
  - h. Recording leads for physiological potentials, where appropriate (eye, respiration, EKG, EMG)
- 3) Obtain technically adequate intraoperative SSEPs by:
  - a. Obtaining relevant neurologic, orthopedic and/or neurosurgical history or any other relevant pathway specific information such as the presence of peripheral neuropathy;
  - b. Selecting appropriate timebase, sensitivity and bandpass settings;

- c. Maintaining stimulating and recording electrode impedance equal and below 5000ohms to assure proper stimulation and recording and decrease stimulation artifact;
  - d. Selecting current of sufficient intensity and duration to elicit a supramaximal motor twitch from the appropriate areas of stimulation and/or that which maximizes the amplitude of a peripherally generated response;
  - e. Using a montage that records obligate peak responses from peripheral nerve, spinal cord, subcortical structures and cerebral cortex as appropriate per departmental protocols;
  - f. Recording from electrodes overlying the scalp surface, peripheral sites and from electrodes placed in the spinous process or epidural space per surgical case
  - g. specifications and/or department protocols;
  - h. Marking waveforms and calculating absolute latencies, amplitudes and inter-peak intervals at baseline and throughout the monitoring procedure per department protocols;
  - i. Delivering unilateral alternating stimulation of left and right sided nerves (or in appropriate setting, i.e., infants, bilateral stimulation) per established protocols; and,
  - j. Following the policy for alarm criteria and reporting and documenting when SSEP data meets those measures.
- 4) Obtain technically adequate spontaneous and triggered intraoperative EMG by:
- a. Measuring waveforms and distances used in routine nerve conduction studies;
  - b. Choosing the appropriate stimulator type (and recording electrode type, if applicable) to be used in the sterile field if triggered EMG/NAP responses will be utilized, based upon established department protocols;
  - c. Correctly passing sterile stimulator (along with reference electrode if needed and any sterile recording electrodes) onto the field at the beginning of the procedure and connecting it/them correctly to the monitoring equipment;
  - d. Choosing the appropriate muscles/nerves to be monitored based on the surgical procedure being performed per department protocol;
  - e. Securely applying recording electrodes that have low and balanced impedance to ensure proper recording of the muscle activity;
  - f. Choosing the appropriate stimulation parameters including intensity, duration, and frequency of stimulation delivery per department protocol;
  - g. Recognizing the benefit of raw EMG sound and using loudspeakers to provide auditory feedback as appropriate according to department protocol;
  - h. Recognizing appropriate alarm criteria and reporting and documenting alerts per department protocol;
  - i. Verifying the level of neuromuscular blockade through “train of four (TOF)” monitoring throughout monitored
  - j. portion of the procedure per department protocol; and,
  - k. Recognizing pedicle screw stimulation thresholds and reporting them per department protocol.
- 5) Obtain technically adequate intraoperative Transcranial Electric Motor Evoked Potentials (tcMEP) by:
- a. Obtaining relevant neurologic, orthopedic and/or neurosurgical history or any other relevant pathway specific information such as the presence of myelopathy;
  - b. Recognizing and documenting contraindications to MEP stimulation;
  - c. Selecting and establishing appropriate timebase, sensitivity and bandpass settings;
  - d. Placing electrodes appropriately on the scalp and maintaining stimulating electrode impedances equal and below 5000ohms to assure proper stimulation and decrease stimulus

- artifact;
  - e. Selecting and implementing current of sufficient intensity, duration, number of pulses and trains, and interstimulus interval to elicit a compound muscle action potential from relevant muscle groups;
  - f. Communicating with staff about probable patient movement and developing a plan to determine safest stimulation times;
  - g. Using a montage that records responses from selected muscle groups appropriate for the operative levels per department protocols;
  - h. Setting waveforms at baseline, noting latency and amplitude according to department protocol;
  - i. Recording waveforms throughout the monitoring procedure per department protocol;
  - j. Stating the importance of bite-blocks for preventing mouth injury, reaching agreement as to who will place them and insuring they are in position at baseline, after all positioning and periodically throughout case; and,
  - k. Recognizing appropriate alarm criteria and reporting and documenting alerts per department protocol.
- 6) Obtain technically adequate Intraoperative EEG by:
- a. Recognizing and documenting all EEG patterns that may be seen during the monitoring and being able to explain their relevance to the performance of IONM;
  - b. Establishing a pre-operative, pre-anesthetic baseline if needed per department protocol; and,
  - c. Establishing a post-anesthetic baseline prior to incision and reestablishing that baseline if necessary due to anesthetic effects, prior to any clamping or any other major surgical event per department protocol.
- 7) Obtain technically adequate Brainstem Auditory Evoked Potentials (BAEP) by:
- a. Obtaining any relevant audiologic, neurologic, and/or neurosurgical history relevant to auditory or vestibular function;
  - b. Assessing the patient's ear canals;
  - c. Noting the results of prior hearing evaluations;
  - d. Using molded ear speakers or insert transducers to avoid contamination of the surgical field;
  - e. Using waterproof adhesive tape and/or bone wax to protect the ear speaker/insert and ear canal from blood and fluids;
  - f. Choosing the appropriate montage, timebase, number of stimuli, sensitivity and bandpass settings per department protocol;
  - g. Choosing the appropriate click polarity, rate and intensity;
  - h. Establishing hearing threshold;
  - i. Correlating elevations in thresholds with any existing hearing loss or conditions of ear structures;
  - j. Expressing click intensity measures in equivalent units of dBSL, dBHL, or dBSPL;
  - k. Using techniques to enhance wave I resolution such as an ear to ear montage derivation or using an ear canal electrode or increasing stimulus intensity;
  - l. Using alternating click polarity to minimize stimulation artifact, or rarefaction or condensation clicks to obtain the best response as appropriate;
  - m. Using an appropriate stimulus intensity per department protocol;
  - n. Using an appropriate stimulus rate to resolve the most important BAEP components and maintaining the same rate throughout;
  - o. Obtaining adequate resolution of obligate waves I, III, and V;

- p. Measuring and calculating the absolute latencies, amplitudes and interpeak intervals of obligate peaks at baseline and throughout monitoring and adjusting the baselines as necessary due to anesthetic and other physiologic changes;
  - q. Masking the contralateral ear with appropriate intensity, when applicable;
  - r. Continuously monitoring the ear ipsilateral to surgical intervention (contralateral is also appropriate for large posterior fossa tumors, or as a control); and,
  - s. Recognizing when to perform a latency intensity series for auditory assessments.
- 8) Perform all requisite communication throughout the case by:
- a. Reporting significant suspected anesthetic effects on neurophysiological signals to the anesthesia provider and surgeon;
  - b. Reporting labeled baseline recordings of all modalities, including pre-positioning baselines if appropriate with optimized stimulation and recording parameters to surgeon; and,
  - c. Reporting and confirming all communication from oversight provider to surgeon.
- 9) Document all pertinent information including:
- a. Anesthetic values on a regular basis according to clinical site policies;
  - b. Inhaled anesthetic volatility and related Minimal Alveolar Concentration (MAC) values;
  - c. Vital signs and other physiologic factors, and their potential effects upon the monitoring being performed including:
    - i. ischemia;
    - ii. changes in blood pressure;
    - iii. oxygen saturation;
    - iv. temperature (core and limb and intradural);
    - v. excessive blood loss;
  - d. Body positional issues;
  - e. Critical periods during the surgery where monitoring is most crucial;
  - f. Pertinent steps to the surgical procedure;
  - g. Patient movement;
  - h. Variations to customary policies and procedures;
  - i. Changes to stimulation and recording parameters with reason for the change;
  - j. Interruptions of monitoring for technical reasons, including trouble shooting;
  - k. All pertinent conversations had during the case;
  - l. All changes in monitored data and communication with the surgeon, anesthesiologist and interpreting physician regarding the changes and corrective action taken, according to clinical site policy and procedure alarm criteria;
  - m. Primary and/or secondary monitoring technologist and any changes in monitoring staff, including case hand-off documentation.
- 10) Recognize anesthetic correlates including:
- a. How specific anesthetic agents affect the central and peripheral nerve functioning;
  - b. How muscle relaxants change responses and how to monitor the level of neuromuscular blockade using “train of four” technique;
  - c. How specific anesthetics change ongoing EEG;
  - d. How specific anesthetics change the latencies and amplitudes of evoked potentials;
  - e. How the method of delivering anesthetics (inhalation, infusion, bolus injection, low flow inhalation) effects EEG and Evoked Potentials;
  - f. Whether the artifact is physiologic or non-physiologic;



- g. Changes in concentration of volatile agents (MAC) on patient and monitoring;
- h. Observing interactions between nitrous oxide and other volatile anesthetics;
- i. Changes in CO<sub>2</sub> and O<sub>2</sub> saturation;
- j. Decline in hemoglobin and hematocrit;
- k. Increase or decrease in core or limb temperature;
- l. Mean arterial pressure changes; and,
- m. IONM patterns for levels of consciousness.

11) Demonstrate proper signal optimization and troubleshooting techniques by:

- a. Evaluating baseline waveforms to assess if any protocol modifications are required, including electrode derivations and other techniques as needed to enhance or clarify the waveforms as a result of changes occurring during the recording process;
- b. Checking the quality of the raw signal regularly or whenever needed;
- c. Applying the concepts of artifact rejection to improve waveforms;
- d. Enhancing the relationship of signal to noise ratio by various means, e.g., increasing the number of sweeps, changing the repetition rate;
- e. Identifying the source of the artifact (e.g., poor electrode application, malfunctioning stimulator, positioning of cables, electrically hostile OR equipment, extension cords) and correcting it accordingly;
- f. Calculating the frequency in Hz of rhythmic artifacts;
- g. Recognizing the effects of an inappropriate bandpass or resorting to using the notch filter to resolve data;
- h. Properly grounding the patient and equipment;
- i. Identifying and documenting if the artifact is physiological or non-physiological;
- j. Identifying appropriate methods of troubleshooting per modality;
- k. Applying the concepts of signal averaging and noise reduction;
- l. Analog to digital conversion including amplitude resolution, sampling rate, analysis time, sampling interval (dwell time) and Nyquist frequency;
- m. Minimizing and balancing electrode impedance;
- n. Applying basic electrical safety concepts;
- o. Replacing electrodes exhibiting questionable activity or contact.

### C. Post-operative phase

- 1) Properly disconnecting equipment from the patient by:
  - a. Cleaning the patient's scalp, hair and skin to remove paste, blood or materials left from the monitoring;
  - b. Checking the patient for burns, skin breakdown under electrode sites/tape and documenting incidents according to hospital or department policy and procedures;
  - c. Accounting for and disposing of sharps in the appropriate manner; and,
  - d. Cleaning and disinfecting the equipment.
- 2) Perform a general post op neurological assessment if patient is alert and able to follow commands.
- 3) Finalize the detailed test data worksheet according to department policy and procedures.
- 4) Store information on appropriate media.

## D. Ethics, Safety and Professional Principles

- 1) Provide a safe recording environment for the patient and other personnel by:
  - a. Following patient confidentiality standards as set by the Health Insurance Portability and Accountability Act (HIPAA);
  - b. Taking appropriate precautions to ensure electrical safety when electrocautery is in use and ancillary equipment is connected to the patient;
  - c. Following hazardous material management guidelines;
  - d. Recognizing and responding to life-threatening situations;
  - e. Recognizing and documenting patient allergies;
  - f. Obtaining and maintaining valid CPR certification;
  - g. Following Standard Precautions and Transmission-Based Precautions for infection control;
  - h. Adhering to the National Patient Safety Standards of The Joint Commission;
  - i. Exemplifying operating room etiquette; and,
  - j. Complying with hospital OR dress code.
- 2) Maintain safe intraoperative neuromonitoring equipment by:
  - a. Recognizing and addressing malfunctions seen in monitoring equipment and
  - b. Following clinical site policies and procedures for implementing and maintaining equipment and documenting this maintenance.
- 3) Discuss the use of safety data sheets (SDS) and proper disposal of hazardous materials (e.g., acetone, collodion, blood products, cleaners, sanitizers).
- 4) Identify electrical safety issues related to:
  - a. Types of recording and stimulating electrodes;
  - b. Cautery units and return grounding pads;
  - c. Other units that are connected to the patient;
  - d. Multiple grounds; and,
  - e. Use of new equipment in the OR (biomed checks at individual hospitals).
- 5) Identify infection control and safety issues surrounding correct protocols for reusable electrodes and probes and sterilization requirements.
- 6) Describe the benefit of future ongoing professional development for continuing competence post-graduation through the:
  - a. Review of intraoperative monitoring procedures with the neurophysiologist on a regular basis and,
  - b. Acquisition of continuing education units (CEUs).
- 7) Explaining general roles, responsibilities and limitations appropriate to his/her credentials from:
  - a. Appropriate credentialing boards;
  - b. Appropriate professional boards;
  - c. Appropriate state licensing requirements; and,
  - d. Individual hospital credentialing requirements.

## III. Clinical Cases

Students must gain practical experience in a significant variety of surgical cases as well as be exposed to a wide variety of monitoring modalities.