



Commission on Accreditation of Allied Health Education Programs

Standards and Guidelines for the Accreditation of Educational Programs in Intraoperative Neurophysiologic Monitoring

Standards initially adopted in 2013; revised 2021 by the:
American Academy of Neurology
American Clinical Neurophysiology Society
ASET - The Neurodiagnostic Society
American Society of Neurophysiologic Monitoring
Committee on Accreditation for Education in Neurodiagnostic Technology
and
Commission on Accreditation of Allied Health Education Programs

The Commission on Accreditation of Allied Health Education Programs (CAAHEP) accredits programs upon the recommendation of the Committee on Accreditation for Education in Neurodiagnostic Technology (CoA- NDT).

These accreditation **Standards and Guidelines** are the minimum standards of quality used in accrediting programs that prepare individuals to enter the Intraoperative Neurophysiologic Monitoring (IONM) profession. Standards are the minimum requirements to which an accredited program is held accountable. Guidelines are descriptions, examples, or recommendations that elaborate on the Standards. Guidelines are not required, but can assist with interpretation of the Standards.

Standards are printed in regular typeface in outline form. *Guidelines* are printed in italic typeface in narrative form.

Preamble

The Commission on Accreditation of Allied Health Education Programs (CAAHEP), Committee on Accreditation for Education in Neurodiagnostic Technology (CoA-NDT) and American Academy of Neurology (AAN), American Clinical Neurophysiology Society (ACNS), ASET – The Neurodiagnostic Society, and American Society of Neurophysiologic Monitoring (ASNM) cooperate to establish, maintain, and promote appropriate standards of quality for educational programs in Intraoperative Neurophysiologic Monitoring (IONM) and to provide recognition for educational programs that meet or exceed the minimum standards outlined in these accreditation **Standards and Guidelines**. Lists of accredited programs are published for the information of students, employers, educational institutions and agencies, and the public.

These **Standards and Guidelines** are to be used for the development, evaluation, and self-analysis of IONM programs. On-site review teams assist in the evaluation of a program's relative compliance with the accreditation Standards.

Description of the Profession

Neurodiagnostics is the allied health profession that records, monitors, and analyzes nervous system function to promote the effective treatment of pathological conditions. Further, Intraoperative Neuromonitoring (IONM) involves continued monitoring of neurological structures during surgical procedures that place these structures at risk.

Intraoperative neuromonitorists hold specialty credentials; demonstrate critical thinking skills; meet educational and performance standards; meeting continuing education requirements; perform within a code of ethics and defined scope of practice; are recognized by physicians, employers, the public, governmental agencies, payors and other health professionals; have a national society whose activities include lobbying for the profession; and, contribute to the advancement of knowledge in neuroscience.

I. Sponsorship

A. Sponsoring Institution

A sponsoring institution must be at least one of the following,

1. A post-secondary institution accredited by an institutional accrediting agency that is recognized by the U.S. Department of Education, and authorized under applicable law or other acceptable authority to provide a post-secondary program, which awards a minimum of a certificate/diploma at the completion of the program.
2. A foreign post-secondary institution acceptable to CAAHEP, which is authorized under applicable law or other acceptable authority to provide a postsecondary program, which awards a minimum of a certificate/diploma at the completion of the program.
3. A hospital, clinic, medical center or IONM service company that is institutionally accredited and authorized under applicable law or other acceptable authority to provide healthcare in the United States, which
 - a. awards academic credit for the program; or
 - b. has an articulation agreement with an accredited post-secondary institution; or
 - c. awards a minimum of a post-baccalaureate academic certificate for the program.
4. A branch of the United States Armed Forces, which awards a minimum of a certificate/diploma at the completion of the program.

B. Consortium Sponsor

1. A consortium sponsor is an entity consisting of two or more members that exists for the purpose of operating an educational program. In such instances, at least one of the members of the consortium must meet the requirements of a sponsoring institution as described in I.A.
2. The responsibilities of each member of the consortium must be clearly documented in a formal affiliation agreement or memorandum of understanding, which includes governance and lines of authority.

C. Responsibilities of Sponsor

1. The Sponsor must ensure that the provisions of these **Standards and Guidelines** are met.

II. Program Goals

A. Program Goals and Outcomes

There must be a written statement of the program's goals and learning domains consistent with and responsive to the demonstrated needs and expectations of the various communities of interest served by the educational program. The communities of interest that are served by the program must include, but are not limited to, students, graduates, faculty, sponsor administration, employers, physicians, and the public.

Program-specific statements of goals and learning domains provide the basis for program planning, implementation, and evaluation. Such goals and learning domains must be compatible with the mission of the sponsoring institution(s), the expectations of the communities of interest, and nationally accepted standards of roles and functions. Goals and learning domains are based upon the substantiated needs of health care providers and employers, and the educational needs of the students served by the educational program.

The program should document its strategy for monitoring community needs.

B. Appropriateness of Goals and Learning Domains

The program must regularly assess its goals and learning domains. Program personnel must identify and respond to changes in the needs and/or expectations of its communities of interest.

An advisory committee, which is representative of at least each of the communities of interest named in these **Standards**, must be designated and charged with the responsibility of meeting at least annually, to assist program and sponsor personnel in formulating and periodically revising appropriate goals and learning domains, monitoring needs and expectations, and ensuring program responsiveness to change.

Advisory committee meetings may include participation by synchronous electronic means.

C. Minimum Expectations

The program must have the following goal defining minimum expectations: "To prepare competent entry-level Intraoperative Neurophysiologic Monitoring Specialists in the cognitive (knowledge), psychomotor (skills), and affective (behavior) learning domains."

Programs adopting educational goals beyond entry-level competence must clearly delineate this intent and provide evidence that all students have achieved the basic competencies prior to entry into the field.

Nothing in this Standard restricts programs from formulating goals beyond entry-level competence.

III. Resources

A. Type and Amount

Program resources must be sufficient to ensure the achievement of the program's goals and outcomes. Resources must include, but are not limited to: faculty; clerical and support staff; curriculum; finances; offices; classroom, laboratory, and ancillary student facilities; clinical

affiliates; equipment; supplies; computer resources; instructional reference materials; and faculty/staff continuing education.

Learning resources should be accessible at times commensurate with the needs of the program and its students.

Examples of computer resources are computer-assisted instruction materials, patient care simulations, and access to internet resources.

B. Personnel

The sponsor must appoint sufficient faculty and staff with the necessary qualifications to perform the functions identified in documented job descriptions and to achieve the program's stated goals and outcomes.

1. Program Director

a. Responsibilities

The program director must be responsible for all aspects of the program, including but not limited to:

- 1) administration, organization, and supervision of the educational program, including ensuring physician interaction with and instruction of students;
- 2) continuous quality review and improvement of the educational program;
- 3) long range planning and ongoing development of the program; and,
- 4) outcomes of the program and appropriate systems to ensure the effectiveness of the program.

b. Qualifications

The Program Director must:

- 1) hold active verifiable certification or registration within the IONM profession(s);
- 2) possess a minimum of a Bachelor's Degree;
- 3) have a minimum of three (3) years clinical experience in IONM; and
- 4) have a minimum of two (2) years teaching experience.

Teaching experience should be within the past 5 years and may be demonstrated by: preparation and/or presentation of IONM workshops, scientific sessions, or teleconferences; faculty rank at a university; preparation and presentation of lectures or in-service seminars; and authorship of exams, computer-aided instruction, course objectives or other education materials.

There should be documentation that the Program Director maintains his/her clinical and technical skills and participates regularly in continuing clinical education.

2. Medical Director

a. Responsibilities

The medical director of the program must:

- 1) provide the input necessary to ensure that the medical components of the curriculum, both the didactic and supervised clinical practice, meet current standards of medical practice;
- 2) demonstrate active involvement in the education of the students;
- 3) promote the cooperation and support of practicing physicians for interaction with and instruction of students.

b. Qualifications

The Medical Director must:

- 1) be a neurologist or clinical neurophysiologist currently licensed and authorized to practice medicine in the United States or the country in which the program is located;
- 2) have the IONM experience required for completion of a clinical neurophysiology fellowship program with a significant component in IONM.
- 3) demonstrate competence in the practice of IONM; and
- 4) have a minimum of three (3) years of current experience in IONM serving as an interpreting and reporting physician on a variety of cases

The medical director should have board certification by ABPN CN; ABCN; ABEM; ABPMR-NM; ABPN-NM; or, ABNM.

There should be documentation that the Medical Director maintains his/her clinical skills and participates in continuing medical education.

Competence may be demonstrated by evidence of participating in recent surgeries, hospital privileges for neuromonitoring, case logs and/or types of cases monitored within the last five years, authorship of scientific publications in professional IONM literature, participation in professional IONM meetings, and preparation and/or presentation of IONM workshops or lectures at professional meetings.

3. Faculty and Clinical Instructional Staff

a. Responsibilities

In classrooms, laboratories, and all clinical facilities where a student is assigned, there must be a qualified individual(s) clearly designated to provide instruction, supervision, and timely assessments of the student's progress in meeting program requirements.

b. Qualifications

Instructors must be knowledgeable in subject matter by virtue of appropriate credential(s), training, and experience in the designated content area

C. Curriculum

The curriculum must ensure the achievement of program goals and learning domains. Instruction must be an appropriate sequence of classroom, laboratory, and clinical activities. Instruction must be based on clearly written course syllabi that include course description, course objectives, methods of evaluation, topic outline, and competencies required for graduation. The curriculum must include competencies in emergency preparedness consistent with the profession.

The program must demonstrate that the curriculum offered meets or exceeds the content requirements of the latest edition of the CoA-NDT Graduate Competencies for Performing Intraoperative Neurophysiological Monitoring Procedures listed in Appendix B of these Standards and Guidelines.

The program must demonstrate physician interaction with students through instruction that contributes to achievement of the program's goals and outcomes.

D. Resource Assessment

The program must, at least annually, assess the appropriateness and effectiveness of the resources described in these **Standards**. The results of resource assessment must be the basis for ongoing planning and appropriate change. An action plan must be developed when deficiencies are identified in the program resources. Implementation of the action plan must be documented and results measured by ongoing resource assessment.

IV. Student and Graduate Evaluation/Assessment

A. Student Evaluation

1. Frequency and purpose

Evaluation of students must be conducted on a recurrent basis and with sufficient frequency to provide both the students and program faculty with valid and timely indications of the students' progress toward and achievement of the competencies and learning domains stated in the curriculum.

2. Documentation

Records of student evaluations must be maintained in sufficient detail to document learning progress and achievements.

B. Outcomes

1. Outcomes Assessment

The program must periodically assess its effectiveness in achieving its stated goals and learning domains. The results of this evaluation must be reflected in the review and timely revision of the program.

Outcomes assessments must include, but are not limited to: national credentialing examination(s) performance, programmatic retention/attrition, graduate satisfaction, employer satisfaction, job (positive) placement, and programmatic summative measures. The program must meet the outcomes assessment thresholds.

“Positive placement” means that the graduate is employed full or part-time in the profession or in a related field; and/or continuing his/her education; and/or serving in the military. A related field is one in which the individual is using cognitive, psychomotor, and affective competencies acquired in the educational program.

“National credentialing examinations” are those accredited by the National Commission for Certifying Agencies (NCCA). Participation and pass rates on national credentialing examination performance may be considered in determining whether or not a program meets the designated threshold, provided the credentialing examination or alternative examination is to be administered prior to graduation from the program. Results from an alternative examination may be accepted, if designated as equivalent by the organization whose credentialing examination is so accredited.

2. Outcomes Reporting

The program must periodically submit to the CoA-NDT the program goal(s), learning domains, evaluation systems (including type, cut score, and appropriateness), outcomes, its analysis of the outcomes and an appropriate action plan based on the analysis.

Programs not meeting the established thresholds must begin a dialogue with the CoA-NDT to develop an appropriate plan of action to respond to the identified shortcomings.

Reports should be submitted to the CoA-NDT in accordance with the established policies and timetables.

V. Fair Practices

A. Publications and Disclosure

1. Announcements, catalogs, publications, and advertising must accurately reflect the program offered.
2. At least the following must be made known to all applicants and students: the sponsor's institutional and programmatic accreditation status as well as the name, mailing address, web site address, and phone number of the accrediting agencies; admissions policies and practices, including technical standards (when used); policies on advanced placement, transfer of credits, and credits for experiential learning; number of credits required for completion of the program; tuition/fees and other costs required to complete the program; policies and processes for withdrawal and for refunds of tuition/fees.
3. At least the following must be made known to all students: academic calendar; student grievance procedure; criteria for successful completion of each segment of the curriculum and graduation; and policies and processes by which students may perform clinical work while enrolled in the program.
4. The sponsor must maintain, and make available to the public, current and consistent summary information about student/graduate achievement that includes the results of one or more of the outcomes assessments required in these **Standards**.

The sponsor should develop a suitable means of communicating to the communities of interest the achievement of students/graduates (e.g., through a website or electronic or printed documents).

B. Lawful and Non-discriminatory Practices

All activities associated with the program, including student and faculty recruitment, student admission, and faculty employment practices, must be non-discriminatory and in accord with federal and state statutes, rules, and regulations. There must be a faculty grievance procedure made known to all paid faculty.

C. Safeguards

The health and safety of patients, students, faculty and other participants associated with the educational activities of the students must be adequately safeguarded.

All activities required in the program must be educational and students, must not be substituted for staff.

D. Student Records

Satisfactory records must be maintained for student admission, advisement, counseling, and evaluation. Grades and credits for courses must be recorded on the student transcript and permanently maintained by the sponsor in a safe and accessible location.

E. Substantive Changes

The sponsor must report substantive change(s) as described in Appendix A to CoA-NDT in a timely manner. Additional substantive changes to be reported to the CoA-NDT within a reasonable period of time include:

1. changes in the curriculum that result in a change of 10% or more of the program credits;
2. converting a seated program to a distance program, or a distance program to a seated program;
3. changes in the degree or certificate awarded;
4. changes in ownership or control of the sponsoring institution; and
5. changes in the organizational structure or mission of the college or hospital, including changes in other departments (e.g., general education) that have an impact on the program.

F. Agreements

There must be a formal affiliation agreement or memorandum of understanding between the sponsor and all other entities that participate in the education of the students describing the relationship, roles, and responsibilities of the sponsor and that entity.

APPENDIX A

Application, Maintenance and Administration of Accreditation

A. Program and Sponsor Responsibilities

1. Applying for Initial Accreditation

- a. The chief executive officer or an officially designated representative of the sponsor completes a "Request for Accreditation Services" form and returns it electronically or by mail to:

Committee on Accreditation for Education in Neurodiagnostic Technology
1449 Hill Street
Whitinsville, MA 01588

The "Request for Accreditation Services" form can be obtained from the [CAAHEP website](#).

Note: There is **no** CAAHEP fee when applying for accreditation services; however, individual committees on accreditation may have an application fee.

- b. The program undergoes a comprehensive review, which includes a written self-study report and an on-site review.

The self-study instructions and report form are available from the Committee on Accreditation for Education in Neurodiagnostic Technology (CoA-NDT). The on-site review will be scheduled in cooperation with the program and CoA-NDT once the self-study report has been completed, submitted, and accepted by the CoA-NDT.

2. Applying for Continuing Accreditation

- a. Upon written notice from the CoA-NDT, the chief executive officer or an officially designated representative of the sponsor completes a "Request for Accreditation Services" form, and returns it electronically or by mail to:

Committee on Accreditation for Education in Neurodiagnostic Technology
1449 Hill Street
Whitinsville, MA 01588

The "Request for Accreditation Services" form can be obtained from the [CAAHEP website](#).

- b. The program may undergo a comprehensive review in accordance with the policies and procedures of the CoA-NDT.

If it is determined that there were significant concerns with the conduct of the on-site review, the sponsor may request a second site visit with a different team.

After the on-site review team submits a report of its findings, the sponsor is provided the opportunity to comment in writing and to correct factual errors prior to the CoA-NDT forwarding a recommendation to CAAHEP.

3. Administrative Requirements for Maintaining Accreditation

- a. The program must inform the CoA-NDT and CAAHEP within a reasonable period of time (as defined by the committee on accreditation and CAAHEP policies) of changes in chief executive officer, dean of health professions or equivalent position, and required program personnel (Refer to Standard III.B.).
- b. The sponsor must inform CAAHEP and the CoA-NDT of its intent to transfer program sponsorship. To begin the process for a Transfer of Sponsorship, the current sponsor must submit a letter (signed by the CEO or designated individual) to CAAHEP and the CoA-NDT that it is relinquishing its sponsorship of the program. Additionally, the new sponsor must submit a "Request for Transfer of Sponsorship Services" form. The CoA-NDT has the discretion of requesting a new self-study report with or without an on-site review. Applying for a transfer of sponsorship does not guarantee that the transfer will be granted.
- c. The sponsor must promptly inform CAAHEP and the CoA-NDT of any adverse decision affecting its accreditation by recognized institutional accrediting agencies and/or state agencies (or their equivalent).
- d. Comprehensive reviews are scheduled by the CoA-NDT in accordance with its policies and procedures. The time between comprehensive reviews is determined by the CoA-NDT and based on the program's on-going compliance with the Standards, however, all programs must undergo a comprehensive review at least once every ten years.
- e. The program and the sponsor must pay CoA-NDT and CAAHEP fees within a reasonable period of time, as determined by the CoA-NDT and CAAHEP respectively.
- f. The sponsor must file all reports in a timely manner (self-study report, progress reports, probation reports, annual reports, etc.) in accordance with CoA-NDT policy.
- g. The sponsor must agree to a reasonable on-site review date that provides sufficient time for CAAHEP to act on an CoA-NDT accreditation recommendation prior to the "next comprehensive review" period, which was designated by CAAHEP at the time of its last accreditation action, or a reasonable date otherwise designated by the CoA-NDT.

Failure to meet any of the aforementioned administrative requirements may lead to administrative probation and ultimately to the withdrawal of accreditation. CAAHEP will immediately rescind administrative probation once all administrative deficiencies have been rectified.

4. Voluntary Withdrawal of a CAAHEP- Accredited Program

Notification of voluntary withdrawal of accreditation from CAAHEP must be made by the Chief Executive Officer or an officially designated representative of the sponsor by writing to CAAHEP indicating: the desired effective date of the voluntary withdrawal, and the location where all records will be kept for students who have completed the program.

5. Requesting Inactive Status of a CAAHEP- Accredited Program

Inactive status for any accredited program may be requested from CAAHEP at any time by the Chief Executive Officer or an officially designated representative of the sponsor writing to CAAHEP indicating the desired date to become inactive. No students can be

enrolled or matriculated in the program at any time during the time period in which the program is on inactive status. The maximum period for inactive status is two years. The sponsor must continue to pay all required fees to the CoA-NDT and CAAHEP to maintain its accreditation status.

To reactivate the program the Chief Executive Officer or an officially designated representative of the sponsor must provide notice of its intent to do so in writing to both CAAHEP and the CoA-NDT. The sponsor will be notified by the CoA-NDT of additional requirements, if any, that must be met to restore active status.

If the sponsor has not notified CAAHEP of its intent to re-activate a program by the end of the two-year period, CAAHEP will consider this a "Voluntary Withdrawal of Accreditation."

B. CAAHEP and Committee on Accreditation Responsibilities – Accreditation Recommendation Process

1. After a program has had the opportunity to comment in writing and to correct factual errors on the on-site review report, the CoA-NDT forwards a status of public recognition recommendation to the CAAHEP Board of Directors. The recommendation may be for any of the following statuses: initial accreditation, continuing accreditation, transfer of sponsorship, probationary accreditation, withhold of accreditation, or withdrawal of accreditation.

The decision of the CAAHEP Board of Directors is provided in writing to the sponsor immediately following the CAAHEP meeting at which the program was reviewed and voted upon.

2. Before the CoA-NDT forwards a recommendation to CAAHEP that a program be placed on probationary accreditation, the sponsor must have the opportunity to request reconsideration of that recommendation or to request voluntary withdrawal of accreditation. The CoA-NDT's reconsideration of a recommendation for probationary accreditation must be based on conditions existing both when the committee arrived at its recommendation as well as on subsequent documented evidence of corrected deficiencies provided by the sponsor.

The CAAHEP Board of Directors' decision to confer probationary accreditation is not subject to appeal.

3. Before the CoA-NDT forwards a recommendation to CAAHEP that a program's accreditation be withdrawn or that accreditation be withheld, the sponsor must have the opportunity to request reconsideration of the recommendation, or to request voluntary withdrawal of accreditation or withdrawal of the accreditation application, whichever is applicable. The CoA-NDT's reconsideration of a recommendation of withdraw or withhold accreditation must be based on conditions existing both when the CoA-NDT arrived at its recommendation as well as on subsequent documented evidence of corrected deficiencies provided by the sponsor.

The CAAHEP Board of Directors' decision to withdraw or withhold accreditation may be appealed. A copy of the CAAHEP "Appeal of Adverse Accreditation Actions" is enclosed with the CAAHEP letter notifying the sponsor of either of these actions.

At the completion of due process, when accreditation is withheld or withdrawn, the sponsor's Chief Executive Officer is provided with a statement of each deficiency. Programs are eligible to re-apply for accreditation once the sponsor believes that the program is in compliance with the accreditation Standards.

Note: Any student who completes a program that was accredited by CAAHEP at any time during his/her matriculation is deemed by CAAHEP to be a graduate of a CAAHEP-accredited program.

APPENDIX B

GRADUATE COMPETENCIES FOR PERFORMING INTRAOPERATIVE NEUROPHYSIOLOGIC MONITORING (IONM)

1. 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:
 - (1) amplifier and preamplifier integrity;
 - (2) filter settings;
 - (3) amplifier gain/display gain; referential and bipolar montages;
 - (4) digital/smoothing filters;
 - (5) electrode types and electrode material composition; and,
 - (6) 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
 - (1) illustrate basic spinal anatomy and structure;
 - (2) identify generally accepted innervation patterns of cervical, lumbar, and sacral nerve roots;
 - (3) describe the surgical devices and implants used along with their function for spinal procedures;
 - (4) identify and locate the cauda equina; and,
 - (5) illustrate the organization of the brachial plexus.
 - b) Spinal Cord Surgery
 - (1) illustrate the topographical organization of major sensory and motor pathways in the spinal cord;
 - (2) differentiate between and locate proprioceptive and nociceptive spinal pathways;
 - (3) illustrate the functional and topographical perfusion of the spinal cord;
 - (4) classify spinal cord tumors as extradural, intradural-extramedullary, and intramedullary; and,
 - (5) locate the cell bodies for sensory and motor neurons in the spinal cord.
 - c) Supra- and Infra-tentorial procedures for tumor resection
 - (1) describe the pathways, functions, and innervation patterns of cranial nerves;
 - (2) identify the topographical organization of the brain, including:
 - (a) 4 lobes and their primary functions;
 - (b) major motor, sensory, and speech/language areas; and,
 - (c) brainstem structure and composition
 - d) Neurointerventional Radiology procedures
 - (1) identify major cerebral arteries and their supply to topographical areas;
 - (2) illustrate and identify the circle of Willis; and,
 - (3) explain the collateral flow concept.
 - e) Vascular surgery
 - (1) explain cerebral and spinal autoregulation and its limitations in pathologic patients;
 - (2) explain the benefits and utility of hypothermia for neuroprotection; and,
 - (3) describe the pattern of spinal cord perfusion from the aorta.
 - f) Otolaryngological surgery
 - (1) identify the muscles innervated by the terminal branches of:
 - (a) the vagus nerve (CN X)
 - i. superior laryngeal nerve
 - ii. recurrent laryngeal nerve; and
 - (b) the facial nerve (CN VII)
 - i. temporal branch
 - ii. zygomatic branch
 - iii. buccal branch
 - iv. 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:
 - (1) confirm somatosensory pathway with pre-incision baselines with scalp electrodes;
 - (2) adapt time base, sensitivity and bandpass, as needed;
 - (3) select appropriate stimulation site (typically contralateral median nerve);
 - (4) record from strip or grid electrodes;
 - (5) prepare stimulus site to reduce stimulating electrode impedance;
 - (6) monitor peripheral nerve site to verify stimulus effect;
 - (7) how to use a referential or bipolar montage to record direct cortical responses and produce a physiologic "phase reversal";
 - (8) obtain adequate resolution of the obligate components; and,
 - (9) 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:
 - (1) 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;
 - (2) who is qualified to place needles for cranial nerve 3,4,6, 9,10 and 12 per department policy;
 - (3) how to check impedance and recording function prior to prepping and draping;
 - (4) how to provide a sterile stimulating probe when needed and understanding the utility of different types of probes;
 - (5) 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 safety issues and following department protocols; and,
 - (6) how to record spontaneous free-running EMG and evoked CMAPs.

 - b) Peripheral nerve mapping
 - (1) Describe the benefit of intraoperative mapping for peripheral nerve repair by:
 - (a) explaining the utility of tripolar stimulation:
 - i. discussing the concept of axonal regrowth following nerve injury and
 - ii. listing and describing the degrees of nerve injury in the Seddon or Sunderland classification systems.

 - c) Electrocochleography.
 - (1) Explain how to record direct nerve action potentials from the cochlea or cranial nerve VIII simultaneously with BAEPs during certain tumor cases by recognizing:
 - (a) how to pass the sterile direct nerve needle electrode;
 - (b) how to use the same auditory clicks, intensity and stimulus rates as the BAEPs;
 - (c) how to use a montage referencing the direct nerve electrode to the ipsilateral ear; and,
 - (d) how to select appropriate timebase and recording sensitivity to record these high amplitude responses.

 - d) Electrocorticography
 - (1) Explain electrocorticography (EcoG) and subdural/depth electrode placement/recording by recognizing:
 - (a) how electrodes are placed and sterile method of transfer of electrodes and cables.
 - (b) what montages are used to record EcoG.
 - (c) what settings and sensitivity are needed.
 - (d) what artifacts are encountered during recording.
 - (e) what EEG waveforms are consistent with epileptogenic foci in the surgical field.
 - (f) what cortical stimulation procedures are used.

- (g) how to correlate epileptogenic foci with neuroanatomy and clinical behaviors.
- (h) sub-clinical seizure patterns, including:
 - i. post-stimulation direct cortical after discharges
 - ii. sub-clinical EMG.
- e) Visual Evoked Potentials.
 - (1) Explain the application and limitations of VEPs including:
 - (a) ideal anesthetic parameters and montages for intraoperative VEPs;
 - (b) how to obtain relevant ophthalmologic and neurologic history;
 - (c) how to assess a patient's ERG;
 - (d) how to use LED goggle stimuli; and,
 - (e) the limitations of Flash and LED stimuli.

2. 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 appropriate communication with the interpreting physician.
 - 3) Recommend criteria for assessing IONM abnormalities and maturation of components based on those established by professional organizations.
 - 4) 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.
 - 5) Discuss with the anesthesiologist and surgeon the optimal anesthetics and physiologic parameters for each modality being monitored and documenting the outcome of these discussions.
 - 6) Identify and discuss contraindications and concerns with specific monitoring techniques with surgeon and anesthesiologist prior to case.
 - 7) Develop an anesthetic regimen best for agreed upon monitoring plan.
 - 8) Discuss with anesthesiologist 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) 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 specifications and/or department protocols;
 - g) marking waveforms and calculating absolute latencies, amplitudes and inter-peak intervals at baseline and throughout the monitoring procedure per department protocols;
 - h) delivering unilateral alternating stimulation of left and right sided nerves (or in appropriate setting, i.e., infants, bilateral stimulation) per established protocols; and,

- i) 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 portion of the procedure per department protocol; and,
 - j) 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 dB SL, dB HL, or dB SPL;
 - 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:
 - (1) ischemia;
 - (2) changes in blood pressure;
 - (3) oxygen saturation;
 - (4) temperature (core and limb and intradural);
 - (5) 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) any 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 CO₂ and O₂ 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.

3. **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.