

Neuroanesthesiology Fellowship Training: Curricular Guidelines From the Society for Neuroscience in Anesthesiology and Critical Care

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Abstract: Standardization and accreditation of fellowship training have been considered in the field of neuroanesthesiology. A prior survey of members of the Society for Neuroscience in Anesthesiology and Critical Care (SNACC) suggested strong support for accreditation and standardization. In response, SNACC created a Task Force that developed curricular guidelines for neuroanesthesiology fellowship training programs. These guidelines represent a first step toward standards for neuroanesthesiology training and will be useful if accreditation is pursued in the future.

Key Words: neuroanesthesiology fellowship, neuroanesthesiology curriculum, neuroanesthesiology guidelines

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The topic of standardization and possible accreditation of neuroanesthesiology fellowships has been discussed in the literature for almost a decade. In 2010, the Society for Neuroscience in Anesthesiology and Critical Care (SNACC) conducted a survey of its members regarding neuroanesthesiology fellowships.¹ The respondents were primarily academic neuroanesthesiologists who demonstrated strong support for fellowship accreditation; no accrediting body was specified. In addition to adult clinical neuroanesthesia, respondents voiced strong support

for neurocritical care, neuromonitoring, and neuro-radiology as important clinical rotations for a neuroanesthesiology fellowship. One year was considered optimal for fellowship training. On the basis of these results, SNACC convened a task force to explore accreditation of neuroanesthesiology fellowships through the American College of Graduate Medical Education (ACGME). This task force appointed 4 SNACC members as a subcommittee to develop a 1-year curriculum based on ACGME competencies.

PROCESS

Members of the subcommittee conducted a review of neuroanesthesiology fellowship curricula throughout the United States and used an ACGME-style curriculum from 1 program as a template that underwent modification based on data from the SNACC survey and curricular elements from various programs. A basic curriculum (consisting of various 4-wk modules) was developed by the subcommittee and submitted to the Chair of the task force; review by the Chair prompted further revision of the curriculum. In parallel, the Chair of the task force conducted a survey of directors of neuroanesthesiology fellowship programs listed on the SNACC Web site (n = 26) to assess the potential for compliance with and feasibility of any proposed curriculum. Data regarding the fellowship characteristics, as reported by 13 respondents (for 50% response rate), are outlined in Tables 1–5. Using the 1-year curriculum and data from the survey as a basis for discussion, a meeting of neuroanesthesiology fellowship directors was held at the International Anesthesia Research Society Annual Meeting in 2012. There was a strong consensus that (1) developing curricular guidelines for neuroanesthesiology fellowships was important but that (2) SNACC should not pursue ACGME accreditation at this time. The basic curricular elements prepared by the subcommittee were critically reviewed by the neuroanesthesiology fellowship directors in attendance and modified until consensus was achieved. The resulting guidelines were additionally reviewed and approved by the executive committee of SNACC as well as the Chair and other senior members of the fellowship task force.

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TABLE 1. Neuroanesthesiology Fellowship Characteristics

Fellowship Characteristics (13 Respondents)	Range
Do you currently offer a neuroanesthesia fellowship?	12 (yes)
Do you currently have a fellow?	6 (yes)
How many fellows have you had between 2009 and 2011?	22 (total # fellows) 0-6 (# fellows)
How many recent fellows had ≥ 1 y prior training in ACGME-approved or equivalent program?	15 (# fellows) 0%-100%
How long (mo) is your fellowship?	12-24
What is the minimum duration (mo) of your fellowship?	6-12

ACGME indicates American College of Graduate Medical Education.

CRITERIA FOR PROGRAM DIRECTORS

These guidelines focus on the curricular elements of a neuroanesthesiology fellowship and are recommended for implementation by departments of anesthesiology having accredited anesthesiology training programs. However, certain criteria for neuroanesthesiology fellowship program directors are desirable for maintaining a high level of training. Although neuroanesthesiology fellowship program directors will be selected by leadership at their home institutions, we suggest that the following characteristics of a program director will be associated with a higher likelihood of successful fellowship training. First, the program director should be board certified by the appropriate credentialing institution (eg, in the United States, the American Board of Anesthesiology). Second, the program director should devote the majority of his or her clinical time to neuroanesthesia; involvement in neurocritical care is also considered beneficial. At least 3 years of clinical practice experience is recommended. Third, the program director should have a documented record of scholarly activity in neuroanesthesiology (broadly construed) in the past 5 years. Finally, the program director should be an active member of the national or international organizations related to neuroanesthesiology or neurocritical care. Ideally, neuroanesthesiology teaching faculty within the division or department should also meet these criteria.

TABLE 2. Characteristics of Host Departments for Neuroanesthesiology Fellowships

How many faculty/attending anesthesiologists are in your department?	65-250
How many residents (sum of CA1 to CA3 years)?	45-160
How many anesthetizing locations (OR and non-OR) per day?	38-135
How many hospitals does your department cover?	2-4
Departmental case load per year?	23,000-100,000*

*Multihospital program.
CA indicates clinical anesthesia; OR, operating room.

TABLE 3. Neuroanesthesiology Fellow Activities

What Percentage of Time Does a Fellow Spend Doing the Following?	Notes (# = Respondents)
OR neuroanesthesia	10%-80%
Anesthesia for interventional neuroradiology	0%-20%
Working in the neurocritical care unit	0%-50% 0% = 1 of 12
Intraoperative neurophysiological monitoring (not while providing anesthesia)	0%-20% 0% = 3
Research	0%-80% ≤20% = 9 of 11
Working as an attending anesthesiologist outside of the neurosurgical OR or ICU	0%-40% 0% = 3 of 10
Taking night call as a resident	0%-25% 0% = 11
Taking night call as a fellow	0%-40% 0% = 9 of 11
Taking night call as an attending	Yes 0% = 3 of 10

ICU indicates intensive care unit; OR, operating room.

USE OF THESE GUIDELINES

The goal of creating these guidelines was to establish a consensus on what constitutes minimally acceptable fellowship training in neuroanesthesiology. The guidelines can be used as a benchmark for currently existing programs and a resource for developing new fellowship programs in neuroanesthesiology. The guidelines represent a first step toward basic standardization of neuroanesthesiology fellowship training across the United States and will help to provide a foundation should SNACC choose to pursue ACGME or other accreditation in the future.

The curriculum below is built upon the unit of 4-week modules for clinical neuroanesthesia (6 modules), neurocritical care (1 module), neuroradiology (1 module), neuromonitoring (1 module), and neuroscience scholarship (1 module). These elements are considered to be essential to neuroanesthesia fellowship training and constitute 40 calendar weeks. The remaining 12 weeks are left for elective rotations, which may include additional

TABLE 4. Neuroanesthesiology Division Characteristics

How many neurosurgical locations (OR and non-OR) per day?	4-13
Are these all in 1 hospital?	10 Yes, 2 No
If no, would the fellow rotate to different institutions?	Yes
How many "core" neuroanesthesiologists do you have?	2-15
Does the neuroanesthesiology service have a presence in the neurocritical care unit?	10 yes; 2 no
Does the neuroanesthesiology service run the intraoperative neurophysiological monitoring service?	9 no; 3 yes
Does the neuroanesthesiology service have separate night call for neurosurgical cases?	11 no; 1 yes

OR indicates operating room.

TABLE 5. Neurosurgical Case Characteristics at Neuroanesthesiology Fellowship Host Institutions

Annual neurosurgical volume (ie, cases/y)?	1200–4600
<i>Case distribution, 2011 estimate by type</i>	
Craniotomy for mass lesion (eg, tumor, intracerebral or subdural hematoma)	260-1800
Craniotomy for vascular lesion (eg, aneurysm, arteriovenous malformation)	55-275
Carotid endarterectomy	9-130
Transphenoidal pituitary surgery	40-300
Spine surgery: simple	80-800
Spine surgery: with instrumentation	200-1000
Approximate % of craniotomies that are infratentorial	10%-30%
Approximate % of emergency cases	10%-30%

neurocritical care training, general anesthesiology, transcranial Doppler ultrasonography, pediatric neuroanesthesiology, or additional scholarship. Vacation time is dependent on the host institution and would be distributed across the modules as the program director sees fit. It is important to stress that the curricular guidelines presented below are intended to be *minimal* rather than *optimal* standards for training.

DESCRIPTION OF FELLOWSHIP MODULES

Clinical Neuroanesthesia (6 Four-wk Modules)

Adult Neurosurgical Patients

Curriculum: Each fellow should be competent in the preanesthetic evaluation and perioperative management of patients undergoing neurosurgical procedures. These include intracranial, spine, and peripheral nerve surgeries, as well as interventional neuroradiologic procedures. The rotation for Adult Neurosurgical Patients consists of 6 mandatory modules. During this rotation, fellows develop expertise in the care of neurosurgical patients, including at least 40 craniotomies (supratentorial and infratentorial), 40 spine surgeries, and any additional interventional neuroradiology cases beyond those obtained in the separate interventional module (described below). Of the intracranial procedures, at least 3 should be awake craniotomies, 3 should be craniotomies for seizure focus localization or excision, and 8 should be craniotomies for intracranial vascular lesions including intracranial aneurysms and arteriovenous malformations. In addition to the craniotomies, the fellows should be involved in the management of at least 5 intracranial shunt procedures. It is anticipated that many craniotomies will be performed for the resection of mass lesions such as tumors, but it is desirable that the fellows gain experience in anesthetic management of traumatic brain injury, endoscopic neurosurgery, and sitting position craniotomy. The spine cases should include anterior and posterior approaches and involve instrumentation in at least 10 cases. Involvement in the management of a mixture of spine cases including the cervical, thoracic, and the lumbar spine, as well as variety of pathologies (such as spinal tumors, trauma, scoliosis, degenerative diseases, and oncologic) is required of the fellow. The interventional neuroradiology

cases should involve intracranial vascular coiling and embolization, stenting, and angioplasty. The fellow should also participate in the educational conferences including problem-based discussions, all relevant presentations related to neuroanesthesia, and journal clubs.

Competencies: At the conclusion of each module of this rotation, the evaluation will depend on the performance in each competency adjusted for expectations based on the length of time already completed in clinical neuroanesthesia rotations. The 4 nonmedical competencies (Practice-Based Learning and Improvement, Systems-Based Practice, Professionalism, Interpersonal Skills) will not be included in the guidelines below.

Patient Care: At the conclusion of the 6 clinical rotations, the fellow must be able to:

1. Perform a basic neurological examination.
2. Recognize the need for advanced airway management to facilitate safe airway control in patients at risk for neurological injury during tracheal intubation.
3. Establish hemodynamic parameters according to the patient baseline, pathology, and surgical procedure, and adjust hemodynamic parameters in a dynamic manner depending on the clinical course.
4. Understand and apply principles of neuroprotection using physiological and pharmacologic means.
5. Manage intracranial hypertension using physiological, pharmacological, and positioning techniques.
6. Manage cerebral and spinal perfusion pressure appropriately with respect to underlying neuropathology.
7. Be aware of anesthetic considerations in cases involving neurophysiological monitoring and choose anesthetic techniques that facilitate monitoring.
8. Manage spinal and ventriculostomy drains, as well as intracranial pressure (ICP) monitors.
9. Prevent and manage complications related to patient positioning.
10. Manage awake craniotomy and deep brain stimulator placement cases during which an alert patient is needed for monitoring during the procedure.
11. Perform a scalp block.
12. Manage intraoperative complications such as venous air embolism.
13. Manage transfusion requirements in complex spine cases.
14. Plan and execute rapid emergence after neurological interventions.
15. Care for patients undergoing diagnostic neuroradiologic procedures with anxiety, claustrophobia, or other psychological/psychiatric conditions.

Medical Knowledge: At the conclusion of the 6 rotations the fellow must demonstrate advanced knowledge of:

1. Neuroanatomy of the normal brain, spine, and major peripheral nerves.
2. Intracranial and spinal blood supply and accompanying changes in pathophysiological conditions.
3. Principles of cerebral blood flow regulation such as autoregulation, chemoregulation, and cerebral metabolic rate.

4. Neuroprotection and relevant pharmacology.
5. Basic pharmacology of common antiepileptic drugs.
6. Indications, contraindications, and potential complications of the following procedures: arterial catheterization, central venous catheterization, pulmonary artery catheterization, noninvasive cardiac output monitoring, cerebrospinal fluid drainage catheters, precordial Doppler sonography, jugular venous oximetry, ICP monitoring, and neurophysiological monitoring.
7. Interactions between neuropathology and anesthetic pharmacology.
8. Hemodynamic goals in relation to the intracranial or spinal pathology.
9. Glasgow Coma Scale score for neurological assessment; Hunt and Hess, Fisher, and the World Federation of Neurological Surgeons (WFNS) grading systems for intracranial hemorrhage; and the Spetzler-Martin grading system for intracranial arteriovenous malformations.
10. Complications of patient positioning for neurosurgical procedures.
11. ICP and treatment options for intracranial hypertension.
12. Initiation, maintenance, and reversal of anticoagulation strategies in cerebrovascular surgery and interventional neuroradiology.
13. Classification and pathophysiology of epilepsy.
14. Pathophysiology of endocrine problems in pituitary tumors and anesthetic management of patients affected by these tumors.
15. Definition, diagnosis, and management of the unstable cervical spine.
16. Performance of a wake-up test during spine surgery.
17. Classification of intracranial tumors, their presentation, and their management.
18. Diagnosis and management of venous air embolism.
19. Anesthetic management of endoscopic intracranial procedures.
20. Anesthetic management of patients with neurological/neurosurgical disease for nonneurosurgical procedures.
21. Benefits and adverse outcomes of craniotomy in the sitting position.

Pediatric Neurosurgical Patients

Curriculum: Fellows who desire experience in the clinical care of pediatric neurosurgical patients can be offered an elective rotation focused on pediatric neuroanesthesiology. This module would be a 4-week-long rotation during which the fellows will be involved in perioperative and anesthetic care of pediatric patients undergoing neurosurgical procedures including intracranial, spinal, and peripheral nerve procedures, as well as interventional neuroradiology. Intracranial procedures will include those described in adults but with more emphasis on the treatment of diseases affecting the pediatric population. Involvement of the central nervous system is

frequently seen in pediatric patients with genetic and metabolic dysfunction. These patients have specific anesthetic challenges including (1) airway issues; (2) anomalies of the cardiac, genitourinary, and pulmonary systems; and (3) specific limitations in the anesthetic agents that may be used. Spine cases in the pediatric population include corrective procedures with instrumentation that may involve ventilation challenges related to restrictive lung disease. Shunt placements are also an important part of pediatric neurosurgery. Rotation in pediatric neurosurgery should only be elected after successful completion of at least 2 rotations in adult neurosurgical anesthesiology. The fellows should also participate in the educational conferences in the pediatric anesthesia division including problem-based discussions, resident presentations, and journal clubs.

Patient Care: At the conclusion of this rotation, the fellow should be able to:

1. Perform preoperative evaluation in patients with information gathered from previous history, history obtained from adults accompanying the pediatric patient, physical examination, and laboratory data.
2. Perform difficult intubations commonly seen in these patients.
3. Provide measures to decrease preoperative anxiety in these patients without jeopardizing mental status or ventilation.
4. Differentiate methods of inserting invasive monitoring lines in the pediatric age group.
5. Implement knowledge acquired during rotations in adult neurosurgical anesthesiology regarding cerebral physiology and pharmacology, hemodynamic monitoring, transport, intraoperative monitoring, pharmacologic effects of antiepileptic medications, while understanding the differences in each for the pediatric population.

Medical Knowledge: At the conclusion of this rotation, the fellow must demonstrate advanced knowledge of:

1. Basic anatomic and physiological differences in the central and peripheral nervous system between adult and pediatric patients.
2. Pharmacological effects of anesthetic and antiepileptic medications in pediatric patients.
3. Neurological manifestations of metabolic and genetic syndromes and their implications for anesthetic management.
4. Indications, contraindications, and possible complications of invasive monitoring in pediatric patients.
5. Age-dependent and pathology-dependent hemodynamic goals for adequate cerebral perfusion in pediatric patients.
6. Maintenance of adequate perfusion in spine procedures.
7. Management of increased ICP in pediatric patients.
8. Identification of disorders and conditions with a higher rate of uncommon but life-threatening anesthetic complications in the pediatric population such as latex allergy and malignant hyperthermia.

Critical Care of the Neurological Patient (1 Four-wk Module)

Curriculum: During this rotation, fellows will be exposed to critically ill patients with neurological or neurosurgical problems. The fellows will experience care of patients who are admitted from the emergency department or transported from an outside medical facility for preoperative evaluation and preparation. They will also be exposed to patients admitted to the intensive care unit (ICU) after surgery, thus experiencing the postoperative care of neurosurgical patients. The fellows will participate in clinical and teaching rounds with the neurosurgical intensive care unit (NICU) attending. Fellows will conduct a history and physical examination and actively manage the care of these patients. This management should include (1) placement, data interpretation, and management of invasive lines; (2) tracheal intubations and other forms of airway management; (3) monitoring of ICP and cerebral perfusion pressure; and (4) understanding the role of multimodal intracranial monitoring. Fellows will be actively involved in writing orders for these patients under the supervision of the NICU attending. Fellows will also manage issues arising from the underlying neurological condition, such as intracranial hypertension, cerebral vasospasm, and the systemic complications of brain injury (including cardiorespiratory, electrolyte, coagulation, and endocrine problems), as well as other common ICU problems including sepsis, systemic shock, and multiple organ failure.

Patient Care: At the conclusion of this rotation, the fellow must be able to:

1. Manage intracranial hypertension in the critically ill patient.
2. Manage patients with traumatic brain injury based on established guidelines.
3. Manage patients with ischemic or hemorrhagic stroke.
4. Manage postoperative neurosurgical patients in preparation for transfer to a general care ward or step-down unit.
5. Admit patients with history of critical neurological or neurosurgical problems, appreciate the emergent need for neurosurgical or endovascular intervention, and be involved in physiological optimization of these patients.
6. Evaluate tracheally intubated patients for weaning and preparing for extubation.
7. Manage the ventriculostomy and spinal drains.
8. Manage patients with cerebral vasospasm.
9. Diagnose brain death based on established guidelines.
10. Manage central nervous system infections.
11. Evaluate and treat perioperative pneumonia.
12. Manage common electrolyte and endocrine abnormalities in the neurologically ill patient.
13. Manage cardiorespiratory complications of neurological injury.
14. Evaluate and manage postoperative pain and implement analgesic regimens tailored to the limitations imposed by the patient's neurological status.
15. Actively be involved in multidisciplinary consultations and implementation of recommendations from consulting service.
16. Actively be involved in family meetings and discussions of end-of-life care.

Medical Knowledge: At the conclusion of this rotation, the fellow must demonstrate advanced knowledge of:

1. Interpretation of hemodynamic and respiratory data in the NICU.
2. Interpretation of multimodal intracranial monitoring data and their application to guide individualized therapy.
3. Hemodynamic effects and mechanisms of inotropic agents.
4. Sensory and motor innervation and neurological examination.
5. Grading of patients with subarachnoid hemorrhage (SAH).
6. Identification and management of hemodynamic changes after SAH.
7. Complications of SAH and their management.
8. Hemodynamic goals in postoperative patients with intracranial vascular abnormalities.
9. Management principles of ischemic stroke including the need for timely intervention.
10. Diagnosis and management of cardiac abnormalities including ischemic changes in NICU patients.
11. Management of cardiac arrhythmias.
12. Use of hyperosmolar therapy to treat intracranial hypertension and/or systemic shock.
13. Use of hypothermia for brain protection.
14. Pharmacologic methods of brain protection.
15. Postoperative sepsis and pneumonia.
16. Mechanical ventilation modes and their implications for patients with neurological diseases.
17. Bioethics and end-of-life decisions; diagnostic criteria for brain death.
18. Sedation and pain management in the ICU.
19. Advanced cardiac life support and resuscitation.

It is acknowledged that further neurocritical care experience during elective time is desirable.

Neuroradiology/Endovascular Care (1 Four-wk Module)

Curriculum: This rotation aims to develop competence in diagnostic and interventional neuroradiology in the context of neuroanesthesiology. During this rotation, fellows will be exposed to neuroimaging modalities that are commonly used in the care of neurological patients. The fellows will also be a part of the interventional neuroradiology team to develop a more in-depth knowledge of therapeutic radiologic procedures. The fellows should be able to perform basic interpretation of brain imaging and understand the technical aspects of interventional neuroradiology. During the 4 weeks of the interventional neuroradiology module, the fellows should experience the preoperative, intraoperative, and postoperative

management of patients who are candidates for interventional procedures. By the end of the rotation, the fellow should have interpreted at least 10 neuroimaging scans with intracranial pathology and have participated in intraoperative hands-on anesthetic care of at least 10 elective or emergent interventional neuroradiology procedures.

Patient Care: At the conclusion of this rotation, the fellow should be able to:

1. Identify the indications for emergent computed tomography or magnetic resonance imaging.
2. Identify indications for different neuroradiologic diagnostic modalities including functional and 3-dimensional methods.
3. Identify indications for Doppler sonography-guided measurements of intracranial blood flow.
4. Guide nursing or other personnel on appropriate transport and sedation of these patients at offsite locations.
5. Identify the indications for interventional neuroradiology procedures in patients with acute ischemic or hemorrhagic stroke, such as intravenous or intra-arterial tissue plasminogen activator administration, as well as mechanical thrombolysis.
6. Identify the indications for emergent cerebral angiography in a patient with suspected cerebral vasospasm.
7. Manage basic technical issues in arterial access during interventional procedures.
8. Appropriately manage anticoagulation (and reversal) in patients undergoing interventional procedures.
9. Manage complications after interventional procedures.

Medical Knowledge: At the conclusion of this rotation, the fellow must demonstrate advanced knowledge of:

1. Principles of brain imaging with computed tomography and magnetic resonance imaging.
2. Cerebrovascular anatomy as it applies to interventional neuroradiology.
3. Principles of transcranial Doppler sonography measurements of intracranial blood flow and diagnostic criteria for cerebral vasospasm; Doppler sonography assessment of cerebral ischemia during carotid endarterectomy and cerebral circulatory arrest.
4. Identification of mass effect, midline shift, effacement of sulci/gyri, loss of gray-white differentiation as signs of increased ICP.
5. Differentiation of subdural and epidural hematoma.
6. Differentiation of hemorrhagic and ischemic stroke.
7. Fisher grading for SAH.
8. Identification of unstable cervical spine.
9. Recognition of complications (eg, intraprocedural cerebral hemorrhage or vessel thrombosis) and their treatment during interventional procedures.

Intraoperative Neuromonitoring (1 Four-wk Module)

Curriculum: Intraoperative neuromonitoring is increasingly used to guide surgical procedures and potentially avoid surgical complications. In many centers, the neuroanesthesiologist is responsible for monitoring and

interpreting the electroencephalogram (EEG) and evoked potentials. In other centers, a neuromonitoring technician performs the recording and a neurologist interprets the finding. Adequate knowledge of the principles of evoked potential monitoring is essential in the management of neurosurgical patients. Evoked potential monitoring includes somatosensory-evoked potentials (SSEP) or motor-evoked potentials (MEP) (or their combination), which are oftentimes performed during complex spine surgery. Brainstem auditory-evoked potentials can also be used for brain monitoring during intracranial surgery. Intracranial surgical procedures are commonly performed to identify and excise epileptogenic foci in the brain. In some instances, there is a need for intraoperative EEG monitoring or electrocorticography, which is especially important during brain mapping. However, intraoperative EEG is also performed during intracranial vascular surgeries or carotid endarterectomy during which EEG wave form changes are monitored to confirm adequacy of intracranial blood flow. Other neuromonitoring modalities include electromyography, ICP monitoring, transcranial Doppler sonography, and cerebral oximetry.

Patient Care: At the conclusion of this rotation, the fellow must be able to:

1. Understand the indications and limitations of neuromonitoring.
2. Identify patients who might benefit from neuromonitoring.
3. Describe the appropriate neuromonitoring for the planned procedure.
4. Identify complications associated with the process of neuromonitoring.
5. Recognize interference caused by some neurophysiological methods on hemodynamic monitors.
6. Manage the impact of anesthetic technique on neurophysiological neuromonitoring.
7. Respond appropriately to changes in evoked potentials.
8. Manage neuromuscular relaxation appropriately in cases with MEP or electromyography.
9. Identify changes in neuromonitoring and list a differential diagnosis to detect causes.
10. Recognize potential complications and implications for anesthetic management in the placement of EEG grids or in patients who have a second anesthetic with the grids in place.
11. Manage intraoperative seizures detected by EEG monitoring.
12. Use and interpret cerebral oximetry.
13. Interpret the results of transcranial Doppler sonography studies.
14. Identify indications for various methods of ICP monitoring.

Medical Knowledge: At the conclusion of this rotation, the fellow must have acquired advanced knowledge of:

1. Rational monitoring choices for complex spine surgery, intracranial cerebrovascular surgery, and carotid endarterectomy.

2. Principles of EEG.
3. EEG changes with medications or anesthetics.
4. Neural pathways involved in the generation of SSEP and MEP.
5. Indications and physiological basis for spontaneous and triggered electromyography.
6. Differential changes in latency and amplitude of neuro-monitoring wave forms with different anesthetics.
7. Effects of ischemic changes on neuromonitoring.
8. Effect of surgical manipulation on neuromonitoring.
9. Anesthetic considerations and surgical complications of EEG grid placement.
10. Complications of neuromonitoring.
11. Principles of near-infrared spectroscopy.
12. Principles of jugular venous bulb oximetry.

Clinical Neuroscience Scholarship (1 Four-wk Module)

Curriculum: This module requires mentoring of the fellow by an attending faculty with experience in scholarly projects in the field of neuroscience. The mentor need not be a neuroanesthesiologist and the level of support and advice will depend on the fellow's experience. The module can involve: (1) designing and conducting a clinical investigation related to neuroanesthesiology, neurocritical care, or a related discipline and (2) preparation of a review article, book chapter, case report/series, or a database project. It is expected that the fellow will gain experience in oral presentation skills and submit written work for publication. This module should likely be conducted early in the year, so that the fellow has adequate time to pursue the research project throughout the fellowship. Alternatively, the project may be developed early in the fellowship, and the research time can be distributed or allotted as needed to accomplish the project. It is expected that substantial basic or translational neuroscience projects will require a second year of fellowship/post-

doctoral training. It is desirable that the fellows present their scholarly projects at the annual meeting of SNACC.

Patient Care: At the conclusion of this rotation, the fellow should be able to (as appropriate):

1. Utilize the information gathered through a research project, or preparation of a case report or review article, to improve patient care.
2. Understand the basic Institutional Review Board regulations and approval process with regard to patient care and patient advocacy.
3. Demonstrate knowledge of the principles of ethical and responsible conduct of research.
4. Know the importance of putting patient rights and wellbeing ahead of any research activity.

Medical Knowledge: At the conclusion of this rotation, the fellow must have acquired advanced knowledge of:

1. Critical review of published studies.
2. Basic study design.
3. Basic statistical methods.
4. Preparation of a manuscript.
5. Ethical principles of clinical investigation.
6. Role of the Institutional Review Board in the approval of studies and maintenance of ethical standards.

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