Goals and Objectives of the Educational Program

Neurosurgical Fellowship Definition:

This fellowship is designed to give concise and formal training in neurosurgical anesthesia at LAC+USC Medical Center and USC University Hospital. The Fellow in Neurosurgical Anesthesia will be expected to participate in both the training and evaluation of competencies as described by the ACGME for Core training. A similar evaluation format will be utilized to evaluate the Fellow.

Duration: 52 weeks for the fellowship training

Level: PGY-5

A) Academic activities (the production of clinical research and the development of training tools) will account for a large portion of the efforts of the fellow.

B) The existing and well-developed clinical program of resident education will serve as the cornerstone of fellowship training in neurosurgical anesthesia.

C) Fellowship training (in distinction to resident training) will be specifically geared toward Neurosurgical anesthesia in order to improve OR management and efficiency, and to enhance the recovery of neurosurgical patients.

D) The fellow will expand his or her level of clinical expertise in approaches and techniques by supervising residents under the direct guidance of faculty as part of routine clinical care and clinical research studies.

E) During fellowship the fellow will develop a more thorough knowledge of preoperative evaluation and intraoperative management of neurosurgical patients, neurophysiologic monitoring, postoperative ICU management, and interventional neuroradiological treatment.
Goals:

A. **Operating Room Care:**
The Fellowship will provide a large variety of routine and complex neurosurgical procedures providing an in depth experience which gives the trainee not only the opportunity to do cases, but also the chance to make significant decisions about the conduct of particular cases under the guidance and supervision of experienced neuroanesthesiologists. The duration of this operating room training will take a significant part of the training period (minimum of 6 months is required).

B. **Neurointensive Care:**
The Fellowship provides experience with preoperative evaluation and postoperative care of neurosurgical patients. This is through a specific rotation in Neurosurgical Intensive Care. Minimum of two months are required.

C. **Neuromonitoring**
Understanding issues in complex neuromonitoring is essential to the practice of Neuroanesthesiology. Such monitoring includes EEG, EP, TCD monitoring. In addition, exposure should be sought to other advanced monitoring techniques including NIRS, P\textsubscript{et}O\textsubscript{2}, microdialysis, S\textsubscript{a}O\textsubscript{2}, and ICP methods commonly used in NICU. To facilitate this 1 month in the Neuromonitoring Service is required.

D. **Didactic Program:**
A specific didactic program will be provided for the fellow. This may be in the form of lectures by the staff and/or trainees, seminars and journal clubs. In addition, fellow can attend conferences in Neurosurgery and Neurology. Fellow should finish his/her training knowledgeable in all the major concepts of Neuroanesthesiology, and should understand the basics of the various diagnostic procedures used for neurosurgical patients. In addition, the fellow should have a good understanding of the pathophysiology of neurosurgical disease processes, and the surgical approaches and outcome of the various treatments (see section below for details). At the completion of training, a trainee's background and knowledge should be adequate to competently discuss issues of patient management with the neurosurgeons, neuroradiologists, and neurologists who come in contact and make decisions about the care of a patient with nervous system disease. In addition, trainees must be familiar with the relevant neuroanesthesiological, neurosurgical and neurologic literature, so that it can be used in their practice and provide a foundation or the acquisition of new knowledge.

E. **Teaching:**
Since many seeking advanced training in Neuroanesthesiology will ultimately join academic centers, the fellow should receive specific experience with teaching
anesthesiology residents and nurses. He/she should have the opportunity to supervise residents in the operating room, and they should prepare lectures and seminars for departmental teaching functions. Lecture and seminar preparation should be done under the direction of experienced and expert supervisors, so that the fellow can develop some of the skills needed for the effective oral communication of information.

F. **Administration:**
Opportunities should be available for the fellow to gain experience in administrative aspects of patient care. This may involve working with surgeons to solve scheduling conflicts, negotiating a consensus toward a particular patient's care, or marking out allocation issues in the Neurosurgical ICU. Financial and legal aspects of anesthetic practice, particularly as they pertain to neurosurgical anesthesia, should not be ignored.

G. **Research:**
Advances in the understanding of basic pathophysiology and the effects of anesthetics and anesthetic management on the disease process often result in improvements in clinical care. Research contributes to such advances and, perhaps more importantly for the trainee, helps teach one to critically evaluate the literature. Thus, most people undertaking advanced training in neurosurgical anesthesia should participate in some form of clinical or basic research. The duration of the research experience will be variable depending on a program's resources and the trainee's interest. The type of investigation will also vary; some will research and report on an interesting case, others will participate in ongoing clinical or laboratory projects, and a few may undertake complex long-term projects. Whatever the project, the trainee should have primary responsibility for its completion. Ideally, this will include preparing the work for publication in a referred journal. In addition to the knowledge gained, an appreciation of the anesthetic literature is often best obtained through writing for it.

**Objectives:**

**Description of fellowship modules**

**Clinical Neuroanesthesiology (6 Four-week 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 or 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 neuroanesthesiology, 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 Neuroanesthesiology 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:

- Perform a basic neurological examination.
- Recognize the need for advanced airway management to facilitate safe airway control in patients at risk for neurological injury during tracheal intubation.
- 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.
- Understand and apply principles of neuroprotection using physiological and pharmacologic means.
- Manage intracranial hypertension using physiological, pharmacological, and positioning techniques.
- Manage cerebral and spinal perfusion pressure appropriately with respect to underlying neuropathology.
- Be aware of anesthetic considerations in cases involving neurophysiological monitoring and choose anesthetic techniques that facilitate monitoring.
- Manage spinal and ventriculostomy drains, as well as intracranial pressure (ICP) monitors.
- Prevent and manage complications related to patient positioning.
- Manage awake craniotomy and deep brain stimulator placement cases during which an alert patient is needed for monitoring during the procedure.
- Perform a scalp block.
- Manage intraoperative complications such as venous air embolism.
- Manage transfusion requirements in complex spine cases.
- Plan and execute rapid emergence after neurological interventions.
- 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:

- Neuroanatomy of the normal brain, spine, and major peripheral nerves.
- Intracranial and spinal blood supply and accompanying changes in pathophysiological conditions.
- Principles of cerebral blood flow regulation such as autoregulation, chemoregulation, and cerebral metabolic rate.
- Neuroprotection and relevant pharmacology.
- Basic pharmacology of common antiepileptic drugs.
- 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.
- Interactions between neuropathology and anesthetic pharmacology.
- Hemodynamic goals in relation to the intracranial or spinal pathology.
- 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.
- Complications of patient positioning for neurosurgical procedures.
- ICP and treatment options for intracranial hypertension.
- Initiation, maintenance, and reversal of anticoagulation strategies in cerebrovascular surgery and interventional neuroradiology.
- Classification and pathophysiology of epilepsy.
- Pathophysiology of endocrine problems in pituitary tumors and anesthetic management of patients affected by these tumors.
- Definition, diagnosis, and management of the unstable cervical spine.
- Performance of a wake-up test during spine surgery.
- Classification of intracranial tumors, their presentation, and their management.
- Diagnosis and management of venous air embolism.
- Anesthetic management of endoscopic intracranial procedures.
- Anesthetic management of patients with neurological/neurosurgical disease for nonneurosurgical procedures.
- Benefits and adverse outcomes of craniotomy in the sitting position.

**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:
- Manage intracranial hypertension in the critically ill patient.
- Manage patients with traumatic brain injury based on established guidelines.
- Manage patients with ischemic or hemorrhagic stroke.
- Manage postoperative neurosurgical patients in preparation for transfer to a general care ward or step-down unit.
- 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.
- Evaluate tracheally intubated patients for weaning and preparing for extubation.
- Manage the ventriculostomy and spinal drains.
- Manage patients with cerebral vasospasm.
- Diagnose brain death based on established guidelines.
- Manage central nervous system infections.
- Evaluate and treat perioperative pneumonia.
- Manage common electrolyte and endocrine abnormalities in the neurologically ill patient.
- Manage cardiorespiratory complications of neurological injury.
- Evaluate and manage postoperative pain and implement analgesic regimens tailored to the limitations imposed by the patient’s neurological status.
- Actively be involved in multidisciplinary consultations and implementation of recommendations from consulting service.
- 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:

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

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

**Neuroradiology/Endovascular Care (1 Four-week 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:

- Identify the indications for emergent computed tomography or magnetic resonance imaging.
- Identify indications for different neuroradiologic diagnostic modalities including functional and 3-dimensional methods.
- Identify indications for Doppler sonography–guided measurements of intracranial blood flow.
- Guide nursing or other personnel on appropriate transport and sedation of these patients at offsite locations.
- 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.
- Identify the indications for emergent cerebral angiography in a patient with suspected cerebral vasospasm.
- Manage basic technical issues in arterial access during interventional procedures.
- Appropriately manage anticoagulation (and reversal) in patients undergoing interventional procedures.
- Manage complications after interventional procedures.

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

- Principles of brain imaging with computed tomography and magnetic resonance imaging.
- Cerebrovascular anatomy as it applies to interventional neuroradiology.
- 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.
- Identification of mass effect, midline shift, effacement of sulci/gyri, loss of gray-white differentiation as signs of increased ICP.
- Differentiation of subdural and epidural hematoma.
Differentiation of hemorrhagic and ischemic stroke.
- Fisher grading for SAH.
- Identification of unstable cervical spine.
- Recognition of complications (e.g., intraprocedural cerebral hemorrhage or vessel thrombosis) and their treatment during interventional procedures.

Intraoperative Neuromonitoring (1 Four-week 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:
- Understand the indications and limitations of neuromonitoring.
- Identify patients who might benefit from neuromonitoring.
- Describe the appropriate neuromonitoring for the planned procedure.
- Identify complications associated with the process of neuromonitoring.
- Recognize interference caused by some neurophysiological methods on hemodynamic monitors.
- Manage the impact of anesthetic technique on neurophysiological neuromonitoring.
- Respond appropriately to changes in evoked potentials.
- Manage neuromuscular relaxation appropriately in cases with MEP or electromyography.
- Identify changes in neuromonitoring and list a differential diagnosis to detect causes.
- 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.

- Manage intraoperative seizures detected by EEG monitoring.
- Use and interpret cerebral oximetry.
- Interpret the results of transcranial Doppler sonography studies.
- Identify indications for various methods of ICP monitoring.

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

- Rational monitoring choices for complex spine surgery, intracranial cerebrovascular surgery, and carotid endarterectomy.
- Principles of EEG.
- EEG changes with medications or anesthetics.
- Neural pathways involved in the generation of SSEP and MEP.
- Indications and physiological basis for spontaneous and triggered electromyography.
- Differential changes in latency and amplitude of neuromonitoring wave forms with different anesthetics.
- Effects of ischemic changes on neuromonitoring.
- Effect of surgical manipulation on neuromonitoring.
- Anesthetic considerations and surgical complications of EEG grid placement.
- Complications of neuromonitoring.
- Principles of near-infrared spectroscopy.
- Principles of jugular venous bulb oximetry.

**Clinical Neuroscience Scholarship (1 Four-week 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/postdoctoral 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):
• Utilize the information gathered through a research project, or preparation of a case report or review article, to improve patient care.
• Understand the basic Institutional Review Board regulations and approval process with regard to patient care and patient advocacy.
• Demonstrate knowledge of the principles of ethical and responsible conduct of research.
• 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:
• Critical review of published studies.
• Basic study design.
• Basic statistical methods.
• Preparation of a manuscript.
• Ethical principles of clinical investigation.
• Role of the Institutional Review Board in the approval of studies and maintenance of ethical standards.

Other Scholarly Activities

A) Academic Presentations
   i) The fellow will present once during the second half of the fellowship year at Anesthesia Grand Rounds covering a topic or case relevant to neurosurgical anesthesia.
   ii) The fellow will deliver once a Monday Lecture including a literature review relevant to neurosurgical anesthesia.

B) Development of Teaching Materials
   i) The fellows will be expected to prepare web-based teaching resources including the resident handbook, curriculum document, and self study and testing materials.
   ii) The fellows will prepare informal didactic handouts and literature reviews with the residents.

C) Bedside Teaching
   i) The fellows will have the opportunity to learn teaching techniques by instructing residents at the bedside in the Regional Anesthesia Area under the supervision of faculty.
   ii) The fellows will have the opportunity to learn teaching techniques under the supervision of faculty.
iii) The fellows will be expected to participate in the education of residents and student nurse anesthetists as part of the fellow’s one-day per week clinical commitment in the general OR.

D) Collaboration Skills

The fellow will be able to work in a team environment, communicating and cooperating with surgeons, nurses, pharmacist, and all members of the perioperative team. By the end of the fellowship, the fellow will be able to:

i) Appreciate the roles of other members of the team

ii) Communicate clearly in a collegial manner that facilitates the achievement of care goals

iii) Help other members of the team to enhance the sharing of important information

iv) Formulate care plans that utilize the multidisciplinary team skills, such as a plan for facilitated recovery.

E) Operating Room Management Skills

The fellow will be able to effectively balance the need for operating room efficiency with a high quality of patient care in the setting of a residency teaching program. The fellow will effectively choose surgeons, patients, techniques and approaches to achieve the best balance possible in order to use regional anesthesia to improve recovery.