

Neurocritical Care Core Curriculum

These guidelines regarding the program content of advanced training in neurocritical care are based on criteria developed for advanced training in critical care medicine by the Society of Critical Care Medicine (SCCM). These guidelines have been reviewed and adapted to ensure that they combine basic aspects of general critical care medicine that are relevant to neurocritical care, as well as specialized skills that are specific to neurocritical care. The following is a listing of cognitive and procedural skills that are fundamental to the training of specialists in neurocritical care, regardless of whether a training program is based in neurology, neurosurgery, internal medicine, anesthesiology, pediatrics, or another specialty. This list also includes pertinent aspects on general critical care, such as cardiac, pulmonary, and infectious disease management.

Program directors may choose to include additional cognitive or procedural skills to augment this listing in order to suit their goals for advanced training for physicians in neurocritical care. These guidelines should be used as recommendations for training directors to use in the development of each program. They are not intended to constrain any training program. They provide the basic framework for future mandates of cognitive and procedural skills necessary for a training program. Each director determines the content of his or her program.

Program Content - Cognitive Skill Set

Acquisition of the following cognitive skills by trainees can be accomplished through the use of any of a number of techniques, including supervised direct patient care, didactic sessions, journal clubs, or literature reviews.

I. Neurological Disease States: Pathology, Pathophysiology, and Therapy

The following are specific diseases, conditions, and clinical syndromes commonly managed by a neurointensivist:

A. Cerebrovascular Diseases

1. Infarction and ischemia
 - Massive hemispheric infarction
 - Basilar artery occlusion and stenosis
 - Carotid artery occlusion and stenosis
 - Crescendo TIAs
 - Occlusive vasculopathies (Moya-Moya, sickle cell)
 - Spinal cord infarction
2. Intracerebral hemorrhage
 - Supratentorial
 - Cerebellar
 - Brainstem
 - Intraventricular
3. Subarachnoid hemorrhage – aneurysmal and other Vascular malformations
 - Arteriovenous malformations
 - AV fistulas
 - Cavernous malformations
 - Developmental venous anomalies
4. Dural sinus thrombosis
5. Carotid-cavernous fistulae
6. Cervical and cerebral arterial dissections

B. Neurotrauma

1. Traumatic brain injury
 - "Diffuse axonal injury"
 - Epidural hematoma
 - Subdural hematoma
 - Skull fracture
 - Contusions and lacerations
 - Penetrating craniocerebral injuries
 - Traumatic subarachnoid hemorrhage
2. Spinal cord injury
 - Traumatic injury (transection, contusion, concussion)
 - Vertebral fracture and ligamentous instability

C. Disorders, Diseases, Seizures, and Epilepsy

1. Seizures and epilepsy
 - Status epilepticus (SE)
 - Convulsive
 - Non-convulsive (partial-complex and "subtle" secondarily generalized SE)
 - Myoclonic
2. Neuromuscular diseases
 - Myasthenia gravis
 - Guillain-Barre syndrome
 - ALS
 - Rhabdomyolysis and toxic myopathies
 - Critical illness myopathy and neuropathy
3. Infections
 - Encephalitis (viral, bacterial, parasitic)
 - Meningitis (viral, bacterial, parasitic)
 - Brain and spinal epidural abscess
4. Toxic-metabolic disorders
 - Neuroleptic malignant syndrome/malignant hyperthermia
 - Serotonin syndrome
 - Drug overdose and withdrawal (e.g., barbiturates, narcotics, alcohol, cocaine, acetaminophen).
 - Temperature related injuries (hyperthermia, hypothermia)
5. Inflammatory and demyelinating diseases
 - Multiple sclerosis (Marburg variant, transverse myelitis)
 - Neurosarcoidosis
 - Acute disseminated encephalomyelitis (ADEM)
 - CNS vasculitis
 - Chemical or sterile meningitis (i.e. posterior fossa syndrome, NSAID induced)
 - Central pontine myelinolysis
 - Others
6. Neuroendocrine disorders
 - Pituitary apoplexy
 - Diabetes insipidus (including triple phase response)
 - Panhypopituitarism
 - Thyroid storm and coma
 - Myxedema coma

- Addisonian crisis

D. Neuro-oncology

1. Brain tumors and metastases
2. Spinal cord tumors and metastases
3. Carcinomatous meningitis
4. Paraneoplastic syndromes

E. Encephalopathies

1. Eclampsia, including HELLP Syndrome
2. Hypertensive encephalopathy
3. Hepatic encephalopathy
4. Uremic encephalopathy
5. Hypoxic-ischemic and anoxic encephalopathy
6. MELAS

F. Clinical syndromes

1. Coma
2. Herniation syndromes with monitoring & ICP
3. Elevated intracranial pressure and Intracranial hypotension/hypovolemia
4. Hydrocephalus detection & treatment
5. Cord compression
6. Death by neurologic criteria, end of life issues, and organ donation
7. Vegetative state
8. Dysautonomia (cardiovascular instability, central fever, hyperventilation)
9. Reversible posterior leukoencephalopathy
10. Psychiatric emergencies (psychosis)

G. Perioperative Neurosurgical Care

H. Pharmacotherapeutics

II. General Critical Care: Pathology, Pathophysiology, and Therapy

A. Cardiovascular Physiology, Pathology, Pathophysiology, and Therapy

1. Shock (hypotension) and its complications (vasodilatory and cardiogenic)
2. Myocardial infarction and unstable coronary syndromes
3. Neurogenic cardiac disturbances (ECG changes, stunned myocardium)
4. Cardiac rhythm and conduction disturbances; use of antiarrhythmic medications; indications for and types of pacemakers
5. Pulmonary embolism
6. Pulmonary edema: cardiogenic versus noncardiogenic (including neurogenic)
7. Acute aortic and peripheral vascular disorders (dissection, pseudoaneurysm)
8. Recognition, evaluation and management of hypertensive emergencies and urgencies
9. Calculation of derived cardiovascular parameters, including systemic and pulmonary vascular resistance, alveolar-arterial gradients, oxygen transport and consumption

B. Respiratory Physiology, Pathology, Pathophysiology and Therapy

1. Acute respiratory failure
 - Hypoxemic respiratory failure (including ARDS)

- Hypercapnic respiratory failure
 - Neuromuscular respiratory failure
2. Aspiration
 3. Bronchopulmonary infections
 4. Upper airway obstruction
 5. COPD and status asthmaticus, including bronchodilator therapy
 6. Neurogenic breathing patterns (central hyperventilation, Cheyne-Stokes respirations)
 7. Mechanical ventilation
 - Positive pressure ventilation (BIPAP)
 - PEEP, CPAP, inverse ratio ventilation, pressure support ventilation, pressure control, and non-invasive ventilation
 - Negative pressure ventilation
 - Barotrauma, airway pressures (including permissive hypercapnia)
 - Criteria for weaning and weaning techniques
 8. Pleural Diseases
 - Empyema
 - Massive effusion
 - Pneumothorax
 9. Pulmonary hemorrhage and massive hemoptysis
 10. Chest X-ray interpretation
 11. End tidal CO₂ monitoring
 12. Sleep apnea
 13. Control of breathing

C. Renal Physiology, Pathology, Pathophysiology and Therapy

1. Renal regulation of fluid and water balance and electrolytes
2. Renal failure: Prerenal, renal, and postrenal
3. Derangements secondary to alterations in osmolality and electrolytes
4. Acid-base disorders and their management
5. Principles of renal replacement therapy
6. Evaluation of oliguria and polyuria
7. Drug dosing in renal failure
8. Management of rhabdomyolysis
9. Neurogenic disorders of sodium and water regulation (cerebral salt wasting and SIADH).

D. Metabolic and Endocrine Effects of Critical Illness

1. Enteral and parenteral nutrition
2. Endocrinology
 - Disorders of thyroid function (thyroid storm, myxedema coma, sick euthyroid syndrome)
 - Adrenal crisis
 - Diabetes mellitus
 - Ketotic and hyperglycemic hyperosmolar coma
 - Hypoglycemia
3. Disorders of calcium and magnesium balance
4. Systemic Inflammatory Response Syndrome (SIRS)
5. Fever, thermoregulation, and cooling techniques

E. Infectious Disease Physiology, Pathology, Pathophysiology and Therapy

1. Antibiotics
 - Antibacterial agents

- Antifungal agents
 - Antituberculosis agents
 - Antiviral agents
 - Antiparasitic agents
2. Infection control for special care units
 - Development of antibiotic resistance
 - Universal precautions
 - Isolation and reverse isolation
 3. Tetanus and botulism
 4. Hospital acquired and opportunistic infections in the critically ill
 5. Acquired Immune Deficiency Syndrome (AIDS)
 6. Evaluation of fever in the ICU patient
 7. Central fever
 8. Interpretation of antibiotic concentrations, sensitivities

F. Physiology, Pathology, Pathophysiology and therapy of Acute Hematologic Disorders

1. Acute defects in hemostasis
 - Thrombocytopenia, thrombocytopeny
 - Disseminated intravascular coagulation
 - Acute hemorrhage (GI hemorrhage, retroperitoneal hematoma)
 - Iatrogenic coagulopathies (warfarin and heparin induced)
2. Anticoagulation and fibrinolytic therapy
3. Principles of blood component therapy (blood, platelets, FFP)
4. Hemostatic therapy (vitamin K, aminocaproic acid, protamine, factor VIIa)
5. Prophylaxis against thromboembolic disease
6. Prothrombotic states

G. Physiology, Pathology, Pathophysiology and Therapy of Acute Gastrointestinal (GI) and Genitourinary (GU) Disorders

1. Upper and lower gastrointestinal bleeding
2. Acute and fulminant hepatic failure (including drug dosing)
3. Ileus and toxic megacolon
4. Acute perforations of the gastrointestinal tract
5. Acute vascular disorders of the intestine, including mesenteric infarction
6. Acute intestinal obstruction, volvulus
7. Pancreatitis
8. Obstructive uropathy, acute urinary retention
9. Urinary tract bleeding

H. Immunology and Transplantation

1. Principles of transplantation (brain death, organ donation, procurement, maintenance of organ donors, implantation)
2. Immunosuppression, especially the neurotoxicity of these agents

I. General Trauma and Burns

1. Initial approach to the management of multisystem trauma
2. Skeletal trauma including the spine and pelvis
3. Chest and abdominal trauma - blunt and penetrating
4. Burns and electrical injury

J. Monitoring

1. Neuromonitoring
2. Prognostic, disease severity and therapeutic intervention scores
3. Principles of electrocardiographic monitoring
4. Invasive hemodynamic monitoring
5. Noninvasive hemodynamic monitoring
6. Respiratory monitoring (airway pressure, intrathoracic pressure, tidal volume, pulse oximetry, dead space, compliance, resistance, capnography)
7. Metabolic monitoring (oxygen consumption, carbon dioxide production, respiratory quotient)
8. Use of computers in critical care units for multimodality monitoring

K. Administrative and Management Principles and Techniques

1. Organization and staffing of critical care units
2. Collaborative practice principles, including multidisciplinary rounds and management
3. Emergency medical systems in prehospital care
4. Performance improvement, principles and practices
5. Principles of triage and resource allocation, bed management
6. Medical economics: health care reimbursement, budget development

L. Ethical and Legal Aspects of Critical Care Medicine

1. Death and dying
2. Forgoing life-sustaining treatment and orders not to resuscitate
3. Rights of patients, the right to refuse treatment
4. Living wills, advance directives; durable power of attorney
5. Terminal extubation and palliative care
6. Rationing and cost containment
7. Emotional management of patients, families and caregivers
8. Futility of care and the family in denial

M. Principles of Research in Critical Care

1. Study design
2. Biostatistics
3. Grant funding and protocol writing
4. Manuscript preparation
5. Presentation preparation and skills
6. Institutional Review Boards and HIPAA

III. Procedural Skills

A. General Neuro-Critical Care

1. Central venous catheter placement; dialysis catheter placement
2. Pulmonary artery catheterization
3. Management of mechanical ventilation, including CPAP/BiPAP ventilation
4. Administration of vasoactive medications (hemodynamic augmentation and hypertension lysis)
5. Maintenance airway and ventilation in nonintubated, unconscious patients
6. Interpretation and performance of bedside pulmonary function tests
7. Direct laryngoscopy
8. Endotracheal intubation
9. Shunt and ventricular drain tap for CSF sampling

10. Performance and interpretation of transcranial Doppler
11. Administration of analgesedative medications, including conscious sedation and barbiturate anesthesia
12. Interpretation of continuous EEG monitoring
13. Interpretation and management of ICP and CPP data
14. Jugular venous bulb catheterization
15. Interpretation of SjvO₂ and PbtO₂ data
16. Management of external ventricular drains
17. Management of plasmapheresis and IVIG
18. Administration of intravenous and intraventricular thrombolysis
19. Interpretation of CT and MR standard neuroimaging and perfusion studies and biplane contrast neuraxial angiography
20. Perioperative and postoperative clinical evaluation of neurosurgical and interventional neuroradiology patients
21. Performance of lumbar puncture and interpretation of cerebrospinal fluid results
22. Induction and maintenance of therapeutic coma and hypothermia

IV. GOALS

The overall goals of the educational program are:

- A.** To provide supervised training in patient care in the neurocritical care setting. This includes the diagnosis and management of life-threatening neurological diseases, as well as the medical conditions that frequently occur as complications.
- B.** To provide supervised training in technical aspects and procedures related to the practice of neurocritical care.
- C.** To provide training and mentoring in fundamental aspects of clinical and/or basic science research related to neurocritical care.
- D.** To provide training in administrative, management, and economic aspects of neurocritical care, with a focus on collaborative practice and multi-disciplinary care delivery.
- E.** To allow the trainee to develop a sense of purpose with regard to ethical and humanistic aspects of care, with an emphasis on compassion and respect for patient-centered values.
- F.** To foster the trainee's transition into a career as an independent, responsible, highly competent and self-sufficient neurointensivist.

V. OBJECTIVES

Advanced training programs in neurocritical care will have the following general purposes and goals (adapted from the ABMS/ACGME General Competencies):

A. Patient Care

Neurointensive care trainees are expected to provide patient care that is compassionate, appropriate and effective for the promotion of health, prevention of illness, treatment of disease, and at the end of life.

1. Gather accurate, essential information from all sources, including medical interviews, physical examinations, medical records and diagnostic/therapeutic procedures.
2. Make informed recommendations about preventive, diagnostic and therapeutic options and interventions that are based upon clinical judgment, scientific evidence, and patient preference.
3. Develop, negotiate and implement effective patient management plans and integration of patient care.
4. Perform competently the diagnostic and therapeutic procedures considered essential to the practice of neurocritical care.

B. Medical Knowledge

Neurocritical care fellows are expected to demonstrate knowledge of established and evolving biomedical and clinical sciences, and the application of their knowledge to patient care and the education of others.

1. Apply an open-minded, analytical approach to acquiring new knowledge.
2. Access and critically evaluate current medical information and scientific evidence.
3. Develop a clinically applicable knowledge of the basic and clinical sciences that underlie the practice of neurocritical care.
4. Apply this knowledge to clinical problem-solving, clinical decision-making, and critical thinking.

C. Practice-Based Learning and Improvement

Neurocritical care fellows are expected to be able to use scientific evidence and methods to investigate, evaluate and improve patient care practices.

1. Identify areas for improvement and implement strategies to enhance knowledge, skills, attitudes and processes of care.
2. Analyze and evaluate practice experiences and implement strategies to continually improve the quality of patient practice.
3. Develop and maintain a willingness to learn from experience and use experience to improve the system or processes of care.
4. Use information technology or other available methodologies to access and manage information, support patient care decisions, and enhance both patient and physician education.

D. Interpersonal and Communication Skills

Neurocritical care fellows are expected to demonstrate interpersonal and communication skills that enable them to establish and maintain professional relationships with patients, families, and other members of the health care team.

1. Provide effective and professional consultation to other physicians and health care professionals and sustain therapeutic and ethically sound professional relationships with patients, their families and colleagues.
2. Use effective listening, nonverbal, questioning, and narrative skills to communicate with patients and families.
3. Interact with consultants in a respectful, appropriate manner.
4. Maintain comprehensive, timely, and legible medical records.

E. Professionalism

Neurocritical care fellows are expected to demonstrate behaviors that reflect a commitment to continuous professional development, ethical practice methods, an understanding and sensitivity to diversity and a responsible attitude toward their patients, their professional, and society.

1. Demonstrate respect, compassion, integrity and altruism in relationships with patients, families, and colleagues.
2. Demonstrate sensitivity and responsiveness to gender, age, culture, religion, sexual preference, socioeconomic status, beliefs, behaviors and disabilities of patients and professional colleagues.
3. Adhere to principles of confidentiality, scientific/academic integrity, and informed consent.
4. Recognize and identify deficiencies in peer performance.

F. Systems-Based Practice

Neurocritical care fellows are expected to demonstrate both an understanding of the contexts and systems in which neurocritical care is provided, and the ability to apply this knowledge to improve and optimize patient care.

1. Understand, access and utilize the resources, providers and systems necessary to provide optimal care.

2. Understand the limitations and opportunities inherent in various practice types and delivery systems, and develop strategies to optimize care for the individual patient.
3. Apply evidence-based, cost-conscious strategies to prevention, diagnosis and disease management.
4. Collaborate with other members of the health care team to assist patients in dealing effectively with complex systems and to improve systematic processes of care.

VI. METHODS OF TRAINING TO BE USED

- A. The educational experience will be provided in the form of a post-residency fellowship, to be conducted at a participating member institution, qualified and in compliance with the program requirements. It is anticipated that in most instances the duration of the fellowship will be two years.
- B. The educational experience will be outlined in the form of a curriculum meeting the standards and requirements specified in the Neurocritical Care Core Curriculum and Neurocritical Care Program Requirements.
- C. Ongoing feedback in the form of progress reports and evaluations will be performed by the program director and designated faculty and provided to the trainee, and assessments of program success and faculty performance will be provided by trainees to the faculty.

VII. METHODS OF EVALUATION

The overall success of the program must be documented in written record and may include:

- A. Yearly tabulation of total applicants and number of accepted applicants.
- B. Total trainees completing the programs.
- C. Record of trainee presentations, abstracts, peer reviewed and other publications during the trainee program.
- D. Documentation of the first professional employment position or activity of the trainee immediately following completion of the training program.
- E. Productivity can also be supplemented by summarizing subsequent employment positions, honors, or other pertinent indicators of recognition received by trainees at any time following the training program experience.
- F. The number of patients who take a certification examination in neurocritical care, and their performance on the exam.

VIII. METHODS OF FEEDBACK

- A. Evaluation of program strengths and weaknesses, based on evaluations and perceptions of the trainees, faculty, and directors should be performed by the Program Director at least yearly and on an as-needed basis.
- B. A summary of these issues should be made yearly by the program director. The directors should discuss potential improvements with the faculty and minutes should be recorded regarding the recommendations.
- C. Reasonable efforts to incorporate helpful or constructive improvements should be made when logistically possible by the directors in the subsequent years of the training program.

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