Neurological Surgery Milestones

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The Milestones are designed only for use in evaluation of resident physicians in the context of their participation in ACGME-accredited residency or fellowship programs. The Milestones provide a framework for the assessment of the development of the resident physician in key dimensions of the elements of physician competency in a specialty or subspecialty. They neither represent the entirety of the dimensions of the 6 domains of physician competency, nor are they designed to be relevant in any other context.

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TABLE 1 **Brain Tumor—Medical Knowledge**

Level 1	Level 2	Level 3	Level 4	Level 5
▪ Correlates neurological deficits with tumor location ▪ Correlates radiographic tumor location with ventricular, cranial nerve, and vascular anatomy ▪ Describes the pathophysiology of mass lesions and obstructive hydrocephalus ▪ Describes acute symptomatic medical therapy for neoplastic mass lesions (eg, steroids, ventricular drainage)	▪ Describes the use of radiation and chemotherapy for brain and spinal cord tumors ▪ Lists indications for biopsy or resection of brain and spinal cord tumors ▪ Categorizes brain and spinal cord tumors by age, histology, and radiographic appearance ▪ Describes the nonneoplastic differential diagnosis of various mass lesions ▪ Describes the natural history of common intrinsic brain tumors	▪ Describes the genetics of brain tumors and genetic markers that impact prognosis ▪ Describes the use of advanced imaging in tumor evaluation and surgical planning (eg, magnetic resonance [MR] tractography, functional imaging, spectroscopy) ▪ Describes the use of neuronavigation and intraoperative imaging for brain tumor surgery ▪ Describes the role of skull-base surgical approaches in tumor resection, attendant complications, and their management	▪ Describes expected outcomes after surgery for brain and spinal cord tumors ▪ Describes the role of radiosurgery in brain tumor therapy ▪ Describes the role of palliative care for brain tumor patients ▪ Describes personalized medicine approaches for brain tumor treatment	▪ Contributes to the peer-reviewed literature in brain and spinal cord tumors ▪ Participates in brain tumor research and clinical trials

TABLE 2 **Brain Tumor—Patient Care**

Level 1	Level 2	Level 3	Level 4	Level 5
▪ Performs a history and physical examination in patients with brain or spinal cord tumors ▪ Provides routine perioperative care for patients with brain or spinal cord tumors ▪ Initiates the workup of a patient with a brain or spinal cord tumor ▪ Recognizes signs of and initiates workup for neurological deterioration	▪ Explains risks and benefits of neurosurgical procedures for brain and spinal cord tumors ▪ Interprets diagnostic studies ▪ Assists with routine procedures (eg, resection of noneloquent glioma or metastasis, stereotactic biopsy) ▪ Recognizes and initiates workup of complications (eg, hematoma, infection, seizure, hydrocephalus)	▪ Formulates a workup and treatment plan for patients with brain, skull base, or spinal cord tumors ▪ Independently performs routine procedures ▪ Performs complex procedures with assistance (eg, resection of eloquent glioma, ventricular or posterior fossa tumor) ▪ Manages unexpected intraoperative events (eg, sinus bleeding, cerebral edema) ▪ Manages complications with assistance	▪ Independently formulates a treatment plan for patients with comorbidities or other complicating factors (eg, systemic illness, radiation, chemotherapy) ▪ Independently performs complex procedures ▪ Adapts standard treatment plans to special circumstances (eg, previous surgery, anticipated neurological morbidity) ▪ Independently manages complications	▪ Systematically reviews treatment outcomes for brain and spinal cord tumors ▪ Participates in quality improvement for brain and spinal cord tumors ▪ Participates in or leads a multidisciplinary brain tumor team or program

TABLE 3 **Critical Care—Medical Knowledge**

Level 1	Level 2	Level 3	Level 4	Level 5
▪ Describes intracranial pressure (ICP), cerebral perfusion pressure (CPP), and cerebral blood flow (CBF) physiology ▪ Describes respiratory and ventilator physiology and effects on the central nervous system (CNS) ▪ Describes the pathophysiology of myocardial infarction (MI) and congestive heart failure (CHF) ▪ Describes physiology of coagulation and hemostasis ▪ Describes principles of nutritional support ▪ Lists indications for ICP monitoring and hematoma evacuation ▪ Describes cerebral autoregulation	▪ Describes the pathophysiology and medical management of intracranial hypertension and cerebral edema ▪ Describes modes of mechanical ventilation and management of pulmonary shunting and dead space ▪ Describes prophylaxis for deep vein thrombosis (DVT) ▪ Describes the pathophysiology and treatment of diabetic ketoacidosis (DKA) ▪ Describes the etiology and imaging of traumatic intracranial hemorrhage and parenchymal injuries	▪ Describes indications for electroencephalography (EEG) monitoring ▪ Discusses indications for and risks of endotracheal intubation/ventilation ▪ Describes the pathophysiology and treatment of systemic critical illness (eg, hypertension, coagulopathy, electrolyte imbalance, alcohol withdrawal) ▪ Lists indications and complications for decompressive craniectomy, cerebral spinal fluid (CSF) drainage, and barbiturate coma in traumatic brain injury (TBI)	▪ Describes expected outcomes after TBI and the impact of intracranial hypertension and of surgical intervention ▪ Understands transcranial Doppler (TCD) sonography and its role in monitoring ▪ Discusses the risks of CSF drainage, hyperosmolar therapy, and hyperventilation ▪ Describes methods to assess intravascular volume and tissue perfusion	▪ Contributes to the peer-reviewed literature in TBI ▪ Describes advanced intracranial monitoring (eg, brain tissue oxygenation, jugular venous oxygen saturation, microdialysis) ▪ Describes advanced imaging for TBI (eg, cerebral metabolism, perfusion) ▪ Describes indications and risks for various methods of hemodialysis and extracorporeal membrane oxygenation (ECMO)

TABLE 4 **Critical Care—Patient Care**

Level 1	Level 2	Level 3	Level 4	Level 5
▪ Performs a history and physical examination in critically ill patients ▪ Orders positioning, analgesics, sedation, neuromuscular blockade, intravenous (IV) fluids and nutrition in critically ill patients ▪ Diagnoses and formulates treatment plans for common pulmonary diseases ▪ Uses electrocardiograms (EKG) to diagnose cardiac arrhythmia; initiates hemodynamic monitoring ▪ Performs a brain death examination	▪ Explains risks and benefits of ventilatory support ▪ Interprets diagnostic studies (eg, chest x-ray [CXR], brain computed tomography [CT], echocardiogram) ▪ Manages intracranial hypertension (eg, hyperosmolar agents, CSF drainage) ▪ Manages airway and performs endotracheal intubation ▪ Inserts arterial and central venous catheters ▪ Diagnoses and manages spinal or hypovolemic shock	▪ Formulates a workup and treatment plan for a comatose patient ▪ Manages refractory intracranial hypertension (eg, blood pressure, CPP) ▪ Obtains confirmatory tests and makes an accurate diagnosis of brain death ▪ Initiates management of pneumonia or systemic infection	▪ Independently formulates a treatment plan for complex patients (eg, failure of cerebral autoregulation, multiorgan failure, nonrecoverable CNS injury) ▪ Diagnoses and initiates management of adult respiratory distress syndrome ▪ Manages difficult and emergency airways ▪ Diagnoses and manages CSF leak ▪ Initiates management of cardiac rhythm disturbances	▪ Systematically reviews outcomes for neurocritical care patients ▪ Participates in quality improvement for a neurocritical care unit ▪ Develops a standard neurocritical care unit management protocol ▪ Leads multidisciplinary neurocritical care team ▪ Manages respiratory failure (eg, mechanical ventilation, bronchoscopy) ▪ Manages cardiac rhythm disturbances

TABLE 5 **Traumatic Brain Injury—Patient Care**

Level 1	Level 2	Level 3	Level 4	Level 5
■ Performs a history and physical examination of a comatose patient and assigns a Glasgow Coma Scale (GCS) score ■ Evaluates a polytrauma patient and assigns an Injury Severity Score ■ Provides initial management of a polytrauma patient ■ Provides routine perioperative care for patients with TBI ■ Detects an altered neurological examination ■ Places an ICP monitor and external ventricular drain	■ Explains risks and benefits of neurosurgical procedures for TBI ■ Interprets diagnostic imaging for a neurotrauma patient ■ Organizes emergency surgical team; positions for craniotomy with cervical precautions ■ Assists with routine procedures (eg, burr hole, craniotomy for hematoma or penetrating injury) ■ Recognizes and initiates workup of complications (eg, hematoma, seizure, sepsis, monitor drift)	■ Formulates an interdisciplinary treatment plan for patients with polytrauma ■ Selects patients for operative intervention ■ Independently performs routine procedures ■ Performs complex procedures with assistance (eg, repair of vascular injury or CSF fistula, posterior fossa hematoma) ■ Manages complications with assistance ■ Manages ventricular drain	■ Prioritizes the management of injuries for a polytrauma patient ■ Independently performs complex procedures ■ Manages unexpected intraoperative events (eg, cerebral edema, hemorrhage, air embolus) ■ Adapts standard treatment plans to special circumstances (eg, medical comorbidity, coagulopathy) ■ Independently manages CNS complications	■ Systematically reviews treatment outcomes for TBI ■ Participates in quality improvement for TBI care ■ Participates in developing a plan for triage in a disaster management scenario ■ Reconstructs complex craniofacial injuries

TABLE 6 **Surgical Treatment of Epilepsy and Movement Disorders—Medical Knowledge**

Level 1	Level 2	Level 3	Level 4	Level 5
■ Describes the embryology and functional anatomy of the basal ganglia, thalamus, and cortex ■ Describes the physical findings and differential diagnosis of common movement disorders ■ Describes the semiology and pathophysiology of common seizure disorders ■ Describes medical therapy for status epilepticus	■ Describes medical therapies for epilepsy and movement disorders ■ Lists surgical indications for patients with epilepsy or movement disorders ■ Describes imaging findings in common epilepsies and movement disorders (eg, magnetic resonance imaging [MRI], single proton emission computed tomography [SPECT], and positron emission tomography [PET]) ■ Describes the principle of arc-centered stereotaxy ■ Describes sources of inaccuracy in stereotaxy (eg, brain shift, human error)	■ Describes the pathophysiology, including genetics, of the common movement disorders ■ Describes the pathophysiology and pathoanatomy of common epilepsies ■ Identifies on MRI the structures targeted for movement disorder surgery ■ Describes the use of surface and invasive EEG in seizure focus localization ■ Identifies common patterns of EEG abnormality	■ Describes expected outcomes after surgery for epilepsy and movement disorders ■ Describes responses to electrical stimulation around intended deep brain simulation (DBS) targets and in various regions of eloquent cortex ■ Describes indications for lesional versus neuromodulatory interventions ■ Describes the role of radiosurgery for functional lesions ■ Describes indications for vagus nerve stimulation (VNS), callosotomy, and hemispherectomy	■ Contributes to the peer-reviewed literature in epilepsy and/or movement disorder treatment

TABLE 7 **Surgical Treatment of Epilepsy and Movement Disorders—Patient Care**

Level 1	Level 2	Level 3	Level 4	Level 5
■ Performs a history and physical examination in patients with epilepsy or movement disorders ■ Evaluates and treats a patient for medical comorbidities affecting functional neurological surgery ■ Provides routine perioperative care for functional neurosurgical patients ■ Initiates the workup of a patient with an apparent seizure ■ Recognizes and initiates treatment of status epilepticus	■ Explains risks and benefits of neurosurgical procedures for epilepsy and movement disorders ■ Interprets diagnostic studies ■ Assists with routine components of functional procedures (eg, burr hole, craniotomy, generator change) ■ Recognizes and initiates workup of complications (eg, hematoma, seizure, infection, device malfunction) ■ Places stereotactic head frame	■ Formulates a workup and treatment plan for patients with epilepsy or a movement disorder (eg, Parkinson disease, essential tremor) ■ Independently performs routine functional procedures (eg, DBS placement, subdural electrode placement, topectomy) ■ Performs complex functional procedures with assistance (eg, temporal lobectomy) ■ Manages complications with assistance ■ Performs stereotactic targeting by using frameless and frame-based systems	■ Independently formulates a treatment plan for patients with comorbidities or other complicating factors (eg, eloquent seizure focus) ■ Independently performs complex procedures ■ Adapts standard treatment plans to special circumstances (eg, previous surgery, neuropsychologic limitations) ■ Independently manages complications	■ Systematically reviews treatment outcomes for epilepsy and/or movement disorders ■ Participates in quality improvement for epilepsy and/or movement disorders

TABLE 8 **Pain and Peripheral Nerves—Medical Knowledge**

Level 1	Level 2	Level 3	Level 4	Level 5
■ Describes the anatomy of spinal cord and thalamic pathways for pain and pain modulation ■ Describes the anatomy of the brachial and lumbar plexi and major nerves of the extremities ■ Describes nerve injury classifications and the prognosis and time course for recovery of each	■ Lists medical therapies for chronic pain (eg, trigeminal neuralgia, brachial plexus neuritis) ■ Describes the anatomy and physical findings of common upper extremity entrapment neuropathies ■ Describes the clinical findings and differential diagnosis of trigeminal neuralgia ■ Lists surgical indications for patients with chronic pain or peripheral nerve disorders	■ Describes the pathophysiology of chronic pain disorders ■ Describes nonoperative therapies for nerve entrapment disorders ■ Describes the anatomy and physical findings of common lower extremity entrapment neuropathies ■ Describes the findings of electromyography (EMG) and nerve conduction studies in peripheral nerve disorders ■ Obtains and interprets diagnostic studies for patients with chronic pain and peripheral nerve disorders	■ Describes expected outcomes after surgery for chronic pain (eg, microvascular decompression [MVD], dorsal root entry zone [DREZ] lesions, cordotomy) ■ Describes expected outcomes after surgery for peripheral nerve disorders (eg, neurolysis, direct anastomosis, grafting) ■ Describes the anatomy and physiology of spinal cord lesioning for pain (myelotomy, cordotomy)	■ Contributes to the peer-reviewed literature in chronic pain and/or peripheral nerve disorders

TABLE 9 **Pain and Peripheral Nerves—Patient Care**

Level 1	Level 2	Level 3	Level 4	Level 5
■ Performs a history and physical examination in patients with chronic pain or peripheral nerve disorders ■ Provides routine perioperative care for patients with chronic pain or peripheral nerve disorders ■ Initiates the workup of a patient with a peripheral nerve injury ■ Recognizes and initiates treatment of baclofen withdrawal or morphine overdose	■ Explains risks and benefits of neurosurgical procedures for pain and peripheral nerve disorders ■ Interprets diagnostic studies ■ Assists with routine procedures (eg, carpal tunnel release, spinal cord stimulation, intrathecal pump) ■ Recognizes and initiates workup of complications (eg, hematoma, infection, device malfunction)	■ Formulates a workup and treatment plan for patients with chronic pain or peripheral nerve disorders (eg, trigeminal neuralgia, carpal tunnel syndrome) ■ Independently performs routine procedures ■ Performs complex procedures with assistance (eg, DREZ lesions, cordotomy, neuroma in continuity, brachial plexus repair, nerve graft, nerve transfer) ■ Manages complications with assistance	■ Independently formulates a treatment plan for patients with comorbidities or other complicating factors (eg, recurrent trigeminal neuralgia) ■ Independently performs complex procedures ■ Adapts standard treatment plans to special circumstances (eg, previous surgery, deafferentation pain) ■ Independently manages complications	■ Systematically reviews treatment outcomes for pain and/or peripheral nerve disorders ■ Participates in quality improvement for pain and/or peripheral nerve disorders

TABLE 10 **Pediatric Neurological Surgery—Medical Knowledge**

Level 1	Level 2	Level 3	Level 4	Level 5
■ Describes the embryology of common CNS congenital anomalies ■ Describes normal CSF physiology ■ Describes the response of the developing brain to injury ■ Describes developmental changes in cardiopulmonary function and vital signs ■ Describes proper utilization and dosing of narcotics in children ■ Calculates circulating blood volume in infants and children	■ Describes abnormal CSF physiology and anatomy in various forms of hydrocephalus ■ Describes the radiologic and clinical features of CNS tumors in children of various ages ■ Describes the radiologic and clinical features of hydrocephalus, benign macrocephaly, and subdural hygroma ■ Describes the physical findings and mechanisms of head shape abnormalities	■ Describes the natural history of congenital CNS anomalies ■ Describes the implications of spinal column development for patterns of injury and treatment choice in children ■ Describes the impact of refractory epilepsy and spastic cerebral palsy on development and function ■ Describes treatment strategies for CNS tumors in children ■ Identifies methods to limit radiation exposure in children during imaging	■ Describes the effects of surgical diversion on CSF physiology ■ Describes the risks, screening, incidence, and management of late effects from chemotherapy and radiation for childhood CNS tumors ■ Describes the natural history of cranial synostosis and tethered cord with or without surgical intervention ■ Describes expected medical and functional long-term outcomes in patients with myelomeningocele	■ Contributes to the peer-reviewed literature in pediatric neurological surgery ■ Describes molecular abnormalities associated with CNS congenital anomalies and tumors ■ Describes the differential diagnosis and pathophysiology of acquired and congenital movement disorders

TABLE 11 **Pediatric Neurological Surgery—Patient Care**

Level 1	Level 2	Level 3	Level 4	Level 5
■ Performs an age-appropriate history and physical examination with developmental assessment ■ Provides routine perioperative care for pediatric neurosurgical patients ■ Programs shunt valves and taps shunts ■ Evaluates CSF shunt function ■ Recognizes and initiates notification and evaluation of nonaccidental trauma	■ Explains risks and benefits of neurosurgical procedures to parents and older children ■ Interprets diagnostic studies with accurate identification of age-related variations ■ Assists with routine procedures (eg, CSF shunt, baclofen pump, Chiari decompression) ■ Recognizes in preverbal children, and initiates workup of complications (eg, hematoma, infection, device malfunction, acute mental status decline)	■ Formulates a workup and treatment plan for pediatric patients (eg, hydrocephalus, synostosis, tethered cord, birth injury) ■ Independently performs routine procedures ■ Performs complex procedures with assistance (eg, brain tumor, synostosis repair, tethered cord, ventricular endoscopy, indirect vascular bypass, craniotomy for epilepsy) ■ Manages complications with assistance ■ Diagnoses brain death in infants/children	■ Independently formulates a treatment plan for patients with comorbidities or other complicating factors (eg, other organ system congenital anomalies) ■ Independently performs complex procedures ■ Adapts standard treatment plans to special circumstances (eg, previous surgery, developmental delay, coagulopathy) ■ Independently manages complications	■ Systematically reviews treatment outcomes for pediatric neurosurgical patients ■ Participates in quality improvement for pediatric neurological surgery ■ Formulates a diagnostic and management plan for a patient with a functioning CSF shunt and chronic headaches ■ Counsels expectant parents regarding fetal congenital anomalies ■ Performs surgical stabilization of the spine in a patient younger than 3 years

TABLE 12 **Spinal Neurosurgery; Degenerative Disease—Medical Knowledge**

Level 1	Level 2	Level 3	Level 4	Level 5
■ Describes vertebral and radicular anatomy by level ■ Describes the physical findings and differential diagnosis of degenerative spinal disorders (eg, radiculopathy, neurogenic claudication, spondylotic myelopathy) ■ Describes basic principles of spinal biomechanics	■ Describes medical and physical therapies for degenerative spinal disorders ■ Lists surgical indications and options for degenerative spinal disorders ■ Describes imaging findings in degenerative spinal disorders (eg, x-ray, MRI, myelography) ■ Describes the natural history of spinal degenerative disorders ■ Describes electromyogram (EMG) findings in spondylotic myeloradiculopathy	■ Describes the pathophysiology of degenerative spondylotic myeloradiculopathy ■ Describes and categorize degenerative spinal deformities by imaging (eg, scoliosis, lumbar spondylolisthesis) ■ Describes indications for anterior versus posterior surgical approaches to the spine ■ Describes the role of instrumentation and bony fusion in surgery for degenerative spinal disorders	■ Describes expected functional and pain outcomes after surgery for spinal degenerative disease ■ Describes criteria for reoperation for degenerative spinal disease ■ Lists indications for vertebroplasty and kyphoplasty ■ Describes the genetics, pathophysiology, and imaging findings of inflammatory spinal disorders	■ Contributes to the peer-reviewed literature in spinal degenerative disease ■ Evaluates and introduces resource efficiencies for surgical spine care

TABLE 13 **Spinal Neurosurgery; Trauma, Tumor, Infection—Medical Knowledge**

Level 1	Level 2	Level 3	Level 4	Level 5
■ Describes spinal cord and cauda equina anatomy ■ Describes dermatomal sensory and motor levels and patterns of spinal cord injury ■ Defines spinal stability and instability ■ Describes the pathophysiology of spine and spinal cord injuries	■ Describes the medical treatment of spinal infections ■ Describes the use and types of external bracing in spinal trauma, tumor, or infection ■ Classifies spinal fractures by mechanism and imaging appearance ■ Lists surgical indications, contraindications, and options for spinal trauma, tumor, and infection ■ Describes the natural history of primary spinal tumors	■ Describes the pathophysiology and imaging findings of spinal tumors (eg, intradural tumor, vertebral metastasis) ■ Describes the pathophysiology and imaging findings in spinal infection (eg, discitis, epidural abscess, tuberculosis, osteomyelitis) ■ Describes the role of instrumentation and bony fusion in surgery for spinal trauma, tumor, or infection	■ Describes expected short- and long-term outcomes and complications after surgery for spinal trauma, tumor, or infection ■ Describes factors affecting outcome in spinal tumor surgery (eg, extent of resection) ■ Describes the use of adjuncts during spinal trauma and tumor surgery (eg, image guidance, ultrasound, monitoring) ■ Describes the role of radiotherapy for treatment of spinal tumors	■ Contributes to the peer-reviewed literature in spinal trauma, tumor, or infection ■ Designs a clinical trial in spinal trauma, tumor, or infection

TABLE 14 **Spinal Neurosurgery—Patient Care**

Level 1	Level 2	Level 3	Level 4	Level 5
■ Performs a history and physical examination in patients with spinal disorders ■ Evaluates and treats a patient for medical comorbidities affecting elective spinal surgery ■ Provides routine perioperative care for spinal surgery patients ■ Initiates the workup of a patient with myelopathy or radiculopathy ■ Safely positions patients for spinal procedures	■ Explains risks and benefits of surgical spine procedures ■ Interprets diagnostic studies (eg, imaging, EMG) ■ Initiates management of a patient with acute spinal cord injury ■ Performs cervical traction/reduction ■ Assists with routine procedures (eg, lumbar or cervical laminectomy, lumbar discectomy) ■ Recognizes and initiates workup of complications (eg, CSF leak, infection, radiculitis)	■ Formulates a workup and treatment plan for patients with lumbar or cervical degenerative disease ■ Formulates a plan for surgical and adjunctive therapy of a patient with spinal column neoplastic disease ■ Independently performs routine procedures ■ Performs complex procedures with assistance (eg, anterior cervical discectomy and fusion [ACDF], posterior lumbar fusion, spinal cord tumor resection, fracture stabilization) ■ Manages complications with assistance	■ Independently formulates a treatment plan for patients with comorbidities, previous surgery, or other complicating factors (eg, multiple system trauma, coagulopathy) ■ Independently performs complex procedures ■ Performs advanced procedures with assistance (eg, thoracolumbar or craniocervical reconstruction, reconstruction after infection or vertebral tumor resection) ■ Independently manages complications	■ Systematically reviews treatment outcomes for spinal disorders ■ Participates in quality improvement for spinal disorders ■ Leads interdisciplinary team in the management of complex spinal disorders ■ Independently performs advanced procedures

TABLE 15 **Vascular Neurosurgery—Medical Knowledge**

Level 1	Level 2	Level 3	Level 4	Level 5
■ Describes intracranial and extracranial vascular anatomy, including vascular territories ■ Describes mechanisms of cerebral autoregulation ■ Describes clinical presentations and imaging characteristics of ischemic and hemorrhagic stroke ■ Describes the embryology and anatomy of vascular lesions (eg, aneurysms and vascular malformations) ■ Describes the pathophysiology of intracranial and extracranial atherosclerotic disease	■ Lists indications for intravenous thrombolytic therapy in ischemic stroke ■ Lists indications for carotid endarterectomy and carotid angioplasty/stent ■ Describes the natural history of aneurysms and vascular malformations ■ Lists indications for surgical and endovascular treatment of aneurysms and vascular malformations ■ Describes the clinical and imaging characteristics of delayed cerebral ischemia after subarachnoid hemorrhage ■ Describes imaging findings in common cerebrovascular conditions	■ Describes the pathophysiology of ischemic stroke (eg, necrotic and apoptotic cell death) ■ Describes methods for evaluating cerebral perfusion and blood flow ■ Lists indications for surgical and endovascular treatment of complex aneurysms and vascular malformations ■ Describes the imaging and angiographic characteristics of cerebral vasculopathies (eg, atherosclerotic disease, dissection, vasculitis)	■ Describes expected outcomes after surgery or endovascular therapy for intracranial and extracranial vascular disease ■ Describes the indications for medical versus endovascular treatment of intracranial arterial stenosis ■ Describes the molecular mechanisms of ischemic protection strategies ■ Describes the genetics and inheritance of familial cavernous malformations and hereditary hemorrhagic telangiectasia	■ Contributes to the peer-reviewed literature in cerebrovascular disease

TABLE 16 **Vascular Neurosurgery—Patient Care**

Level 1	Level 2	Level 3	Level 4	Level 5
■ Performs a history and physical examination in patients with ischemic or hemorrhagic stroke ■ Provides routine perioperative care for patients undergoing extracranial and intracranial vascular surgery ■ Initiates the workup of a patient with ischemic or hemorrhagic stroke ■ Explains risks and benefits of diagnostic catheter angiography	■ Explains risks and benefits of surgery and endovascular therapy for aneurysms, vascular malformations, and ischemic stroke ■ Interprets CT, MR, and angiographic studies ■ Assists with routine components of procedures (eg, pterional craniotomy, diagnostic catheter angiography) ■ Recognizes and initiates workup of complications after surgery or endovascular therapy (eg, hemorrhage, ischemic stroke, cardiovascular compromise	■ Formulates a workup and treatment plan for patients with aneurysms, vascular malformations, or ischemic stroke ■ Independently performs routine components of procedures ■ Performs complex procedures with assistance (eg, carotid endarterectomy, aneurysm clipping, arteriovenous malformation resection) ■ Manages complications with assistance	■ Independently formulates a treatment plan for patients with comorbidities or other complicating factors (eg, previous stroke, coronary artery disease, anticoagulation) ■ Independently performs complex procedures ■ Performs advanced procedures with assistance (eg, aneurysm coiling, vascular malformation embolization, extracranial-intracranial bypass) ■ Independently manages complications	■ Systematically reviews treatment outcomes for neurovascular disease ■ Participates in quality improvement for neurovascular disease ■ Independently performs advanced procedures

TABLE 17 **Relational—Interpersonal and Communication Skills**

Level 1	Level 2	Level 3	Level 4	Level 5
▪ Describes the ethical principles of informed consent ▪ Describes methods to compassionately break bad news ▪ Identifies elements of safe patient handoffs and procedural pause ▪ Prioritizes and conveys simultaneous critical clinical events	▪ Obtains and documents informed consent ▪ Participates in breaking bad news to a patient or family ▪ Participates in an advanced directive discussion ▪ Leads procedural pause ▪ Uses checklists and informatics to support patient handoffs ▪ Communicates effectively with patients and families from varied cultural and socioeconomic backgrounds ▪ Prioritizes, conveys, and manages simultaneous critical clinical events	▪ Obtains and documents informed consent in challenging circumstances (eg, language or cultural barrier) ▪ Breaks bad news to a patient or family member ▪ Leads and documents an advanced directive discussion ▪ Supervises patient handoffs ▪ Communicates effectively with physicians, health professionals, and health agencies	▪ Quantifies evidence for risk-benefit analysis during informed consent for a complex, elective neurosurgical procedure ▪ Manages and documents an unexpected outcome (eg, patient, care team and risk management communication) ▪ Leads response to an intraoperative or critical care emergency ▪ Acts in a consultative role to other physicians	▪ Designs consent instrument for a human subject research study; files an Institutional Review Board (IRB) application ▪ Designs and implements a procedural safety or sign-out exercise ▪ Designs and implements a team building and communications exercise

TABLE 18 **Technology—Interpersonal and Communication Skills**

Level 1	Level 2	Level 3	Level 4	Level 5
▪ Uses electronic medical record (EMR) and radiology access systems for timely reporting of clinical information ▪ Creates accurate patient orders and demonstrates use of EMR dosing and drug interaction safety mechanisms	▪ Completes timely and accurate operative notes and ACGME Case Log entries ▪ Lists the elements necessary for evaluation and management (E&M) coding at each encounter type/level	▪ Uses Health Insurance Portability and Accountability Act (HIPAA) protection safeguards for protected health information (PHI) and EMR ▪ Designs and implements an EMR template	▪ Creates or updates a neurosurgical care pathway and order set; implements use	▪ Uses EMR with IRB approval to conduct formal clinical research and/or quality improvement (QI); reports results

TABLE 19 **Compassion—Professionalism**

Level 1	Level 2	Level 3	Level 4	Level 5
▪ Demonstrates honest and caring patient interactions; respects privacy and autonomy ▪ Describes basic bioethical principles	▪ Forms effective therapeutic bond with patients; receives praise from patients and families ▪ Identifies and manages common ethical challenges during patient care	▪ Mitigates impact of cultural, ethnic, or socioeconomic differences on patient care outcomes ▪ Responds to patient needs that supersede self-interest	▪ Identifies and manages complex ethical challenges during patient care ▪ Acts as a mentor and role model to other residents	▪ Participates in or develops programs to promote equality of care in vulnerable and underserved patient populations ▪ Participates in or designs physician wellness programs

TABLE 20 **Accountability—Professionalism**

Level 1	Level 2	Level 3	Level 4	Level 5
■ Is punctual for conferences, rounds, pages, and operating room (OR) ■ Manages fatigue and sleep deprivation ■ Reports duty hours in a timely and accurate manner ■ Presents appropriate attire and respectful demeanor ■ Seeks patient information with reliability, industry, and confidentiality	■ Recognizes individual limits in clinical situations and asks for assistance when needed ■ Manages personal emotional, physical, and mental health ■ Seeks and accepts professional criticism	■ Demonstrates personal ownership of complications and patient outcomes ■ Acts as effective team leader for physicians and other health care personnel ■ Leads accurate and effective discussions at morbidity and mortality conference	■ Assumes leadership responsibility for clinical care team decisions and outcomes ■ Mediates conflict amongst members of the health care team ■ Recognizes and responds to physician impairment in self or others	■ Serves as a role model for other practicing and resident physicians for standards of ethical behavior and professionalism ■ Participates in or leads institutional ethics board or program, or IRB

TABLE 21 **Economics—Systems-Based Practice**

Level 1	Level 2	Level 3	Level 4	Level 5
■ Identifies the range of practice variation (eg, medication, laboratory tests, imaging, and procedures) ■ Describes US health payment systems	■ Describes the cost impact of practice variation in the context of system and national health resource utilization ■ Describes principles of ethical coding (eg, diagnostic, E&M, and procedural)	■ Uses health care resources responsibly (eg, test ordering, OR efficiency, timely discharges/transfers) ■ Accurately codes diagnoses and procedures in the ACGME Case Log System	■ Cites peer-reviewed cost and outcomes data to support resource utilization decisions	■ Designs and implements cost-effective patient care pathways with monitoring and feedback mechanisms

TABLE 22 **Safety and Systems—Systems-Based Practice**

Level 1	Level 2	Level 3	Level 4	Level 5
■ Defines medical errors, near misses, and sentinel events; provides system-based examples of each ■ Assists care coordinator with discharge and outpatient services arrangements ■ Works in interdisciplinary teams to enhance safety and quality	■ Uses protocols and checklists for patient handoffs, medication orders, and emergencies ■ Effects interfacility transfer, including records and physician communication	■ Reports problematic behaviors, processes, and devices, including errors and near misses ■ Coordinates interdisciplinary inpatient care	■ Conducts root cause or failure mode analysis of systems-based errors and effects prophylaxis ■ Coordinates team for interdisciplinary procedure ■ Establishes timeline and identifies resources for transition to practice ■ Improves care systems to achieve optimal patient care ■ Works effectively in various health care delivery settings and systems	■ Leads multidisciplinary patient safety team or initiative ■ Leads interdisciplinary care team or clinic ■ Mentors colleagues in practice building and administration

TABLE 23 **Lifelong Learning—Practice-Based Learning and Improvement**

Level 1	Level 2	Level 3	Level 4	Level 5
■ Identifies limitations in knowledge, skills, and experience; incorporates feedback ■ Demonstrates information technology skills for evidence gathering	■ Sets learning and improvement goals; identifies resources, and performs appropriate learning activities ■ Participates in informal patient, medical student, and resident teaching	■ Uses data for practice improvement (eg, systematic reviews, meta-analyses, practice guidelines, clinical outcomes data) ■ Teaches colleagues and other health professionals in both formal and informal settings	■ Participates in evidence-based practice improvement ■ Organizes educational activities at the program level	■ Develops educational curriculum and/or assessment tools

TABLE 24 **Research—Practice-Based Learning and Improvement**

Level 1	Level 2	Level 3	Level 4	Level 5
■ Describes basic concepts in clinical epidemiology, biostatistics, and clinical reasoning ■ Describes the design and use of clinical registry outcomes data in practice improvement	■ Categorizes research study designs; evaluates quality and relevance ■ Contributes to the peer-reviewed neurological surgery literature ■ Incorporates evidence into routine clinical care decisions	■ Contributes systematic clinical or scientific information to the peer-reviewed literature ■ Participates in clinical outcomes data gathering and analysis	■ Formulates question or hypothesis, designs investigation, executes project, and reports results ■ Uses morbidity and mortality and program-level outcome data to institute systematic clinical practice changes	■ Independently plans, funds, and executes a research program ■ Leads or participates in a clinical research trial ■ Participates in the peer-review and/or research funding review processes ■ Leads or participates in a clinical outcomes registry