CHAPTER

34

Resident Curriculum Guidelines for Neurosurgery

Congress of Neurological Surgeons Education Committee

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CONTENTS

Spinal Surgery
Stereotactic and Functional Neurosurgery

INTRODUCTION

This curriculum was created to detail the body of knowledge that should be attained by an individual completing residency training in neurological surgery. The specific structure of resident education in neurological surgery is defined by the American Board of Neurological Surgery, and each program is examined periodically by the Residency Review Committee. It is not the intent of this curriculum to direct or influence these two entities in any way. The curriculum is meant to serve as a template to be used by individual neurosurgery residency program directors and residents as they see fit. In many respects, this comprehensive and specific curriculum delineates the "ideal," and therefore complete compliance to the curriculum will be difficult or impossible to achieve for most if not all programs. Nevertheless, it represents a goal toward which to strive.

This document will assist program directors, faculty, and residents in structuring an adequate postgraduate experience in neurological surgery. It should serve to create an organizational structure of academic, clinical, and technical criteria for the training of residents in neurological surgery. The curriculum should prompt members of established training programs to examine their educational experience and to assist new program developers in designing a comprehensive educational experience. The goal is to improve patient care by ensuring that residents completing training have achieved the highest possible level of competency in neurological surgery.

Although each portion of the curriculum has been examined by a number of recognized experts and leading educators in neurological surgery, it is recognized that an absolute consensus concerning the definition of essential knowledge for the practice of neurological surgery has not and will not be achieved. Despite this inevitable shortcoming, wide distribution of this resource to program directors, faculty, and residents will allow for each program to maximize its strengths, to address its weaknesses, and to promote constructive dialog among all involved parties.

It is noted that there is redundancy in the curriculum. This has arisen because many areas of neurosurgery overlap. The curriculum structure is based on performance. Hopefully, this will facilitate self-directed resident study and will impart some objectivity to periodic resident evaluations. The curriculum is constructed in such a manner that the educational experience is divided into three levels—junior, middle, and senior. The resident should display competency in each level before progressing to the next. Those individuals who do not stay on track will be promptly

identified in an objective manner, thereby enabling more timely remedial attention or dismissal. Furthermore, it will force each program to examine its faculty and the structure of the basic and clinical training programs to ensure an optimal educational experience. The curriculum does not define how information is imparted, only the body of knowledge that must be mastered. It is up to the program developers to determine whether achievement of the goals will be accomplished through conferences, required readings, scheduled lectures or workshops, and so forth.

Adequate supervision of resident performance is critical to ensure proper care of the patient and learning of the resident. It is recognized, however, that a great deal of learning also takes place without supervision. Programs should be structured to allow residents to act independently at various tasks commensurate with their skills and the specific medical situation.

Although the assessment of resident, faculty, and program performance is extremely important, the curriculum does not include specific outcomes measures. Currently, a resident evaluation is performed in a nonuniform manner by the faculty and directors of each individual program. Hopefully there will be homogeneous evaluation of the knowledge and performance for each level of residency in the future.

Lastly, it should be recognized that a great number individuals have provided input and reviewed this work. Many of these persons are not listed as authors, but without their assistance the completion of this curriculum would not be possible.

NEUROANATOMY

Unit Objective

Demonstrate knowledge of anatomy that is pertinent to the diagnosis of diseases of the nervous system and the practice of neurological surgery.

Competency-Based Knowledge Objectives

JUNIOR LEVEL

General

1. Review the embryological development of the brain, cerebellum, brainstem, glial elements, spinal cord, conus medullaris, cauda equina, sympathetic and parasympathetic systems, and the peripheral nervous system.
2. Discuss the embryological development of the skull, craniovertebral junction, and spine.

3. Describe and differentiate the different types of neurons.
4. Discuss the microanatomy of the neuron including the
   a. cell body
   b. dendritic process
   c. axonal process
5. Diagram and describe the microanatomy of the synapse.
6. List the microglial elements and review their microanatomy.
   a. astrocytes
   b. oligodendrocytes
   c. microglia
   d. ependyma
   e. choroid epithelium
7. Diagram and describe in detail the carotid and vertebral arteries and their branches that provide blood supply to the face, scalp, skull, meninges, brain, brainstem, cerebellum, and rostral spinal cord.
8. Discuss in detail the arterial blood supply to the spinal cord. Include in the discussion the spinal and radicular arteries and the concept of watershed ischemia.
9. Identify and review the venous drainage of the central nervous system (CNS).
10. List and identify the bones of the skull.
11. Describe each of the sutures of the skull.
12. Identify each named foramen of the skull and list its contents.
13. Describe the anatomy of the meninges including the
    a. dura mater
    b. arachnoid mater
    c. pia mater
14. Describe the anatomy of the dura including the falx cerebri and tentorium.
15. Review the layers of the scalp and discuss its innervation.
16. Diagram the cerebral ventricles.
17. Discuss the major arachnoid cisterns.
18. Review the anatomy of the arachnoid villi.
19. Discuss the anatomic correlates pertinent to the production, flow, and reabsorption of cerebrospinal fluid (CSF).
20. Identify and describe the gross anatomy of the spine including
    a. atlas
    b. axis
    c. subaxial cervical vertebrae
    d. thoracic vertebrae
    e. lumbar vertebrae

   f. sacrum
   g. coccyx
   h. intervertebral disc complex
   i. supporting ligaments of the spine
21. List the muscles related to the skull and spine.
22. Describe the gross anatomy of the neck.
23. Discuss the anatomic basis for the blood–brain barrier in detail.

Central Nervous System

1. Describe the gross anatomy of the brain, brainstem, cerebellum, cranial nerves, and spinal cord in detail.
2. Describe the anatomy of the cerebral cortex in detail including
   a. cortical layers
   b. sensory areas
   c. motor areas
   d. prefrontal cortex
   e. fiber tracts
   f. calcarine cortex
3. Describe the anatomy of the olfactory pathways, hippocampal formation, and amygdala in detail including
   a. rhinencephalon
   b. olfactory pathways
   c. anterior commissure
   d. hippocampal formation (including cytoarchitecture)
   e. amygdala
   f. limbic system
4. Describe the anatomy of the corpus striatum in detail including
   a. striatum
   b. globus pallidus
   c. claustrum
   d. subthalamic region
   e. striatal afferent and efferent connections
   f. pallidal afferent and efferent connections
   g. pallidofugal fiber systems
5. Describe the anatomy of the hypothalamus and pituitary in detail including
   a. cytoarchitecture of the hypothalamus
   b. afferent and efferent connections of the hypothalamus
   c. supraoptic nuclei and tracts
   d. hypophysial portal system
   e. anatomy of the pituitary stalk
   f. anterior and posterior pituitary

   g. cellular organization of the anterior pituitary
   h. hormonally active cells of the hypothalamus and pituitary
6. Describe the anatomy of the diencephalon in detail including
   a. midbrain–diencephalon junction
   b. caudal diencephalon
   c. epithalamus
   d. thalamus (including nuclei)
   e. thalamic radiations
   f. internal capsule
   g. visual pathways
7. Describe the anatomy of the cerebellum in detail including
   a. cerebellar cortex including organization
   b. deep cerebellar nuclei
   c. cerebellar connections
   d. cerebellar peduncles
8. Describe the anatomy of the mesencephalon in detail including
   a. superior colliculus
   b. inferior colliculus
   c. pretectal region
   d. posterior commissure
   e. mesencephalic nuclei
   f. oculomotor nerve
   g. tegmentum
   h. mesencephalic reticular formation
   i. substantia nigra
   j. crus cerebri
   k. ascending and descending tracts
9. Describe the anatomy of the pons in detail including
   a. vestibulocochlear nerve
   b. facial nerve
   c. abducens nerve
   d. trigeminal nerve
   e. ascending and descending tracts
10. Describe the anatomy of the medulla in detail including
   a. olivary nucleus
   b. medullary reticular formation
   c. cranial nerves of the medulla
   d. ascending and descending tracts
11. Review the location and connections of each cranial nerve nuclei. Trace the course of each cranial nerve from nucleus to end organ termination.

12. Describe the external topography and landmarks of the fourth ventricle.
13. Describe the anatomy of the spinal cord in detail including
    a. nuclei and cell groups
    b. cytoarchitectural lamination (Rexed laminae)
    c. somatic and visceral efferent neurons
    d. posterior horn neurons
    e. descending tracts
    f. ascending tracts
    g. upper and lower motor neurons
    h. somatotopic organization

Autonomic Nervous System

1. Distinguish pre- and postganglionic neurons.
2. Describe the sympathetic nervous system.
3. Describe the parasympathetic nervous system.
4. Review the visceral afferent fibers.
5. Describe the structure of the autonomic ganglia.
6. Discuss the central autonomic pathways.

Peripheral Nervous System

1. Differentiate between segmental and peripheral innervation.
2. Diagram the anatomy of the spinal nerve root.
3. Diagram and discuss the cervical, brachial, and lumbosacralplexi.
4. Outline the anatomy of the major peripheral nerves of the upper and lower extremities including
    a. axillary
    b. suprascapular
    c. median
    d. ulnar
    e. radial
    f. long thoracic
    g. musculocutaneous
    h. lateral femoral cutaneous
    i. femoral
    j. obturator
    k. sciatic
    l. saphenous
    m. peroneal
    n. tibial
5. Describe the microanatomy of the peripheral nerves in detail.
6. Explain the difference between myelinated and unmyelinated nerves.

7. Review the anatomy of the Schwann cell.
8. List the peripheral afferent receptors and describe the anatom of each.
9. Segregate peripheral neurons by size and explain the rationale for such a classification scheme.

Muscle

1. Explain the concept of the motor unit.
2. Describe the anatomy of the motor end plate.
3. Describe the microscopic anatomy of striated and smooth muscle.
4. Discuss the subcellular components of muscle.

MIDDLE LEVEL

1. Discuss the clinical presentation in anatomic terms of syndromes of the brain and its coverings including
   a. epidural hematoma
   b. acute subdural hematoma
   c. chronic subdural hematoma
   d. subgaleal hematoma
   e. injury to innervation of the scalp
2. Discuss the syndromes produced by mass lesions affecting the cranial nerves including
   a. suprasellar lesions
   b. lesion of the jugular foramen
   c. lesion of the internal auditory canal
   d. lesions or distortion at the incisura
3. Review the expected effects of stroke or mass lesion at different locations within the brainstem and cerebellum.
4. List the expected effects of destructive lesions in the basal ganglia and cerebellum.
5. Describe the expected effects of ischemic or destructive lesions of the white matter tracts of the cerebrum.
6. Discuss the expected effect of destructive lesions of specific regions of the cerebral cortex.
7. Review the clinical presentation of stroke in the distribution of the supratentorial cerebral blood vessels.
8. Discuss the relationship of the spinal nerves to the vertebral level of exit.
9. Diagram the structures comprising the boundaries of the spinal neural foramina.
10. Discuss the clinical manifestation of injury for each of the major peripheral nerves.

11. Describe the anatomy and presentation of common entrapment syndromes of peripheral nerves including
    a. thoracic outlet syndrome
    b. carpal tunnel syndrome
    c. ulnar nerve entrapment syndrome at the wrist and elbow
    d. anterior interosseous syndrome
    e. posterior interosseous syndrome
    f. meralgia paresthetica
    g. peroneal nerve palsy
    h. tarsal tunnel syndrome
12. Describe the surgical exposure of common peripheral nerve entrapments including
    a. carpal tunnel
    b. ulnar nerve at the elbow
    c. ulnar nerve at the wrist
    d. lateral femoral cutaneous nerve
    e. peroneal nerve
13. Discuss the clinical presentation and neurological deficits associated with common lesions of and injuries to the spinal cord and nerve roots.

Competency-Based Performance Objectives

MIDDLE LEVEL

1. Identify at the time of surgery
    a. occipital artery
    b. superficial temporal artery
    c. frontalis muscle
    d. pterion
    e. inion
    f. asterion
    g. coronal suture
    h. sagittal suture
    i. middle meningeal artery
    j. sagittal sinus
    k. transverse sinus
    l. foramen rotundum
    m. foramen ovale
    n. foramen spinosum
    o. superior orbital fissure
    p. jugular foramen
    q. internal auditory canal

r. superior sagittal sinus
s. sigmoid sinus
t. incisura
u. each cranial nerve
v. each named cerebral artery and vein
w. components of the brainstem
x. named structures on the floor of the fourth ventricle
y. foramina of Magendie and Luschka
z. cerebral peduncles
aa. components of the cerebellum
bb. cerebellar tonsils
cc. brachium cerebelli
dd. vermis
ee. major supratentorial gyri
ff. supratentorial lobes
gg. Sylvian fissure
hh. central sulcus

2. Identify at the time of surgery structures visible in the lateral ventricles including
   a. foramen of Monro
   b. fornix
   c. caudate
   d. thalamus
   e. choroidal fissure
   f. named veins
   g. glomus of the choroid plexus
   h. hippocampus
3. Identify the parts of the vertebral column, spinal cord, and nerve roots at the time of surgery including
   a. spinous process
   b. lamina
   c. superior facet
   d. inferior facet
   e. pedicle
   f. pars interarticularis
   g. uncovertebral joint
   h. neural foramen and nerve root
   i. nerve root ganglion
   j. disc space
   k. vertebral artery
   l. dorsal column and lateral column of the spinal cord
   m. intradural afferent and efferent rootlets

NEUROPHYSIOLOGY

Unit Objective

Demonstrate knowledge of physiology that is pertinent to the understanding of neurological disease.

Competency-Based Knowledge Objectives

JUNIOR AND MIDDLE LEVELS

1. Review the basic biology of the nerves including
   a. synthesis and movement of proteins in the nerve
   b. membrane potential and membrane properties
   c. ion channels
   d. generation and conduction of an action potential
2. Discuss synaptic transmission including
   a. types of synaptic transmission
   b. transmitter release
   c. nerve–muscle transmission
   d. chemical messengers
   e. direct gated receptors
   f. second messenger linked receptors
3. Describe the physiology of the sensory systems including
   a. sensory receptor physiology
   b. anatomy of the somatic sensory system
   c. coding of modality-specific sensory information
   d. pain and analgesia
   e. cortical integration of sensory perception
   f. visual system
      i. processing of information in the retina
      ii. processing of vision in the central visual pathways
      iii. columnar units of the visual cortex
      iv. processing in the geniculate nucleus
      v. visual perception of motion and form
   g. auditory system. Within this description, review the processing of hearing in the cochlea and the central auditory pathways.
   h. olfaction and taste
4. Discuss the physiology of the motor system including
   a. mechanisms of muscle contraction
   b. muscle receptors and spinal reflexes
   c. spinal reflexes concerned with position
   d. brainstem reflexes controlling motion
   e. vestibular nuclei control of movement and posture
   f. red nucleus control of movement

g. cortical control of movement
h. cerebellar control of movement
    i. regional and cellular organization of the cerebellum
    ii. functional divisions of the cerebellum
    iii. the role of the cerebellum in planning movement
i. basal ganglia
    i. the anatomy of basal ganglia pathways
    ii. neural transmitters in the circuits within the basal ganglia
j. thalamus

5. Describe the attributes of the autonomic nervous system including both the sympathetic and parasympathetic systems.
6. Review the physiological basis of arousal and emotion. Include within this review the
    a. noradrenergic systems
    b. limbic system. Include within this review the physiological basis for emotion and memory.
    c. sleeping and sleep states
    d. reticular activating system
7. Describe the higher cortical functions including
    a. anatomy of language
    b. function of association cortex
8. Describe the physiological basis for CSF production and reabsorption.
9. Review the physiological control of the cerebral vasculature.
10. Discuss in detail the physiology of the hypothalamus and pituitary, particularly as they relate to endocrinology.

NEUROPATHOLOGY

Unit Objective

Demonstrate knowledge of neuropathology that is pertinent to the diagnosis of diseases of the nervous system and practice of neurological surgery.

Competency-Based Knowledge Objectives

MIDDLE LEVEL

General Neuropathology

1. Describe the techniques available for examination of surgical specimens from the CNS, peripheral nervous system, skeletal muscle, pineal, and pituitary.
2. Review the use of standard chromatic, histochemical, and selected immunohistochemical stains used to evaluate surgical

specimens from the CNS, peripheral nervous system, skeletal muscle, pineal, and pituitary.

3. List the techniques available for morphological examination of CSF and the abnormalities observed in CSF from patients with meningeal carcinomatosis, meningeal lymphomatosis, pyogenic meningitis, and aseptic meningitis.

Central Nervous System

1. Describe the gross and histopathological features and, when applicable, the genetic basis of the following congenital and perinatal disorders
   a. encephaloceles and cranial meningoceles
   b. myelomeningoceles and meningoceles
   c. hydromyelia
   d. diastematomyelia and diplomyelia
   e. syringomyelia and syringobulbia
   f. Chiari I malformation
   g. Chiari II malformation
   h. Dandy–Walker malformation
   i. arachnoid cysts
   j. porencephaly
   k. aqueductal stenosis
   l. subependymal germinal matrix hemorrhages
   m. posthemorrhagic hydrocephalus
   n. periventricular leukomalacia (white matter infarcts)
2. Describe the gross and histopathological features and characteristics of the causative agents of the following infectious diseases
   a. cranial and spinal epidural abscesses
   b. cranial and spinal subdural abscesses
   c. pyogenic bacterial meningitis and ventriculitis
   d. brain abscesses
   e. tuberculous meningitis and tuberculomas
   f. CNS sarcoidosis
   g. CNS cryptococcosis
   h. CNS mucormycosis
   i. CNS toxoplasmosis
   j. CNS cysticercosis
   k. herpes simplex encephalitis
   l. CNS human immunodeficiency virus infections
   m. CNS cytomegalovirus infection

3. Describe the gross and histopathological features of the following vascular lesions
   a. acute, subacute, and remote infarcts
   b. border zone and watershed infarcts
   c. manifestations of embolic infarcts including those secondary to atheromatous embolization and embolization from extracorporeal pumps
   d. vasculitis including temporal arteritis, primary CNS vasculitis, granulomatous angiitis, and Wegener's granulomatosis
   e. moyamoya
   f. hypertensive intracerebral hemorrhages
   g. lobar intracerebral hemorrhages
   h. amyloid angiopathy
   i. malformations including arteriovenous malformations, cavernous angiomas, venous angiomas, and capillary telangiectases
   j. vein of Galen "aneurysms"
   k. saccular aneurysms
   l. infectious ("mycotic") aneurysms
   m. giant aneurysms
   n. traumatic and dissecting aneurysms
   o. venous and dural sinus occlusive disease
   p. vascular malformations of the spinal cord
   q. spinal cord infarcts
4. Describe the gross and histopathological features of the following traumatic lesions.
   a. skull fractures
   b. entrance and exit gunshot wounds of the skull
   c. gunshot wounds of the brain including internal ricochet
   d. epidural hematomas
   e. acute subdural hematomas
   f. chronic subdural hematomas
   g. recent and remote cerebral contusions
   h. traumatic intraparenchymal hemorrhages
   i. diffuse axonal injury
   j. traumatic cranial nerve injuries
   k. spinal cord injuries
   l. cerebral herniation syndromes
   m. fat embolization
   n. CNS trauma in infancy
   o. CNS radiation injuries
   p. manifestations of prior surgical intervention

5. Describe the gross and histopathological features and, when applicable, the metabolic basis for the following intoxications and deficiency states.
   a. hypoxic–anoxic encephalopathy
   b. carbon monoxide intoxication
   c. ethanol intoxication
   d. alcoholic cerebellar degeneration
   e. central pontine myelinolysis
   f. CNS complications of diagnostic agents including contrast material
   g. CNS complications of antimicrobial therapy
   h. CNS complications of antineoplastic therapy
   i. CNS complications of "street drugs"
   j. Wernicke's encephalopathy and thiamine deficiency
   k. subacute combined degeneration and B12 deficiency
6. Describe the gross and histopathological features of the following demyelinating diseases.
   a. multiple sclerosis
   b. progressive multifocal leukoencephalopathy
   c. human immunodeficiency virus vacuolar myelopathy
   d. postinfectious encephalomyelitis
7. Describe the gross and histopathological features and the metabolic basis for the following leukodystrophies.
   a. adrenoleukodystrophy and adrenomyeloneuropathy
   b. Krabbe's disease
   c. metachromatic leukodystrophy
8. Describe the gross and histopathological features and, when applicable, the genetic basis for the following dementias and degenerations.
   a. Alzheimer's disease including familial forms
   b. vascular dementia including Binswanger's disease and cerebral autosomal dominant arteriopathy
   c. Pick's disease
   d. other frontotemporal dementias
   e. Creutzfeldt–Jacob's disease and other prion diseases
   f. Parkinson's disease
   g. diffuse Lewy body disease
   h. Huntington's disease
   i. amyotrophic lateral sclerosis
   j. paraneoplastic degenerative diseases
9. Describe the gross and histopathological features and, when applicable, the biochemical and genetic basis for the following metabolic diseases.

a. Wilson's disease
b. Tay Sachs disease and other GM-2 gangliosidoses
c. neuronal ceroid lipofuscinoses
d. hepatic encephalopathy
e. Reye's syndrome

10. Describe the gross and histopathological features and, when applicable, the grading criteria for the following CNS neoplasms.
    a. diffuse fibrillary astrocytomas
    b. gemistocytic astrocytomas
    c. anaplastic astrocytomas
    d. glioblastoma multiforme including giant cell glioblastoma and gliosarcomas
    e. pilocytic astrocytomas including cerebellar, diencephalic, dorsal exophytic pontine, and cerebral pilocytic astrocytomas
    f. subependymal giant cell astrocytomas
    g. pleomorphic xanthoastrocytoma
    h. oligodendrogliomas including anaplastic oligodendrogliomas and mixed oligoastrocytomas
    i. ependymomas including myxopapillary ependymomas
    j. subependymomas
    k. choroid plexus tumors
    l. colloid cysts
    m. gliomatosis cerebri
    n. gangliocytomas and gangliogliomas
    o. dysembryoplastic neuroepithelial neoplasms
    p. central neurocytomas
    q. medulloblastomas
    r. atypical teratoid/rhabdoid tumors
    s. primitive neuroectodermal tumors and cerebral neuroblastomas
    t. olfactory neuroblastoma
    u. spinal paragangliomas
    v. meningiomas including meningothelial (syncytial) fibrous, transitional, psammomatous, angiomatous, and papillary meningiomas
    w. anaplastic and malignant meningiomas
    x. meningeal hemangiopericytomas
    y. other meningeal mesenchymal tumors
    z. meningeal melanomatosis and melanomas
    aa. hemangioblastomas

bb. lipomas
cc. primary CNS lymphomas
dd. metastatic carcinomas including leptomeningeal carcinomatosis
ee. teratomas
ff. dermoids and epidermoids
gg. schwannomas including acoustic neurinomas or vestibular schwannomas, schwannomas of other cranial nerves, and spinal root schwannomas

11. Describe the gross and histopathological features and the genetic basis for the following tumor syndromes.
    a. neurofibromatosis type 1
    b. neurofibromatosis type 2
    c. von Hippel–Lindau syndrome
    d. tuberous sclerosis
    e. Cowden syndrome
    f. Turcot syndrome

Peripheral Nervous System

1. Describe the gross and histopathological features and, when applicable, the genetic and biochemical basis for the following disorders of peripheral nerves.
    a. compressive and traumatic neuropathies
    b. leprosy
    c. diabetic and uremic neuropathy
    d. Charcot–Marie–Tooth disease
    e. Guillain–Barré syndrome
    f. sympathetic dystrophy
2. Describe the gross and histopathological features of the following neoplastic and tumorous disorders of peripheral nerves.
    a. peripheral schwannoma
    b. neurofibromas
    c. malignant peripheral nerve sheath tumors
    d. spinal root and peripheral nerve root cysts

Pituitary and Pineal

1. Describe the gross and histopathological features of the following pituitary conditions.
    a. pituitary adenomas including null cell adenomas, growth hormone-secreting adenomas, prolactin-secreting adenomas, ACTH-secreting adenomas, and oncocytomas

   b. craniopharyngiomas including adamantinomatous and squamopapillary craniopharyngiomas
   c. Rathke pouch (cleft) cysts
   d. pituitary involvement by metastatic neoplasms
   e. lymphocytic hypophysitis
   f. pituitary infarcts including pituitary "apoplexy"
   g. pituitary lesions resulting from closed head trauma
   h. empty sella syndromes
2. Describe the gross and histopathological features of the following lesions of the pineal.
   a. germinomas
   b. teratomas and embryonal carcinomas
   c. pineoblastomas and pineocytomas
   d. metastatic carcinoma

Skull and Spine (Including Intervertebral Discs)

1. Describe the gross and histopathological features of the following disorders of the skull.
   a. dermoids and epidermoids
   b. hemangiomas
   c. osteomas
   d. chordomas
   e. solitary and multifocal eosinophilic granulomas
   f. Paget's disease including secondary osteosarcomas
   g. metastatic carcinomas
   h. plasmacytoma including myeloma
2. Describe the gross and histopathological features of the following disorders of the spine and intervertebral discs.
   a. herniated intervertebral discs
   b. pyrophosphate disease including involvement of the ligamentum flavum
   c. tumorous calcinosis
   d. hemangiomas
   e. chordomas
   f. eosinophilic granulomas
   g. metastatic carcinomas including epidural metastases
   h. plasmacytoma including myeloma
   i. lymphomas
   j. primary bone tumors
   k. spinal osteomyelitis including tuberculous and fungal spinal osteomyelitis

Eye and Orbit

1. Describe the gross and histopathological features of the following ocular lesions.
   a. retinoblastomas
   b. ocular melanomas
2. Describe the gross and histopathological features of the following orbital lesions.
   a. optic nerve gliomas
   b. optic nerve meningiomas
   c. orbital lymphomas and pseudotumors
   d. orbital metastases

Miscellaneous

1. List the gross and histopathological features found in temporal lobectomy and cerebral hemispherectomy specimens removed during epilepsy surgery.
2. Review the gross, histopathological, and cytopathological features that can be observed in shunt revision specimens.
3. Describe the gross, histopathological, and cytopathological features that can be observed with indwelling pump and intrathecal catheter specimens.
4. Cite the techniques for the examination of foreign objects removed from the nervous system and the need for documentation of chain of custody when of potential legal significance.
5. Describe the histopathological features of myotonic dystrophy and central core myopathy and list the potential implications of these diseases with regard to adverse anesthetic reactions including development of malignant hyperthermia.

NEUROPHARMACOLOGY

Unit Objective

Demonstrate knowledge of pharmacology that is pertinent to the treatment of neurological disorders and diseases that affect the nervous system.

Competency-Based Knowledge Objectives

JUNIOR LEVEL

1. Review basic cellular neurotransmission. During the course of this review discuss
   a. the synapse
   b. membrane potentials

   c. ion pumps
   d. ion channels
   e. transmitter secretion
   f. transmitter identification
2. Define and discuss receptors and receptor pharmacodynamics including
   a. receptor classification
   b. receptor identification
   c. dose–response curves
   d. agonists and antagonists
   e. receptor modulation
3. Discuss the neurotransmitter acetylcholine in detail. Include within the context of the discussion
   a. cholinergic receptor classification
   b. functional aspects of cholinergic receptors
   c. synthesis, storage, and release of acetylcholine
4. Discuss the catecholamine neurotransmitters (norepinephrine and dopamine) in detail. Include within the context of the discussion
   a. biosynthesis of catecholamines
   b. storage and release of catecholamines
   c. anatomy of catecholamine receptors
   d. α and β adrenergic receptors
   e. dopaminergic receptors
5. Discuss the neurotransmitter serotonin in detail. Include within the context of the discussion
   a. anatomy of serotonin receptors
   b. biosynthesis, storage, and release of serotonin
   c. subtypes of serotonin receptors
6. Discuss the neurotransmitter glutamate in detail. Include within the context of the discussion
   a. biosynthesis, storage, and release of glutamate
   b. inotropic glutamate receptors
      i. NMDA receptors and subunits
      ii. non-NMDA receptors and subunits
   c. metabotropic glutamate receptors
      i. group I metabotropic receptors and subunits
      ii. group II metabotropic receptors and subunits
      iii. group III metabotropic receptors and subunits
   d. role in neurological disorders
7. Discuss the neurotransmitters gamma aminobutyric acid and glycine in detail. Include within the context of the discussion
   a. synthesis, uptake, and release

b. physiology and pharmacology
c. clinically relevant agonists and antagonists of gamma aminobutyric acid and glycine receptors
8. Discuss the peptide neurotransmitters.
9. Describe the pharmacology of each of the drugs used to treat neurological disorders.

NEUROLOGY

Unit Objective

Demonstrate an understanding of the neurological examination, diagnostic neurological testing, and neurological diseases and their treatment.

Competency-Based Knowledge Objectives

JUNIOR AND MIDDLE LEVELS

1. Discuss electroencephalography (EEG). Recognize normal and abnormal EEG patterns. Identify specific epileptic conditions by EEG findings.
2. Describe the principles of sensory evoked potential (SEP) testing. Discuss how SEPs may be useful diagnostically.
3. List the indications for using intraoperative SEP monitoring and describe in detail how the procedure may be performed.
4. Describe the principles of visual evoked potential (VEP) testing. Discuss how VEPs may be useful diagnostically.
5. Describe the principles of motor evoked potential (MEP) testing. Discuss how MEPs may be useful diagnostically.
6. List the indications for using intraoperative MEP monitoring and describe in detail how the procedure may be performed.
7. Discuss electromyographic (EMG) testing in detail. Describe how the testing is performed and review the diagnostic capabilities of EMG testing. Describe the EMG changes associated with neuromuscular pathology.
8. List the indications for using intraoperative EMG testing and describe in detail how the procedure may be performed.
9. Discuss nerve conduction velocity (NCV) testing in detail. Describe how the testing is performed and review its diagnostic capabilities. List the transmission velocities of the major nerves. Describe NCV changes observed in neuropathy.
10. Define delirium and dementia. List the differential diagnoses for each.
11. Define and discuss coma and altered states of consciousness.

12. Describe the evaluation of a patient with syncope.
13. Describe the etiology and pathogenesis of cerebrovascular disease.
14. Review the clinical presentation and discuss the radiographic evaluation, clinical evaluation, and management of the following.
    a. transient ischemic attacks
    b. cerebral infarction
    c. cerebral and cerebellar hemorrhage
    d. subarachnoid hemorrhage
    e. venous infarction
15. Identify the primary causes of stroke in the pediatric population.
16. Discuss comprehensively the etiology, clinical presentation, diagnostic evaluation, and management of cerebral vasculitis.
17. Differentiate between basal occlusive disease with and without telangiectasia. Review the prognosis and treatment options for each.
18. Describe the acute and chronic effects of ionizing radiation on the CNS.
19. Review the diagnosis and management of pseudotumor cerebri.
20. Discuss the diagnosis and management of normal pressure hydrocephalus.
21. Discuss the management of hyperosmolar hyperglycemic nonketotic diabetic coma.
22. Review the neurological manifestations of altitude sickness.
23. List the neurological manifestations of decompression sickness.
24. Describe autism.
25. Review the general topic of chromosomal abnormalities as they may relate to the CNS, including etiology, inheritance patterns, penetrance, and laboratory diagnosis.
26. List the major syndromes characterized by obesity and hypogonadism, including Prader–Willi syndrome.
27. Discuss agenesis of the corpus callosum.
28. Discuss anencephaly, microencephaly, and megalencephaly.
29. List the major disorders of amino acid and purine metabolism. Discuss the neurological manifestations of each.
30. Review each of the major storage diseases including
    a. GM1 gangliosidoses
    b. GM2 gangliosidoses
    c. Fabry disease
    d. Gaucher disease
    e. Niemann–Pick disease
    f. Farber disease

g. Wolman disease
h. Refsum disease
i. cerebrotendinous xanthomatosis
j. neuronal ceroid lipofuscinoses

31. Review each of the major leukodystrophies including
    a. Krabbe leukodystrophy
    b. metachromatic leukodystrophy
    c. X-linked leukodystrophies with and without adrenal involvement
32. Review each of the major mucopolysaccharidoses including
    a. Hurler syndrome (MPS IH)
    b. Hunter syndrome (MPS II)
    c. Sanfilippo syndrome (MPS III)
    d. Morquio syndrome (MPS IV)
    e. Maroteaux–Lamy syndrome (MPS VI)
33. Review the disorders of carbohydrate metabolism including
    a. glycogen storage diseases
    b. Lafora disease and other polyglucose storage diseases
34. Discuss hyperammonemia as it relates to neurological dysfunction.
35. Discuss adrenoleukodystrophy as it relates to neurological dysfunction including Reye's syndrome.
36. Review the major syndromes of dysfunctional copper metabolism including
    a. hepatolenticular degeneration (Wilson disease)
    b. trichopoliodystrophy (Menkes' syndrome)
37. Review the pathogenesis, clinical presentation, diagnosis, and treatment of acute intermittent porphyria. List drugs to avoid in patients with porphyria (e.g., sulfa drugs).
38. Review the pathogenesis, clinical presentation, diagnosis, and treatment of abetalipoproteinemia.
39. List the neurological disorders associated with xeroderma pigmentosum.
40. List the major cerebral degenerative disorders of childhood including
    a. progressive sclerosing poliodystrophy
    b. spongy degeneration
    c. infantile neuraxonal dystrophy
    d. Hallervorden–Spatz disease
    e. Pelizaeus–Merzbacher disease
    f. Alexander disease
    g. Cockayne syndrome

h. peroxisomal diseases
i. Leigh disease

41. Review in detail the major neurocutaneous disorders including
    a. neurofibromatosis, types 1 and 2
    b. encephalotrigeminal angiomatosis
    c. incontinentia pigmenti
    d. tuberous sclerosis
42. Discuss Leber hereditary optic atrophy.
43. Review the salient features of progressive external ophthalmoplegia.
44. Define peripheral neuropathy, polyneuropathy, mononeuropathy, mononeuropathy multiplex, and neuritis.
45. Review the major inherited neuropathies including
    a. peroneal muscle atrophy
    b. Dejerine–Sottas disease
    c. Refsum disease
    d. hereditary sensory neuropathy
    e. porphyric neuropathy
46. Discuss the etiology, clinical presentation, diagnosis, treatment, and prognosis of Guillain–Barré syndrome.
47. List the major acquired neuropathies other than Guillain–Barré syndrome including
    a. chronic demyelinating polyneuritis
    b. acute and chronic idiopathic sensory neuropathy
    c. acute pandysautonomia
    d. tick paralysis
    e. brachial neuropathy (neuralgic amyotrophy)
    f. radiation neuropathy
    g. cold neuropathy
    h. cryoglobulin neuropathy
    i. diabetic neuropathy
    j. hypothyroid neuropathy
    k. acromegalic neuropathy
    l. vasculitic neuropathy
    m. uremic neuropathy
    n. hepatic neuropathy
    o. infectious neuropathies
        i. leprosy
        ii. acquired immunodeficiency syndrome
        iii. Lyme
        iv. herpes zoster
    p. sarcoid neuropathy

q. paraneoplastic neuropathy
r. amyloid neuropathy
s. polyneuropathy associated with plasma cell dyscrasia
t. polyneuropathy associated with dietary deficiencies
u. neuropathy induced by metals
    i. arsenic
    ii. lead
    iii. mercury
    iv. thallium
v. drug-induced neuropathy
w. neuropathy produced by aliphatic chemicals

48. Discuss the major hereditary ataxias including
    a. Friedreich ataxia
    b. Levy–Roussy syndrome
    c. hereditary cerebellar ataxia
49. Review the major noninherited forms of cerebellar ataxia including
    a. acute cerebellar ataxia in children
    b. ataxia telangiectasia
    c. Marinesco–Sjögren syndrome
    d. Ramsay–Hunt syndrome
    e. Joseph disease
50. Discuss the pathophysiology, clinical presentation, treatment, and prognosis of Alzheimer's disease, Pick's disease, and diffuse Lewy body disease.
51. Define hemichorea and hemiballismus.
52. Review the pathophysiology, clinical presentation, treatment, and prognosis of Sydenham chorea, Huntington's disease, and senile chorea.
53. Define myoclonus.
54. Review Tourette's syndrome.
55. Review the major general and focal dystonic conditions.
56. Define benign essential tremor.
57. Discuss the pathophysiology, clinical presentation, diagnosis, treatments, and prognosis of parkinsonism in detail.
58. Define progressive supranuclear palsy.
59. Review the pathophysiology, clinical presentation, diagnosis, and treatment of tardive dyskinesia.
60. Discuss hereditary spastic paraplegia.
61. List the major generalized and focal forms of spinal muscular atrophy including
    a. Wernig–Hoffmann disease

b. Kugelberg–Welander syndrome
c. benign focal amyotrophy

62. Describe the pathophysiology and neurological manifestations of poliomyelitis.
63. Review the pathophysiology, clinical presentation, diagnosis, treatment, and prognosis of amyotrophic lateral sclerosis.
64. Review the pathophysiology, clinical presentation, diagnosis, treatment, and prognosis of subacute combined degeneration of the spinal cord.
65. Review the pathophysiology, clinical presentation, diagnosis, treatment, and prognosis of juvenile and adult myasthenia gravis.
66. Review the pathophysiology, clinical presentation, diagnosis, treatment, and prognosis of botulism.
67. Review the common muscular dystrophies including
    a. Duchenne muscular dystrophy
    b. fascioscapulohumeral muscular dystrophy
    c. myotonic muscular dystrophy
    d. myotonia congenita
    e. congenital muscular dystrophy
68. Review the major periodic paralysis syndromes including
    a. familial periodic paralysis
    b. hypokalemic periodic paralysis
    c. hyperkalemic periodic paralysis
    d. paramyotonia congenita
69. Discuss polymyositis.
70. Review the epidemiology, pathophysiology, clinical presentation, diagnosis, treatment, and prognosis of multiple sclerosis.
71. Define Marchiafava–Bignami disease.
72. Review central pontine myelinolysis in detail.
73. Discuss multiple-system atrophy.
74. Review the pathophysiology, clinical presentation, diagnosis, treatment, and prognosis of migraine headaches.
75. Discuss the diagnosis and management of nonmigrainous headache syndromes.
76. Review the pathophysiology, clinical presentation, diagnosis, treatment, and prognosis of the common epileptic disorders in detail.
77. Define status epilepticus and discuss its medical treatment.
78. Describe the neurological implications of the common collagen–vascular diseases.
79. Describe the neurological implications of alcoholism.

80. Discuss the neurological aspects of pregnancy.
81. Review malignant hyperthermia.

NEURORADIOLOGY

Unit Objective

Demonstrate an understanding of neuroradiological imaging and interventions as they relate specifically to neurosurgical patients.

Competency-Based Knowledge Objectives

JUNIOR LEVEL

1. Describe the precautions that should be taken when performing radiological examinations.
2. Identify the normal anatomic structures of the skull on anteroposterior, lateral, Towne, and submental vertex radiographs.
3. List the indications for carotid and cerebral angiography.
4. Review the potential complications to intravenous contrast agents and discuss their management.
5. Identify the major arteries and veins of the neck and brain on angiograms.
6. Describe the concepts of computed tomographic (CT) scanning.
7. Identify the normal anatomic structures of the scalp, skull, dura, brain, and cranial vasculature on CT scans.
8. Describe the concepts of magnetic resonance imaging (MRI). Review the various imaging sequences that may be obtained.
9. Identify the normal anatomic structures of the scalp, skull, dura, brain, and cranial vasculature on MR images.
10. Recognize common traumatic injuries that may be detected by skull radiographs including
    a. linear skull fractures
    b. depressed skull fractures
    c. pneumocephalus
    d. foreign bodies
11. Recognize common pathological conditions that may be detected by skull radiographs including
    a. neoplasms
    b. fibrous dysplasia
    c. congenital bone diseases
    d. metabolic bone disorders
    e. infections

12. Recognize common traumatic injuries that may be detected by CT head scans including
    a. skull fractures
    b. pneumocephalus
    c. intracranial hematomas
        i. epidural
        ii. acute subdural
        iii. chronic subdural
        iv. intraparenchymal
        v. intraventricular
    d. cerebral contusions
    e. subarachnoid hemorrhage
    f. foreign bodies
13. Recognize common pathological conditions that may be detected by CT head scans including
    a. ischemic infarction
    b. venous infarction
    c. hydrocephalus
    d. cysts
    e. tumors
    f. cerebral edema
    g. infections
    h. congenital abnormalities
    i. infections
14. Recognize common traumatic injuries that may be detected by MR head images including
    a. pneumocephalus
    b. intracranial hematomas
        i. epidural
        ii. acute subdural
        iii. chronic subdural
        iv. intraparenchymal
        v. intraventricular
    c. cerebral contusions
    d. diffuse axonal injury
15. Recognize common pathological conditions that may be detected by MR head images including
    a. ischemic infarction
    b. venous infarction
    c. hydrocephalus
    d. cysts
    e. tumors

   f. cerebral edema
   g. vascular occlusions
   h. infections
   i. congenital abnormalities
16. Identify the normal anatomic structures of the craniovertebral junction on plain radiographs.
17. Review the radiographic diagnoses of platybasia and cranial settling.
18. Describe the plain radiographic findings of common traumatic injuries to the craniovertebral junction including
   a. occipital condyle fractures
   b. atlanto-occipital dislocation
   c. Jefferson fractures
   d. posterior atlas fractures
   e. dens fractures
   f. axis body fractures
   g. hangman's fracture
   h. atlas and axis facet fractures
   i. atlantoaxial rotatory dislocation
19. Distinguish between orthotropic and dystropic os odontoideum.
20. Describe the common congenital abnormalities of the craniovertebral junction.
21. Recognize common spinal congenital abnormalities on plain radiographs.
22. Recognize common spinal traumatic injuries that may be detected by plain radiographs including
   a. vertebral body fractures
   b. facet fractures and dislocations
   c. posterior element fractures
   d. transverse process fractures
   e. vertebral subluxation/dislocation
23. Recognize common spinal degenerative conditions that may be detected by plain radiographs.
24. Discuss the indications for CT scanning and MRI of the spine in the setting of trauma.
25. Describe the appearance of the CT scan for each of the traumatic spinal lesions listed previously.
26. Describe the appearance of the MR image of
   a. spinal ligament injury
   b. traumatic disc herniation
   c. spinal cord contusion
   d. spinal epidural hematoma

27. Recognize common spinal degenerative conditions that that may be detected by MRI including
    a. disc degeneration
    b. disc herniation
    c. degenerative spinal stenosis
    d. facet hypertrophy
    e. osteophyte formation
    f. foraminal stenosis
    g. degenerative spondylolisthesis
    h. degenerative scoliosis
    i. ossification of the posterior longitudinal ligament
28. Identify spinal and spinal cord tumors on CT scans and MR images.
29. Discuss the indications for spinal myelography.
30. Review the indications for spinal angiography.
31. Discuss the use of both the radiographic contrast and radionuclide shuntogram in evaluating neurosurgical patients.

MIDDLE LEVEL

1. Identify the common carotid and vertebral circulation congenital variants on angiograms.
2. Recognize intracranial aneurysms on angiograms.
3. Identify and characterize intracranial vascular malformations on angiograms. Recognize
    a. arteriovenous malformations
    b. venous angiomas
    c. arteriovenous fistulas
    d. feeding vessels
    e. draining veins
    f. associated aneurysms
    g. degree of shunting
4. Discuss the angiographic evaluation of carotid and vertebral disease.
5. Review the role of MR angiography and venography in the evaluation of cerebrovascular disease, neoplasms, and trauma.
6. Describe the radiological evaluation of CNS vasculitis.
7. Describe the radiological evaluation of spinal vascular malformations.
8. Discuss the role of myelography in the evaluation of neurosurgical patients.
9. Discuss the radiological evaluation of suspected CNS and spinal infection.

10. Review MR neurography.
11. Describe the appearance of peripheral nerve tumors on MR images.
12. Review the role of radionuclide scans in the evaluation of patients with suspected cranial and spinal disease.
13. Discuss the use of intraoperative radiographs and fluoroscopy.
14. List the indications for CT- and MR-guided biopsies.
15. Describe the concepts of ultrasonography.
16. Review the findings of normal and abnormal neonatal cranial ultrasonic images.
17. Review the findings of normal and abnormal carotid ultrasonic images.
18. Discuss the use of transcranial Doppler ultrasonography in the management of patients with subarachnoid hemorrhage, trauma, and occlusive vascular disease.

SENIOR LEVEL

1. Review the indications for interventional endovascular therapies for
   a. aneurysms
   b. vasospasm
   c. cranial vascular malformations
   d. spinal vascular malformations
   e. tumor embolization
   f. carotid and vertebral stenosis
   g. carotid and vertebral dissection
2. Describe the indications and techniques of endovascular trial occlusions.
3. Review the role of quantitative cerebral blood flow studies in the management of neurosurgical patients.
4. Describe the concepts of positron emission tomography. Review the indications for obtaining these scans.
5. Describe the concepts of functional MRI. Review the indications for obtaining these images.
6. Describe the concepts of MR spectroscopy. Review the indications for obtaining such evaluations in neurosurgical patients.
7. Discuss the indications and technique of discography. Describe the procedure.
8. Discuss the indications for percutaneous vertebroplasty. Describe the procedure.

Competency-Based Performance Objectives

JUNIOR LEVEL

1. Order appropriate radiological evaluations in a timely fashion.
2. Complete radiological requisitions properly.
3. Demonstrate the ability to interpret accurately the radiographic studies of trauma patients.

MIDDLE LEVEL

1. Demonstrate the ability to interpret accurately carotid and vertebral angiograms.
2. Demonstrate the ability to interpret accurately spinal angiograms.
3. Demonstrate the ability to interpret accurately spinal myelograms and postmyelogram CT scans.
4. Demonstrate the ability to interpret accurately cranial and spinal CT scans and MR images of nontraumatic lesions.

SENIOR LEVEL

1. Demonstrate the ability to interpret accurately radiological examinations of neurosurgical patients.
2. Demonstrate the ability to use intraoperative ultrasonography.

FLUIDS, ELECTROLYTES, AND NUTRITION

Unit Objectives

Demonstrate an understanding of normal and pathological fluid and electrolyte homeostasis. Demonstrate an ability to maintain normal electrolyte balance. Demonstrate an understanding of the basics of nutritional management in neurosurgical patients.

Competency-Based Knowledge Objectives

JUNIOR AND MIDDLE LEVELS

1. Discuss the normal distribution of intracellular and extracellular fluid and electrolytes including
   a. sodium and water distribution and metabolism
   b. clinical assessment of water and sodium balance and the concept of osmolality
   c. normal maintenance requirements
   d. management of pathological conditions such as diabetes insipidus and the syndrome of inappropriate antidiuretic hormone secretion
   e. cerebral salt wasting

2. Review the potential implications of diuresis and fluid restriction on water and electrolyte balance.
3. Review briefly the potential clinical implications of calcium, phosphorous, and magnesium excesses and deficiencies, and the treatment of same.
4. Review the criteria for nutritional assessment including
   a. history of significant weight loss
   b. hypoalbuminemia
   c. impaired immune response including diminished total lymphocyte count and anergy
   d. physical signs of malnutrition
5. Describe briefly the metabolic responses to starvation and stress.
6. Describe and contrast the indications, contraindications, complications, and benefits of enteral and parenteral nutrition.
7. Analyze the implications of specific nutritional deficiencies as they relate to neurological and neurosurgical diseases.
8. Review briefly swallowing disorders.
9. Describe the common changes of metabolism and nutritional requirements of trauma patients and their evaluation.

Competency-Based Performance Objectives

JUNIOR AND MIDDLE LEVELS

1. Demonstrate an ability to manage the fluid and electrolyte requirements of neonatal, pediatric, and adult neurosurgical patients.
2. Demonstrate the ability to place central venous catheters.
3. Demonstrate the ability to place enteral feeding tubes.
4. Demonstrate the ability to prescribe appropriate parenteral and enteral nutrition.
5. Recognize and treat the complications of parenteral and enteral feeding including
   a. line sepsis
   b. glucose intolerance
   c. diarrhea
   d. dehydration
6. Recognize swallowing disorders and manage them.

GENERAL CRITICAL CARE

Unit Objectives

Demonstrate an ability to perform triage for neurosurgical patients in and out of a critical care setting. Demonstrate a knowledge of and the ability to manage neurosurgical patients in the critical care setting.

Competency-Based Knowledge Objectives

JUNIOR LEVEL

1. Define the adult and pediatric patient who would be best served in a critical care setting. Include both medical and neurosurgical issues within the context of this discussion.
2. Review general medical issues pertinent to the management of neurosurgical patients in a critical care setting including
   a. prophylaxis of gastrointestinal hemorrhage
   b. prophylaxis of pulmonary morbidity
   c. prophylaxis, diagnosis, and treatment of venous thrombosis and pulmonary embolism
   d. skin care
   e. eye care
   f. physical therapy to maintain strength and joint range of motion
   g. universal precautions
   h. workup and treatment of sepsis
3. Describe the indications and pharmacokinetics for medications commonly used in the management of critically ill neurosurgical patients including
   a. vasoactive drugs
   b. inotropic drugs
   c. bronchodilators
   d. diuretics
   e. antiarrhythmics
   f. antihypertensives
   g. antimicrobials
   h. anticonvulsants
4. Describe the clinical presentation, evaluation, and treatment of infections that commonly occur in critical care neurosurgical patients.
5. Review the indications for intubation including
   a. loss of patient airway
   b. respiratory insufficiency
   c. inability to protect airway
6. Discuss commonly used pulmonary values including
   a. measured pulmonary functions
      i. rate
      ii. minute ventilation
      iii. spontaneous tidal volume
      iv. forced vital capacity
      v. functional residual capacity
      vi. maximum ventilatory volume

b. ventilator modes and settings
   i. pressure versus volume ventilation
   ii. continuous positive airway pressure
   iii. intermittent positive airway pressure
   iv. pressure support
   v. assist control
   vi. intermittent mandatory ventilation
   vii. positive end expiratory pressure
   viii. rate
   ix. tidal volume

7. Review the indications for weaning patients from ventilatory support. Describe the methods by which this is accomplished and the general pulmonary parameters a patient must demonstrate before extubation.
8. Discuss the medications used to improve pulmonary function.
9. Review briefly the following cardiac function parameters.
   a. preload
   b. afterload
   c. contractility
10. Review the indications for implementing the following monitoring devices. Describe briefly how the information obtained is used to optimize patient management.
    a. arterial catheters
    b. central venous catheters
    c. Swan–Ganz catheters
    d. pulse oximetry
    e. electrocardiographic monitoring
    f. end-tidal carbon dioxide monitors
11. List the signs of acute myocardial ischemia and briefly discuss the emergent treatment of this condition.
12. Review the impact of renal insufficiency as it pertains to the management of neurosurgical patients.
13. Discuss briefly the diagnosis and management of acute renal insufficiency.
14. Describe the diagnosis and management of an ileus. List the differential diagnosis for an ileus.
15. Review the diagnosis and management principles of the following endocrine disorders.
    a. hypo- and hyperthyroidism
    b. hypo- and hyperparathyroidism
    c. adrenal cortical excess and deficiency
    d. diabetes mellitus
    e. diabetes insipidus

16. Review the medical and legal definitions of brain death.
17. Discuss moral and ethical issues pertaining to critically ill neurosurgical patients including
    a. patient or family requests to withhold or withdraw treatment
    b. organ donation
18. Summarize the physiology of hydrogen ion production and excretion.
19. Discuss briefly the acute and chronic buffering systems.
20. Discuss metabolic acidosis and alkalosis.
21. Discuss respiratory acidosis and alkalosis.
22. Review the effects of acid–base disturbances on the CNS and intracranial pressure (ICP).

Competency-Based Performance Objectives

JUNIOR AND MIDDLE LEVELS

1. Obtain ACLS and ATLS certification.
2. Demonstrate the ability to perform an initial evaluation and management of critically ill neurosurgical patients.
3. Perform the following procedures.
    a. orotracheal intubation
    b. nasogastric intubation
    c. bladder intubation
4. Serve on a trauma team.
5. Demonstrate an ability to manage neurosurgical patients in a critical care setting.
6. Diagnose and treat acid–base abnormalities in neurosurgical patients.
7. Demonstrate an understanding of the management of complex acid–base disturbances in the critical care setting.

SENIOR LEVEL

1. Oversee and direct the junior- and middle-level resident management of critically ill neurosurgical patients.

INFECTION

Unit Objectives

Demonstrate an understanding of the factors related to the acquisition, diagnosis, and treatment of infections as they pertain to neurosurgical patients. Describe the typical presentation and treatment of common neurosurgical infections. Review the methods used to minimize infectious complications in neurosurgical patients. Demonstrate an understanding of the techniques to minimize the risk of spread of viral infections, including hepatitis and human immunodeficiency virus.

Competency-Based Knowledge Objectives

JUNIOR AND MIDDLE LEVELS

1. List the common organisms responsible for meningitis in an age-related fashion.
2. List the common CNS infections and describe the populations that are most at risk for each.
3. List the common opportunistic CNS infections and describe the populations that are most at risk for each.
4. Describe in detail the clinical and pathological symptoms and findings associated with CNS infections.
5. Discuss the radiological evaluation of patients with suspected and known CNS infections.
6. Review the indications for alerting individuals at risk for infections based on exposure to a patient with a known CNS infectious process.
7. Review each major class of antimicrobial drugs.
   a. Describe the potential of resistance to each drug.
   b. List the potential complications of each agent.
   c. Review the serological monitoring of each antimicrobial agent including the need for monitoring renal, hepatic, and hemopoietic function.
   d. Indicate those drugs that will traverse the blood–brain barrier and those that will not.
   e. Demonstrate a knowledge of the pharmacokinetics of each antimicrobial agent.
   f. Describe the potential complications of each antimicrobial drug and explain how to monitor for and detect them.
   g. Review the rationale for monitoring drug levels and list the therapeutic levels of antimicrobials commonly used to treat neurosurgical infections.
8. Discuss the advantages and disadvantages of treatment of CNS infections with corticosteroids.
9. Review the role of anticonvulsant therapy in the management of CNS infections.
10. List the universal precautions for prevention of infection as they pertain to health care workers in general and neurosurgeons in particular.
11. Discuss the role of hand washing as the most important method of preventing infection.
12. Describe the role of the clinical epidemiologist in tracking infectious disease incidence and potential sources of infection within the hospital and community settings.

13. Review the mode of transmission, diagnosis, and treatment of non-CNS infections that may commonly arise in neurosurgical patients, such as
    a. respiratory infections
    b. urinary tract infections
    c. wound infections
14. Review the prevention, diagnosis, and management of sepsis.
15. List the common sources of a postoperative fever.
16. Describe the workup for a febrile patient.
17. Discuss the use of prophylactic antibiotics.
18. Review the symptoms, clinical evaluation, and management of patients with shunt infections.
19. Discuss prion disease and precautions to be taken when it is suspected.

Competency-Based Performance Objectives

JUNIOR AND MIDDLE LEVELS

1. Demonstrate the ability to use universal precautions.
2. Demonstrate the ability to use sterile technique.
3. Diagnose and treat appropriately non-CNS infections in neurosurgical patients.
4. Diagnose and treat appropriately CNS infections in neurosurgical patients.

PRACTICE LEGAL, AND SOCIOECONOMIC ISSUES

Unit Objective

Demonstrate an understanding of the principles of practice management and the business aspects associated with the delivery of health care.

Competency-Based Knowledge Objectives

JUNIOR AND MIDDLE LEVELS

1. Discuss the ethical and moral factors associated with the practice of neurosurgery.
2. Review the role of the neurosurgical leadership in the community and hospital settings.
3. Explain the neurosurgeon's responsibilities in terms of health care cost containment.
4. Review the features and relationships of the health care system including

   a. treatment facilities
   b. third-party payment systems
      i. Medicare
      ii. Medicaid
      iii. employer-provided insurance
      iv. private insurance
   c. physician practice organizations
   d. medical equipment manufacturers
   e. pharmaceutical companies
5. Recite the rules and regulations of the training hospitals as they pertain to the practice of neurosurgery in which the residency is performed.
6. Name the institutional and social service agencies in your community and review their roles in the overall management of neurosurgical patients.
7. Demonstrate a knowledge of the rules and regulations of your state medical board.
8. Discuss the concept of informed consent.
9. Discuss mandatory reporting laws.
10. Discuss issues pertinent to the topic of the impaired physician.
11. Name and describe the local, regional, and national neurosurgical organizations including their purposes, roles, activities, and interactions.
12. Discuss the importance of tracking morbidity, mortality, and patient outcomes.
13. Review the career options available at the completion of neurosurgical residency in detail including
   a. private practice
   b. academic practice
   c. subspecialty fellowship
   d. research
   e. administration
   f. military
14. Discuss postresidency fellowship training program availability, application process, and career usefulness.
15. Describe the types and characteristics of surgical practice organizations including
   a. solo practice
   b. group practice
      i. partnership
      ii. professional association
      iii. corporation

c. academic practice
d. health maintenance organizations (HMOs)
   i. preferred provider organizations (PPOs)
   ii. individual practice associations
   iii. staff model (Kaiser–Permanente type)
e. federal
   i. Department of Veterans Affairs
   ii. military
   iii. Public Health Service

16. Discuss hospital payment systems (e.g., DRGs per diem rates), and describe their incentives and how they affect hospital profitability.
17. Discuss the role and influence of national quality oversight and review organizations for hospitals and health plans (Joint Commission on Accreditation of Healthcare Organizations, NCQA).
18. Discuss the history, changes, eligibility, funding, and problems associated with the Medicare program.
19. Describe the Medicare program features, such as eligibility, funding, administration, federal–state relationship, benefits, and payment methods.
20. Discuss federal funding of graduate medical education and how current federal budget allocations and proposals for changes in funding affect or will affect neurosurgical training programs.
21. Discuss the significance of the following issues as they relate to the practice of neurosurgery.
    a. legislative/regulatory requirements
       Americans with Disabilities Act
       Clinical Laboratory Improvement Amendments
    b. federal/professional regulatory institutions
       i. Health Care Financing Administration
       ii. Joint Commission on Accreditation of Healthcare Organizations
       iii. Occupational Safety and Health Administration
    c. miscellaneous
       i. affirmative action
       ii. equal opportunity
       iii. sexual harassment
22. Discuss the common causes of malpractice actions and effective measures to reduce the risk of malpractice complaints.
23. Describe the ways, means, and reasons physicians influence the political process at the national, state, and local levels.

24. Discuss the demographics of neurosurgeon distribution, numbers, workload studies, and workforce needs.
25. Outline the requirements for certification by the American Board of Neurological Surgery.
26. Formulate a strategy to evaluate personal and professional considerations in making a career choice.
27. Appraise the importance of family involvement in making career choices, including geographic location.

SENIOR LEVEL

1. Review the requirements to obtain certification from the American Board of Neurological Surgery.
2. Discuss the available opportunities to obtain continuing medical education credits.
3. Describe the political, economic, and social factors that impact the practice of medicine generally and neurosurgery specifically.
4. Demonstrate a working knowledge of the International Classification of Diseases and current procedural terminology (CPT) coding and analysis.
5. Discuss the concept of relative values units.
6. Summarize the process of impairment determination as it relates to the neurosurgical patient population.
7. Review the availability, requirements, and application procedures for postresidency fellowship if appropriate.
8. Discuss the following issues as they relate to planned neurosurgical practice.
   a. health care delivery systems, including managed care
   b. health care economics
   c. political and legislative processes in health care
9. Obtain a demographic profile of potential practice locations including population and medical demographics.
10. Outline the essential business characteristics of neurosurgical practice including
    a. content and interpretation of financial reports
    b. management of human resources
    c. facility design and maintenance
    d. billing and collection processes
11. Discuss the key elements of a provider professional services agreement, such as a PPO or HMO contract, and identify provisions that require particular attention.
12. Describe the typical provisions and considerations in a physician employment contract including what to look for and what to avoid.

13. Describe, compare, and contrast partnership versus corporate practice structures, including the tax and liability advantages and disadvantages of each.
14. Describe the advantages and disadvantages of solo, single-specialty group, and multispecialty group practices.
15. Review the financial issues associated with the neurosurgical career options under consideration.
16. Describe the administrative structures and processes required for managing an office practice including
    a. billing and collection for medical services
    b. financial accounting and reporting
    c. scheduling
    d. transcription
    e. medical record management
    f. appointment scheduling
    g. information systems
    h. facility selection and maintenance
    i. secretarial services
17. Describe the content, interpretation, and use of the following financial documents.
    a. balance sheet
    b. income and expense statement
    c. accounts payable and receivable
    d. collection analysis
18. Discuss the insurance requirements associated with neurosurgical practice including
    a. personal and professional liability
    b. personal health and disability
    c. casualty, fire, and theft
    d. personal life
19. Discuss the issues of quality assurance as related to neurosurgical practice including
    a. maintenance of the clinical record
    b. review and documentation of morbidity and mortality
    c. risk management
20. Discuss the theory and organization of CPT coding, along with examples of complex procedural coding.
21. Describe the considerations in evaluation and management coding, including documentation requirements.
22. Describe the work, practice expense, and malpractice expense components of Medicare's Resource-Based Relative Value Scale (RBRVS) and how they are derived.
23. Explain how Medicare and commercial payer conversion factors are derived and used to create a fee schedule from the RBRVS.

24. Describe commonly used methods of physician risk contracting, such as capitation payment, and explain the considerations in negotiating such a contract.
25. Describe the practice information necessary to manage a neurosurgical risk contract safely and profitably.
26. Review the features, similarities, and differences in various third-party payment systems including
    a. Medicare
    b. Medicaid
    c. commercial insurance
    d. worker's compensation
27. Contrast HMO and PPO health plans.
28. Describe the meaning of "managed care" and its typical components including
    a. contractual discounts
    b. provider risk arrangements
    c. use management
    d. provider report cards
    e. practice guidelines
    f. restricted access models
        i. primary gatekeeper
        ii. point of service
        iii. open access
29. List and discuss the ethical issues and conflicts of interest involved in managed care treatment decisions such as
    a. capitation reimbursement
    b. risk pools
    c. cost-saving incentive bonuses
30. Discuss antitrust considerations faced by physicians in payer contract negotiations including the concepts of collective bargaining, price fixing, and group boycott.
31. Describe the types of retirement plans, and funding considerations and limitations.
32. Explain the differences between occurrence and claims-made professional liability insurance and considerations made in selecting insurer and coverage levels.

Competency-Based Performance Objectives

JUNIOR AND MIDDLE LEVELS

1. Demonstrate an ability to interact effectively, professionally, and respectfully with
    a. patients and their families
    b. fellow residents

   c. allied health care personnel
   d. hospital staff
   e. medical students
   f. faculty physicians
   g. referring physicians
2. Demonstrate the ability to maintain accurate and current medical records.
3. Discuss neurosurgical career options with
   a. faculty
   b. peers
   c. family
   d. nonfaculty neurosurgeons and other mentors
4. Accumulate information about postresidency career options.
5. Create and keep current a resume/curriculum vitae.
6. Record CPT codes for office visits and procedures performed on service.
7. Document accurately H&P and consultations according to the American Medical Association CPT evaluation and management documentation guidelines.

SENIOR LEVEL

1. Demonstrate the ability to code neurosurgical activities properly.
2. Assign accurately and justify medical impairment ratings for neurosurgical patients.
3. Outline a postresidency career track.
4. Apply for postresidency fellowship if appropriate.
5. Obtain information about specific practice, research, or administrative career opportunities as appropriate.
6. Compose a list of questions to ask and things to see when interviewing for a neurosurgical position.
7. Read and interpret a financial report.
8. Design a structure for an office practice including a listing of the generic office processes and how to arrange staffing.
9. Prepare lists of neurosurgical instruments/equipment needed for specific operative procedures.
10. Select a proper practice, research, or administrative opportunity if appropriate.
11. Complete license and registration requirements for your chosen location.
12. Complete applications for hospital staff membership and clinical privileges.

13. Complete a resident case data sheet for the American Board of Neurological Surgery and have it signed by the program chair.

CEREBROVASCULAR SURGERY

Unit Objectives

Demonstrate an understanding of the anatomy, physiology, pathophysiology, and presentation of cerebrovascular diseases, including ischemic and hemorrhagic stroke, and other diseases and malformations of intracranial, extracranial, and spinal vasculature. Demonstrate the ability to formulate and implement a diagnostic and treatment plan for cerebrovascular diseases, including medical and surgical management.

Competency-Based Knowledge Objectives

JUNIOR LEVEL

1. Describe the anatomy of the extracranial and intracranial vessels, including the carotid, vertebral, and spinal arteries.
2. Describe the location of key perforating arteries involving the anterior and posterior circulation, their target distribution, and the consequence of occlusion or injury.
3. Review the anatomy of the venous circulation as it pertains to the CNS.
4. Identify the classic syndromes of vessel occlusion of the following.
   a. internal carotid artery
   b. middle cerebral artery
   c. anterior cerebral artery
   d. recurrent artery of Heubner
   e. anterior choroidal artery
   f. vertebral artery
   g. posterior inferior cerebellar artery
   h. lower and upper basilar trunk
5. Identify the classic brainstem ischemic syndromes.
6. Explain the concepts of cerebral blood flow, cerebral autoregulation (hemodynamic and metabolic), ischemic thresholds, ICP, and cerebral perfusion pressure. Describe the impact on cerebral blood flow of intracranial hypertension with and without mass lesion.
7. Recognize the common causes of brain ischemic states including
   a. cardiac embolism
   b. embolism from proximal vasculature
   c. large-vessel occlusion
   d. intracranial conducting vessel occlusion

e. small-vessel disease

8. Associate CT and MR evidence of ischemic injury with likely anatomic substrates.
9. Describe the epidemiology, physiology, and underlying pathophysiology of ischemic brain injury, including concepts of the critical therapeutic window.
10. Recognize the common causes of intracranial and intraspinal hemorrhage including
    a. aneurysmal disease
    b. vascular malformations
    c. hypertension
    d. vasculopathies
    e. degenerative diseases
    f. hemorrhagic arterial infarction
    g. venous infarction.
11. Relate typical imaging characteristics of CNS hemorrhagic lesions to probable causes.
12. Categorize common causes of intracranial hemorrhage, subarachnoid hemorrhage, and ischemic stroke.
13. Explain the principles of fluid and electrolyte resuscitation and maintenance, respiratory physiology, cardiac physiology, and nutritional physiology, as applied to the neurological patient following ischemic or hemorrhagic stroke. Integrate this knowledge with the specific issues of the perioperative period.
14. Recognize the need for laboratory evaluation for systemic illness.
15. List the appropriate diagnostic neuroimaging studies used to evaluate ischemic and hemorrhagic stroke.
16. Recognize the typical clinical course of patients with ischemic and hemorrhagic stroke, including peak risk intervals for edema, vasospasm, rebleeding, and so forth.
17. Identify the periods of high vulnerability to systemic complications of cerebrovascular illness, including deep venous thrombosis, pulmonary embolism, bacterial pneumonia, aspiration, congestive heart failure, and so on.
18. Explain the principles of augmentation of cerebral blood flow during cerebral vasospasm.
19. Discuss the principles and indications for medical, endovascular, and surgical interventions for ischemic and hemorrhagic stroke.
20. Relate the principles of timing of medical, endovascular, and surgical intervention in these same disease states.
21. Explain the principles, indications for, and complications of barbiturate coma.

22. Recognize the principles and interpretation of normal and common abnormal findings on skull, chest, and abdominal radiographs in the critical care unit.
23. Describe the fundamentals of CT scanning, including the typical appearance of acute, subacute, and chronic blood, calcification, ventricular anatomy, and mass effect.
24. Describe the typical CT appearance of hemorrhagic and ischemic stroke. Provide a detailed explanation for the typical delay between the onset of stroke and appearance of confirmatory CT findings.
25. Explain the fundamentals of MRI. Distinguish between normal and abnormal findings within the realm of cerebrovascular disease. Recognize the classic MR appearance of
    a. arteriovenous malformations
    b. venous angiomas
    c. cavernous malformations
    d. aneurysms
26. List the indications for noninvasive vascular imaging, including ultrasound, MR angiography, and CT angiography. Recite the limitations of noninvasive studies.
27. Describe the practical application of commonly employed noninvasive studies, such as transcranial Doppler, in the setting of cerebral vasospasm.
28. List the indications for catheter angiography. Interpret the findings of angiography in ischemic and hemorrhagic cerebrovascular conditions. Identify the key segments of the internal carotid artery including the upper cervical, petrous, cavernous, and supraclinoid components.
29. Recite the principles of localizing focal intracranial and spinal vascular pathology by the use of traditional topographic measurements and the application of stereotactic guidance.
30. Describe the surgical anatomy and the principles of exposure of the cervical carotid artery.
31. Describe the principles of pterional craniotomy, including scalp and bony anatomy, as well as the anatomy of the sphenoid ridge.
32. Explain the principles of cerebrovascular surgery detailed in the previous objectives to medical students and allied health personnel during conferences.

MIDDLE LEVEL

1. Recognize controversies regarding the basic neuroscience knowledge concepts mastered during junior residency.

2. Explain the principles of ischemic neuronal protection and salvage.
3. Review the principles of guideline development and outcome assessment related to the basic knowledge objectives achieved during junior residency.
4. Display an understanding of the principles of hypothesis development and testing, and statistical analysis as applied to clinical research trials, as well as the critique of scientific manuscripts.
5. Recognize areas of controversy related to management protocols in cerebrovascular patients achieved during junior residency.

SENIOR LEVEL

1. Demonstrate a sophisticated understanding of current literature related to basic neuroscience knowledge objectives acquired as a junior and middle resident. Define scientific hypotheses in relation to controversies and evolving knowledge regarding these same objectives, and demonstrate the ability to interpret and adapt new knowledge to evolving patient care paradigms.
2. Demonstrate a mature fundamental knowledge in clinical and teaching conferences, specialty conferences, and in publications and scientific presentations.
3. Understand the guidelines, protocols, and literature controversies regarding the diagnostic imaging modalities available in cerebrovascular disease.

Competency-Based Performance Objectives

JUNIOR LEVEL

1. Perform a comprehensive neurological history and clinical examination.
2. Perform a comprehensive systemic evaluation.
3. Adapt comprehensive evaluations to specific, pertinent positives and negatives with regard to ischemic and hemorrhagic stroke.
4. Demonstrate an understanding of urgency and the ability to prioritize during emergent aspects of hemorrhagic and ischemic disease states.
5. Demonstrate the ability to manage cardiac and pulmonary complications following cerebrovascular illness and therapy, and review the need for specialty and subspecialty consultations.
6. Apply the principles of perioperative care after common endovascular and surgical procedures directed at cerebrovascular disease.
7. Demonstrate the ability to be vigilant in the clinical detection of subtle neurological change during the acute and subacute phases of illness.

8. Demonstrate the ability to place an arterial catheter, central venous catheter, and pulmonary artery catheter. Perform placement of a ventricular catheter via a burr-hole or twist-drill craniotomy.
9. Perform lumbar puncture and CSF reservoir tapping.
10. Define the proper placement of a craniotomy flap in the planned surgical evacuation of hematoma. This should be performed using both topographical as well as stereotactic-assisted navigation techniques.
11. Assist in the opening, exposure, and closure of cervical carotid procedures.
12. Assist during pterional craniotomy for vascular disease.
13. Assist in the performance of intracranial hematoma evacuation.
14. Demonstrate the ability to keep accurate and timely records.

MIDDLE LEVEL

1. Perform pterional craniotomy for vascular disease.
2. Demonstrate the ability to make independent management decisions regarding ischemic and hemorrhagic stroke states.
3. Supervise care delivered by PGY1 and junior resident physicians for cerebrovascular patients.
4. Demonstrate efficient prioritization skills for clinical assessment of multiple simultaneous problems in the same or different patients. Display a clear sense of prioritization regarding timing and urgency of medical and surgical intervention for ischemic and hemorrhagic stroke states. Recognize the impact of systemic conditions on prioritization and timing issues.
5. Interpret and respond correctly to changes in patient status related to systemic and neurological parameters.
6. Implement patient care protocols regarding perioperative management.
7. Display independence in making decisions regarding the critical care of cerebrovascular patients. Recognize the need for reporting such decisions to the senior resident and attending staff.
8. Demonstrate the ability to obtain appropriate medical and surgical consultation.
9. Display skills in prioritization of diagnostic interventions, including the choice and sequence of studies in the setting of ischemic and hemorrhagic states.
10. Interpret invasive and noninvasive diagnostic imaging studies in relation to cerebrovascular disease.
11. Formulate preliminary and surgical planning.
12. Perform frameless navigation procedures.

13. Perform routine and complicated twist-drill or burr-hole procedures for the drainage of the ventricular system or intracranial hematomas.
14. Perform exposure of the cervical carotid artery for endarterectomy or proximal arterial control.
15. Observe and assist in the performance of plaque removal and arterial closure during carotid endarterectomy.
16. Practice microsurgical techniques in the laboratory setting.
17. Demonstrate a mature understanding of the planning and performance of pterional craniotomy for intracranial vascular pathology. Perform pterional craniotomy with initiation of microsurgical clinical skills. Observe the microsurgical dissection of the Sylvian fissure and basal cisterns for vascular pathology.
18. Perform the surgical approach to vascular structures via a craniotomy other than pterional.
19. Supervise and assist junior residents in burr-hole and twist-drill procedures for ventricular access or ICP monitoring.
20. Realize an increasingly progressive teaching responsibility to medical students, interns, and junior residents in the various educational objectives of the cerebrovascular curriculum.
21. Supervise the junior residents in the technical performance of cerebrovascular procedures, as well as critical care catheter procedures commensurate with their level of expertise.
22. Organize clinical and teaching rounds and conferences, as well as the presentation of cases.
23. Prepare topic reviews in lecture and manuscript formats, including literature summaries and reference compilations.

SENIOR LEVEL

1. Review fundamental concepts of cerebrovascular disease during conferences and clinical rounds with the house staff and medical students.
2. Demonstrate mature clinical judgment related to the spectrum of problems encountered in hemorrhagic and ischemic stroke states.
3. Formulate independent plans for patient assessment and management, including prioritization in cerebrovascular disease, while maintaining a clear reporting relationship with the faculty.
4. Supervise house staff and medical student teams in daily patient assessment and care.
5. Identify the indications and controversies of endovascular catheter procedures, perioperative management, and follow-up. Implement and supervise patient care protocols related to these procedures.

6. Display a mature and detailed understanding of indications, principles, and interpretation of the full spectrum of the neurodiagnostic armamentarium. Formulate independent management plans based on sophisticated interpretation of diagnostic studies for concise presentation to faculty.
7. Apply evolving technology and new methods to patient protocols and to the education of house staff and medical students.
8. Demonstrate a mature understanding of surgical strategies and approaches to common and unusual vascular disease.
9. Apply the principles of intraoperative anesthetic management, proximal and distal control, temporary arterial occlusion, brain protective strategies, and intraoperative localization as applied to vascular disease.
10. Complete the planning, positioning, and execution of pterional craniotomy for common vascular disease.
11. Perform microsurgical dissection of the Sylvian fissure and exposure of the basal cisterns for vascular disease.
12. Perform microsurgical exposure and clipping of an intracranial aneurysm.
13. Complete the planning, positioning, and execution of nonpterional craniotomy for intracranial vascular disease.
14. Assist in the microsurgical management of highly complex cerebrovascular disease.
15. Plan and execute a craniotomy for the evacuation of intracranial hematomas.
16. Supervise other house staff in meeting their surgical objectives.
17. Describe the exposure and treatment of intraspinal vascular lesions. Assist in such operations.
18. Oversee all aspects of patient care and identify appropriate cases for database analysis, morbidity, mortality, conferences, and discussions. Supervise medical students and house staff in every aspect of patient care.
19. Report appropriate patient care issues to responsible faculty members in a timely fashion.
20. Organize and administer teaching conferences.
21. Display mature participation in specialty conferences.
22. Assign responsibilities to junior residents and residents, with the aim of fulfilling their respective educational objectives.

NEUROSURGICAL ONCOLOGY

Unit Objectives

Demonstrate an understanding of the anatomy, physiology, pathophysiology, and presentation of tumor-related diseases of the cranium.

Demonstrate the ability to formulate and implement a diagnostic and treatment plan for tumor-related diseases of the cranium that are amenable to surgical intervention.

Competency-Based Knowledge Objectives

JUNIOR LEVEL

1. Summarize the epidemiology, incidence, and risk factors for intracranial neoplasms.
2. Summarize the tenets of tumor biology including genetic factors and biochemical processes associated with invasion. Describe the natural history of intracranial neoplasms.
3. List a differential diagnosis of lesions requiring biopsy and describe their pathophysiology.
4. List the various types of bone tumors involving the calvarium.
5. Describe and differentiate
   a. astrocytomas, including the accepted World Health Organization grading scheme
   b. gliomas other than astrocytomas
   c. metastatic tumors, including location and common origins
   d. infectious, granulomatous, and cystic lesions that may present in a tumor-like manner
6. Define the cell or origin of meningioma, its common intracranial locations, and the expected presentation for each location.
7. Define the embryological origin of arachnoid cysts and their natural history. List the etiologies of other cystic lesions of the brain, including tumorous and infectious lesions.
8. Describe the anatomic location, cell of origin, clinical presentation, age at presentation, and natural history of common intrinsic posterior fossa neoplasms, including cerebellar astrocytoma, medulloblastoma, and ependymoma.
9. Describe the anatomy of the posterior fossa and the relation of the cranial nerves to the brainstem and skull.
10. Illustrate the relationship of the facial, vestibular, and cochlear components of the acoustic nerve at the internal auditory meatus.
11. Describe the various tumors that may arise in the cerebellopontine angle.
12. Describe the management of a patient with a brain abscess, including the role of stereotactic drainage or open drainage.
13. Explain the medical workup of a patient with a diagnosed brain abscess.
14. Specify the follow-up and evaluation of the patient with a brain abscess after surgical treatment.

15. Describe the embryological origin of craniopharyngioma. List the common locations of the tumor.
16. Describe the common presentations of pituitary tumors, the cell of origin, and endocrinopathies associated with
    a. null cell adenomas
    b. somatotrophic adenomas
    c. prolactinomas
    d. corticotrophic secreting adenomas
    e. thyrotrophic secreting adenomas
17. Define the medical management of the secreting pituitary tumors. Explain the role of surgery in each of the tumors just listed.
18. Describe the etiology of fibrous dysplasia, its presentation, and general management. List the indications for surgery for benign tumors of bone at the base of the skull, and potential adjuvant therapy.
19. List the tumors that may be approached routinely through a transtemporal route.
20. Describe the indications for use of lumbar spinal drainage in skull base surgery, and its implementation. List all complications associated with continuous lumbar spinal drainage.
21. Illustrate the general principles of stereotaxis and the underlying localization techniques used in the currently used frame-based and frameless systems.

MIDDLE LEVEL

1. Describe appropriate postoperative management with drainage of brain abscess or cyst.
2. Describe the appropriate surgical management and postoperative treatment of bony skull lesions.
3. Describe the role of surgery in arachnoid cysts, infectious cysts, and tumor-related cystic lesions. Describe the adjuvant treatment of parasitic cysts.
4. Explain the rationale and indications for various skull base approaches to the anterior, middle, and posterior cranial fossae. Identify the important anatomic landmarks for each approach. Illustrate the general principles used in prophylaxis of CSF leaks employed in skull base surgery.
5. Describe the neurosurgical management for the following tumors involving the anterior cranial fossa.
    a. meningioma
    b. fibrous dysplasia

c. esthesioneuroblastoma
d. osteoma of the frontal sinus
e. chondroma, chordoma
f. mucocele
g. bony metastasis

6. Explain the use of the balloon occlusion test of the carotid artery, its indication for use in skull base tumor surgery, how it is performed, and how the information gained influences surgical management.
7. Explain the surgical advantage of transposing the facial nerve during a transtemporal skull base approach.
8. Describe the transcondylar approach, the relationship of the lower cranial nerves, and the exposure gained over a routine suboccipital craniectomy.
9. Illustrate the transpetrosal approach and the relationship of the transverse and sigmoid sinuses with skull bony landmarks such as the asterion, mastoid, and inion.
10. Describe the intradural course of the trochlear nerve, trigeminal nerve through Meckel's cave, and the abducens nerve and Dorello's canal.
11. Describe the surgical management of the frontal sinus that has been exposed during craniotomy for anterior skull base surgery. Illustrate the development and use of a frontal vascularized pericranial flap and explain its indication. Similarly, illustrate the use of a musculocutaneous flap of the temporalis muscle and list the locations for application.
12. Describe the general methods used for embolization of tumors of the head and neck, and the indications for such procedures.
13. Compare and contrast the methods for stereotactic radiation, including particle beam, gamma ray, or linear accelerator, and the indications for each technique.

SENIOR LEVEL

1. Describe the indications for transcranial orbitotomy and list the lesions that require this approach.
2. Discuss the surgical management and postoperative treatment of astrocytomas, gliomas other than astrocytomas, metastatic brain tumors, infectious granulomas, and cystic lesions presenting in a tumor-like manner. Review the role of radiotherapy, chemotherapy, and other adjunctive treatments of these neoplasms.
3. Describe the role of surgery for intracranial meningioma, and the relation between the surgical option and the location of the

tumor. Discuss adjuvant treatments of meningioma and their efficacy.

4. Discuss the surgical treatment of common, intrinsic posterior fossa neoplasms, including cerebellar astrocytoma, medulloblastoma, and ependymoma, including the roles of ventricular drainage and surveillance imaging. Present adjuvant treatment options and outcomes for the various posterior fossa intrinsic tumors.
5. Address the surgical goals of treatment, complications of surgical treatment, and adjuvant therapy for posterior fossa meningioma.
6. List and illustrate the various approaches for removal of a vestibular schwannoma, and the rationale and indication for each approach.
7. Describe the role of stereotactic radiosurgery and microsurgery in the management of vestibular schwannoma.
8. List the various approaches to the midline clivus and review the indications for each approach. Outline the surgical and medical management of tumors of the clivus and midline skull base.
9. Explain the management goal for a patient with craniopharyngioma, and the risks of surgical treatment and conservative treatment. Describe the various surgical approaches used to resect craniopharyngiomas and the options for adjuvant treatment, including radiotherapy and chemotherapy (systemic and local).
10. Illustrate the transnasal–transsphenoidal approach and its indications. Define the options for treatment of recurrent pituitary tumors of all types (including medical management). Describe the risks of the approach and the management of the complication of CSF leak.
11. Illustrate the various skull base approaches to the anterior, middle, and posterior cranial fossae in detail, explaining the key anatomic landmarks and strict indications for the approach. List the complications relevant to each approach and the management of each complication.
12. List a differential diagnosis of orbital tumors, their usual location within the orbit, medical and surgical management of the tumor, and the approach used to remove the tumor if indicated.
13. List the various tumors and their locations in which an orbitocranial approach may be indicated for their removal.
14. Compare and contrast the exposure offered by the pre- and postauricular infratemporal approach, and the indications for each approach.

15. Illustrate transposition of the facial nerve during a transtemporal skull base approach.
16. Describe the location of meningiomas intracranially that are amenable to preoperative embolization.

Competency-Based Performance Objectives

JUNIOR LEVEL

1. Perform a complete history and physical examination on patients with intracranial neoplasms.
2. Review appropriate radiographic studies with a radiologist and formulate a differential diagnosis for patients with intracranial neoplasms.
3. Prepare patients for cranial tumor surgery.
4. Understand the positioning of patients for craniotomy and craniectomy.
5. Assist in the opening and closing of craniotomies and craniectomies for neoplasms.
6. Place lumbar drains.
7. Demonstrate the ability to open and close scalp incisions.
8. Perform ventriculostomies.
9. Demonstrate proper postoperative wound care.

MIDDLE LEVEL

1. Determine independently a differential diagnosis based on the patient's history, physical examination, and radiographic studies.
2. Position patients for craniotomy and craniectomy.
3. Perform the opening and closing of craniotomies and craniectomies.
4. Assist in the resection of intracranial neoplasms.
5. Resect skull lesions.
6. Treat supra- and infratentorial brain abscesses surgically.
7. Demonstrate the ability to manage postoperative complications including
   a. brain edema
   b. meningitis
   c. cranial flap infection
   d. postoperative seizures
8. Assess the need for appropriate pre-, intra-, and postoperative monitoring.
9. Obtain proper non-neurosurgical consultation in tumor patients.
10. Identify patients requiring rehabilitation services.
11. Use appropriate support agencies and groups for patients with intracranial neoplasms.

SENIOR LEVEL

1. Demonstrate the capability to function independently in all phases of management of patients with intracranial neoplasms.
2. Perform resection of supra- and infratentorial intra-axial and extra-axial neoplasms.
3. Perform resection of pituitary lesions.
4. Perform or serve as first assistant for skull base procedures.
5. Oversee the pre- and postoperative management of patients with intracranial neoplasms.
6. Assume teaching responsibilities for junior residents as assigned.
7. Assume responsibility for managing the psychosocial aspects of intracranial neoplasms.

NEUROTRAUMA AND NEUROSURGICAL CRITICAL CARE

Unit Objectives

Demonstrate an understanding of the anatomy, physiology, pathophysiology, and presentation of traumatic injuries of the brain, spinal cord, and peripheral nervous system, including their supporting structures. Demonstrate the ability to formulate and implement appropriate diagnostic and treatment plans for traumatic injuries to the nervous system, including both surgical and nonsurgical management.

Competency-Based Knowledge Objectives

JUNIOR LEVEL

1. Describe the systematic assessment of polytrauma patients.
2. Rank management priorities in polytrauma patients appropriately.
3. Discuss principles of resuscitation of polytrauma patients, including appropriate fluid resuscitation, and explain the anticipated effects of shock and resuscitation on fluid shifts and on electrolyte balance.
4. Name an initial choice for intravenous fluids for newly admitted intensive care unit (ICU) patients with the following diagnoses and explain changes in that choice based on specific changes in the patient's diagnosis, clinical condition, and electrolyte and volume status.
   a. head injury
   b. stroke
   c. tumor
   d. infection
   e. hydrocephalus
5. Propose appropriate initial ventilator settings for patients with different types of common neurosurgical conditions and explain

changes in that choice based on specific changes in the patient's metabolic or pulmonary status.
6. List the mechanisms of action and potential complications of commonly used pressors and hypotensive agents.
7. Discuss indications, pharmacological mechanism, duration of action, and effect on the neurological examination for sedative, paralytic, and analgesic agents commonly used in the ICU.
8. Explain the indications, advantages, and risks for various hemodynamic monitoring tools (e.g., pulmonary artery catheters, indwelling arterial lines) used in critically ill patients.
9. Discuss the pathophysiology and management of coagulopathy after head injury.
10. Describe basic principles of nutritional management in neurosurgical critical care.
11. Explain the treatment of post-traumatic seizures.
12. Outline basic principles of ICU management of patients with spinal cord injury.
13. Name the major structures supplied by the major vessels of the brain and spinal cord.
14. Discuss the evaluation, treatment, and prognosis of subarachnoid hemorrhage, both traumatic and spontaneous.
15. Explain the pathophysiology and treatment of cerebral vasospasm.
16. Formulate a diagnostic and treatment plan for patients with cerebral ischemia.
17. Explain the evaluation and management of birth-related intracranial hemorrhage, spinal cord injury, and brachial plexus injury.
18. Describe a systematic approach to the examination of the peripheral nervous system.
19. Describe the basic principles of management of peripheral nerve injuries.
20. List the principles of rehabilitation of different types of neurosurgical patients.
21. Define brain death and discuss methods of making such a diagnosis.
22. Describe the pathophysiology of electrical injuries to the nervous system and review their treatment.

MIDDLE LEVEL

1. Describe the pathophysiology of intracranial hypertension and explain a plan for its management, including arguments for and against various treatments.

SENIOR LEVEL

1. Discuss management priorities in polytrauma patients with severe neurological and systemic trauma.

Competency-Based Performance Objectives

JUNIOR LEVEL

1. Perform and document pertinent history, physical findings, and radiological findings in a polytrauma patient.
2. Differentiate central from peripheral nervous system injuries.
3. Insert intravascular monitoring devices for use in the hemodynamic management of critically ill patients, including central venous lines, pulmonary artery catheters, and arterial catheters.
4. Insert ICP monitoring devices, including ventriculostomy catheters and electronic (fiberoptic or miniaturized strain gauge) devices.
5. Perform twist-drill or burr-hole drainage of subdural fluid collections.
6. Decide appropriately which patients require emergency craniotomy and other procedures.
7. Position patients appropriately for procedures/surgery and begin emergency procedures if more experienced neurosurgeons have not yet arrived.
8. Assist with opening and closure of craniotomies.
9. Perform elective tracheotomies and be able to perform emergency tracheotomies.
10. Be able to intubate patients in both emergency and elective situations.

MIDDLE LEVEL

1. Perform the following surgical procedures in uncomplicated cases.
   a. craniotomy for subdural and/or epidural hematoma
   b. craniotomy for penetrating head injury
   c. craniotomy for intracerebral hematoma or contusion
   d. craniotomy for depressed skull fracture
   e. decompressive craniectomy
   f. repair/cranialization of frontal sinus fracture
   g. craniotomy/craniectomy for posterior fossa epidural, subdural, or intracerebral hematoma
   h. simple cranioplasty

2. Manage traumatic skull base fractures with a CSF leak.
3. Manage infections associated with open CNS injuries.

SENIOR LEVEL

1. Perform the procedures for middle level, item 1, in complicated cases.
2. Reconstruct complex cranial defects with assistance from other specialties as indicated.
3. Reconstruct traumatic skull base defects with assistance from other specialties as indicated.
4. Explore and repair peripheral nerve injuries.
5. Supervise and teach junior- and middle-level residents with patients appropriate for their level.
6. Lead the critical care team in the treatment of patients with neurological injuries, either in isolation or in polytrauma patients.

PAIN MANAGEMENT

Unit Objectives

Demonstrate an understanding of the anatomic and physiological substrates of pain and pain disorders. Demonstrate an ability to formulate and execute diagnostic and therapeutic plans for management of pain and disorders giving rise to pain.

Competency-Based Knowledge Objectives

JUNIOR LEVEL

1. Describe the anatomy and physiology of nociception within the peripheral and central nervous systems.
2. Differentiate the basic categories of pain syndromes.
   a. acute
   b. chronic
   c. nociceptive
   d. neuropathic (including complex regional pain syndromes)
   e. musculofascial
   f. cancer related
   g. postoperative
3. Explain the concept of pain as a biopsychosocial disorder.
4. Discuss the role of rehabilitation in pain management.
5. Describe methods for assessing pain in pediatric patients.
6. Discuss ethical standards in pain management and research.
7. Discuss methods of assessing outcomes of pain treatment and describe common assessment tools.

8. Describe a typical history of a patient with trigeminal neuralgia, trigeminal neuropathic pain, and atypical facial pain.
9. Diagram the anatomy of the trigeminal nerve divisions (ophthalmic, maxillary, and mandibular nerves), foramen ovale, Meckel's cave, trigeminal (gasserian) ganglion, cistern of Meckel's cave, retrogasserian root, descending tract and nuclei, nervus intermedius, and glossopharyngeal nerve.
10. Illustrate the appropriate medical management of patients with trigeminal neuralgia, trigeminal neuropathic pain, and atypical facial pain.
11. Discuss the potential complications of percutaneous procedures for trigeminal neuralgia.
12. Describe the brainstem anatomy and physiology of the spinothalamic and trigeminothalamic systems.
13. Describe the anatomy of the primary sensory cortex (S1), Rolandic fissure, and the relationship of S1 to the primary motor cortex.
14. Describe the functional anatomy of the following thalamic nuclei: ventral posterolateral, ventralis caudalis externus, ventral posteromedial, and ventralis caudalis internus. Review the functional anatomy of the medial thalamic nuclei (e.g., nervus parafascicularis).
15. Identify the primary indications for spinal cord stimulation (SCS), peripheral nerve stimulation, and intraspinal (epidural, intrathecal) drug infusion therapy.
16. Diagram the spinal anatomy pertinent to SCS and intraspinal drug administration, including the spinous process–interspinal ligament–spinous process complex, ligamentum flavum, and dorsal epidural space. Review the different degrees of angulation of the spinous processes at various spine levels in the cervical and thoracic areas.
17. Diagram the spinal cord anatomy pertinent to spinal ablative procedures for pain management.
18. Recognize complications arising from implantation of pulse generators/receivers and infusion pumps.
19. Describe the anatomy of the major peripheral nerves, brachial plexus, and lumbosacral plexus.
20. Describe the anatomy of the sympathetic nervous system and explain its role in pain.
21. List the common mechanisms of peripheral nerve injury and describe the changes that occur in an injured nerve at both the microscopic and macroscopic levels. Explain the theories of pain generation in peripheral nerve injury.

22. Describe the pharmacology of local anesthetic agents (e.g., lidocaine, procaine, tetracaine, bupivacaine) and the use of epinephrine with local anesthetic agents.
23. Discuss the indications for a peripheral neural blockade. Explain the principles of blocking procedures including the techniques and expected outcomes. Cite the complications of a peripheral neural blockade (including anaphylaxis, neural injury, and intravascular or intrathecal administration). List the alternatives to a temporary blockade including neurolytic blocks, ablative neurosurgical procedures, augmentative neurosurgical procedures, alternative traditional pain management procedures, and alternative medicine approaches.
24. Review the indications for radiofrequency facet rhizolysis.
25. Discuss the anatomy and biomechanics of the facet complex with emphasis on bone, cartilage, fibrous capsule, synovial fluid, and innervation of this structure.

MIDDLE LEVEL

1. Name and differentiate the major classes of medications that are used commonly for pain treatment (opioids, nonsteroidals and acetaminophen, antidepressants, anticonvulsants).
2. Review the psychosocial issues that may influence a pain disorder and describe the role of behavioral interventions in pain management.
3. Explain the rationale for multidisciplinary management of pain disorders.
4. Contrast impairment and disability.
5. Explain the basis of chemical, balloon compression, and radiofrequency neurolysis in the treatment of trigeminal neuralgia.
6. Relate subcortical and brainstem sites that appear to be involved in the modulation of nociception to targets for deep brain stimulation for pain control.
7. Explain how central neurostimulation (cortical, subcortical) is thought to produce analgesia.
8. Explain the role of ablative brain and brainstem procedures (e.g., cingulotomy, mesencephalic tractotomy, trigeminal tractotomy) in the management of chronic benign pain and cancer pain.
9. Discuss the possible complications of subcortical and brainstem ablative procedures for deafferention pain.
10. List the primary indications for the following spinal ablative lesions.
    a. dorsal root entry zone (DREZ) lesion

b. open and percutaneous anterolateral cordotomy
c. myelotomy

11. Discuss SCS, including types of stimulation systems and electrodes available, basic techniques of insertion of percutaneous and plate electrodes, the rationale and goals of intraoperative SCS testing (paresthesia coverage of painful area, avoidance of undesirable stimulation), the rationale and techniques for testing SCS, and the advantages and disadvantages of different sites of implantation of a SCS pulse generator/receiver.
12. Explain the key aspects of intraspinal drug administration, including the pharmacology of intraspinal drugs, the various types of infusion systems available, the rationale for testing intraspinal drug infusions, basic techniques for insertion of intrathecal and epidural catheters, and the proper location for infusion pump implantation.
13. Discuss the role of neurectomy and neurolysis for pain control in nerve injury and compare alternative techniques for pain control.
14. Describe the anatomy of the dorsal root ganglion, the bony anatomy of the nerve root foramen, and the location of the ganglion within that foramen. Discuss indications for ganglionectomy and describe long-term outcome from ganglionectomy with emphasis on pain recurrence and deafferentation.
15. Describe the indications for peripheral nerve stimulation and contrast them with SCS.
16. Describe indications for ablative peripheral neurolysis. Review the pharmacology and histopathological effects of neurolytical agents (e.g., phenol, glycerine/glycerol, chlorocresol, absolute alcohol, ammonium chloride/sulfate).
17. Discuss basic principles of ablative neurolytic procedures in terms of technique, expected outcomes, and complications including neural injury, injury to surrounding soft tissue, and inadvertent intravascular or intrathecal administration. Describe the alternatives to neurolysis, including temporary anesthetic blocks, ablative neurosurgical procedures, augmentative procedures, alternative traditional pain management procedures, and alternative medicine approaches.
18. Describe the principles of radiofrequency lesioning. Include in the discussion the following topics.
    a. probe
    b. thermocouple and thermistor
    c. time

d. intensity of heat
e. isotherm fields

19. Discuss basic principles of radiofrequency facet rhizolysis and list the equipment used, technique employed, expected outcomes, and complications (including damage to other nerve root branches, potential for spinal instability, inadvertent damage to the radicular artery, CSF leak, and spinal cord injury).
20. Compare the alternatives to radiofrequency lesioning.
    a. local anesthetic facet blocks
    b. epidural injections
    c. neurolytical facet blocks
    d. ablative neurosurgical procedures
    e. augmentative neurosurgical procedures
    f. alternative traditional pain management procedures
    g. alternative medicine approaches
    h. surgical intervention such as instrumentation and fusion

SENIOR LEVEL

1. Distinguish the indications for surgical and nonsurgical treatment of pain.
2. Construct a management strategy relating to the application of percutaneous trigeminal neurolytical procedures, retrogasserian rhizotomy, and microvascular decompression in the care of patients with trigeminal neuralgia.
3. Describe and contrast the approaches to the cerebellopontine angle for microvascular decompression or rhizotomy of the trigeminal and glossopharyngeal nerves.
4. Identify the various target spine levels for SCS according to the pain topography (simple and complex).
5. Identify the various intraspinal structures based on their responses to mechanical and electrical stimulation (dura mater, lateral canal wall, dorsal columns, dorsal roots, ventral roots, motor neurons).
6. Compare the different methods of intraspinal drug administration (epidural, intrathecal, tunneled catheter, implanted infusion system).
7. Describe the techniques for testing intraspinal drugs.
8. Compare the pharmacodynamics of different drugs delivered intrathecally (e.g., hydrophilic versus lipophilic).
9. Describe the possible complications of SCS electrode or spinal catheter insertion and their evaluation and treatment.
    a. paralysis

b. nerve root damage
c. electrode or catheter migration
d. electrode or catheter breakage
e. epidural hematoma
f. CSF leak

10. Describe the common drug side effects associated with intraspinal analgesic administration.
11. Describe the correct placement of lesions for DREZ, cordotomy, and myelotomy, including lesion depth and structures affected.
12. Discuss the possible neurological sequelae of spinal ablative procedures with both correct and incorrect lesion placement, with anatomic correlates.
13. Describe the role of DREZ lesioning in the overall management of the patient with deafferented pain.
14. Describe the techniques for exposure of the major peripheral nerves.
15. Demonstrate knowledge of the basic principles of nerve grafting, including regeneration, graft length considerations, and use of allograft donor nerves.
16. Describe the role and outcomes of ganglionectomy in the management of various pain syndromes, contrasting it with augmentative techniques.
17. Discuss in detail the surgical technique of ganglionectomy.
18. Describe percutaneous methods of gangliolysis.
19. Explain the effects of blocking agents at the membrane and synaptic cleft, and the biochemistry and histology of neurotoxicity.
20. Explain the histological effects of neurolytic agents at the membrane level and display a comprehensive level of understanding with regard to toxicity.
21. Describe the histological effects of radiofrequency lesioning.
22. Discuss in detail the evaluation and management of a patient selected for radiofrequency lesioning of the facets.
23. Discuss the alternatives to radiofrequency lesioning, with particular emphasis on the potential surgical remedies including decompression, instrumentation, and fusion.

Competency-Based Performance Objectives

JUNIOR LEVEL

1. Obtain a pertinent history and perform an appropriate physical examination for a patient with a primary complaint of pain.
2. Formulate and implement treatment plans for simple pain syndromes (e.g., acute postoperative pain, acute low back pain).

3. Evaluate and diagnose a patient with trigeminal neuralgia, trigeminal neuropathic pain, and atypical facial pain.
4. Assist with radiofrequency, glycerol, or balloon compression neurolysis of the trigeminal nerve in patients with trigeminal neuralgia.
5. Assist with surgical exploration of the trigeminal nerve, nervus intermedius, or glossopharyngeal nerve for MVD or rhizotomy.
6. Illustrate appropriate patient selection for spinal ablative or augmentative procedures for pain management.
7. Locate the spinal epidural space and place a percutaneous SCS electrode with supervision.
8. Assist with the implantation of a plate electrode for SCS.
9. Insert with supervision a spinal catheter for drug administration.
10. Implant with supervision an SCS system pulse generator/receiver and extension wire.
11. Implant with supervision an intraspinal drug infusion pump.
12. Assist with a spinal ablative procedure for pain management (cordotomy, myelotomy, DREZ).
13. Perform, record, and report complete patient evaluation and assessment for peripheral nerve repair, neurectomy, and neurolysis, including a comprehensive neuromuscular examination of affected nerve distributions.
14. Evaluate electrodiagnostic studies pertaining to peripheral nerve injury.
15. Recognize and treat the potential complications of peripheral nerve repair, neurectomy, and neurolysis, including hematoma formation, infection, and local wound problems.
16. Assist in the surgical treatment of peripheral nerves.
17. Assist with the implantation of a peripheral nerve stimulation system.
18. Perform, record, and report a complete patient evaluation and assessment for dorsal root ganglionectomy.
19. Recognize and treat the potential complications of dorsal root ganglionectomy including CSF leak, infection, and local wound problems.
20. Assist in foraminotomy and exposure of dorsal root ganglion.
21. Assess patients for appropriateness of local anesthetic blocks.
22. Perform simple superficial blocks with supervision and assist in complicated procedures. After these procedures
    a. Assess the outcome of the nerve block.
    b. Recognize and treat complications.
    c. Record and monitor the effects of the block over a specified time interval.

d. Assess the need for repeat blocks.

23. Assess the patient for appropriateness of ablative neurolysis. Perform simple superficial neurolysis with supervision and assist in complicated procedures. After ablative neurolysis
    a. Assess the outcome of the procedure.
    b. Recognize and treat complications.
    c. Record and monitor the effects of neurolysis over a specified time interval.
    d. Assess the need for repeat procedures.

MIDDLE LEVEL

1. Formulate and implement an appropriate treatment program for complicated pain syndromes (e.g., chronic back pain, "failed back surgery syndrome").
2. Assess the need for multidisciplinary management of pain disorders.
3. Demonstrate appropriate management of psychosocial factors complicating a pain disorder.
4. Employ the Hartel technique to perform radiofrequency, glycerol, or balloon compression neurolysis of the trigeminal nerve in patients with trigeminal neuralgia.
5. Implant a plate electrode.
6. Demonstrate appropriate methods for testing SCS and intraspinal drug administration systems.
7. Implant a peripheral nerve stimulation system.
8. Assess the patient for appropriateness of radiofrequency facet blocks. Perform radiofrequency facet blocks with supervision. After performing these procedures
    a. Assess the outcome of the facet blocks.
    b. Recognize and treat complications.
    c. Record and monitor the effects of the facet blocks over a specified time interval.
    d. Assess the need for repeat facet blocks.
9. Diagnose and formulate appropriate treatment plans for sympathetically maintained pain.
10. Diagnose and formulate an appropriate treatment plan for a patient with occipital neuralgia.

SENIOR LEVEL

1. Recognize and execute intelligent treatment choices for different pain syndromes including nociceptive, neuropathic, and cancer pain.

2. Demonstrate the appropriate use of each of the major classes of medications in common use for treating pain.
3. Demonstrate the appropriate selection of patients for surgical treatment of pain disorders.
4. Perform microvascular decompression and rhizotomy of the trigeminal nerve and glossopharyngeal nerves.
5. Assist a junior resident in performing a percutaneous ablative procedure for trigeminal neuralgia.
6. Formulate and implement an appropriate treatment plan for management of pain using spinal ablative and augmentative techniques according to pain etiology, pain topography, and status of spinal column (e.g., previous surgery at implant level, scoliosis, stenosis, etc.).
7. Select and implant an appropriate SCS system, recognizing how to modify the electrode insertion technique and location based on intraoperative responses.
8. Implant a plate electrode in a patient with previous spinal surgery at the same level.
9. Demonstrate proficiency with maintenance and programming of spinal drug administration systems and SCS systems.
10. Recognize and evaluate malfunctions of SCS and intraspinal drug administration systems.
11. Perform surgical revision of SCS and intraspinal drug administration systems.
12. Demonstrate proficiency in identification and lesioning of the DREZ, even in cases of nerve root avulsion.
13. Demonstrate proficiency in performing myelotomy and cordotomy.
14. Expose major peripheral nerves and perform closure of extremity incision for peripheral neurectomy/neurolysis.
15. Demonstrate proficiency in neurolysis and nerve grafting techniques.
16. Plan and execute surgical approaches to injuries of the major peripheral nerves.
17. Plan a peripheral nerve reconstruction including exposure, preparation of donor site, and nerve graft.
18. Demonstrate proficiency in the technique of ganglion resection.
19. Incorporate ganglionectomy as one part of an integrated approach to the patient with intractable pain.
20. Display appropriate patient selection for local anesthetic blocks.
21. Perform simple superficial blocks with minimal supervision. Relative to these blocks perform the following.
    a. Assess the outcome of the block.

b. Recognize and treat complications.
c. Maintain detailed records of the effects of the block and follow-up.
d. Assess the need for repeat blocks.

22. Provide information regarding alternatives for a failed nerve block.
23. Perform complicated nerve block procedures with direct supervision. Recognize and treat the complications of these procedures.
24. Display appropriate patient selection for ablative peripheral neurolysis.
25. Perform simple neurolytic procedures with minimal supervision. Relative to these procedures perform the following.
    a. Assess the outcome of the procedure.
    b. Recognize and treat complications.
    c. Maintain detailed records of the effects of neurolysis and follow-up.
    d. Assess the need for repeat neurolysis.
26. Provide information regarding alternatives for failed neurolysis.
27. Perform complicated neurolytic procedures with direct supervision.
28. Display appropriate patient selection for radiofrequency facet rhizolysis.
29. Perform simple facet blocks with minimal supervision. Relative to these procedures perform the following.
    a. Assess the outcome of the procedure.
    b. Recognize and treat complications.
    c. Maintain detailed records of the effects of the facet blocks and follow-up.
    d. Assess the need for repeat facet blocks.
30. Provide information regarding alternatives for failed facet blocks.
31. Perform complicated facet blocks with direct supervision.
32. Perform sympathectomy.

PEDIATRIC NEUROSURGERY

Unit Objectives

Demonstrate an understanding of the anatomy, physiology, pathophysiology, and presentation of diseases in children that a neurosurgeon may be called on to diagnose and treat. Demonstrate the ability to formulate and implement a diagnostic and treatment plan for these diseases.

Competency-Based Knowledge Objectives

JUNIOR LEVEL

Myelomeningocele and Its Variants, Meningocele, Encephalocele, Chiari Malformations, Occult Spinal Dysraphism, Split Cord Anomalies, Segmentation Anomalies, Craniofacial Syndromes, and Phakomatosis

1. Review the embryology of the CNS and its supporting structures.
2. List the abnormalities a neurosurgeon may treat that are congenital/developmental in nature and classify them with respect to their embryological defect.
3. Describe the incidence, epidemiology, and inheritance patterns.
4. State other disorders associated with this set of diseases.
5. Describe the anatomic and pathophysiological parameters that distinguish among these diseases.
6. Develop a diagnostic treatment plan along with a prognostication of the outcome with optimal management.
7. List disorders that may be referred for neurosurgical care but do not require surgery.
8. Display current knowledge of the molecular basis for these diseases when known.
9. Describe the expected outcome if treatment is not undertaken.

Hydrocephalus and Other Disorders of CSF Circulation

1. Describe the normal physiology of CSF.
2. Delineate the different etiologies of hydrocephalus and their relative incidence.
3. Explain how to differentiate between CSF collections that require treatment and those that do not.
4. Indicate the various treatment options for the management of hydrocephalus.
5. Distinguish between treatment options for hydrocephalus with normal CSF and contaminated CSF (e.g., infection, blood).
6. List the complications associated with each treatment option for hydrocephalus and the diagnosis and their treatment.
7. Differentiate between low-pressure and high-pressure hydrocephalus.
8. Describe the presentation and diagnostic approach to a patient with suspected shunt malfunction.
9. Define how the diagnosis of hydrocephalus is made.
10. List nonsurgical diseases that may be mistaken for hydrocephalus but require treatment different than surgery.

11. Review the causes of cerebral atrophy.

Neoplasia

1. Delineate the differences between pediatric and adult tumors.
2. List the common tumor types occurring in children and their typical location.
3. Describe the changing tumor type and location based on age.
4. Identify lesions that require biopsy as part of the treatment and diagnostic plan.
5. Describe the typical presentations of tumors.
6. Describe the appropriate evaluation for patients suspected of having a tumor.
7. Classify tumor types regarding degree of malignancy, role of surgical versus nonsurgical therapy, and outcomes of optimal treatment.
8. Discuss the possible complications associated with specific tumor types.
9. Describe the pertinent anatomy for surgical treatment of midline or hemispheric cerebellar tumors and hemispheric cerebral tumors.
10. Discuss the appropriate preoperative management of patients with tumors.
11. Compare the role of biopsy, subtotal resection, and total resection in the management of tumors.
12. List the possible complications of the treatment options, their diagnostic evaluation, and treatment.

Infection

1. Describe the presentations of a shunt infection.
2. List the indications for ventricular lumbar and subarachnoid CSF sampling.
3. List the common organisms seen in shunt infections.
4. Describe treatment plans for shunt infection.
5. List risk factors, risks of shunt infection, and the proper diagnostic protocol to establish the presence of a shunt infection.
6. Describe the common presentations of intracranial and intraspinal suppuration.
7. List the host risk factors that are associated with CNS infections.
8. Describe the appropriate diagnostic protocol to establish the presence of CNS infection.
9. Discuss the timeliness and usefulness of surgical therapy for the treatment of CNS infection both shunt related and nonshunt related.

Other

1. Delineate the various types of spasticity and movement disorders seen in children.
2. List seizure types.
3. Describe surgical lesions that may be related to seizures.
4. Describe surgical and nonsurgical treatment options regarding the alleviation of spasticity in children.
5. Discuss the pathophysiology of craniosynostosis.

Cerebrovascular

1. Delineate the possible causes of an atraumatic intracerebral or subarachnoid hemorrhage.
2. Delineate the possible causes of cerebral infarction/ischemia.
3. Discuss the common locations of arteriovenous shunts and their presentation, evaluation, and treatment (includes dural arteriovenous malformations).
4. Discuss the embryology of the cerebral and spinal vasculature and its possible role in vascular anomalies in children.
5. Describe the common locations and types of aneurysms seen in children and how they differ from those seen in adults.
6. List the possible presentations of vein of Galen aneurysms, their diagnosis, and management.
7. List the possible causes of aneurysms in children that are not congenital in nature.
8. Describe the pathophysiology, treatment, and outcome of intraventricular hemorrhage in the neonate.

Trauma

1. List the appropriate diagnostic tests to evaluate a child who has sustained multisystem trauma.
2. Describe the Glasgow Coma Scale and its use.
3. List the salient historical and examination features that lead one to the diagnosis of nonaccidental trauma.
4. Discuss the management of the cervical spine in a child who is comatose.
5. Describe the anatomy of the child's spine that causes the epidemiology of spinal cord injury to differ from adults.
6. Describe the common injuries seen as a result of birth trauma and discuss their diagnosis and management.
7. Describe the use of antibiotics and anticonvulsants in CNS trauma.
8. Review the evaluation and management of a child who has

sustained a head injury with loss of consciousness but is now awake.
9. Discuss the management of depressed skull fractures, both open and closed.
10. Describe the diagnosis and management of spinal column injury.
11. Discuss the diagnosis and management of spinal cord injury without radiological abnormality.
12. Describe the ICP compliance curve and discuss its usefulness in the management of head injury.
13. List the parameters needed to decide on letting an athlete who has sustained a CNS injury return to activity.
14. Discuss the concept of brain death, its diagnosis, and its role in organ donation.
15. Discuss the importance and interplay between ICP and cerebral perfusion pressure in the management of head and spinal cord injury.
16. Define the concept of "secondary injury."
17. Discuss the role of invasive monitoring in all its forms in closed head injury.

MIDDLE LEVEL

Myelomeningocele and Its Variants, Meningocele, Encephalocele, Chiari Malformations, Occult Spinal Dysraphism, Split Cord Anomalies, Segmentation Anomalies, Craniofacial Syndromes, and Phakomatosis

1. Enumerate the indications for surgery, surgical options, and expected outcomes for each disease entity.
2. Explain the indications for and the usefulness of intraoperative monitoring.
3. Describe the appropriate timing of intervention and its rationale.
4. Describe the pathophysiology and presentation of the tethered cord syndrome.

Hydrocephalus and Other Disorders of CSF Circulation

1. Describe normal ICP dynamics and their relation to establishing a differential diagnosis of CSF flow disturbance.
2. Define "slit ventricle system" and how it is diagnosed and treated.
3. Define "brain compliance" and relate how it can affect ventricular size.
4. List indications for and describe the technique of accessing a shunt for CSF samples.