

NEURORADIOLOGY EDUCATIONAL PROGRAM for Radiology Residents

NEURORADIOLOGY CORE CURRICULUM

Each topic to cover relevant anatomy, pathogenesis, clinical presentation, imaging strategies, differential diagnosis, and evidence-based clinical and imaging management

I. Brain

- A. Imaging techniques in the brain, head and neck, and spine
 - 1. Radiography
 - 2. Myelography
 - 3. Computed tomography (incl. CT angiography, CT perfusion)
 - 4. Magnetic resonance imaging
 - Basic physics
 - Sequence selection
 - Artifacts
 - Advanced imaging (incl. MRS, DWI, DTI, perfusion, fMRI)
 - 5. Positron emission tomography
- B. CNS Infections
 - 1. Extraaxial
 - Meningitis
 - Complications of meningitis
 - Epidural abscess
 - Empyema
 - 2. Intraparenchymal
 - Bacterial
 - Viral encephalitis
 - Granulomatous
 - Parasitic
 - Spirochetes Prion diseases
 - Immunocompromised host
- C. White Matter Disease
 - 1. Multiple sclerosis
 - 2. Acute Disseminated Encephalomyelitis (ADEM)
 - 3. Osmotic myelinolysis (Central pontine myelinolysis)
 - 4. Small vessel ischemic disease, hypertension, vascular disease
 - 5. White matter changes in the elderly
 - 6. Radiation/chemotherapy changes
 - 7. Trauma (axonal injuries)
 - 8. Demyelinating and dysmyelinating disorders
- D. Trauma
 - 1. Cortical contusions
 - 2. Diffuse axonal injury (DAI) - shearing
 - 3. Subarachnoid hemorrhage (SAH)
 - 4. Subdural hemorrhage (SDH)

5. Epidural hemorrhage (EDH)
 6. Parenchymal hematoma
 7. Intraventricular hemorrhage
 8. Diffuse cerebral swelling & edema
 9. Herniation syndromes
 10. Skull fractures: types, complications
 11. Vascular injuries
 12. Non-accidental trauma
 13. Superficial and soft tissue injuries (e.g., Cephalohematoma)
- E. Neoplasm and other mass lesions
1. Neoplasms by histology
 - Glial (WHO grades I-IV)
 - Fibrillary astrocytoma
 - Oligodendroglioma
 - Ependymoma
 - Pilocytic astrocytoma
 - Giant cell astrocytoma
 - Pleomorphic xanthoastrocytoma
 - Subependymoma
 - Glioneuronal
 - Central neurocytoma
 - Ganglioglioma
 - PNET
 - DNET
 - Lymphoma
 - Metastasis
 - Meningioma
 - Choroid plexus tumors
 - Pineal tumors
 - Pituitary tumors
 - Hamartomas
 - Epidermoid
 - Arachnoid cyst
 - Other mesenchymal tumors
 - Primary bone tumors
 2. Tumor evaluation by location
 - Intra-axial vs. Extra-axial
 - Infra-tentorial intra-axial masses - Pediatric
 - Infra-tentorial masses - Adult
 - Sellar/Parasellar
 - Skull base
 - Pineal Region
 - Cerebellopontine angle
 - Intraventricular

F. Cerebrovascular disease

1. Infarction
 - Hypertension
 - Embolic
 - Hypoperfusion
 - Hypoxic-ischemic encephalopathy
2. Atherosclerosis (vessel wall, stenosis, occlusion)
3. Primary abnormalities of the vessel wall
 - Fibromuscular dysplasia
 - Vasculitis
 - Connective tissue disorders
 - Moya-Moya
4. Dissection
5. Vasculitides
6. Intracerebral hemorrhage
7. Subarachnoid hemorrhage
8. Aneurysm
 - Berry
 - Fusiform
 - Mycotic
 - Traumatic
 - Atherosclerotic
9. Vasospasm
10. Vascular malformations
11. Dural vascular malformations
12. Venous thrombosis and infarction

G. Congenital CNS Lesions

1. Disorders of organogenesis
 - Anencephaly
 - Cephaloceles
 - Chiari malformations (I-IV)
 - Corpus callosum anomalies: dysgenesis, lipomas
 - Hydranencephaly
 - Porencephaly
2. Disorders of neuronal migration & sulcation
 - Lissencephaly
 - Cortical dysgenesis: agyria-pachygyria, polymicrogyria
 - Heterotopia
 - Schizencephaly
 - Unilateral megalencephaly
3. Disorders of diverticulation and cleavage
 - Holoprosencephaly (alobar, semilobar, lobar)
 - Septo-optic dysplasia
 - Absent septum pellucidum
4. Posterior fossa cystic disorders

- Dandy-Walker complex
- Mega cisterna magna
- Arachnoid cyst
- 5. Disorders of histogenesis (Phakomatoses)
 - Neurofibromatosis Type I & Type II
 - Tuberous sclerosis
 - Sturge-Weber-Dimitri syndrome
 - Von Hippel-Lindau
 - Ataxia-Telangiectasia: Louis-Bar syndrome
 - Rendu-Osler-Weber syndrome
 - Basal cell nevus syndrome

II. HEAD AND NECK RADIOLOGY

A. Paranasal Sinuses

1. Congenital disease
 - Dermal sinus tract
 - Encephalocele
 - Choanal atresia
 - Dacrocystocele
 - Nasal glioma
2. Inflammation/Infection
 - Acute sinusitis
 - Chronic sinusitis - (Allergic, Fungal, Granulomatous)
 - Polyposis
 - Mucocele
3. Benign Sinus Tumors
 - Osteoma
 - Antrochoanal polyp
 - Juvenile angiofibroma
 - Inverted Papilloma
 - Schwannoma
 - Hemangioma
4. Malignant Sinus Tumors
 - Squamous cell carcinoma
 - Esthesioneuroblastoma
 - Adenocarcinoma
 - Lymphoma
 - Metastases
 - Minor salivary gland tumors
 - Rhabdomyosarcoma
 - Lethal midline granuloma

B. Oral Cavity, Oropharynx, Hypopharynx

1. Masses
 - Squamous cell carcinoma
 - Dermoid/Epidermoid

- Lingual thyroid
- Thyroglossal duct cyst
- Ranula
- Hemangioma

2. Infection
 - Cellulitis, tonsillitis, abscess

C. Parapharyngeal Space

1. Location, contents, anatomy, and importance
2. Dissemination patterns of infections and neoplasms
 - Danger space
 - Perineural spread, etc.
3. Infection (tonsillar abscess, adenitis)
4. Neoplasms and other masses
 - Squamous cell CA
 - Non-Hodgkin's lymphoma
 - Salivary gland neoplasms
 - Paragangliomas
 - Metastases
 - Thornwaldt cyst
 - Hemangioma
 - Branchial cleft cyst
 - Nerve sheath tumors
5. Vascular lesions
 - Aneurysm
 - Pseudoaneurysm

D. Salivary glands

1. Infection
 - Sialadenitis
 - Ductal stricture
 - Calculi
2. Inflammatory disorders
 - Sjogren's
3. Neoplasms
 - Lymphoepithelial lesions
 - Pleomorphic adenoma
 - Warthin's tumors
 - Mucoepidermoid carcinoma
 - Adenoid cystic carcinoma
 - Metastases
 - Lymphoma

E. Larynx

1. Squamous cell carcinomas
 - Staging and surgical approaches

Supraglottic, glottic, subglottic

Treatment effects (surgery and radiation)

2. Trauma
3. Vocal cord paralysis

F. Thyroid

1. Masses
 - Multinodular goiter
 - Adenoma
 - Cyst
 - Carcinoma
2. Parathyroid

F. Cystic Neck Masses

1. Second brachial cleft cyst
2. Thyroglossal duct cyst
3. Cystic hygroma
4. Laryngocele, internal, external
5. Abscess
6. Ranula

G. Lymphadenopathy (including size and imaging criteria on CT/MR)

1. HIV
2. Lymphoma
3. Metastases (aerodigestive carcinoma)
4. Cat scratch fever
5. Atypical mycobacterium
6. Mononucleosis

H. Temporal bones

1. Trauma
 - Fractures
 - Ossicular disruption
 - CSF leaks
2. Tumors
 - Schwannoma
 - Vestibular (8th) (common)
 - Facial (7th) and trigeminal (5th)
 - Meningioma
 - Lipoma
 - Dermoid/Epidermoid
 - Metastases
 - Paragangliomas
 - Cholesteatoma
 - Cholesterol granuloma
 - Hemangioma

3. Vascular
 - High riding/dehiscent jugular bulb
 - Aberrant carotid
 - AV fistula
 - Atherosclerotic disease
 - Dissection
 - FMD
4. Inflammatory Diseases
 - Otitis externa
 - Otitis media
 - Mastoiditis
 - Labyrinthitis
5. Congenital anomalies
 - Cochlear hypoplasia/aplasia, Mondini
 - External ear atresia/hypoplasia (ossicular anomalies)
 - Enlarged vestibular/cochlea aqueducts
 - Cochlear/vestibular aplasias-hypoplasias

I. Orbits

1. Extra-conal Masses
 - Orbital wall or sinus neoplasms with extension
 - Subperiosteal abscess/orbital cellulitis from sinusitis/osteomyelitis
 - Metastases
 - Lymphoma/Leukemia/Myeloma
 - Lymphangioma/Hemangioma
 - Rhabdomyosarcoma
 - Histiocytosis
 - Pseudotumor and granulomatous disease
 - Hematoma
2. Extra-ocular Muscles
 - Grave's Disease
 - Orbital myositis (Pseudotumor)
 - Granulomatous disease
 - Lymphoma/Leukemia
 - Metastases
3. Intra-conal lesions
 - Glioma
 - Meningioma
 - Optic neuritis
 - Increased intracranial pressure
 - Pseudotumor
 - Meningeal carcinomatosis
 - Leukemia
 - Cavernous angioma, capillary angioma
 - Varix

- Neurofibroma/Schwannoma
- Lymphoma
- Infection
- Metastases
- 4. Intra-ocular
 - Melanoma
 - Metastases
 - Drusen
 - Retinoblastoma
 - Retrolental fibroplasia
 - Coat's disease
 - Primary Hypertrophic Persistent Vitreous (PHPV)
 - Metastases
 - Retinal detachment
 - Infection and inflammation (endophthalmitis)
 - Phthisis bulbi
- 5. Trauma
 - Fractures of the orbital wall
 - Extra-ocular muscle entrapment
 - Orbital emphysema
 - Intra-orbital hematoma
 - Penetrating soft tissue injuries
 - Ocular - Ruptured globe, intra-ocular hemorrhage, dislocated lens
 - Foreign Body
- 6. Lacrimal Gland Tumors
 - Epithelial
 - Pleomorphic adenoma
 - Carcinomas
 - Lymphoma
 - Dermoid
 - Metastases

III. Spinal Imaging

- A. Trauma
 1. Mechanisms of injury
 2. Stable fractures and ligamentous injuries
 - Compression fracture
 - Isolated anterior column
 - Isolated posterior column
 - Unilateral locked facet
 - Hyperextension, teardrop
 - Clay Shoveler's (Spinous process C7)
 3. Unstable injuries (Involvement of the middle column and ligaments)
 - Hyperflexion teardrop
 - Facet joint disruption and dislocation (bilateral locked facets)
 - Hyperflexion ligamentous injury without fracture

- Odontoid fracture
- Distraction fracture (Hangman's) (C2/C3)
- Chance
- Burst
- 4. Traumatic disc herniation
- 5. Extrinsic cord compression
- 6. Cord contusion
- 7. Intra-spinal hemorrhage
 - Epidural hematoma (EDH)
 - Subdural hematoma (SDH)
 - SAH Subarachnoid hemorrhage (SAH)
 - Cord hematoma (hematomyelia)
- 8. Post-traumatic abnormalities
 - Instability with spondylolisthesis
 - Syringomyelia
 - Arachnoiditis
 - Pseudomeningocele and root avulsion
- B. Degenerative disease
 1. Disc degeneration
 2. End plate degeneration
 3. Disc herniation
 4. Facet arthritis
 5. Ligamentous degeneration
 6. Spinal stenosis
 7. Post-operative changes
 - Epidural scar
 - Arachnoiditis
 - Recurrent herniation or stenosis
- C. Inflammatory, Infectious, and Demyelinating Disease
 1. Discitis/osteomyelitis
 - Acute
 - Epidural and paravertebral abscess
 - Chronic discitis
 - Vertebral body tuberculosis
 2. Meningitis
 3. Abscess, granuloma
 4. Transverse myelitis/ADEM
 5. Multiple Sclerosis
- D. Neoplastic Disease
 1. Osseous
 - Hemangioma
 - Osteoid Osteoma/Osteoblastoma
 - Chondroid tumors
 - Giant Cell
 - Aneurysmal Bone Cyst (ABC)
 - Chordoma

- Osteosarcoma
- Chondrosarcoma
- Metastases
- Lymphoma
- Myeloma
- Leukemia
- 2. Extradural
 - Neurofibroma
 - Lymphoma
 - Metastases
- 3. Intradural extramedullary
 - Meningioma
 - Schwannoma
 - Neurofibroma
 - Dermoid
 - Lipoma
 - Epidermoid
 - Metastases (Carcinomatous Meningitis)
 - Lymphoma
- 4. Intramedullary
 - Ependymoma
 - Astrocytoma
 - Hemangioblastoma
 - Metastases
 - Lymphoma
- E. Cystic lesions
 1. Meningocele
 2. Pseudo-meningocele (post-operative and post-traumatic)
 3. Perineural cysts and terminal meningocele
 4. Arachnoid cyst
 5. Hydrosyringomyelia
- F. Vascular lesions
 1. Dural arteriovenous fistula
 2. AVM
 3. Cavernous Angioma
 4. Spinal cord infarct
- G. Developmental Spine Disease
 1. Open dysraphisms
 2. Myelomeningocele
 3. Lipomyelomeningocele
 4. Myelocele
 5. Diastematomyelia
 6. Occult spinal dysraphisms
 7. Tight filum, thick filum
 8. Intradural lipoma
 9. Dorsal dermal sinus

10. Tethered cord

H. Invasive procedures

1. Myelography
2. Lumbar puncture, C1-2 puncture
3. Facet injection
4. Nerve root block
5. Biopsy
6. Vertebroplasty/Kyphoplasty

General Competencies: Neuroradiology

Patient Care

Residents must be able to provide patient care that is compassionate, appropriate and effective for the diagnosis and treatment of health problems. Residents are expected to:

- communicate effectively and demonstrate caring and respectful behaviors when interacting with patients and their families
- gather essential and accurate medical and radiologic history pertinent to the procedure for which the patient is scheduled or for the examination that the patient has had.
- work with health care professionals, including those from other disciplines to provide patient-focused care

Assessment by direct faculty and staff observation and reported by faculty and staff evaluation forms

Medical Knowledge

Residents must demonstrate knowledge about established and evolving clinical and research sciences and the application of this knowledge to patient care. During this rotation, residents are expected to:

- learn the normal anatomy and basic anatomic variants of the central nervous system, head and neck, and spine
- gain a thorough knowledge of normal anatomy and basic normal variants of the central nervous system, head and neck, and spine
- learn to interpret the anatomic and pathologic features of CT, MR, and angiographic studies of the central nervous system, head and neck, and spine
learn the radiographic manifestations of common diseases that affect the central nervous system and structures of the head and neck and spine
- enhance knowledge of the physical principles underlying CT, MR, and fluoroscopy
- gain a thorough understanding of the appropriate indications, limitations and contraindications to MRI, CT, angiographic, and radiographic studies of the central nervous system, head and neck, and spine
- demonstrate the ability to apply this knowledge to appropriately protocol imaging studies of the central nervous system, head and neck, and spine for all modalities

- develop a thorough knowledge of the indications for and risks of cerebral angiography, myelography, and other image-guided percutaneous procedures of the head and neck and spine
- gain basic experience in the performance of cerebral angiography, myelography, and other image-guided percutaneous procedures of the head and neck and spine

Assessment by faculty observation and evaluation forms, in-service examination, pre-call quiz.

Practice-Based Learning and Improvement

Residents must be able to investigate and evaluate their patient care practices, appraise and assimilate scientific evidence, and improve their patient care practices. Residents are expected to:

- apply knowledge of study designs and statistical methods to the effective clinical use of CT, MR, and angiographic neuroradiological studies
- use information technology to manage information, access on-line medical information, and support their own education
- facilitate the learning of students and other health care professionals (medical students and residents from other disciplines will periodically rotate through Neuroradiology)
- locate, appraise, and assimilate evidence from scientific studies
- maintain a personal procedure log
- demonstrate knowledge and use of medical informatics in patient care and education

Assessment by direct faculty and staff observation and reported by faculty and staff evaluation forms

Interpersonal and Communication Skills

Residents must be able to demonstrate interpersonal and communication skills that result in effective information exchange with technologists, referring physicians, and other medical personnel. Residents are expected to:

- have full command of terminology used to describe imaging techniques and findings relating to the central nervous system, head and neck, and spine
- interact effectively and sensitively with patients and with family members of patients when explaining diagnostic and invasive imaging studies, answering questions, obtaining informed consent, and explaining study results

- work professionally and effectively with other health care professionals, including technologists, secretaries, schedulers, nurses, students, residents, and physicians
- communicate findings effectively to referring physicians
- communicate and document the communication of critical findings with the appropriate medical personnel in a timely fashion

Assessment by direct faculty and staff observation and reported by faculty and staff evaluation forms

Professionalism

Residents must demonstrate a commitment to carrying out professional responsibilities, adherence to ethical principles, and sensitivity to a diverse patient and professional population. Residents are expected to:

- demonstrate respect and compassion for all
- maintain an appropriate professional demeanor
- demonstrate a commitment to excellence and on-going educational and professional development
- demonstrate a commitment to ethical principles pertaining to provision or withholding of clinical care, confidentiality of patient information, and business practices
- demonstrate sensitivity and responsiveness to patients' culture, age, gender, and disabilities
- display appropriate grooming and dress habits

Assessment by direct faculty and staff observation and reported by faculty and staff evaluation forms

Systems-Based Practice

Residents must demonstrate an awareness of and responsiveness to the larger context and system of health care and the ability to effectively call on system resources to provide care. Residents are expected to:

- understand how their professional practice affects other health care professionals, the health care organization, and the larger society
- assist referring clinicians in providing cost-effective health care
- practice cost-effective health care and resource allocation that does not compromise quality of care

Assessment by direct faculty and staff observation and reported by faculty and staff evaluation forms

Neuroradiology Resident Rotation-Specific Training Goals and Objectives

First-year rotation

Patient Care

- Learn to explain the risks and benefits of contrast enhanced CT/MR to the patient. Learn appropriate techniques for injection of contrast (including use of power injectors). Learn to recognize and treat contrast reactions.
- Learn to explain the risks and benefits of moderate sedation for diagnostic imaging studies.
- Learn to use the clinical information system to obtain information about patients relevant to the performance and interpretation of their imaging studies
- Learn to obtain information from other health care professionals relevant to the performance and interpretation of patient imaging studies
- Learn the risks of medical radiation in neuroimaging

Medical Knowledge

- Become familiar with imaging parameters, including window and level settings, slice thickness, inter-slice gap, and helical imaging parameters, and image reconstruction algorithms (e.g., soft tissue and bone). Learn the typical CT density of commonly occurring processes such as edema, air, calcium, blood, and fat.
- Learn the basic physical principles of MR. Be able to identify commonly used pulse sequences and become familiar with standard MR protocols. Learn the intensity of normal tissues on routine pulse sequences.
- Become familiar with the appearance of major intracranial structures as visualized on axial CT and MR scans. Be able to identify all major structures and components of the brain, ventricles, and subarachnoid spaces.
- Learn to interpret CT scans of the head with a particular emphasis on studies performed on individuals with acute or emergent clinical abnormalities (e.g., infarction, intracerebral hemorrhage, subarachnoid hemorrhage, traumatic brain injury, infection, hydrocephalus, and brain herniation).
- Learn the imaging anatomy of the calvarium, skullbase and soft tissues of the neck.
- Identify the major anatomic subsites of the aerodigestive tract (oral cavity,

oropharynx, hypopharynx, larynx) and anatomic compartments of the soft tissues (carotid space, parapharyngeal space, parotid space, etc)

- Learn to identify acute abnormalities of the face, skull base, and neck (e.g., neck abscess, mastoiditis, orbit hematoma, skull fracture, airway compromise) on radiographs and CT
- Become familiar with the normal appearance of the spine on plain radiographs and CT scans. Be able to assess spine alignment and be able to identify all osseous components of the spinal canal.
- Learn to interpret radiographs and CT scans of the spine with a particular emphasis on studies performed in the setting of acute trauma.
- Observe the performance of diagnostic angiograms of the cervical and cranial vessels
- Learn to identify the large vessels of the neck and head (carotid, vertebral and basilar arteries, jugular veins, and dural venous sinuses) as they appear on CT and MR studies of the head and neck.
- Learn to identify steno-occlusive disease of the major arteries of the head and neck.
- Learn to perform fluoroscopically guided punctures of the lumbar spinal canal for the purpose of myelography, spinal fluid collection, and intrathecal injection of medications
- Learn to recognize the normal appearance of the brain, spine and head & neck encountered in the newborn, infant and child. Be able to identify the features of hydrocephalus on cross sectional imaging studies.
- Begin to develop an understanding of the relative strengths and weaknesses of neuroimaging studies
- Begin to learn how to protocol CT studies for specific indications
- Read one of the recommended initial Neuroradiology texts in its entirety

Interpersonal and Communication Skills

- Learn the terminology necessary to explain neuroimaging studies to health care providers and patients
- Learn how to present a coherent description of the patient's clinical problems and relevant past medical history, prior to image interpretation.
- Learn how to create a clear, concise, and informative radiology report
- Learn how to take urgent requests for imaging studies from referring physicians
- Become aware of the ACR practice guideline for communication (*acr.org*).
- Learn how to provide direct communication to the referring physician when there is an urgent or unexpected finding and document this communication in the report.
- Learn the names and roles of physicians, nurses, technologists, administrators, and secretaries in the Neuroradiology division

Professionalism

- Report to the neuroradiology division on time
- Attend all neuroradiology conferences.

- Approach work with a positive attitude, treating each patient's study or procedure as if it were the study of a valued friend
- Display proper grooming and dress habits.
- Maintain an appropriate professional demeanor.
- Demonstrate professional values and ethical behaviors, including integrity, honesty, compassion and sensitivity to patient concerns. Serve as a role model for medical students and residents in other specialties.

Practice Based Learning

- Contribute to the Neuroradiology Interesting case log
- Follow up on unknown or interesting cases and report what you've learned at the weekly interesting case conference
- Read nightly on at least one imaging finding seen during the day

Systems Based Practice

- Begin to become familiar with the Neuroradiology ACR Appropriateness Criteria.
- Begin to understand the relative costs of the various neuroimaging procedures
- Learn basic principles of cost effectiveness

Second-year rotation

Patient Care

- Demonstrate ability to treat contrast reactions and arrange follow-up clinical evaluation
- Demonstrate ability to treat oversedation
- Routinely use clinical information system to obtain information about patients relevant to the performance and interpretation of their imaging studies
- Independently obtain information from other health care professionals relevant to the performance and interpretation of patient imaging studies
- Be able to modify imaging protocols based on identification of unexpected or novel findings. Provide provisional interpretations and consultations of plain radiographs and CT scans performed in the Emergency Department.

Medical Knowledge

- Improve knowledge of CT artifacts
- Learn the principles necessary to explain signal intensity on basic MR pulse sequences. Learn to identify common MR artifacts.
- Gain more detailed knowledge of intracranial structures on CT and MR scans. Be able to identify all visible structures of the brain
- Improve ability to interpret CT scans of the head including acute, subacute, and chronic processes.

- Develop complete differential diagnoses for most head CT findings especially those related to acute infarction and intracranial hemorrhage.
- Become familiar with the complex anatomy of the orbit, temporal bone, and skullbase on CT
- Be able to characterize facial fractures based on clinical classification systems (e.g., Le Fort fractures).
- Learn to identify neoplastic masses arising in the orbit, skull base, petrous bone and soft tissues of the neck. Be able to use the standard anatomic classification schemes to accurately describe the location of mass lesions.
- Learn the imaging anatomy of the spine on MRI.
- Learn the CT, MRI and myelographic findings of spinal cord compression.
- Be able to accurately localize and characterize degenerative disorders of the spine (e.g., disc herniation, facet arthropathy)
- Participate in the performance of diagnostic angiograms of the cervical and cranial vessels. Learn safe femoral arterial access.
- Learn to identify the large vessels of the neck and head (carotid, vertebral and basilar arteries, jugular veins, and dural venous sinuses) as they appear on angiographic studies.
- Learn the indications, limitations, risks and benefits of techniques used for visualization of vascular anatomy and pathology.
- Learn to identify aneurysms and vascular malformations of the central nervous system.
- Learn to recognize the appearance of ischemic, and traumatic disease of the the brain, spine and head & neck encountered in the newborn, infant and child.
- Describe anatomic subsites of the oral cavity, oropharynx, larynx and hypopharynx
- Learn differential diagnosis of common cystic and solid neck masses based on location and imaging characteristics.
- Strengthen understanding of the relative strengths and weaknesses of CT, MRI, angiography, and myelography in evaluation of the central nervous system
- Assist senior residents, fellows, and faculty in the performance of image-guided biopsies. Be able to perform myelography under the supervision of an attending radiologist.
- Master protocoling of CT studies for specific indications

Interpersonal and Communication Skills

- Be able to completely explain the neuroimaging studies to be performed to the patient, providing the opportunity for the patient to ask questions. Be able to answer most questions in a complete and clear fashion.
- Master ability to present a coherent description of the patient's clinical problems and relevant past medical history, prior to image interpretation.
- Learn how to create a clear, concise, and informative radiology reports

- Begin to learn how to provide advice for referring physicians asking questions about CT and MR examinations of the central nervous system, head and neck, and spine

- Learn the ACR practice guideline for communication.
- Demonstrate proficiency in providing direct communication to the referring physician when there is an urgent or unexpected finding and document this communication in the report.
- Interact effectively with physicians, nurses, technologists, administrators, and secretaries in the Neuroradiology division

Professionalism

- Report to the neuroradiology division on time and organize the day's activities
- Attend all neuroradiology conferences.
- Understand the ethical issues pertinent to the practice of neuroradiology, including patient confidentiality, informed consent and proper documentation.
- Increase personal efficiency in the protocoling and interpretation of imaging studies
- Approach work with a positive attitude, treating each patient's study or procedure as if it were the study of a valued friend
- Display proper grooming and dress habits.
- Maintain an appropriate professional demeanor.
- Demonstrate professional values and ethical behaviors, including integrity, honesty, compassion and sensitivity to patient concerns. Serve as a role model for medical students and residents in other specialties.

Practice Based Learning

- Contribute to the Neuroradiology Interesting case log
- Follow up on unknown or interesting cases and report what you've learned at the weekly interesting case conference
- Read nightly on at least one imaging finding seen during the day

Systems Based Practice

- Understand the Neuroradiology ACR Appropriateness Criteria.
- Know the relative costs of the most common neuroimaging procedures
- Apply principles of cost effectiveness in coordinating care for patients

Third-year rotation

Patient Care

- Demonstrate the ability to screen patients for contraindications to MRI

- Routinely use clinical information system to obtain information about patients relevant to the performance and interpretation of their imaging studies
- Evaluate requested neuroimaging studies to determine if there is an appropriate indication for the study requested. If necessary, be able to suggest alternatives to the referring physician.
- Independently obtain information from other health care professionals relevant to the performance and interpretation of patient imaging studies
- Be able to modify imaging protocols based on identification of unexpected or novel findings.
- Provide provisional interpretations and consultations of radiographs, CT scans, and MRI studies performed in the Emergency Department.
- Provide excellent periprocedure patient evaluation and care for all invasive studies.

Medical Knowledge

- Learn the principles necessary to explain signal intensity on most MR pulse sequences. Learn to identify most MR artifacts.
- Learn the most important issues relevant to imaging of the central nervous system, head and neck, and spine in common clinical scenarios.
- Gain more detailed knowledge of intracranial structures on CT and MR scans. Be able to identify subdivisions and fine anatomic details of the brain (gray matter structures, white matter tracts), the ventricles, subarachnoid space, vascular structures, skullbase, and cranial nerves.
- Improve ability to interpret CT scans of the head including acute, subacute, and chronic processes.
- Develop complete differential diagnoses for brain MRI findings especially those related to acute infarction and intracranial hemorrhage.
- Expand knowledge of nonneoplastic lesions in the orbit, skull base, petrous bone and soft tissues of the neck. Be able to identify all key structures and have knowledge of established anatomic classification systems for each area.
- Be able to accurately localize (Intramedullary, extramedullary intradural, and extradural) and characterize tumors and vascular disorders of the spine
- Participate in the performance of diagnostic angiograms of the cervical and cranial vessels. Learn safe femoral arterial access.
- Learn to identify more detailed angiographic anatomy of the vessels of the neck and head (ICA, ECA, and vertebrobasilar branches) as they appear on angiographic studies.
- Describe staging of head and neck tumors based on anatomic location
- Improved ability to identify aneurysms and vascular malformations of the central nervous system. Learn complex patterns of abnormality seen in Moya-Moya disease, vasculitis, and arteriovenous fistulas
- Learn to recognize the appearance of common malformations and neoplasms of the brain, spine and head & neck encountered in the newborn, infant and child.

- Strengthen understanding of the relative strengths and weaknesses of CT, MRI, angiography, and myelography in evaluation of the central nervous system
- Assist fellows and faculty in the performance of image-guided biopsies. Be able to perform myelography under the supervision of an attending radiologist.
- Begin to learn how to protocol MRI examinations of the central nervous system, head and neck, and spine
- Begin to learn the post processing of CT and MR angiograms

Interpersonal and Communication Skills

- Begin to be able to completely explain the results of neuroimaging studies to patients
- Learn how to create a clear, concise, and informative radiology reports
- Learn how to provide advice for referring physicians asking questions about CT and MR examinations of the central nervous system, head and neck, and spine
- Demonstrate increasing proficiency in providing direct communication to the referring physician when there is an urgent or unexpected finding and document this communication in the report.
- Interact effectively with physicians, nurses, technologists, administrators, and secretaries in the Neuroradiology division

Professionalism

- Report to the Neuroradiology division on time and organize the day's activities
- Attend all Neuroradiology conferences.
- Understand the ethical issues pertinent to the practice of neuroradiology, including patient confidentiality, informed consent and proper documentation.
- Increase personal efficiency in the protocoling and interpretation of imaging studies
- Approach work with a positive attitude, treating each patient's study or procedure as if it were the study of a valued friend
- Display proper grooming and dress habits.
- Maintain an appropriate professional demeanor.
- Demonstrate professional values and ethical behaviors, including integrity, honesty, compassion and sensitivity to patient concerns. Serve as a role model for medical students, junior Radiology residents, and residents in other specialties.

Practice Based Learning

- Contribute to the Neuroradiology Interesting case log

- Follow up on unknown or interesting cases and report what you've learned at the weekly interesting case conference
- Read nightly on at least one imaging finding seen during the day
- Maintain a procedure log of the invasive procedures that you have performed in a computerized database. Minor and major complications of procedures must be logged into the database

Systems Based Practice

- Understand the Neuroradiology ACR Appropriateness Criteria.
- Know the relative costs of the most neuroimaging procedures
- Apply principles of cost effectiveness in coordinating care for patients

Fourth-year rotation

Patient Care

- Independently and consistently use clinical information system to obtain all information about patients relevant to the performance and interpretation of their imaging studies
- Evaluate requested neuroimaging studies to determine if there is an appropriate indication for the study requested. If necessary, be able to suggest alternatives to the referring physician.
- Be able to modify imaging protocols based on identification of unexpected or novel findings.
- Provide provisional interpretations and consultations of radiographs, CT scans, and MRI studies performed in the Emergency Department.
- Provide excellent peri-procedure patient evaluation and care for all invasive studies.

Medical Knowledge

- Learn the principles necessary to explain signal intensity on all MR pulse sequences. Learn to identify all MR artifacts.
- Learn the most important issues relevant to imaging of the central nervous system, head and neck, and spine in most clinical scenarios.
- Improve ability to interpret CT scans of the head including acute, subacute, and chronic processes.
- Develop the ability to use imaging findings to differentiate different types of focal intracranial lesions (neoplastic, inflammatory, vascular) based on anatomic location, contour, intensity and enhancement pattern. Learn to identify and differentiate diffuse intracranial abnormalities. Learn to recognize treatment related findings (e.g. post surgical and postradiation). Become familiar with the utility of Diffusion/Perfusion imaging, diffusion tensor imaging, functional MR and MR spectroscopy.

- Be able to provide focused and accurate differential diagnoses for lesions in the orbit, skull base, petrous bone and soft tissues of the neck. Understand and be able to identify patterns of disease spread within and between areas of the head and neck (e.g. perineural and nodal spread). Learn to recognize treatment related findings (post-surgical and post radiation).
- Be able to provide focused and accurate differential diagnoses for Intramedullary, extramedullary intradural, and extradural lesions of the spine. Learn to identify and differentiate congenital malformations of the spine
- Participate in the performance of diagnostic angiograms of the cervical and cranial vessels. Learn basics of safe catheter manipulation. Learn the appropriate dose of contrast material for angiography of each vessel. Learn the angiographic protocols for the evaluation of a variety of disease processes (e.g., aneurysmal subarachnoid hemorrhage). Learn to recognize complications of these procedures and to initiate appropriate treatment.
- Know the detailed angiographic anatomy of the vessels of the neck and head.
- Be able to provide focused and accurate differential diagnoses for most angiographic findings. Learn the indications, risks and benefits for neurointerventional procedures including thrombolysis, embolization, angioplasty and stenting.
- Learn to recognize the appearance of acquired lesions (traumatic, ischemic, inflammatory and neoplastic) of the newborn, infant, child and adolescent.
- Know the relative strengths and weaknesses of CT, MRI, angiography, and myelography in evaluation of the central nervous system
- Serve as primary operator in the performance of image-guided biopsies under the supervision of an attending radiologist.
- Learn how to protocol complex MRI examinations of the central nervous system, head and neck, and spine, including the use of fat suppression, saturation bands, magnetization transfer
- Be able to perform postprocessing of CT and MR angiograms

Interpersonal and Communication Skills

- Learn to completely explain the results of neuroimaging studies to patients
- Master the creation of clear, concise, and informative radiology reports
- Learn how to provide advice for referring physicians asking questions about CT and MR examinations of the central nervous system, head and neck, and spine
- Demonstrate increasing proficiency in providing direct communication to the referring physician when there is an urgent or unexpected finding and document this communication in the report.
- Interact effectively with physicians, nurses, technologists, administrators, and secretaries in the Neuroradiology division

Professionalism

- Report to the Neuroradiology division on time and organize the day's activities
- Attend all Neuroradiology conferences.
- Understand the ethical issues pertinent to the practice of neuroradiology, including patient confidentiality, informed consent and proper documentation.
- Increase personal efficiency in the protocoling and interpretation of imaging studies, reaching levels needed for independent practice
- Approach work with a positive attitude, treating each patient's study or procedure as if it were the study of a valued friend
- Display proper grooming and dress habits.
- Maintain an appropriate professional demeanor.
- Demonstrate professional values and ethical behaviors, including integrity, honesty, compassion and sensitivity to patient concerns. Serve as a role model for medical students, junior Radiology residents, and residents in other specialties.
- Act as a consultant to junior radiology residents.
- Learn to identify those cases that require the additional expertise in assessment of imaging studies.

Practice Based Learning

- Contribute to the Neuroradiology Interesting case log
- Follow up on unknown or interesting cases and report what you've learned at the weekly interesting case conference
- Review published literature on advanced neuroradiology topics encountered during patient care
- Maintain a procedure log of the invasive procedures that you have performed in a computerized database. Minor and major complications of procedures must be logged into the database

Systems Based Practice

- Understand the Neuroradiology ACR Appropriateness Criteria.
- Know the relative costs of the most neuroimaging procedures
- Apply principles of cost effectiveness in coordinating care for patients

Educational Program: Neuroradiology

Daily case review

The resident on the neuroradiology rotation is expected to review 15-20 CT or MR imaging cases per day. For each case they will learn the relevant clinical history, independently review the imaging study, compare the imaging study to relevant prior studies, and formulate an interpretation of the study. They will then review each study with an attending neuroradiologist. Faculty neuroradiologists are expected to use this time for one-on-one teaching relevant to the clinical case material and imaging techniques. The resident will report critical findings to the necessary persons. They will dictate the imaging report and edit the transcribed report for accuracy. Neuroradiology faculty will evaluate the reports and provide constructive criticism. Similar case review occurs daily for residents supervising on-call emergency studies of the central nervous system, head and neck, and spine.

Invasive Procedures

The resident on the neuroradiology rotation is expected to assist in invasive diagnostic and therapeutic procedures under the direct supervision of a neuroradiology faculty member. The residents are given graduated responsibility in the performance and interpretation of these procedures. Responsibility for procedures includes pre-procedure patient management, including review of the clinical history, performance of relevant physical examination, and review laboratory and imaging studies. Delegation of procedures is conducted by neuroradiology fellow. The pre-procedure workup will be directly supervised by neuroradiology faculty or fellow and the plan discussed. Post-procedure evaluation will similarly performed and supervised. The trainee is required to maintain a procedure log of the invasive procedures that they have performed. The resident is to participate in department QA activities.

Didactic Neuroradiology Conference

All residents attend the didactic Neuroradiology lectures given by the Neuroradiology faculty. These lectures occur from 12:15-1 pm as part of the Radiology Department lecture series. A total of 36 such conferences are given each year. The curriculum follows a two-year cycle and includes both didactic lectures and case conferences at which resident participation is required

Didactic lectures given in the past two years include:

- Neuroanatomy
- Cerebrovascular anatomy and imaging
- Craniocerebral trauma
- CNS Infections
- Intra-axial brain tumors
- Extra-axial brain tumors
- Pediatric Brain Tumors
- Sella and parasellar Lesions
- Basal ganglia lesions

- Functional MRI
- Brain attack
- Congenital malformations
- Cerebrovascular intervention
- Vascular Malformations
- Hydrocephalus
- Spine Anatomy and Congenital Anomalies
- Extradural spine lesions
- Intramedullary spine lesions
- Spine tumors
- Spine Trauma
- Degenerative Disease of the spine
- Vertebroplasty and kyphoplasty
- Cystic Neck Masses
- Solid neck masses
- Head and Neck malignancies
- Salivary Glands
- Temporal Bone anatomy and pathology
- Inflammatory sinonasal pathology
- Sinonasal neoplasms
- The Orbit

In addition, an ENT lecture is given on the 3rd Friday of every month at 7:15 am. Attendance is mandatory.

Other conferences

The neuroradiology resident is required to attend the following educational conferences

- Neuroradiology case review (weekly)
- Cerebrovascular conference (weekly)
- Pediatric neuroradiology conference (biweekly)
- Neuroradiology journal club (periodic)

Other conferences attended by neuroradiology faculty that the residents are encourage to attend

- Neuro-oncology tumor board
- Endocrinology conference
- Epilepsy conference
- Head and neck tumor board
- Neurology megarounds
- Neurology grand rounds

Reading Materials

Initial texts:

Osborn's Brain: Imaging, Pathology and Anatomy
AG Osborn. 2012

Neuroradiology: The Requisites.
RI Grossman, DM Yousem. 3rd ed. Mosby; 2016

Diagnostic Imaging: Head and Neck.
R Harnsberger, P Hudgins, R Wiggins, C Davidson. 2nd ed. Salt Lake City: Amirsys;
2010

Neuroradiology Cases. C Eskey, C Belden, D Pastel, A Vossough, A Yoo. Oxford. 2012.

Reference texts:

Clinical Magnetic Resonance Imaging [for MR physics chapters in vol 1].
RR Edelman, J Hesselink, M Zlatkin. 3rd ed. Saunders; 2005

Practical Neuroangiography

P Morris. 3rd Lippincott Williams & Wilkins; 2013

Magnetic Resonance Imaging of the Brain and Spine

SW Atlas. 4th ed. Lippincott Williams & Wilkins; 2008

Pediatric Neuroimaging

AJ Barkovich. 5th ed. Lippincott Williams & Wilkins; 2011

Head and Neck Imaging

PM Som, HD Curtin. 5th ed. Mosby; 2011

ONLINE resources:

RAD Primer strongly encourage for junior residents