

FOURTH YEAR (R4)

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Should also review everything in the R1 – R3 curriculum

I. TECHNIQUE AND INDICATIONS

1. Review to ensure independent proficiency (R4 – 1 month)
 - a. Obtaining informed consent
 - b. Overseeing conscious sedation
2. Independently perform (with appropriate supervision) (R4 – 1 month)
 - a. Lumbar Punctures
 - b. Myelography
 - c. Cisternography
3. Post-Processing (R4 – 3 month)
 - a. Continue proficiency at creating 3D reformats for CT and MRI
 - b. Continue proficiency at processing MR perfusion images
 - c. Become familiar with DTI tractography
4. Contrast – Be familiar with the following (R4 – 3 month)
 - a. Macrocyclic vs. linear gadolinium agents
 - b. Relaxivity
5. Observe and participate in spine biopsies (R4 – 6 month)
6. Develop more in depth knowledge of advanced MRI techniques (R4 - 6 month)
 - a. MR perfusion (further knowledge for use in neoplasms and stroke; specifically distinguish recurrent high grade glioma from radiation necrosis)
 - b. MR spectroscopy (NAA, Choline, lactate)
 - c. Susceptibility weighted imaging
7. Develop more in depth knowledge of CT techniques
 - a. Dual energy CT (technique and applications) (R4 – 6 month)
 - b. Radiation dose reduction (R4 – 6 month)

II. ANATOMY

1. General
 - a. Be proficient with anatomy in the brain, spine, head & neck in appropriate depth on multi-planar and multi-modality images and especially be able to interrogate 3D image volumes to identify small structures. (R4 – 1 month)
2. Brain
 - a. Be proficient with cortical anatomy in the eloquent regions (motor/sensory cortex – identify central sulcus, pre- and post-central gyri, superior and middle frontal gyri, superior frontal sulcus; Broca’s area – inferior frontal gyrus including pars triangularis and pars opercularis; Wernicke’s area – superior and middle temporal gyri, superior temporal sulcus) (R4 - 3 months)
 - b. Review more global gyral and sulcal anatomy (R4 - 6 months) (i.e., cingulate gyrus, angular gyrus, cuneus, calcarine sulcus, parahippocampal gyrus)

3. Head & Neck
 - a. Name and recognize the anatomy of the spaces of the neck to include the nasopharynx, oropharynx, hypopharynx, oral cavity, larynx, prevertebral space, carotid space, parotid space, masticator space, pharyngeal mucosal space, parapharyngeal space. (R4 – 1 month)
 - b. Be proficient with anatomy of the skull base, sinonasal region, temporal bone, and orbits. (R4 – 3 month)
 - c. Become more familiar with the anatomical course of cranial nerves 1-12 including the 3 major divisions of CN 5. (6 months)
4. Spine
 - a. Be proficient with the pertinent craniocervical junction anatomy including ligaments such as the alar and transverse ligaments and the tectorial membrane. (R4 – 3 month)
 - b. Routinely recognize the main ligaments of the spine, including the anterior and posterior longitudinal ligaments, ligamentum flavum, interspinous ligaments, supraspinous ligament, and nuchal ligament.
 - c. Be able to anatomically localize the extradural, intradural extramedullary, and intramedullary spaces.
5. Vascular
 - a. Identify the main extra- and intracranial arteries.
 - i. Neck – Aortic arch, brachiocephalic trunk, left and right common and internal carotid arteries, the external carotid arteries and their main branches (SALFOPSM mnemonic) (R4 – 1 month)
 - ii. Head – Internal carotid arteries, anterior cerebral arteries, middle cerebral arteries, anterior communicating artery, vertebral arteries, posterior inferior and anterior inferior cerebellar arteries, superior cerebellar arteries, basilar artery, posterior cerebral arteries, posterior communicating arteries. Know the segmental anatomy of these named arteries as well as their major branches.

III. BRAIN

1. General concepts
 - a. Further develop the ability to use imaging findings to differentiate different types of focal intracranial lesions (neoplastic, inflammatory, vascular) based on anatomic location (e.g. intra- vs. extra-axial), contour, intensity and enhancement pattern. (R4 – 1 month)
 - b. Accurately identify and differentiate diffuse intracranial abnormalities (e.g. hydrocephalus versus atrophy). (R4 – 3 month)
 - c. Be able to identify and differentiate acquired lesions (traumatic, ischemic, inflammatory and neoplastic) of the newborn, infant, child, and adolescent. (R4 – 3 month)
 - d. Learn to recognize congenital lesions, malformations, and disorders of the perinatal period on CT and MR. (R4 – 6 month)

- e. Deepen knowledge of treatment related findings (e.g. post-surgical and post-radiation) and the imaging techniques to discern these scenarios. (R1 – 3 month)
 - f. Be able to access and incorporate clinical history including prescribed medications/therapies (bevacizumab) and histologic biopsy information as they impact imaging exam performance, protocol and interpretation. (R4 – 3 month)
2. Be proficient with the following scales
- a. American Society of Anesthesiologists (ASA) physical status classification system (prior to sedation) (R4 – 1 month)
 - b. Glasgow Coma Scale (GCS) (R4 – 1 month)
 - c. Alberta Stroke Program Early CT Score (ASPECTS) score (R4 – 1 month)
 - d. National Institutes of Health Stroke Scale (NIHSS) (R4 – 3 month)
 - e. Spetzler-Martin Arteriovenous (AVM) grading system (R4 – 3 month)
 - f. Hunt-Hess score (aneurysms) (R4 – 6 month)
 - g. Fisher Scale (subarachnoid hemorrhage) (R4 – 6 month)
3. Stroke
- a. Proficiency in interpretation of CT/CTA, MR/MRA, CT/MR perfusion images (R4 – 1 month)
 - b. Grade internal carotid artery stenosis using NASCET criteria. (R4 - 1 month)
 - c. Deepen familiarity with contraindications to tPA (e.g., MCA infarct greater than ½ of MCA territory, acute hemorrhage, time cut offs for IV tPA and mechanical thrombectomy) (R4 – 1 month)
 - d. Recognize patterns of acute infarction (e.g., embolic, watershed/borderzone, vasculitis, diffuse hypoxic ischemia, venous infarction) (R4 - 3 month)
 - e. Routinely identify cervical arterial stenosis in the carotid and vertebral arteries. (R4 - 3 month)
 - f. Be able to routinely process and interpret MR and CT perfusion images for acute stroke cases. (R4 – 6 month)
 - g. Confidently interact with clinical stroke team and neurointerventionalists. (R4 – 6 month)
4. Tumor
- a. Become proficient with the most recent WHO brain tumor classification (R4 – 3 month)
 - b. Comfort with conventional MR imaging with DWI, MR perfusion, MR spectroscopy in initial tumor assessment and follow-up imaging (R4 - 6 month)
 - c. Be able to list a reasonable differential for masses based on imaging appearance, location, age, sex, and clinical history (R4 – 6 month)
 - d. Interpret MR perfusion to differentiation tumor progression from radiation necrosis (R4 – 6 month)
5. Vascular

- a. Proficiently identify the correct anatomical location of aneurysms (R4- 3 month)
 - b. Be able to routinely recognize and grade AVMs, and recognize cavernous malformations, developmental venous anomalies, and capillary telangiectasias (R4 - 6 month)
 - c. Become proficient with the indications, risks and benefits for neurointerventional procedures including thrombolysis, embolization, angioplasty, and stenting. (R4 – 6 month)
 - d. Be familiar with certain etiologies of parenchymal hemorrhage (e.g., AVM, cavernous malformation, hypertension, amyloid angiopathy, primary tumors and metastases (R4 – 6 month)
6. CNS infections
- a. Comfort with diagnosing bacterial cerebral abscess and subdural empyema, recognizing source if via direct extension (e.g., paranasal sinus or mastoid temporal bone origin) (R4 – 1 month)
 - b. Broaden and deepen your knowledge of viral and atypical infections (e.g., herpes encephalitis, tuberculosis, Lyme disease, progressive multifocal leukoencephalopathy, Creutzfeldt-Jakob Disease, neurocysticercosis, coccidioidomycosis) (R4 – 3 month)
7. White matter
- a. Broaden and deepen your knowledge of demyelinating and dysmyelinating diseases – (e.g., ADEM, PML, more in depth knowledge of MS) (R4 – 3 month)
 - b. Broaden and deepen your knowledge of inherited metabolic disorders (i.e., MELAS, Alexander’s disease, Canavan’s disease) (R4 – 6 month)
 - c. Broaden and deepen your knowledge of additional white matter diseases – (e.g., central pontine myelinolysis/extrapontine myelinolysis, heroin inhalation leukoencephalopathy, X-linked adrenal leukodystrophy) (R4 – 6 month)
8. Neurodegenerative
- a. Broaden and deepen your knowledge of the more common and some of the rare neurodegenerative disorders (e.g., Alzheimer Disease, Parkinson disease, iron deposition disease, Wernicke encephalopathy, normal pressure hydrocephalus, multisystem atrophy, progressive supranuclear palsy, amyotrophic lateral sclerosis) (R4 – 6 month)
 - b. Recognize and correlate the typical patterns of Alzheimer disease on PET, MRI, and CT
9. Cranial Nerve Pathologies
- a. Differentiate cerebellopontine angle vestibular schwannoma from meningioma (R4 – 1 month)
 - b. Recognize optic nerve pathology such as optic neuritis, optic nerve glioma and meningioma. (R4 – 3 month)
 - c. Know the segments of the facial nerve and which can normally enhance (R4 – 3 month)

- d. Become proficient with the assessment of perineural spread of tumor and the connections between CNs 5 and 7 as well as their branches (R4 – 6 month)

10. Congenital/developmental

- a. Know some of the childhood causes of hydrocephalus (e.g., aqueductal stenosis, communicating hydrocephalus from infection or subarachnoid hemorrhage, choroid plexus papilloma) (R4 – 1 month)
- b. Be familiar with the phakomatoses (e.g., NF1, NF2, tuberous sclerosis, Sturge-Weber, Von Hippel-Lindau) (R4 – 3 month)
- c. Broaden and deepen your knowledge of brain malformations (e.g., schizencephaly, focal cortical dysplasia), sulcation and migrational anomalies (e.g., lissencephaly, heterotopia, polymicrogyria, holoprosencephaly spectrum) (R4 – 6 month)

IV. SPINE

1. General concepts to know

- a. Be able to localize spinal lesions to the appropriate space (extradural, intradural-extramedullary, intramedullary) and have a short differential for lesions in each space. (R4 – 1 month)
- b. Be proficient in differentiating inflammatory and neoplastic lesions. (R4 – 3 month)
- c. Broaden and deepen your knowledge of the imaging features of intraspinal processes including syringomyelia, arachnoiditis, and spinal dysraphism. (R4 – 3 month)
- d. Reliably recognize expected post-surgical findings and short term and long term complications of surgery (i.e., epidural scarring, CSF leak, phlegmon/abscess, hardware failure, non-union) (R4 – 3 month)
- e. Reliably recognize congenital lesions, malformations, and disorders of the perinatal period on CT and MR. (R4 – 6 month)
- f. Be able to integrate patient symptoms with imaging findings to discuss culprit lesions with referring clinicians and in interdisciplinary settings. (R4 – 6 month)

2. Congenital

- a. Gain more understanding of the spinal imaging findings of the phakomatoses (e.g., von Hippel-Lindau, NF2) (R4 – 6 month)
- b. Broaden and deepen your knowledge of neural tube defects (e.g., myelomeningocele, epidermoid) (R4 – 6 month)
- c. Learn more about segmentation anomalies (e.g., Klippel-Feil Spectrum, Diastematomyelia) (R4 – 6 month)

3. Degenerative

- a. Routinely use standard nomenclature and classification of lumbar disc pathology (R4 – 1 month)
- b. Differentiate disc bulge, protrusion, and extrusion (R4 – 1 month)
- c. Recognize the specific nerve root affected by degenerative lumbar disc pathology in the lateral recesses and foramina (R4 - 3 month)
- d. Be able to identify varying degrees of spinal canal stenosis, cord compression, and myelomalacia (R4 - 3 month)

- e. Know imaging features of diffuse idiopathic skeletal hyperostosis (DISH) and ossification of the posterior longitudinal ligament (OPLL) (R4 - 6 month)
4. Spine vascular/trauma
 - a. Be able to differentiate epidural hematoma, subdural hematoma, and subarachnoid hemorrhage (R4 - 1 month)
 - b. Recognize traumatic spinal cord edema and hemorrhage (R4 - 1 month)
 - c. Proficiently identify carotid and vertebral artery dissection on CT/CTA and MRI/MRA (R4 - 3 month)
 - d. Routinely identify spinal ligamentous injury (e.g., ALL, PLL, ligamentum flavum, transverse ligament, tectorial membrane) (R4 - 3 month)
 - e. Be familiar with the classification of spinal arteriovenous malformations/fistulas (types 1-4) (R4 - 6 month)
 5. Spine Infection/Inflammation
 - a. Consistently identify discitis/osteomyelitis and associated paraspinalepidural phlegmon and abscess (R4 - 1 month)
 - b. Recognize subacute combined degeneration (R4 - 3 month)
 - c. Know imaging features of ankylosing spondylitis and spinal rheumatoid arthritis (R4 - 3 month)
 - d. Recognize spinal multiple sclerosis imaging findings (R4 - 3 month)
 - e. Know imaging features of neuromyelitis optica (R4 - 6 month)
 6. Nerve plexus
 - a. Be proficient with brachial and lumbosacral plexus anatomy (R4 - 3 month)
 - b. Be proficient with brachial and lumbosacral plexus pathology (e.g., trauma, intrinsic/extrinsic tumor, infection) (R4 - 6 month)

V. HEAD AND NECK

1. General concepts to know
 - a. Identify pathologic processes on multi-planar MRI examinations. (R4 - 1 month)
 - b. Further hone the differential diagnosis of mass lesions. (R4 - 3 month)
 - c. Be able to identify landmarks and anatomic features pertinent to the operative approaches to the sella and skull base. (R4 - 3 month)
 - d. Learn to recognize post-treatment related findings (e.g. post-surgical and post-radiation). (R4 - 3 month)
 - e. Reliably identify key areas of involvement which impact cancer staging schemes. (R4 - 6 month)
 - f. Understand and be able to reliably identify patterns of disease spread within and between areas of the head and neck (e.g. perineural and nodal spread). (R4 - 6 month)
 - g. Understand and reliably recognize congenital lesions, malformations, and disorders of the perinatal period on CT and MR. (R4 - 6 month)
2. Sinonasal cavities
 - a. Describe adjacent anatomy to sinonasal tumors for pre-operative considerations (R4 - 1 month)

- b. Broaden and deepen your knowledge of invasive fungal sinusitis, allergic fungal sinusitis, sinonasal polyposis (R4 – 3 month)
 - c. Be familiar with some of the more common congenital lesions (e.g., pyriform aperture stenosis, choanal atresia) (R4 – 3 month)
 - d. Become familiar with functional endoscopic sinus surgery (FESS) (R4 – 6 month)
3. Skull base
- a. Be able to describe the components of the skull base typically involved in trauma or tumor (R4 – 1 month)
 - b. Develop a differential for lesions within and around the sella turcica (R4 – 3 month)
 - c. Be familiar with the various types of encephaloceles (R4 – 6 month)
 - d. Be able to describe the course of perineural tumor spread from primary tumor to brainstem including skull base foramina. (R4 – 6 month)
4. Orbits/Face
- a. Accurately recognize post-septal infection and abscess, invasive fungal sinusitis (R4 - 1 month)
 - b. Be proficient in recognizing and describing with zygomaticomaxillary complex (ZMC) fractures, naso-orbitoethmoid (NOE) fractures, and LaFort 1, 2, and 3 fractures. (R4 – 3 month)
 - c. Be familiar with some of the congenital lesions (e.g., coloboma, dermoid/epidermoid, persistent hyperplastic primary vitreous (PHPV)) (R4 – 3 month)
 - d. Be able to offer an ordered, appropriate differential diagnosis for orbital lesions (R4 – 6 month)
5. Temporal bone
- a. Broaden and deepen your knowledge of mastoiditis and complications (R4 – 1 month)
 - b. Have a differential diagnosis for imaging findings that could explain tinnitus and trigeminal neuralgia (R4 – 3 month)
 - c. Understand and be familiar with the utility of DWI for cholesteatoma detection and recurrence (R4 – 3 month)
 - d. Be familiar with the third window phenomenon and some of its causes (most notably superior semicircular canal dehiscence) (R4 - 6 month)
6. Suprahyoid and Infrahyoid Neck
- a. Become familiar with the imaging findings of squamous cell carcinoma, lymphoma, and minor salivary gland tumors (R4 – 3 month)
 - b. Learn about human papillomavirus (HPV) associated squamous cell carcinoma (R4 – 3 month)
 - c. Develop a differential for lesions in each of the suprahyoid neck subsites (R4 – 3 month)
 - d. Be familiar with some of the more common congenital head and neck lesions (e.g., hemangioma, venolymphatic malformation, branchial cleft cysts) (R4 - 3 month)

- e. Become familiar with the AJCC criteria for the various head and neck subsites and develop comfort in identifying the appropriate anatomy to give the correct T-stage. (R4 - 6 month)
7. Nodes
- a. Know the lymph node level classification per the American Joint Committee on Cancer (AJCC) (R4 - 6 month)
 - b. Be familiar with the up to date AJCC cancer staging system for nodal metastatic disease from head and neck cancer (R4 - 6 month)
8. Post-surgical/Post-treatment Neck
- a. Recognize expected post-operative changes (R4 - 3 month)
 - b. Recognize expected post-radiation changes on CT and MRI (R4 - 3 month)
 - c. Identify post-operative complications (R4 - 3 month)
 - d. Be able to identify post-operative tumor recurrence on CT and MRI (R4 - 6 month)
9. Become familiar with the following scales
- a. Keros Classification (R4 - 6 month)
 - b. AJCC lymph node classification as above (R4 - 6 month)
 - c. AJCC criteria for the various head and neck subsites for T and N staging as above (R4 - 6 month)