

Neuroimaging Core Curriculum

Program Content

The purpose of the training program is to prepare the physician for the independent practice of neuroimaging. Neuroimaging is the subspecialty of Neurology dedicated to the study of the structure and function of the nervous system with techniques that provide an anatomical rendition, both static and dynamic, of the nervous system and related structures, information on the physiology of the cerebral circulation, or information on the anatomic distribution over time of biological compounds in the nervous system and related structures. Neuroimaging techniques currently include mainly x-ray angiography, computed tomography, nuclear magnetic resonance, ultrasound, positron emission tomography, single photon emission computed tomography and near infra-red spectroscopy. Emphasis is placed on the correlation of the clinical data with information derived from the various methods used to image and evaluate the nervous system and related structures (integrated neuroimaging) and on the updating of algorithms leading to a cost effective and efficient use of imaging modalities for the diagnosis and treatment of the different disorders of the nervous system.

This training must be based on supervised neuroimaging work with increasing responsibility for the selection, performance and interpretation of neuroimaging procedures. It must have a foundation of organized instruction in basic neuroscience, particularly as it relates to neuroanatomy, cerebral hemodynamics and neurobiochemistry. It should also include instruction in physics, applied to the neuroimaging procedures used in the program.

A. Goals

The goals of the Neuroimaging Fellowship are to provide the trainee with the opportunity to develop diagnostic, procedural, and technical skills essential to the performance of neuroimaging, including:

- a. To gain knowledge in the technical aspects of imaging
- b. To gain clinical experience in interpretation of images
- c. To gain competence in the independent performance of Neuroimaging

B. Objectives

The objectives of the Neuroimaging Fellowship are:

- a. To understand in the technical aspects of imaging and be able to apply this knowledge in the clinical setting
- b. To gain the ability to independently interpret neuroimages and express that interpretation in a complete, clear, organized, and accurate report

CORE CONTENT

I. Technical Aspects/Physics

A. *X-Computed Tomography*

1. X-ray production
2. Collimation
3. Interaction of X-ray in tissue
4. CT radiation safety
5. CTA
6. CT contrast agents
7. CT artifacts
8. CT perfusion
9. Patient issues and practical application of CT

B. Magnetic Resonance Imaging

1. MRI hardware and safety
2. Electricity and nuclear magnetism
3. Radiofrequency pulse sequences
4. MRI signals and parameters
5. Fourier transforms
6. Conventional spin-echo technique
7. Gradient-echo technique
8. Fast spin-echo and fast imaging
9. Echo planar imaging
10. MR angiography
11. MRI Contrast agents
12. MRI artifacts
13. MR spectroscopy
14. Diffusion and perfusion MRI
15. Patient issues and practical application of MRI and related techniques

C. *Nuclear Medicine*

1. General principles of SPECT imaging
2. General principles of PET imaging

D. Catheter angiography

1. Technical aspects relevant to the interpretation of catheter angiography

II. Clinical Aspects/Applications:

A. Primary Tumors/Masses/Cysts

1. Astro-Glial (Glioma)
 - i. Astrocytoma
 - ii. Choroid plexus papilloma
 - iii. Ependymoma/Subependymoma
 - iv. Glioblastoma multiforme
 - v. Gliomatosis cerebri
 - vi. Oligodendroglioma
2. Germ Cell
 - i. Germinoma
 - ii. Teratoma
3. Maldevelopmental
 - i. Craniopharyngioma
 - ii. Lipoma
4. Meningeal
 - i. Meningioma
5. Mesenchymal and Lymphoreticular
 - i. Hemangioblastoma
 - ii. Hemangiopericytoma
 - iii. Lymphoma
6. Neuronal Origin
 - i. Ganglioglioma
 - ii. Hamartoma
 - iii. Neurocytoma
7. PNET
 - i. Esthesioneuroblastoma
 - ii. Medulloblastoma
8. Peripheral Nervous System
 - i. Neurofibroma
 - ii. Schwannoma (neuroma)
9. Regional Neoplasms
 - i. Pineoblastoma
 - ii. Pineocytoma
 - iii. Pituitary adenoma
10. Non-neoplastic Cysts
 - i. Arachnoid (leptomeningeal) cyst
 - ii. Colloid cyst
 - iii. Dermoid
 - iv. Epidermoid
 - v. Neuroepithelial (neuroglial) cyst
 - vi. Pineal cyst
 - vii. Rathke's cleft
11. Spinal tumors
 - i. Intramedullary

- ii. Extramedullary/intradural
 - iii. Extramedullary/extradural
12. Other tumors

B. Metastatic Disease

- 1. Brain/spinal parenchymal metastases.
- 2. Calvarial and meningeal metastases
- 3. Extra-axial spinal metastases

C. *Cerebrovascular Diseases*

1. Ischemic

- i. Thromboembolism
- ii. Atherosclerotic Lesions
 - 1. Extracranial
 - 2. Intracranial
- iii. Borderzone infarction
- iv. Lacunar syndromes
- v. Venous thrombosis
- vi. Arterial dissection
- vii. Periventricular and subcortical white matter disease
- viii. Hypertensive encephalopathy/Reversible Posterior Encephalopathy Syndrome

2. *Hemorrhagic*

- i. Intraparenchymal Hemorrhage
- ii. Subdural Hemorrhage
- iii. Subarachnoid Hemorrhage
- iv. Aneurysms
 - 1. Saccular, Giant
 - 2. Dolichoectasia
- v.. Vascular malformations
 - 1. Arteriovenous malformations
 - 2. Cavernous malformations
 - 3. Capillary Telangiectasia
 - 4. Developmental venous anomalies
- vi. Intratumoral and secondary hemorrhage

- 3. Spinal cord infarction and hemorrhage
- 4. Other cerebrovascular disorders

D. *Trauma*

- 1. Cerebral contusions/Traumatic brain injury
- 2. Spinal cord hemorrhage/Spinal trauma

E. *Infectious/Granulomatous Diseases*

- 1. Pyogenic/Bacterial
- 2. Viral
- 3. Fungal

4. Parasitic
5. Sarcoidosis
6. Prion-associated
7. Myelitis
8. Other infectious/granulomatous diseases

F. *Toxic/Metabolic Diseases*

1. Chemotherapeutic/Immunosuppressive agents
2. Ethanol-related:
 - i. Degeneration/atrophy
 - ii. Wernicke's encephalopathy
3. Hepatic failure
4. Mitochondrial disorders
5. Radiation injury
6. Toxin exposure
7. Wilson's disease
8. Other toxic/metabolic diseases

G. *Degenerative and heredo-degenerative Diseases*

1. Alzheimer's disease
2. Frontotemporal dementias
3. Parkinsonian syndromes
4. Huntington's disease
5. Amyotrophic lateral sclerosis
6. Friedreich's and other hereditary ataxias
7. Hallervorden-Spatz disease
8. Wallerian degeneration
9. Spinal degenerative diseases
 - i. Disc herniation
 - ii. Spinal stenosis
10. Other degenerative and heredo-degenerative diseases
11. Imaging changes with normal aging

H. *Seizures/Epilepsy*

1. Mesial Temporal Lobe Sclerosis
2. Cortical migration disorders

I. *Hydrocephalus/CSF Disorders*

1. Benign Intracranial Hypertension
2. Hydrocephalus
 - i. Noncommunicating
 - ii. Communicating
3. Intracranial Hypotension

J. *Neurocutaneous Syndromes*

1. Neurofibromatosis

2. Sturge-Weber Syndrome
3. Tuberous sclerosis complex
4. Von Hippel-Lindau and Hemangioblastomas
5. Other (e.g., Hypomelanosis of Ito)

K. Demyelinating/Inflammatory Diseases

1. Multiple Sclerosis
2. Acute Disseminated Encephalomyelitis
3. Central Pontine Myelinolysis
4. Myelitis
5. Neuromyelitis Optica (Devic's Disease)
6. Other non-infectious, non-granulomatous inflammatory disorders

L. Congenital Anomalies/Developmental Disorders

1. Brain malformations
2. Spinal cord and spinal canal malformations

M. Miscellaneous

1. Normal tomographic imaging anatomy of head and spine
2. Incidental findings outside the neuro axis
3. Orbital and pituitary imaging

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