CNS Hybrid Imaging: Anatomy, Variants, Urgent Findings

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with special thanks to Amit Saindane, MD
Talk can be found at radiology.emory.edu
Department of Radiology & Imaging Sciences

Fostering a Culture of Giving

Department of Radiology and Imaging Sciences continues to cultivate a culture of giving by fostering donations from individuals who support the department’s mission. Emory Radiology is known worldwide for its state-of-the-art technology, clinical resources for specialized care, and leading scientists and physicians. Through gift giving, we are able to sustain the innovation and discovery that helps the department to detect diseases in the earliest stage and provide preventative care to patients.

Read more in the February Rad Report.

Recent Accomplishments

NIH Study Section Panel

Dr. Foo was invited to participate in the NIH Biomedical Imaging Technology (BMIT) Study Section. The BMIT Study Section reviews grant applications involving basic, applied, and pre-clinical aspects of the design and development of medical imaging system technologies, their components, software, and mathematical methods for studies at the cellular, organ, small or large animal, and human scale.
Clinical Divisions - Nuclear Medicine & Molecular Imaging

The faculty of the Emory Division of Nuclear Medicine & Molecular Imaging offers the highest quality patient care, incorporating the latest knowledge, innovation and equipment. Nuclear Medicine not only uses the most advanced methods, but also helps set the bar for the field. All of the physicians are board certified in nuclear medicine, and some are double-boarded in other fields; particularly Radiology, many have national and international reputations in their fields.

Equipment includes PET/CT and SPECT/CT scanners at Emory University Hospital (Clifton campus), and Emory University Hospital Midtown. We offer a wide variety of specialized nuclear medicine therapies including that for thyroid cancer, bone cancer pain palliation, lymphoma, neuroendocrine tumors and Y-90 liver therapy in cooperation with Interventional Radiology. Research devices at our disposal include one of the few PET-MR units in the world, a high-resolution brain PET scanner, micro-PET for animal research, and a research cyclotron. A full range of nuclear medicine and PET/CT services are also provided at Grady Memorial Hospital and the Atlanta VA Medical Center. The Division is integrally involved in research conducted by the Emory University School of Medicine faculty, including close collaboration with colleagues in radiology and cardiology and at the Emory Winship Cancer Institute. Our faculty are principal investigators and co-investigators on many research grants including those sponsored by the NIH.

- David M. Schuster, MD
  Director, Division of Nuclear Medicine and Molecular Imaging

Recent Accomplishments
You are reading a PET-CT and see this....
Is it abnormal?

And what is it?
First review:
Slice by Slice
Correlative Anatomy
Keep in Mind…

- Normal high $^{18}\text{F-FDG}$ uptake in the brain
- Higher grey matter uptake compared with white matter
- Must specially window to see pathology on PET portion of the exam
Interhemispheric fissure
Corpus Callosum

- Genu
- Body
- Splenium
Lateral ventricles (choroid plexus within posteriorly)

Genu of corpus callosum

Splenium of corpus callosum
Thalamus

Lentiform nuclei (globus pallidus medially and putamen laterally)

Septum pellucidum

Anterior horn of lateral ventricle

Head of caudate nucleus

Thalamus
Internal capsule
(anterior and posterior limbs)
Posterior horns of lateral ventricle with calcified choroid plexus

Third ventricle
Occipital fissure
Occipital lobe
Suprasellar cistern

Cerebellar vermis

Midbrain level

Quadrigeminal plate and cistern
Lateral rectus
Medial rectus
Fourth ventricle
Inferior rectus
Pons
Fourth ventricle
Inferior rectus
Middle
cerebellar
peduncles
What are the Basal Ganglia?
(some prefer term Basal Nuclei)

• Three major nuclei
  – Caudate
  – Globus pallidus
  – Putamen
  – Some include
    • Subthalamic nuclei
    • Claustrum (*lateral to globus pallidus*)

Other terms:
• Corpus striatum
  – Caudate
  – Lentiform nuclei
    • Globus pallidus
    • Putamen
  – Anterior limb internal capsule
Know this anatomy for DaTscan

DaT Distribution of Ioflupane is Consistent with Human Striatal Anatomy

DaTSCAN Visualizes Striatal DaT

Anatomy for DaTscan
Visual Detection of DaT Distribution *in vivo*

Normal

Abnormal
CSF Spaces of Brain

http://emedicine.medscape.com
Start from Vertex
Common to see benign venous lakes
Superior orbital rim
Lateral orbital wall
Ethmoid sinus

Lesser wing of sphenoid

Dorsum sella
Superior orbital fissure
(Trigeminal V1 exits, also III, IV, VI)
Nasolacrimal duct

Carotid canal
Mastoid sinus

Middle turbinate

IAC

Middle ear and auditory ossicles
Zygomatic arch

Pterygopalatine fossa

Foramen rotundum, ovale, spinosum

Zygomatic arch

Rotundum: Maxillary nerve (V2) exits

Ovale: Mandibular nerve (V3) exits

Spinosum: Middle meningeal artery and vein; nervus spinosus from mandibular nerve
Mandibular condyle
Maxillary sinus

Pterygoid plate (lateral and medial)

Inferior turbinate

Maxillary sinus
Foramen magnum
Normal Uptake and Variants
Brain

- Cortical and deep gray much greater than white matter
Don’t confuse normal brain with base of skull spread
Spinal Cord

- Mild diffuse uptake especially in cervical region
Optic Muscles

• Especially if motion during uptake phase
  – May also see eyelid muscles
• Inferior rectus more intense and more common by our experience
Optic Muscles
Know variants...

Left orbit exenteration for squamous cell in lacrimal sac

Now asymmetric right orbital muscles
Be Aware of Edema Pattern

White matter edema on noncontrast CT. Suspect brain lesion.
Must Window Properly

PET windowed at body settings

PET windowed at brain settings
As the brain ages, the sulci widen and the ventricles enlarge...
Dementia

- Patient is a 32-year-old married white male with an 8-month history of progressive cognitive loss with forgetfulness, misplacing things, good mood, and also having interference with work and social performance. The patient also had some word finding difficulty.
- MRI negative; PET ordered
Subtle frontal and interhemispheric fissure atrophy inappropriate for a young man….

Increased confidence to interpret as FTD
Triad urinary incontinence, gait disturbance, cognitive decline

Notice there is some atrophy but the ventricles are too big compared with the degree of cortical atrophy…
Classic NPH Pattern on CSF Flow Scintigraphy

NM CSF Cisternog
POST L SPINE

NM CSF Cisternog
Anterior HEAD

NM CSF Cisternog
Posterior HEAD

NM CSF Cisternog
LT LAT HEAD

NM CSF Cisternog
24 HR Anterior

NM CSF Cisternog
24 HR Posterior

NM CSF Cisternog
24 HR PLat

NM CSF Cisternog
24 HR LLAT
Hydrocephalus may also be from obstructive causes
13 year old with headaches from aqueductal stenosis
But when hydrocephalus is obstructive from an unexpected mass, it becomes an emergency. Always call.
Cerebral Abscess

Midline shift, obstruction at 3rd ventricle with enlargement left lateral ventricle
Lateral and 3\textsuperscript{rd} ventricular hydrocephalus may be from brainstem glioma with obstruction at level of 4\textsuperscript{th} ventricle
You may also find other unexpected tumors that have no relation to the primary lesion. But may impact the patient care.
Like this incidental pituitary mass seen on PET-CT in a patient with gastric cancer. Note widening of sella turcica.
Both benign and malignant pituitary masses may have increased FDG uptake

Or this patient: IDC left breast post left mastectomy

- ALND positive nodes so PET ordered.
- No distant disease except for FDG uptake in neck.
- Since expanders could not get MR so contrast CT.
Glomus tumor/paraganglioma. (typically FDG avid)

Surgery since large size.
Course of Vagus Nerve
Though uncommon in the Nuclear Medicine setting, you may come across other incidental serious findings on CT and PET.
Not Uncommon to See Infarcts. Most Are Already Known.
Left MCA Infarct with Crossed Cerebellar Diaschisis

Motion and misregistration degrades images
Evolution of MCA Infarct

Subtle Acutely - Hours
Subarachnoid Hemorrhage
Intracranial Arterial Injury
Epidural Hematoma

- Clinical: often associated with fracture
- Clinical: “lucid interval” (50%)

**IMAGING**

- Convex
- Does not cross sutures
- Does not extend into interhemispheric fissure
- Can cross midline
Epidural Hematoma
Delayed EDH - 1st Scan
Delayed EDH - 2nd Scan
Subdural Hematoma

- 30% of patients who sustain severe trauma
- Concave
- Cross sutures
- Can extend into interhemispheric fissure
- Do not cross midline
- Value of contrast for isodense SDH
Subdural Hematoma
Chronic Subdural Hematoma
Mixed Density SDH
Subtle ISODENSE SDH
Not all fluid collections are due to bleeding. More common to have benign congenital process such as arachnoid cyst:

Benign intra-arachnoid collections of CSF.
Can be loculated or communicate with CSF.

Middle cranial fossa most common.
Can erode skull.
Nuclear Medicine may help in some cases to see if communicate with CSF
$^{111}$Indium DTPA fills from lumbar injection proving communication with CSF space
Arachnoid cysts may look like *epidermoid cysts* which are congenital or acquired inclusions.

Epidermoids encase and engulf arteries and nerves while arachnoid cysts displace adjacent structures.
Don’t forget to look at bone windows…
Paget’s Disease of the Skull
The End….

Stay tuned for ENT…