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Didactic
Cerebral Perfusion and Metabolism Agents

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SPECT Brain Perfusion Imaging

• Common Agents:
  • Tc-99m HMPAO (Exametazine, Ceretec)
  • Tc-99m ECD (Bicisate, Neurolite)

• Lipophilic radiopharmaceuticals

• Passive diffusion across the intact BBB and retained by the brain in proportion to rCBF
  • High first pass extraction, minimal redistribution
  • Underestimate true rCBF
  • Fixed within neuron, both become hydrophilic – demonstrate rCBF at time of injection
Normal Distribution of Cerebral Perfusion Agents

• Grey matter receives 2x the blood flow as white matter
  • White matter lesions much harder to detect
• Activity is generally symmetric
• Age Impact:
  • Children – decrease perfusion in frontal lobes
  • Adults – global activity decreased, predominantly in the frontal lobes
Tc-99m HMPAO

• Accumulates more in frontal lobes, thalamus, and cerebellum
• 80% first pass extraction; 3.5-7% dose localizing to brain at 1 minute postinj.
  • In neuron becomes polar hydrophilic molecule
• Two forms
  • Unstable in vitro – should be injected within 30 minutes after preparation
  • Stabilized form available with 4 hour shelf life
• SPECT imaging can be done 15 min – 2 hours post injection
• Excretion – Renal (40%), Gastrointestinal (15%)
• Target Organ: Gall-bladder
Tc-99m ECD

• Accumulates in the parietal and occipital lobes
• 60-70% first pass extraction; 5-6% brain activity
  • Rapid de-esterification to polar metabolite in neuron
• Stable, $T_{1/2} = 6$ hours
• SPECT imaging best at 15-30 mins postinj.
• Nearly 25% of brain activity has cleared by 4 hours
• Target Organ: gall bladder
Normal Brain Perfusion
HMPAO vs ECD

• ECD better blood clearance = better brain to background ratio
  • ECD is preferred in stroke
Metabolism in the brain looks very much like perfusion in the brain; SPECT resolution is less but the patterns/images will be very similar.

Cerebellar, pons and thalamic uptake is relatively low on FDG compared to perfusion agents.
Performing the Exam

• Patient Preparation
  • Patient must be able to lie still for exam
    • Sedation – given 10-15 minutes after injection
    • Caffeine, alcohol, other drugs that could affect CBF should be withheld for 24 hours before exam
• 15-30mCi HMPAO or ECD
• Short delay then Scan 10-60 minutes
• Constant environment
• EEG Monitoring with seizure patients
Cerebral SPECT Imaging Specific Uses:
Cerebrovascular Imaging

• Carotid artery balloon occlusion studies
  • Evaluate vascular reserve
  • HMPAO injection in angio suite at time of occlusion
    • WADA testing – testing other hemisphere
    • Balloon deflated at 1 minute; SPECT imaging done once balloon removed.
Specific Uses:
Cerebrovascular Imaging

• Diamox Brain Stress Scan
  • Used to evaluate cerebral perfusion reserve
    • Uses: evaluation of carotid or other vascular lesion, mapping vascular steal from an AVM, distinguishing AD from MID

• Exam:
  • 1 gm Diamox injected; radiotracer injected 20 minutes later
  • Baseline can be performed day before or after or only if stress is abnormal; Split dose

• Adverse effects
  • Vertigo, tinnitus, paresthesias, nausea, and postural hypotension, migraines
  • Contraindicated with sulfa drug allergies and within 3 days of acute stroke
Specific Uses:

Dementia

• Alzheimer’s dementia
  • symmetric decreased uptake in the bilateral posterior temporoparietal lobes

• Frontotemporal degeneration (Pick’s Disease)
  • Heterogenous groups of dementias with decreased frontal uptake, left greater than right, may involve temporal lobes

• Multi-infarct dementia
  • Focal, asymmetric, wedge-shaped perfusion defects – occipita, temporoo-occipital, or temporoparietal cortex
    • Defects worsen with Diamox

• AIDs dementia
  • Multifocal frontal, temporal, and parietal regions
  • Basal ganglia may also be involved
Specific Uses:

Seizures

- Most clinical utility with partial complex seizures of temporal lobe
  - Interictal imaging, seizure focus is hypoperfusion
  - Ictal imaging, seizure focus is hyperperfused
Specific Uses:
Other

- Herpes simplex encephalopathy – bilateral temporal lobe hyperperfusion
- Tumors and AVMS – perfusion defects
- Post-trauma contusions – perfusion defects
- Focal hypoperfusion with schizophrenia, depression, and chronic fatigue syndrome
Potential Pitfalls:

- Diaschisis – uninvolved area presenting as decreased uptake
- Luxury perfusion with HMPAO – metabolism becomes uncoupled with blood flow and HMPAO is deposited into infarcted tissue
Additional Cerebral Perfusion Agent

• F-18 FDG

• Glucose analog accurate assessment of rCGM
  • Phosphorylation by hexokinase
  • Reflects rCBF and tumor viability

• Half life 110 minutes

• 4% localizes to brain at 35 minutes postinjection

• Excretion: Urine – FAST 10-40% dose cleared in 2 hours

• Limitations due to cost and availability
Radiotracers: F18-FDG PET

- paracentral lobule (pre and postcentral gyri): primary sensorimotor cortex (PSMC)
- posterior cingulate gyrus-PCG (intensity of uptake high similar to visual cortex)
- Caudate (CN), putamen (Pu) and thalamus (Th)
- uptake along the temporal lobe lateral cortex pretty uniform
Radiotracers: F18-FDG PET

- Cingulate gyrus (cingulate sulcus)
- Precuneous (between marginal branch of the cingulate sulcus and parietooccipital sulcus)
- Semiquantitative three-dimensional stereotactic surface projection (3DSSP) and Z-score images and age-matched Z score
F-18 FDG

• Dose 10 -20 mCi and imaged 45 min post inj.

• Perfusion patterns:
  • Higher grade tumors – generally high SUV
  • Radiation necrosis – no uptake
  • Cerebral infarct – no uptake
  • Interictal PET – decreased uptake at seizure focus
F-18 FDG

- Potential Pitfalls
  - Lack of specificity – infection, tumor, or inflammation can demonstrate uptake
  - Uptake in normal brain – making worrisome lesions less conspicuous
  - Blood glucose levels can effect uptake
  - Steroid use can effect uptake
Planar Brain Imaging

• Tc-99m pertechnetate or DTPA
  • Do not cross BBB unless it is disrupted

• How it is performed:
  • Dose 20 mCi
  • 2 phases
    • Dynamic or angiographic study
      • Rapid sequential images of radioactive bolus
    • Delayed static images (10 min – 2 hrs postinj.)
      • Records distribution of radiopharmaceutical in the sagittal sinus

• Most common application of planar technique is in suspected brain death.
Thallium Brain Tumor Scan

• Used to differentiate recurrent neoplasm from radiation necrosis or discriminating AIDS-related lymphoma from toxoplasmosis
  • $^{201}$TI concentrates in viable tumor; does not cross BBB

• No preparation required

• Dose 3-4 mCi and imaged at 10-30 min postinj.

• Normal brain should have no uptake
Case 1.
Case 1.

- **Findings:**
  - Decreased perfusion involving the parietal and temporal lobes bilaterally
- **Diagnosis:**
  - Alzheimer’s dementia
Case 2.
Case 2.

• Findings:
  • Decreased perfusion to the left peripheral MCA territory

• Diagnosis:
  • Vascular disease
Case 3.
Case 3.

• Findings
  • Increased perfusion involving the right temporal lobe

• Diagnosis:
  • Seizure focus in the right temporal lobe
Suggested Articles


