

UNIVERSITY OF WASHINGTON SCHOOL OF MEDICINE



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Didactic



Cerebral Perfusion and Metabolism Agents

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SPECT Brain Perfusion Imaging

- Common Agents:
 - Tc-99m HMPAO (Exametazime, 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

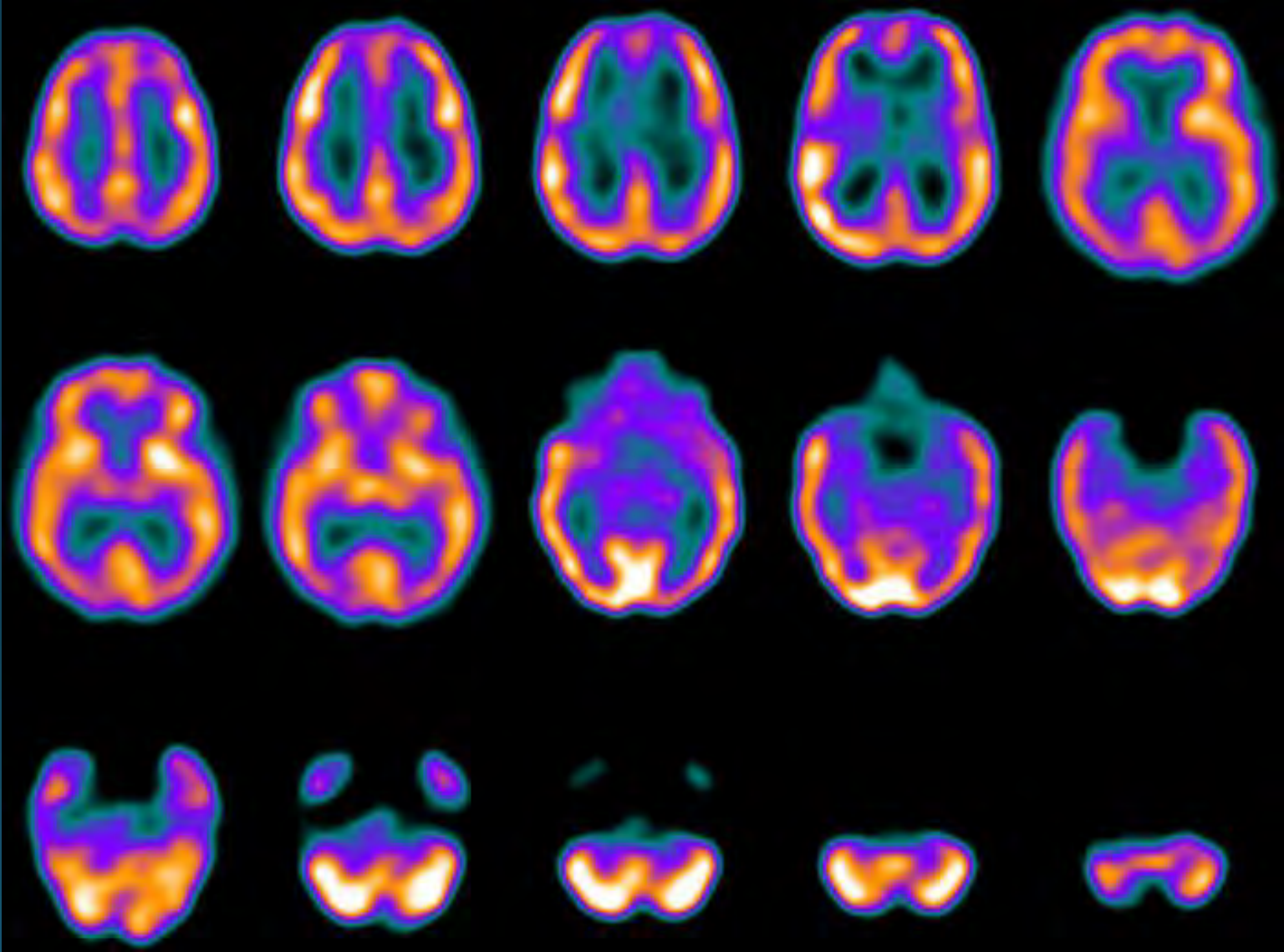
Tc-99m HMPAO

- 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



Tc-99m ECD

HMPAO vs ECD

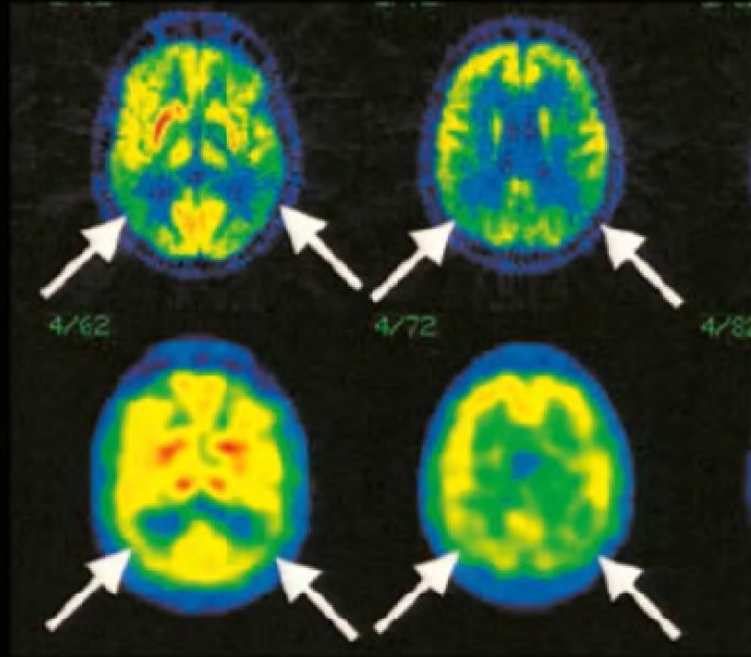
- ECD better blood clearance = better brain to background ratio
 - ECD is preferred in stroke

Tc99m-ECD/Tc99m-HMPAO vs FDG- PET

Comparison between [18F]FDG PET and perfusion SPECT

Metabolism-PET

Perfusion -SPECT



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, temporo-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

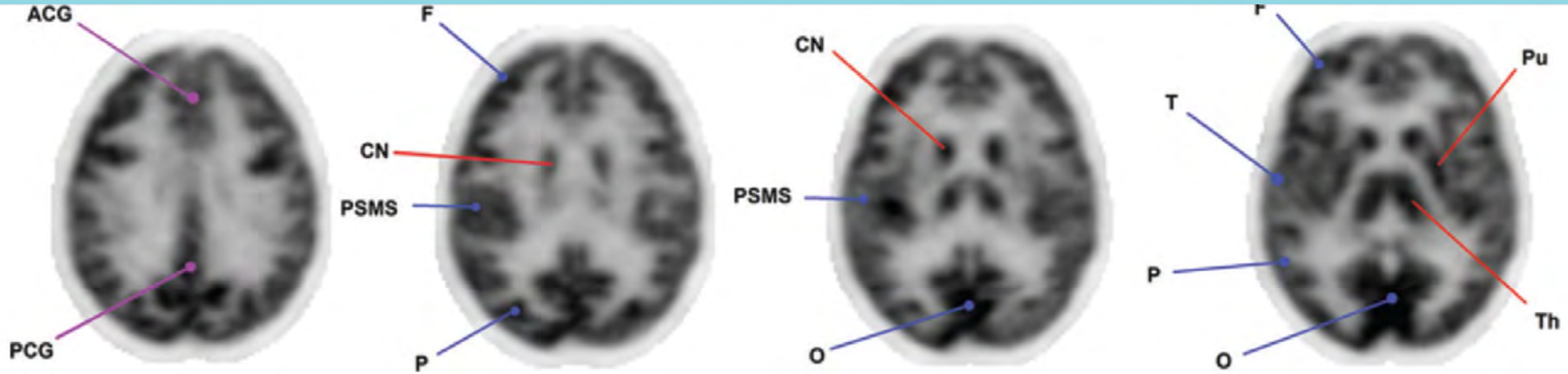
Potential Pitfalls:

- Diaschisis – uninjured 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

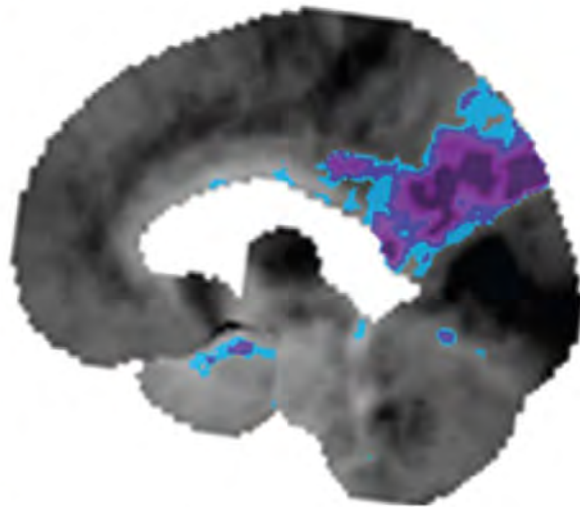
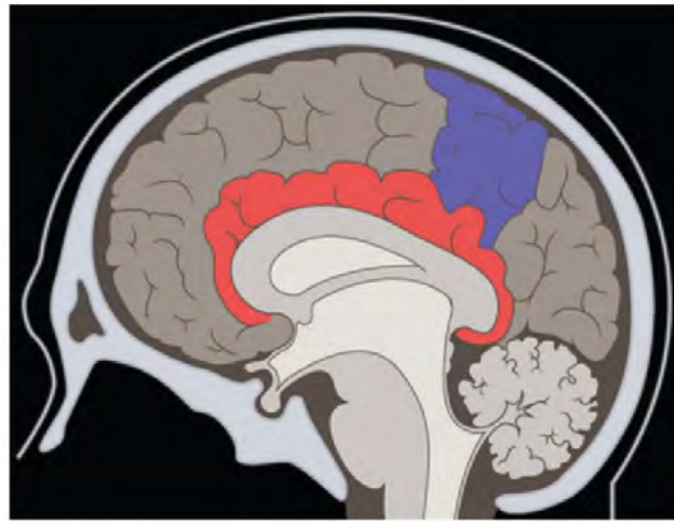
- F-18 FDG
- Glucose analog accurate assessment of rCGM
 - Phosphorylation by hexokinase
 - Reflects rCBF and tumor viability
- Half life 110 minutes
- 4% localizes to brain at 35 minutes postinjection
- Excretion: Urine – FAST 10-40% dose cleared in 2 hours
- Limitations due to cost and availability

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



Z-score on 3D-SSP images

- 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

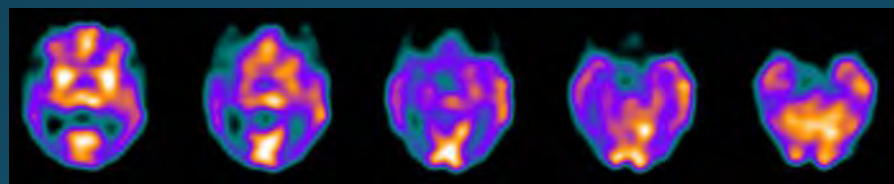
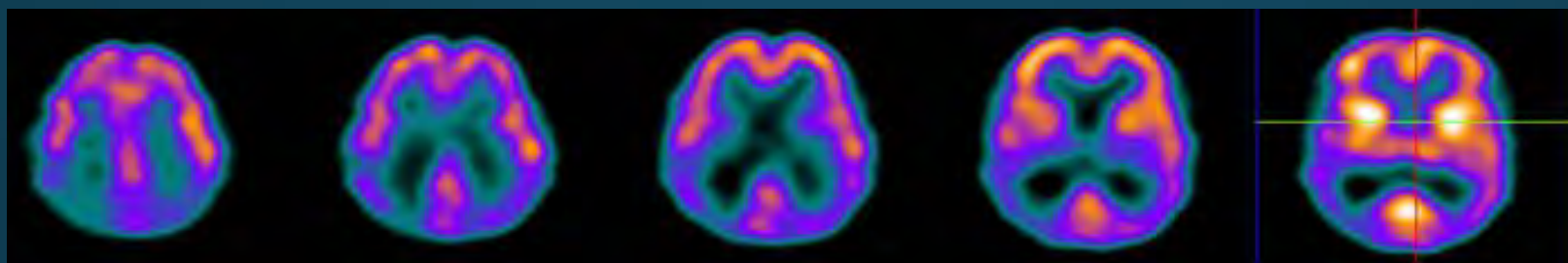
Planar Brain Imaging

- 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}Tl 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
 - Potential Pitfalls: necrosis – false neg., abscess – false pos.

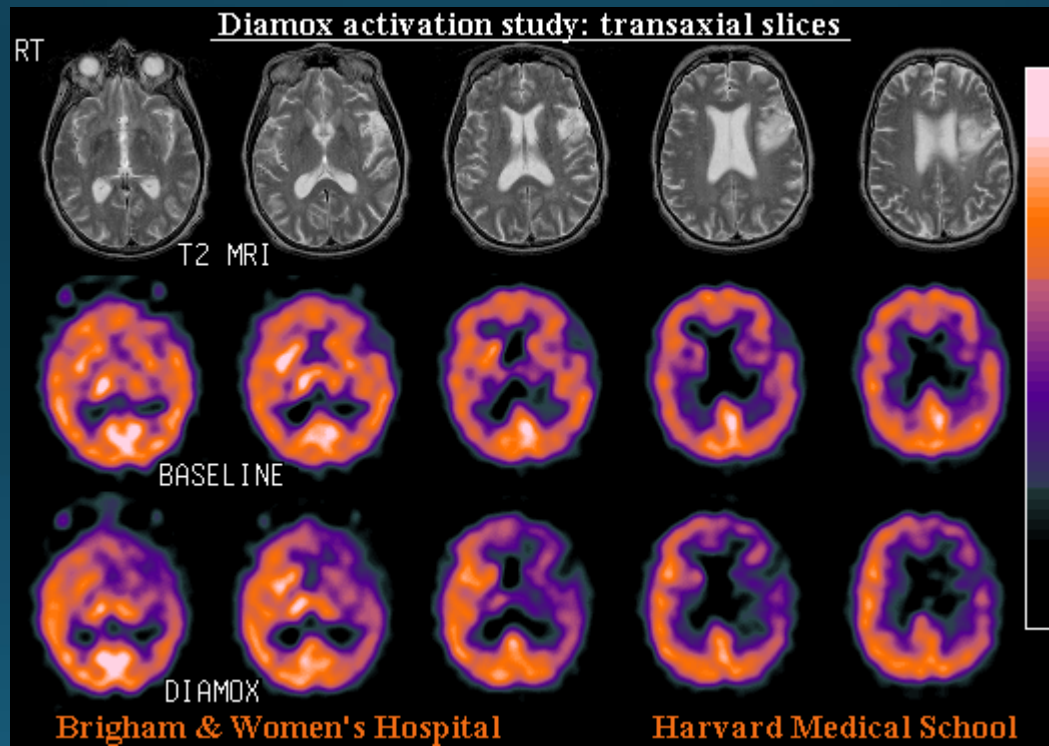
Case 1.



Case 1.

- Findings:
 - Decreased perfusion involving the parietal and temporal lobes bilaterally
- Diagnosis:
 - Alzheimer's dementia

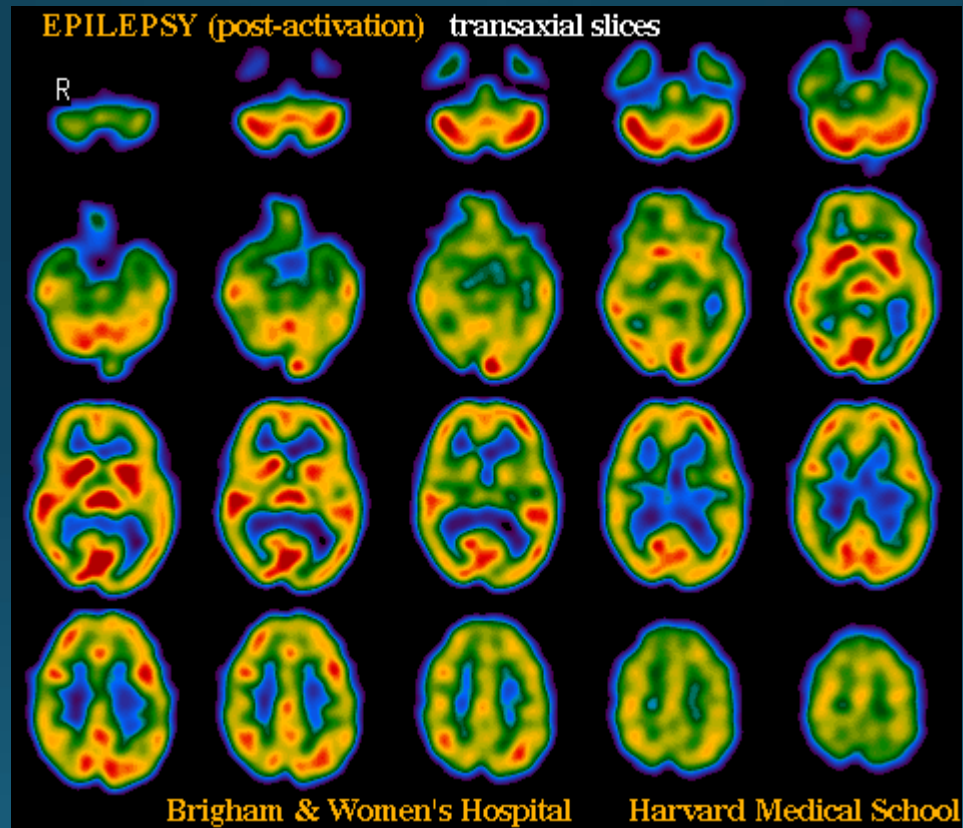
Case 2.



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

1. Taylor, A. et al. A Clinician's Guide to Nuclear Medicine. Society of Nuclear Medicine. Reston, VA. 2000.
2. Sato Y. J Nucl Med 2011;; et al. Preoperative central benzodiazepine receptor binding potential and cerebral blood flow images on SPECT predict development of new cerebral ischemic events and cerebral hyperperfusion after carotid endarterectomy. 52: 1400-1407.
3. Lorberboym M; Nucl Med 1996 et al. Brain perfusion imaging during preoperative temporary balloon occlusion of the internal carotid artery. 37: 415-420.
4. Brown R et al. Brain PET in Suspected Dementia: Patterns of Altered FDG Metabolism. Radiographics; 681-701.