Brain SPECT and CT Fusion in neurological disorders
Clinical Indications

CBF-SPECT
Dementia
Differential diagnosis of Parkinson Syndrome*
Evaluation of cerebrovascular disease
Detection of seizure focus*
Suspected brain trauma
Diagnosis of brain death
Substance abuse
Inflammation/Infection

FDG-PET
Dementia
Differential diagnosis of Parkinson Syndrome
Presurgical localisation of epileptic foci
Tumor
Neuroreceptor imaging

*In case of Parkinson Syndrome, the use of Ioflupane 123I (commercial name: DAT scan) is the best radiopharmaceutical choice to visualize the striatum using SPECT
*Actually, PET scan appears to be more appropriate than SPECT to identify seizure foci
SPECT Nuclear Medicine Brain Imaging

- $^{99mTc}$-HMPAO and $^{99mTc}$-ECD can accurately diagnose:
  - Acute stroke at earliest time
    Typical: no blood flow to major cerebrovascular territory
  - Use of regional CBF (rCBF):
    Determination of critical hemodynamic compromise (pts candidates to percutaneous transluminal angioplasty/bypass)
  - Differential diagnosis between cortical microembolic disease and progressive degenerative dementia (such as Alzheimer’s disease)
Essential requirements of a radiopharmaceutical to function as rCBF agent

Freely diffusible tracer, able to cross blood brain barrier (lipophilic, neutral at physiologic pH

Long retention time in the brain (trapping needed: enzymatic, ionization of agent, chemical reaction rendering the agent non diffusible)

Radiopharmaceuticals

99mTc-Hexamethylpropyleneamine oxime (Exametazime: HMPAO) (555-1110MBq: 15-30 mCi)
Best quality image +/-90 min

99mTc-Bisicate (ethylcysteine dimer) (ECD) (740MBq: 20mCi)
Best quality image +/-60 min

18-fluoro-2-deoxyglucose (FDG)
Characteristics of radiopharmaceuticals

HM-PAO
(hexamethylpropylene amine oxime)

3 different isomeric forms, D-D, L-L, D-L

The d,l diastereomer: superior brain retention, minimal redistribution (Ceretec R) labeled with 99mTc

Brain retention is due to interaction of 99mTc-HMPAO with glutathione by a conversion of lipophilic forms of 99mTc-HMPAO to secondary more polar form

After injection of d,l form, radionuclid reaches a steady concentration in tissue reflecting a pattern dominated by blood flow

Low stability

Ethyl cysteinate dimer

L,L configuration is required to be retained in brain

99mTc L,L ECD is metabolized to one or more polar 99mTc-complexes (deesterification) (Bicisate R)

Metabolites are diacid 99mTc-ethylene dicysteine (enzymatic reaction)

Retention by brain is due to metabolism of lipophilic neutral diester complex to monoacid and diacid products, ionized at physiologic pH

Rapid brain uptake (about 7% of injected dose), gradual washout (25% decrease at 4 H)
Patient preparation

- Avoid caffeine, alcohol or drugs affecting CBF (or glucose metabolism for PET), avoid psychoactive drugs
- If sedative drugs necessary: not earlier than 5 min post-injection (99mTc tracers)
- Evaluation for ability to cooperate
- Consistent environment (tracer injection and uptake)
- Patient has to be quiet, ears unplugged, comfortable, no speech (or read)
- IV access 10 min prior to injection (accommodation)
- No interaction with patient prior, during or up to 5 min postinjection

- It is mandatory to know current medication and when last taken, recent CT, MRI, EEG (E)
STROKE
60 years old patient
Presenting on with
regressive right upper limb
paresy (left hemispheric TIA)
a: transversal 99mTc ECD
Slides
b: coregistration 99mTc ECD/CT
Evaluation of hemodynamic significant compromise with Acetazolamide or CO2: increases the sensitivity of SPECT to detect a cerebral territory at risk of ischemic transient attack.

Acetazolamide (carbonic anhydrase inhibitor) -> strong vasodilatory challenge

Increase local pCO2 -> arteriolar dilatation -> local increase in rCBF (represents index of vascular reserve)

Cerebrovascular reactivity: reduced in pts at risk for stroke and limit of increase in rCBF is governed by condition of vasculature

IV 1 g acetazolamide -> increase CO2 -> dilatation cerebral vasculature -> increase CBF

Protocol: resting state 99mTc-HMPAO or 99mTc-ECD (baseline blood flow) vasoreactive challenge SPECT: same dose of 99mTc-HMPAO after 24 or 48H or back-to-back studies (much higher dose than initial resting dose) first technique seems to be more appropriate (740 MBq or 20 mCi HMPAO)

PTA: invasive procedure, need to objectivate benefit-risk ratio before PTA
Stroke:

Coregistration CT/SPECT (GE Hawkeye) in the same patient: CT shows a left temporo-fronto-parietal hypodense lesion, comparison between anatomic lesion and functional lesion.
72 years old man
Coregistration
CT/SPECT of a left
Hemispheric stroke
Right thalamic stroke leading to a reduction of uptake by ipsilateral cortex
Second left cortico-frontal focal stroke
Vascular dementia

Heterogeneity of vascular lesions that may cause dementia: local, strategic lesions (thalamus), multiple brain infarcts, hypertensive encephalopathy
Second problem: relationship between the vascular problem and the dementia syndrome

Dementia, vascular clinical pathology and vascular lesions on anatomical imaging are required in most diagnostic criteria

Functional imaging demonstrate multiple sites with decreased activity distributed in vascular territories
81 years old woman with dementia: multiple cortical defects compatible with vascular dementia and microembolic infarctions, note possible superadded symmetrical parieto-occipital defects.
82 years old man: dementia: multiple cortical defects more pronounced in frontal cortex in favour of microvascular dementia
Frontotemporal dementia

International diagnostic criteria

Progressive dementia
Early loss of interpersonal interaction and personal conduct
Emotional blunting, loss of insight

Functional imaging: decrease of frontal activity extending to anterior portion of basal ganglia
Depression is frequently associated with a decrease of (left) frontal activity, though less important
81 years old woman with behaviour abnormalities: this scan is compatible with frontal dementia rather than multi-infarct dementia.
Mixed dementia: frontal/vascular: CT shows images suggestive of multiinfarct disease and SPECT is in favour of frontal dementia, resulting in a mixed dementia.
Alzheimer’s disease

International diagnostic criteria

Dementia syndrome with progressive evolution
Normal consciousness
No other psychiatric, systemic, metabolic, toxic aetiology

Relative reduction of CBF (or glucose metabolism) in posterior parietal or parieto-temporal regions bilaterally
Low activity in posterior cingulate

Precentral and prefrontal portions: more variable: observed with the progress of disease

Primary cortices, basal ganglia, cerebellum preserved

Pattern less characteristic in the elderly (other pathologies contribute to dementia)

Activity of medial temporal region: matter of debate (not specific for Alzheimer disease: observed in Parkinson, normoP hydrocephalia, dementia in Down’s syndrome)
Patients complaining with memory defects

A and b: reduction of tracer uptake in parietal (-parieto-occipital) parts of both hemispheres compatible with Alzheimer disease (vs Lewy Body disease?)
Dementia, Alzheimer type: note frontal activity and decreased parito temporal uptake
Drug abuse
Alcoholism

Important alteration in rCBF and 99mTc Bisicate uptake in a case of chronic drug abuse. (Note that patient is reported to be clinically asymptomatic. Severity of the SPECT alteration correlate well with the degree of neuropsychological testing impairment. It improves after treatment for drug addiction. Same observation is done in case of alcohol abuse.