

What effect can a cup of coffee have on dipyridamole or adenosine stress test?

- Caffeine in coffee, tea, soft drinks or food such as chocolate are chemically related to dipyridamole and adenosine and can block the effect of dipyridamole pharmacological stress testing.

What percentage of stenosis at rest is necessary in the coronary arteries for resting blood flow to be effected?

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- > 85 – 90%

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- Lung uptake is also significant.
- The lung and liver clear with time and the target to background ratio improves.

What pharmaceutical is administered to allow the Tc-99m to bind to RBC?

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- Stannous (tin) pyrophosphate and stannous chloride have been used.

What part of the RBC does the Tc-99m
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- Beta chain of hemoglobin when the patient is pretreated with stannous ion.

What do amplitude and phase images
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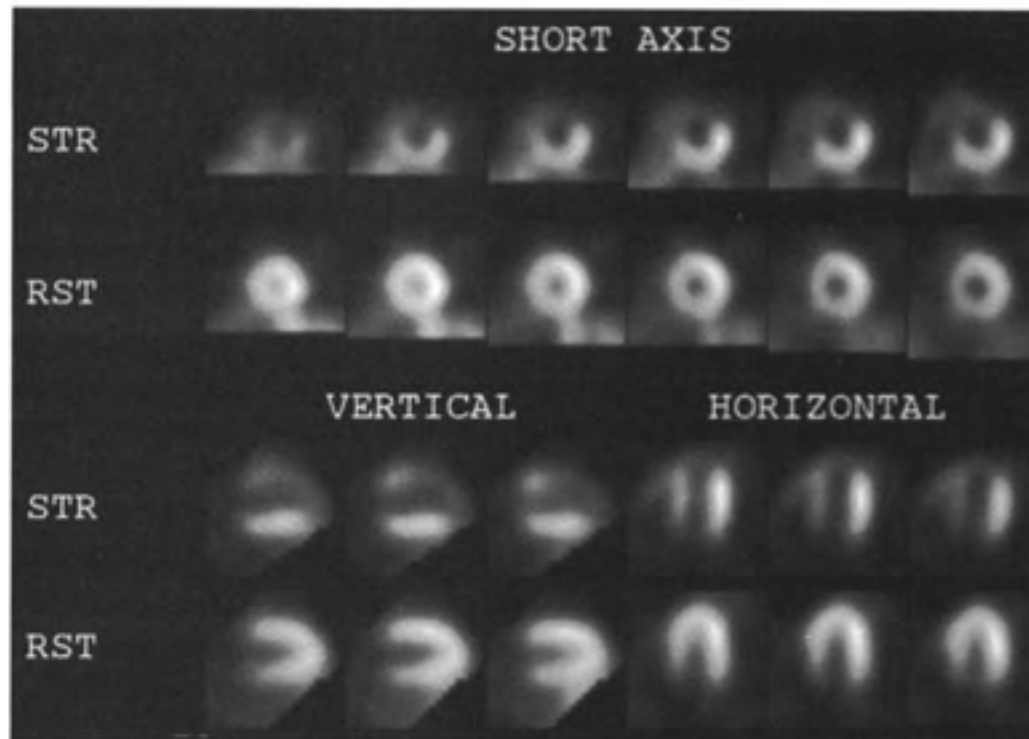
What do amplitude and phase images portray?

- Amplitude and phase images are parametric or derived images.
- The amplitude images portrays the maximum count difference at each pixel location during the cardiac cycle. High EF areas have high amplitude and background areas have low amplitude.
- The phase images portrays the timing of cyclical activity with respect to a reference standard.

What is the hallmark of a ventricular apical aneurysm by phase analysis?

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- Aneurysms demonstrate paradoxical motion.
- Activity in the area of the aneurysm is typically 180 degrees out of phase with the rest of the ventricle.

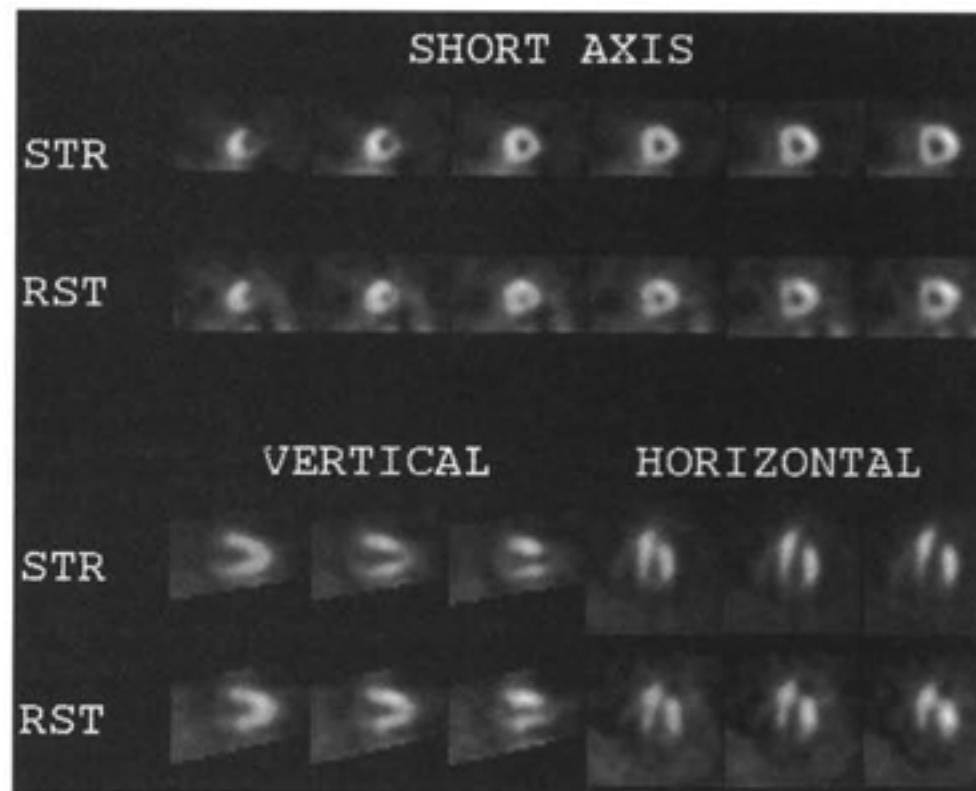


A 55-year-old man with exertional chest pain had a stress single photon emission computed tomography (SPECT) myocardial perfusion study.

1. Describe the perfusion abnormalities and give your interpretation.
2. Name the culprit vessel or vessels.
3. List any ancillary scan findings.
4. List clinical findings related to the stress test relevant to interpretation of the scan.

LAD ischemia

1. Severe decreased perfusion in the majority of the anterior wall, apex and septum which normalizes on the rest image indicating extensive severe ischemia.
2. LAD territory.
3. Transient cavity dilatation.
4. VT, angina related ST abnormalities, decreased systolic pressure and level of exercise achieved.

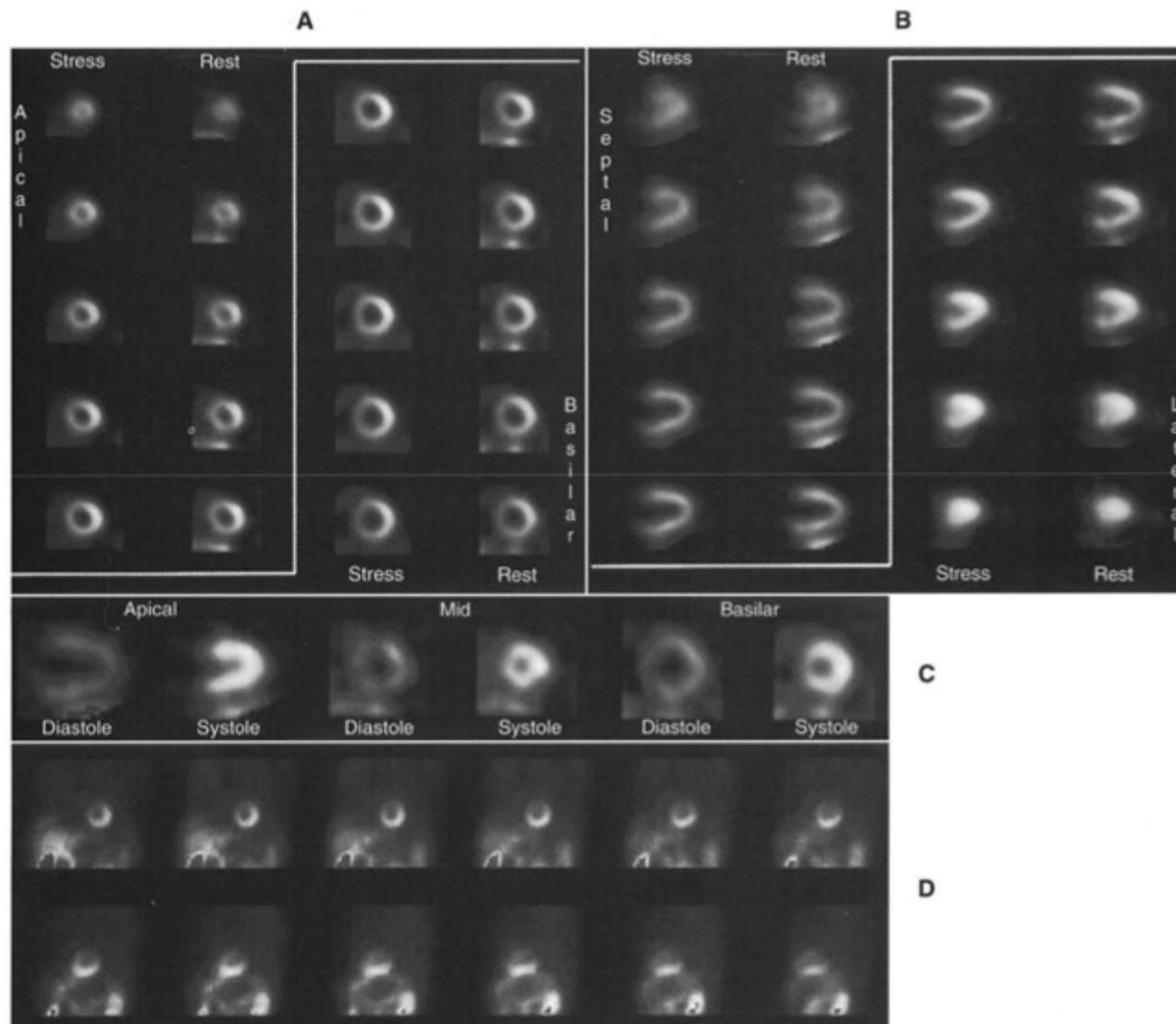


A 60-year-old man with a history of remote myocardial infarct and CABG surgery. Echocardiography results were normal.

1. Describe the SPECT findings.
2. Provide the differential diagnosis.
3. Give the most likely diagnosis.
4. Explain the discrepancy between the cardiac echocardiogram and the SPECT scan.

Apical infarct

1. Fixed stress and rest severe apical perfusion defect. Heart and cavity size appear normal.
2. Myocardial infarction, apical thinning and attenuation.
3. Small apical lateral scar.
4. Technical factors, operator error and interpretation error

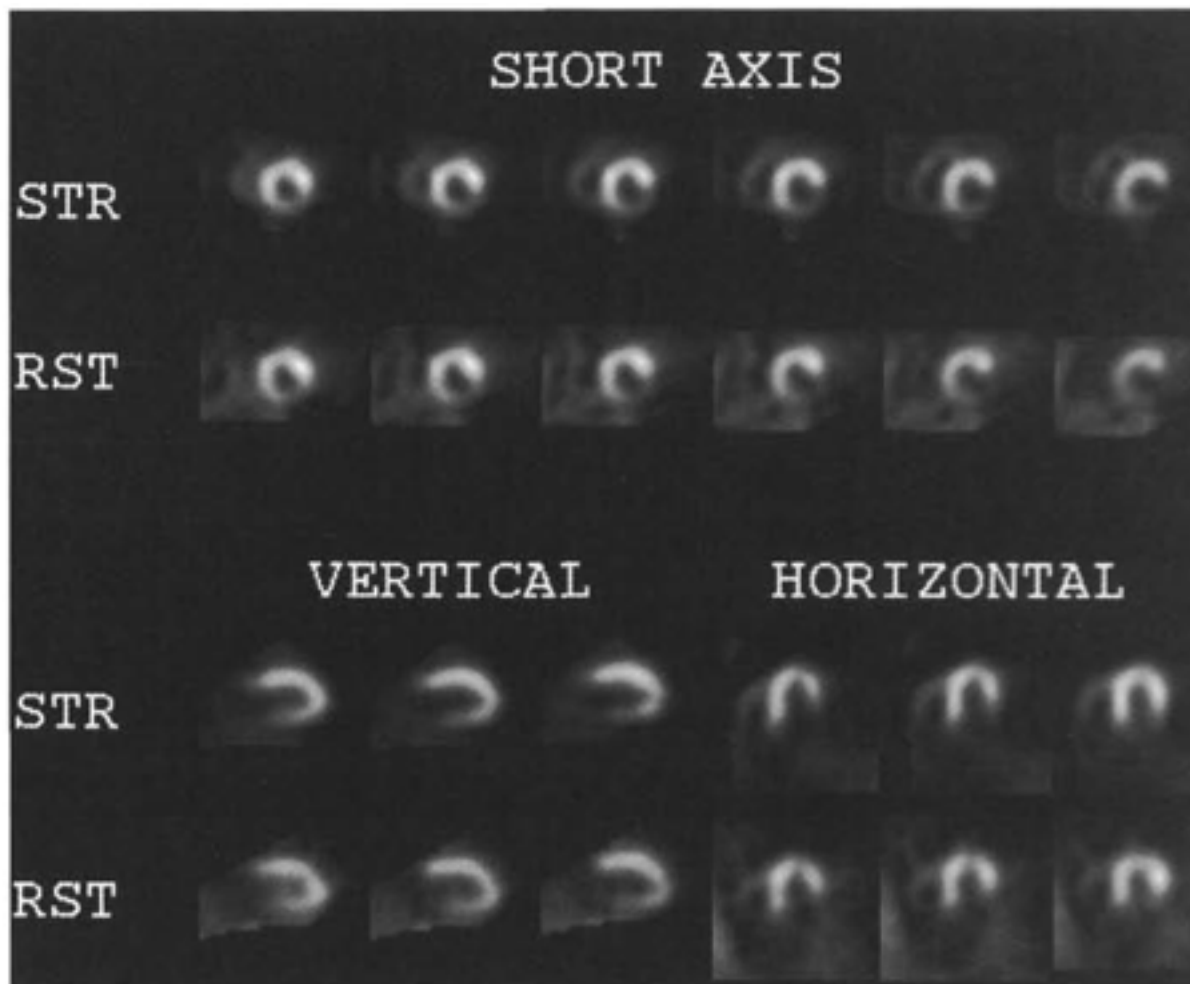


A 50-year-old woman has atypical chest pain. The exercise treadmill test result with adequate exercise was interpreted as negative. SPECT perfusion images (A, gated short-axis; B, vertical long-axis; C, SPECT wall thickening; D, sequential raw data projection acquisition images) are provided.

1. Describe the SPECT myocardial perfusion image findings and gated SPECT.
2. What information is available from the raw data sequential projection images?
3. What is the most likely diagnosis?
4. List the advantages of electrocardiograph-synchronization (gating) to SPECT.

Breast attenuation

1. Mild fixed anteroseptal hypoperfusion that demonstrates uniform brightening on gated SPECT, indicating normal myocardial wall thickening on gated images.
2. Apparent decreased tracer in the upper portions of the heart is most obvious on the left anterior oblique and lateral frames.
3. Normal perfusion study with normal wall thickening and breast attenuation.
4. Assessment of regional wall motion/ wall thickening and LVEF

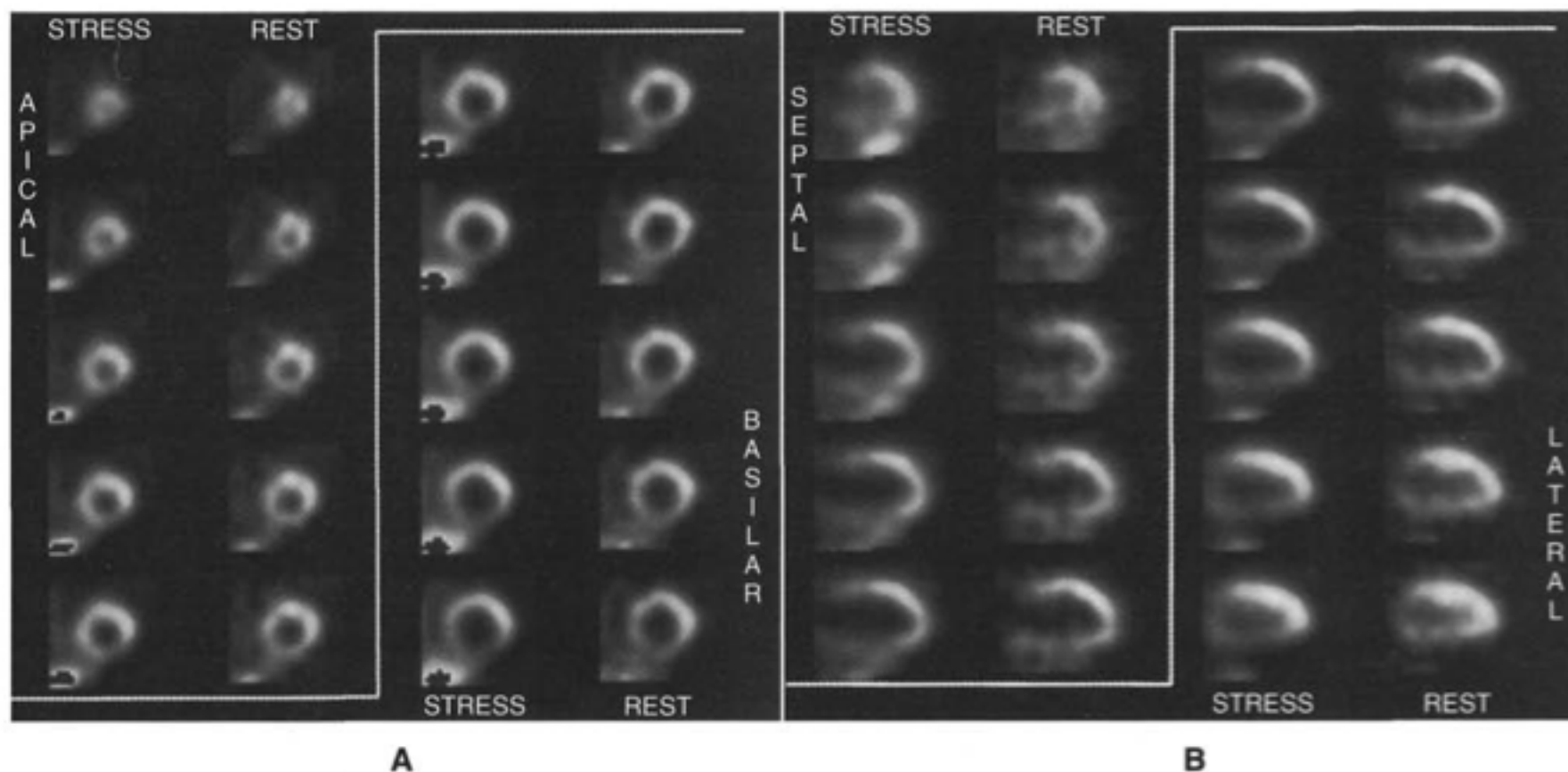


A 50-year-old patient with diabetes achieved 4.0 METS (metabolic equivalent) and 60% of maximum age-predicted heart rate (MPHR) on the exercise treadmill stress test.

1. When should the exercise treadmill stress test be discontinued?
2. Describe the myocardial stress and rest perfusion SPECT image findings.
3. Provide the differential diagnosis and likely involved vessel(s).
4. Discuss any other factor important to the interpretation of the scan.

Inferolateral wall infarction

1. If the patient develops severe angina chest pain, a decrease in blood pressure, frequent premature ventricular contraction or ST elevation suggestive of acute infarct. Also if patient can walk no further on the treadmill because of general fatigue, leg pain or dyspnea.
2. Severe stress and rest fixed defect in the basolateral, inferior and inferolateral walls, sparing the apex.
3. MI or possibly hibernation. Circumflex artery.
4. The exercise stress level.

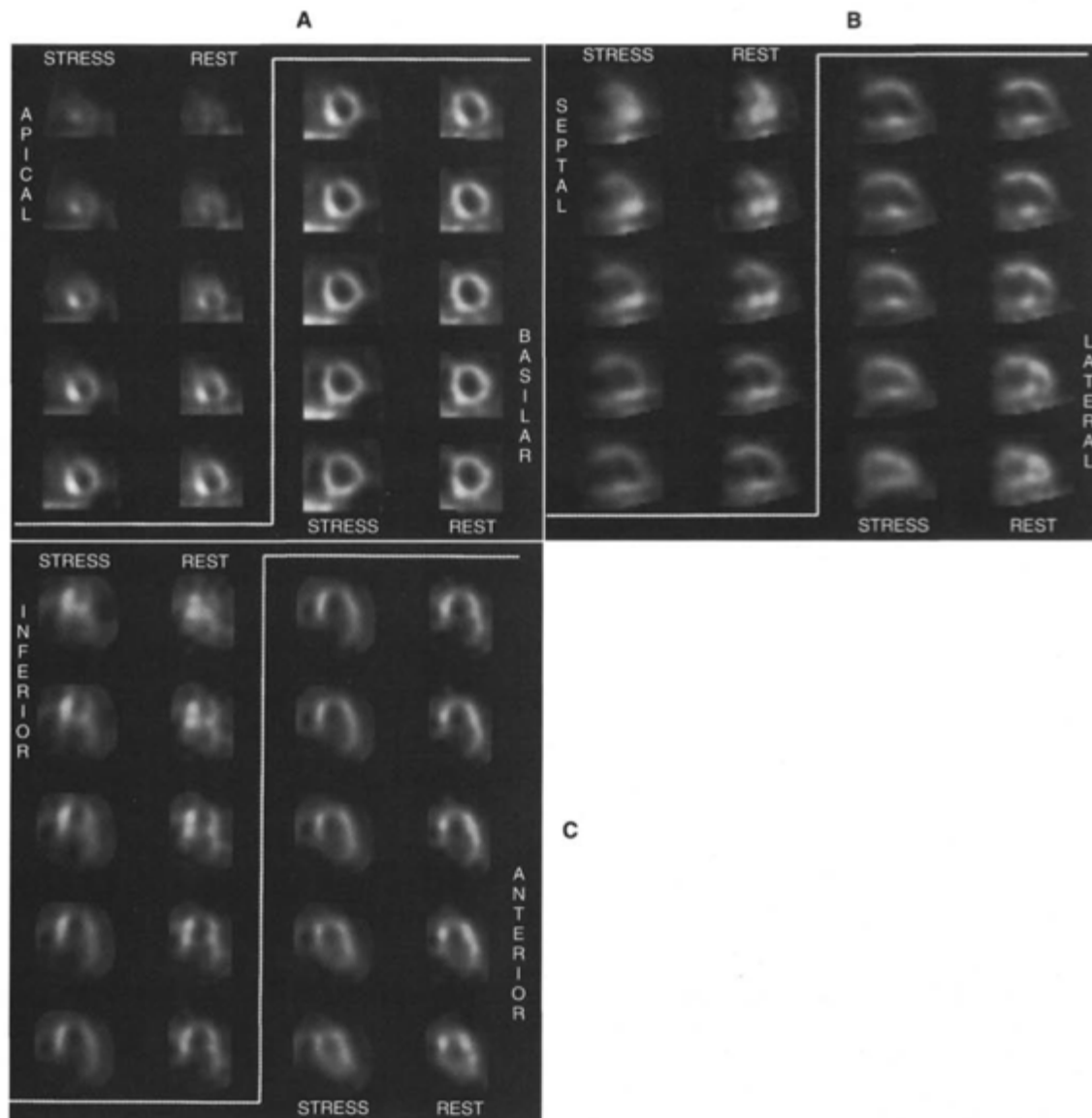


A 53-year-old man who had a recent myocardial infarction had a dipyridamole stress myocardial SPECT study before hospital discharge. SPECT short-axis (*A*) and vertical long-axis (*B*) images are shown.

1. Describe the SPECT findings.
2. Name the likely coronary artery or arteries involved.
3. Provide the differential diagnosis.
4. What prognostic information does the scan provide?

Dipyridamole induced reversible ischemia

1. A perfusion defect involving the entire inferior wall extending to the apex shows partial reversibility.
2. RCA
3. Inferior wall ischemia with incomplete reversibility. The latter may represent scar or hibernating myocardium.
4. The patient is at risk for further cardiac event, either infarct or death.

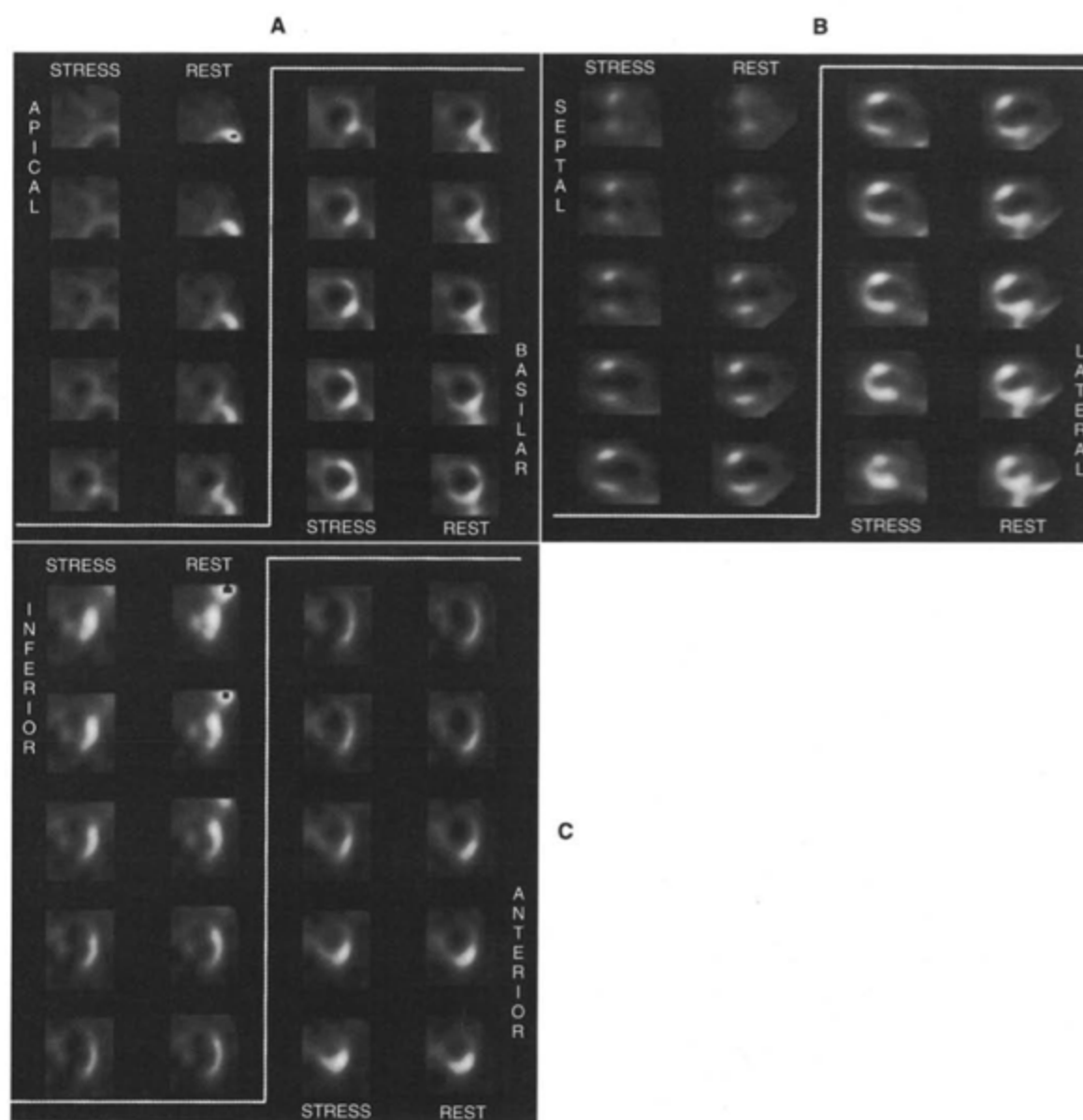


SPECT adenosine stress/rest myocardial perfusion images. SPECT short-axis (A), vertical long-axis (B), and horizontal long-axis (C) images are shown.

1. Describe the procedure for adenosine stress (a), adenosine's duration of action (b), and the procedure to deal with side effects of adenosine (c).
2. List contraindications to the use of intravenous adenosine.
3. Describe the SPECT findings and the diagnosis.
4. What are clinical indications for adenosine stress?

Adenosine stress

1. A. adenosine is infused IV for 6 minutes (140 $\mu\text{g}/\text{kg}/\text{min}$) after 3 min the tracer is injected and adenosine is continued for 3 more minutes. B. adenosine is cleared from circulation <10 sec. return to baseline blood flow levels occurs in 2 to 3 minutes after stopping the infusion. C. stop infusion
2. Sinus node disease, 2nd to 3rd degree block, bronchospastic lung disease and adenosine allergy
3. Small to moderate severe fixed defect at the apex on both stress and rest images consistent with infarct. Mildly improved perfusion of the anterior and lateral walls at rest compared with stress consistent with mild anterolateral ischemia.
4. Whenever adequate exercise stress is not possible.

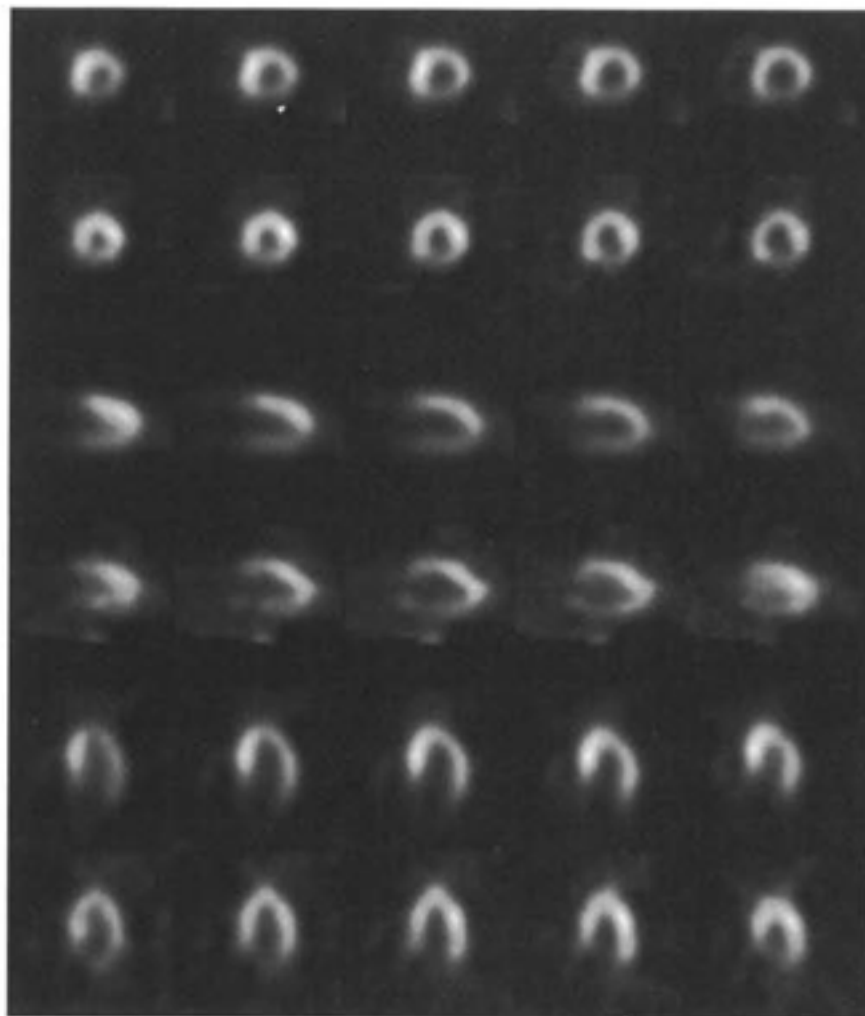
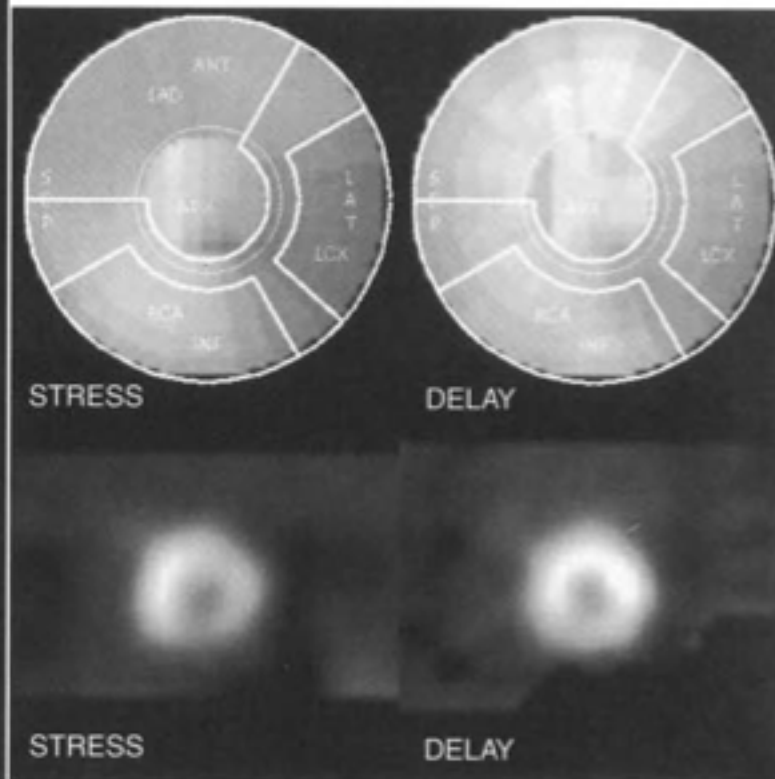


A 55-year-old man with CAD but no history or ECG evidence of myocardial infarction. SPECT short-axis (A), vertical long-axis (B), and horizontal long-axis (C) are shown.

1. Describe the findings on the SPECT.
2. Provide the differential diagnosis.
3. Describe the blood flow and functional state of hibernating myocardium.
4. Describe the blood flow and functional state of stunned myocardium.

Viability

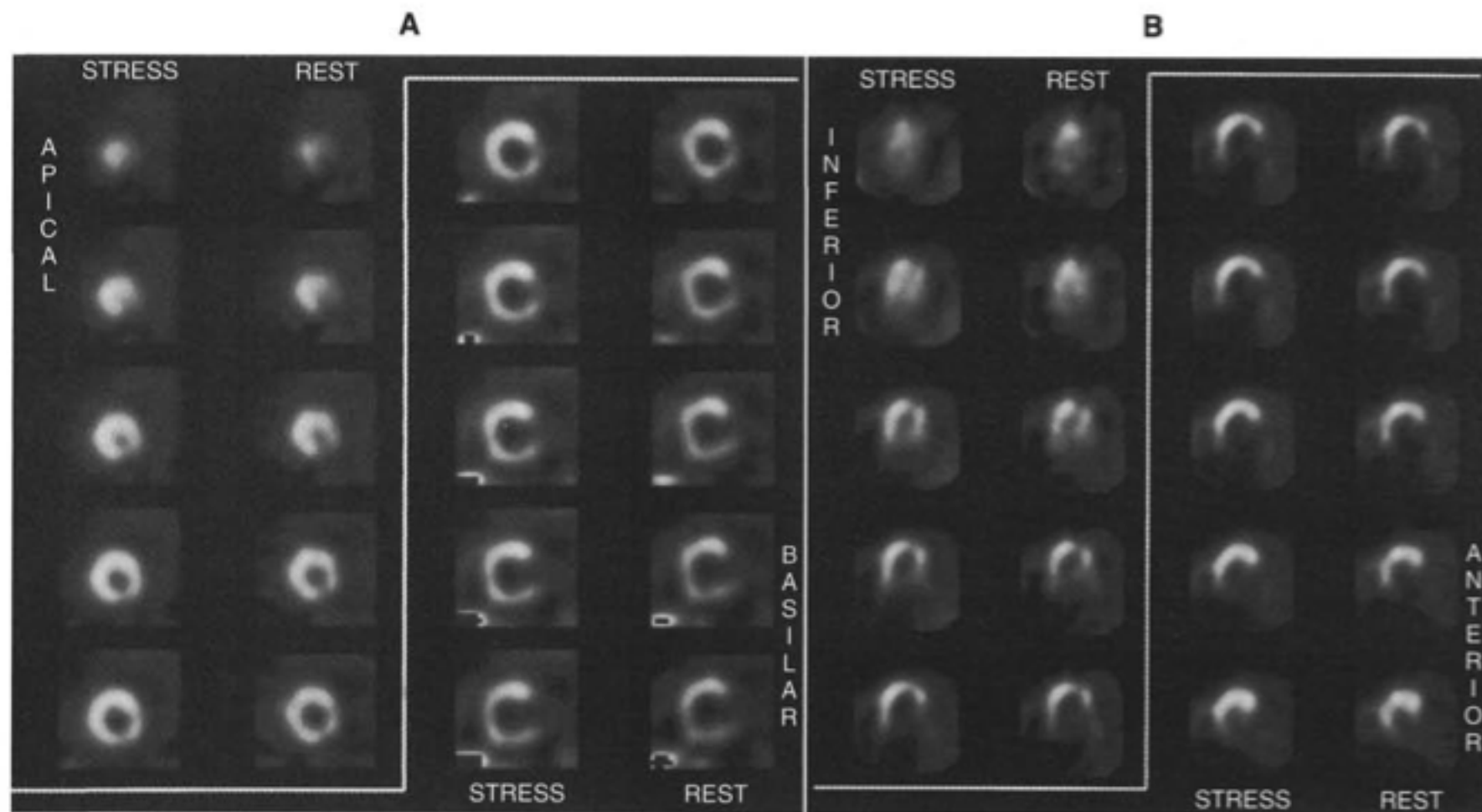
1. Extensive fixed defects involving the anterior wall, apex, septum extending to the lateral wall.
2. Myocardial infarction vs. hibernating myocardium.
3. In hibernating myocardium, blood flow and function e.g.. contractility are chronically reduced.
4. Blood flow is normal with reduced function.



1. Describe the bull's-eye format for SPECT myocardial perfusion studies.
2. List possible errors that may occur when applying a bull's-eye quantitative analysis technique to myocardial perfusion SPECT.
3. Describe the findings and the likely culprit coronary artery or arteries. Does the bull's-eye plot confirm the image findings?
4. List the characteristics of perfusion scan abnormalities that should be included in any report.

Bull's eye

1. A polar plot is constructed by layering short axis slices one on top of the other with the apex forming the center and the base of the heart being the outermost portion.
2. Misregistration use of inappropriate reference database.
3. Stress; hypoperfusion of the anterior, lateral and inferior walls. Rest; normalized perfusion of the anterior and lateral walls and incomplete normalization of the inferior wall. Most consistent with ischemia of the LCX and infarct of the right RCA.
4. Include location and extent, severity and reversibility for each perfusion abnormality. If gated SPECT is performed, include LVEF, wall motion with or without wall thickening fractions.

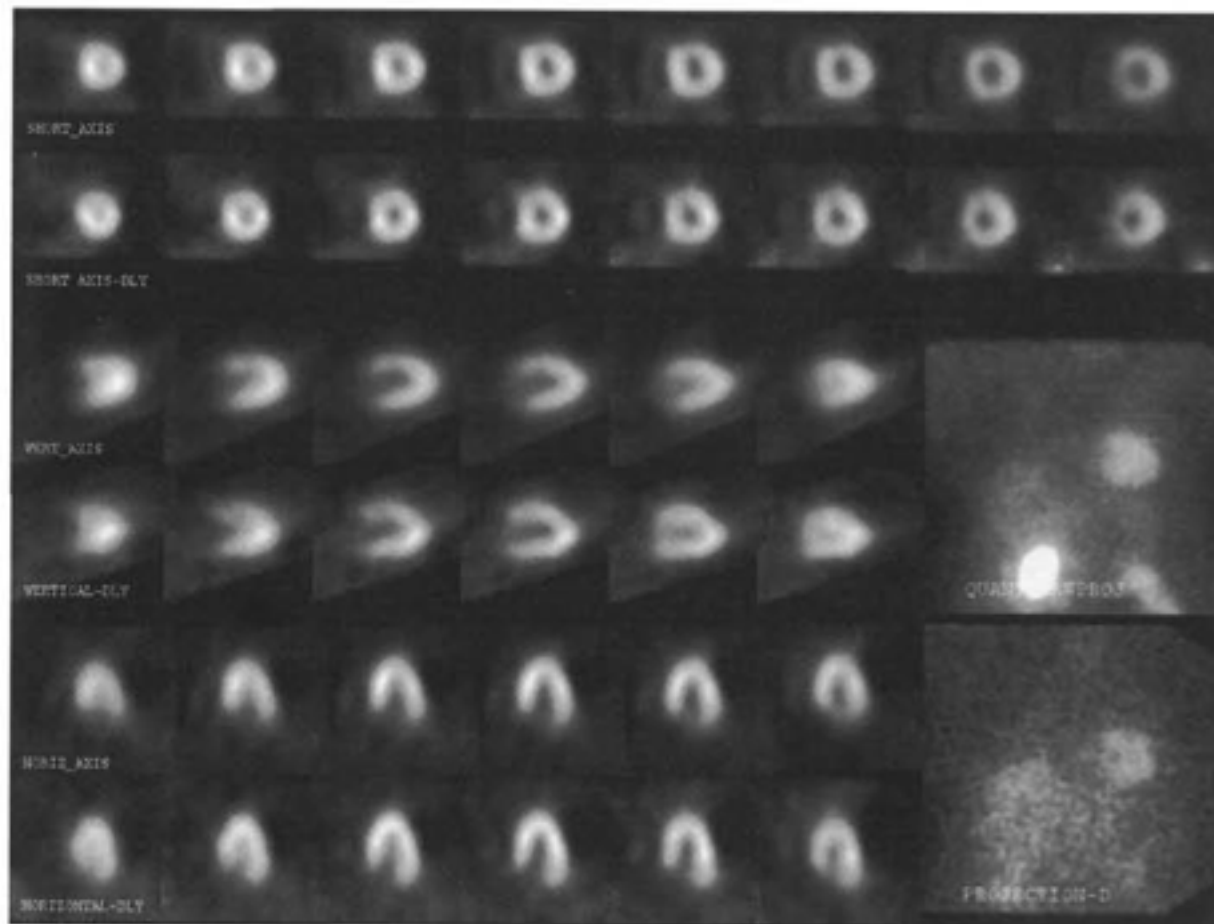


A patient had atrial fibrillation and high baseline resting heart rate. The patient exercised for only 3.5 minutes, achieved only 3.0 METS, but reached 100% of age-predicted maximum heart rate. SPECT short-axis (*A*) and horizontal long-axis perfusion images (*B*).

1. Describe any perfusion abnormalities.
2. Describe any other findings.
3. What is the most likely culprit coronary artery?
4. Discuss the significance of failure to achieve adequate exercise.

Inadequate stress

1. Severe fixed defect involving the both entire lateral wall
2. Dilated left ventricular cavity at both stress and rest.
3. LCX artery
4. False negative studies for ischemia may result

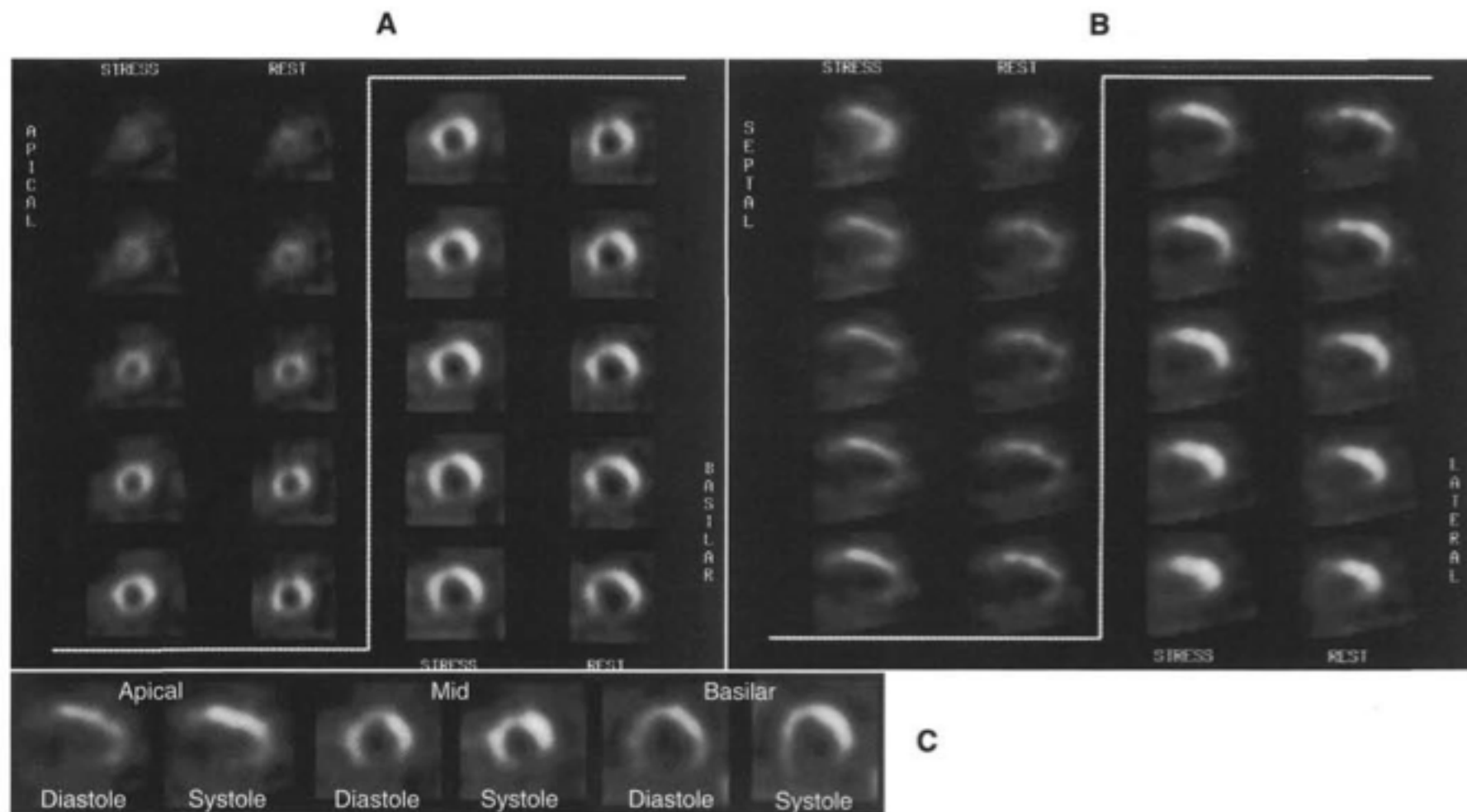


A 55-year-old woman with abnormal baseline ECG and left bundle branch block (LBBB) is sent for a stress dual-isotope SPECT study. LVEF and wall thickening by gated SPECT are normal.

1. Name the appropriate stress technique.
2. List stress methods that would be disadvantageous in this patient and state the reason.
3. Discuss the physiological advantage of adenosine or dipyridamole compared with other stress methods.
4. Describe the scintigraphic findings.

LBBB

1. Dipyridamole or adenosine
2. Exercise or dobutamine. Methods of stress that result in increased heart rate can be associated with false positive findings of septal reversibility in patient with LBBB
3. These agents do not result in an increased in heart rate.
4. The mild decreased activity in the anterior wall appears fixed and likely is caused by breast attenuation in light of the reported normal wall motion.

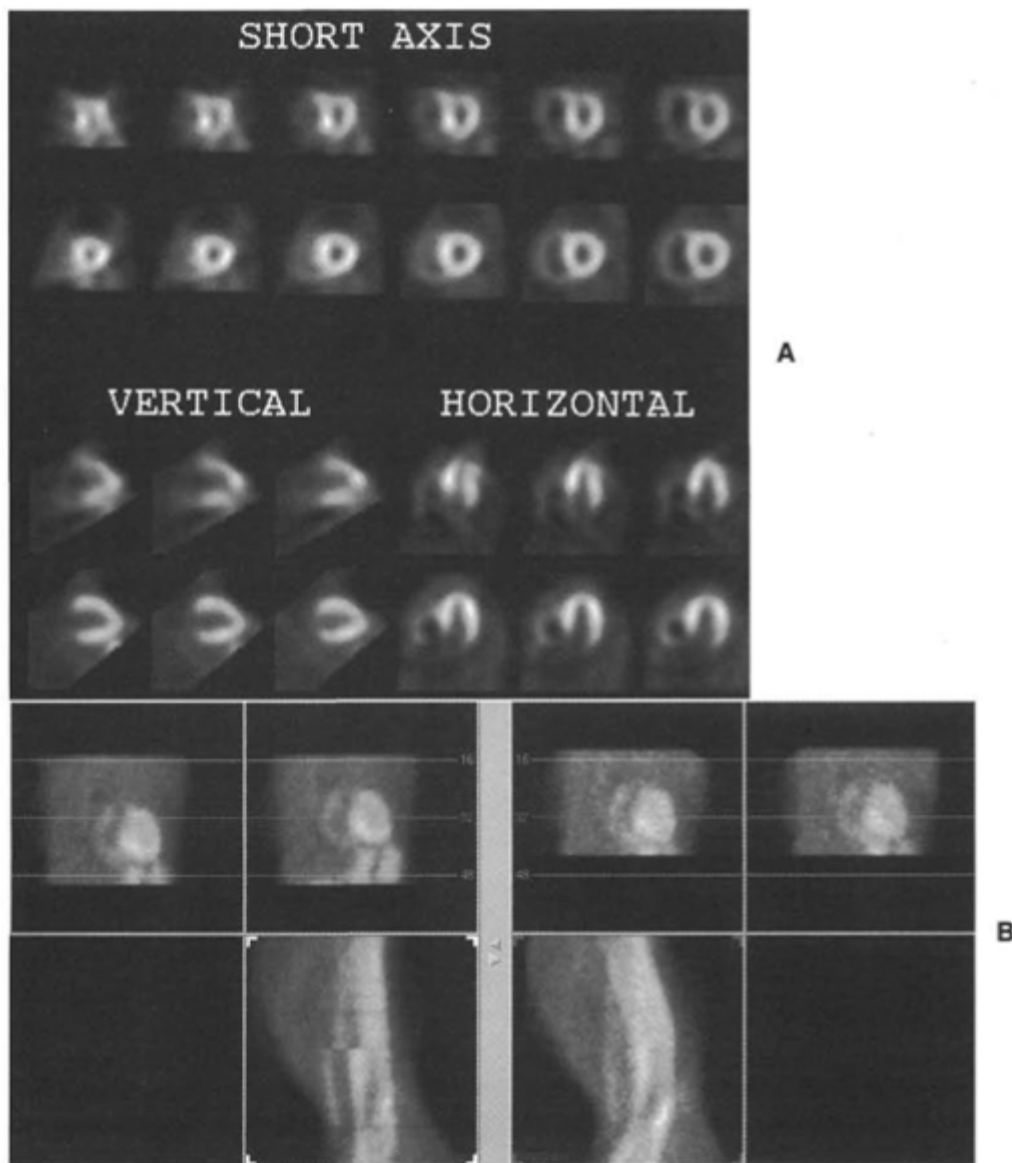


A 48-year-old patient with COPD and claudication. She has asthma. SPECT perfusion images (A, short-axis; B, vertical long-axis; and C, select gated poststress SPECT images). The left ventricular ejection fraction (LVEF) is 20%.

1. What is the appropriate stress technique for this patient? In what other patients is this the stress method of choice?
2. Why is this considered a second-line pharmacological stress agent?
3. Describe the SPECT image findings in this case.
4. What is the mechanism of cardiac uptake for ^{99m}Tc sestamibi and ^{99m}Tc tetrofosmin?

Dobutamine stress

1. Dobutamine stress; patients who are not candidate for either exercise; asthma
2. Angina and inability to tolerate dobutamine
3. Mild fixed anteroseptal perfusion defect with decreased wall thickening. Severe fixed inferior defect with absent wall thickening. Dilate LV. No reversibility. Myocardial thickening and wall motion signify functioning viable myocardium.

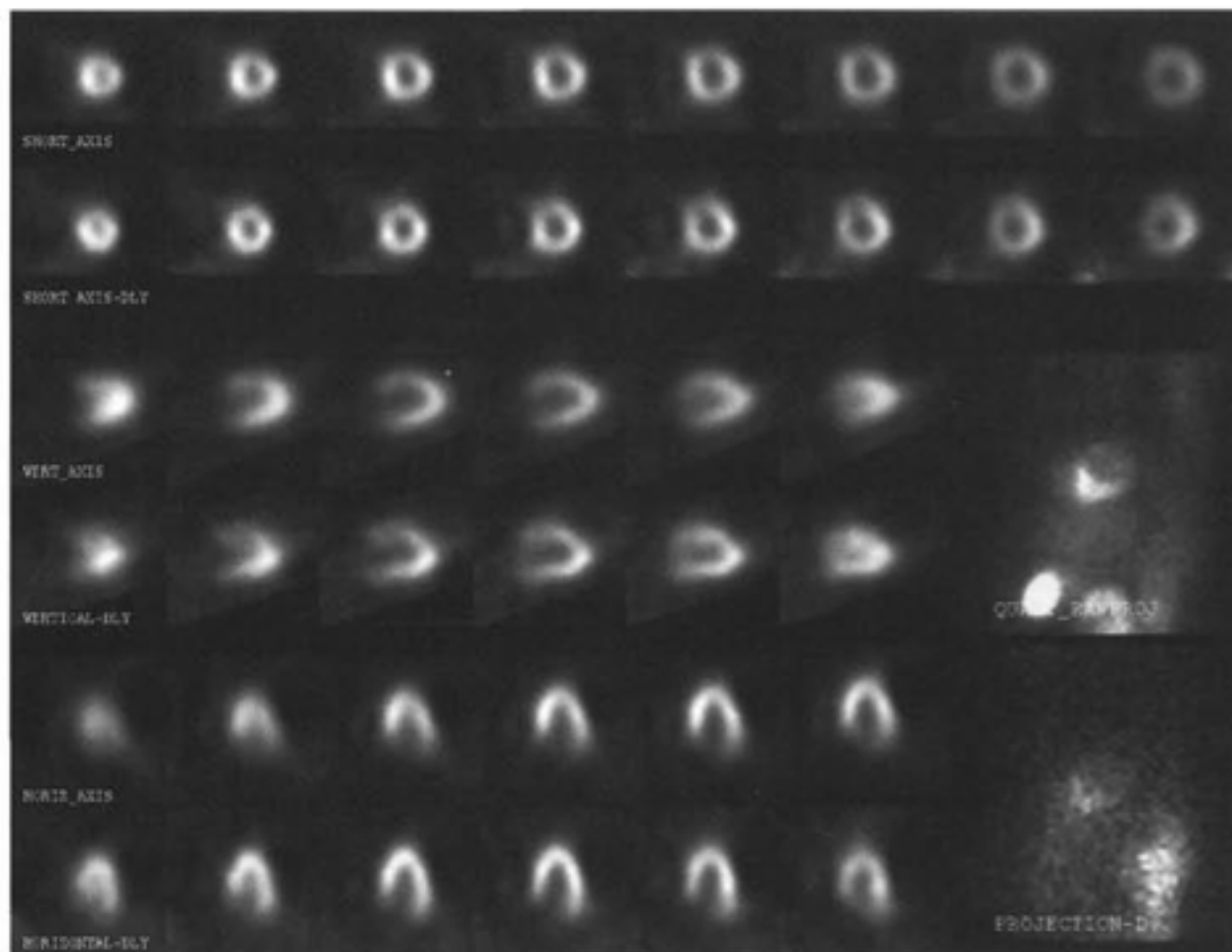


A, Exercise myocardial SPECT perfusion studies. The patient's initial stress study acquisition (*above*) and repeat acquisition (*below*). B, Sinograms for the first (*left*) and second (*right*) scans.

1. Describe the findings based on the SPECT images and sinograms.
2. Describe the purpose of the sinogram.
3. List other techniques in addition to the sinogram that can be used similarly.
4. Provide the diagnosis.

Patient motion artifact

1. A. the first study shows an abnormal configuration of the anterior wall; the repeat study is normal. B, The initial sinogram shows a discontinuity or break, the second is normal.
2. To visually present the raw unprocessed projection images to evaluate for patient motion.
3. Review SPECT projection, image by image or in cinematic display.
4. Artifact caused by patient motion.

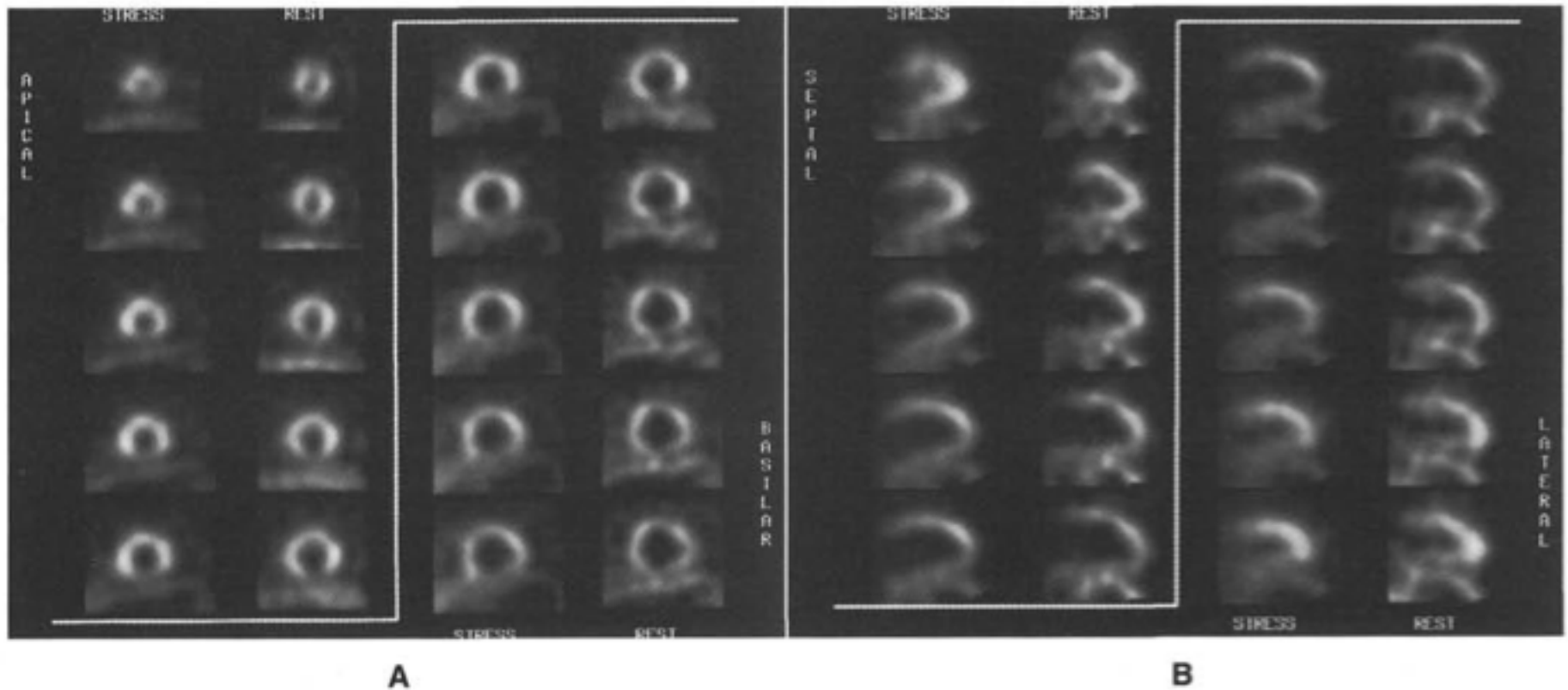


Stress and rest SPECT myocardial perfusion images and a single projection of unprocessed acquisition data from a cine loop (*right*) are provided.

1. What radiopharmaceuticals can be used for this stress study?
2. Describe the SPECT findings and any additional information available from the cine loop stress and rest projection images.
3. List the differential diagnosis.
4. List the advantages of adding ECG-synchronization (gating) to SPECT myocardial perfusion imaging.

Breast attenuation

1. Tc-99m sestamibi, tetrofosmin and not Tl-201 because the GB is seen.
2. Mild fixed defect in the anterior wall. Projection images; decreased uptake in the half of the heart at stress and rest
3. Breast attenuation, anterior wall infarction.
4. Assessment of regional wall motion, wall thickening and EF



Dipyridamole (Persantine) sestamibi SPECT myocardial perfusion study. Short-axis (A) and vertical long-axis images (B) are shown.

1. List the mechanism of action of dipyridamole. List foods and medications that counteract its pharmacological effect.
2. Describe the timing of radiotracer injection with respect to dipyridamole administration and the management of dipyridamole side effects.
3. Describe the SPECT image findings.
4. List maneuvers to deal with the problem of abdominal (liver and intestinal) activity.

Bowel activity

1. Dipyridamole inhibits the action of adenosine deaminase, increasing endogenous adenosine, a potent coronary artery vasodilatation. Coffee, tea, caffeine containing soft drinks or chocolate, theophylline and aminophylline.
2. Dipyridamole is infused for 4 minutes. Tracer is given 3 minutes after completion of dipyridamole infusion. Side effects can be reversed with aminophylline.
3. Mild to moderate fixed defect of the anterior wall. Severe, mostly fixed defect involving the entire inferior wall but small area of reversibility in the inferioapical region. Dilated LV.
4. Obtained delayed SPECT to allow additional hepatic clearance or movement of bowel activity, have the patient drink water.

Brain scintigraphy

Pearls & Pitfalls

Brain imaging

- The commonest indications for brain imaging are perfusion abnormalities (stroke), dementia (Alzheimer's or multi infarct), epilepsy, brain death, and distinguishing recurrent tumor from radiation necrosis.
- The radiopharmaceutical Tc-99m HMPAO, TC-99m ECD, N-13 PET.
- The radiopharmaceutical Tc-99m HMPAO, TC-99m ECD are lipophilic, extracted on first pass and reflect perfusion.
- Their uptake is highest in the cortical and subcortical grey matter.
- On imaging, the central area of decreased activity is primarily white matter and should not be mistaken for dilated lateral ventricle

Pearls & Pitfalls

Brain imaging

- The radiopharmaceuticals Tl-201 and FDG PET are metabolic agents that show activity in viable recurrent and persistent tumors but not in areas of radiation necrosis.
- Multi infarct dementia presents with multiple asymmetric cortical perfusion defects.
- Multiple small perfusion defects can also occur from cocaine abuse or vasculitis

Pearls & Pitfalls

Brain imaging

- Alzheimer's dementia classically presents with symmetrically decreased activity in the posterior parietal-temporal lobes with preserved activity in the calcarine cortex and basal ganglia and can be also seen in Parkinson's dementia.
- About 30% of Alzheimer's patients have symmetrically decreased activity.
- Herpes encephalitis can be seen as increased activity in the temporal lobe

Pearls & Pitfalls

- Epileptic seizure foci show increased perfusion (Tc-99m HMPAO or Tc-99m ECD) and metabolism FDG PET during seizure activity but decreased or normal activity interictally

Brain imaging

- A normal radionuclide angiographic examination of the brain presents a trident appearance of intracranial flow in the anterior cerebral and right and left middle cerebral territories.
- In brain death, there is no obvious arterial phase (the trident is absent) and only scalp activity is seen, which is often accompanied by a hot nose sign.

Pearls & Pitfalls

- These studies can also be performed by Tc-99m HMPAO or Tc-99m ECD.

Brain imaging

- A Diamox challenge study evaluate cerebral vascular reserve.
- In areas of vascular disease, regional perfusion worsens after Diamox compared with perfusion without Diamox

Pearls & Pitfalls

CSF imaging

- Common indications for CSF imaging are for evaluation of a CSF leak or for differentiating normal-pressure hydrocephalus from other causes of hydrocephalus.
- These study are done with intrathecal administration of In-111 DTPA
- Most CSF leaks occur in the ear, paranasal sinuses or nose

Pearls & Pitfalls

CSF imaging

- Substantial leaks can be imaged by noting asymmetric activity around the region of the ears on the frontal view or activity in the nose on the lateral view.
- Some leaks are detected only by removing and counting cotton pledgets that were placed in the area of concern

Pearls & Pitfalls

CSF imaging

- Cysternography images are usually obtained anteriorly.
- Six hours after injection, these images normally show a trident appearance of activity produced by labeled CSF in the anterior interhemispheric, right and left sylvian cisterns
- Any abnormal entry into the lateral ventricles is seen as heart shape activity

Pearls & Pitfalls

CSF imaging

- Early ventricular entry with stasis, accompanied by lack of activity over the superior surface of the brain after 24 to 48 hours, support the diagnosis of normal pressure hydrocephalus.
- The classical clinical triad of normal hydrocephalus includes ataxia, incontinence and dementia

FDG

RADIOPHARMACEUTICALS	F-18 FDG	
HOW THE STUDY IS PERFORMED	<ul style="list-style-type: none"> - IV FDG (10-20 mCi) - Imaged about 45 min later - Patient sit in a quiet, darkened room - EEG monitoring 	
PATIENT PREPARATION	<ul style="list-style-type: none"> - Fasting except water - Withheld alcohol/caffeine/psychiatric medication - Differ 4-6 weeks after RT 	
UNDERSTANDING THE REPORT	FDG uptake dependent on blood flow & by active cells	
	Neoplasia	FDG is taken up by higher grade tumors
		Most metastasis have increased uptake
		Radiation necrosis have little or no uptake
	Dementia	Alzheimer's dementia= decreased uptake in bilateral posterior temporoparietal, posterior cingulate gyrus and frontal lobe if more advanced
		Prick's disease = decreased uptake at frontotemporal
		Lewy bodies = temporoparietal and more occipital
		Parkinson's dementia = temporoparietal and visual cortex
		Vascular dementia = focal, asymmetric, wedge shape at cortical and subcortical
		AIDS dementia = multifocal cortical at frontal, temporal and parietal
	Seizures	Ictal = seizure = hyperperfusion
		Interictal = after seizure = hypoperfusion
POTENTIAL PROBLEMS	Diaschisis	phenomenon which abnormal in one segment will decreased uptake in uninvolved region
	False positive	Inflammation / radiation necrosis with gliosis
	False negative	Steroid/ high glucose/ RT/ small lesion/ low histologic grade
	Thyroid disease	Hypothyroid may effect FDG uptake at parietal and temporal region

Brain perfusion SPECT imaging		
RADIOPHARMACEUTICALS	Tc-99m HMPAO / Tc-99m ECD / Xenon-133	
HOW THE STUDY IS PERFORMED	<ul style="list-style-type: none"> - IV RPC (15 – 30 mCi) - Patient went in the dark room for 5 – 15 min - For seizure, EEG is compulsory 	
PATIENT PREPARATION	<ul style="list-style-type: none"> - Fasting except water - Withheld alcohol/caffeine/psychiatric medication - Differ 4-6 weeks after RT 	
UNDERSTANDING THE REPORT	Cerebrovascular disease	Brain perfusion highly sensitive to blood flow
		Hemorrhagic stroke cannot be differentiated from other infarct
		Lacuna strokes may be too small to detect
	Dementia	Alzheimer’s dementia= decreased uptake in bilateral posterior temporoparietal, posterior cingulate gyrus and frontal lobe if more advanced
		Prick’s disease = decreased uptake at frontotemporal
		Lewy bodies = temporoparietal and more occipital
		Parkinson’s dementia = temporoparietal and visual cortex
		Vascular dementia = focal, asymmetric, wedge shape at cortical and subcortical
		AIDS dementia = multifocal cortical at frontal, temporal and parietal
	Seizures	Ictal = seizure = hyperperfusion
		Interictal = after seizure = hypoperfusion
POTENTIAL PROBLEMS	Diaschisis	phenomenon which abnormal in one segment will decreased uptake in uninvolved region
	Age of infarct	It is not possible to determine the age of infarct
	Luxury perfusion	Radiotracer may be deposited at an infarct due to increased flow, even the brain cells are actually nonfunctioning. It’s seen with Tc-99m HMPAO

PATIENT PREPARATION

None.

RADIOPHARMACEUTICAL

Technetium-99m glucoheptonate or Tc-99m DTPA,
20 mCi (740 MBq)

INSTRUMENTATION

Collimator: high resolution, low energy. Camera setup:
large-field-of-view gamma.

Window: 15% over 140-keV photopeak

Camera formatter setup: 2- to 3-sec flow images for 30
sec, then immediate and delayed static images in
multiple views

Computer setup: 1-sec flow images for 60 sec (64×64
byte mode), then static images (128×128 frame
mode)

IMAGING PROCEDURE

1. Inject radiopharmaceutical as an intravenous bolus.
2. Acquire dynamic flow study.
3. *Immediate* 750k static images in the anterior, posterior, right lateral, and left lateral views (optional).
4. Starting 2 hours after injection, acquire *delayed* 750k static images in the anterior, posterior, right lateral, and left lateral views. Vertex view if needed.
5. SPECT (optional).

Blood Brain barrier protocol

PATIENT PREPARATION

None.

RADIOPHARMACEUTICAL

20 mCi technetium-99m HMPAO (Ceretec) or Tc-99m ECD (Neurolite)

INSTRUMENTATION

Camera: triple-headed SPECT

Collimators: ultra-high resolution

Computer setup: SPECT acquisition parameters

Matrix size: 64×64

Zoom: 2

Rotation: step and shoot

Orbit: circular

Angle step size: 3°

Stops: 40 per head

Time per stop: 40 sec (total time, 1600 sec or 27 min)

IMAGING PROCEDURE

Prepare dose according to package insert. Note shelf life.

Position patient so that brain is entirely within field of view of all detectors.

Position collimators as close as possible to patient's head.

Begin scanning 15 min or later after radiopharmaceutical injection.

PROCESSING

Filtered backprojection

Filter: Hamming, 1.2 high-frequency cut-off

Attenuation correction: 0.11 cm^{-1}

SPECT cerebral perfusion imaging protocol

Brain death scan

RADIOPHARMACEUTICALS	Tc-99m HMPAO / Tc-99m ECD / Tc-99m pertechnetate / Tc-99m DTPA	
HOW THE STUDY IS PERFORMED	<ul style="list-style-type: none"> - Tc-99m pertechnetate / DTPA bolus (20 mCi) for cerebral blood flow - Tc-99m HMPAO / ECD (15 – 30 mCi), delayed images from 20 min to 2 hours post injection 	
PATIENT PREPARATION	- No specific preparation	
UNDERSTANDING THE REPORT	Absent of cerebral blood flow	
	Hot nose sign	
POTENTIAL PROBLEMS	Barbiturates or hypothermia	Barbiturate coma, taking phenobarbital or hypothermia
	False negative	Scalp blood flow may be increased due to inflammation
	Continuum of brain death	Ineffective blood flow can persist despite true brain death

Diamox Brain stress scan

RADIOPHARMACEUTICALS	Tc-99m HMPAO / Tc-99m ECD	
HOW THE STUDY IS PERFORMED	<ul style="list-style-type: none"> - 1 g Diamox injected - Rpc (9 mCi) injected 20 min later - The base line scan can be performed a day before or after 	
PATIENT PREPARATION	<ul style="list-style-type: none"> - Contraindication for sulfa drug allergy - Diamox is to be avoided within 3 days of acute stroke 	
UNDERSTANDING THE REPORT	Carotid artery stenosis	Decreased flow to the affected region on Diamox scan compared to base line
	Multiinfarct dementia or Alzheimer's disease	MID = defect are often pronounced following Diamox AD = normal
POTENTIAL PROBLEMS	Side effect of Diamox = vertigo/ tinnitus/nausea/ postural hypotension	
	Completely balanced bilateral lesion may give false negative	

Thallium-201 or Tc-99m SestaMIBI Brain Scan

RADIOPHARMACEUTICALS	<p>Tc-99m sestamibi = localizes in mitochondria by active diffusion across an interrupted BBB</p> <p>Thallium 201 = concentrated like potassium in viable tumor, less in inflammatory and no in necrotic tissue</p>	
HOW THE STUDY IS PERFORMED	<ul style="list-style-type: none"> - Tl-201 (2 – 4 mCi) IV , image at 10 – 30 min and delayed at 2 – 4 hours - Tc-99m SestaMIBI (10 – 30 mCi) IV an image at 10 min to 4 hours 	
PATIENT PREPARATION	<ul style="list-style-type: none"> - No special preparation 	
UNDERSTANDING THE REPORT	Normal brain	Little or no thallium uptake
	High grade gliomas and lymphoma	Increased uptake “hot”
	Infection or radiation necrosis	No significant increase from background
POTENTIAL PROBLEMS	False positive	<p>There has been reports of thallium uptake with abscess, certain infections, inflammatory demyelinating disease and radiation necrosis</p> <p>SestaMIBI less prone to false positive</p>
	False negative	<p>If a lesion is necrotic, partially treated, near an areas of normal uptake in the skull base or scalp, or below the resolution of imaging</p>

Radionuclide Cysternogram

RADIOPHARMACEUTICALS	Indium-111 DTPA 3 days half life Study requires 24 – 72 hours	
HOW THE STUDY IS PERFORMED	<ul style="list-style-type: none"> - LP is performed - In-111 DTPA (9-18 MBq) into intrathecal - Image at 1-4 hr, 24 hr, up to 48 – 72 hr 	
PATIENT PREPARATION	<ul style="list-style-type: none"> - Lumbar puncture should be informed to patient before procedure - LP and radiotracer administration under fluoroscopic guidance 	
UNDERSTANDING THE REPORT	Normally radiotracer reaches basal cisterns by 1 hr, frontal poles and Sylvian fissures by 2 – 6 hr Convexity by 12 hr Sagittal sinus by 24 hr	
POTENTIAL PROBLEMS	Lumbar puncture	Extravasation will manifest as persistent activity at the lumbar puncture site and slow or no progression to the cranium
	Overlapping patterns	Often there is overlap of finding

PATIENT PREPARATION

None.

RADIOPHARMACEUTICAL

Indium-111 DTPA, 250 μ Ci

INSTRUMENTATION

Camera: large-field-of-view gamma

Collimator: medium energy

IMAGING PROCEDURE

Inject slowly into lumbar subarachnoid space using a 22-gauge needle with the bevel positioned vertically.

Patient should remain recumbent for at least 1 hr after injection.

All images should be obtained for 50k counts.

Imaging times:

1 hr: thoracic-lumbar spine for evaluation of injection adequacy.

3 hr: base of the skull to visualize basilar cisterns.

24 and 48 hr: evaluation of ventricular reflux and arachnoid villi resorption.

Obtain anterior, posterior, and both lateral views of the head at 3, 24, and 48 hr.

Cysternography protocol

CSF leak

RADIOPHARMACEUTICALS	Indium-111 DTPA 3 days half life
HOW THE STUDY IS PERFORMED	<ul style="list-style-type: none">- Before the exam, labeled cotton pledgets are placed into the nasal cavity and/or ears by ENT- In-111 DTPA is introduced into the thecal sac via LP (9 – 18 MBq)- Patient lies supine or in Trendelenberg- Image at 1 – 4 hr- Patient may be asked to Valsalva to increased CSF pressure- The pledgets usually withdrawn when leak is detected or at 4 – 24 hr and weighed and counted for radioactivity- Plasma sample is collected to calculate a pledget to plasma radioactivity ratio because CSF is absorbed into the blood stream and will appear in normal nasal secretions- Further delayed up to 72 hr
PATIENT PREPARATION	<ul style="list-style-type: none">- Informed for lumbar puncture
UNDERSTANDING THE REPORT	A corrected pledget to plasma ratio > 2:1 indicates CSF leakage
POTENTIAL PROBLEMS	Lumbar puncture
	Pledgets falling out
	Nasal secretion radioactivity

PATIENT PREPARATION

Nasal pledgets should be placed and labeled as to location. The pledgets should be weighed before placement.

After intrathecal injection, place patient in Trendelenburg position to pool the radiotracer in the basal regions until imaging begins.

Once radiotracer reaches basal cisterns, position patient in a position that increases cerebrospinal fluid leakage.

Rhinorrhea: incline patient's head forward and against camera face with the camera positioned in the lateral position.

Otorrhea: obtain posterior images instead of lateral views.

RADIOPHARMACEUTICAL

In-111 DTPA, 250 μ Ci

INSTRUMENTATION

Camera: large-field-of-view gamma

Collimator: medium energy

IMAGING PROCEDURE

Setup

Inject intrathecally 500 μ Ci of In-111 DTPA in 5 ml of dextrose 10% in water.

Begin imaging when activity reaches the basal cisterns (1 to 4 hr).

Acquisition

Acquire 5 min/frame for 1 hr in the selected view, then acquire anterior, left lateral, right lateral, and posterior views.

Obtain 50k images every 10 min for 1 hr in the original view.

Remove pledgets and place in separate tubes. Draw a 5-ml blood sample.

Count pledgets and 0.5-ml aliquots of plasma.

Repeat views may be indicated at 6 and 24 hr.

Calculate the ratio of pledgets-to-plasma activity:

pledget counts/pledget capacity divided by serum counts/0.5 ml.

Interpretation

Positive for CSF leakage if the pledget/plasma activity ratio is greater than 2-3:1

CSF leak protocol

CSF Shunt Patency scan

RADIOPHARMACEUTICALS	Tc-99m DTPA/ MAA In-111 DTPA
HOW THE STUDY IS PERFORMED	<ul style="list-style-type: none"> - Tc-99m DTPA or MAA (0.5 – 1 mCi) Or In-111 DTPA (0.25 – 0.5 mCi) injected into the shunt - Image taken at 30 min to 2 hr
PATIENT PREPARATION	<ul style="list-style-type: none"> - Aware type of shunt
UNDERSTANDING THE REPORT	<p>Normal flow through the tubing should be seen with significant reservoir clearance by 30 min</p> <p>Ventriculoperitoneal shunt free distribution within abdominal cavity</p> <p>If the tip is intra arterial – MAA is trapped in the lungs</p> <p>Hold up of tracer at shunt tip in peritoneum indicates a loculation</p> <p>Ventricular chemotherapy shunt – radiotracer appear at convexities by 24 hr if no obstruction</p>
POTENTIAL PROBLEMS	Unfamiliar with shunt
	Peri shunt injection – injecting not into reservoir will cause false positive

PATIENT PREPARATION

None.

RADIOPHARMACEUTICAL

Technetium-99m DTPA, 0.5 to 1 mCi, or indium-111 DTPA, 250 μ Ci

INSTRUMENTATION

Camera: wide-field-of-view gamma.

Collimator: all purpose.

Computer and camera setup: 1-min images for 30 min.

IMAGING PROCEDURE

Using aseptic technique. Clean the shaved scalp with Betadine.

Penetrate the shunt reservoir with a 25- to 35-gauge needle.

Once the needle is in place, position the patient's head under the camera with the reservoir in the middle of the field of view.

Inject the radiopharmaceutical.

Take serial images for 30 min.

If no flow is seen, place the patient in an upright position and continue imaging for 10 min.

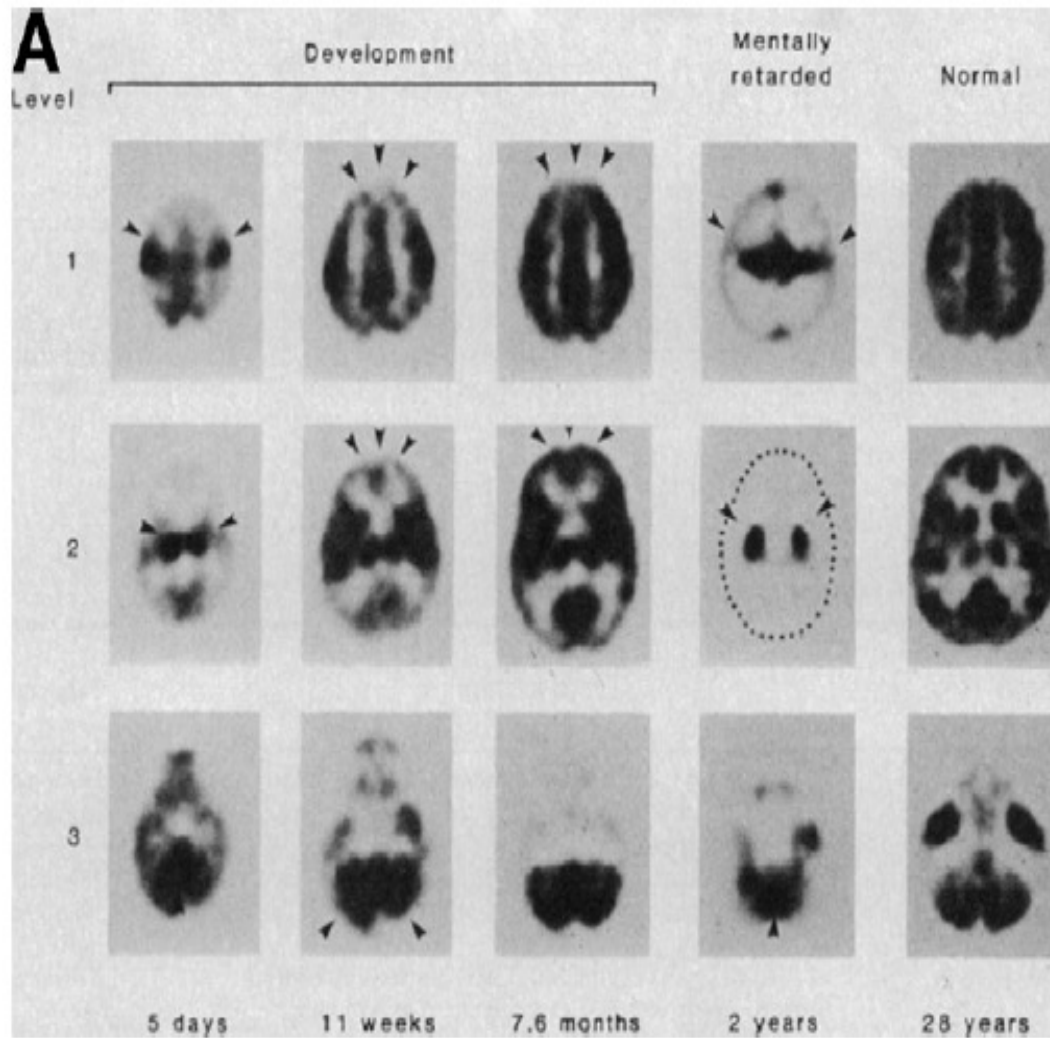
If still no flow is seen, obtain static images of 50k after 1 and 2 hr.

If flow is demonstrated at any point, obtain 50k images of the shunt and tubing every 15 min until flow to the distal tip of the shunt tubing is identified or for 2 hr, whichever is first.

To determine proximal patency of the reservoir, the distal catheter can be manually occluded during the procedure so that the radiotracer will reflux into the ventricular system.

Shunt patency protocol

Prick's disease	Generalize cortical hypoperfusion and hypometabolism favoring prefrontal regions
Multiinfarct dementia	Scattered foci of decreased cortical perfusion and metabolism
Alzheimer's disease	Hypoperfusion and metabolism in temporoparietal regions
Huntington's disease	Decreased glucose metabolism and perfusion in caudate nucleus and putamen
Wilson's disease	Severe depression of lenticular nuclei glucose metabolism
AIDS dementia	Diffuse hypometabolism affecting subcortical more than cortical gray matter



B

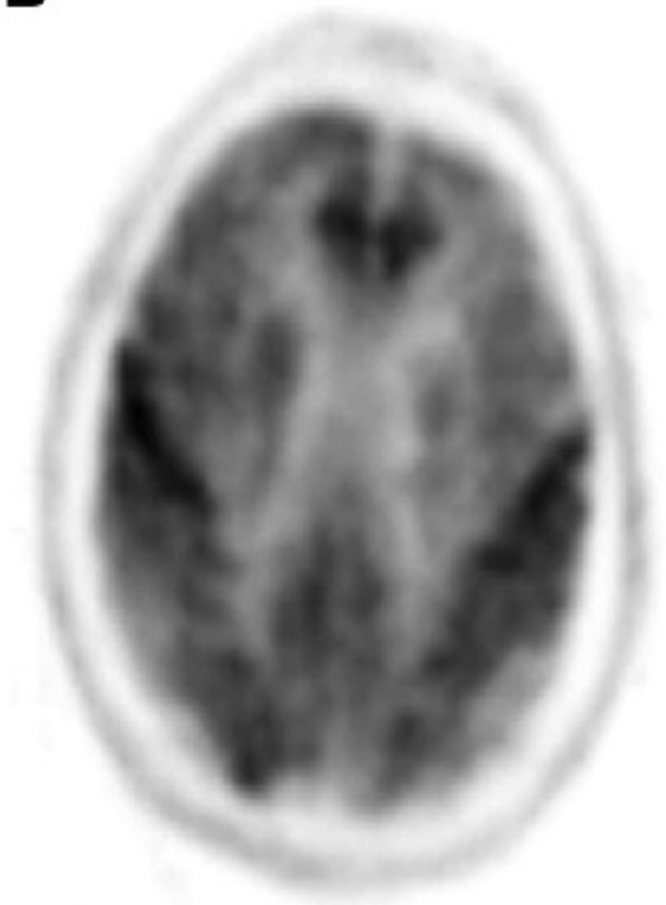
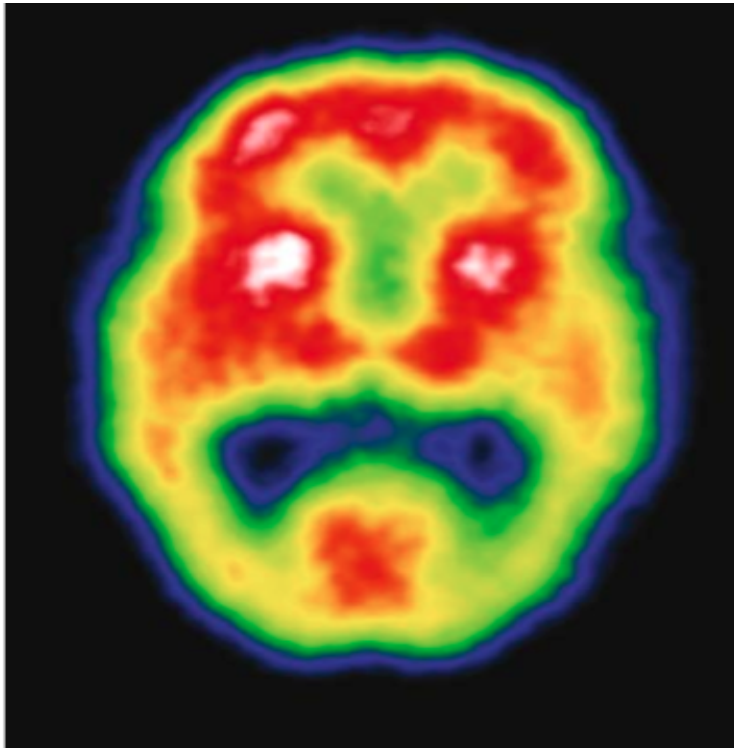
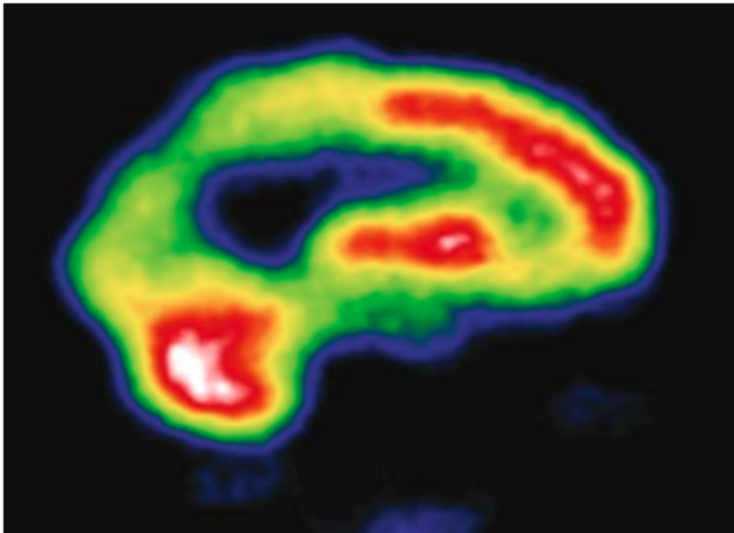
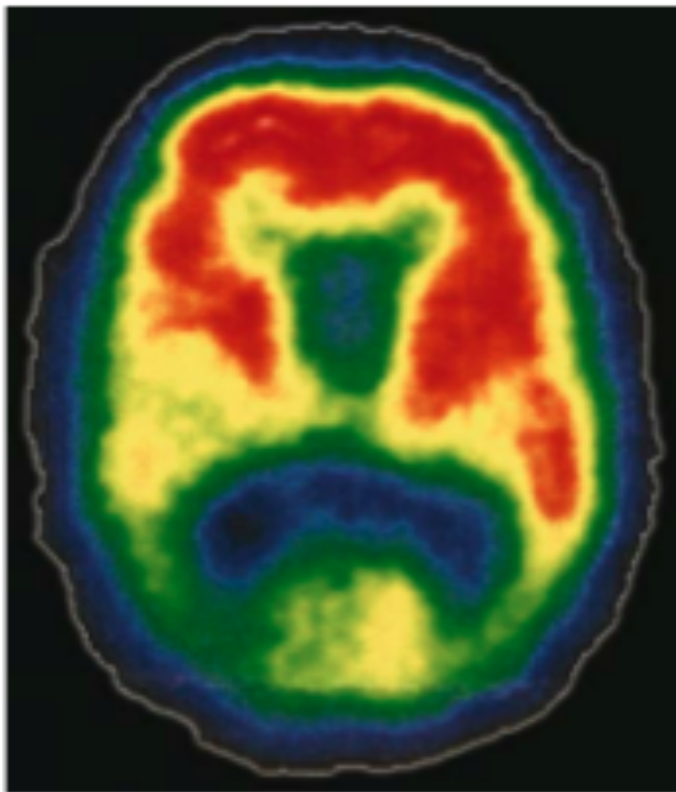


Figure 3 Glucose utilization in infants with increasing age using FDG-PET imaging (A). In infants at age 5 days, highest glucose metabolism is seen in sensorimotor cortex, thalamus, midbrain, and vermis (arrows). By 3 months, activity increases in parietal, temporal, and occipital cortices (arrows) and basal ganglia with subsequent increase in frontal cortices and association cortices by 8 months (arrows). (Reprinted with permission from Chugani and Phelps.⁸⁷) Note preservation of glucose metabolism in sensory-motor cortex in patient with Alzheimer's disease (B) which mimics metabolic activity in infants up to 5 weeks of age.

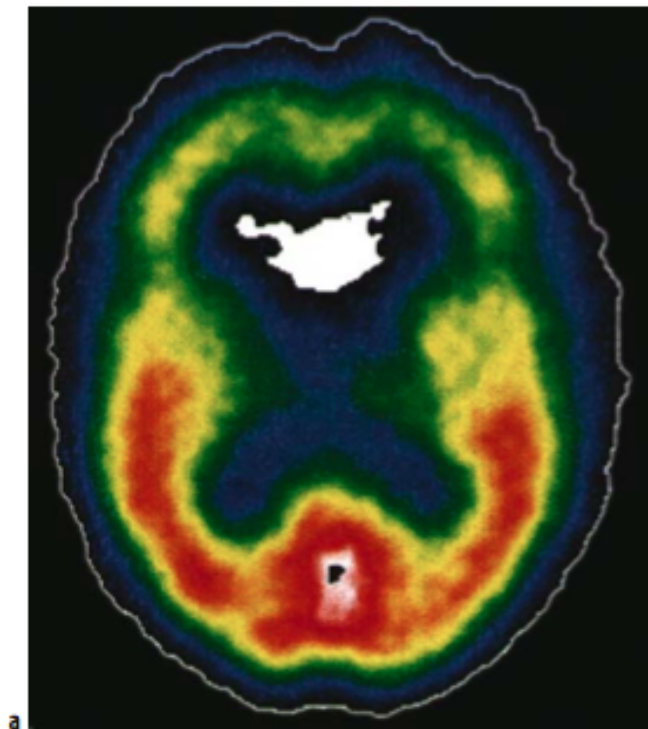


Tc-99m HMPAO SPECT for brain in Alzheimer's disease showing posterior temporoparietal defects

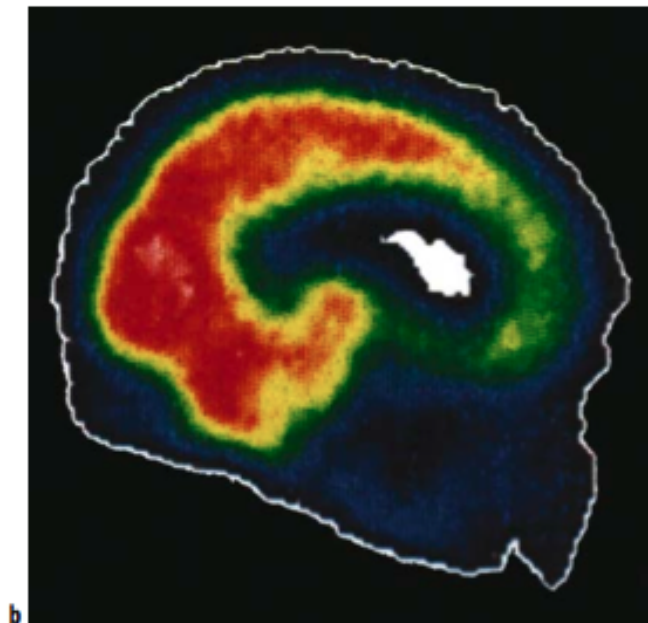


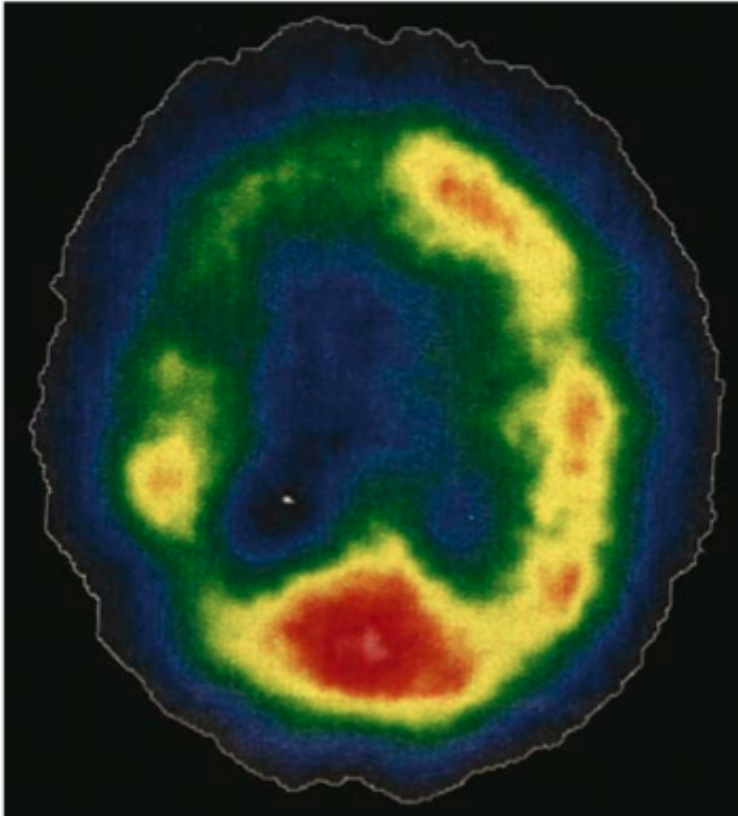


Tc-99m HMPAO SPECT of the brain in dementia of Lewy bodies showing posterior perfusion defect with involvement of occipital cortex



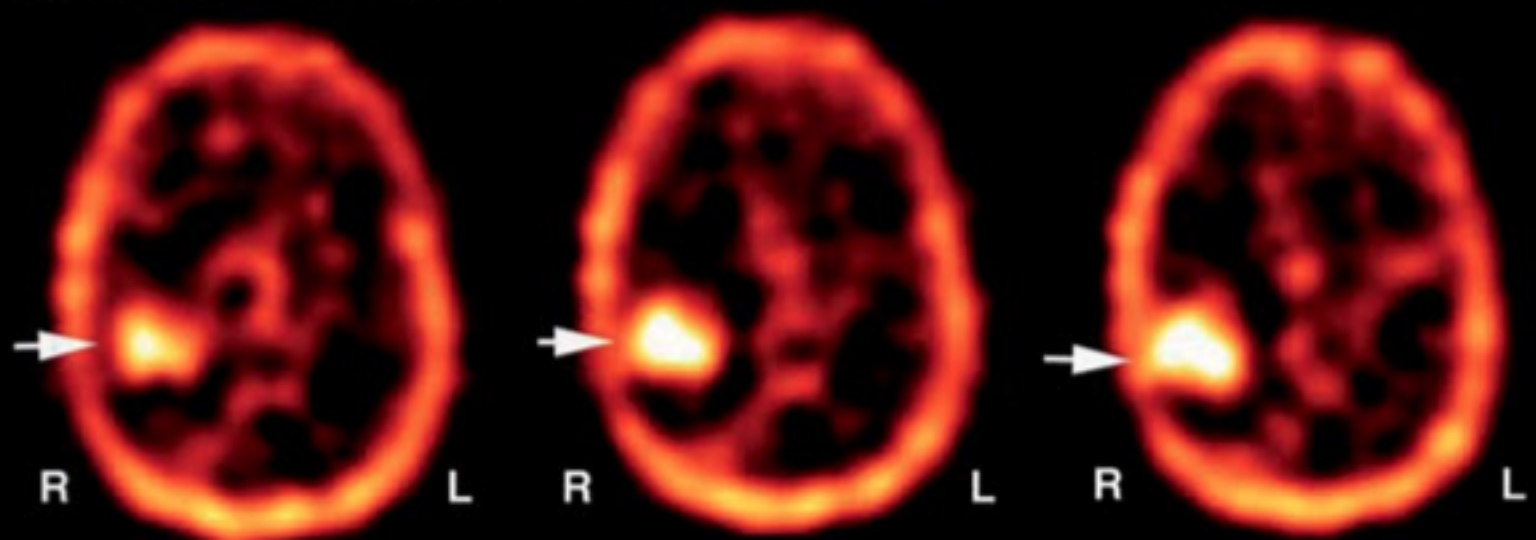
Tc-99m HMPAO SPECT of the brain in frontotemporal dementia (Prick's disease) of showing anterior perfusion defect



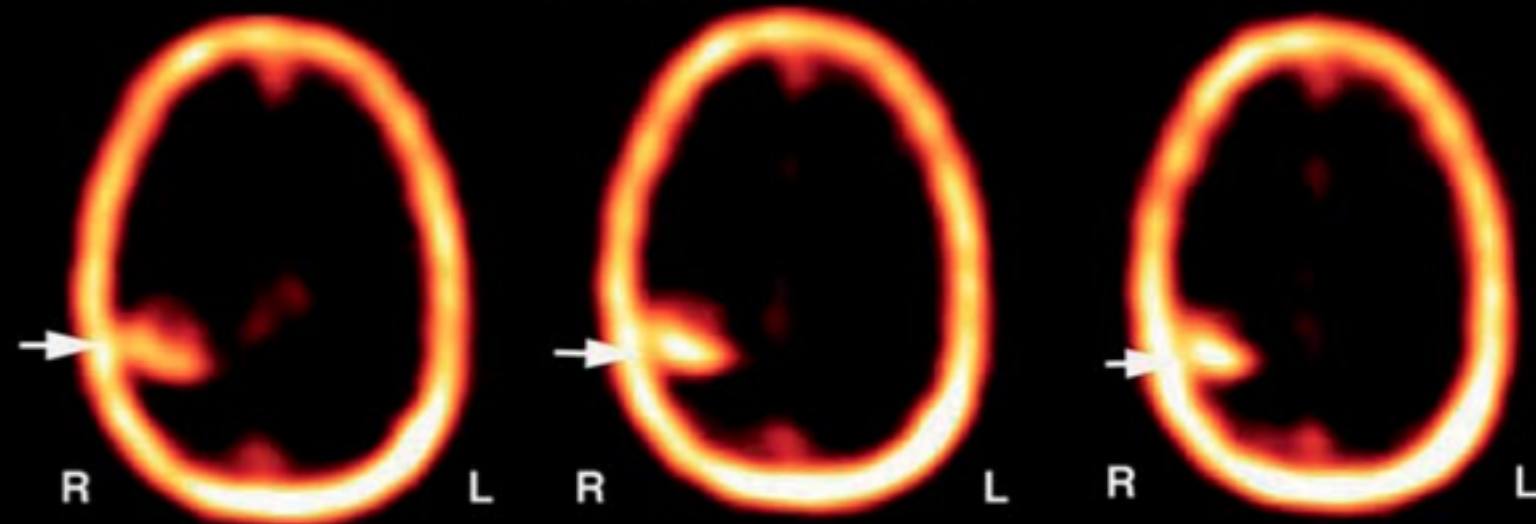


Tc-99m HMPAO SPECT of the brain in vascular dementia showing multiple perfusion defects, with generally reduced perfusion in the right internal carotid territory

High Grade Brain Tumor **Tl-201 SPECT**



Tc-99m MIBI SPECT



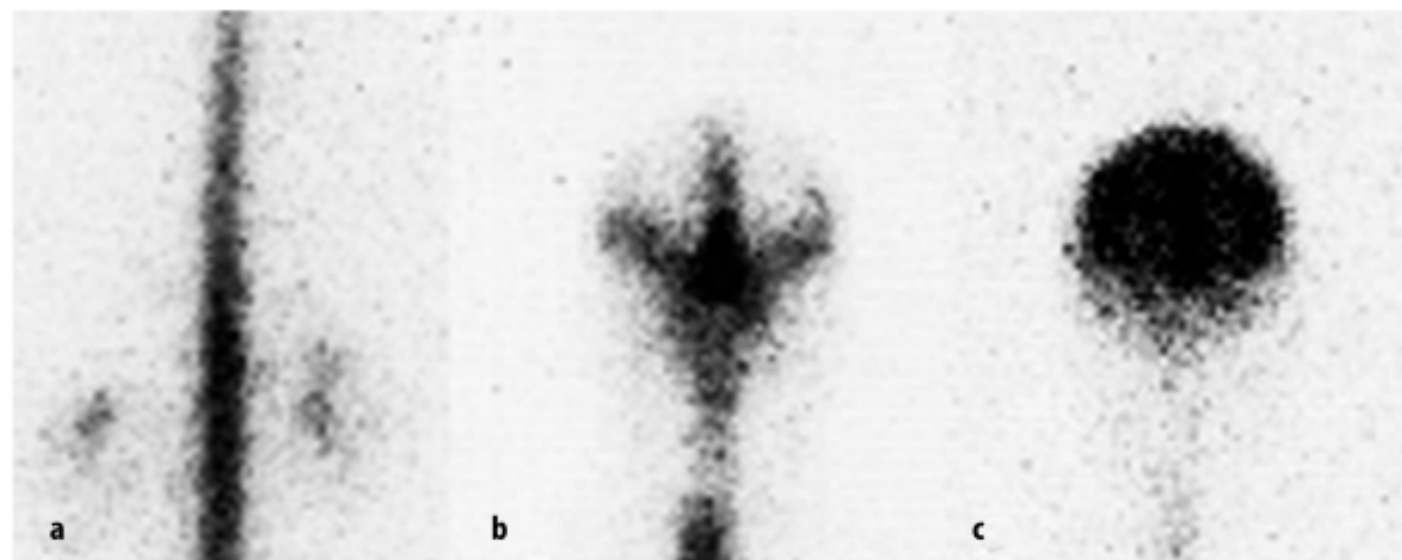


Fig. 3.11. Normal CSF flow pattern: Images at 2 h (a) reveal radiotracer, in CSF, ascending up the thoraco-lumbar spinal canal; at 6 h (b) the radiotracer is in the basilar cisterns and at 24 h (c) the radiotracer is being reabsorbed in the arachnoid villi at the convexity of the brain

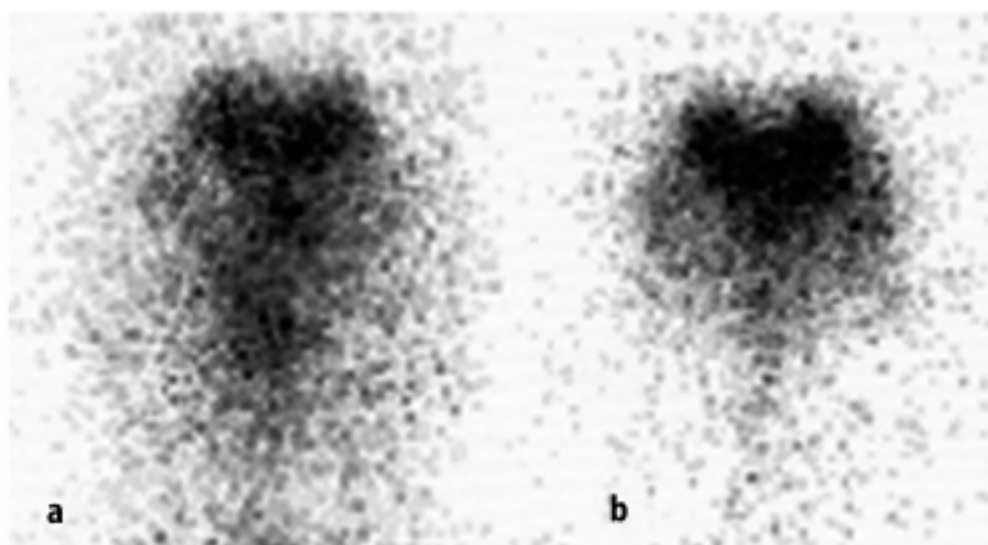
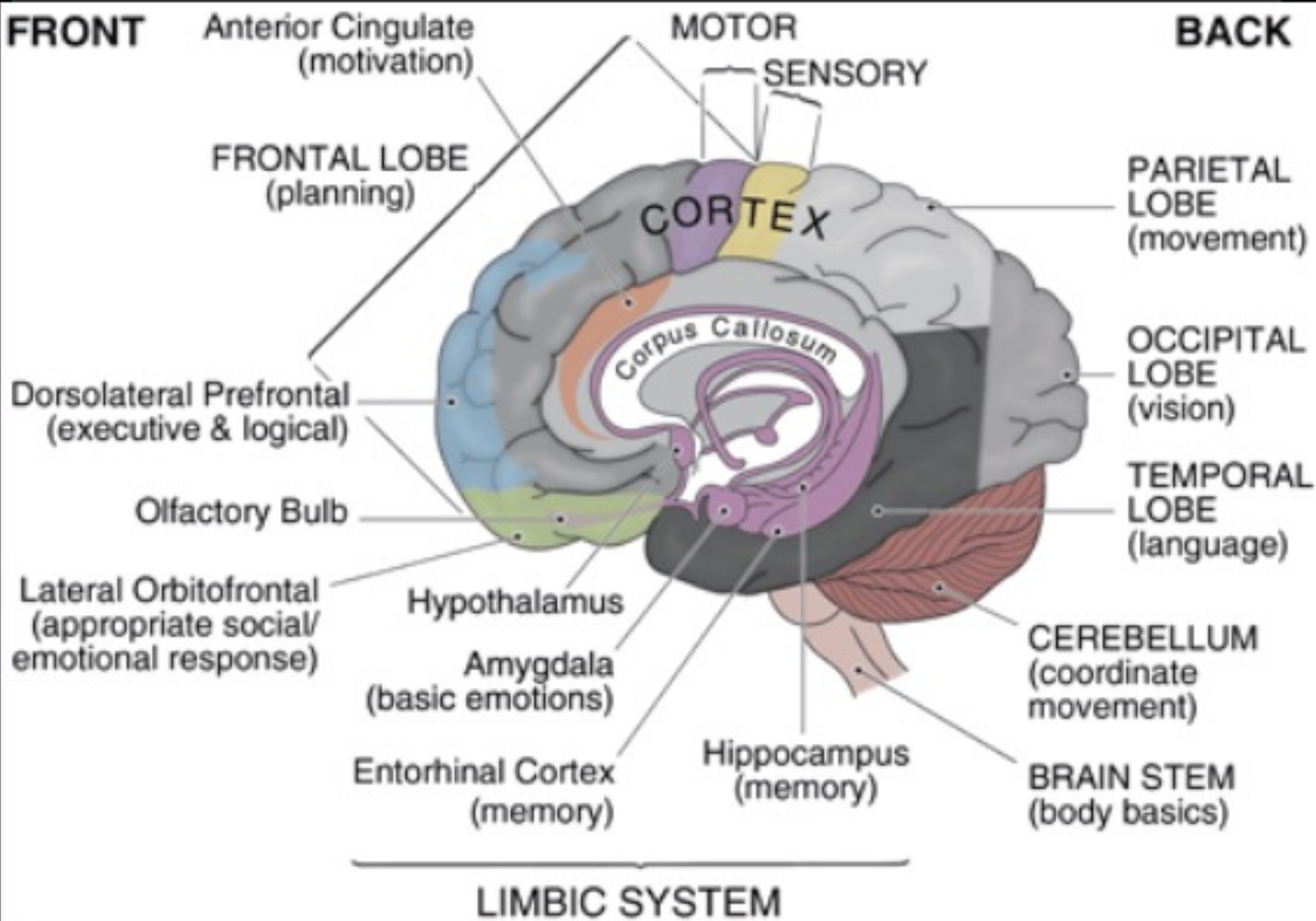


Fig. 3.12. Normal pressure hydrocephalus pattern: Images at 24 h (a) demonstrate radiotracer in the lateral ventricles, “ventricular penetration,” and at 48 h (b) persistence of radiotracer in the lateral ventricles, “ventricular stasis” and no movement of the radiotracer beyond the basilar cisterns consistent with extra-ventricular obstruction to CSF flow



Cerebral Requirements of Blood flow and Metabolism

Parameter	Requirement
-----------	-------------

Percentage of total body weight	2%
Percentage of global cardiac output	20%
Cerebral blood volume	120 mL
Blood-flow needs	750 mL/min
Oxygen needs	50 mL/min
Glucose needs	100 mg/min
Global cerebral blood flow	55 mL/100 g/min
Gray-matter blood flow	80 mL/100 g/min
White-matter blood flow	20 mL/100 g/min

Normal Brain Distribution

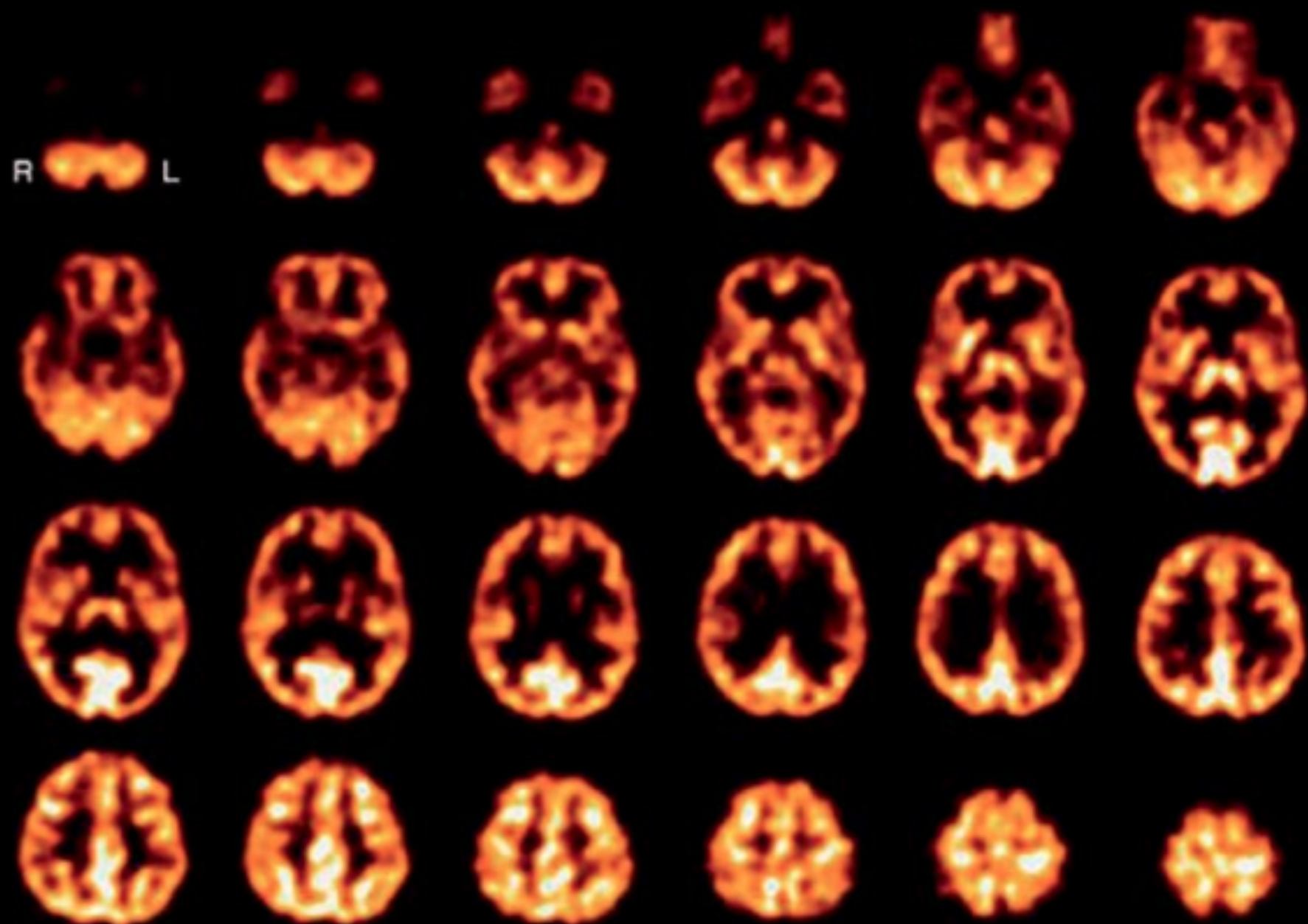
- In a normal brain perfusion SPECT and PET, high perfusion and metabolism is observed in the gray matter including basal ganglia and thalami and especially in the primary visual cortex.

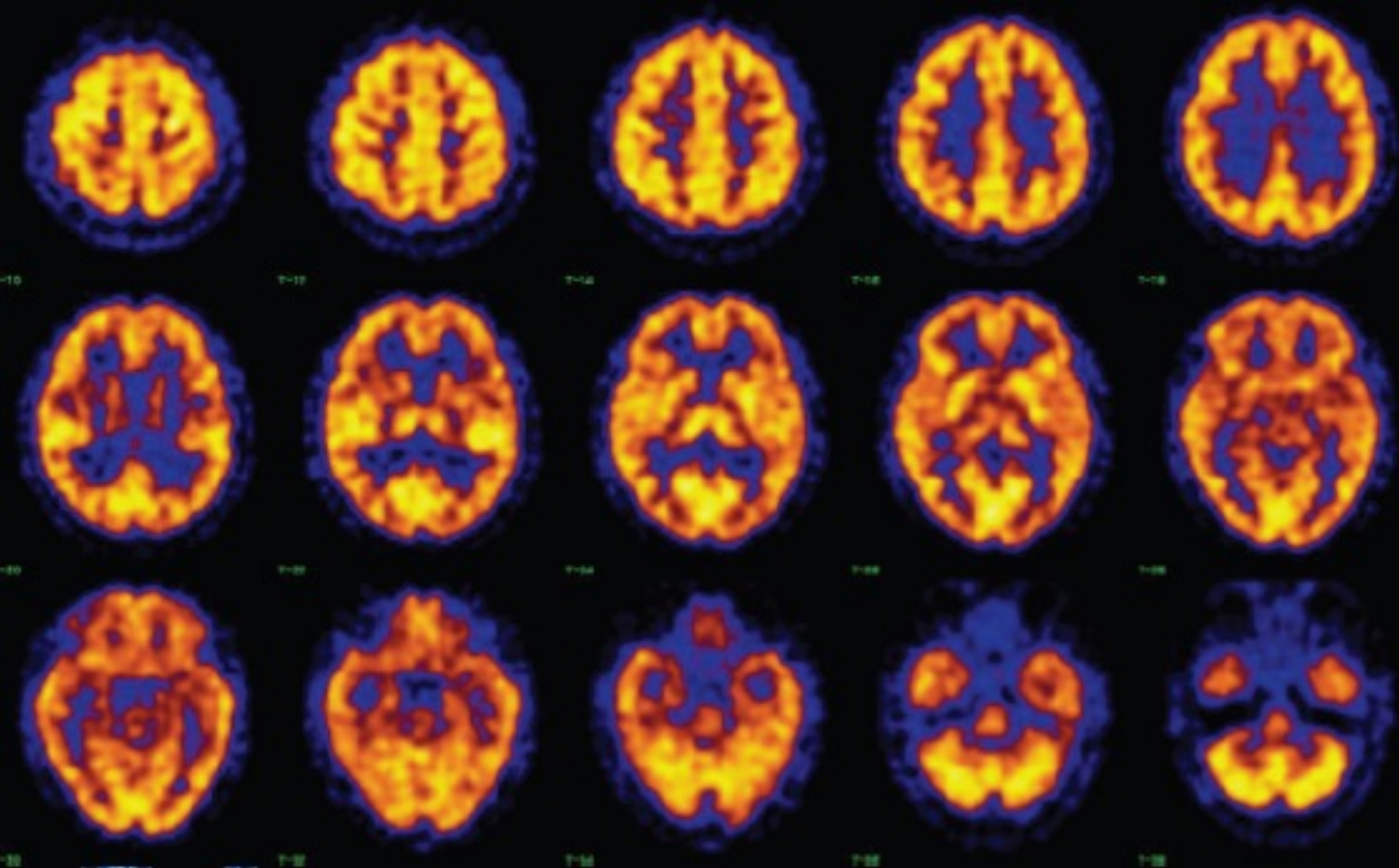
Developmental variation of CBF :

- at birth - globally lower than adulthood
- until the age of 7 years - gradually increasing
- after age of 7- gradually decreasing to be similar to that of an adult
- aging brain - reduction of blood flow and metabolism in the frontal, anterior cingulate cortices



Normal Tc-99m HMPAO Brain Scan

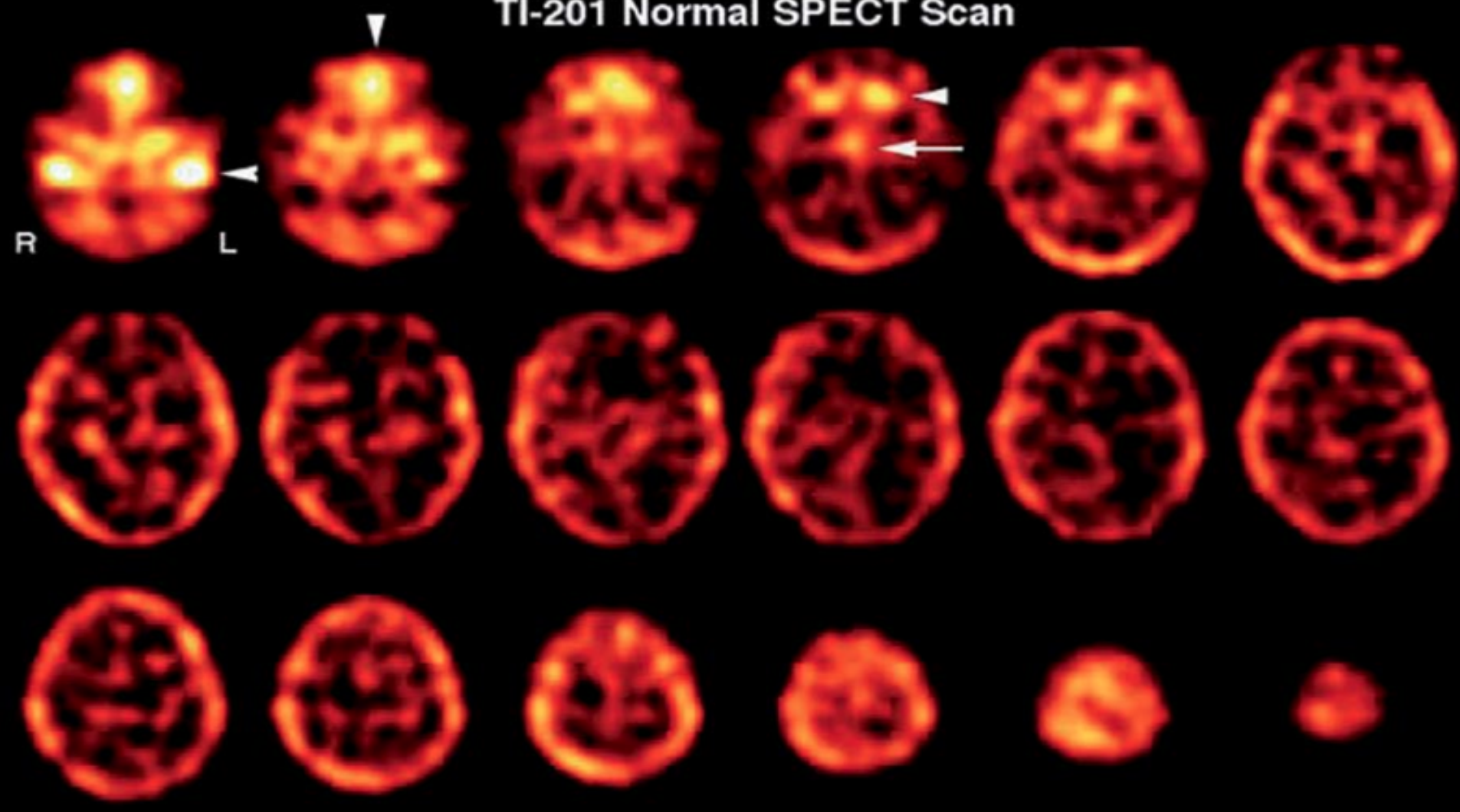




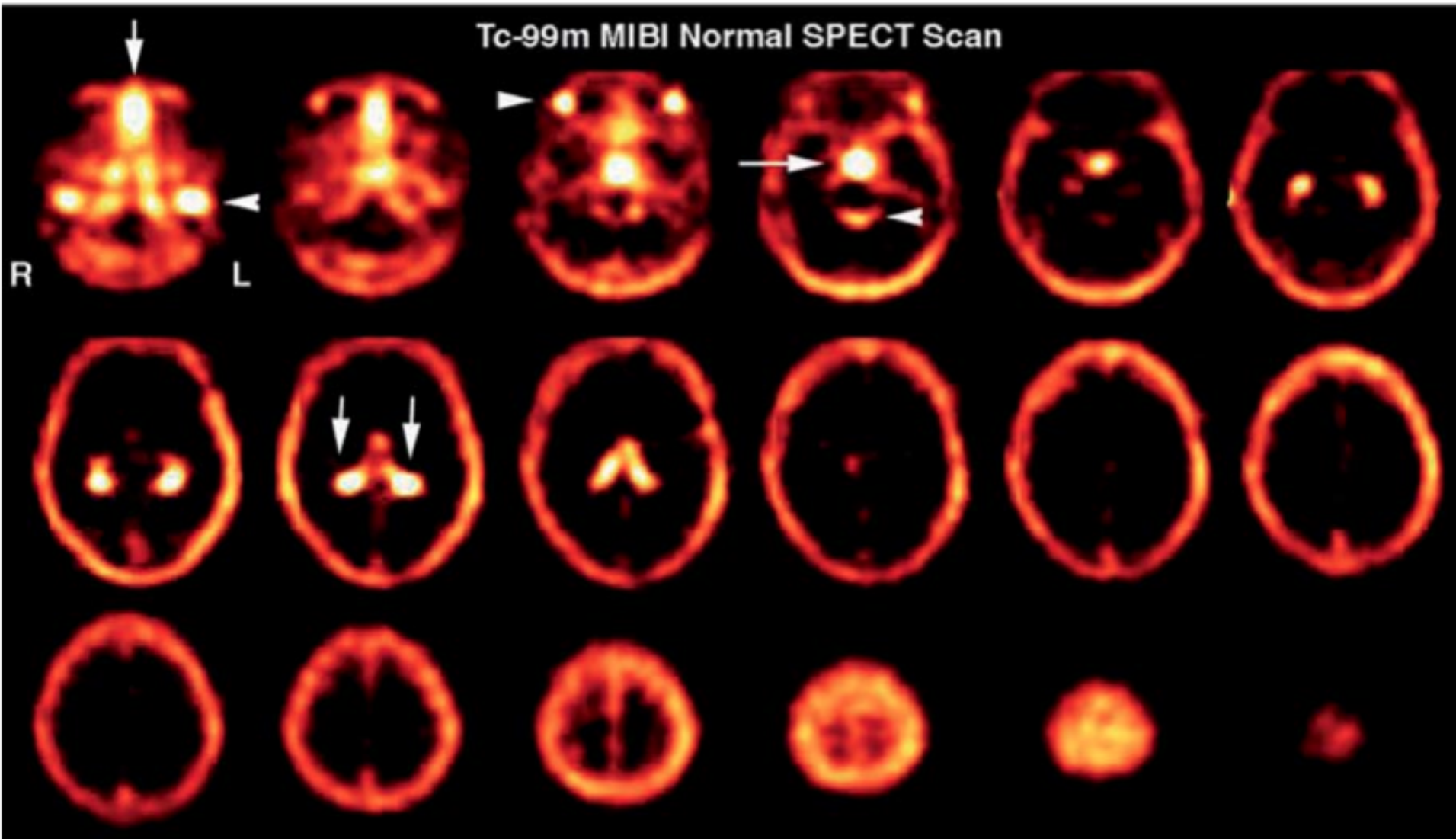
Distribution of normal cerebral blood flow measured by ^{99m}Tc ECD SPECT



TI-201 Normal SPECT Scan

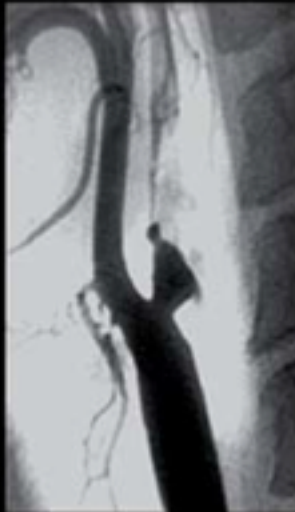


Tc-99m MIBI Normal SPECT Scan



Case: D.B. L ICA Occlusion

Pre-Angioplasty



Tc-99m HMPAO SPECT



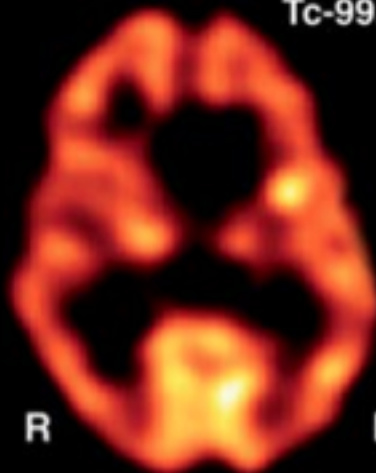
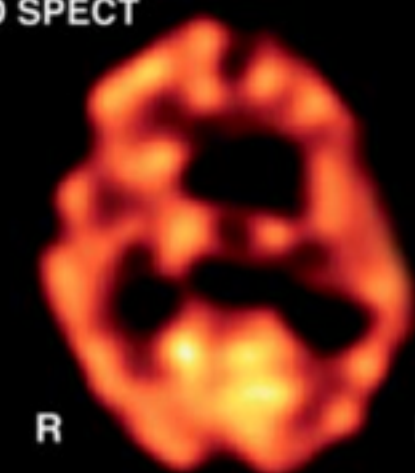
Pre-Diamox

Post-Diamox

Post-Angioplasty



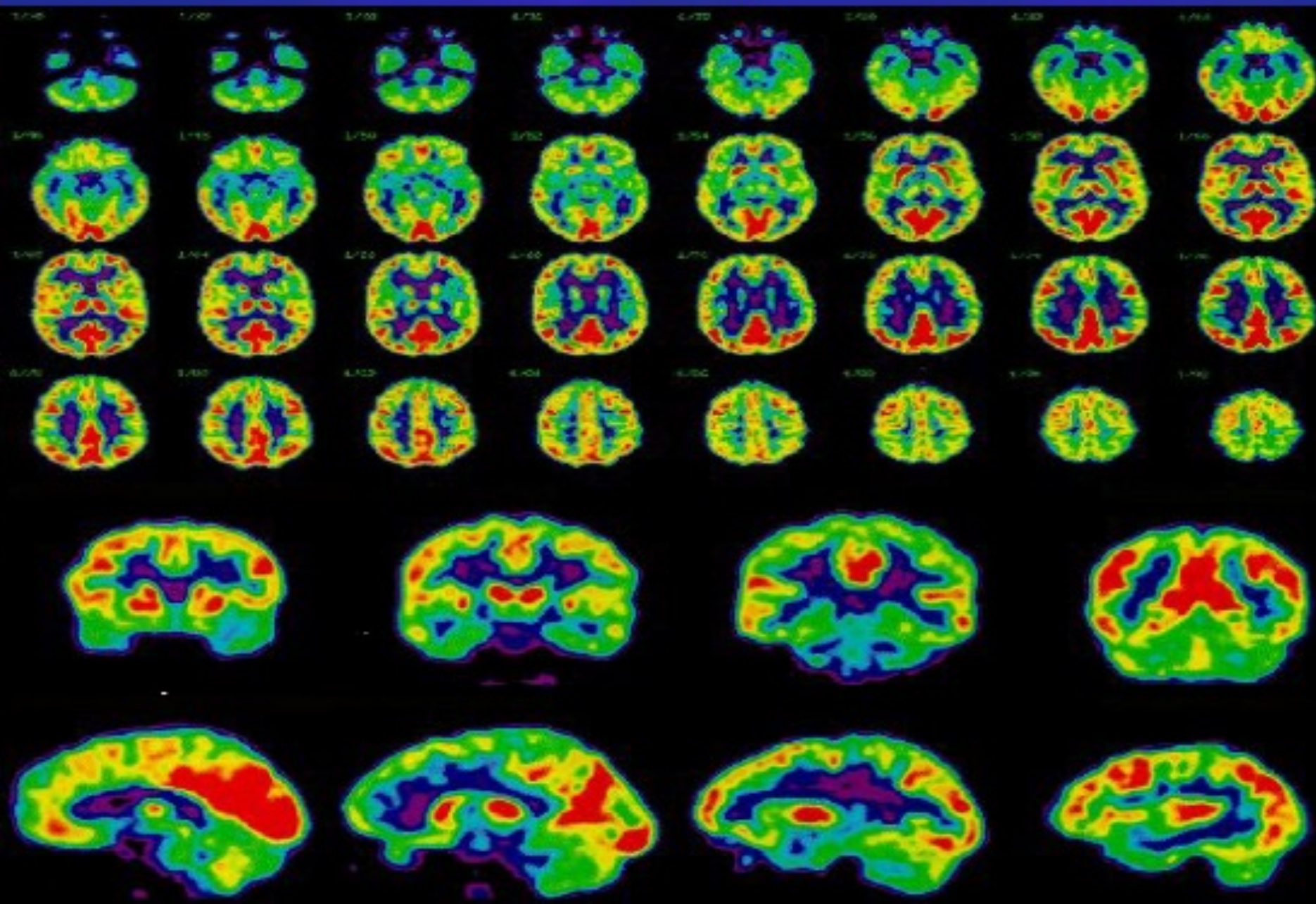
Tc-99m HMPAO SPECT

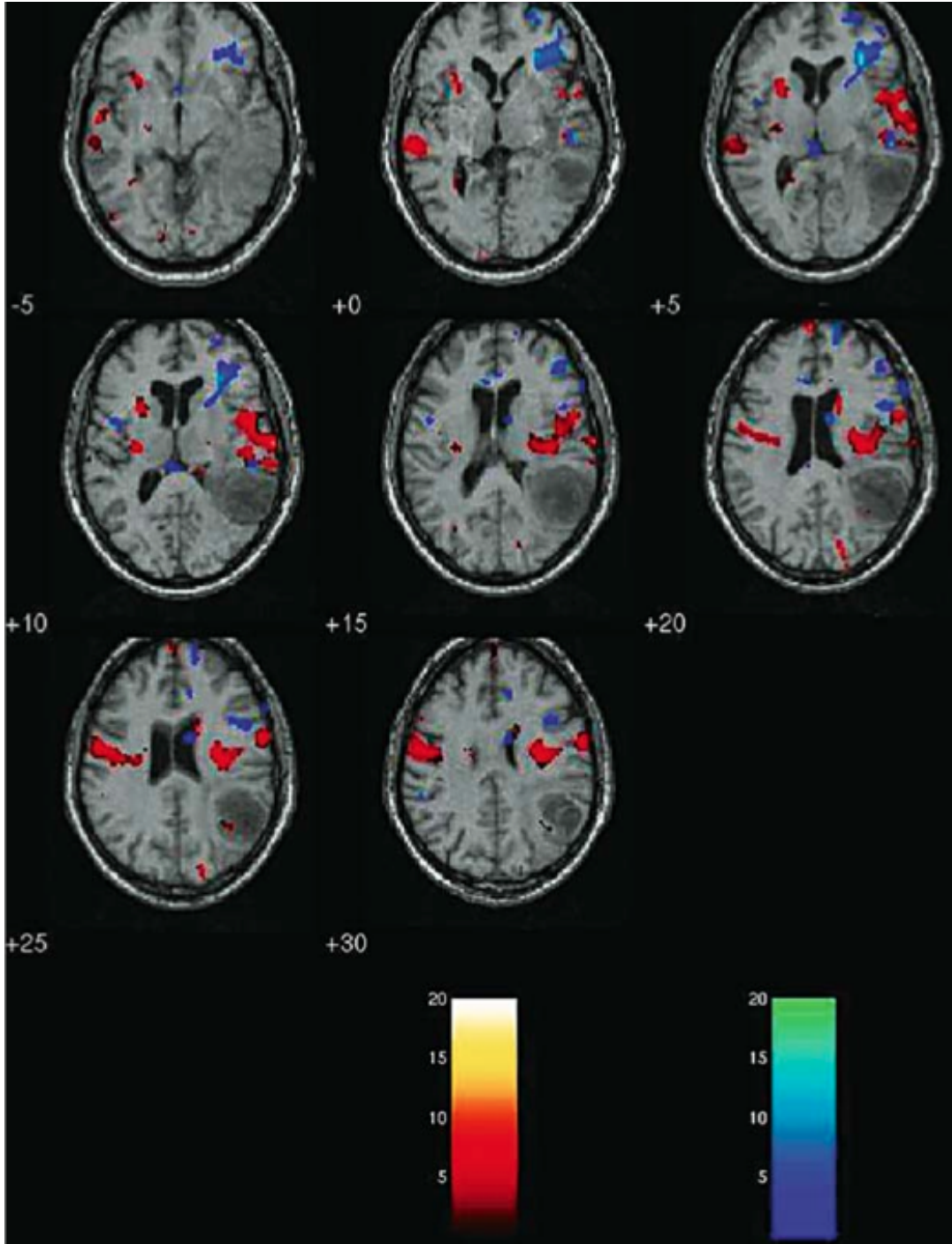


Pre-Diamox

Post-Diamox

Normal ^{18}F -FDG uptake in brain







a



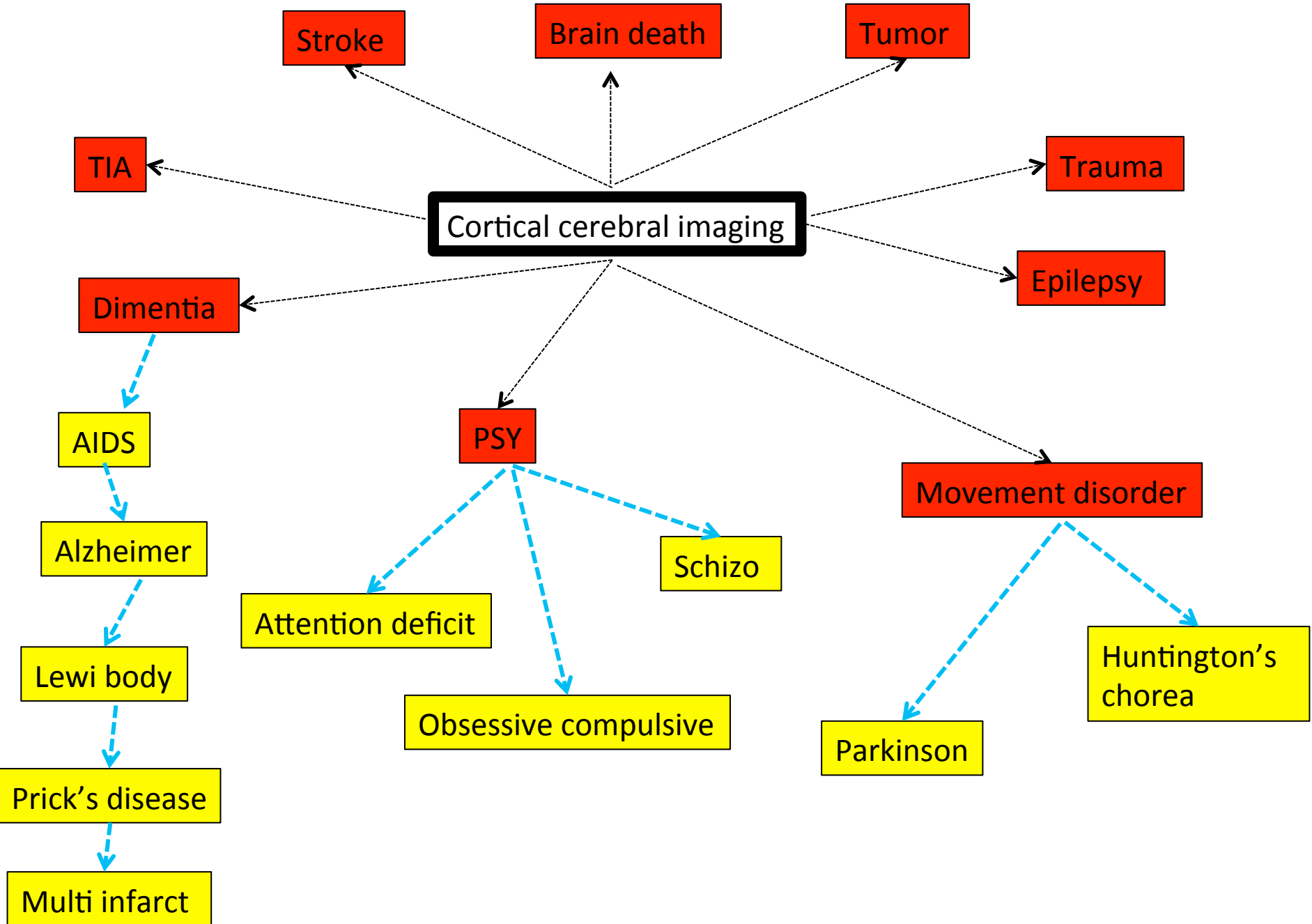
b

Coronal a and b ^{11}C methionine PET in a patient with recurrent glioma in the left temporal lobe

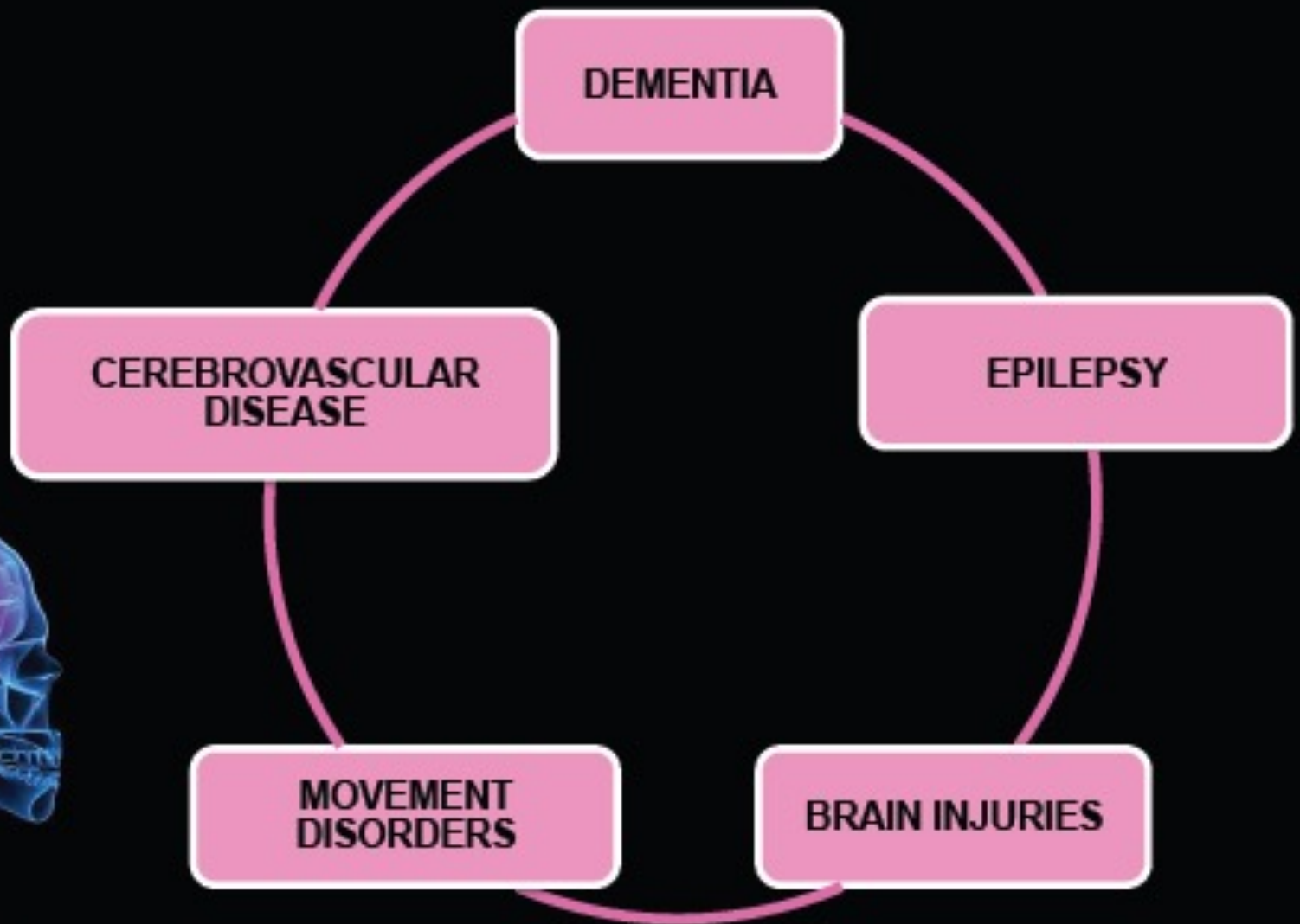
Causes of Different Tracer Uptake Patterns in Brain Perfusion SPECT Images

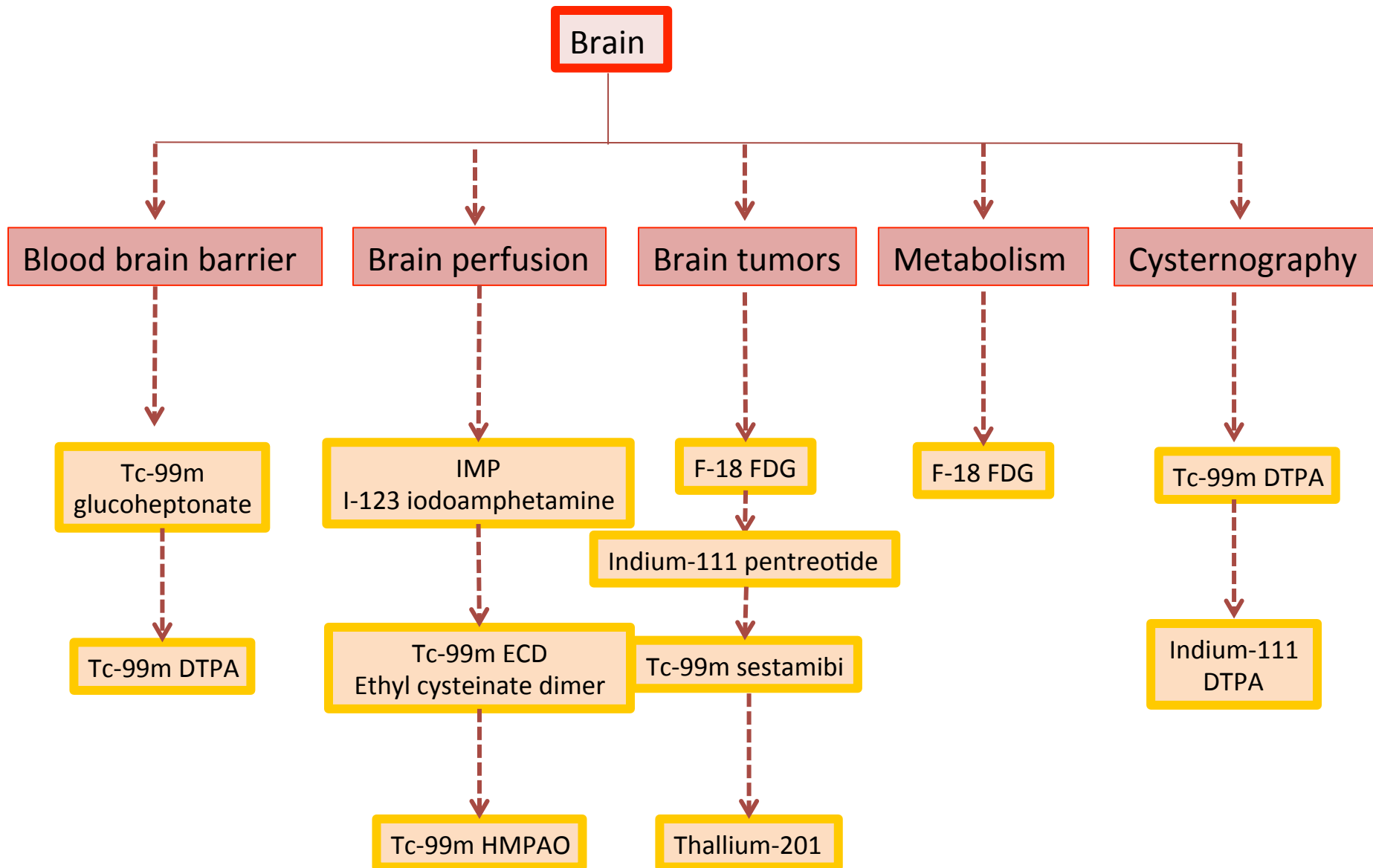
Tracer uptake pattern	Cause
Cold (no uptake)	Cerebrospinal fluid Edema Necrosis Space-occupying lesions (e.g., hemorrhage, tumors,* cysts, AVM, malformation, postsurgery)
Hypoactive (decreased uptake)	Ischemia Hypometabolism (hypofunction): degeneration, deafferentation Atrophy
Hyperactive (increased uptake)	Luxury perfusion Encephalitis Acetazolamide-induced vasodilation Hyperfunction (epilepsy [ictal], neuroactivation, other causes of increased neuronal activity) Tumors*

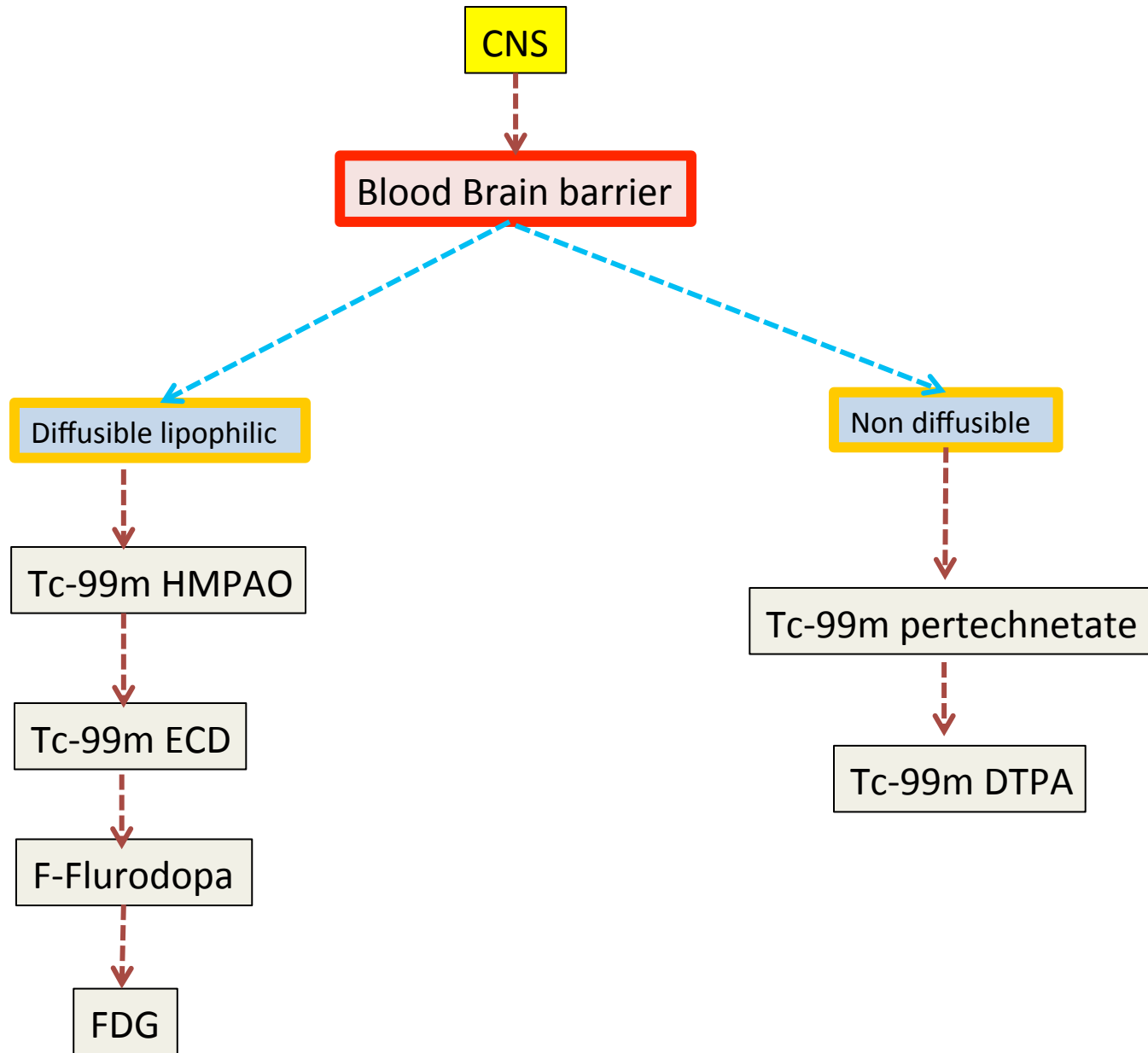
* Tumors can produce a variety of patterns in SPECT perfusion images. The most frequent tumors with increased tracer uptake are meningiomas.



Clinical Applications







	Tc-99m HMPAO	Tc-99m ECD
Accumulation	Frontal thalamus cerebellum	parietal occipital
Extraction	80%	60-70%
Dose remains in blood	1 hour < 12%	1 hour 5% Good brain to background ratio
Imaging time	Can image until 24 hours	Superior quality 15-30 min Suboptimal quality if delayed
Excretion	Renal 40% and GI	Renal and GI

Cerebrovascular Disease

- ^{99m}Tc -HMPAO and ^{99m}Tc -ECD are sensitive indicators of regional cerebral blood flow (rCBF) changes
- SPECT has been used in :
 - ✧ acute stroke, ischemia, transient ischemic attacks (TIAs), monitoring of medical or surgical therapy
 - ✧ Stroke rehabilitation and prediction of functional recovery
 - ✧ Chronic cerebrovascular disease
 - ✧ estimation of prognosis
 - ✧ assessment of interventional sequelae
 - ✧ Subarachnoid hemorrhage
 - ✧ Head injury



Cerebrovascular Disease

Transient Ischaemic Attack

- A focal or diffuse area of hypoperfusion - if the tracer is injected at the time of the attack.
- After the event, study findings may be normal.
- Should the perfusion defect persist in the first few days after TIA - the risk of early stroke is high.



- Sensitivity for detection of TIAs :

approximately 60% in the first 24 h

approximately 40% in the first week.

Cerebrovascular Disease

Acute Stroke

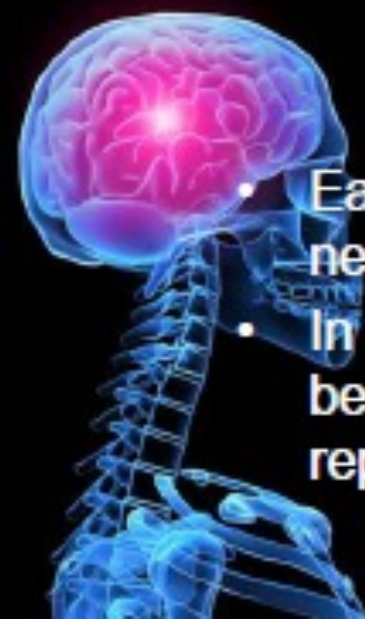
- Brain SPECT with ^{123}I -IMP, $^{99\text{m}}\text{Tc}$ -HMPAO or $^{99\text{m}}\text{Tc}$ -ECD is far superior to anatomic imaging modalities in detecting acute stroke in the first few hours following the event.
- Focal or regional area of hypoperfusion or no perfusion seen immediately after the acute event. The area is larger than the lesion that will be later shown on CT or MRI.

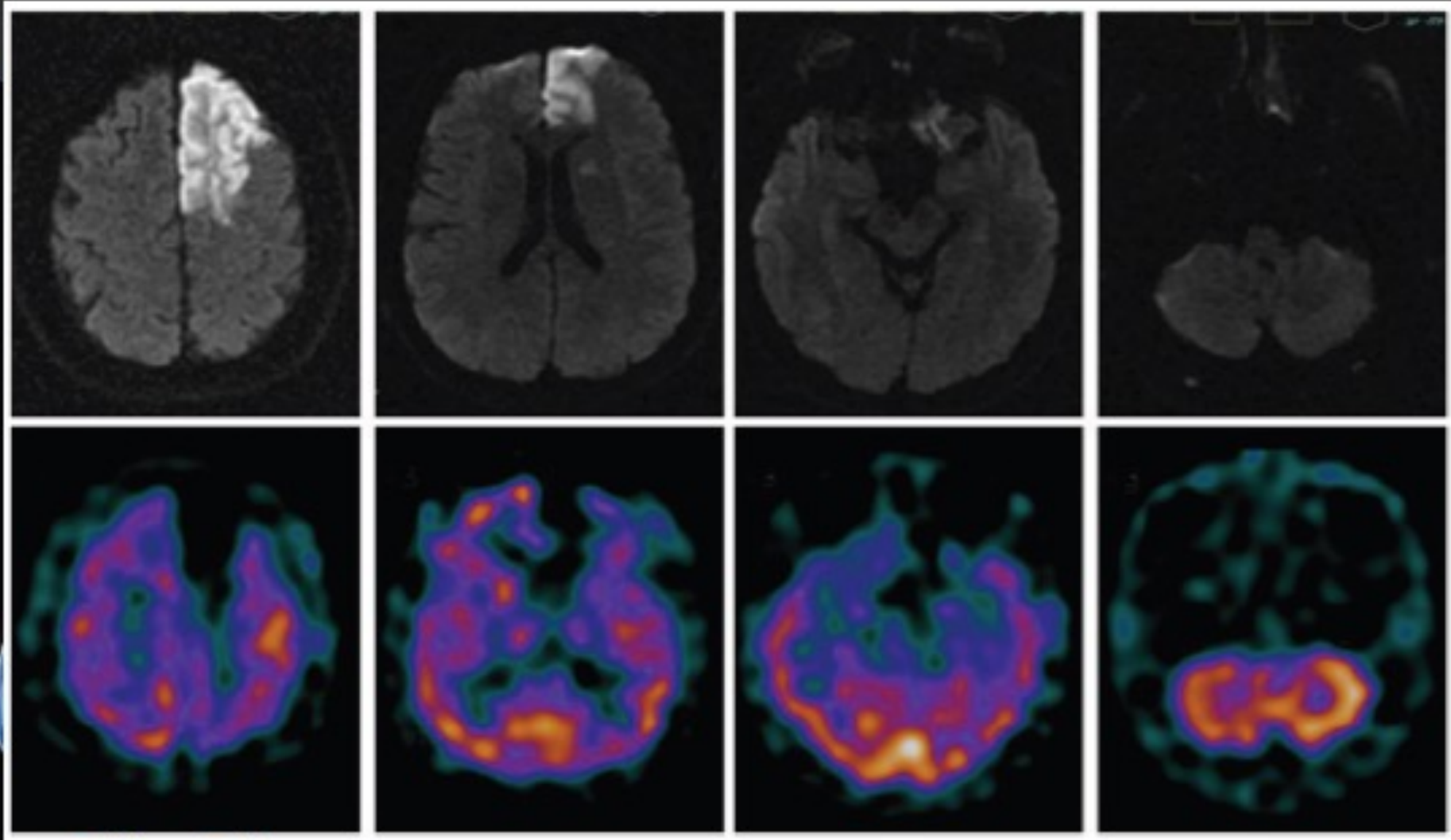
Sensitivity and specificity of brain SPECT for stroke localization are 85.5% and 97.6%,



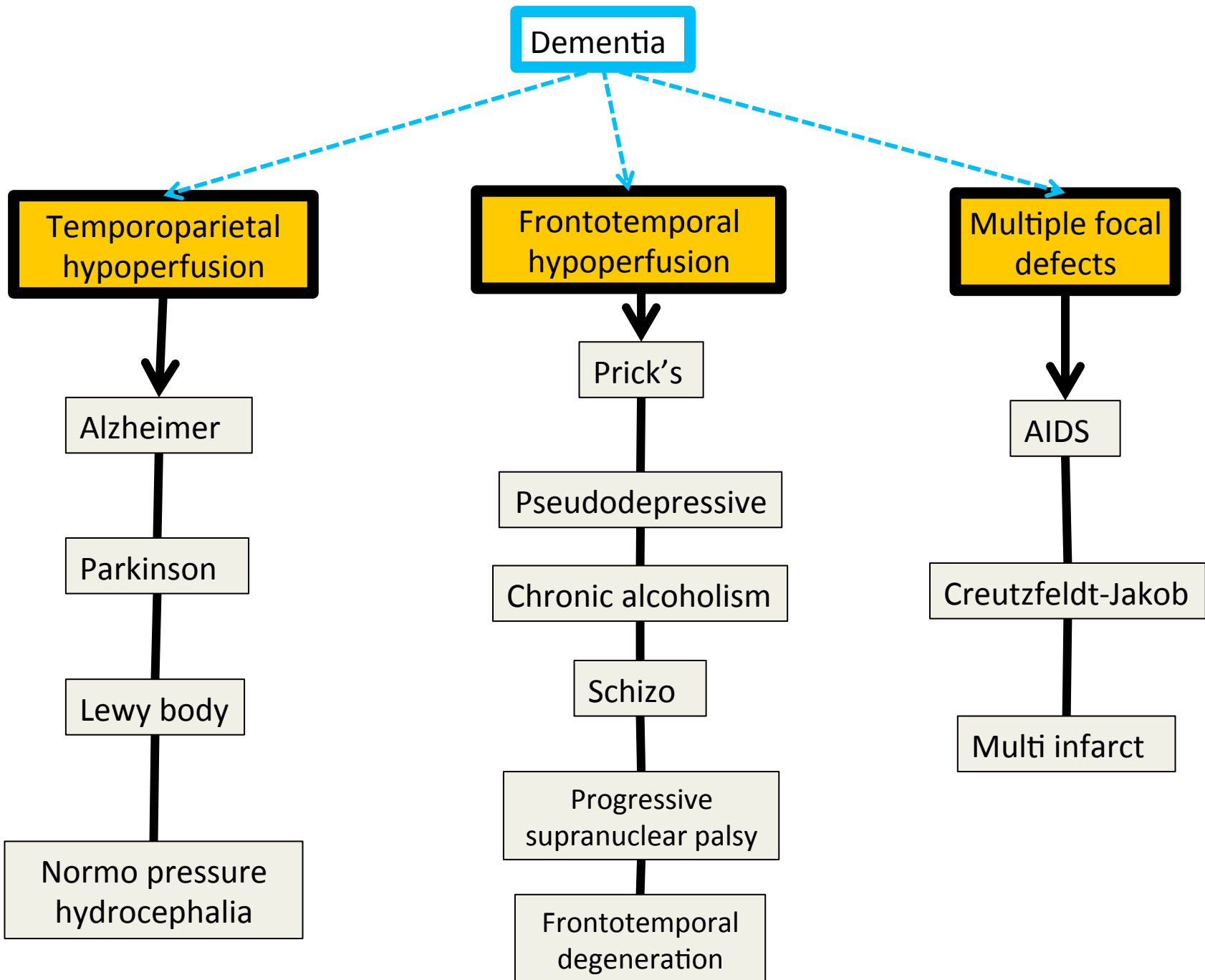
CVD – Acute stroke

- False-negative brain SPECT findings in acute stroke may be caused by lacunar or small cortical infarcts.
- Early imaging has prognostic implication and is also important for choosing the best candidates for therapy.
 - Acute focal absence of rCBF = poor prognosis and unlikely benefit from therapy
 - Decreased but not absent blood flow = possibly indicates the best candidates for therapy.
- Early severe hypoperfusion (<6 H) was highly predictive of poor neurologic outcome in 92% of patients.
- In the subacute phase (beyond the first 48 hours), SPECT may be even less sensitive because of the presence of spontaneous reperfusion.





Acute infarction at left medial frontal lobe (ACA territory) and crossed cerebellar diaschisis



Dementia

- Dementia is a clinical syndrome characterized by memory impairment and other deficits of cognitive ability - seriously interferes daily life.
- Plaques, deposition of amyloid and neurofibrillary tangles are found in postmortem specimens.
- Alzheimer's disease (AD) - a leading cause of neurodegenerative dementia and accounts for approximately 60-70% case of dementia.

- AD is characterized by:

progressive, global and irreversible deterioration of cognitive function, which usually begins with memory problems, followed by deficits in language, mathematical and visuospatial skills, abstract thinking and planning, as well as personality and behavioral changes.



Dementia – Alzheimer's

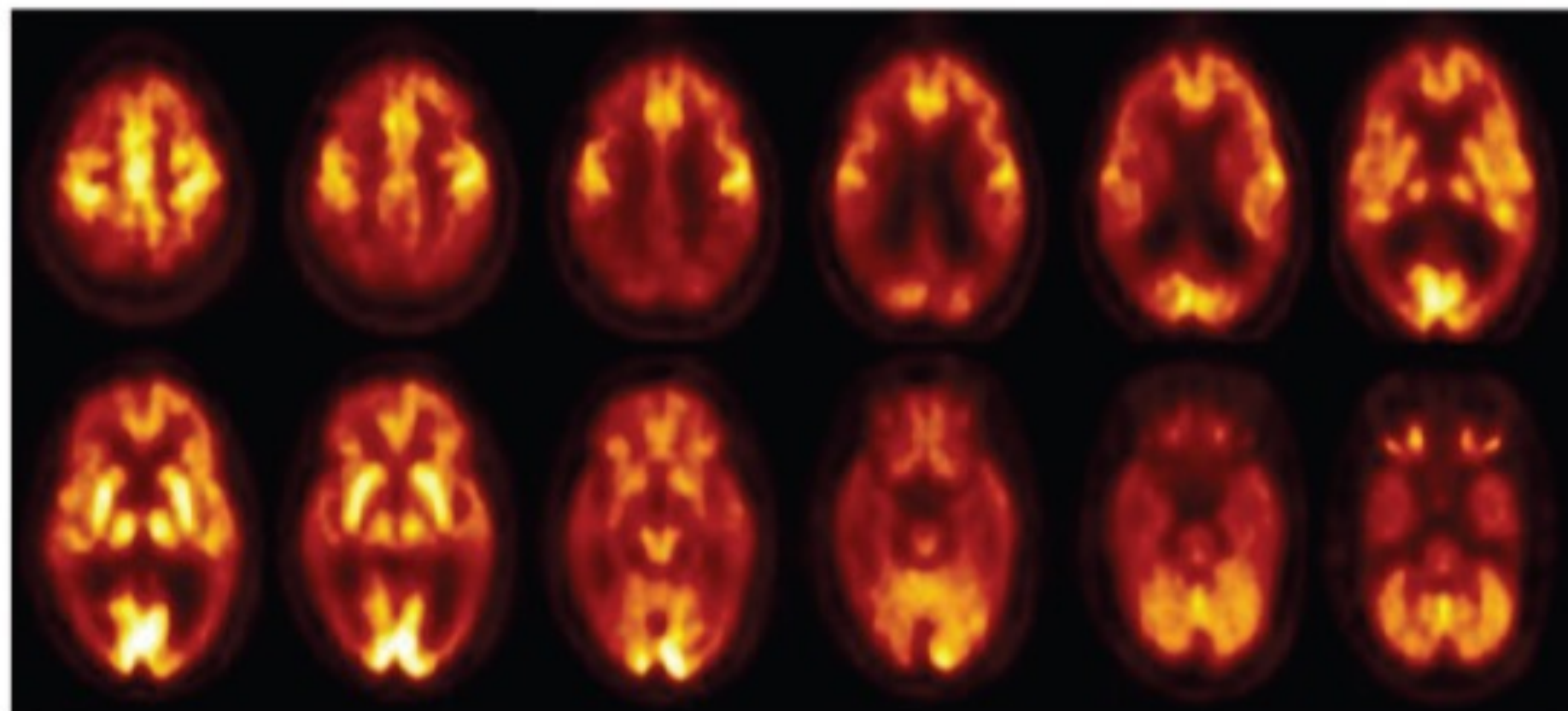
- FDG PET can be used for 3 major purposes in management of patients with dementia.
 1. Noninvasive tool to help establish an early diagnosis.
 2. Determining differential diagnoses - identifying Alzheimer's vs other dementia disorders and identification of coexisting conditions.
 3. To evaluate response to therapy - whether a patient is benefiting from a particular medication or treatment.

- **In Alzheimer's Dementia;**

FDG PET shows a characteristic pattern of metabolic impairment

- posterior cingulate cortex and parietotemporal association cortices and often is bilateral.
- medial temporal lobes particularly the hippocampus.

Fig. 4 A typical finding of FDG PET in a patient with Alzheimer's disease



Average sensitivity of 95% (range 90-96%)

Average specificity of 71% (range 67-97%)

Dementia

- Ability of FDG PET showing early demonstration of metabolic impairment is particularly important to predict the disease outcome in MCI.
- About 10% to 30% progressed and newly diagnosed as AD in 1 year.
- Normal FDG PET in MCI indicates a low chance of progression within 1 year, even if there is a severe memory deficit on neuropsychological testing.



Dementia

- *VDs (Multiinfarct Dementias)* - impairment of intellectual function due to multiple infarcts that may occur unilaterally or bilaterally - usually asymmetric and may involve any part of the cerebral cortex. The history of one or more events can be disclosed and the symptoms will have the characteristic profile.
- Brain SPECT shows multiple focal areas of hypoperfusion randomly distributed. Motor and sensory cortices may also be involved.



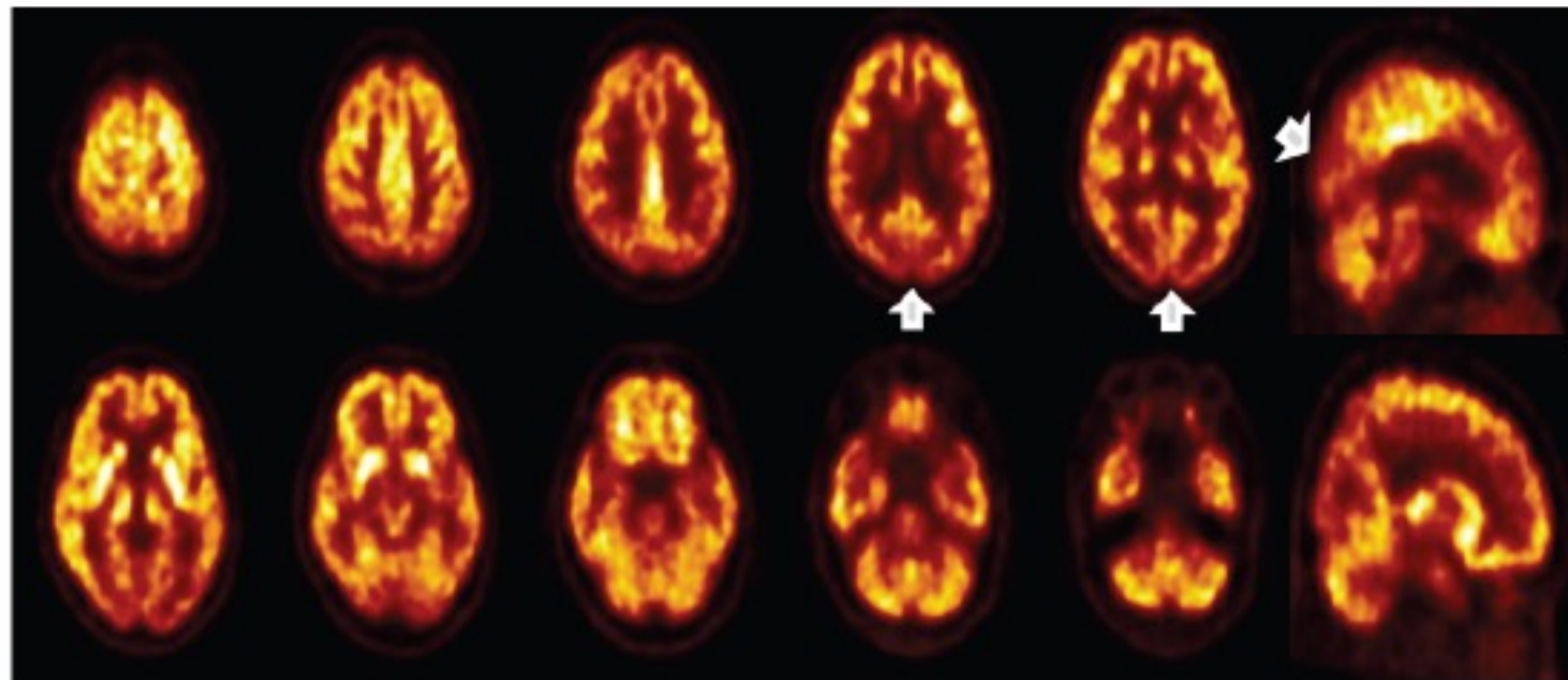
Dementia – with Lewy Body

Dementia with Lewy Body (DLB)

- One of the common cause of degenerative dementia in the elderly
- Clinically characterized by progressive cognitive decline with fluctuations in cognition and alertness, recurrent visual hallucinations and Parkinsonism.
- It shares clinical and pathological features with both AD and PD
- Metabolic patterns display widespread cerebral hypometabolism with marked reduced glucose metabolism in the occipital cortex (both primary visual and visual association cortex) compared with AD.



Fig.3 A representative FDG PET image in a patient with DLB.

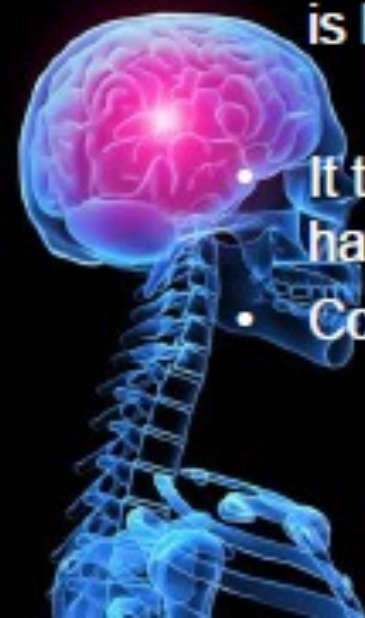


FDG PET, overall sensitivity and specificity to differentiate between DLB and AD are reported as about 90% and 80%, respectively.

Dementia – Frontal Temporal Lobe

Frontal Temporal Lobe Dementia (FTD)

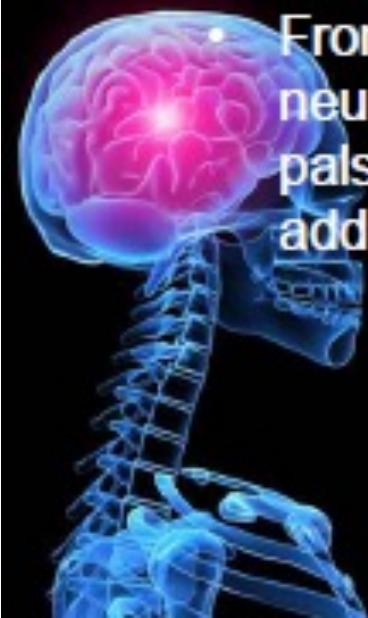
- Common type of dementia presented in patients under the age of 65 years.
- Usually presented as progressive decline in behavior or language associated degeneration of the frontal and anterior temporal lobes.
- Cognitive impairment is not prominent in early stage but it has rapid progression and moreover treatment with antiCh-esterase is less effective to FTD in contrast to AD.
- It tends to have a strong hereditary - up to 40% of FTD patients have a history that is suggestive of familial transmission
- Cortical atrophy in the frontal and temporal lobes is often seen

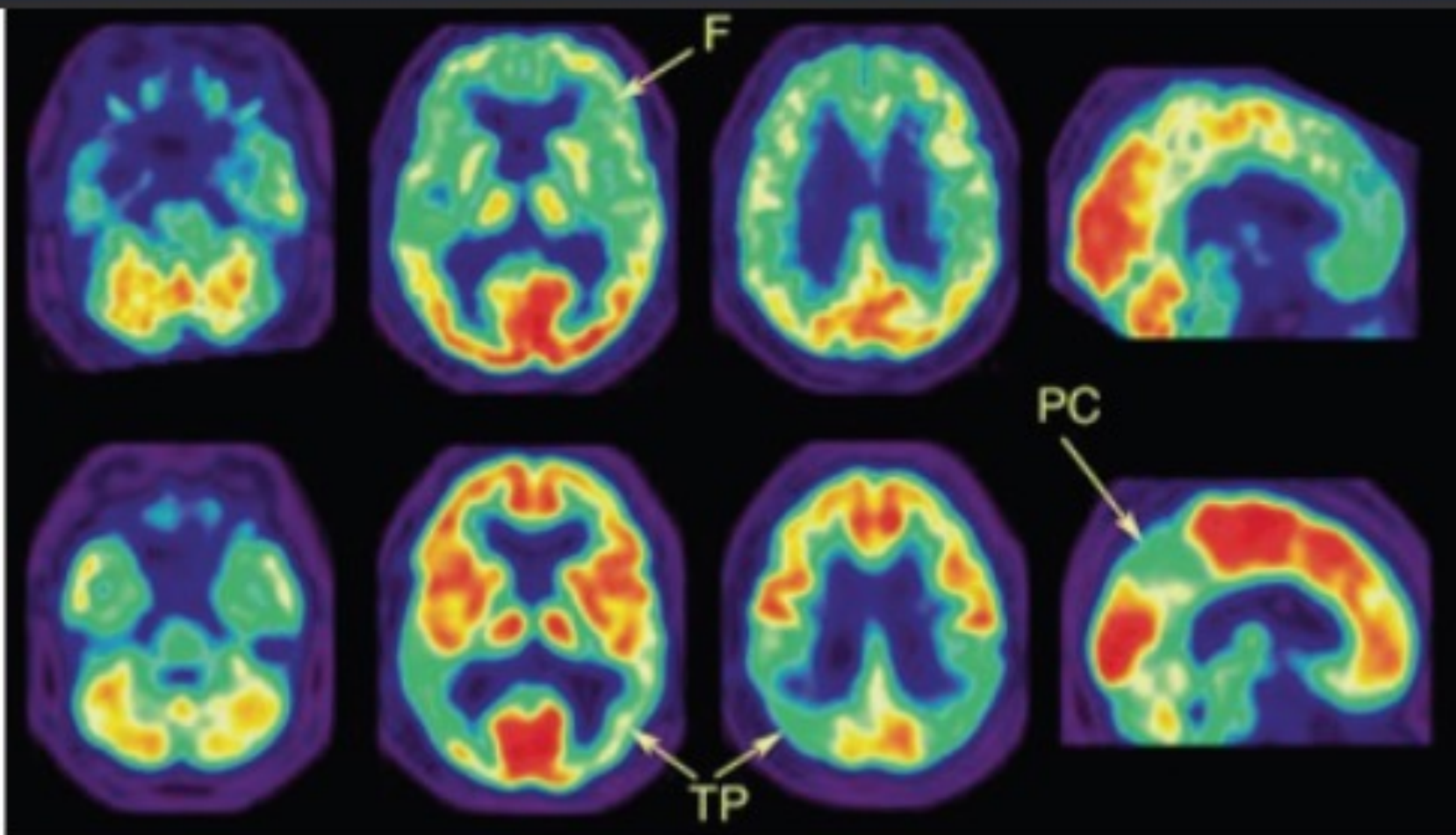


Dementia – Frontal Temporal Lobe

- PET and SPECT : Consistently shown reductions in glucose metabolism and blood flow in the frontal and anterior temporal cortices with frequent asymmetric patterns. Occasionally, metabolic or flow reduction in the striatum and thalamus has been observed.
- Involvement of parietal region is also noted by FDG PET
- Characteristic hypometabolism pattern on FDG PET can differentiate AD and FTD - specificity of more than 97%.
- Frontal hypometabolism can be observed in other neurodegenerative disease such as progressive supranuclear palsy (PSP), spinocerebellar ataxia or dementia induced by drug addiction.

About 10% of clinically diagnosed AD patients have an FTD pattern of hypometabolism in the frontal cortex.

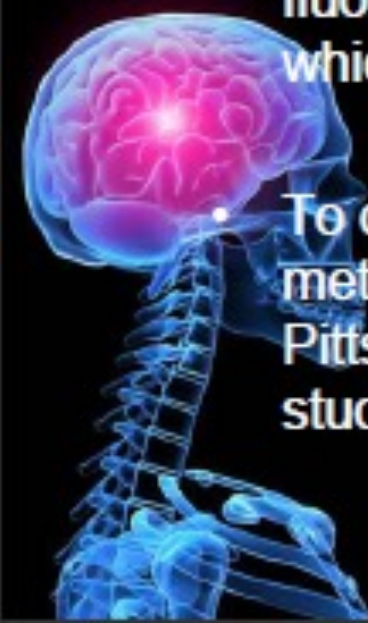




The FTLN patient shows reduced glucose metabolism in frontal cortex (F), whereas the AD patient shows reduced metabolism in temporoparietal (TP) and posterior cingulate cortex and precuneus (PC).

Dementia – Other Tracers

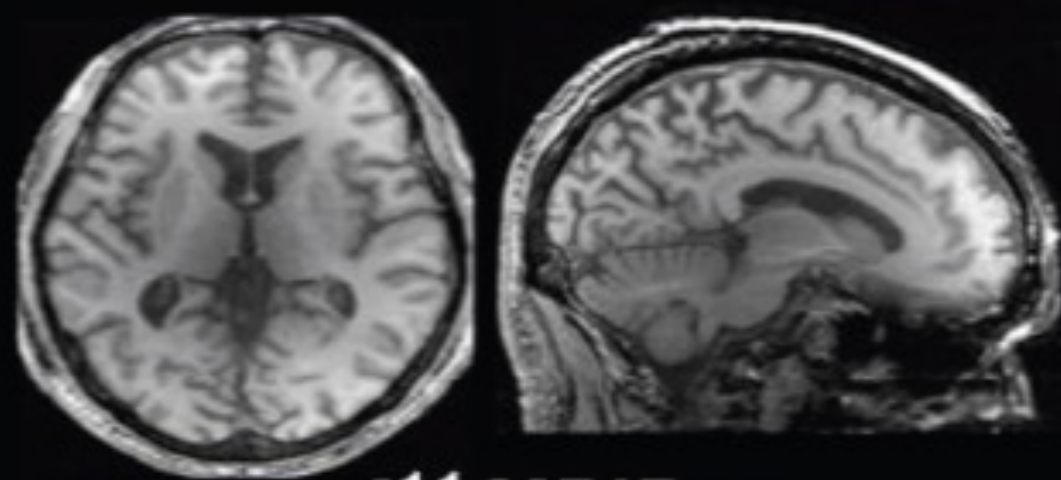
- Confirmation of clinical diagnosis of AD is based on the detection of amyloid plaques and neurofibrillary tangles in the brain. Recent developments in radiotracers may now allow for the measurement of amyloid plaques and neurofibrillary tangles in the brain in vivo.
- First in-vivo imaging of AD pathology in living patients with AD was successfully conducted with ^{18}F FDDNP (2-(1-{6-[2- ^{18}F fluoroethyl]-(methyl)- amino}-2-naphthyl)ethylene)malononitrile), which binds to the plaque and tangles.
- To date, ^{11}C labeled 6- OH-BTA (N-methyl-]2-(4'-methylaminophenyl)-6-hydroxybenzothiazole (6-OH-BTA) - Pittsburgh Compound B or PIB - most widely used in researched studies.



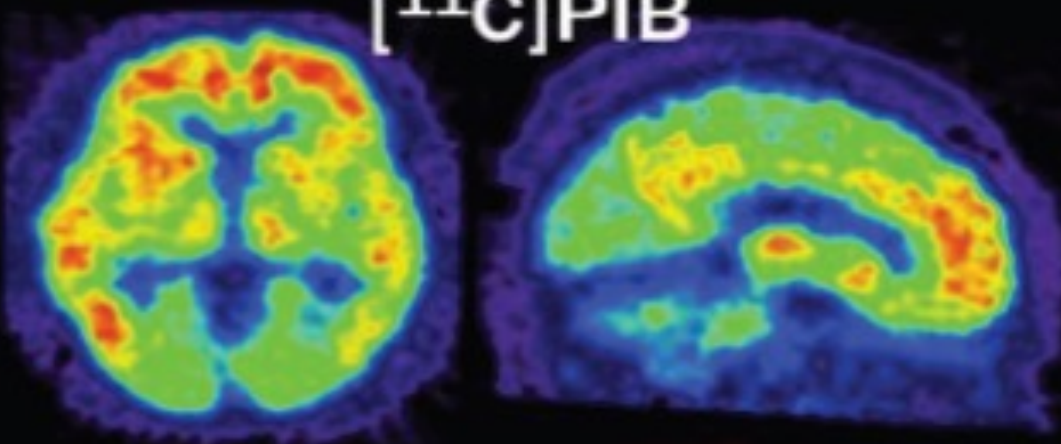
Dementia

- Due to short half-life of ^{11}C - may limit the use of amyloid imaging in community based diagnosis.
- Recently, several amyloid imaging agents labeled with ^{18}F e.g. Flobetapir (^{18}F -AV-45) and ^{18}F -Flutemetamol have been successfully tested in clinical trial.
- Amyloid plaque imaging will be of use not only in diagnosis of AD but also in the investigation of the temporal relationship between amyloid deposition, neuronal loss and cognitive decline and assessment of the effects of drugs in disease progression.
- It may provide treatment for AD patients early in their disease when response to treatment is usually better.

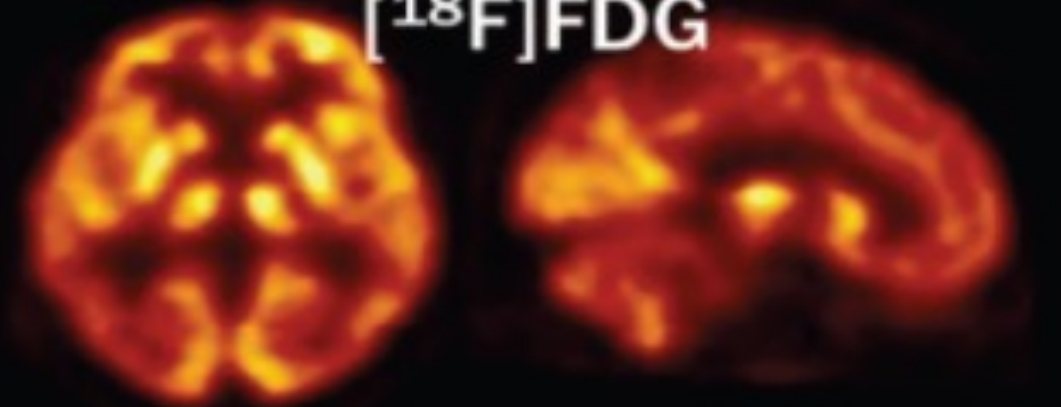




[¹¹C]PIB



[¹⁸F]FDG



In AD, cortical PIB retention is detected in the posterior cingulate/precuneus, medial inferior frontal cortex and lateral temporal cortex with sparing of sensorimotor areas and occipital cortex.

PIB positive can be detected in 89% - 95% of patients with clinically diagnosed AD, while, PIB negative can be seen in 10% -20% of patients with clinically diagnosed AD.

Dementia

- Hypothyroid dementia has been described in patients with hypothyroidism. Brain SPECT of these patients shows global cortical hypoperfusion that normalizes with effective therapy.
- Brain SPECT should be used in early diagnosis and follow-up of AIDS patients, especially when CT and MRI still show normal findings.



Epilepsy - SPECT

Brain perfusion SPECT

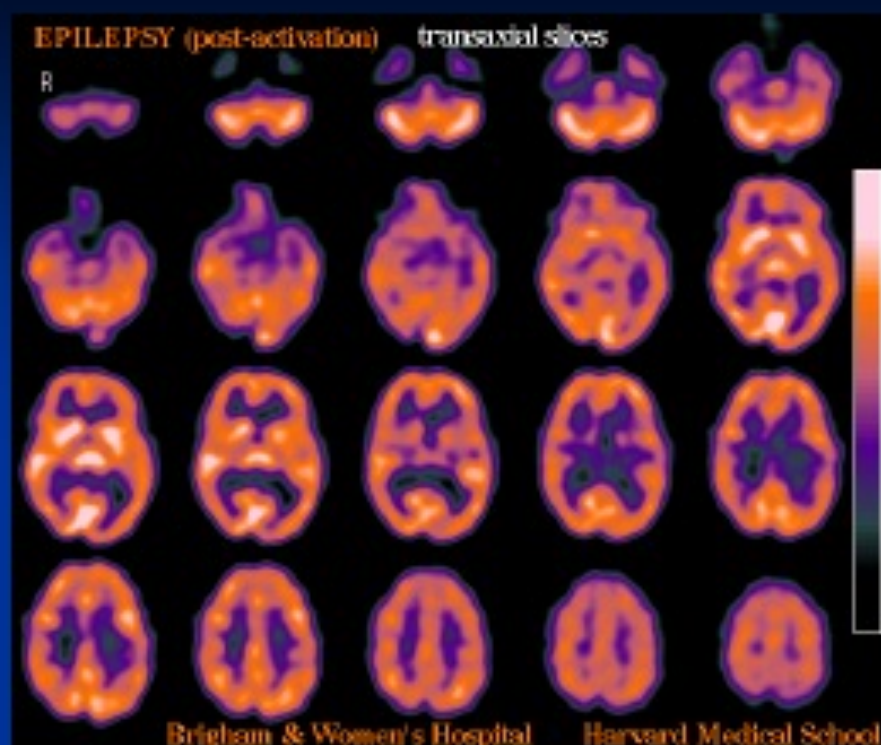
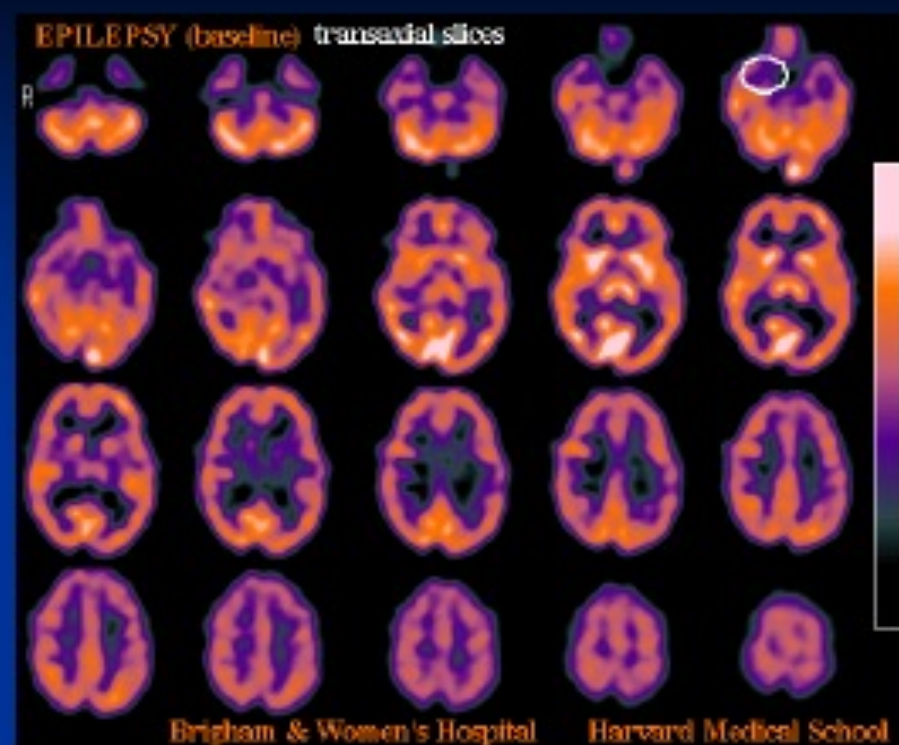
- Role of brain SPECT in epilepsy is not the diagnosis of the disease but the localization of the seizure focus for surgical therapy, especially in temporal lobe epilepsy.
- Ideally, there should be two images : interictal or seizure-free condition and ictal condition, with the tracer injected at the very beginning of a seizure episode.
- Interictal or seizure-free study, brain SPECT shows focal or diffuse hypoperfusion - usually at the anteromedial temporal lobe +/- extend to the ipsilateral frontal lobe.
- Approximately 50% of the patients may have normal findings.
- 10% of the study may show hyperperfusion.



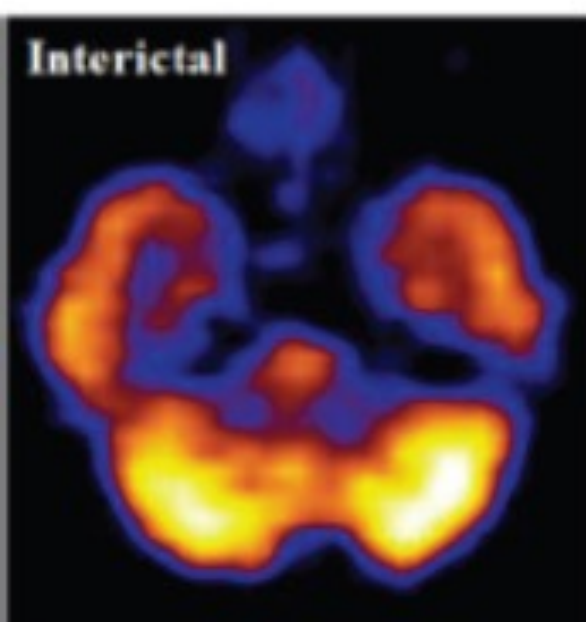
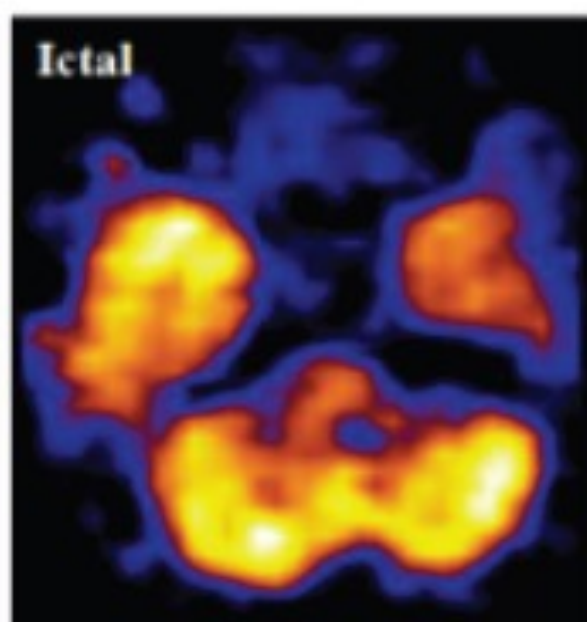
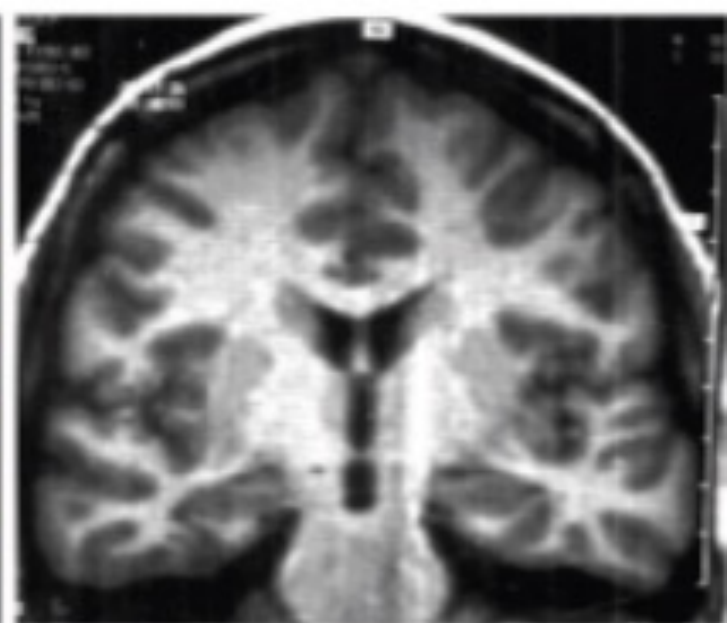
Epilepsy - SPECT

- Ictal images shows hyperperfusion of the temporal lobe, usually extending to the ipsilateral basal ganglia and thalamus and possibly also extending to the ipsilateral motor cortex and contralateral cerebellar cortex.
- Postictal study is defined as a tracer injection between 1 and 10 min after a seizure. The images usually show hypoperfusion that may extend to the ipsilateral hemisphere and contralateral temporal lobe.





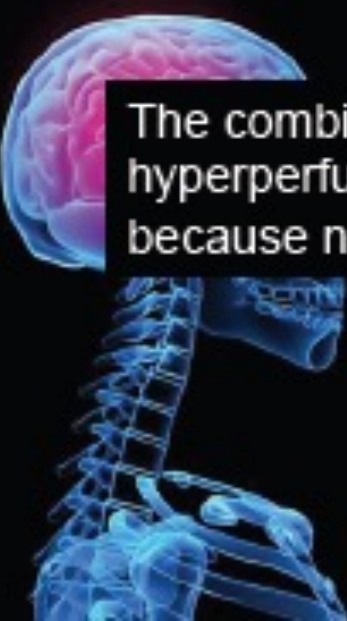
- **Ictal perfusion** study demonstrates **hyperperfusion** to the right superior temporal lobe. A small focal region of increased perfusion is also noted in the left lateral frontal lobe.
- **Interictal (baseline)** study: Areas of relative hyperperfusion in the temporal lobes bilaterally (right greater than left), left superior temporal lobe, and left frontal lobe, as seen in the ictal study, **have resolved**. In addition, the increased perfusion noted in the right basal ganglia on the ictal study is no longer identified.
- **IMPRESSION: Hyperperfusion in right superior temporal lobe** consistent with seizure focus.



A typical interictal/ictal perfusion SPECT of medial temporal lobe epilepsy

Sensitivity of brain SPECT, in comparison with EEG and surgery, in TLE

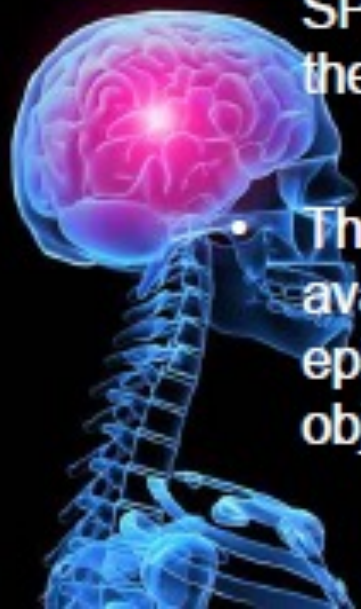
	Interictal	Ictal	Postictal
EEG	44%	97%	75%
Surgery	43%	100%	77%



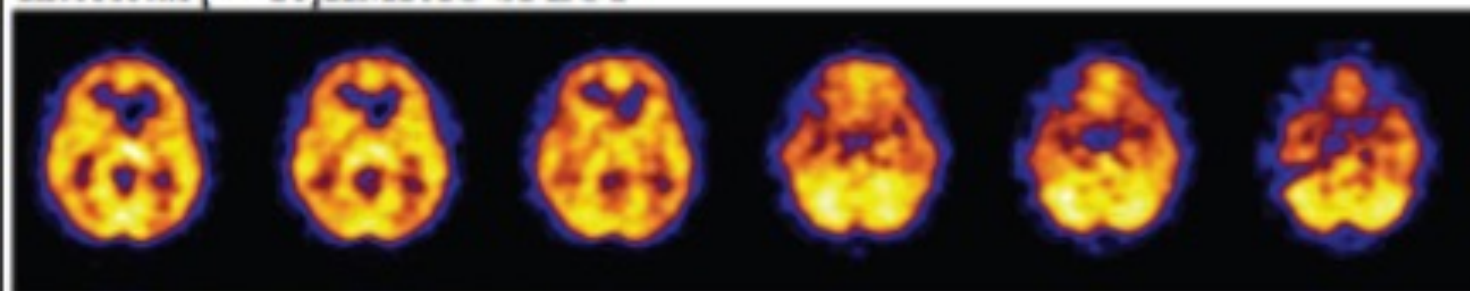
The combination of hypoperfusion in the interictal study followed by hyperperfusion in the ictal study in the same area has absolute specificity, because no other neurologic condition can cause this .

Epilepsy - SPECT

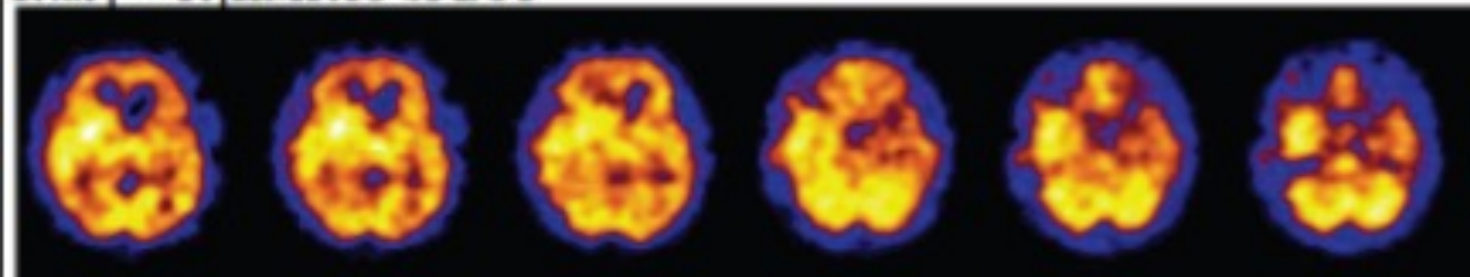
- Detection of focal hyperperfusion change, which may indicate potential sites for ictal onset, has been evaluated by visual assessment of ictal SPECT or side-by-side visual comparison of ictal and interictal SPECT.
- Recently, computer-aided image analysis techniques, such as subtraction ictal SPECT coregistered to MRI (SISCOM), Ictal–Interictal SPECT Analyzed by SPM (ISAS) or statistical ictal SPECT coregistered to MRI (STATISCOM) are used to improve the reliability of SPECT findings in seizure focus localization.
- These analytic methods are fast, accurate and routinely available, more sensitive and specific in the detection of the epileptic onset zone than visual assessment and provide objective ways to study individual propagation patterns.



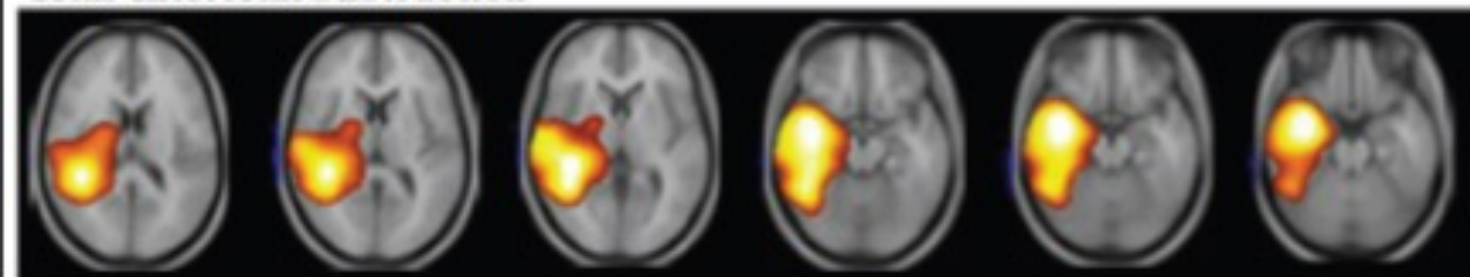
Interictal [^{99m}Tc]HMPAO SPECT



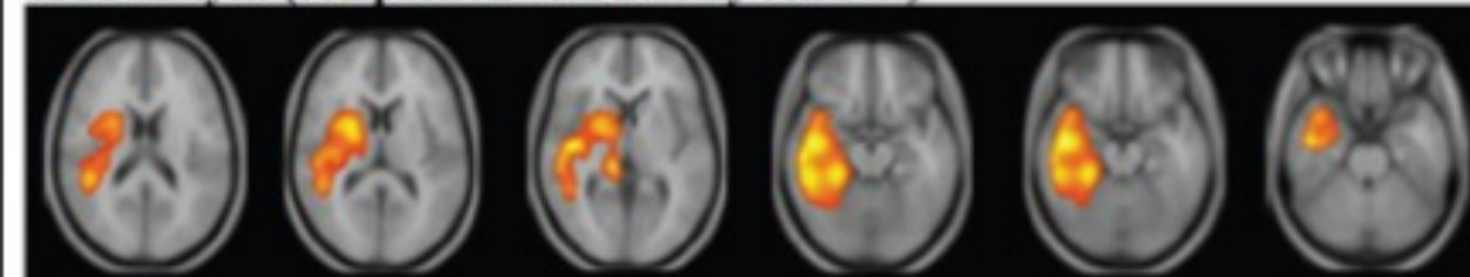
Ictal [^{99m}Tc]HMPAO SPECT



Ictal-Interictal Subtraction



SPM analysis (comparison with healthy controls)



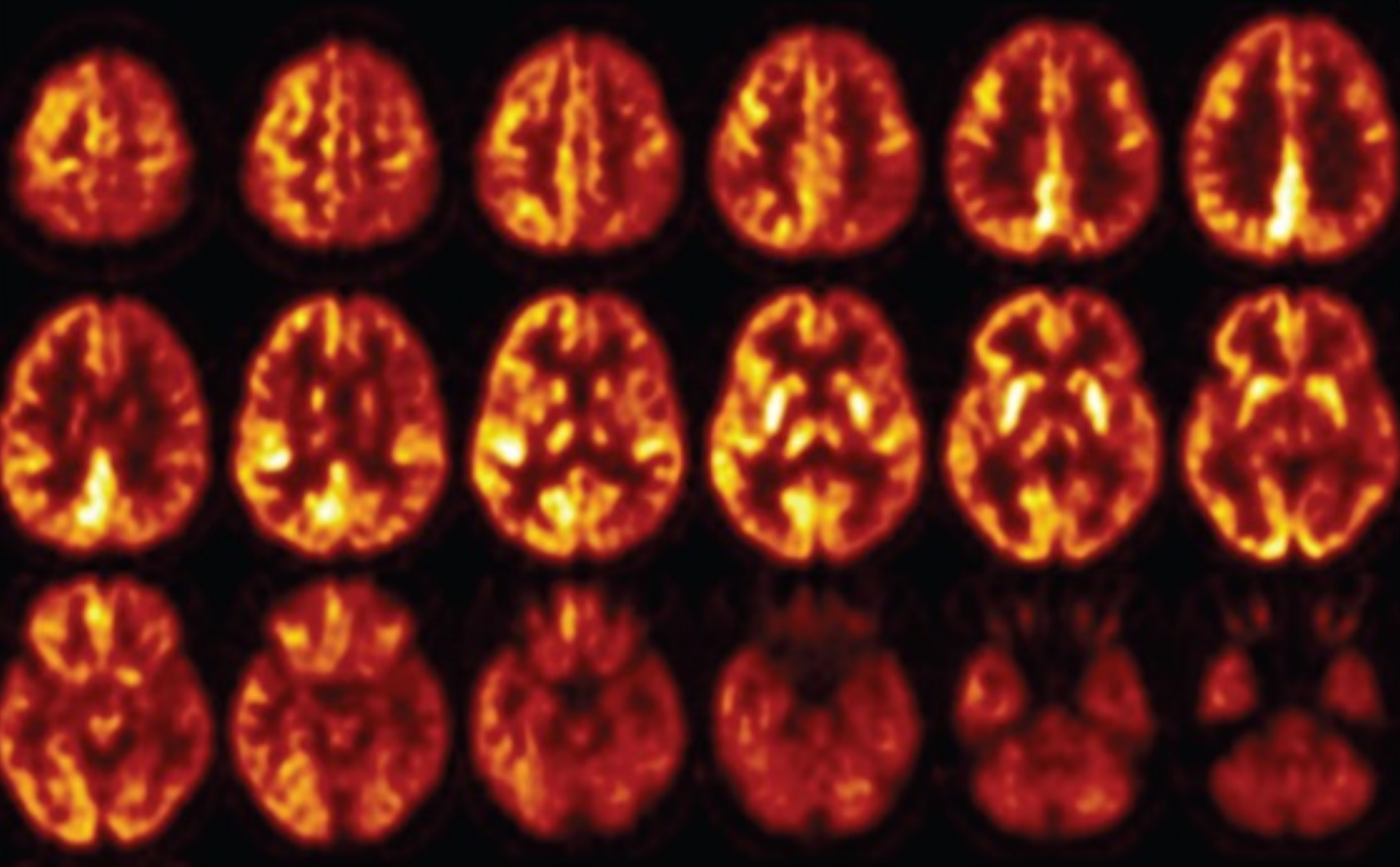
Detection of hyperperfusion as a epileptogenic focus using subtraction and SPM analysis.

Epilepsy - PET

- The classic pattern for FDG-PET in mTLE (without lesions other than mesial temporal sclerosis) reveals relative hypometabolism in mesial temporal, temporal polar, and anterolateral temporal neocortical regions.
- Typical sensitivity of FDG PET for detecting temporal lobe hypometabolism in mesial temporal lobe epilepsy (mTLE) ranges between 80 and 90%.
- If structural lesions are present in brain MRI, the presence of hypometabolism at the lesion is almost 100%.
- FDG PET also effectively localizes the epileptic focus in non-lesional (MRI- negative) medial temporal lobe epilepsy.



Extratemporal hypometabolism in a patients with left temporal lobe epilepsy.
Hypometabolism in the adjacent temporal and ipsilateral frontal, parietal cortex.



Movement Disorders

- **Ataxia** - affects the part of your brain that controls coordinated movement (cerebellum).
- **Dystonia** - muscles contract involuntarily, (generalized dystonia or focal dystonia).
- **Essential tremor** - involuntary shaking affecting hands or other parts of the body.
- **Huntington's disease** - inherited progressive, neurodegenerative disorder that causes rapid, jerky, involuntary movements of the face, arms, and legs, decreased cognitive abilities and psychiatric conditions.
- **Multiple system atrophy** - may cause ataxia or parkinsonism



Movement Disorders

- **Progressive supranuclear palsy (PSP)** - rare neurological disorder .
- **Wilson's disease** - inherited (genetic) disorder that causes excessive amounts of copper to build up in the body, causing neurological problems.
- **Parkinson's Disease** - Akinesia, bradykinesia, tremor, rigidity and disturbance of postural reflexes are characteristic of Parkinson's disease.



Parkinson's disease

- Diagnosis of PD is usually based :
 - clinical cardinal motor features
 - associated and exclusionary symptoms and
 - response to levodopa.
- Clinical diagnostic accuracy made by a qualified neurologist was 65% at initial and 76% after 12 years of follow up in pathologically proven cases.
- Two main pathological hallmark of PD is **the loss of dopaminergic neurons in the substantia nigra** and the presence of Lewy bodies.



Parkinson's disease

- FDG PET and SPECT cerebral blood perfusion images show no abnormality in PD.
- Presynaptic and postsynaptic dopamine agents are used in clinical settings.
- Various PET tracers have been used to study these presynaptic targets such as :
 - ^{18}F -DOPA for the aromatic acid decarboxylase
 - ^{11}C -DTBZ (dihydrotetrabenazine) for VMAT-2
 - ^{11}C - PE2I for the DAT
- Various cocaine analogues labelled with ^{123}I for SPECT have shown to bind with high affinity to DAT.



Parkinson's disease

- Currently β -CIT, ^{123}I beta-CIT (β -carbomethoxy-3- β -(4-iodophenyl)-tropane) - **DOPASCAN** and FP-CIT, (N-(3-fluoropropyl)-2 β -carbomethoxy- 3 β -(4-iodophenyl) nortropane - **DaTSCAN** are commercially available in Europe.
- These scans help to differentiate essential tremor from tremor due to Parkinsonian syndrome (idiopathic Parkinson's disease, MSA and PSP = these 3 conditions have been associated with dopaminergic neurodegeneration).
- But the scans were not designed to distinguish among different forms of PS
- It is used as an adjunct to other diagnostic evaluations

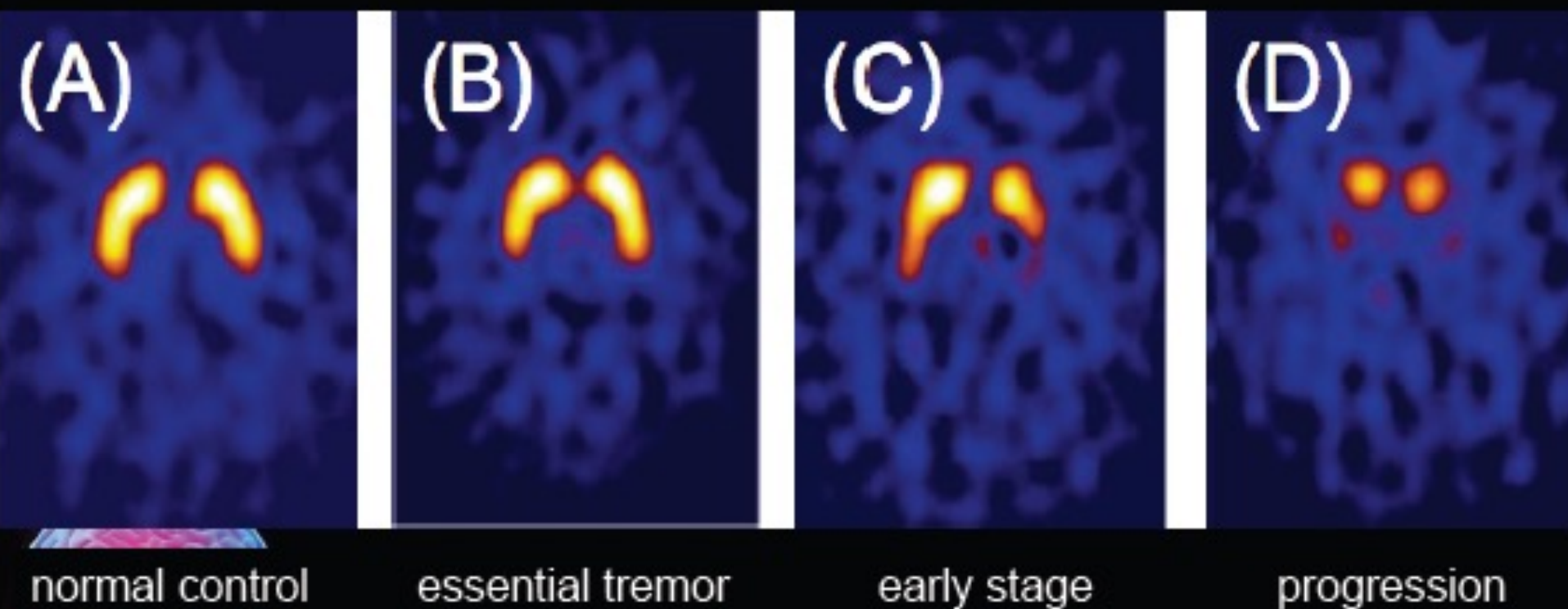


Parkinson's disease

- Potential tool in the establishment of early diagnosis of neurodegenerative parkinsonism. DAT SPECT imaging is suitable for assessing the presynaptic deficit in early PD.
- Also indicated for the assessment of disease severity. DAT binding is related to the clinical stage and severity of PD.



^{123}I beta-CIT images



Parkinson's disease

- The sensitivity of ^{123}I beta-CIT in a quantitative manner for diagnosing PD was 92% and specificity of 100% *.
- In PD, DAT uptake shows a particular pattern so called the - rostrocaudal gradient. Reduced uptake starts in the posterior putamen, advancing to the caudate nucleus. The decreased putamen/caudate nucleus ratio reflects the severity of disease.
- Reduced uptake usually begins in unilateral striatum – involves the other side of striatum as the disease progresses.



* ^{123}I beta-CIT and single-photon emission computed tomographic imaging vs clinical evaluation in Parkinsonian syndrome: unmasking an early diagnosis. Arch Neurol. Aug 2004;61(8):1224-1229.

Gliomas & Astrocytoma

- WHO classification

Grade I : Most benign (pilocytic)

Grade II : Benign to semi benign
(oligoastrocytoma)

Grade III: Semi benign to malignant (astrocytoma)

Grade IV : Malignant (glioblastoma multiforme)

Primary brain tumor (Gliomas)

- 3 main types of gliomas:
 1. astrocytomas
 2. oligo- dendrogliomas,
 3. mixed oligoastrocytomas,
- Low-grade or WHO grades I and II and high-grade or WHO grades III (anaplastic tumor) and IV (glioblastoma).
- Glioblastoma - most malignant and most common glioma, accounting for 45-50% of all gliomas.



✧ FDG uptake is generally high in high-grade tumors.

✧ FDG uptake has prognostic value :

high FDG uptake in a previously known low-grade tumor = diagnosis of anaplastic transformation.

Primary Brain Tumor

- FDG PET study is able to distinguish high grade glioma from low grade glioma
- Low grade gliomas usually shows similar metabolism with normal white matter, but higher grade gliomas have equal or increased metabolism to normal gray matter.

- Delbeke et al : In FDG PET study, discriminating feature using a brain tumor to gray matter ratio of greater than 0.6 or brain tumor to white matter ratio of greater than 1.5 was reported as 100% of sensitivity and 67% of specificity *.

Optimal cutoff levels of F-18 fluorodeoxyglucose uptake in the differentiation of low-grade from high-grade brain tumors with PET. Radiology. 1995;195(1):47-52.

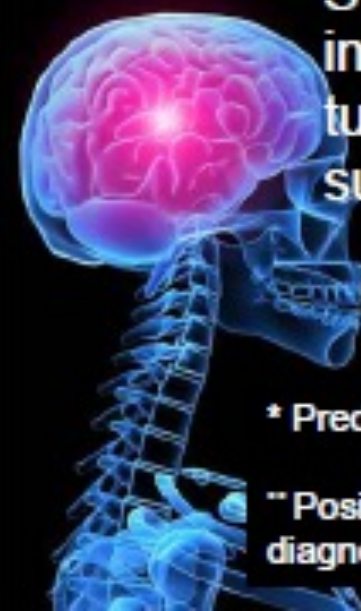


Primary Brain Tumor

- As a tool for disease survival indicator of brain tumor.
- According to Padma et al in patients with highly FDG uptake tumors, the 1-year survival was only 29% as opposed to 94% in patients with low FDG uptake tumors *.
- Semiquantitative analysis using a tumor to background ratio of SUV max was evaluated by . The mean survival was 5 months in brain glioma with ratio of greater than 1.4. However, brain tumor with ratio of lesser than 1.4 had 19 months of mean survival **.

* Prediction of pathology and survival by FDG PET in gliomas. J Neurooncol. 2003;64(3):227-37.

** Positron emission tomography using [18F] fluorodeoxyglucose in brain tumors. A powerful diagnostic and prognostic tool. Invest Radiol. 1987;22(5):360-71



Primary Brain Tumor

- Limitations of FDG-PET :
 1. High physiological glucose metabolic rate in normal brain tissue – decreased the sensitivity of lesion detection
 2. Variability in FDG uptake in high- grade tumors especially for high-grade tumors after treatment.



Primary brain tumor

Recurrence vs. Radiation Necrosis

- Useful modality in distinguishing post radiation necrosis from tumor aggravation.
- Generally, tumor recurrence is FDG avid, but post radiation necrosis is not.
- Langleben et al reported the sensitivity and specificity of FDG PET was 81~86% and 40~94%, respectively*
- But within the first 3 months after radiotherapy, FDG avid inflammatory cells such as macrophage - in the status of edema, neovascularity, demyelination and necrosis can give a false positive results.

Langleben DD, Segall GM. PET in differentiation of recurrent brain tumor from radiation injury. J Nucl Med. 2000;41(11):1861-7.



Primary Brain Tumor

- Fusion of FDG PET to contrast MRI images - helpful for anatomic correlation and helps distinguish uptake within a lesion from normal activity of gray matter.
- Chao et al reported non-fusion FDG PET images had 55% of sensitivity and 85% of specificity, respectively. After fusion of FDG PET to contrast MRI images, sensitivity was increased to 86% and specificity to 80% *

- This criteria were used with radiotherapy, a sensitivity of 96% and specificity of 77% in evaluating recurrent tumor versus radiation necrosis were demonstrated. **

* The sensitivity& specificity of FDG PET in distinguishing recurrent brain tumors from radionecrosis in pts treated with stereotactic radiosurgery. Int J Cancer 96:191- 197, 2001

** FDG-PET on irradiated brain tumor: Ten years' summary. Acta Radiol 47:85-90, 2006



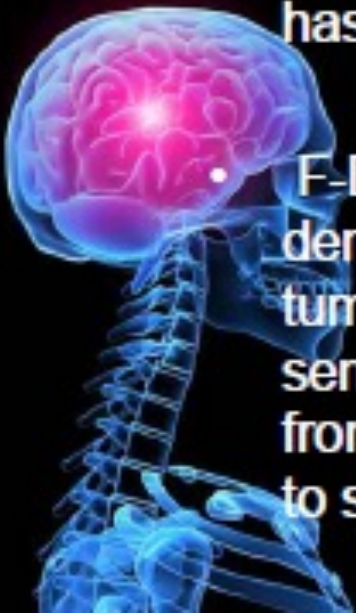
Primary brain tumor

- Several new developing radiotracers can give more specific information about tumor characteristic such as cellular proliferation, protein synthesis and hypoxia.
- Amino acid tracers appear more sensitive to visualize tumor and potentially having better diagnostic performance than FDG-PET in the evaluation of radiation necrosis.



Primary Brain Tumor

- ^{11}C -methionine as one of amino acid radiotracer - a predictor of biologic behavior. It can cross the blood brain barrier but uptake in the cortex is low. Brain tumor with hypo or isometabolism on FDG PET can be detected and differentiated with high sensitivity (86%) and greater specificity (100%) using ^{11}C -methionine PET.
- Owing to the short half life of ^{11}C radiotracer, ^{11}C -methionine has been substituted by the other tracer .
- F-DOPA is an amino acid analog and was shown to demonstrate excellent visualization of high and low-grade tumors. In case of gliomas, ^{18}F -FDOPA PET had 98% of sensitivity and 86% of specificity to distinguish recurrent glioma from post radiation necrosis using a SUV cut off ratio of tumor to striatum (ratio = 0.75).



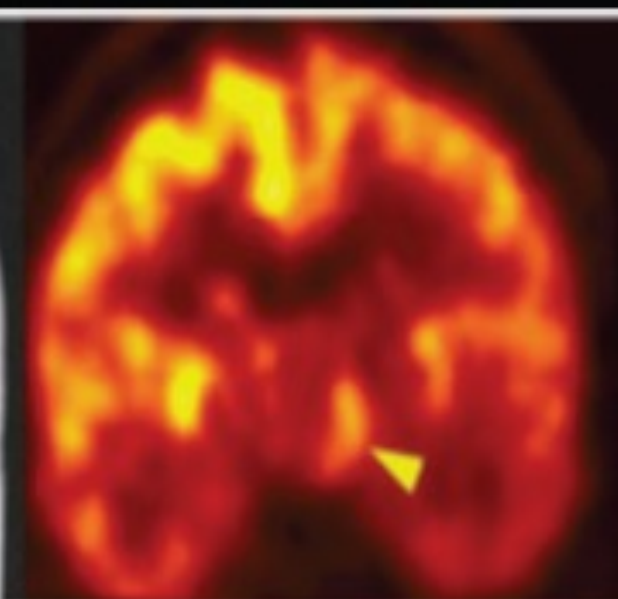
Primary Brain Tumor

- ^{18}F - fluoromisonidazole (FMISO), was developed as a PET imaging agent to image hypoxia and now it is helpful in therapeutic planning due to hypoxia which is associated with radioresistance.
- Thymidine analog ^{18}F – fluorothymidine FLT-PET was developed as a noninvasive method to evaluate tumor cell proliferation and has potential for monitoring treatment response.
- ^{18}F -FET PET can distinguish recurrent glioma from post radiation necrosis with 93% of sensitivity and 100% of specificity. Also it accurately distinguishes low and high grade gliomas.

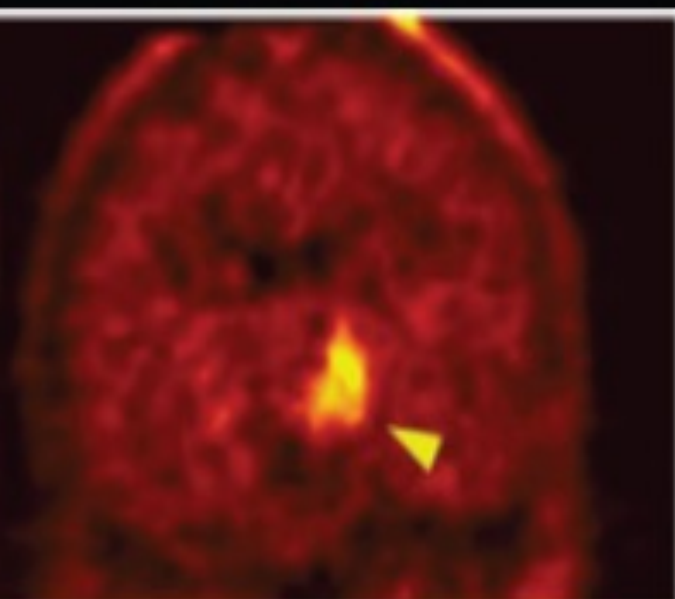




Enhanced MRI

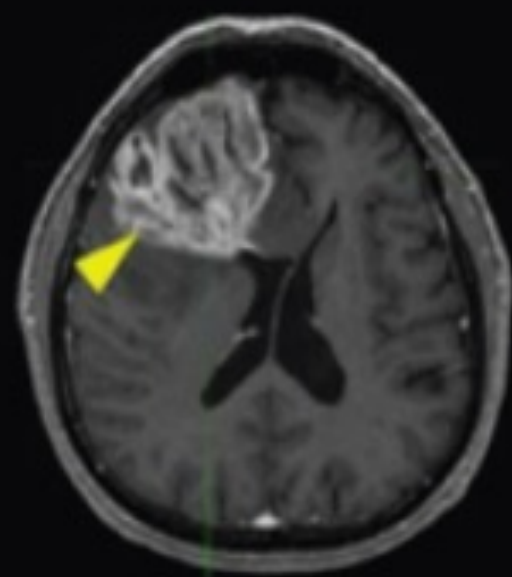


^{18}F -FDG

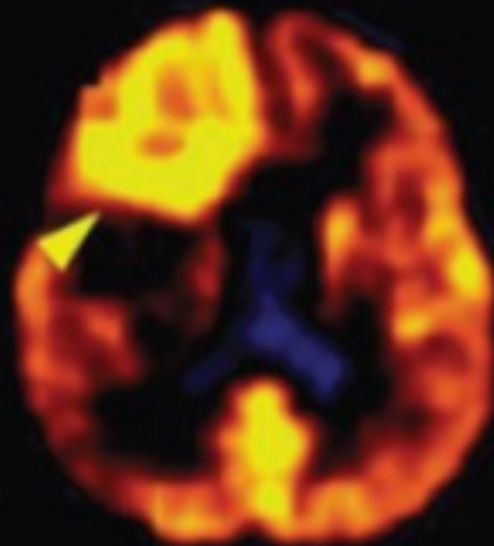


^{11}C -Methionine PET

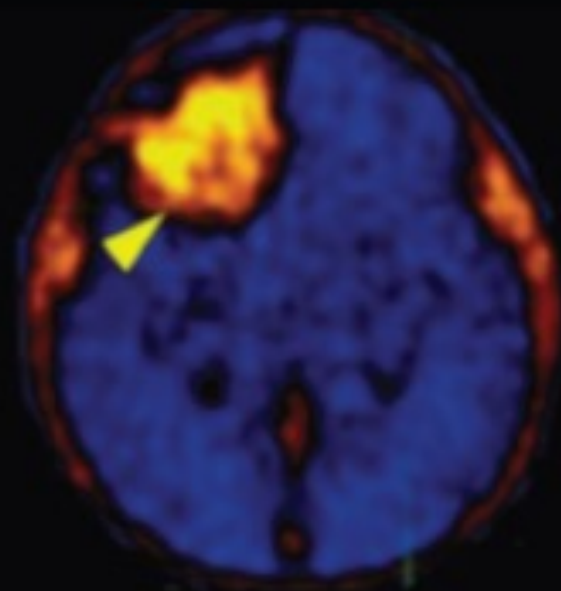
Recurred anaplastic astrocytoma.



Enhanced MRI



FDG PET



^{18}F -FLT PET

Glioblastoma. Right frontal lesion shows increased metabolism of FDG PET and ^{18}F -FLT PET.

Chen et al. J Nucl Med 2005; 46:945–952

Primary Brain tumor

- SPECT imaging can be a valuable imaging modality as an alternative to PET. Commonly used radiotracers are ^{201}Tl , $^{99\text{m}}\text{Tc}$ -sestamibi and ^{111}In dium-pentetreotide. They demonstrates low uptake to normal brain tissue, which allows for a high target to background ratio.



Metastases Brain Disease

- In FDG PET, activity depends on tumor histology
 - Classical hypermetabolic FDG lesions : lung, breast, colorectal, head and neck, melanoma and thyroid
 - Classical hypometabolic : mucinous adenocarcinoma, renal cell carcinoma
- Normal brain metabolism can hide small metastases.
- SPECT - valuable modality as an alternative to FDG PET and particularly useful in brain tumors that are not FDG avid such as renal cell cancer or lesion located near the physiologically active cortex.
- But, SPECT imaging had limited sensitivity for tumors smaller than 10 to 15 mm compared with 7 to 10 mm for FDG PET.



Brain Injuries

- Brain SPECT is more sensitive than CT or MRI for revealing lesions caused by head injury, especially in the acute phase (< 24 h).
- In the subacute (2 d to < 6 mo) and chronic (>6 mo) phases, the performance of brain SPECT is less well documented.
- Regardless of the type of injury (subdural hematoma, cerebral contusion or subarachnoid hemorrhage), the images show focal, multifocal or regional areas of hypoperfusion that correlate better with the clinical status of the patient than do structural images
- Focal cerebral hyperemia after head injury was associated with a lower mortality rate and better outcome than was lack of hyperemia after head injury.



Brain injuries

- In mild traumatic brain injury patients with normal CT findings - brain SPECT is sensitive enough to show perfusion changes, even when the patient did not lose consciousness – these changes correlated better with neurologic findings in the absence of anatomic abnormalities.
- Normal brain SPECT findings were found to be a reliable tool in the exclusion of the clinical sequelae of mild head injury



Psychiatry

- Many brain perfusion and metabolic rate studies were carried out in a number of psychiatric illnesses e.g. Obsessive Compulsive Disorder, depression, schizophrenia, panic and anxiety disorder, eating disorder and substance abuse.
- Functional imaging using PET or SPECT can be used in the functional evaluation of the patient, course prediction and therapy evaluation.



Psychiatry

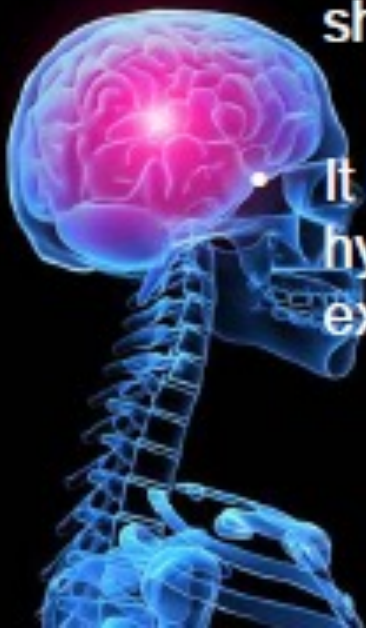
Substance Abuse and Dependence

- Brain SPECT = PET, has shown disseminated cerebral blood flow defects in abusers of cocaine and alcohol.
- Disappearance or improvement of the lesions after a period of abstinence has been described, suggesting that arterial spasms may cause the defects.
- Patients with a history of inhalation of industrial solvents, such as glue, paint, and gasoline, have similar perfusion abnormalities.



Cerebrospinal Fluid Imaging

- A number of radiopharmaceuticals have been investigated for use in CSF imaging since Crow et al first used sodium 24 injected into the cisterna magna.
- The radiopharmaceuticals commonly used today is ^{111}In DTPA.
- In shunt patency examinations, either ^{111}In DTPA or $^{99\text{m}}\text{Tc}$ DTPA; sometimes $^{99\text{m}}\text{Tc}$ pertechnetate is used - due to the short examination duration.
- It has a role in detection of CSF leakage, evaluation of hydrocephalus, evaluation of CSF flow and shunt patency examination.



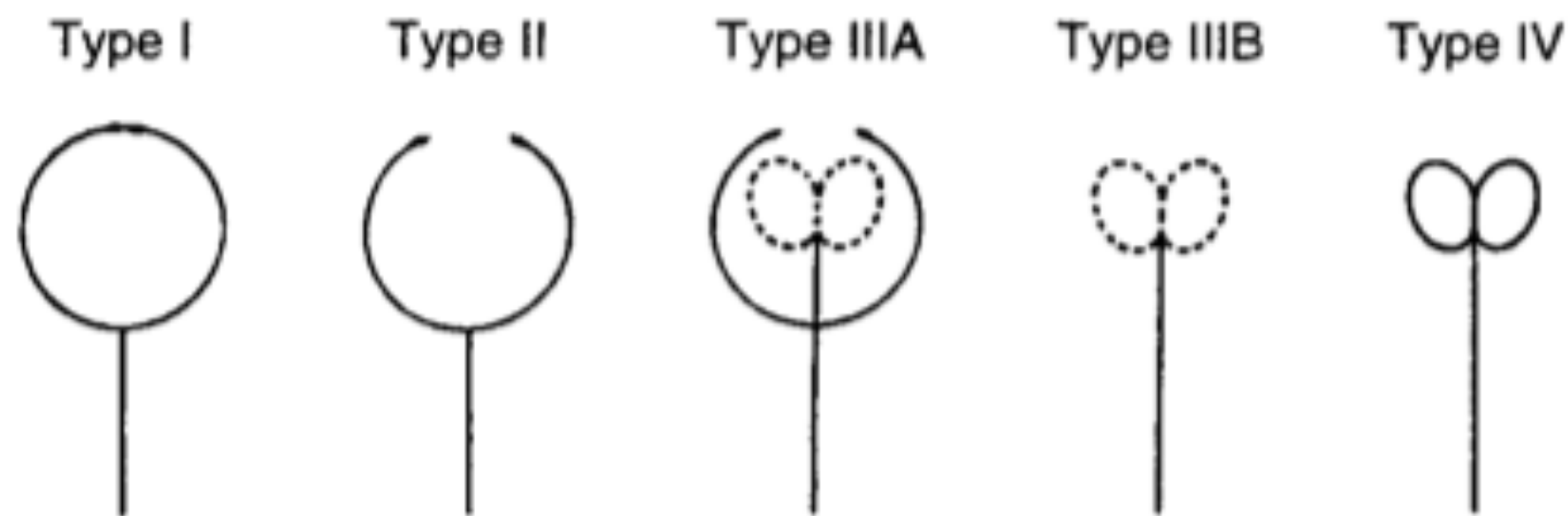


Fig. 12-28 Abnormal patterns of cerebrospinal fluid flow (Table 12-5).

Table 12-5 Cerebrospinal fluid flow patterns in hydrocephalus

Type	Pattern	Etiologies
I	Basal cistern, 2-4 hr Sylvian fissure, 6 hr Over convexities, 24 hr Decreased activity, 48 hr	Normal Intraventricular obstructive hydrocephalus
II	No ventricular activity Delayed migration	Cerebral atrophy Increased intracerebral pressure Advanced age Noncommunicating hydrocephalus
IIIA	Transient ventricular activity Clearance by usual migration (often)	Cerebral atrophy Evolving or resolving communicating hydrocephalus
IIIB	Transient ventricular activity, clearance without usual migration	Communicating hydrocephalus with alternative pathway of resorption (transependymal)
IV	Persistent ventricular activity, inadequate clearance	Communicating hydrocephalus

Ventriculoperitoneal Shunt Study

- Indications - evaluation of shunt patency
- Normal findings:
 - Radiotracer reflux from reservoir to ventricles and/or subarachnoid space.
 - Visualization of radiotracer in tube
 - Radiotracer disperses in distal cavity
 - Pleural space
 - Peritoneal space
 - Visualization of kidneys and bladder signifies systemic absorption.



Reservoir site
shaved and cleaned



Reservoir site



Reservoir site draped



Patient positioning
before the procedure



Injection of
radiopharmaceutical

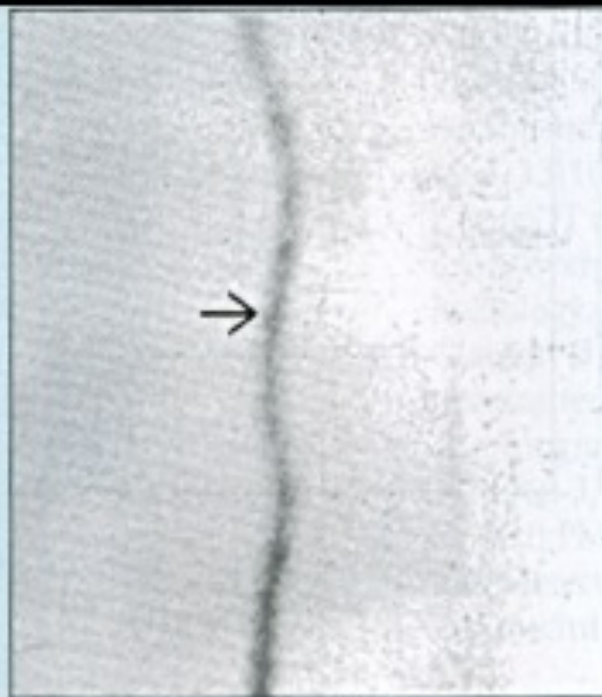


Outcomes

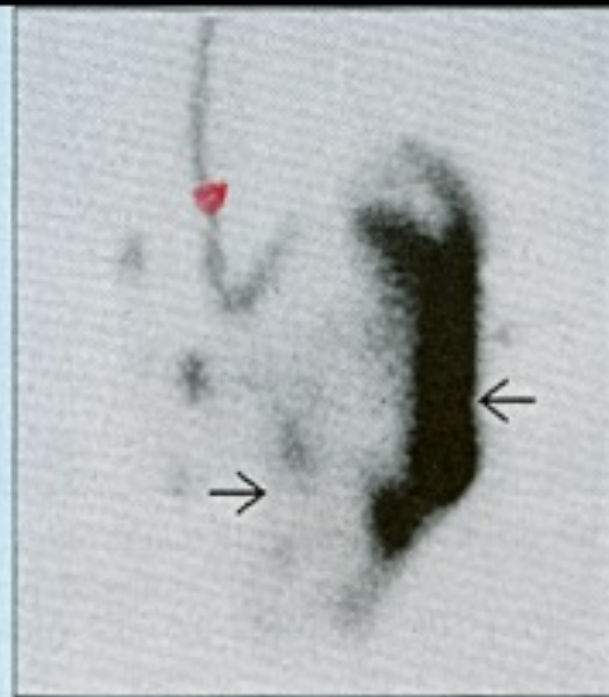
Patent VP shunt



Ventricular Reflux



Thoracolumbar Tube



Peritoneal Dispersion



Injection site

1 min

2 min

3 min

4 min

5 min

6 min

7 min

8 min

9 min

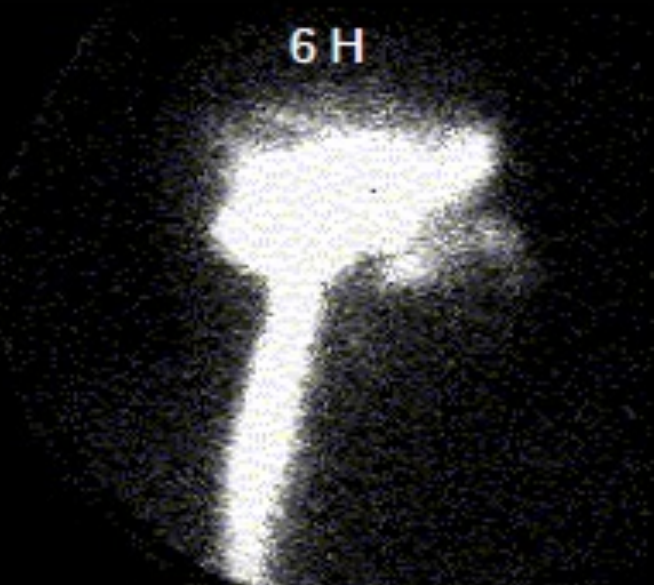
10 min

Normal Flow

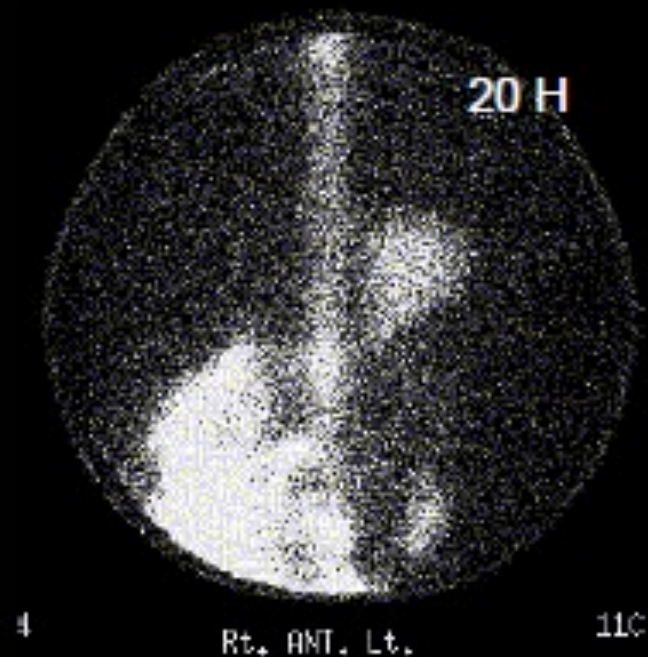


57 year old woman had a nasal polyp removed four years ago. Two years ago, she began noticing clear rhinorrhea whenever she bent over. Initially the fluid came from her left nostril, but now it occurs bilaterally. This study was requested to rule out a CSF leak.

In-111 DTPA, lumbar subarachnoid injection



Normal tracer activity is present in the basal cisterns. In addition, tracer extends inferiorly and anteriorly into the nasopharynx and nose. This abnormal distribution of tracer is consistent with a CSF leak.



An anterior image of the abdomen demonstrates activity within the stomach and bowel, likely as a result of swallowing CSF that had leaked into the nasopharynx.

Brain Death

- “Irreversible loss of function of the brain, including brain stem”
- Three cardinal findings are present in brain death :
 1. Coma with no response to noxious stimuli.
 2. Absence of brain stem reflexes.
 3. Apnea testing
- Cerebral perfusion imaging is used as a confirmatory test.
- Although the diagnosis can be made on purely clinical bases, a confirmatory test is recommended for patients in whom specific components of clinical testing cannot be evaluated reliably.
- In a small clinical trial – cerebral perfusion imaging showed efficacy in shortening the time to declaration of brain death – particular significance in patient considered for organ procurement.

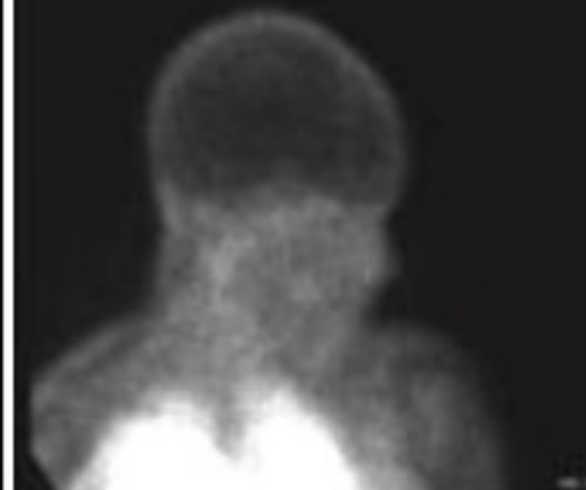


Planar Imaging of a young boy who was involved in MVA

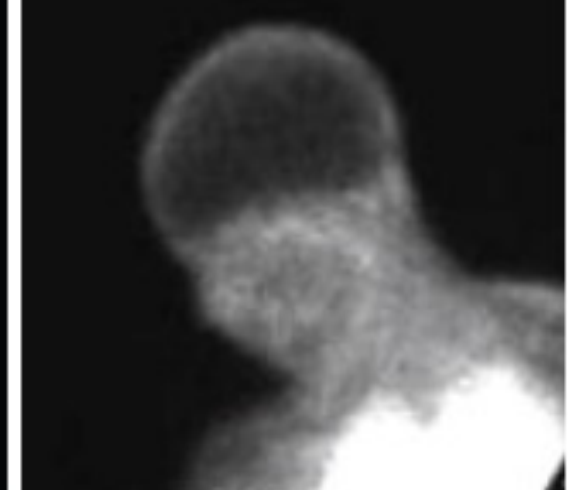
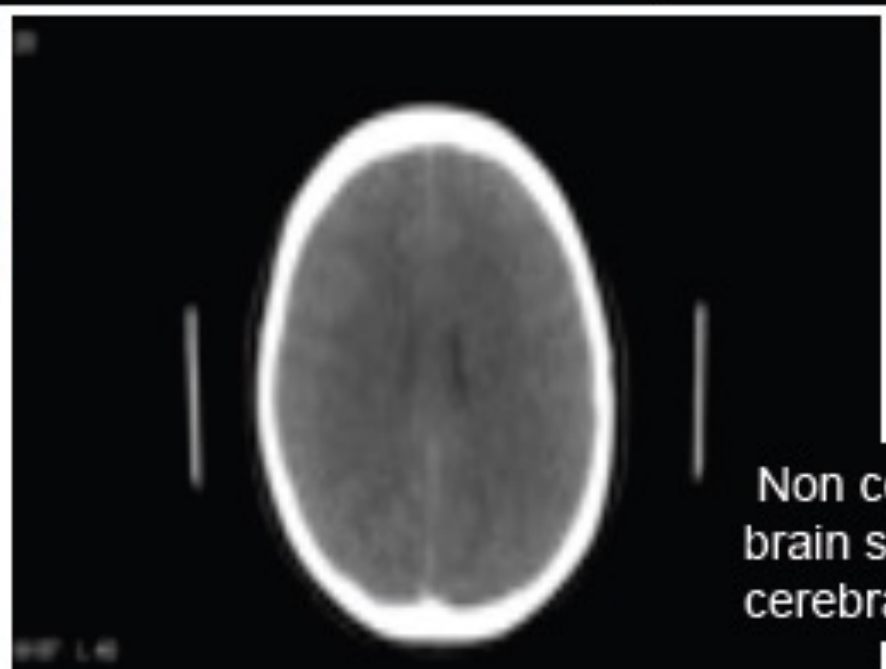
Anterior



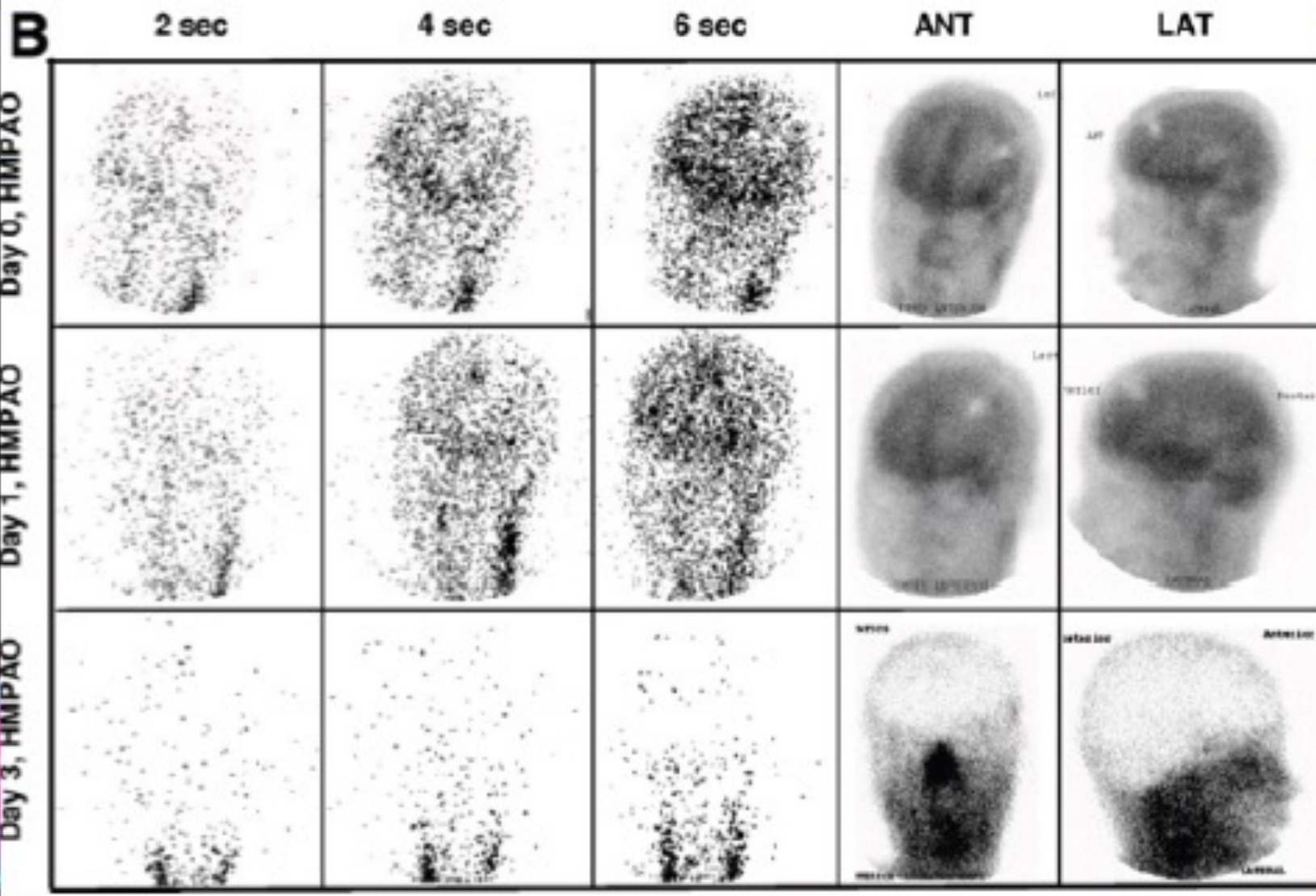
RAO



LPO



Non contrasted CT
brain showing diffuse
cerebral oedema



All 3 studies were performed with HMPAO. Both initial study and second study performed the following day demonstrated evidence of brain perfusion on angiographic and parenchymal phases of the examination. The study converted to absent perfusion on the third day (third row).

Concerning Tc-99m HMPAO

- A. Tc-99m HMPAO crosses BBB
- B. Regional uptake of Tc-99m HMPAO is proportional to regional cerebral blood flow to the same area
- C. Distribution of Tc-99m HMPAO in the brain is independent of brain maturation
- D. Diffuse lung uptake of Tc-99m HMPAO is seen only in people with a history of smoking
- E. Focal cerebral uptake is seen in herpes simplex encephalitis

Concerning Tc-99m HMPAO

- TTFTT

Brain SPECT

- A. The distribution of Tc-99m HMPAO reflects regional glucose metabolism
- B. Tc-99m HMPAO has to be used within 30 min of being prepared
- C. It is helpful to create images in the axis of temporal lobes when investigating temporal lobe epilepsy
- D. Bright light or loud sounds at the time of injection may alter the distribution of Tc-99m HMPAO
- E. It is possible to accurately assess the size of lateral ventricles with brain blood flow tracer

Brain SPECT

- FTTTF

Concerning dementia

- A. Increased accumulation of cerebral blood flow tracer is seen in the frontal lobes in Prick's disease
- B. Abnormalities in Alzheimer's disease are often bilateral and predominantly affect temporal and parietal lobe
- C. AIDS dementia complex usually shows no abnormalities on brain SPECT imaging
- D. Typical blood flow changes are seen in the basal ganglia in asymptomatic patients with Huntington's chorea
- E. A characteristic pattern of reduced rCBF is seen in idiopathic Parkinson's disease

Concerning dementia

- FTFTF

Concerning brain scintigraphy

- A. In the initial stage of cerebral ischemia, regional cerebral blood flow increases.
- B. In the initial stage of cerebral ischemia, regional oxygen extraction fraction increases.
- C. With cerebral infarction, cerebral metabolic rate for glucose increases.
- D. Following cerebral infarction, local cerebral blood flow increases.
- E. In Parkinson's disease, PET perfusion studies demonstrate decreased perfusion to the basal ganglia contralateral to the affected limb.

Concerning brain scintigraphy

- FFFTF

Concerning brain scintigraphy

- A. In Parkinson's disease, there is increased F-18 flourodopa uptake by the stratum (caudate and putamen nuclei).
- B. Concerning brain tumors, an advantage of PET is that it can image metabolically active cells versus gadolinium enhanced MRI and contrast enhanced CT, which image areas where there is blood brain barrier breakdown.
- C. Gadolinium enhanced MRI and F-18 FDG PET imaging are equally capable of distinguishing between recurrent brain tumor and radiation necrosis.
- D. All malignant brain tumors demonstrate hypermetabolism over F-18 FDG.
- E. In differentiating between infectious and neoplastic brain lesions, the presence of hypermetabolism is not useful.

Concerning brain scintigraphy

- FTFFF

Concerning brain scintigraphy

- A. F-18 FDG freely crosses the BBB via the same carrier mediated transport system as glucose
- B. Local cerebral metabolic rates of glucose (specific areas of the thalamus, basal ganglia, lobes) can be determined through PET studies
- C. Approximately 20 – 30 mCi of FDG PET should be administered for a brain study
- D. A routine FDG study can be performed 5 minutes after radiopharmaceutical administration
- E. External stimuli can increased regional glucose metabolism within particular areas of the brain

Concerning brain scintigraphy

- TTFFT

Concerning brain scintigraphy

- A. Global glucose metabolism compared with normal decreases to a greater degree in multiinfarct dementia than in Alzheimer's dementia
- B. Small white matter lacunar infarcts are much more easily identified with FDG PET than with CT
- C. CT can reliably distinguish Alzheimer's disease from multiinfarct dementia
- D. In Huntington's disease, changes in the caudate nuclei can be observed on PET earlier than the CT
- E. Persistent ventricular filling on a radionuclide cisternogram is diagnostic of communicating hydrocephalus

Concerning brain scintigraphy

- FFFTT

Concerning Tc-99m DTPA in brain scintigraphy

- A. Does not cross the BBB
- B. Redistribute over several hours
- C. In subacute stroke appears as an area of increased uptake
- D. Is the current agent of choice for radionuclide cisternography
- E. Requires preparation with oral perchlorate to block the unwanted choroid plexus uptake

Concerning Tc-99m DTPA in brain scintigraphy

- TFTFF

Which radiopharmaceuticals have
been used for blood brain
scintigraphy?

Which radiopharmaceuticals have been used for blood brain scintigraphy?

- Tc-99m pertechnetate, Tc-99m DTPA and Tc-99m GH. The latter two were preferred because of their faster background clearance, lack of choroid plexus uptake and lower radiation dose.

What is the 'flip-flop' phenomenon seen in the cerebrovascular scintigraphy and what is the significance?

What is the 'flip-flop' phenomenon seen in the cerebrovascular scintigraphy and what is the significance?

- On the flow phase, parenchymal flow is delayed on the abnormal side compared with the contralateral normal side. Thus, as the normal cortex clears, uptake in the abnormal side peaks. This may be seen with the high grade carotid artery stenosis with or without cerebral infarction. Delayed carotid flow is seen concomitantly.

Pearl

- A 'hot nose' may be seen on the flow phase images and delayed images as a result of shunting of the blood from the internal to the external carotid system that supplies the face and the nose in patients with severe carotid stenosis, brain death, psychoactive drug use and use of other drugs that cause nasal congestion.

What is luxury perfusion?

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- Increased perfusion may be seen in the region of an infarct after a recent stroke (1 to 10 days) caused by an uncoupling of blood flow from metabolism and oxygen demand.

How is brain death diagnosed?

How is brain death diagnosed?

- The diagnosis is primarily by clinical. The patient must be in deep coma with total absence of brainstem reflexes and spontaneous respiration. Reversible causes (drug or hypothermia) must be excluded; the cause of the dysfunction must be diagnosed (trauma or stroke); and the clinical findings of brain death must be present for a defined period of observation (6 to 24 hours). Confirmatory EEG and radionuclide must be used to increased diagnostic certainty, but the diagnosis is primarily clinical. The radionuclide study is more specific than EEG.

Which radiopharmaceuticals are used to evaluate brain death and what are the advantages of each?

Which radiopharmaceuticals are used to evaluate brain death and what are the advantages of each?

- Tc-99m flow agents such as DTPA are inexpensive. The 60 second flow study can be interpreted at the bed side. Because Tc-99m HMPAO and Tc-99m ECD fix in the cortex, delayed static images can be obtained and interpreted for diagnosis. The clinician is not dependent on a flow study, which demand a good bolus and good timing with proper computer acquisition. However it is more expensive.

What is the difference in mechanism of uptake between F-18 FDG and Tc-99m cerebral perfusion imaging

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- F-18 FDG is a glucose analog and its uptake represent regional glucose metabolism. It's metabolically trapped intracellularly.
- Tc-99m HMPAO and Tc-99m ECD are lipid soluble cerebral perfusion agents taken up in proportion to regional cerebral blood flow. They fixed intracellularly.

How can SPECT brain perfusion or PET
FDG imaging can be useful in the
differential diagnosis of dementia?

How can SPECT brain perfusion or PET FDG imaging can be useful in the differential diagnosis of dementia?

- Multiinfarct dementia is characterized by multiple areas of past infarct, recognized as areas of decreased uptake that correspond to the vascular distributions.
- Alzheimer's disease exhibits characteristic pattern of bitemporal and parietal hypoperfusion and hypometabolism.
- Pick's disease is associated with decreased frontal lobe uptake.
- AIDS dementia complex is associated with a pattern of multifocal or patchy cortical regions of decreased uptake seen particularly in the frontal, temporal and parietal lobes and the basal ganglia

What is the purpose of cerebral perfusion imaging in patients with seizure and what is the expected PET or SPECT pattern?

What is the purpose of cerebral perfusion imaging in patients with seizure and what is the expected PET or SPECT pattern?

- PET F-18 FDG and SPECT cerebral perfusion studies can often localize the seizure focus in patients requiring surgery (typically temporal lobectomy) for seizure control.
- Interictally, a seizure focus shows decreased metabolism (FDG) on PET and decreased perfusion on SPECT.
- Ictally there is increased activity is seen during a seizure.

Which radiopharmaceuticals have been found useful in imaging brain tumors and what is their clinical utility?

What is the purpose of cerebral perfusion imaging in patients with seizure and what is the expected PET or SPECT pattern?

- F-18 FDG imaging demonstrates increased uptake in tumors owing to increased glycolysis. Uptake of FDG is proportional to the malignant grade of glioblastomas.
- SPECT with Tl-201 and Tc-99m sestamibi can be used in similar manner. Both Tl-201 and PET can differentiate lymphoma from infection, most often toxoplasmosis in AIDS patients.
- Uptake of Tl-201 or FDG is indicative of lymphoma.

Name the radiopharmaceutical used
for cysternography and the most
common clinical indication in this
study

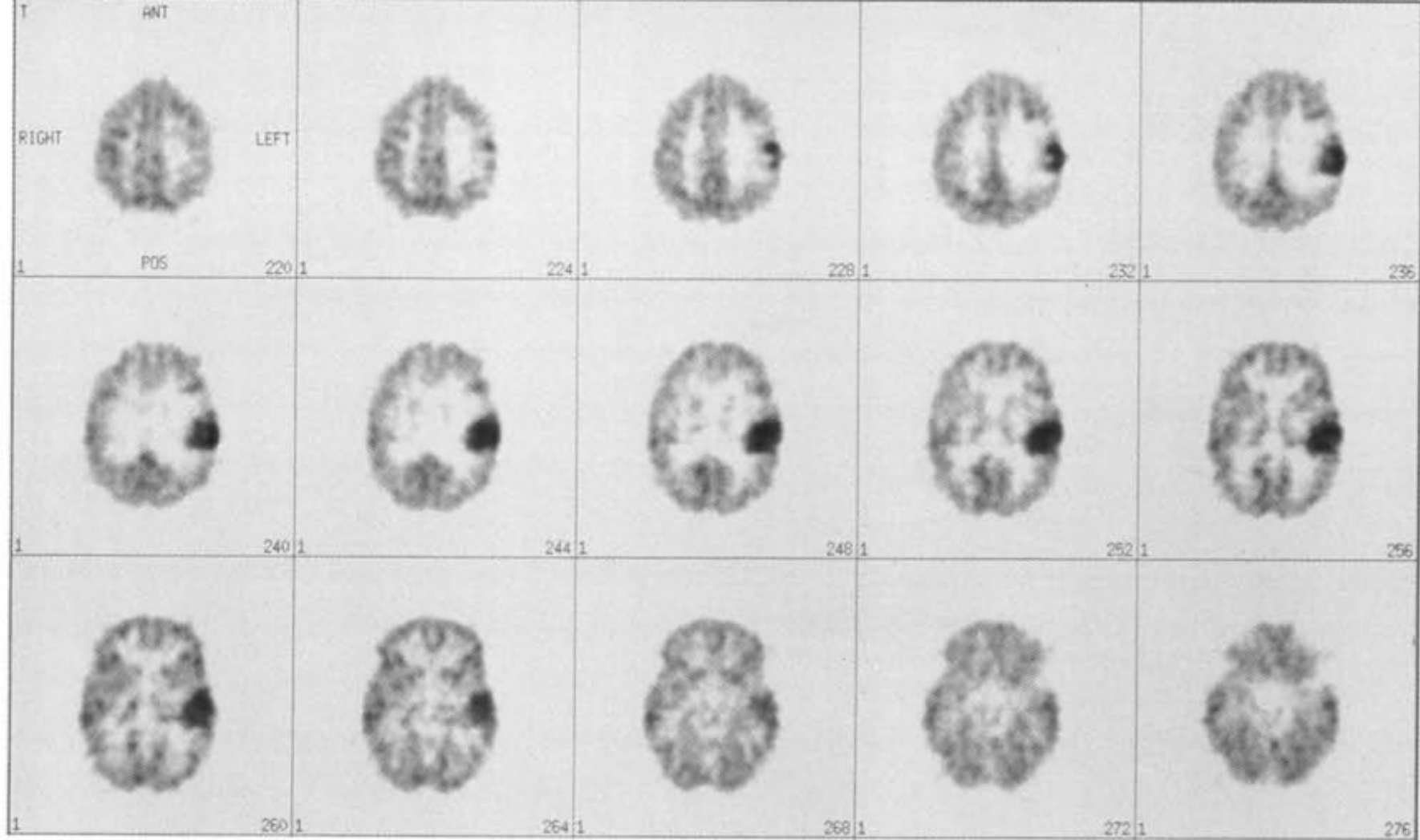
Name the radiopharmaceutical used for cyssternography and the most common clinical indication in this study

- In-111 DTPA. The most common use of this radiopharmaceutical in modern practice is to confirm the diagnosis of normal pressure hydrocephalus (NPH). The next common use is for (CSF) leaks.

What is the pattern of NPH on
cysternography?

What is the pattern of NPH on cysternography?

- Persistent ventricular filling and evidence of convexity block.
- The symptoms of NPH are incontinence, dementia and gait disturbance.

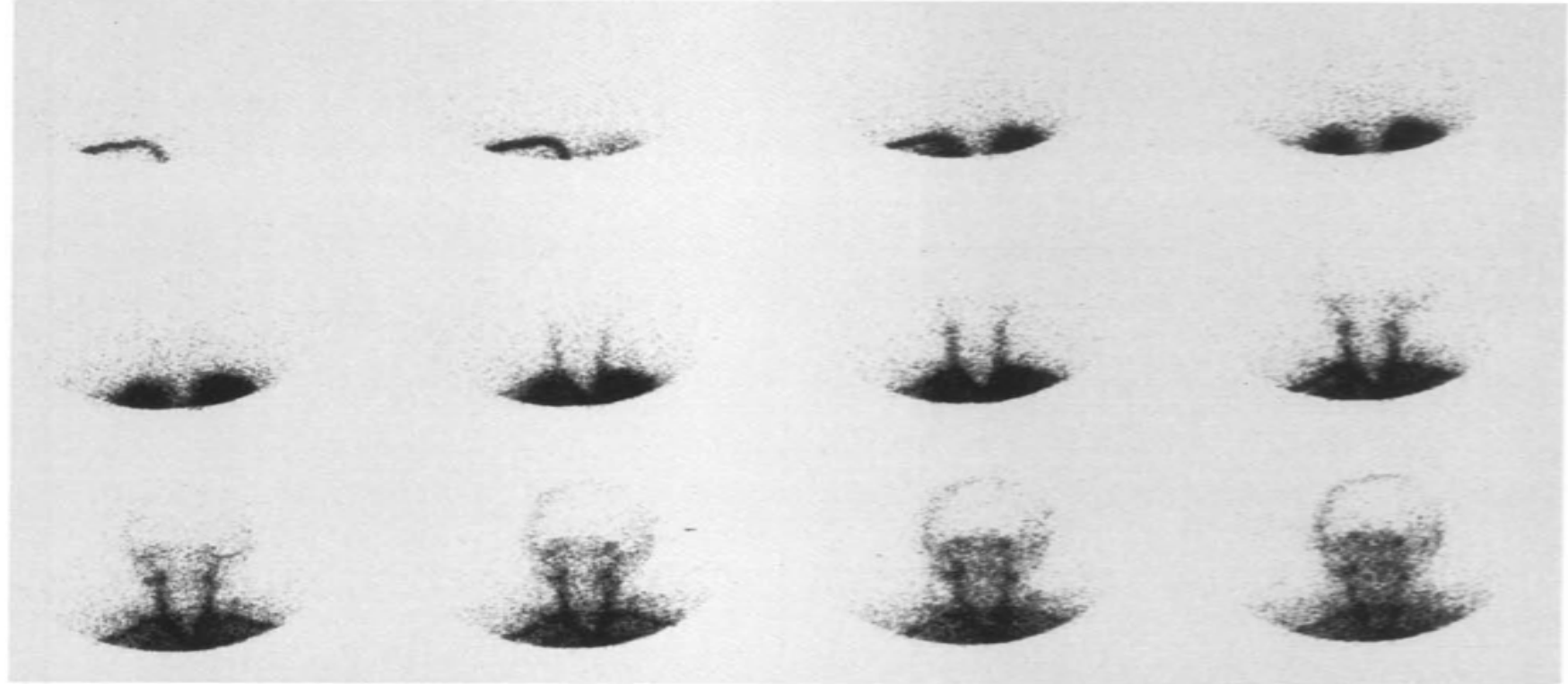


A 38-year-old man had a diagnosis of grade I-II astrocytoma and was treated 11 years ago. He has had a recent onset of seizures. MRI showed no definite change from the many prior studies (B).

1. What FDG-PET scan findings are expected with a low-grade glioma?
2. What is the finding on this FDG-PET scan (A)?
3. Interpret this study.
4. Would ^{99m}Tc HM-PAO show a similar appearance?

Primary brain tumor

1. Low grade gliomas typically have poor or no uptake
2. Intense uptake in the large temporoparietal mass
3. Transformation of a low grade to a high grade glioma
4. No. malignant tumors usually do not have receptor for binding of RP, which is necessary before intracellular incorporation

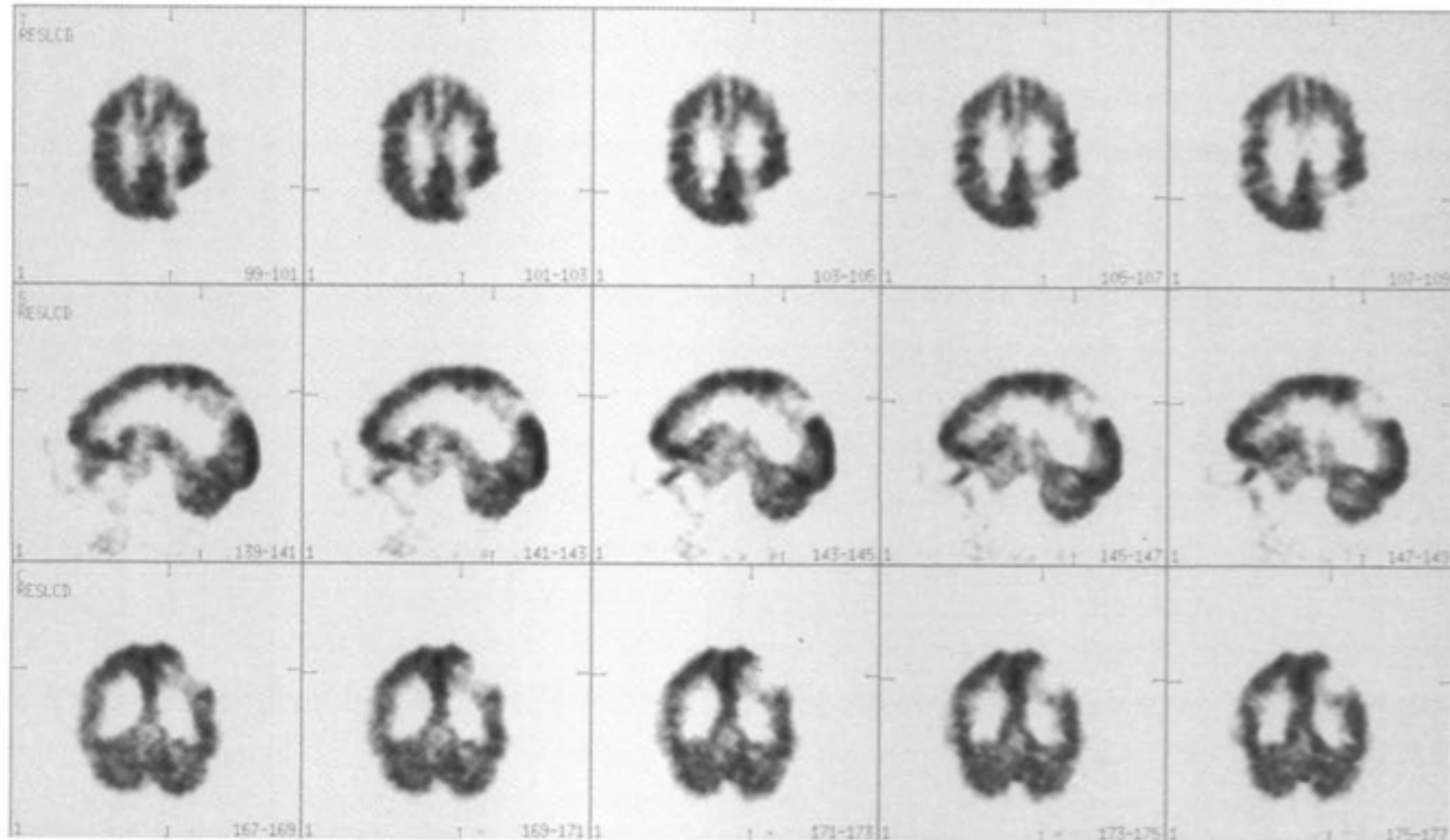


A 35-year-old man has been comatose for 2 weeks since a recent severe head injury. The electroencephalogram (EEG) is flat and he is being considered as an organ donor.

1. If the EEG is a flat line, why is another study indicated?
2. What are the clinical findings of brain death?
3. List two different types of radiopharmaceuticals with different mechanisms that could be used for this study.
4. What are the scintigraphic findings and the diagnosis?

Brain death

1. Flat EEG :hypothermia/ barbiturates/ depressive drugs
2. Deep coma/ no spontaneous breathing/ no brain stem reflex
3. Tc-99m DTPA/ Tc-99m pertechnetate or Tc-99m HMPAO/ Tc-99m ECD
4. Tc-99m DTPA – no blood flow to cerebral cortex,
Tc-99m HMPAO – shows salivary gland/ normal brain perfusion – cerebral cortical activity seen



A 65-year-old man with recent acute onset of right-sided hemiparesis undergoes ^{18}F FDG-PET scanning.

1. What is the radiopharmaceutical used for metabolic cerebral imaging with PET, and what is the mechanism of uptake?
2. What are the radiopharmaceuticals used for PET cerebral perfusion imaging?
3. Describe this patient's PET imaging findings (above, transverse; middle, sagittal; bottom, transverse)?
4. What is the differential diagnosis?