Appearance of the scans can vary because they are taken by different centers and different camera types.

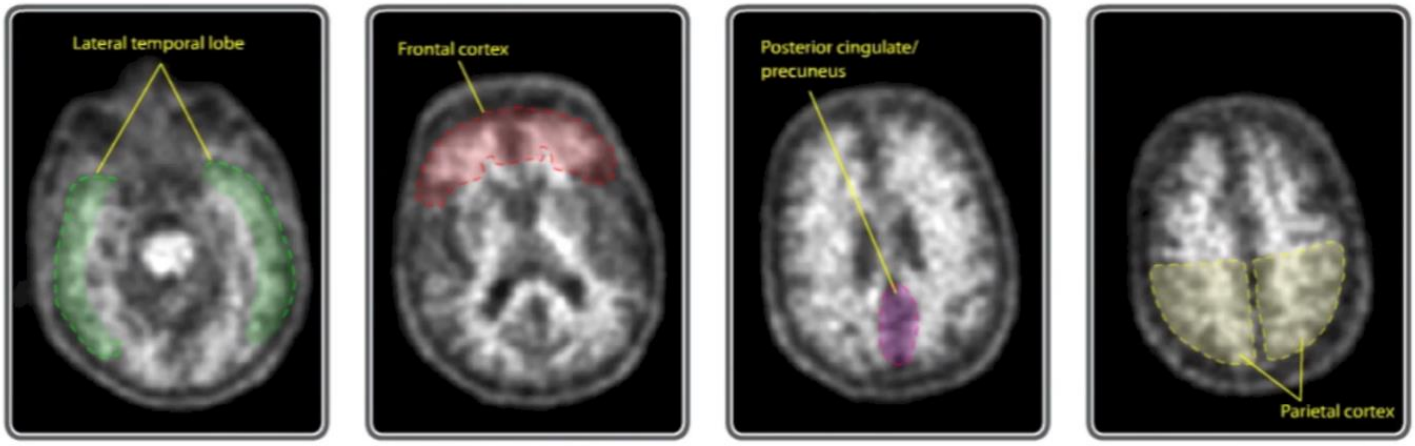
Factors affecting appearance include:

- Brain anatomy, such as atrophy and vascular pathology
- Patient positioning
- Patient movement

Therefore, it is important to have a systematic and uniform approach to reading florbetaben PET scans.

- PET images are read in a transaxial orientation using a gray scale
- PET images come from different sites and cameras
  - Therefore, images will differ in resolution, filtering, and more
- MRI scans are frequently unavailable for the PET images
- Provide an accurate interpretation viewing only a PET scan
- Follow the Brain Amyloid Plaque Load (BAPL) algorithm exactly
  - This will be reviewed later in this lesson

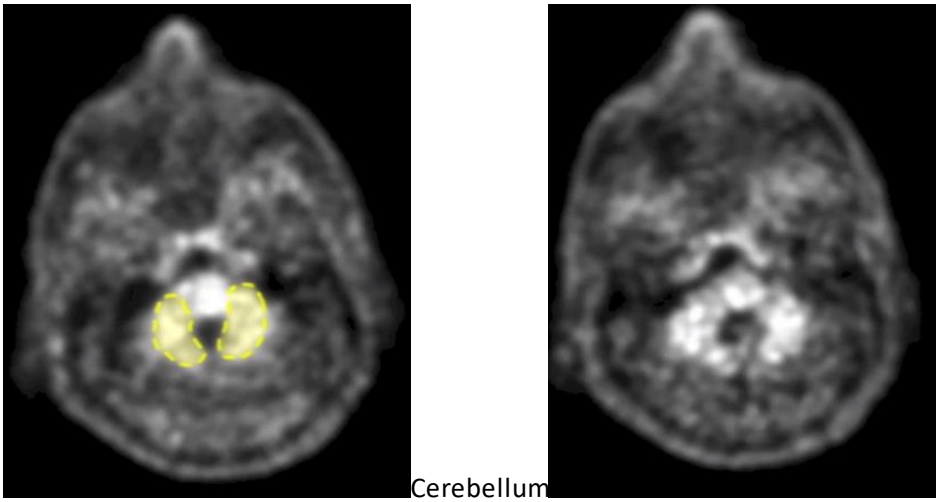
- Focus on the following 4 regions of the brain:
  - Lateral temporal lobe
  - Frontal cortex
  - Posterior cingulate/precuneus
  - Parietal cortex

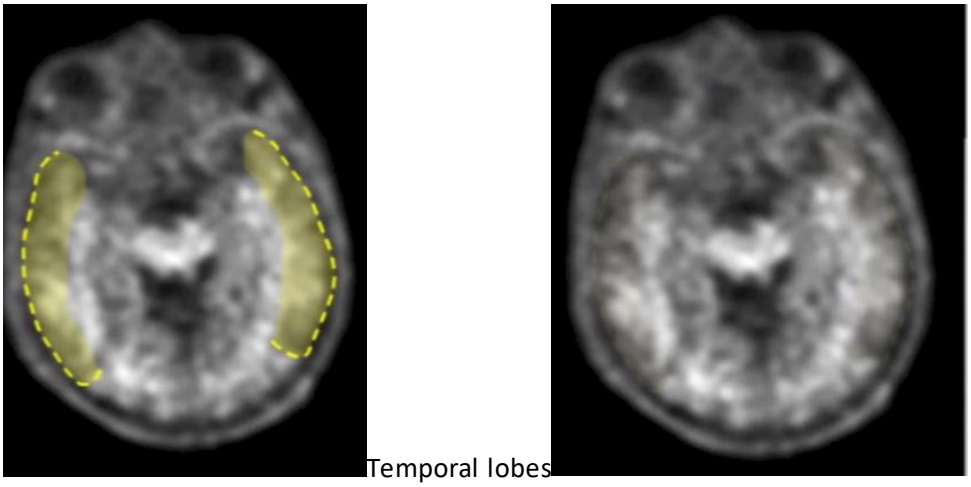


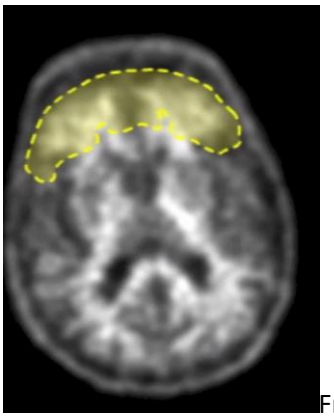
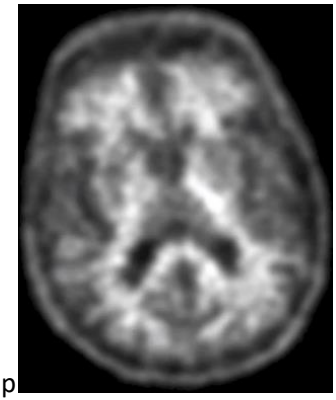
Score from these 4 areas only

- Focus on the following 4 regions of the brain:
  - Lateral temporal lobe
  - Frontal cortex
  - Posterior cingulate/precuneus
  - Parietal cortex

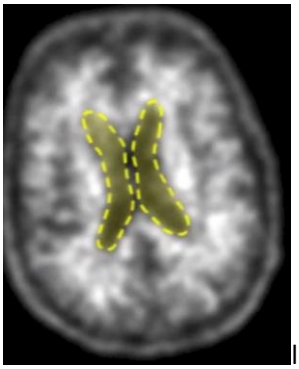
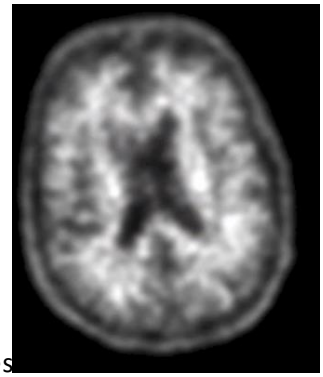
- Some helpful landmarks and anatomical features:
  - Lateral temporal lobe:
    - Cerebellum
    - Middle cranial fossa/temporal bone
  - Frontal cortex:
    - Orbital roof
    - Central sulcus
    - Lateral sulcus
  - Posterior cingulate/precuneus:
    - Lateral ventricles
    - Splenium
  - Parietal cortex:
    - Lateral ventricles
    - Central sulcus
    - Longitudinal cerebral fissure
  - Outer bright rim of the scalp and the adjacent dark ring of the skull and cerebrospinal fluid (CSF)

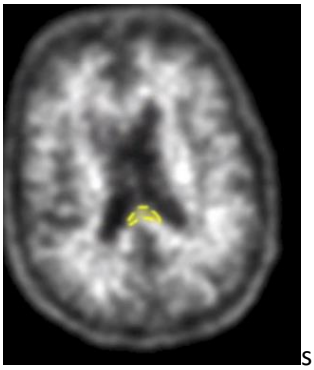
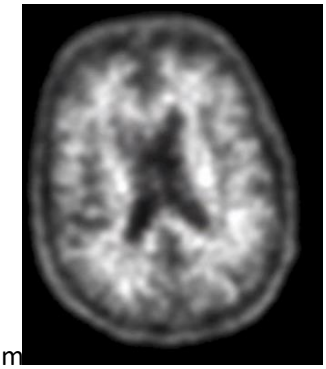

Cerebellum

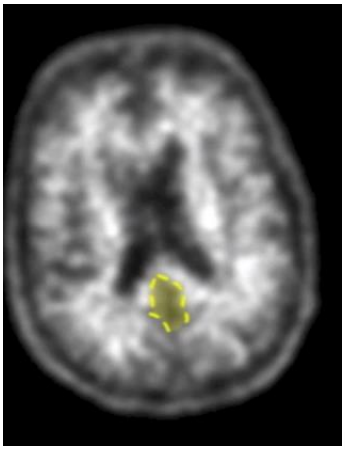

Temporal lobes

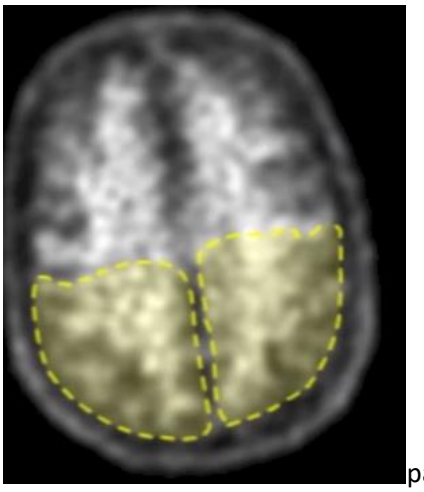
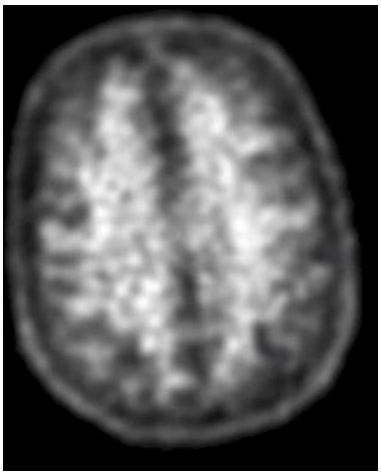
 Frontal lobes appear next as you go up 

To identify the posterior cingulate/precuneus, identify the lateral ventricles and splenium

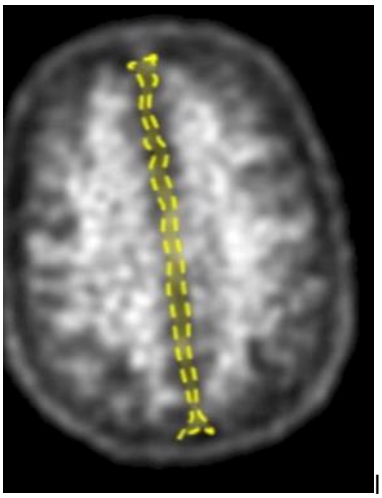
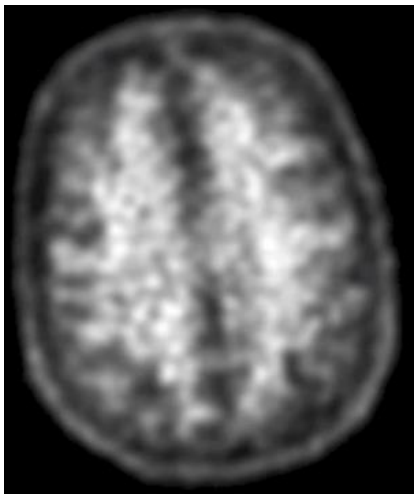
 lateral ventricles 

 splenium 

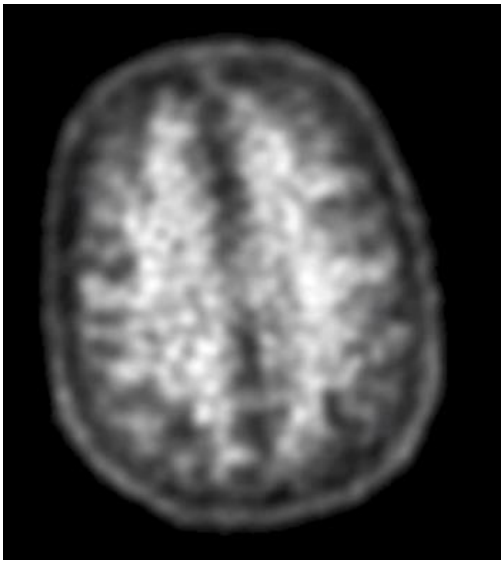
 post cing/precun: on a normal scan, it's posterior to the splenium and is a dark hole; can't distinguish the 2 on PET


parietal cortex


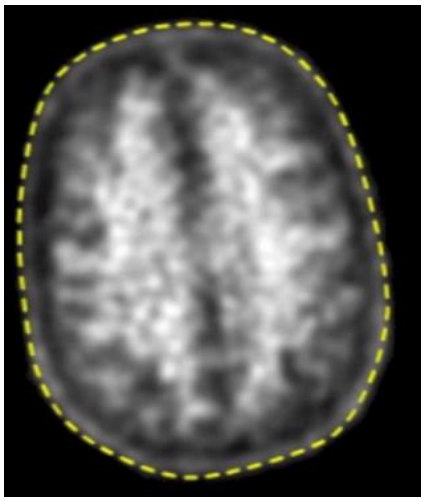
Parietal cortex is just above lateral ventricles, separated from frontal lobe by central sulcus


longitudinal fissures


in a positive scan, the longitudinal fissure will be narrowed by uptake in the parietal cortex

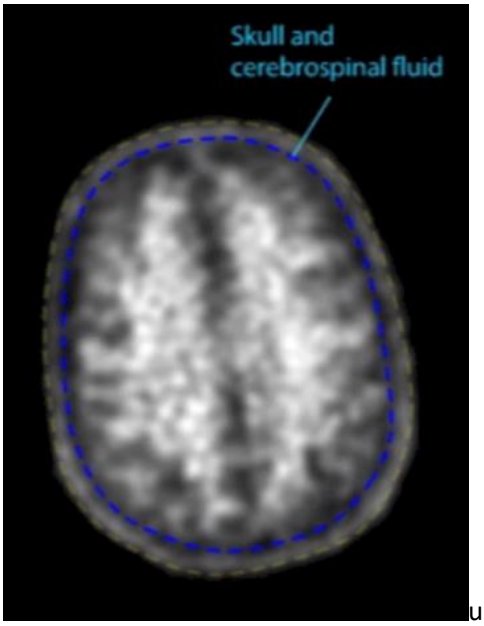


outer bright rim of scalp



(FYI: outer rim of scalp will be thickened if there is motion)

look for outer bright rim of scalp & adjacent dark ring of the skull/CSF



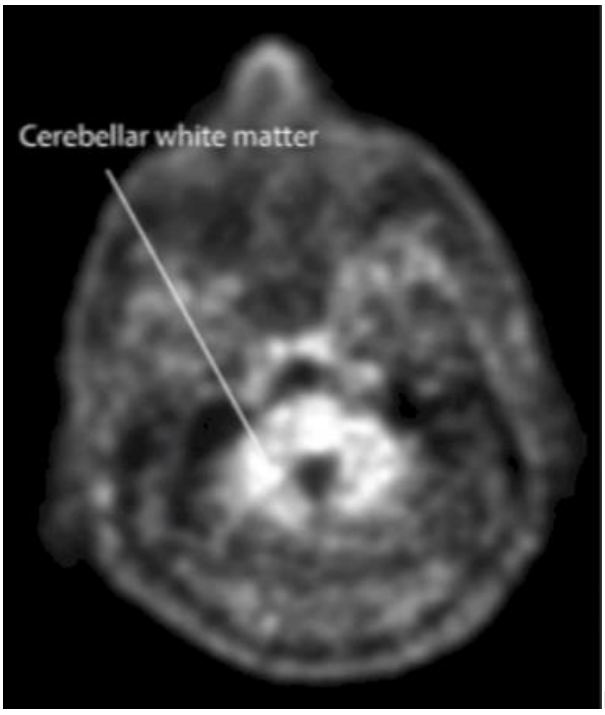
uptake won't be seen in this area of skull/CSF

Rule 1

View the brain systematically, starting from the cerebellum, and scrolling upward through the transaxial slices:

1. Lateral temporal
2. Frontal
3. Posterior cingulate
4. Parietal

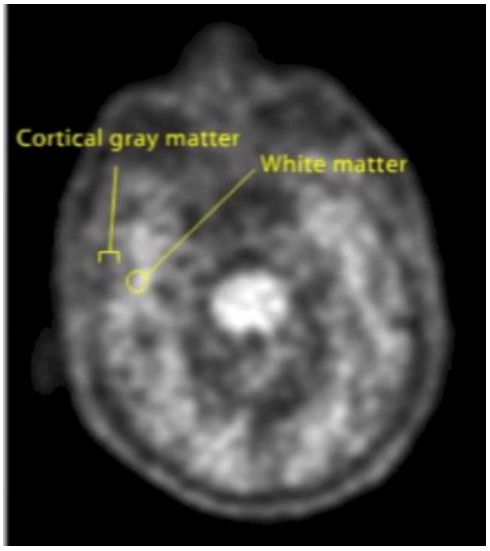
The signal intensity of the cerebellar white matter serves as the reference target intensity required for positivity in the cortex.



For positivity, this degree of tracer activity must be seen in the cerebral cortex

Rule 2

Always compare the signal intensity present in cortical gray matter with that in the adjacent white matter (if visible).



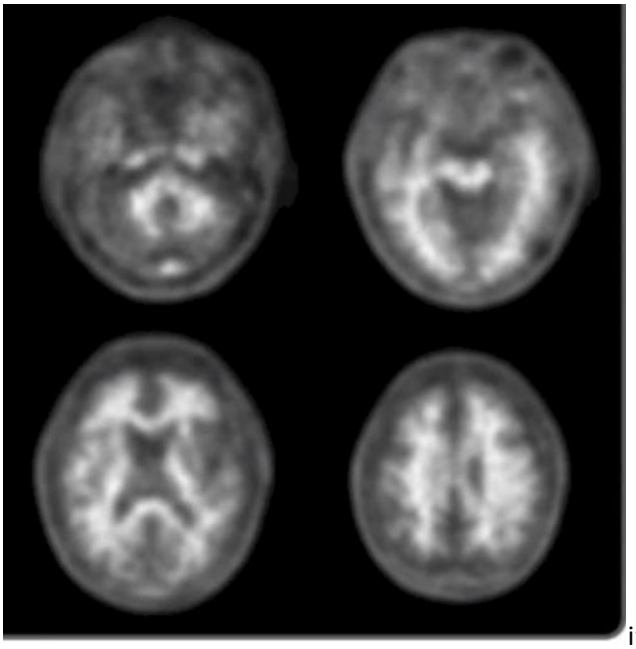
Can use cerebellar white matter as reference for target signal intensity

At the individual slice level, you can use this max intensity rule. Locate max white matter intensity for slice you are viewing and compare to that of signal intensity of the cortical grey matter

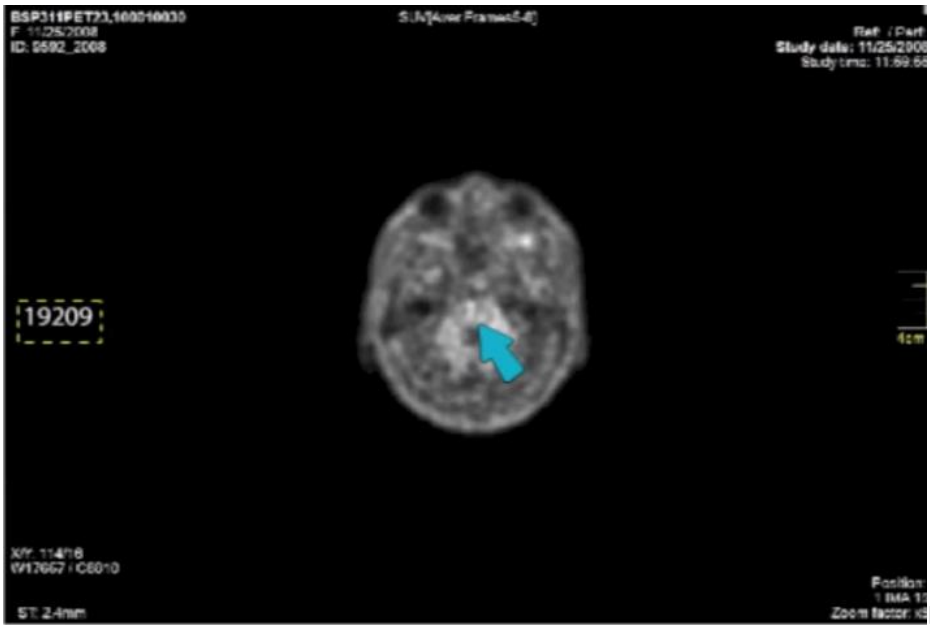
Strategy 2a

Compare the region(s) of maximum signal intensity, which is the "target" signal intensity in the white matter.

If you have this feature, may be helpful to use the “digital value feature.”



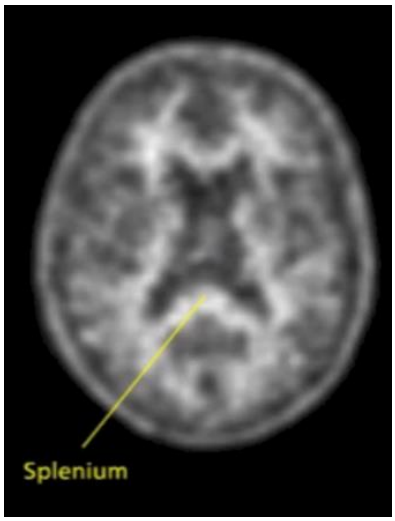
if the slice showing the region with the target signal intensity is visible on the screen, visual comparison can then be drawn to other regions



In rare cases in which the slice with the target signal intensity is not present in the slide to be examined, the digital value of the target signal intensity of the cerebellar white matter can be used and read from the screen. Only do rarely

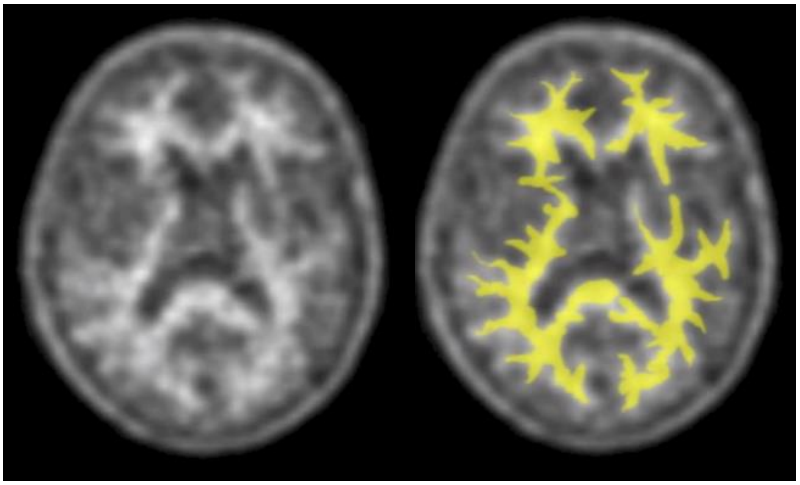
Strategy 2b

Identify regions that "anatomically" always correspond to white matter structures, eg, the splenium.

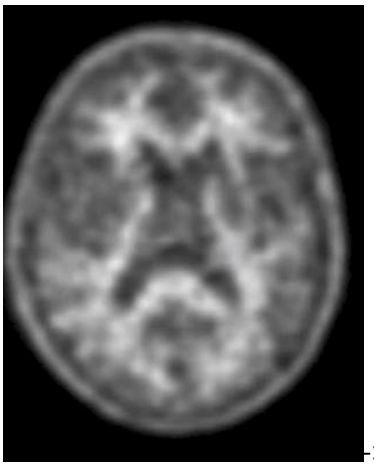
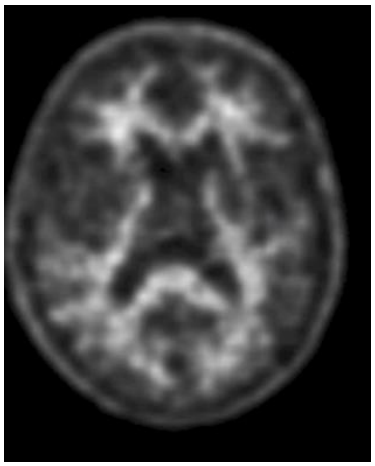


Strategy 2c

In slices involving the frontal and lateral temporal lobes, look for the spiculated or "spiky," irregular appearance of the white matter in the frontal lobe and the mountainous "skeleton" of white matter seen in the lateral temporal lobe in the absence of cortical tracer uptake.

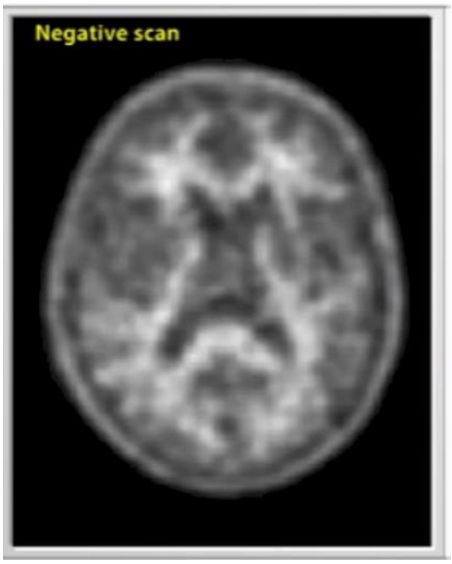


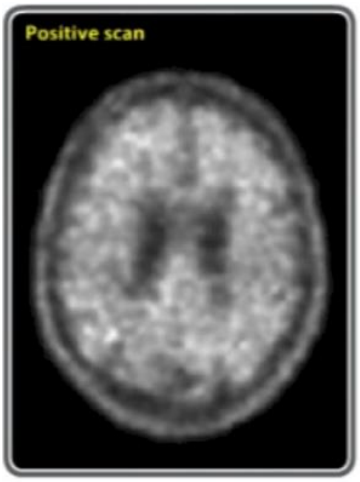
If marginal image quality, adjusting the gamma correction (windowing) will improve the delineation of WM to GM

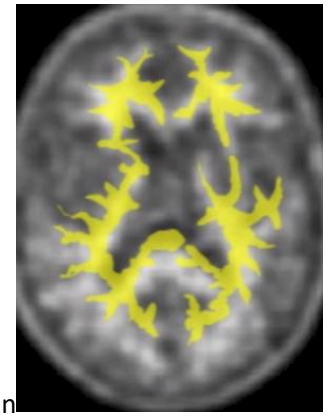

-> -> -> -> ->


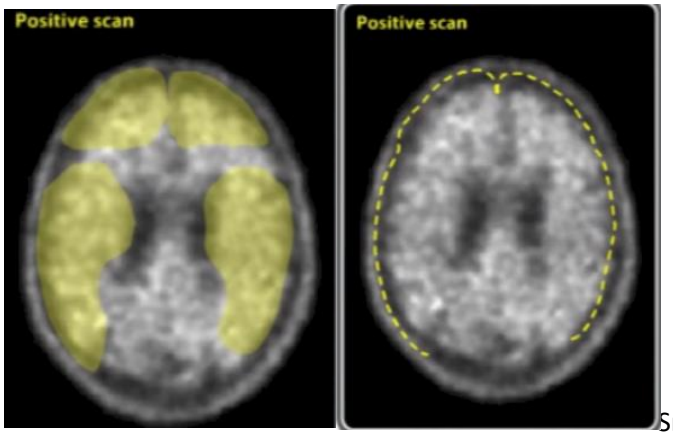
Strategy 2d

In slices involving the frontal and lateral temporal lobes in a positive (abnormal) scan, note the "blossomed" or "plumped" appearance of the frontal lobe in the presence of cortical uptake extending out to the cortical rim and the filled-in appearance of the lateral temporal lobe with smooth delineation of the cortical margin.





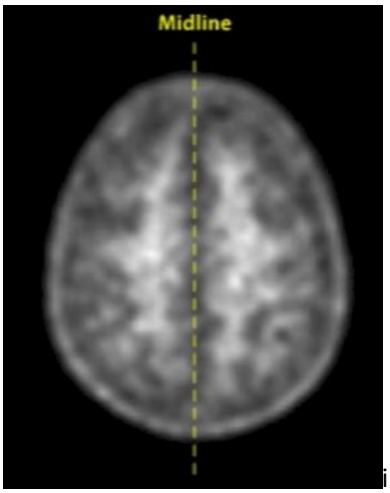
+ scan, spiky appearance is not seen 

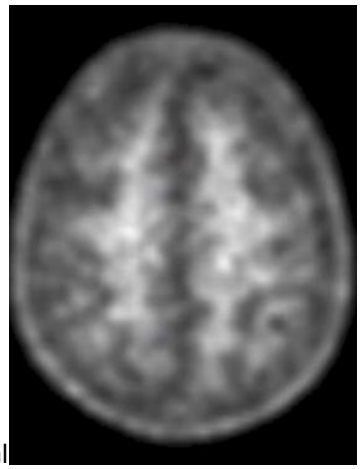
But rather the frontal lobe appears plump or blossomed and temporal lobe is filled in with no mountainous or skeletal appearance 

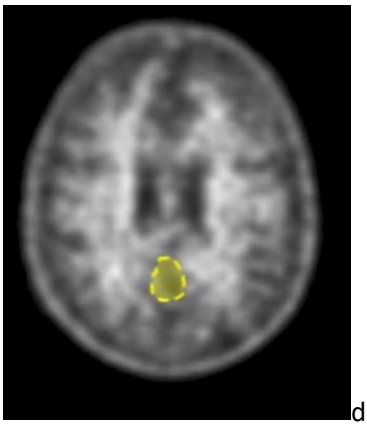
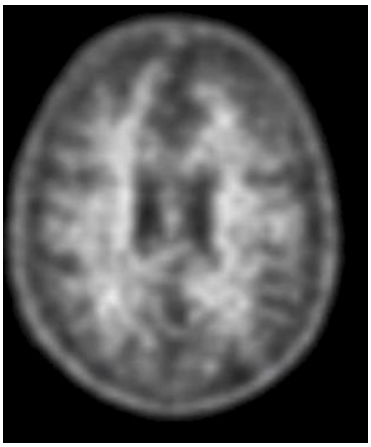
Smooth delineation of the cortical edge or rim (differentiation between WM and GM is not possible or barely discernable)

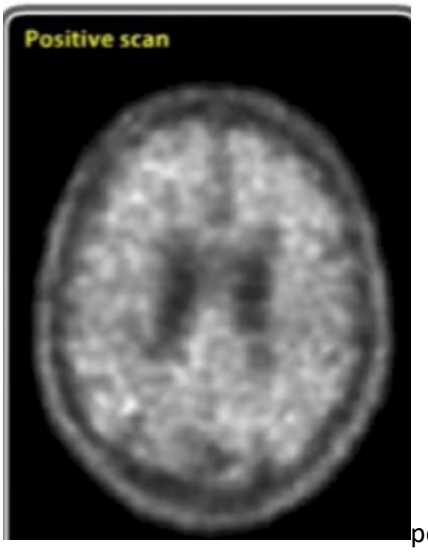
Strategy 2e

In the parietal lobe, just superior to the ventricles, observe whether the midline between hemispheres is clearly visible. Also see whether the posterior cingulate region imposes as a hypo-intense hole along the lower midline. In the presence of tracer uptake, both areas "fill up" and are not or are barely discernible.



is the midline between ventricles clearly visible? Normal 


does the post cing look like a dark hole, 



positive scan: post cing/midline fills up; and uptake extends out to cortical margin

Rule 3

Take a visual step back and see if your regional scoring matches your overall impression of the scan. If not, go back through each region again to take another systematic look.

Review

Rule 1:

- View the brain systematically, starting from the cerebellum and scrolling up through the transaxial slices (lateral temporal and frontal lobes, posterior cingulate/precuneus region, and the parietal lobe)

Rule 2:

- Always compare the signal intensity present in cortical gray matter with that in adjacent white matter (if visible)
  - Strategy 2a: Compare the region(s) of maximum signal intensity in the white matter—this is the "target" signal intensity for comparison with cerebral cortex
  - Strategy 2b: Identify regions that "anatomically" always correspond to white matter structures (eg, the splenium)
  - Strategy 2c: In the frontal lobe note the spiculated ("spiky"), irregular appearance of the white matter and the mountainous white matter "skeleton" in the lateral temporal lobe in the absence of cortical tracer uptake
  - Strategy 2d: In slices involving the frontal and lateral temporal lobes in a positive (abnormal) scan, note the "blossomed" or "plumped" appearance of the frontal lobe in the presence of cortical uptake extending out to the cortical rim and the filled-in appearance of the lateral temporal lobe with smooth delineation of the cortical margin
  - Strategy 2e: In the parietal lobe, just superior to the ventricles, observe whether the midline between hemispheres is clearly visible. Also observe whether the posterior cingulate region imposes as a hypo-intense hole along the lower midline. In the presence of tracer uptake, both areas "fill up" and are not or are barely discernible

Rule 3:

- After completing the regional assessment, take a "visual step back" and see if the regional scoring matches your overall impression—if not, take another "systematic look"

Step 1:

Make a technical assessment

- Rate overall technical quality of the images, eg, check for artifacts, positioning problems

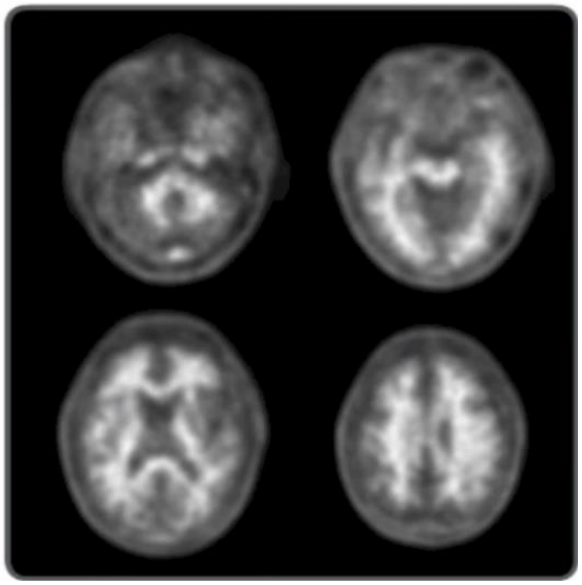
Step 2:

Systematically score each region

Step 3:

Provide an overall rating

- Presence or absence of uptake consistent with β-amyloid deposition



Step 2 systematic scoring: use the RCTU (Regional Cortical Tracer Uptake) score

RCTU Score		Condition for Assessment
1	No tracer uptake	Tracer uptake (signal intensity) in gray matter in the region is lower than in white matter.
2	Moderate tracer uptake	Smaller area(s) of tracer uptake equal to or higher than that present in white matter: • Extending beyond the white matter rim to the outer cortical margin • Involving the majority of the slices within the respective region For a score of 2, the uptake may appear to be "patchy," which means it does not cover the entire transaxial diameter.
3	Pronounced tracer uptake	At least one confluent area of pronounced tracer uptake equal to or higher than that present in white matter: • Extending beyond the white matter rim to the outer cortical margin • Involving the majority of the slices within the respective region

RCTU 1: When making this comparison, compare to maximum target intensity of white matter

RCTU 2: Smaller areas of uptake in the GM (not involving the entire transaxial diameter) $\geq$ WM

RCTU 3: With regard to tracer uptake, confluent means involving all or most of the region in the transaxial plane and the majority of the transaxial slices of that region

After you do RCTU, give subject level assessment scoring Brain Amyloid Plaque Load (BAPL)

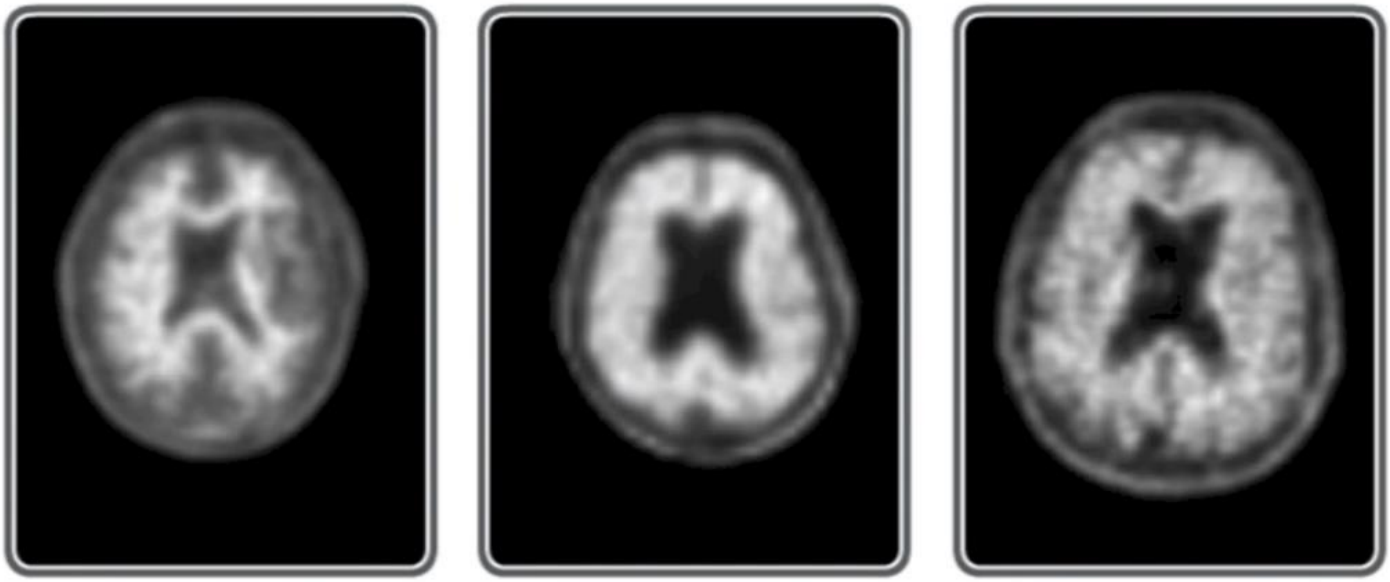
BAPL Score		Rule for Assessment
1	Scan without β-amyloid deposition	RCTU score 1 in each of the 4 brain regions 1, 2, 3, and 4
2	Scan with moderate β-amyloid deposition	RCTU score 2 in any or all of the 4 brain regions 1, 2, 3, and 4 and no score 3 in these 4 regions
3	Scan with significant β-amyloid deposition	RCTU score 3 in at least one of the brain regions 1, 2, 3, and 4

Remember that the BAPL score is derived from the RCTU scores.

BAPL 1: No amyloid deposition: RCTU is 1 in all 4 brain regions

BAPL 2: Moderate amyloid; RCTU 2 in at least 1 of the 4 brain regions & no 3 anywhere

BAPL 3: Significant amyloid; RCTU 3 in at least 1 region



BAPL 1 BAPL 3 BAPL 2

BAPL 1

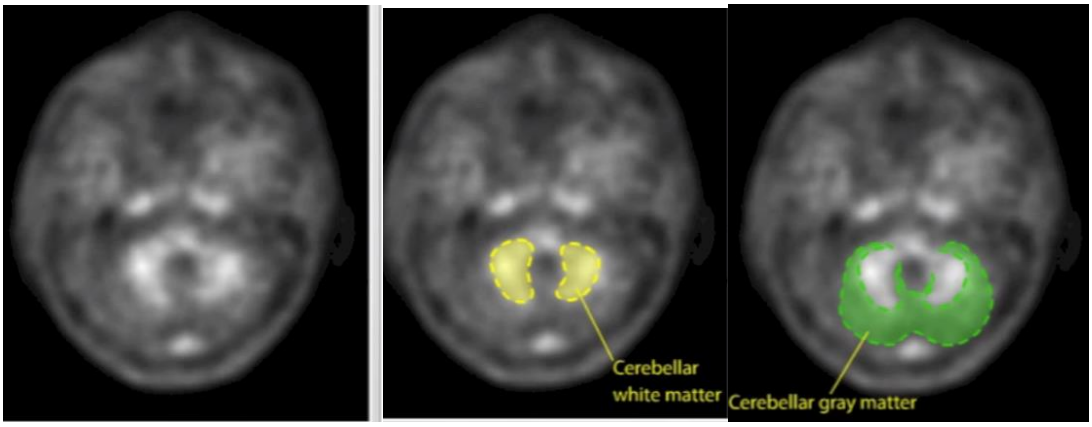
Visual Representation of BAPL 1

RCTU 1

- Tracer uptake (signal intensity) in gray matter in the region is lower than in white matter

BAPL 1

- Scan without β-amyloid deposition
- RCTU score 1 in each of the 4 brain regions 1, 2, 3, and 4



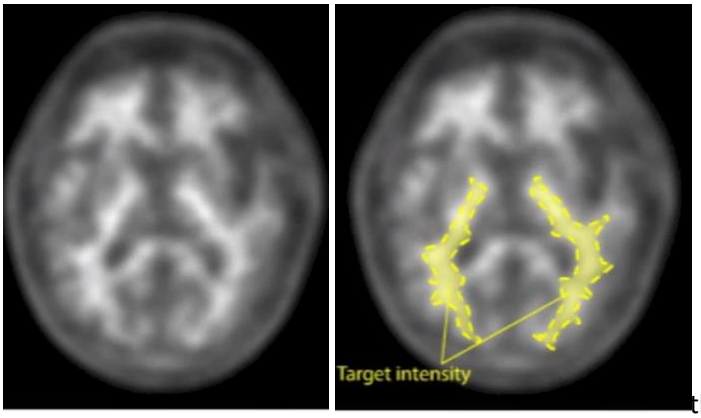
Note the intensity of the white matter, this is your target signal intensity that should be noted when going through the 4 regions

Note if one side is coming in first (pt is wonky in the scanner)-symmetry of the scan

Note how many slices the lateral temporal lobe involves; and particularly important to analyze the lobes separately from one another because they do overlap in this scan

They talk a lot about landmarks on the video; knowing where things are (didn't include here)

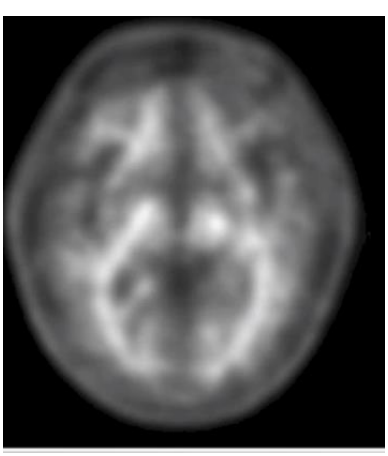
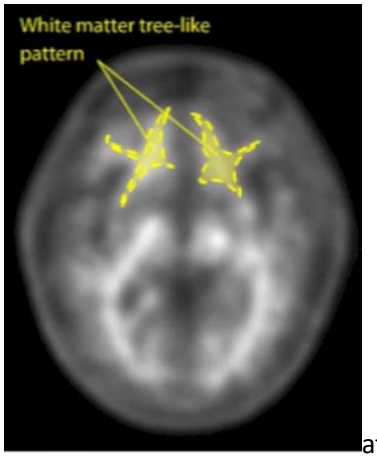
Lateral temporal lobes: RTCU 1



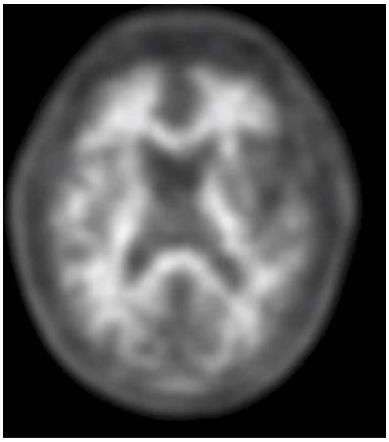
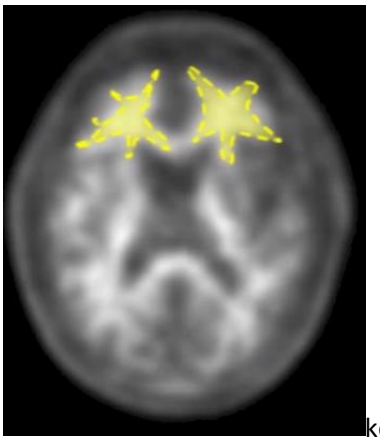
there is solely a WM pattern and this target intensity in the lateral temporal lobe does not extend out to the cortical margin-RCTU 1

Frontal lobe: RTCU 1

Talking about all the landmarks for the frontal lobes: scroll up from cerellum, start to see basal frontal lobes at level of orbits and keep going up; scroll entirely through the frontal lobes

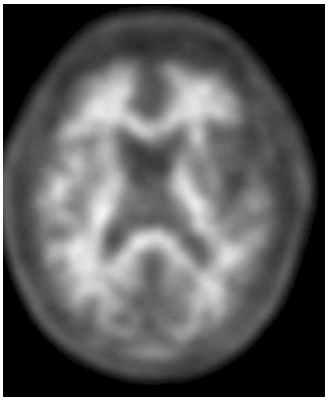
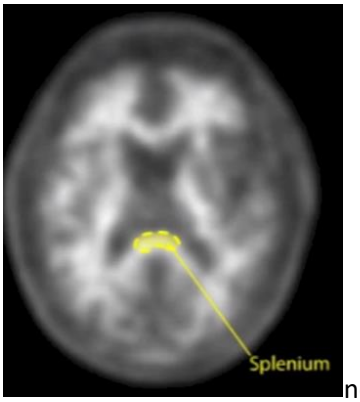
at frontal basal area, you see WM tree like pattern



keep seeing trees up to and including mid ventrical level

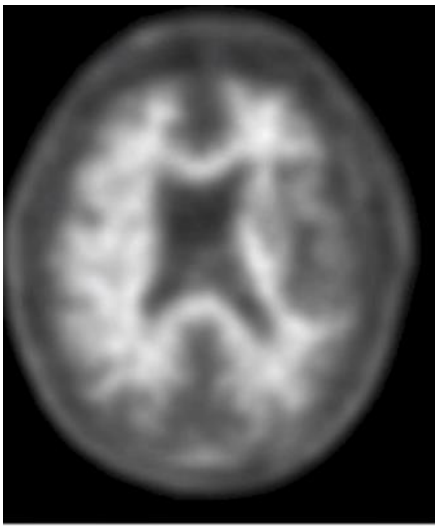
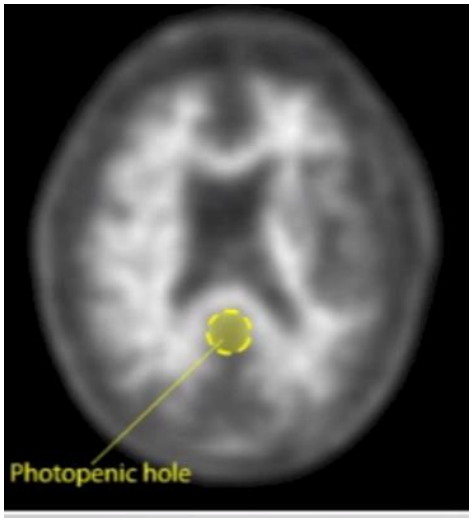
Target intensity does not extend out to cortical margin

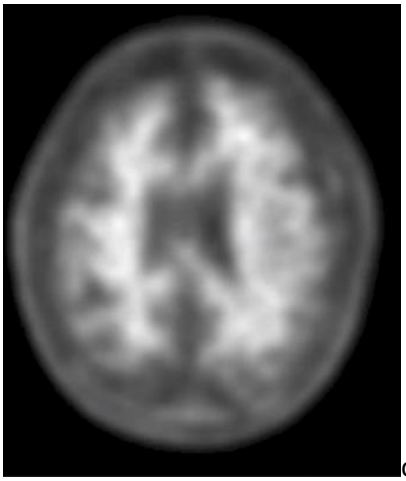
Frontal lobe = RTCU 1

Posterior cingulate/precuneus: starts at level of splenium; in this case RTCU 1

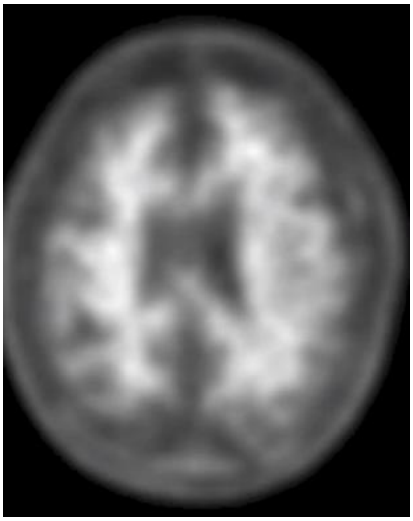
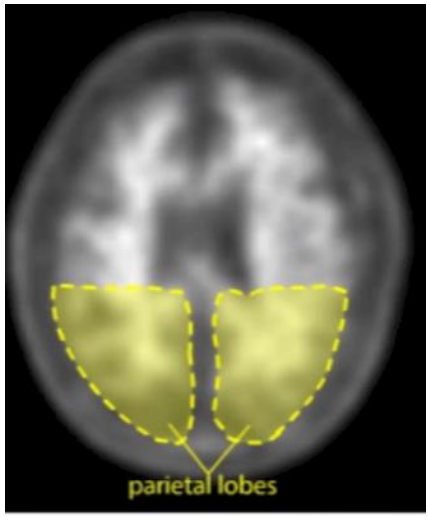



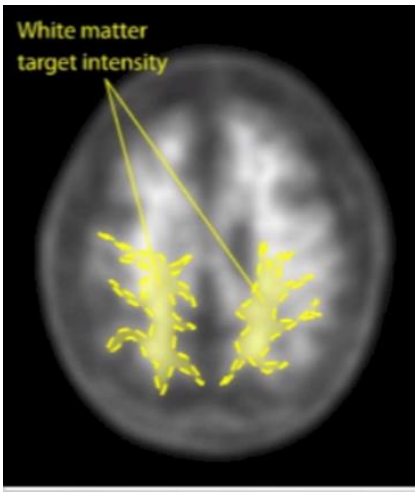
notice target intensity at splenium; this is your target intensity for this level of the scan; intensity does not extend beyond the WM boundary

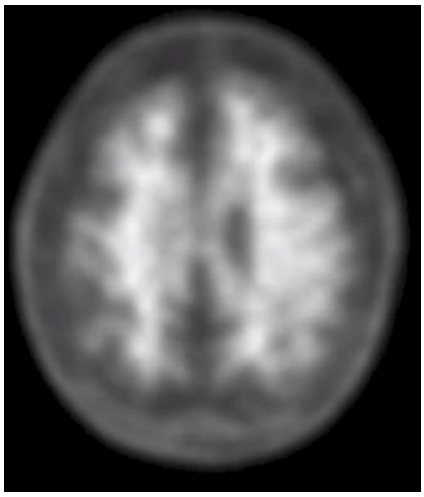

photopenic hole 


continue to scroll up thru all regions comprising this region, notice the hole does not fill up -> indicating absence of cortical tracer uptake = RCTU 1

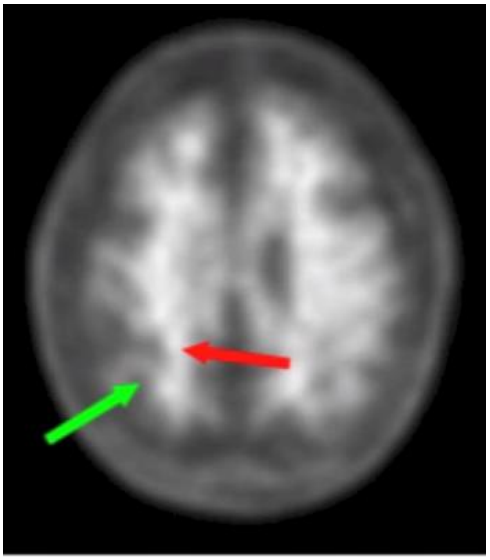
Parietal region: RTCU 1

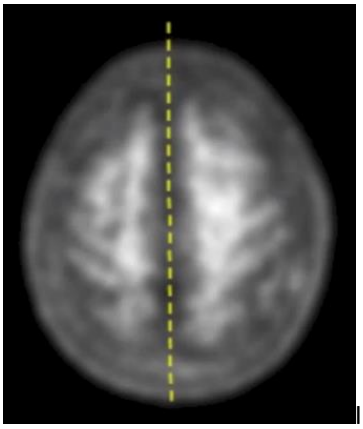
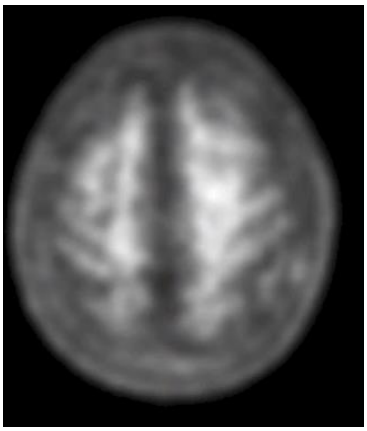







Continue up in the parietal lobe:


Notice WM mountain (red arrow) and ratty appearance of the cortex that is free of tracer (green arrow)


Interhemispheric line 
would be barely or not discernible in the presence of tracer uptake

RTCU 1 in lat temp, frontal, post cing/precuneus & parietal = BAPL 1 (all regions have RCTU no higher than 1)

BAPL 3

Visual Representation of BAPL 3

RCTU 3

- At least one confluent area (either in the transaxial or AP-direction) of uptake equal to or higher than that present in white matter
- Extension beyond the white matter rim to the outer cortical margin
- Involvement of all or most of the region, including the majority of slices within that respective region

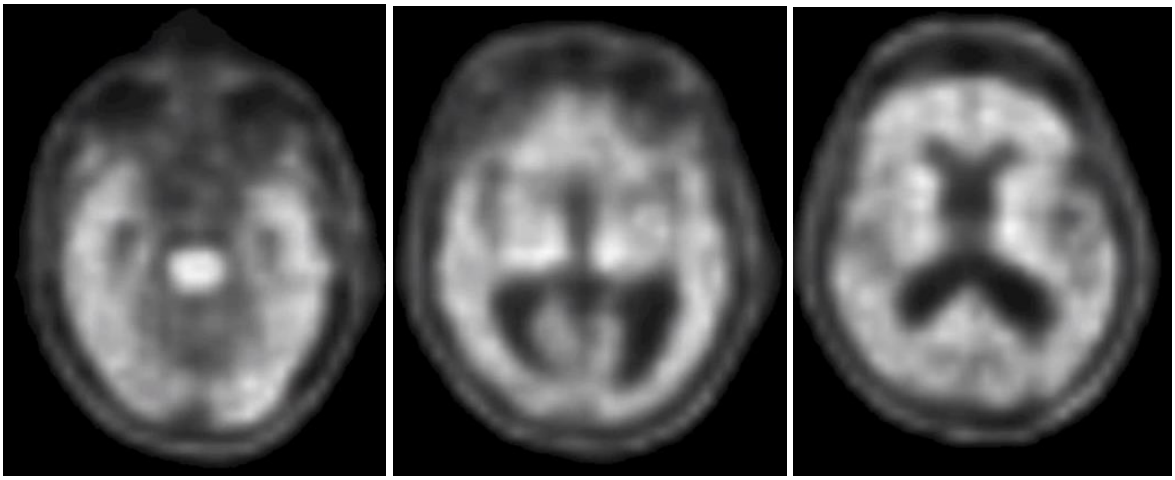
BAPL 3

- Scan with pronounced β-amyloid deposition
- RCTU score 3 in at least one of the brain regions 1, 2, 3, and 4

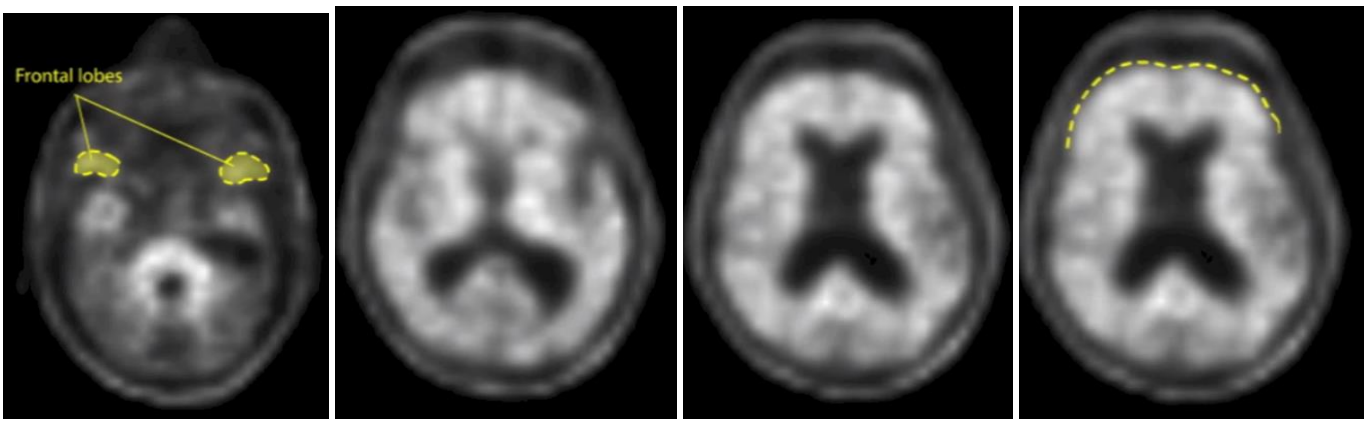
Always start at cerebellum; see target signal intensity and go up

Can't discern WM pattern; can't determine which is WM and which is GM

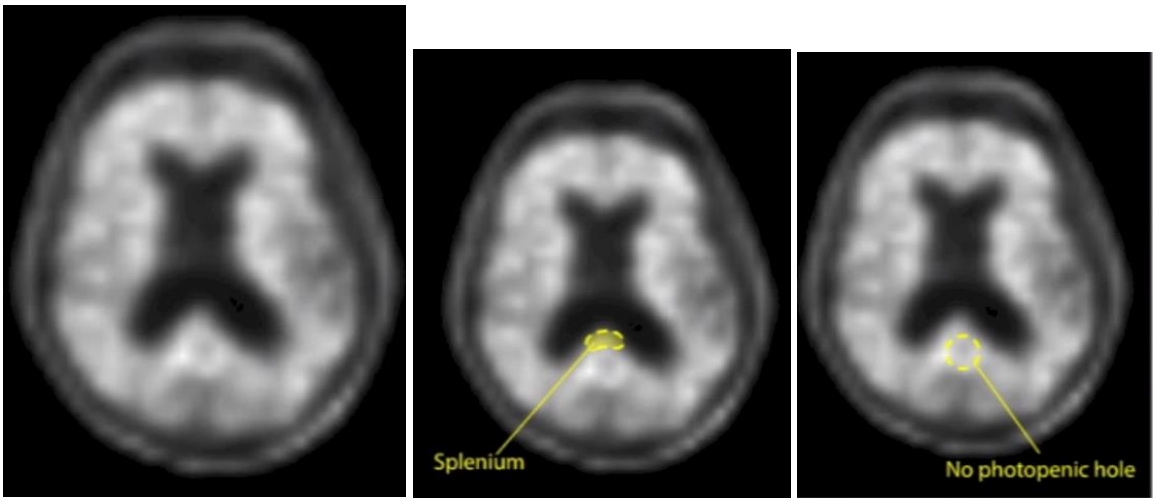
Lateral temporal here is RCTU 3; throughout lateral temp lobe, can't discern WM pattern



Frontal lobe: RCTU 3: throughout frontal lobe, no discernible WM pattern; max intensity WM extends to cortical margin

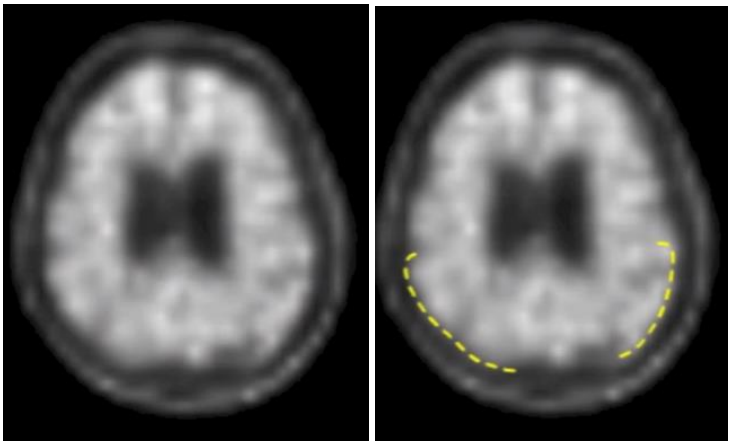


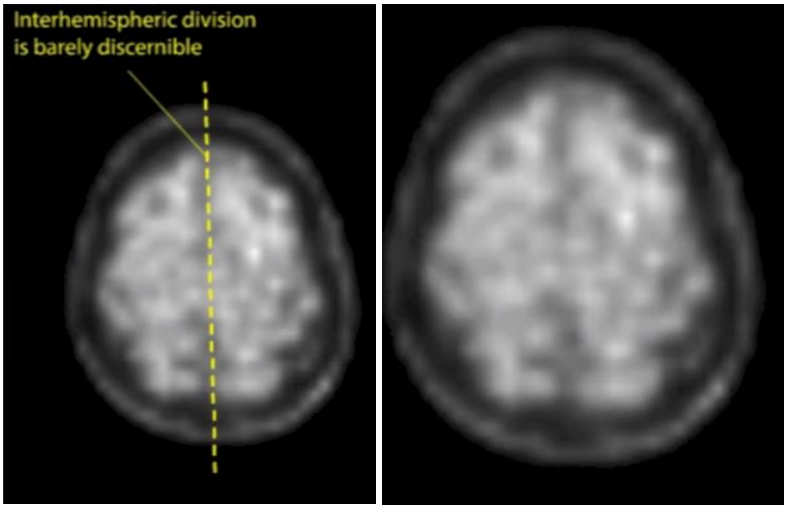
Post cing/precuneus: see splenium and no photopenic hole; RCTU 3



Parietal region: RCTU 3

No WM mountain appearance; not differentiate WM from GM on any of the slices


max intensity WM extends to cortical margin;



All 3 (4??) regions are RCTU 3-> BAPL of 3; even if only 1 region was a RCTU 3, the whole scan would be a BAPL 3

BAPL 2

Visual Representation of BAPL 2

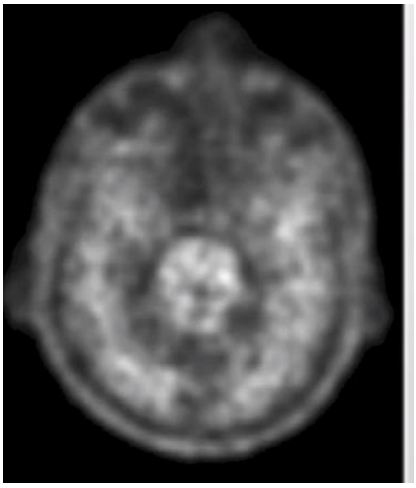
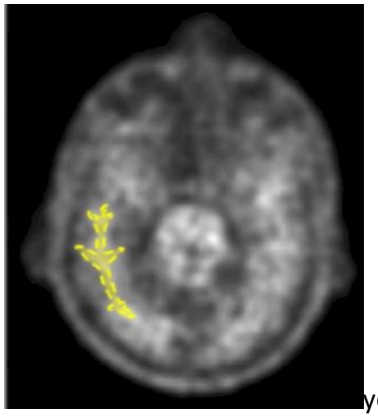
RCTU 2

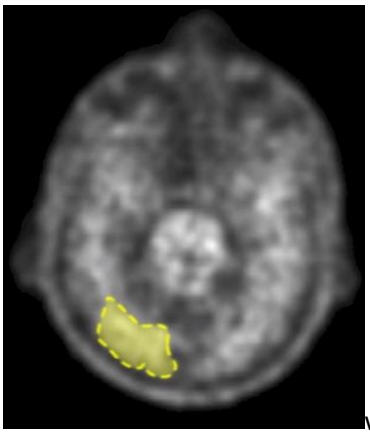
- Smaller area(s) of uptake equal to or higher than that present in white matter; may be "patchy"
- Extension beyond the white matter rim to the outer cortical margin
- Involvement of the majority of the slices within the respective region

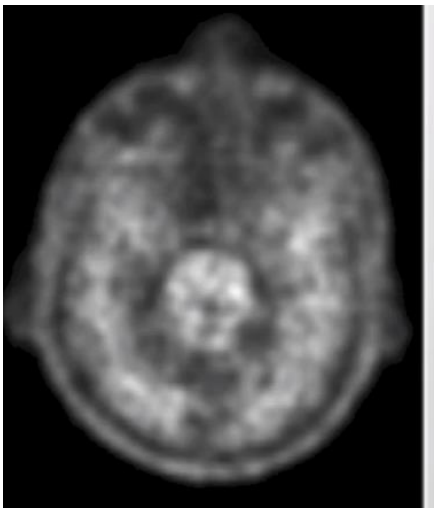
BAPL 2

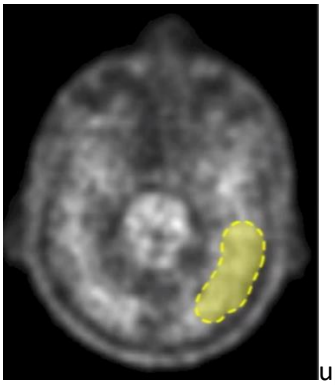
- Scan with moderate β-amyloid deposition
- RCTU score 2 in any or all of the 4 brain regions 1, 2, 3, and 4 and no score 3 in these 4 regions

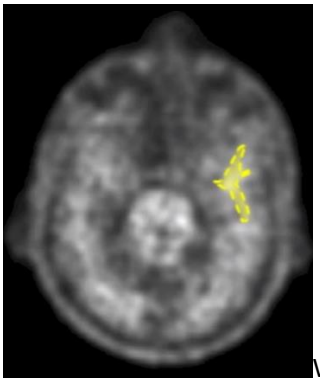
Start at cerebellum; use cerebellar WM as target intensity as you go through the study



you do have a WM pattern BUT

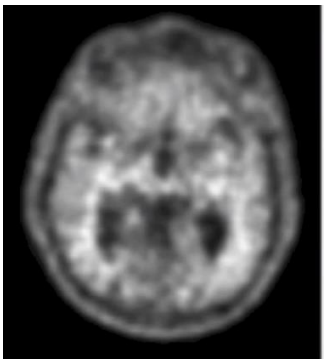

when you look lower, it looks like uptake extends to the cortical margin=RCTU 2 (smaller area of uptake = to or higher than what is present in the WM but it may be patchy)

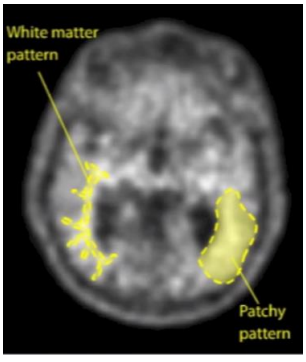

Lateral temporal lobe on the contralateral side of the original image: RCTU 2


uptake appears patchy with less of a clear WM pattern & a little more diffuse uptake BUT

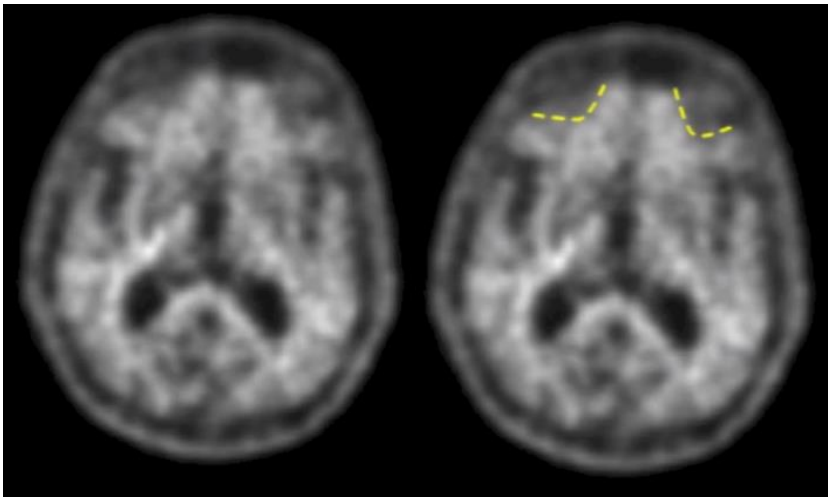

WM pattern anteriorly

More superiorly in lateral temp lobes: still see patchy pattern; not a pure WM pattern; lot of uptake extending to edge of cortex but not always

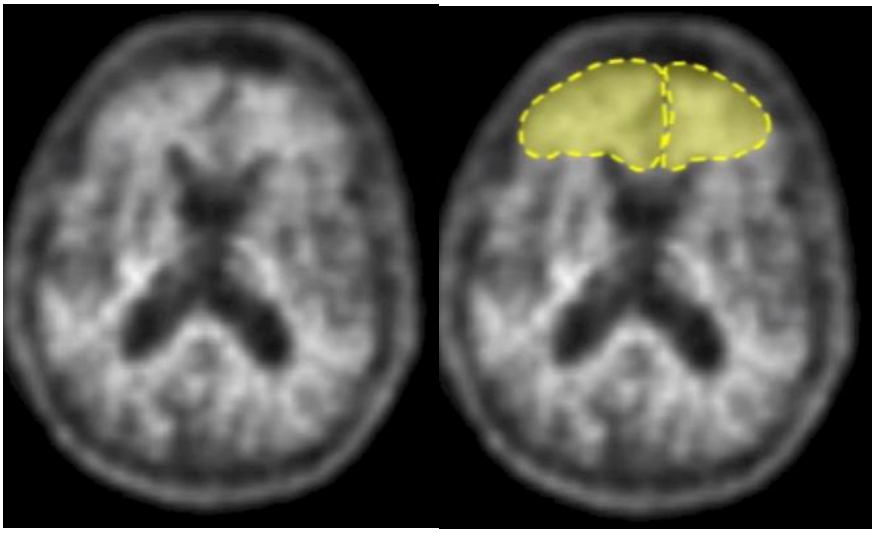




Up higher, you see a divet which you expect to see with a more WM pattern but it's not a clear WM pattern

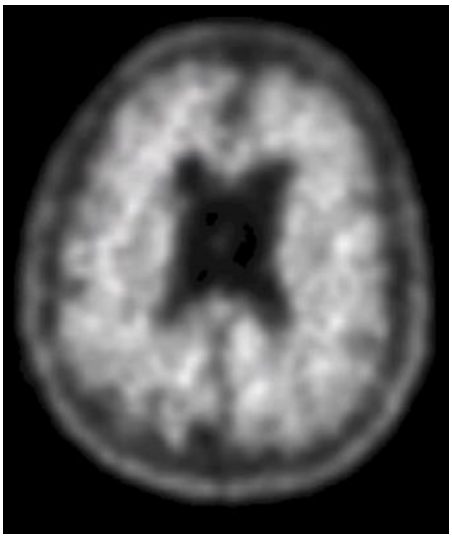


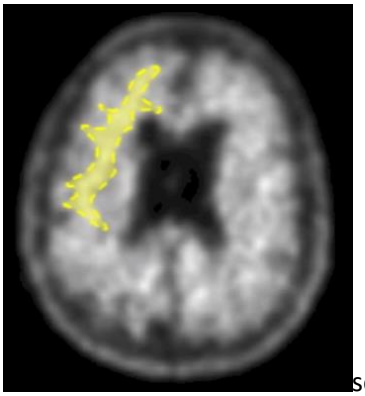
Keep going up: patchy but there is extension out to cortical edge in frontal lobes



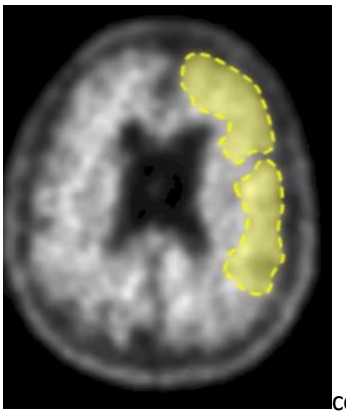
Note whole frontal lobe that's involved with extensive confluent uptake involving both WM and GM; instead it's just a portion of the region that shows that extension out to the cortical margin = RCTU 2

Up to level of mid ventricle



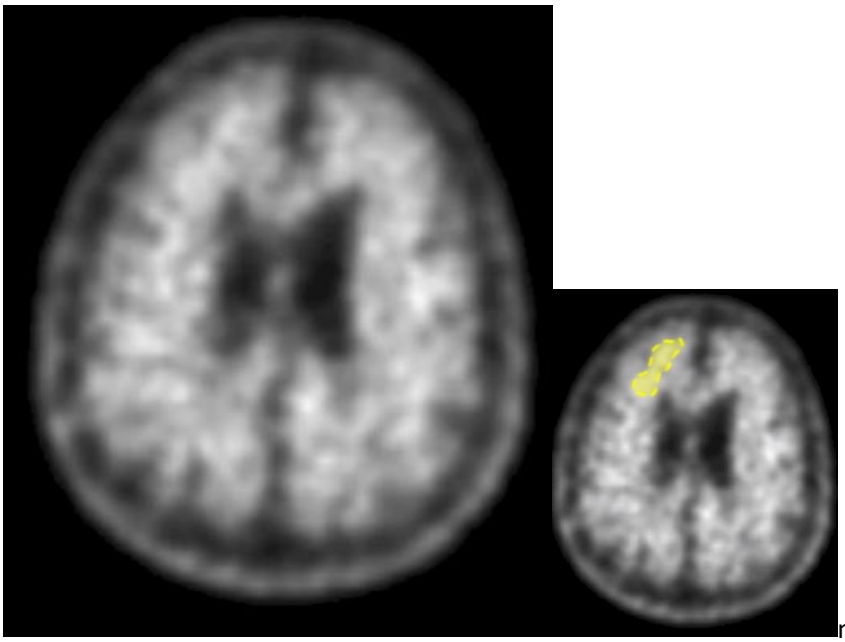


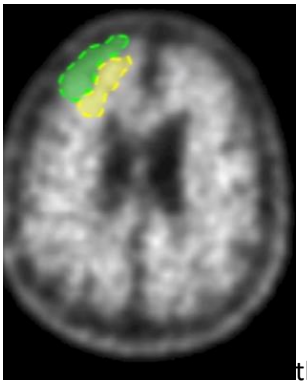
see more intense uptake here that is WM

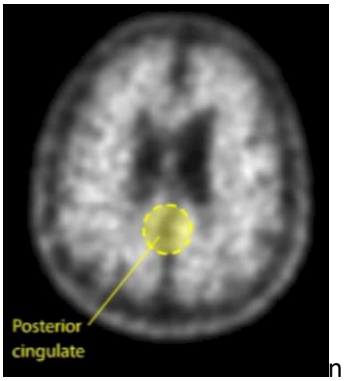


compared to the other side where there is equal intensity in the WM and GM

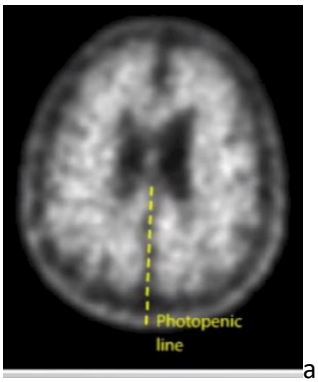
*key point when assigning 2: these are really subtle differences; BAPL 2 is not straightforward to identify as a BAPL 1 or BAPL 3


more intensity in this yellow highlighted area


than in this green area; translates into patchy uptake; also see posterior cingulate region

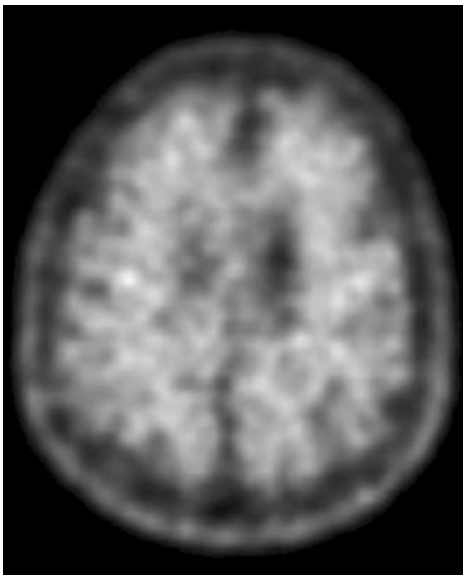


notice you don't see the donut hole that you'd expect to see with RTCU 1; but doesn't fill in like an RTCU 3



also see the photopenic line between the 2 hemispheres

Going up higher; the difficulty with this scan is seeing the heterogeneity in uptake: it's not purely a WM pattern, but rather it's a patchy pattern of extension



Overall this is a BAPL2 and a positive scan; in this scan you don't see a pure WM scan of uptake, instead there's a patchy pattern of uptake that extends to the margin that you see on each axial slice but it also extends throughout the volume of that region

Rules for Making a Visual Assessment

- Follow these rules when reading florbetaben PET scans:
  - View the brain systematically, starting at the cerebellar level
  - Always compare the signal intensity present in cortical gray matter with that in the adjacent white matter (if visible)
  - Take a visual step back and see if your regional scoring matches your overall impression

Steps to Making a Visual Assessment

- Step 1: Make a technical assessment
  - Rate overall technical quality of the images, eg, check for artifacts, positioning problems
- Step 2: Systematically score each region
- Step 3: Provide an overall rating
  - Presence or absence of uptake consistent with β-amyloid deposition

RCTU Scoring System

- The regional cortical tracer uptake (RCTU) scoring system for making a visual assessment of florbetaben PET scans
  - RCTU score 1: no cortical tracer uptake
  - RCTU score 2: moderate cortical tracer uptake
  - RCTU score 3: pronounced cortical tracer uptake

BAPL Scoring System

- The overall brain amyloid plaque load (BAPL) of florbetaben PET scans
  - BAPL score 1: scan without β-amyloid deposition
  - BAPL score 2: scan with moderate β-amyloid deposition
  - BAPL score 3: scan with pronounced β-amyloid deposition

Module 3, Part 2: Shows examples to reinforce what they taught; reviews challenging cases—Really need to review this video individually

Look for asymmetry, rotation

Rule: GM must be equal to or greater in intensity compared to WM

Smoothing filter?

Ventriculomegaly or atrophic changes do not affect the positivity of neuraceq pets

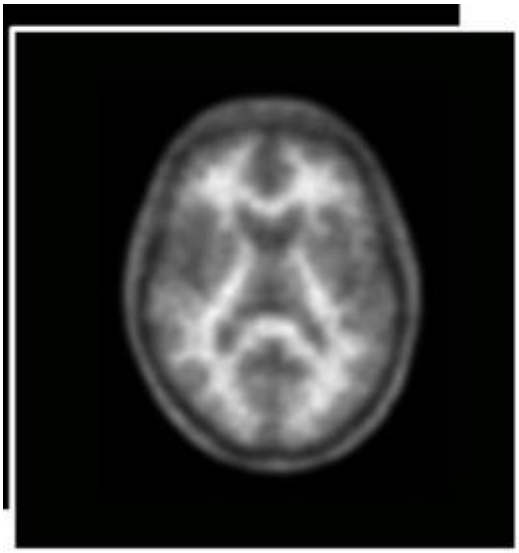
Even if a region is positive on one side only, the entire region should be scored as positive

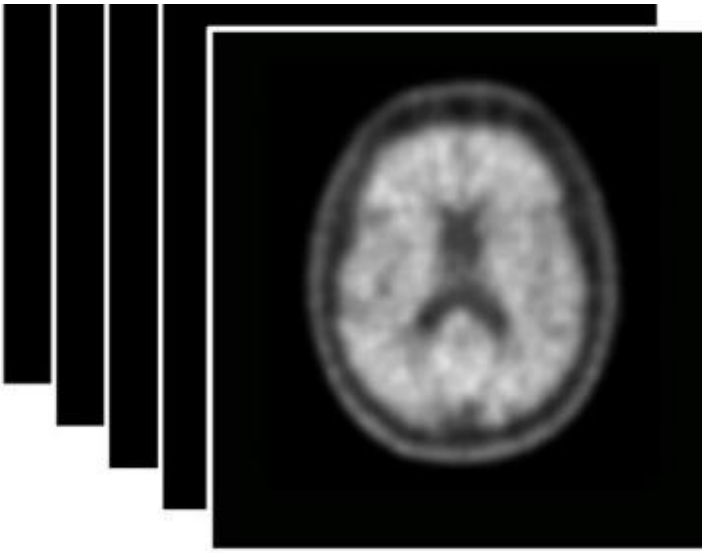
Gamma correction (windowing/thresholding) to enhance the contrast pattern of a scan

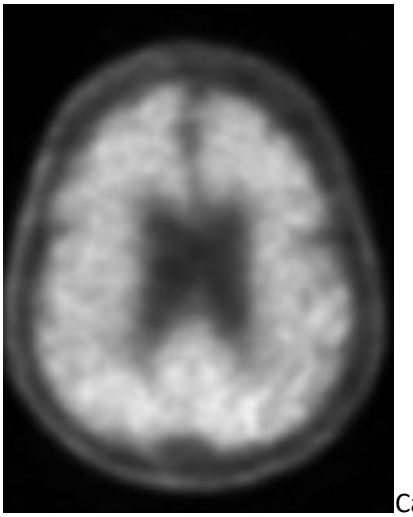
Rarely there are big differences between the region of interest on Neuraceq scans

Scalp will be thicker if there's motion

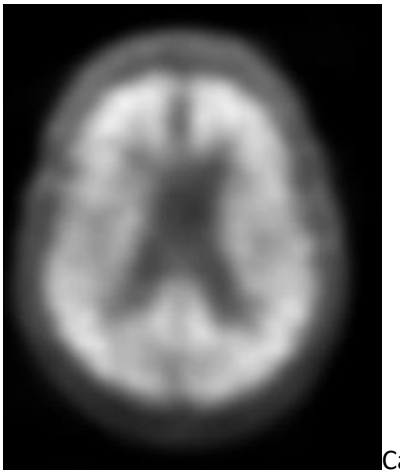
Test:



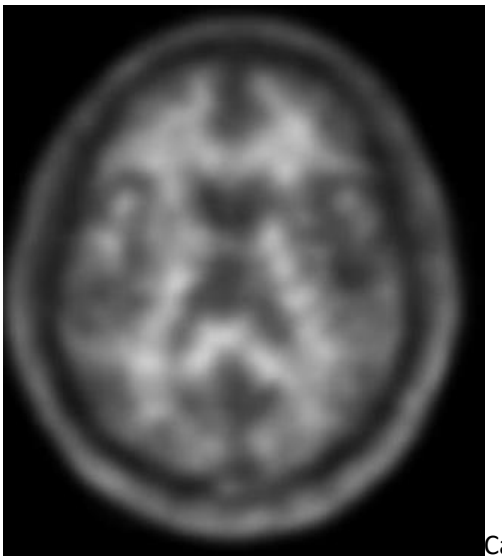


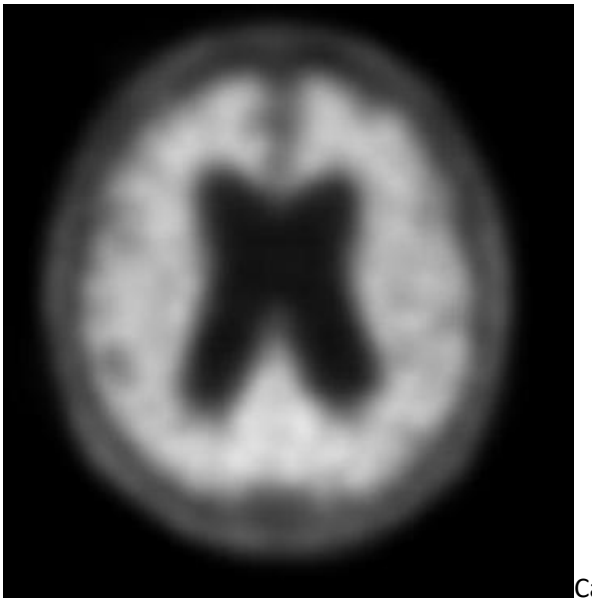


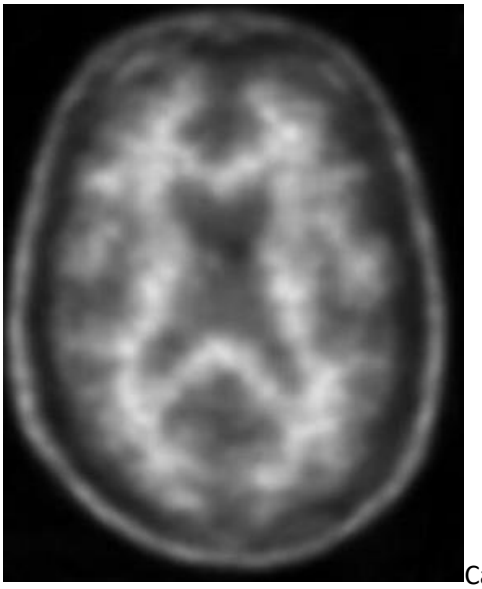
Case 1: Positive

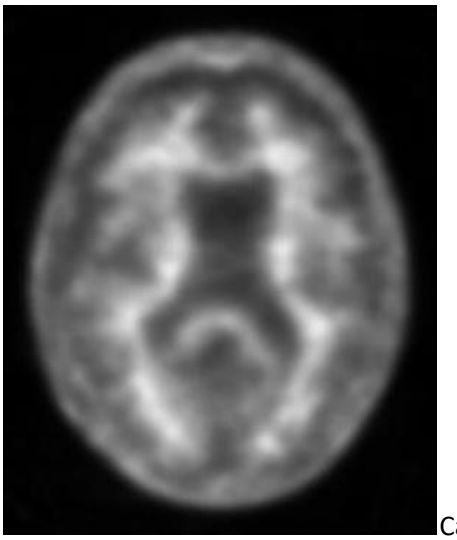


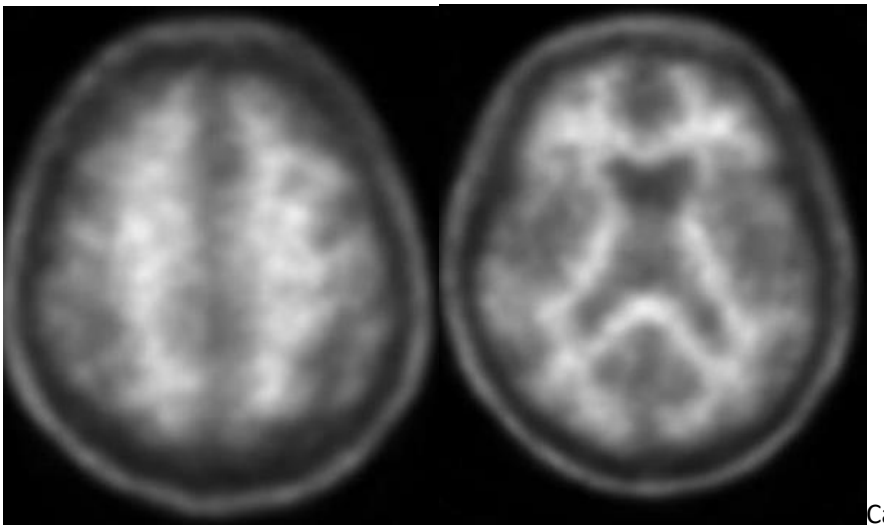
Case 2: Positive

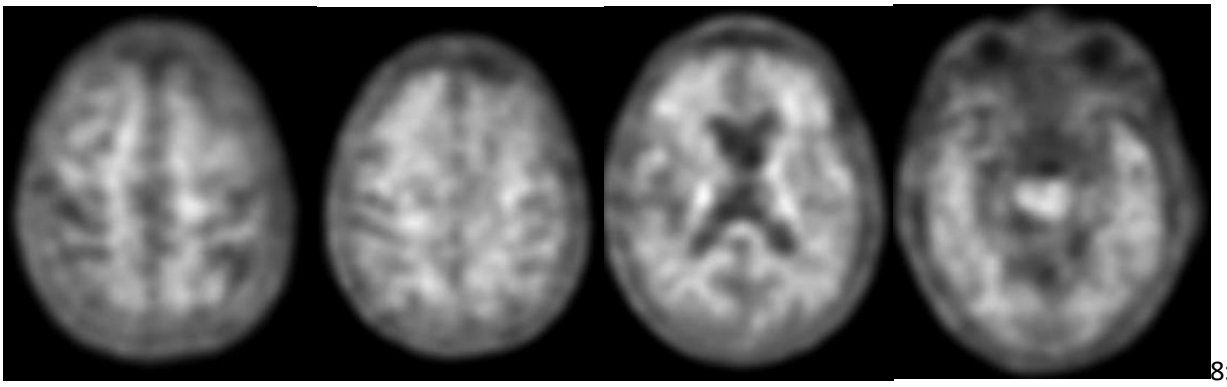

Case 3: Negative

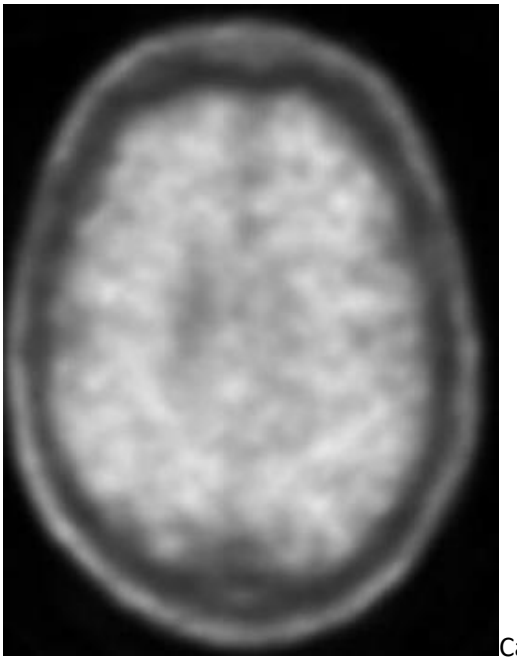

Case 4: Positive


Case 5: Negative

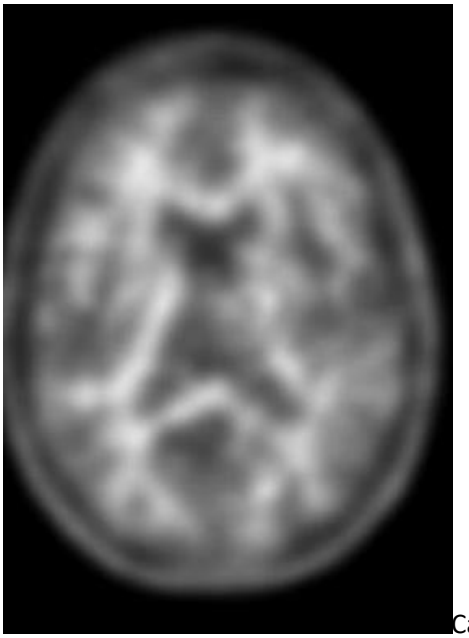

Case 6: Negative


Case 7: Negative

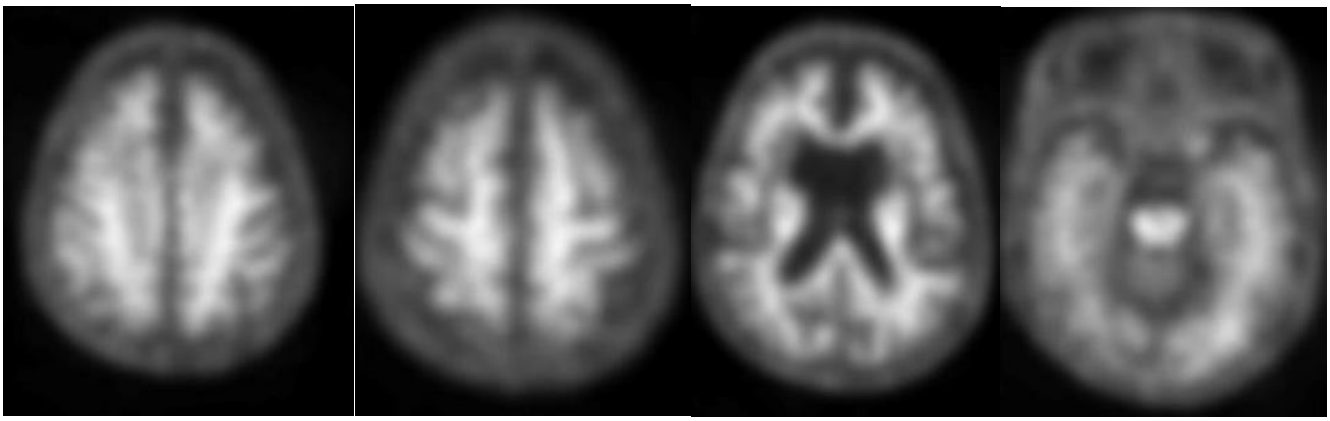

8: Positive



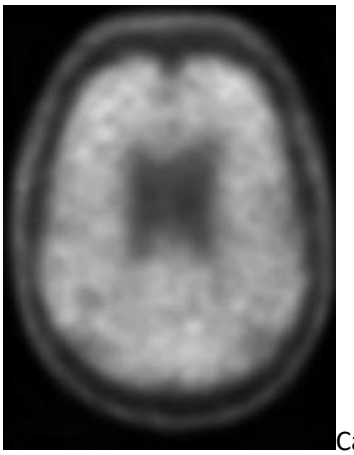
Case 9: Positive

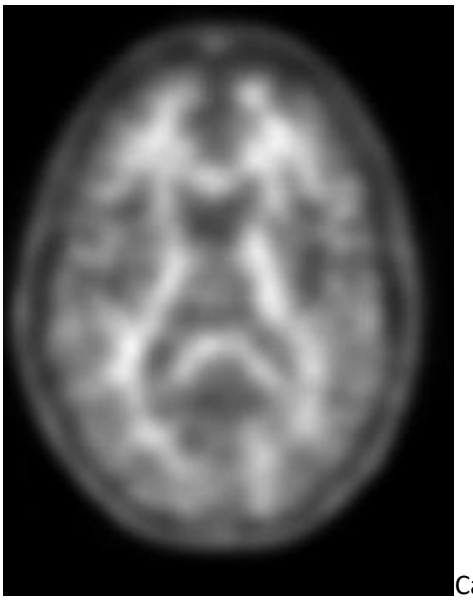


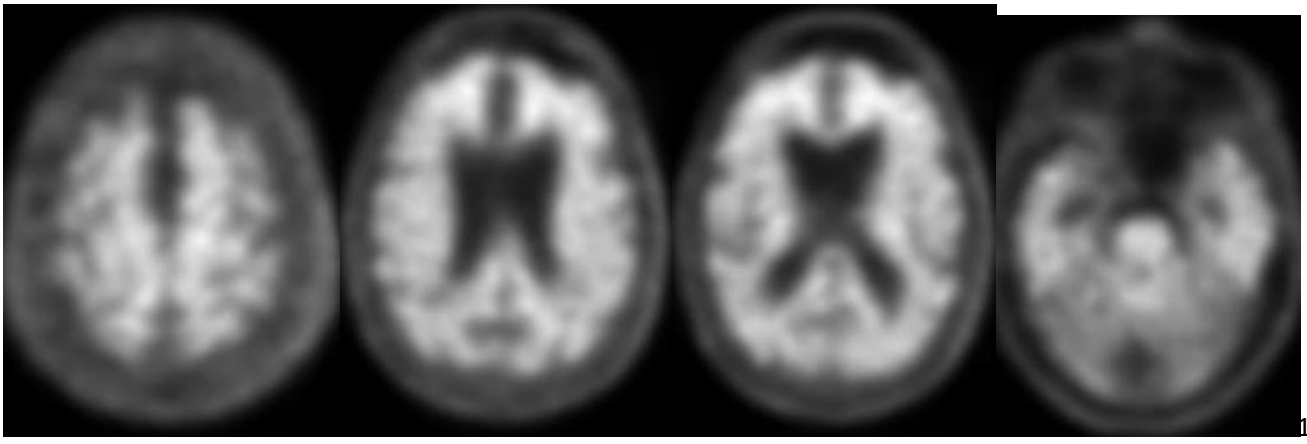
Case 10: Negative

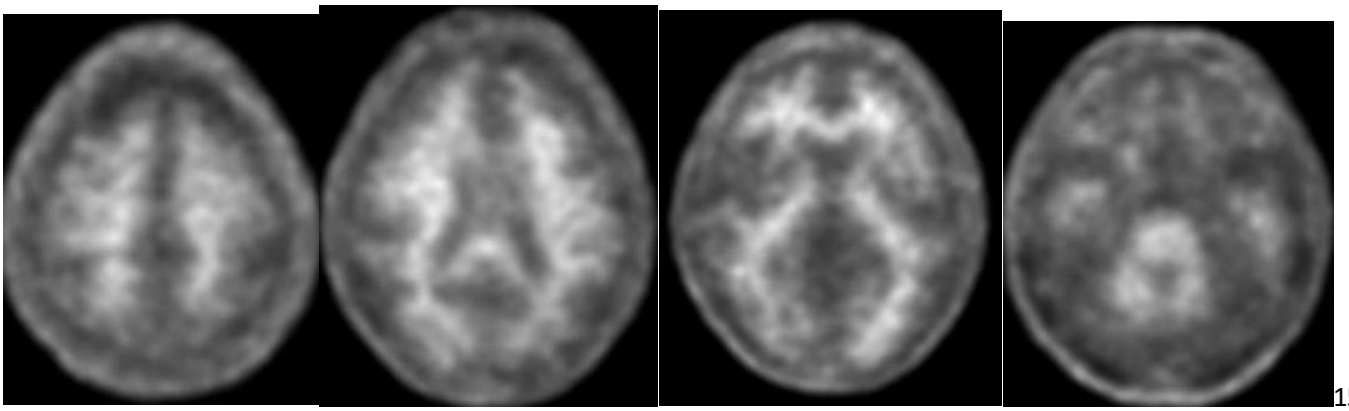


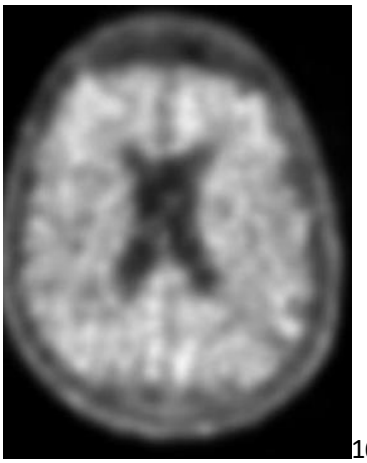
Case 11: I called this Positive but this is actually Negative

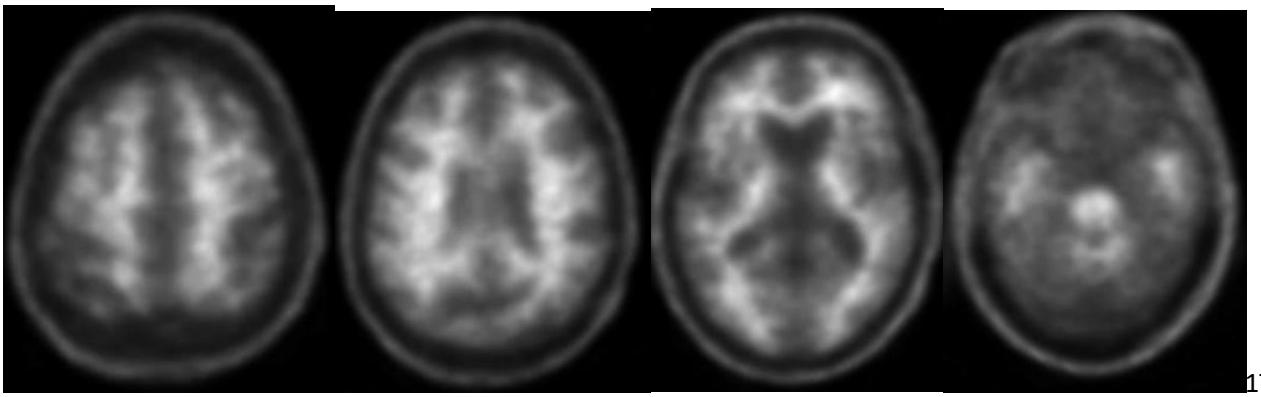

Case 12: Positive

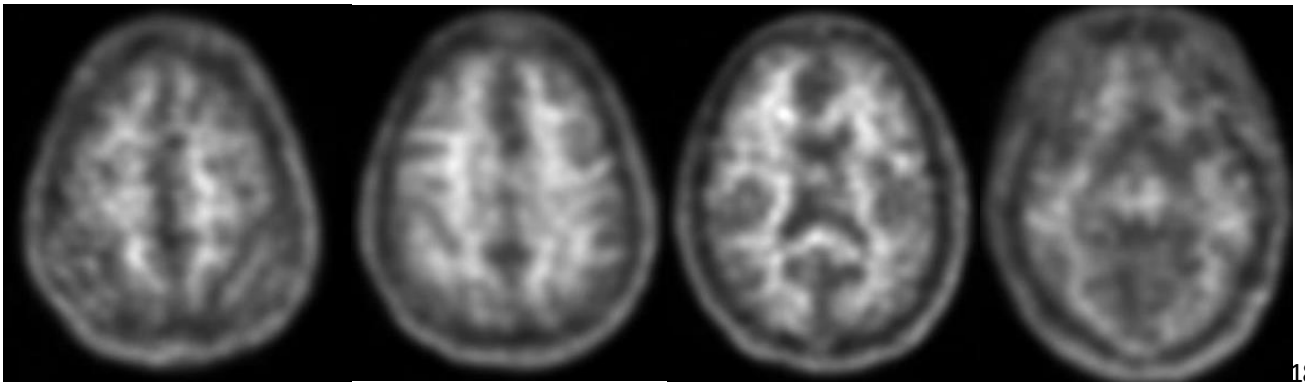

Case 13: Negative

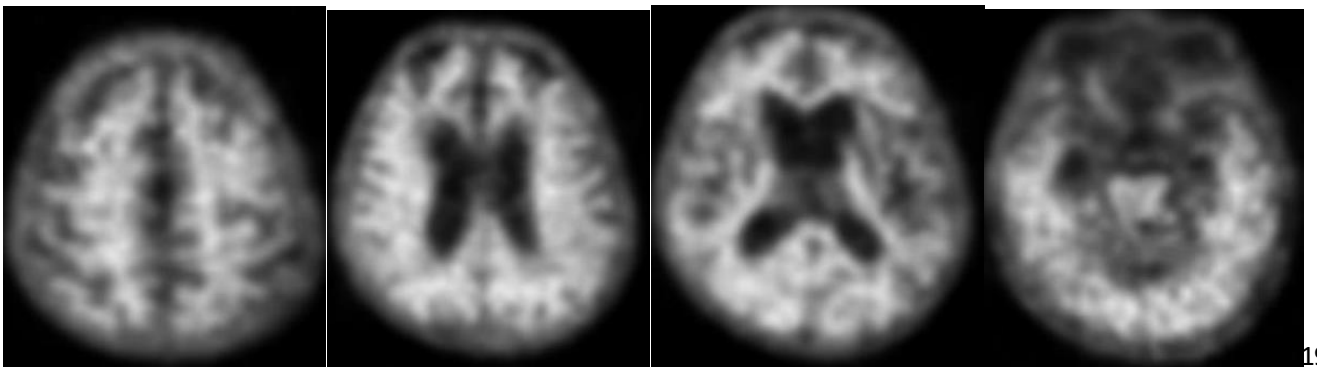

14: Positive

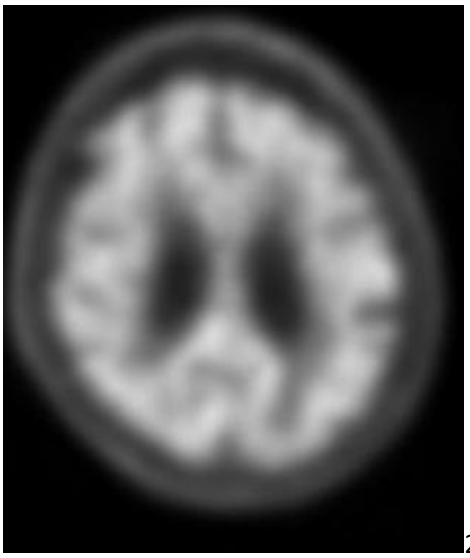

15: Neg


16: Positive


17: Negative


18: Negative


19: Positive


20: Positive