

CNS imaging techniques for neurocognitive impairment in HIV-infected patients

Review by

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Disclaimer

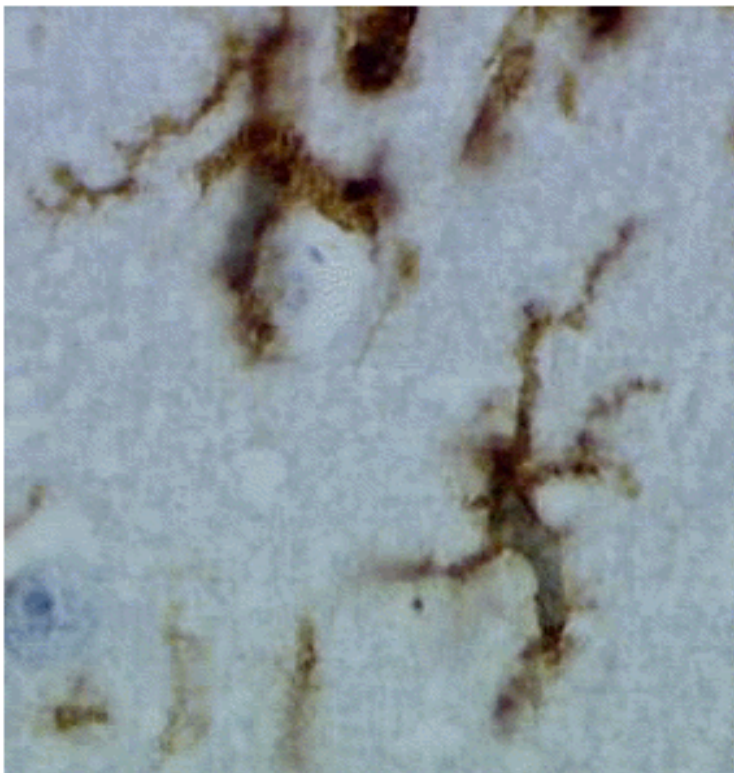
- Most of the material from this review has not been obtained by the author himself. The purpose of this talk is to give the audience at the 4th International Symposium on Psychiatry and HIV an idea of what imaging modalities are present, what are their fundamental differences and an overall idea of how much those modalities would cost if available.
- Although most of this material is scheduled to be presented, the final version may include changes.

Background

Long-term perinatally infected survivors of HIV now reaching adolescence and young adulthood

- Increased incidence neuropsychiatric and neurocognitive impairment compared to age and gender-matched cohort of HIV-exposed but uninfected
- Depression and other affective disorders
- Increased proportion c/o pain; under-recognized by caregivers
- Subset with progressive decrements in language, memory
- Impaired ability to learn new environments
- Decreased capacity independent life
- Clinically distinct from adult HIV neurocognitive impairment and dementia

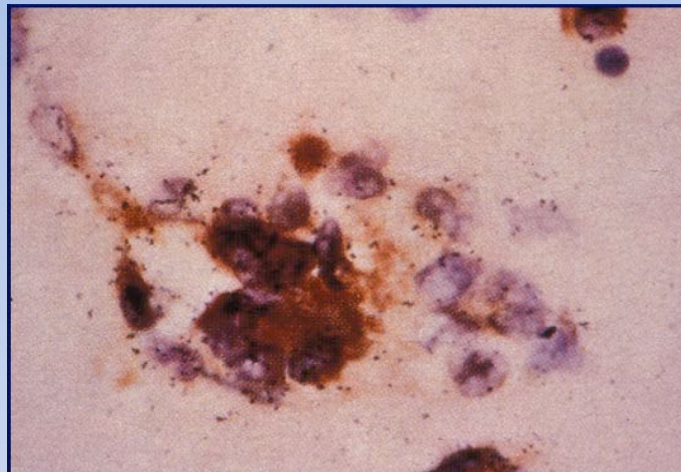
Microglia (brain macrophages)



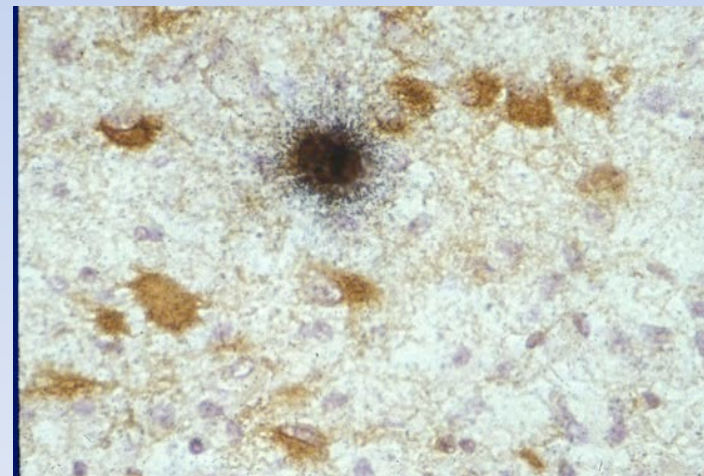
- Primary targets HIV in CNS (M-tropic)
- Monocytic origin: CD4 /CCR5 positive
- Primary site - productive new virus
- Source of multiple pro-inflammatory substances

Classic Neuropathology Pediatric HIV-1: A persistent and progressive challenge

Predominant: productive
infection of microglial
cells of monocytic
origin



Post-mortem in situ studies
pediatric brains: ~ 20%
subcortical astrocytes are
HIV-1 infected

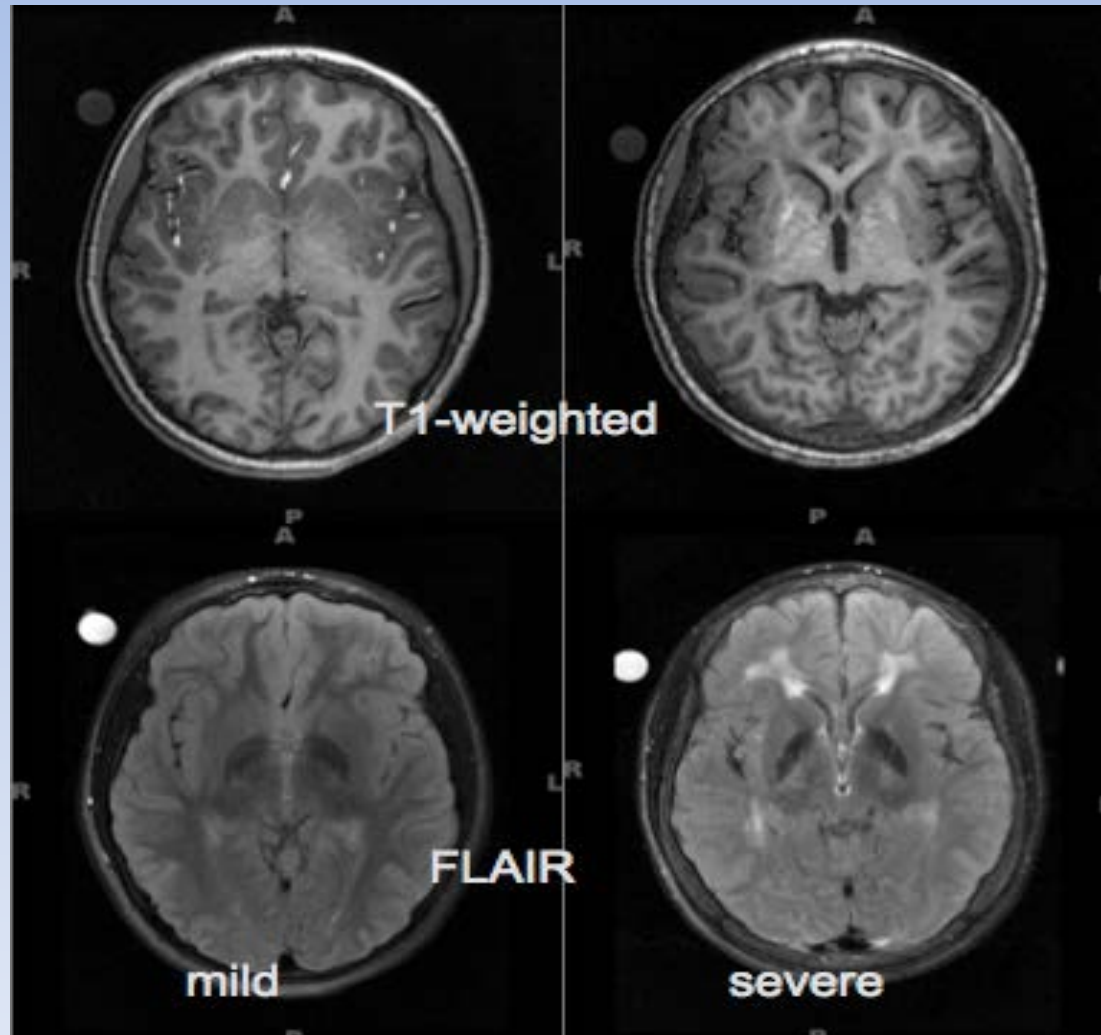


Structural MRI

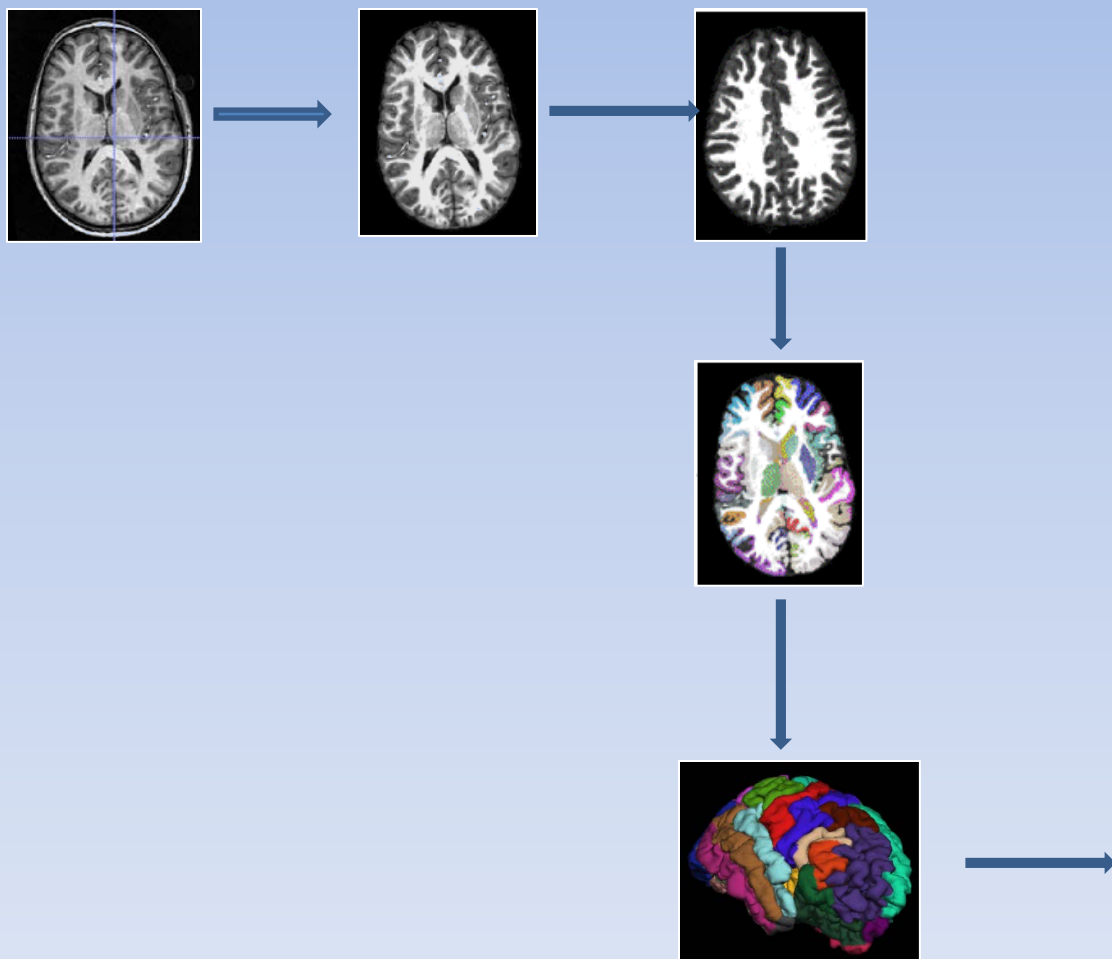
1. T1

2. T2

3. PD



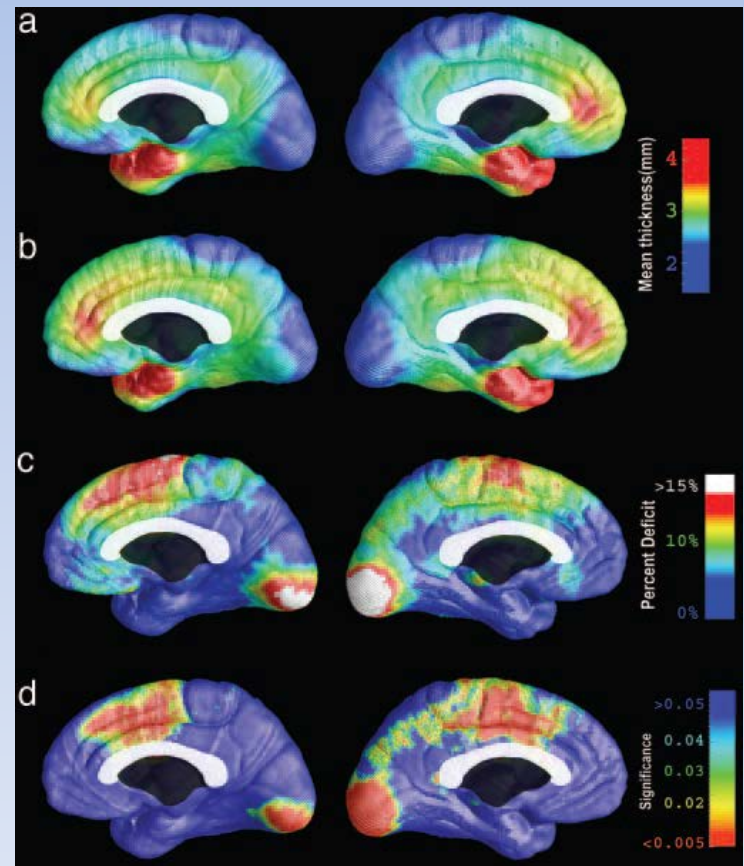
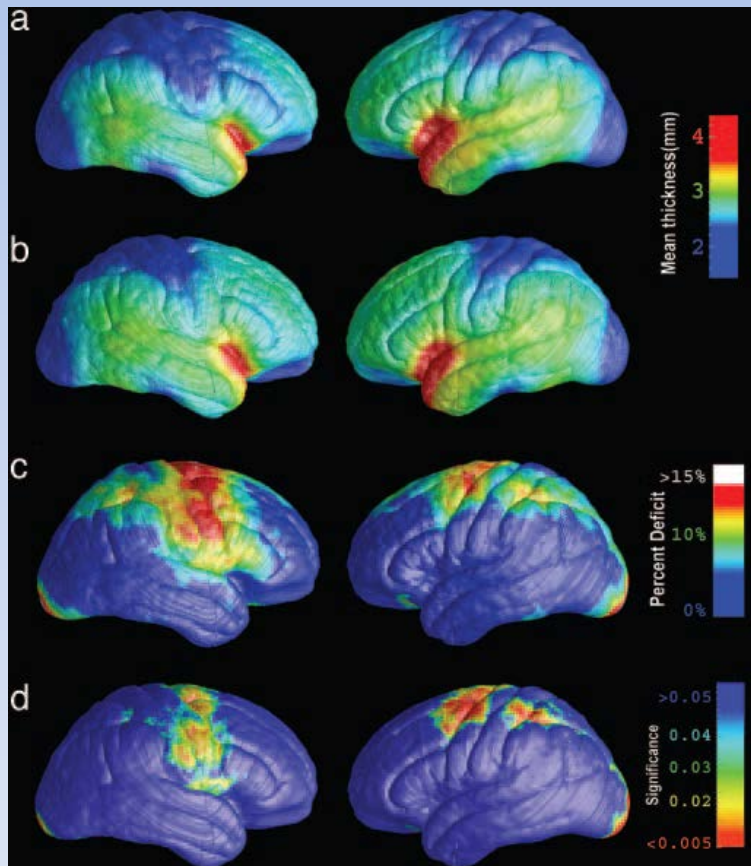
Structural MRI



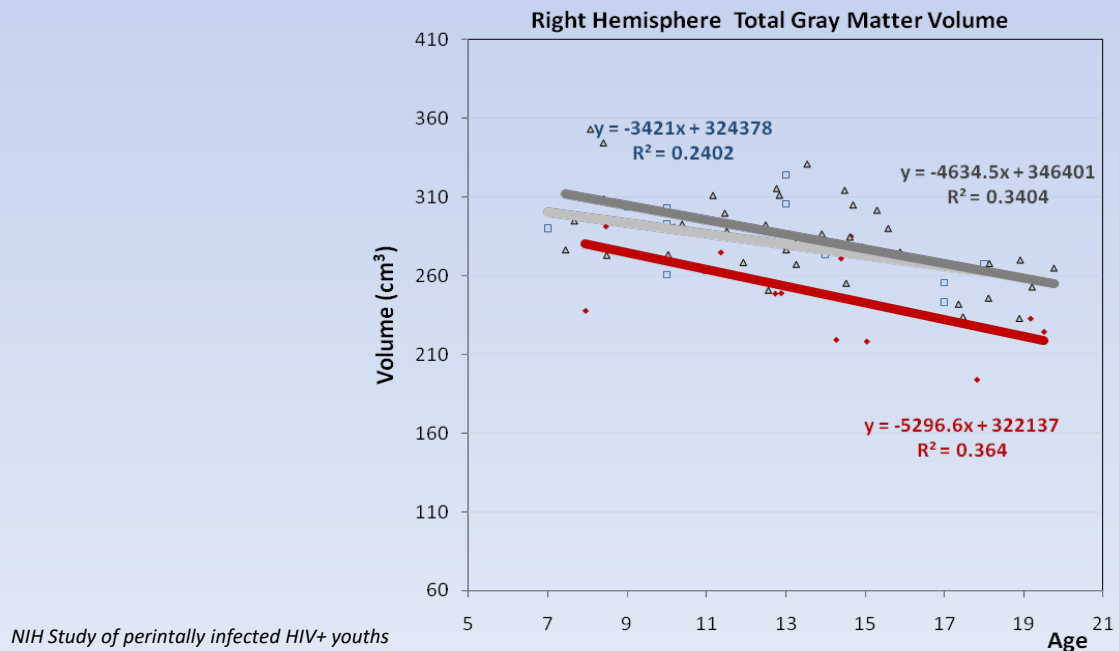
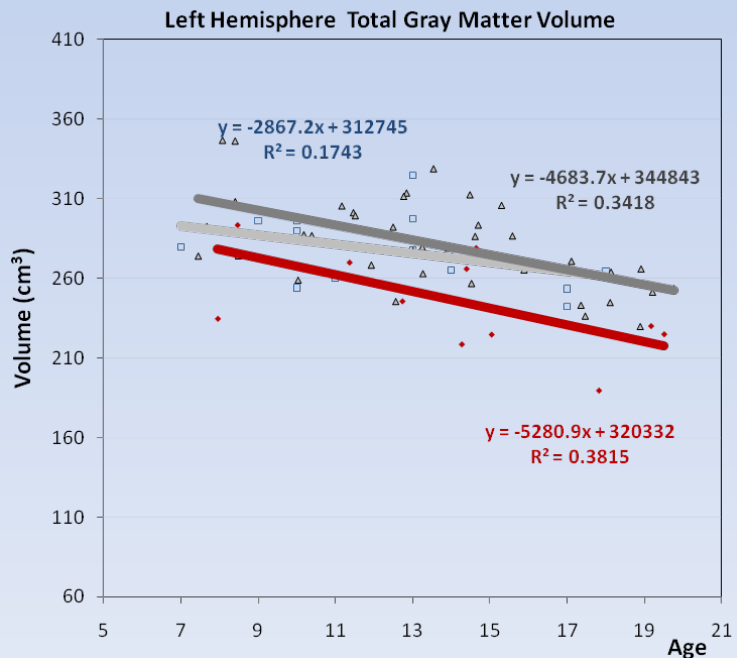
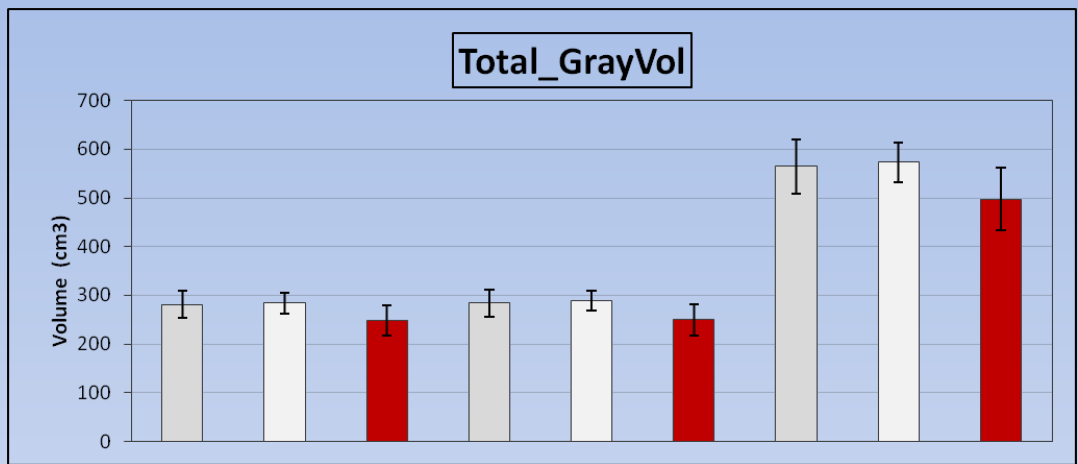
- 1. Volume
- 2. Surface Area
- 3. Folding Index

1. NIH Study of perinataly infected HIV+ youths
2. Dale, A.M, 1999, Neuroimage.

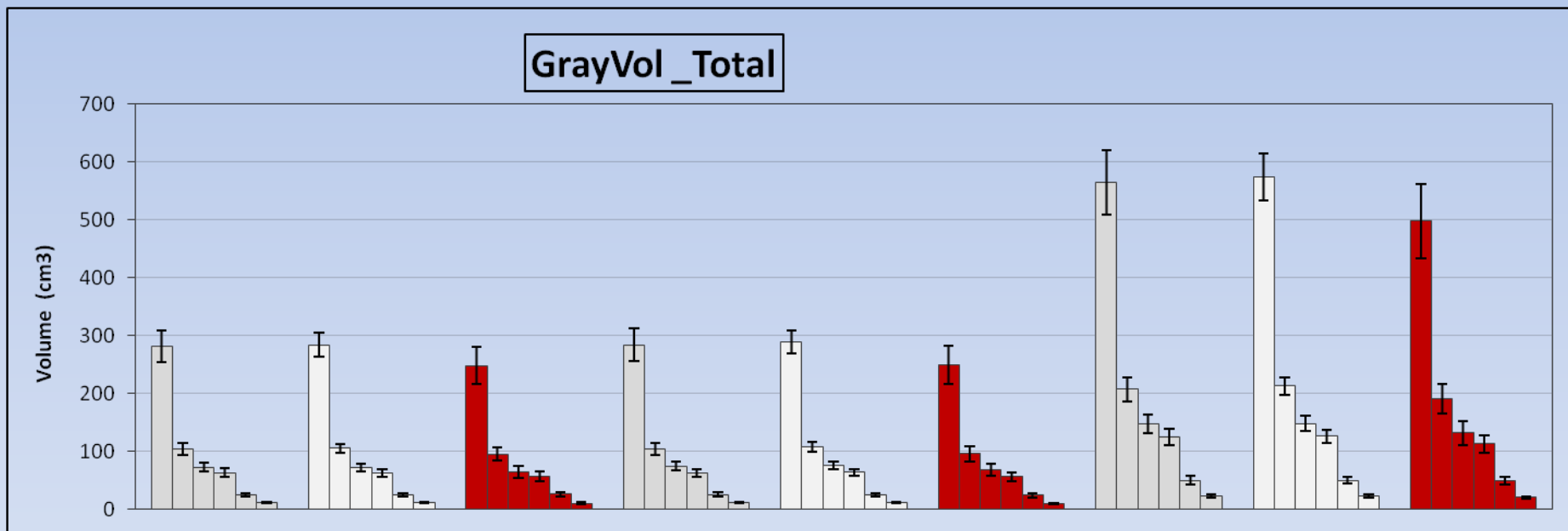
Gray Matter Adults



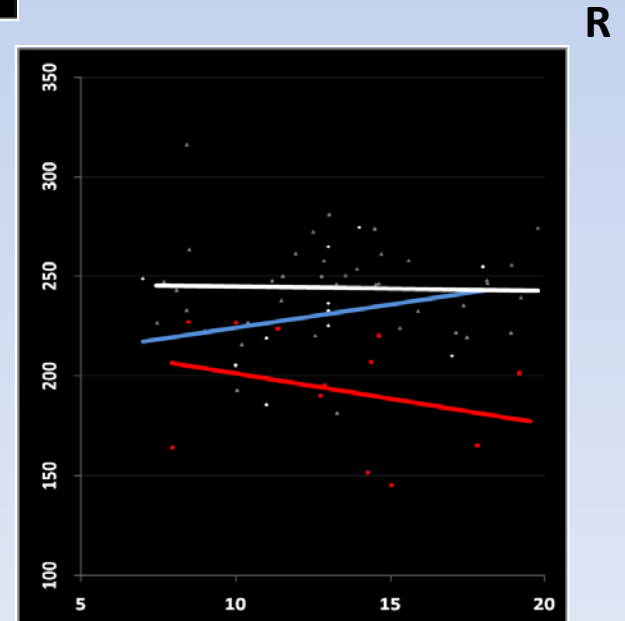
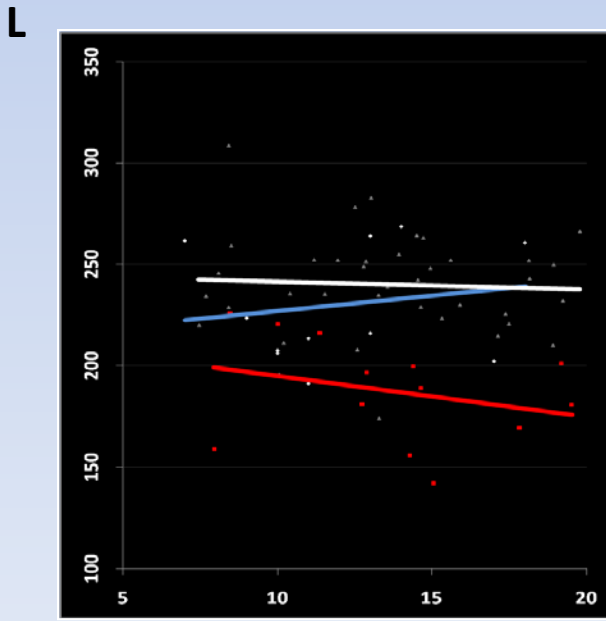
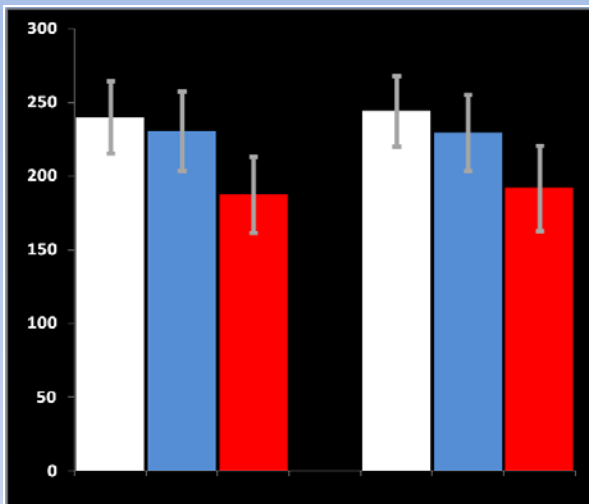
Gray Matter Perinatally affected Youths



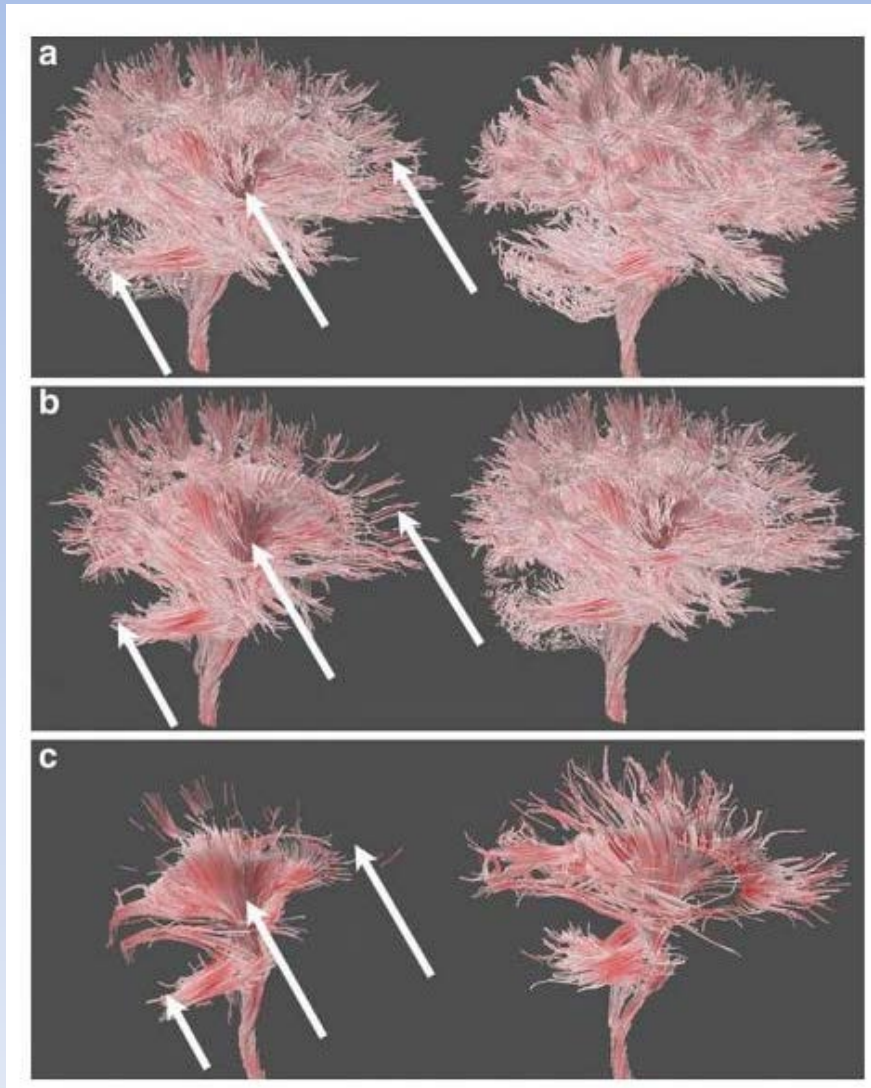
Gray Matter - Perinatally affected Youths



Total Cerebral White Matter

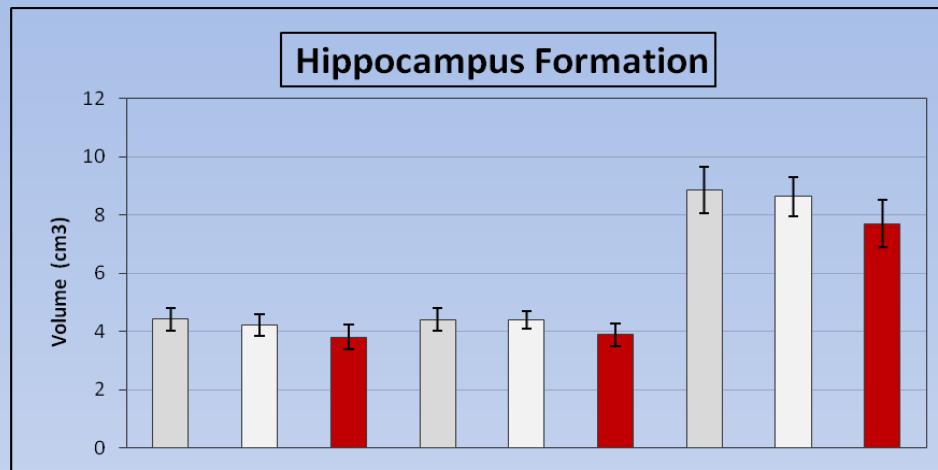


DTI

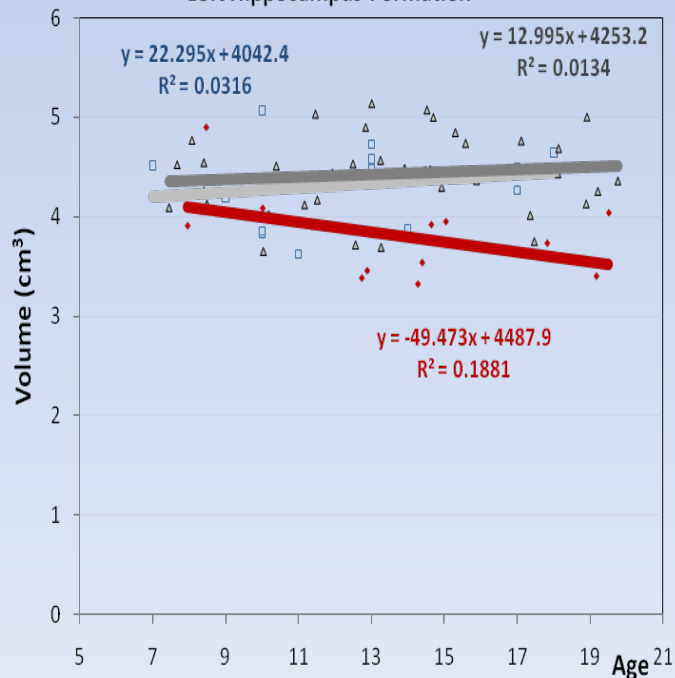


1. Saito et al., *Neurology* 1994.
2. Tornatore et al., *Neurology* 1994.

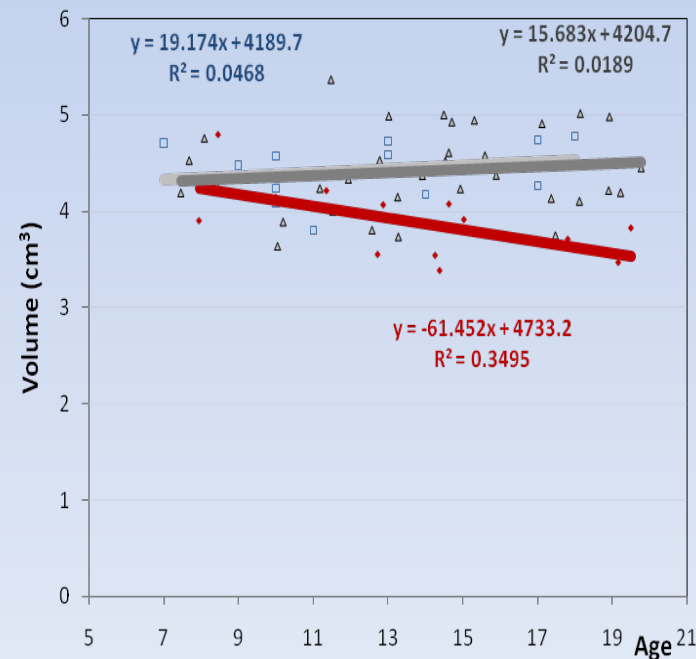
Subcorritical Structure - The Hippocampus



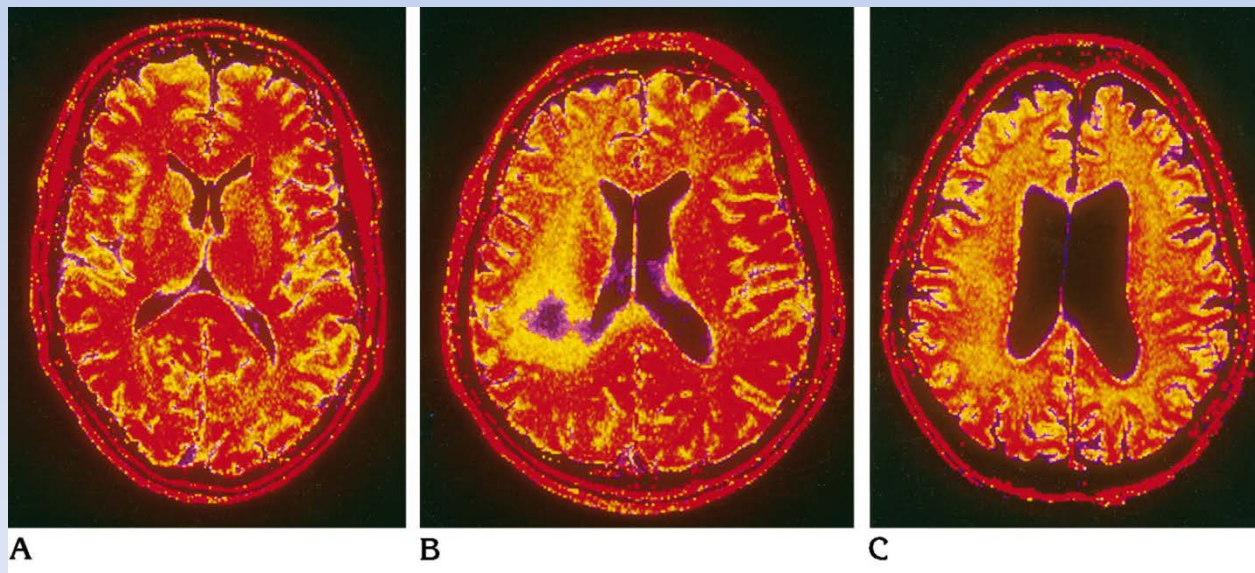
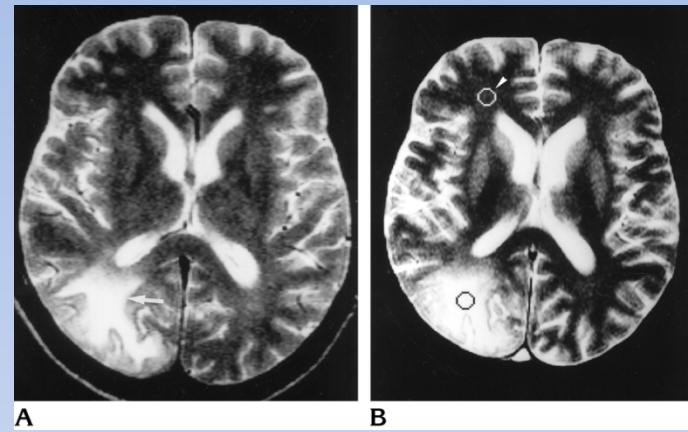
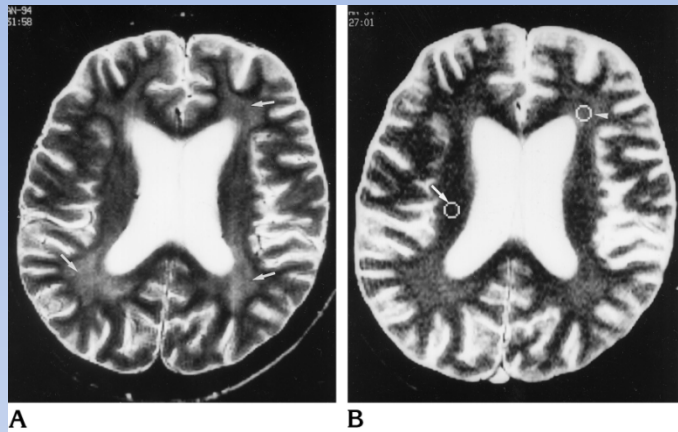
Left Hippocampus Formation



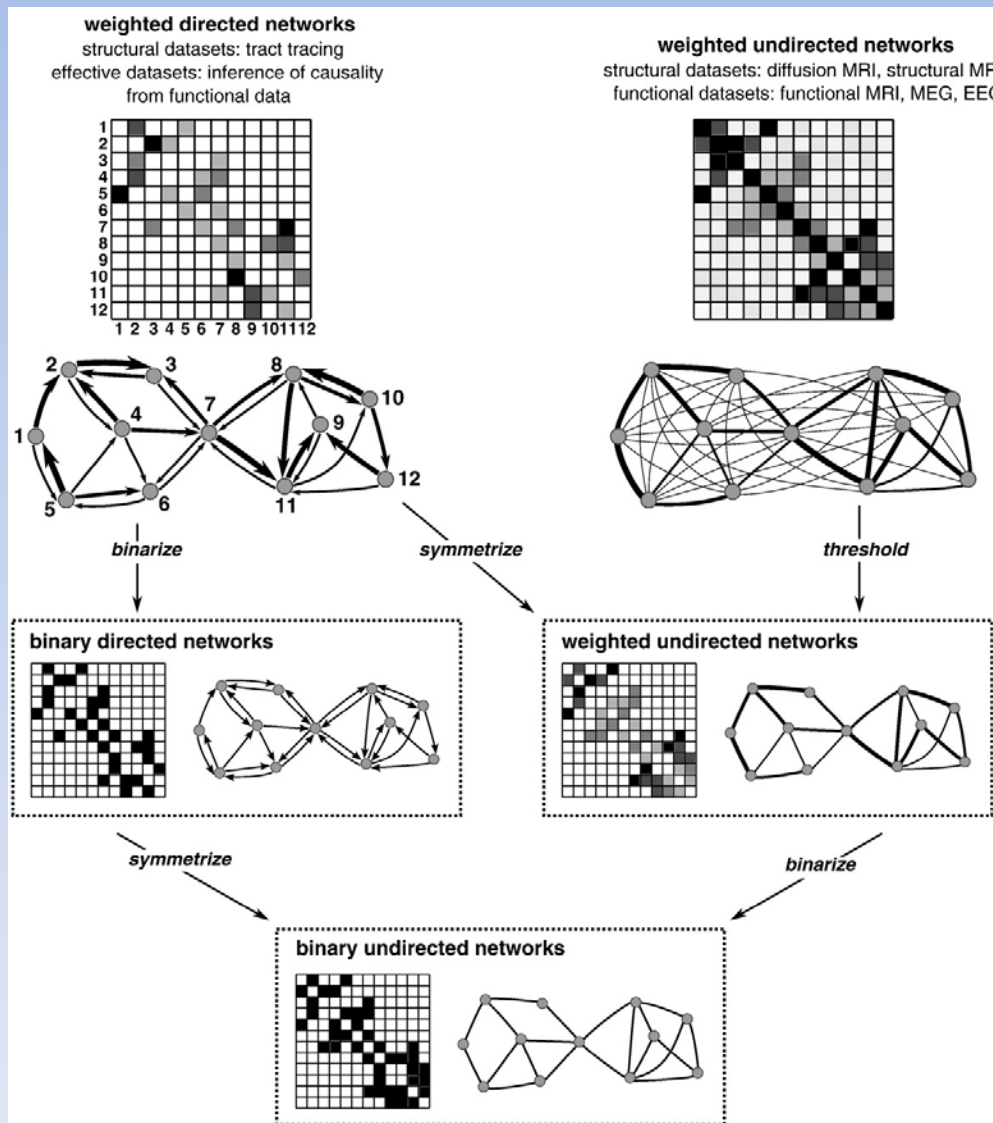
Right Hippocampus Formation



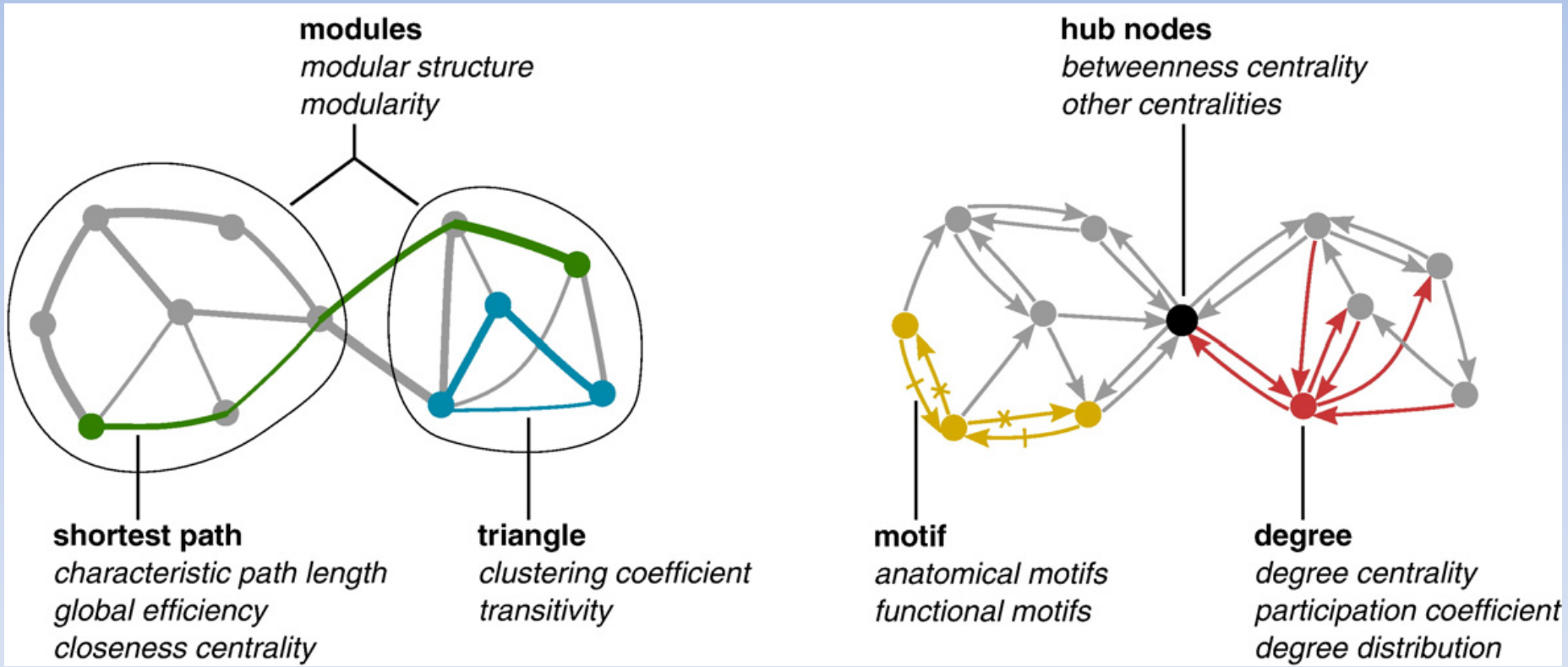
Magnetization Transfer Imaging



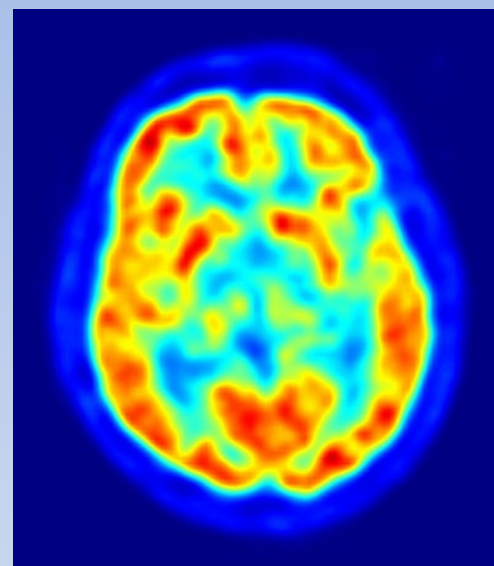
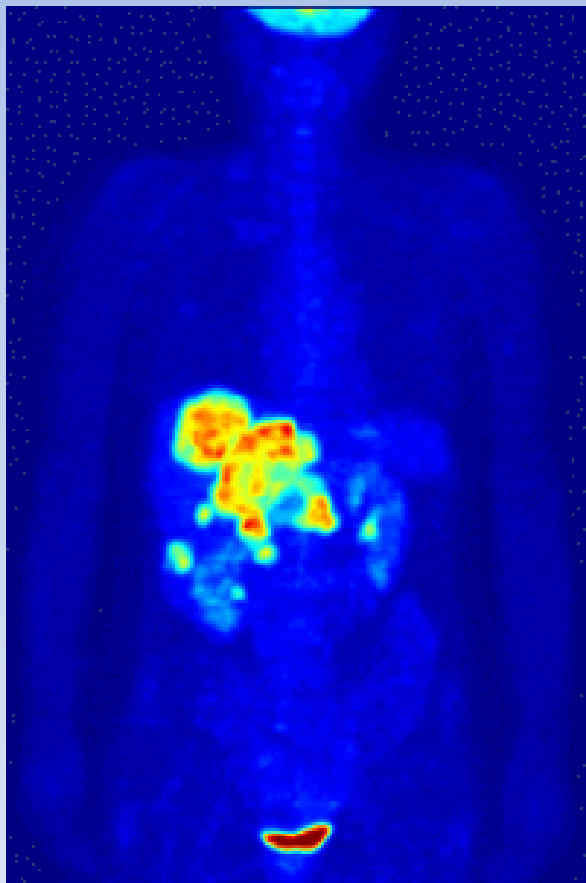
Functional MRI (fMRI)



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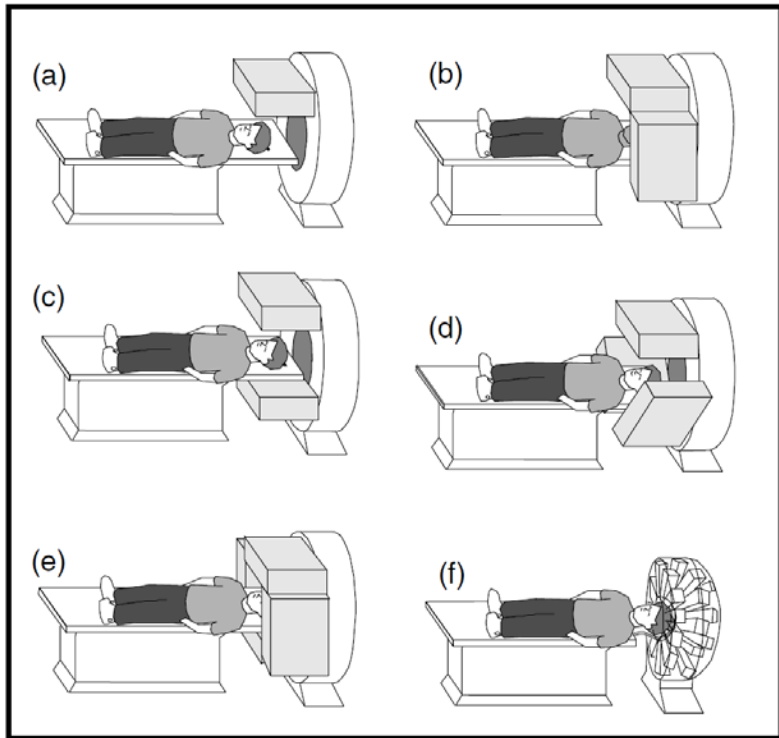
SPECT / PET Nuclear Imaging



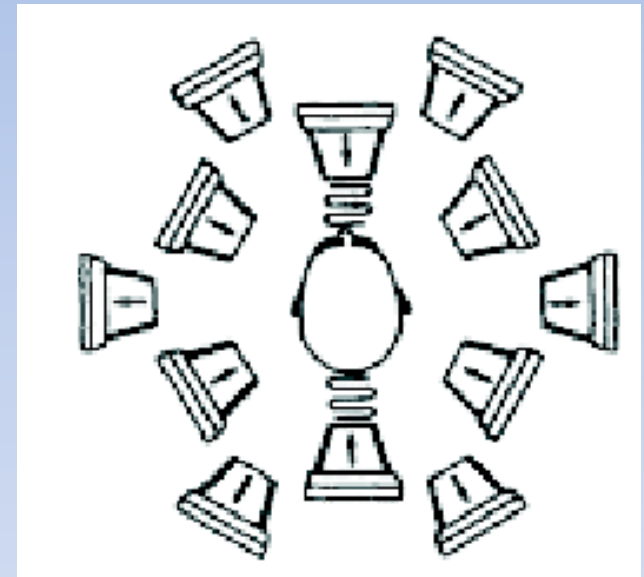
A diagnostic imaging technique in which tomographs of a radionuclide distribution are generated from gamma photons detected at numerous positions about the distribution.

1.Saito et al., *Neurology* 1994.
2.Tornatore et al., *Neurology* 1994.

SPECT Multi Detectors

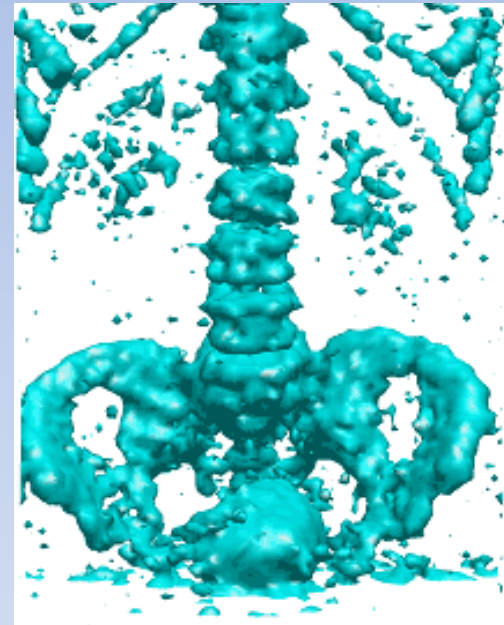
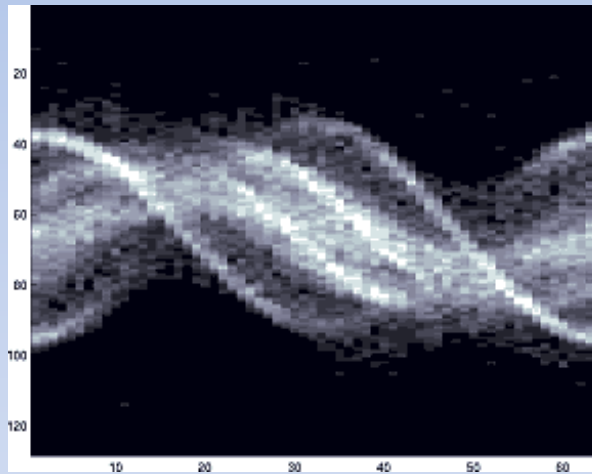
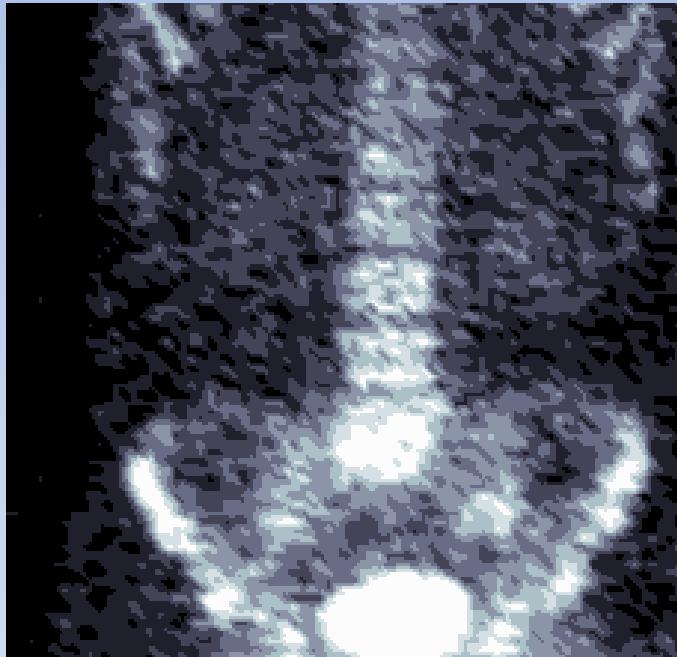


Gamma camera is rotated about the object and data are acquired for multiple slices simultaneously.



In standard protocols, during a camera rotation, 64 or 128 measurements (representing 64 or 128 detector elements) are acquired for 64 or 128 transaxial slices of the object at each angle.

SPECT Correction For Scatter and Attenuation



Signal projections, corrected for scatter and attenuation, is filtered and back-projected to form an image.

SPECT Illustration

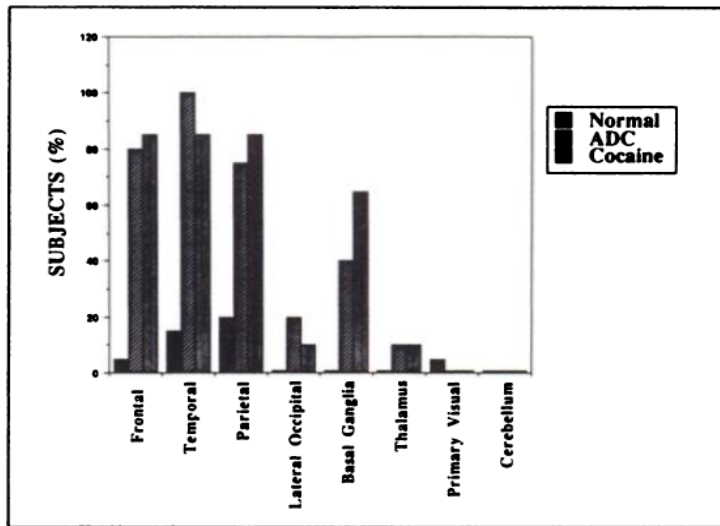
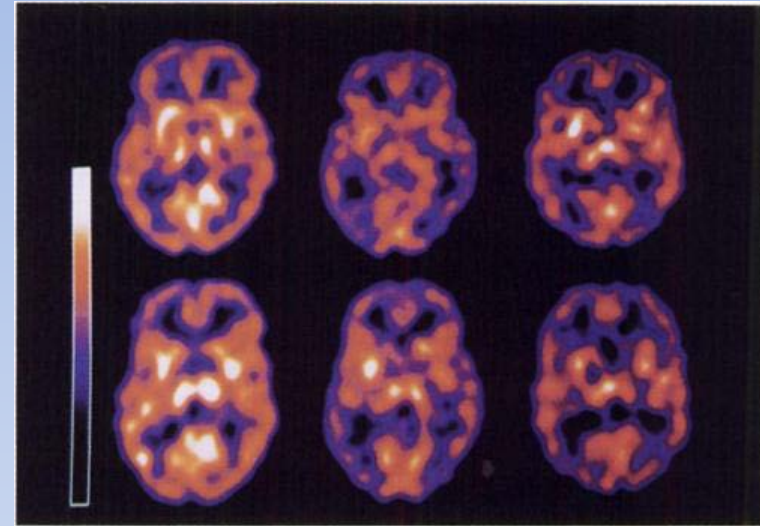
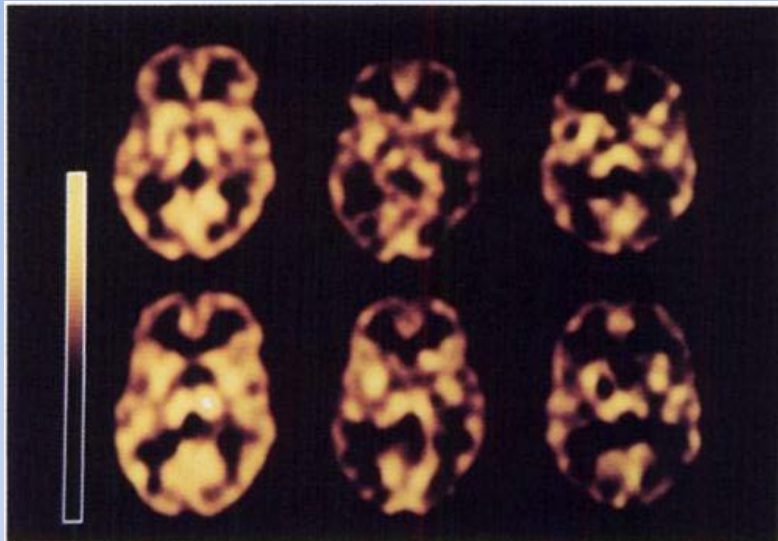
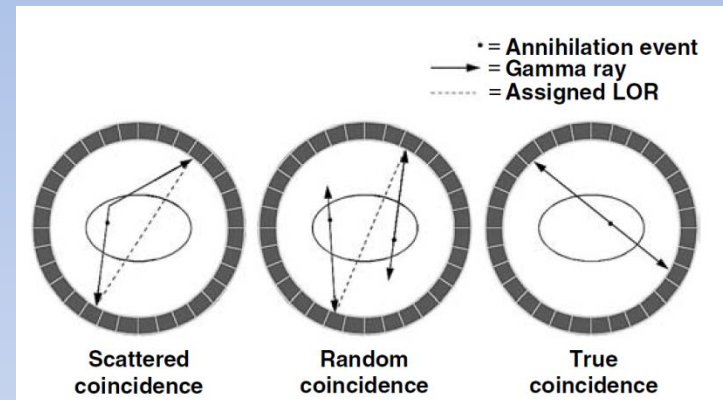
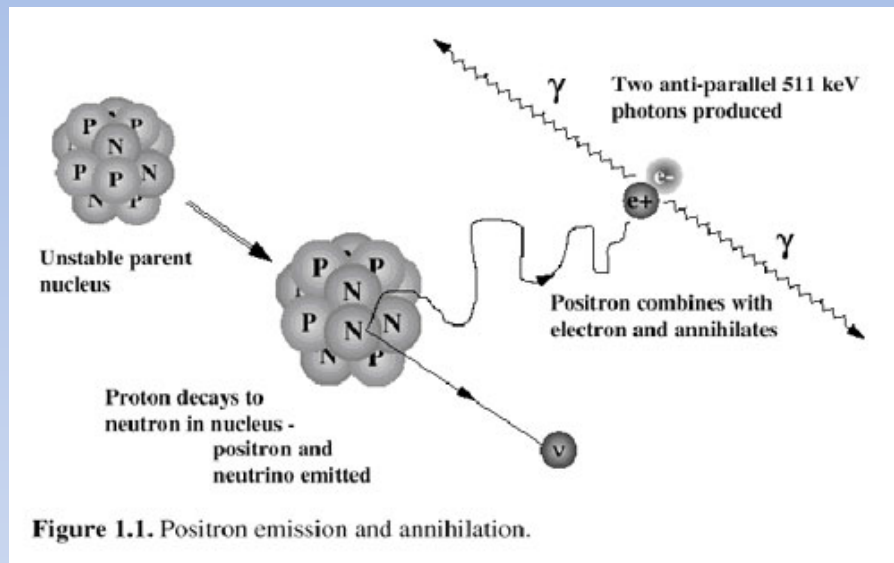
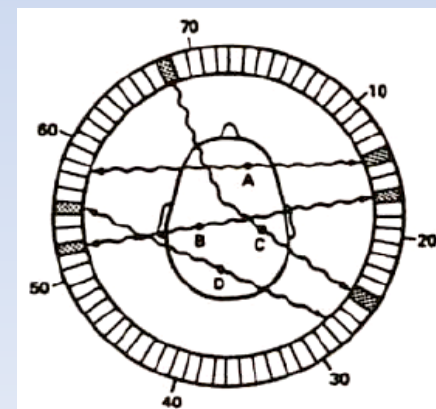


FIGURE 2. Number of subjects with focal perfusion defects.

Positron Emission Tomography



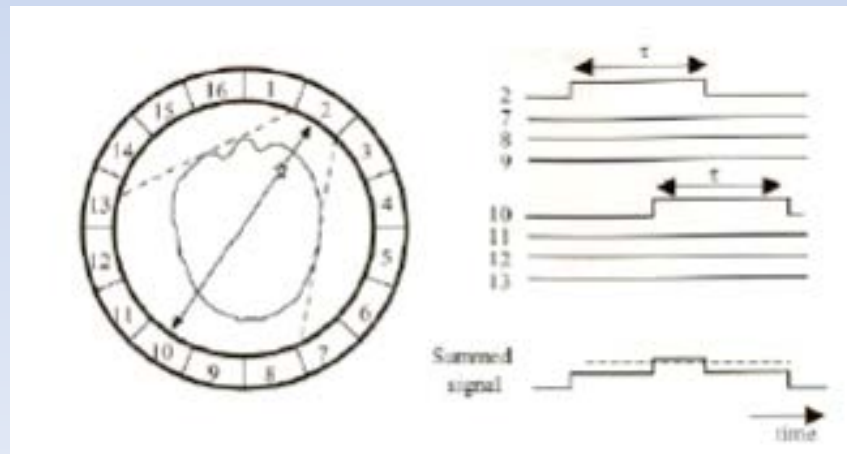
Gamma rays are detected in coincidence by detectors that surround the patient.



Generation images of the distribution of positron emitters in vivo. PET systems rely on the detection of annihilation gamma rays that follow positron decay.

PET – Coincidence Time Factor

- **“Coincidence Detection Circuitry :** If the signal coming from the PMT has a voltage within the the predetermined Pulse Height Analyzer window, it generates a “logic pulse” (Tau = 6-10 ns long) which is sent to the coincidence detector.
- When a second Gamma-ray is detected and produces a voltage that is accepted a second logic pulse is sent to the coincidence detector.
- If both logic pulses are sent to the coincidence detector within the system coincidence resolving time, 2 Tau, then the summed signal lies above the threshold value (dashed line above) and a coincidence is recorded.”



Brain MRI “Ball Park” Costs & Availability

Modality	Ball Park Price range (\$)	Availability
Structural MRI	~\$2,000 – \$3,000 (More time in the scanner, more costs)	~ 8 per million
fMRI	Same as Structural (fMRI scans are time dependent on the clinical testing used)	Same as Structural
DTI	Same as Structural; Only takes a few mins per scan; MRIs charged by hour – should be a fraction of structural	Same as Structural
MRS	Only takes a few mins per scan; MRIs charged by hour – should be a fraction of Structural	Usually done alongside structural
SPECT	\$1,000 to \$2,000. Multiple exams might be bundled and offered and price per scan might be cheaper	
PET	\$3,000 - \$6,000	

Wrap up / Questions

References

<http://www.radiologyinfo.org/en/info.cfm?pg=gennuclear>

Emission tomography – The fundamentals of PET and SPECT – Edited by Miles Wernick and John Aarsvold

Description PET-MIPS-anim.gif Maximum Intensity Projection of a ^{18}F -FDG wholebody PET acquisition; Source Own work; Date 22th May 2006; Author Jens Langner (<http://www.jens-langner.de/>)

Extracted from Lecture Slides by Tsourkas, Andrew, Fall 2008, University of Pennsylvania

Vancouver Hospital and Health Sciences Centre's Medical Imaging Research Group's (MIRG's) SPECT Tutorial Web Site

http://www.physics.ubc.ca/~mirg/home/tutorial/fbp_recon.html

Centre for Positron Emission Tomography, Austin Hospital, Melbourne, Australia.

http://www.petnm.unimelb.edu.au/pet/detail/images/pet_nuc_1.jpg