

Concussion/TBI

Scope of the Problem



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Epidemiology

- Incidence (increasing)
 - 95/100,000
 - 80% Mild, 10% Moderate, 10% Severe
 - 1 Million Emergency Department visits/year
 - Estimated 1.5 million incidents/year
- Prevalence
 - **3.2-5.3 million**
 - 50,000 fatalities/year (decreasing)



TBI Incidence

- Greater than
 - Breast cancer
 - HIV/AIDS
 - Multiple sclerosis
 - Spinal Cord Injury

COMBINED!

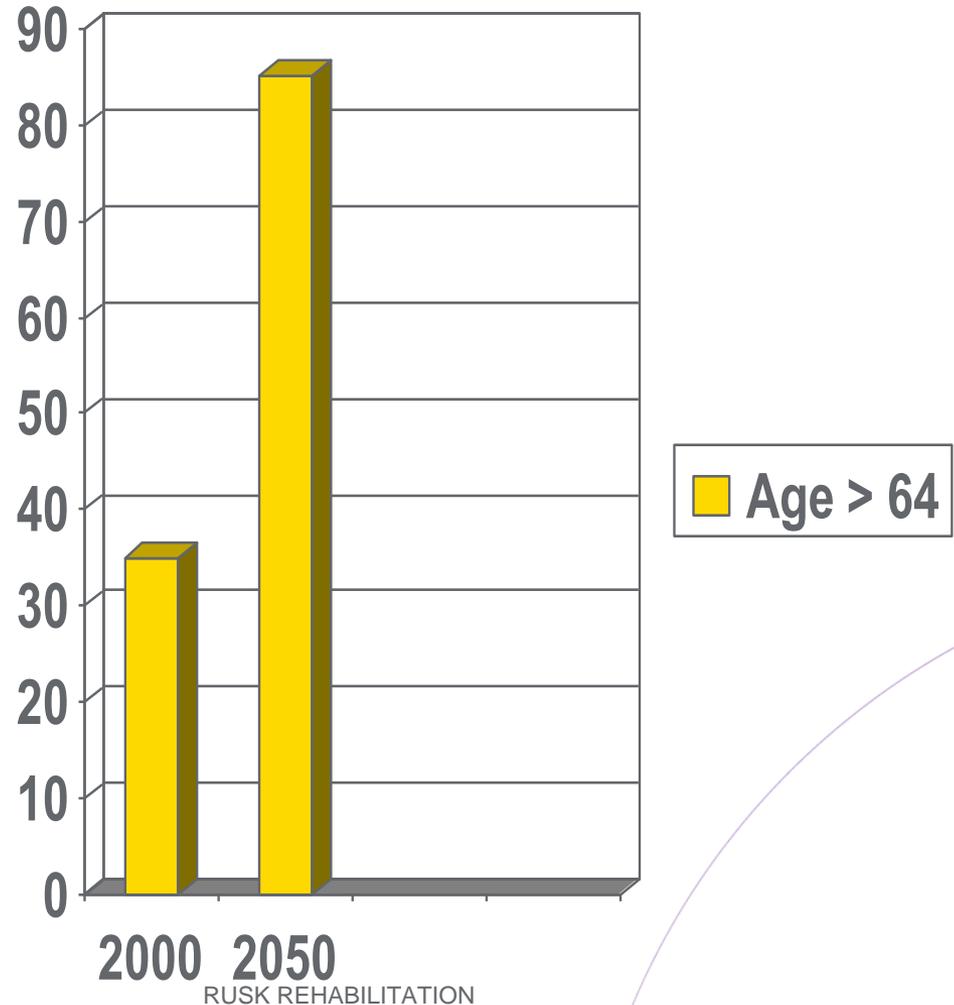
Age at Injury

- Increased risk for
 - Adolescents and Young Adults
 - Greater than 75 years of age
 - Higher mortality
 - Greater disability
 - Male : Female = 2-3:1 overall
 - Equal distribution in the elderly
 - Men are from Mars



Scope of the Problem

- Changing demographics
 - 2000 census: 35 million \geq 65 years
 - 2050: > 86 million
- US Census Bureau 2004



Cause of Injury

- Vehicular/Traffic related
 - Most common cause of *severe TBI*
- Assault
 - More common in urban areas
- Falls
 - Increased incidence with advancing age
 - Latest CDC data reports falls as most common cause
- Recreational
 - Sports
 - Chronic Traumatic Encephalopathy
- Military Injuries



“...in an adult trauma patient, acute injury is not just a brief physiological setback to a healthy life, but rather signals significant long-term mortality in a large number of patients.”

Davidson GH et al. Long-term survival of adult trauma patients. JAMA 2011;305:1001-1007



RUSK REHABILITATION

How Common are Sport Concussions in the United States?

- 2.5 million ED/Hospitalizations/Death for TBI
 - 75% mild (i.e. concussion)
 - 65% children and adolescents
 - < 20% result in LOC
- Estimated up to 3.8 million occurrences/year
- Many are likely unrecognized, not reported or misdiagnosed

Are all injured athletes identified?

- Talavage TM et al: J Neurotrauma 2010
- High school varsity/JV football players
 - Dx'd with concussion:
 - Altered ImPACT and fMRI
 - Not dx'd with concussion but high # or high magnitude collisions
 - Altered ImPACT and fMRI

American Congress of Rehabilitation Medicine

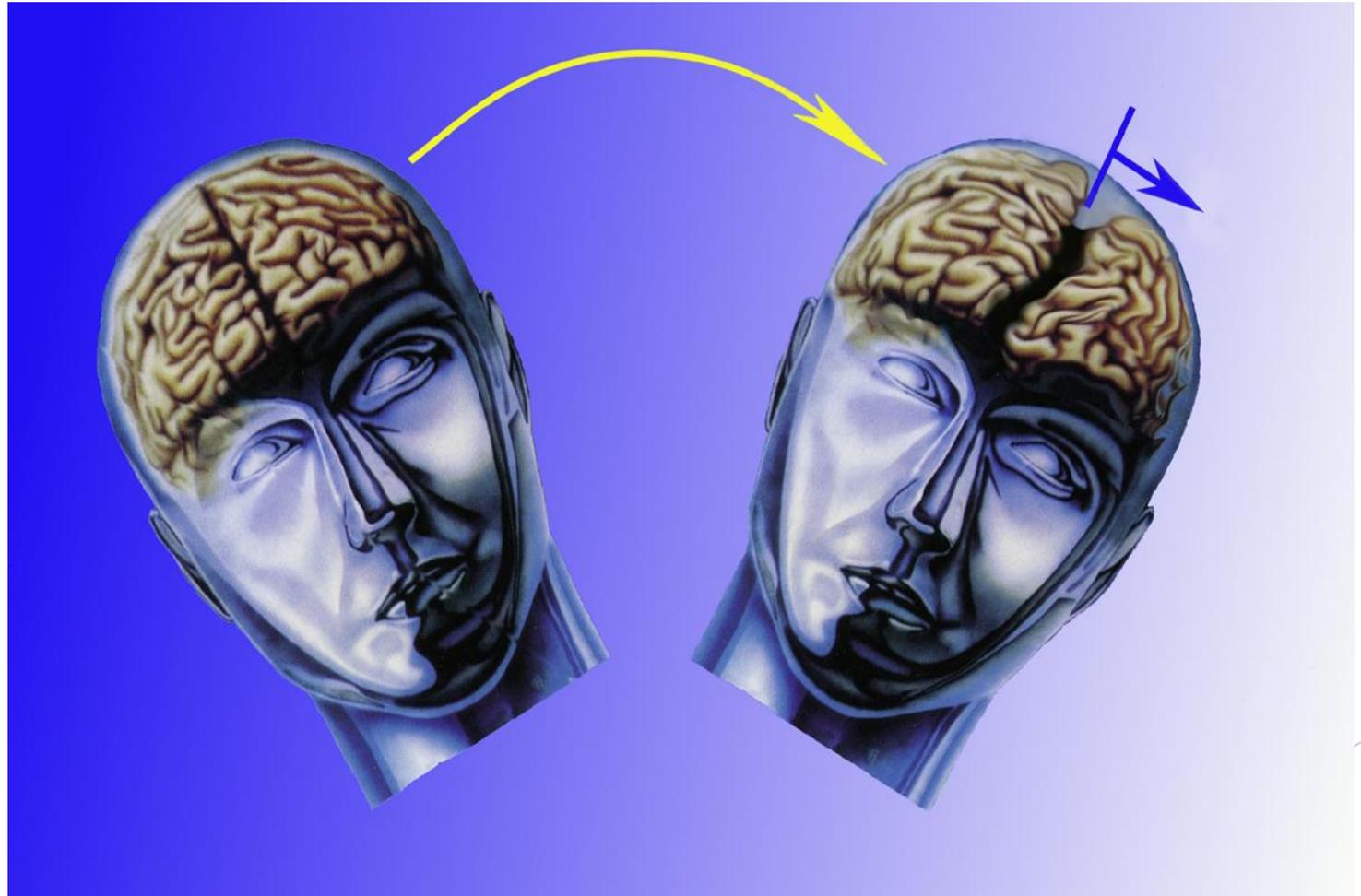
- Traumatically induced alteration in brain function, manifested by at least one of the following
 - Loss of consciousness
 - Memory loss either before or after the event
 - Feeling Dazed or Confused
 - Focal neurological finding

Consensus Statement on Concussion in Sport: the 3rd International Conference on Concussion in Sport held in Zurich, 2008

Concussion is defined as a complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces. Several common features that incorporate clinical, pathologic and biomechanical injury constructs that may be utilised in defining the nature of a concussive head injury include:

1. Concussion may be caused either by a direct blow to the head, face, neck or elsewhere on the body with an "impulsive" force transmitted to the head.
2. Concussion typically results in the rapid onset of short-lived impairment of neurologic function that resolves spontaneously.
3. Concussion may result in neuropathological changes but the acute clinical symptoms largely reflect a functional disturbance rather than a structural injury.
4. Concussion results in a graded set of clinical symptoms that may or may not involve loss of consciousness. Resolution of the clinical and cognitive symptoms typically follows a sequential course; **however it is important to note that in a small percentage of cases however, post-concussive symptoms may be prolonged.**
5. **No abnormality on standard structural neuroimaging studies is seen in concussion.**

Stretching the axons



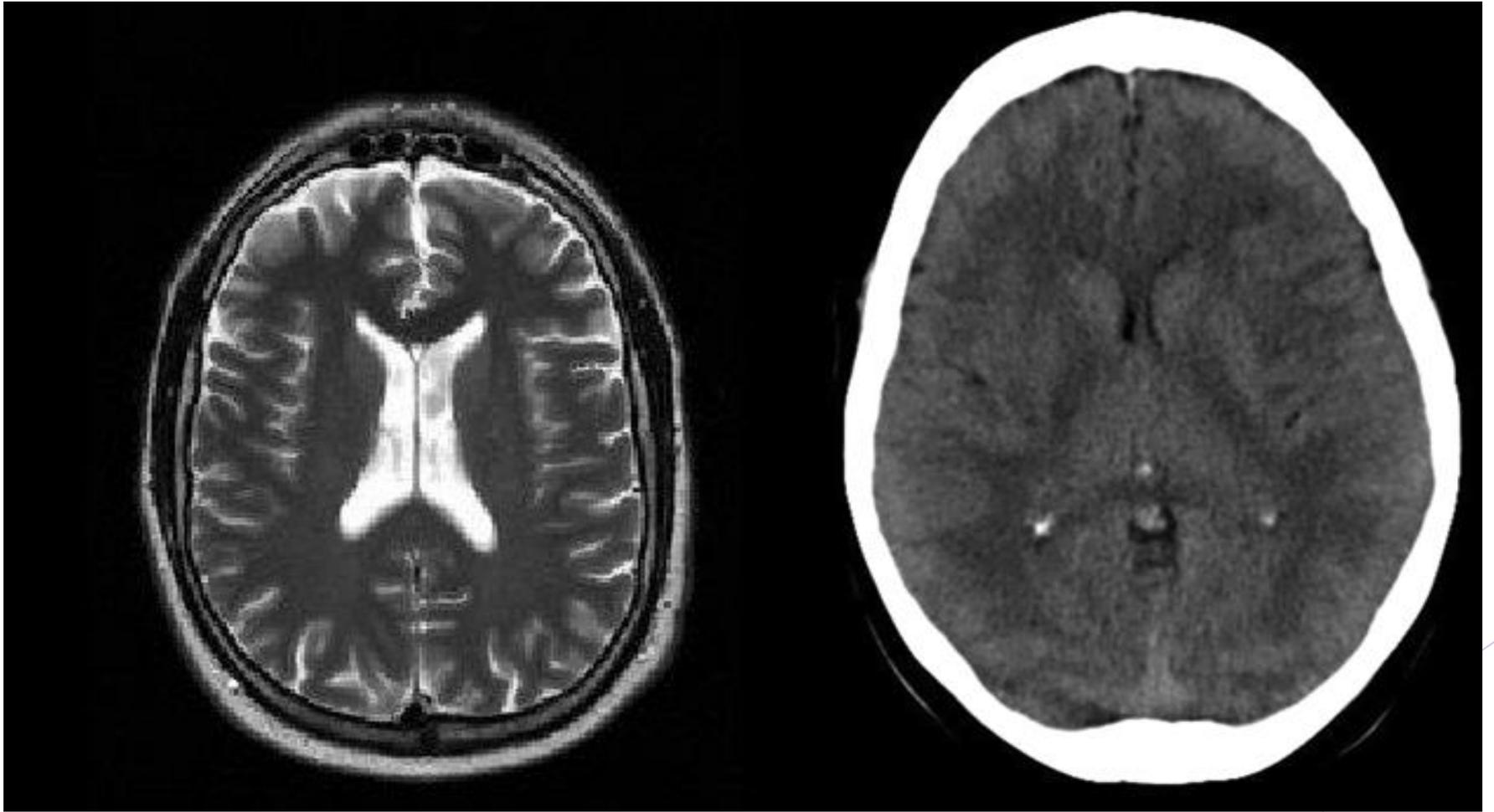
Axons-like telephone wires

RUSK REHABILITATION

Slide courtesy of Steven Galleta, MD

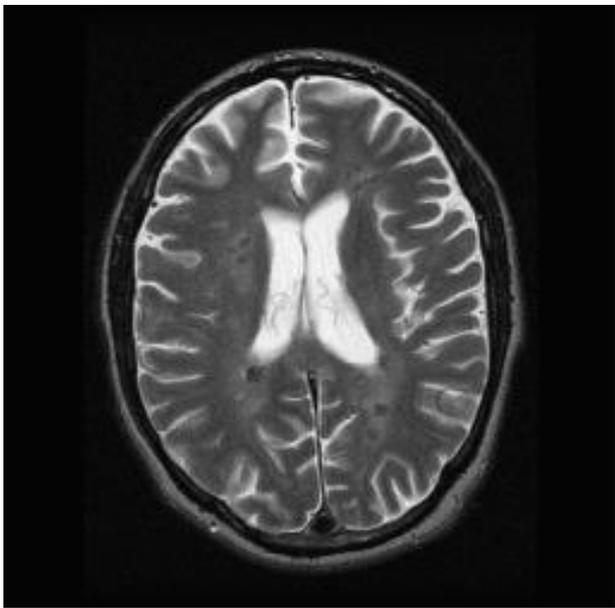


Axonal transport interruption, swelling and disconnection, like an Earthquake has occurred to a Highway- you get a big traffic jam



Summary

- TBI/Concussion is common
- Severe TBI often associated with long-term medical problems
- Smaller percentage of mild TBI develop chronic problems
- Much remains to be learned re:
 - Objective diagnosis
 - Effectiveness of treatments
 - Proper identification
 - Definitions



**CEREBRAL NEUROIMAGING
AND CONCUSSION
WHAT IT TELLS US.
HOW CAN WE USE IT?
HOW WE CANNOT USE IT (YET)**

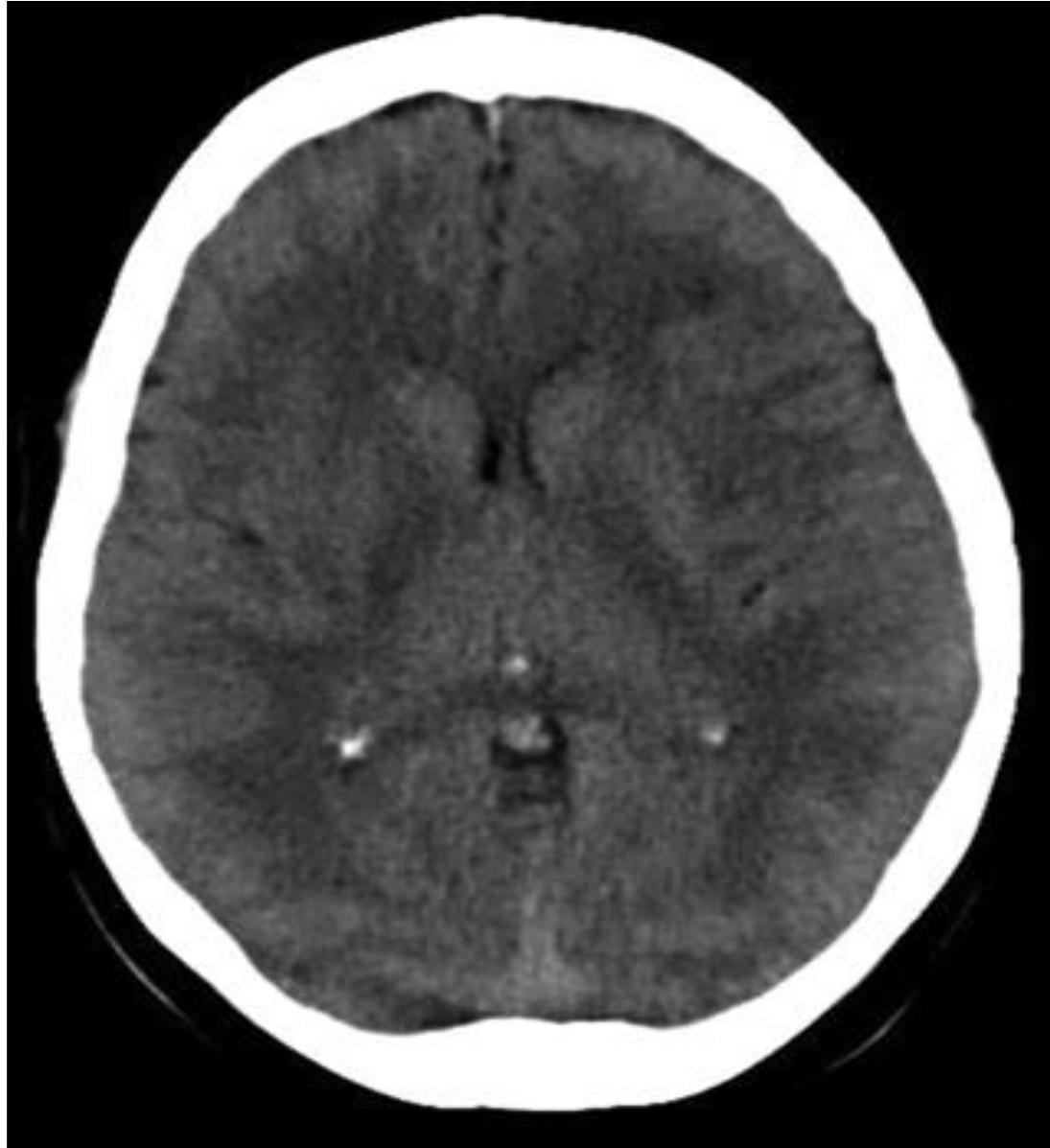
CT Scan

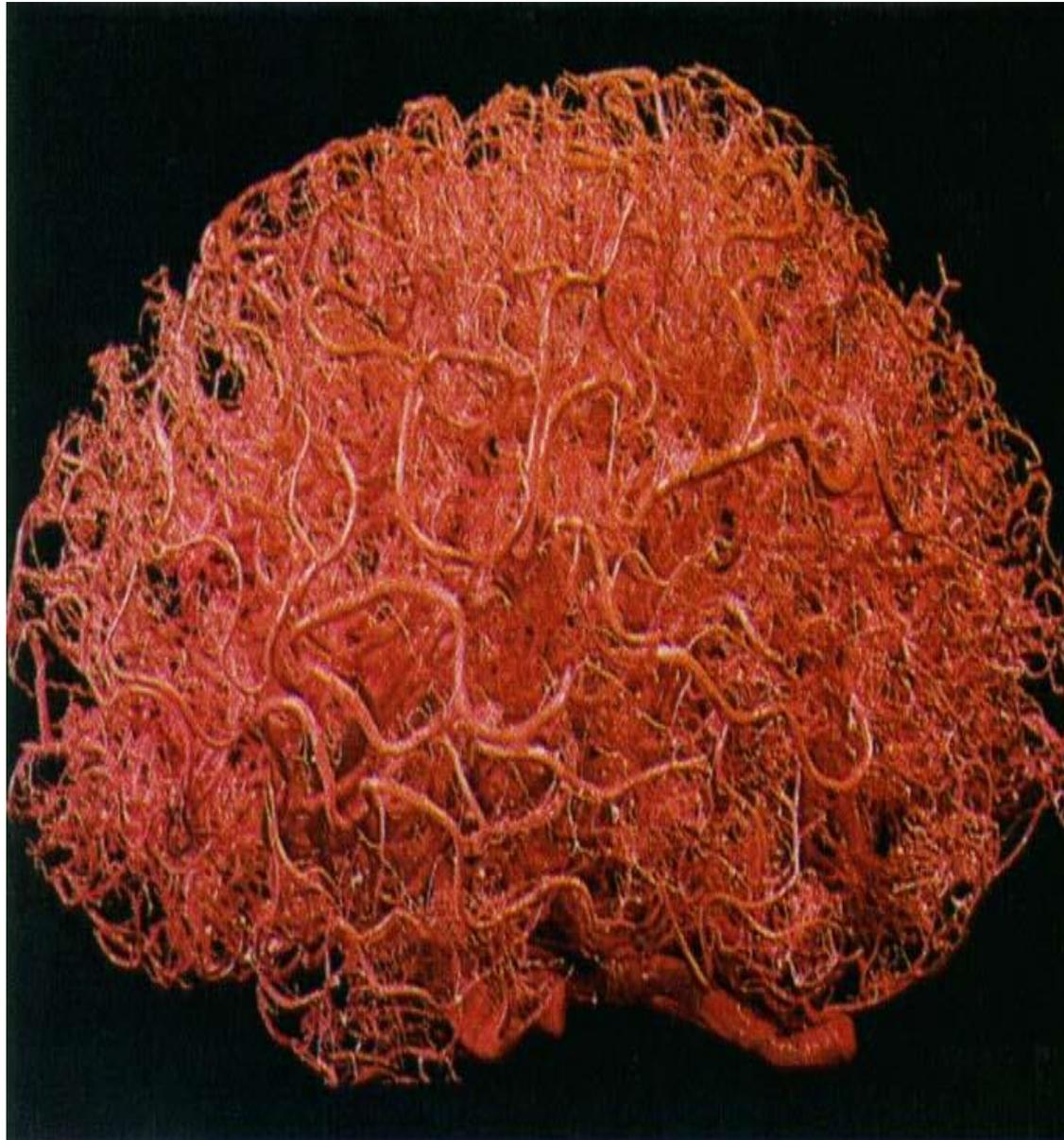
Standard MRI

- You can see the big stuff
 - Stroke
 - Large hemorrhages
 - Tumors
 - Mass effect

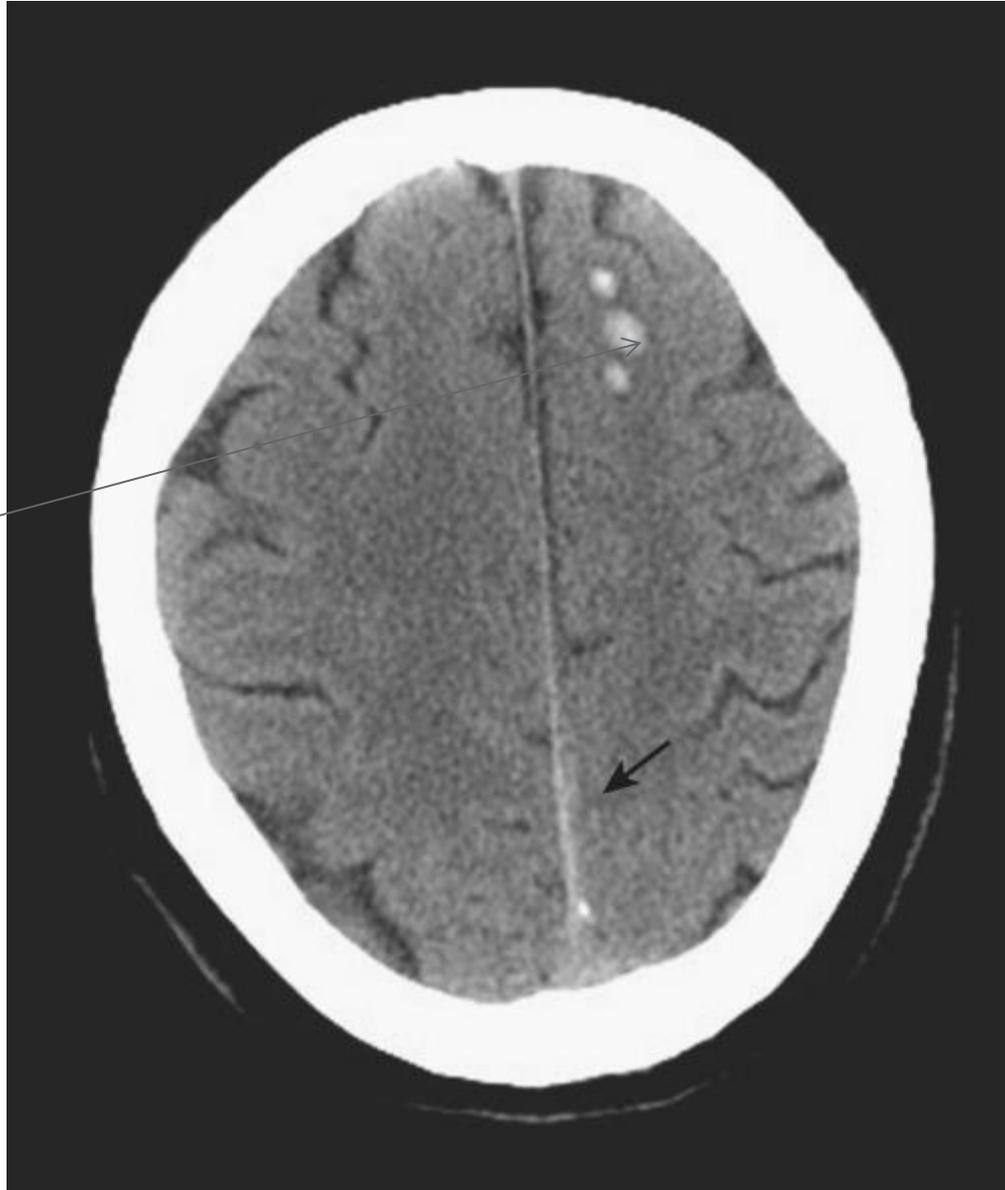
- You can't see the small stuff
 - Microscopic lesions
 - Function/Physiology

CT of DAI





DAI

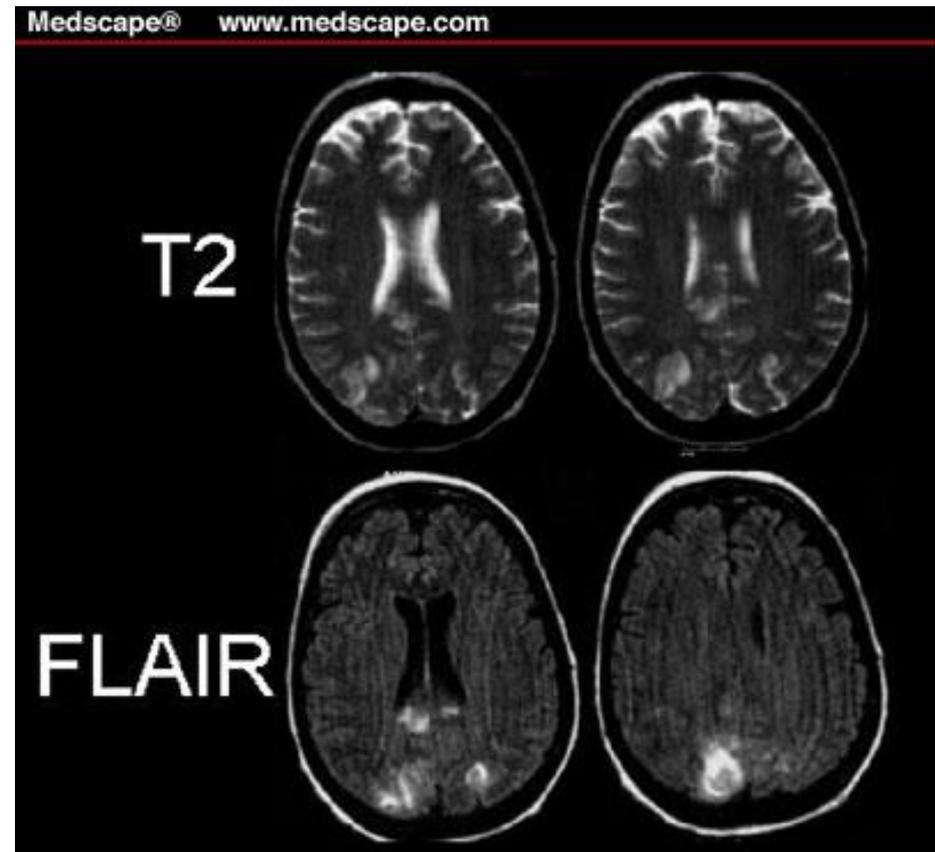


Petechial
Hemorrhages

FLAIR (FLuid Attenuated Inversion Recovery) vs “Standard” T2

- FLAIR

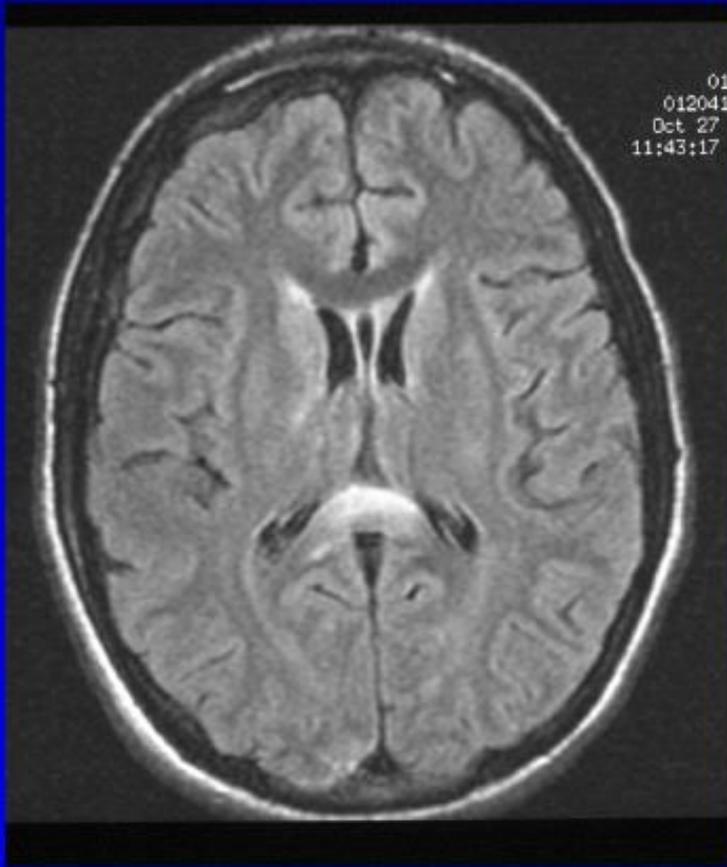
- Heavily T2 weighted image
- Attenuates signal coming from fluid
- Improves visualization of lesions in proximity to CSF
 - Gray-White matter interface
 - Corpus callosum



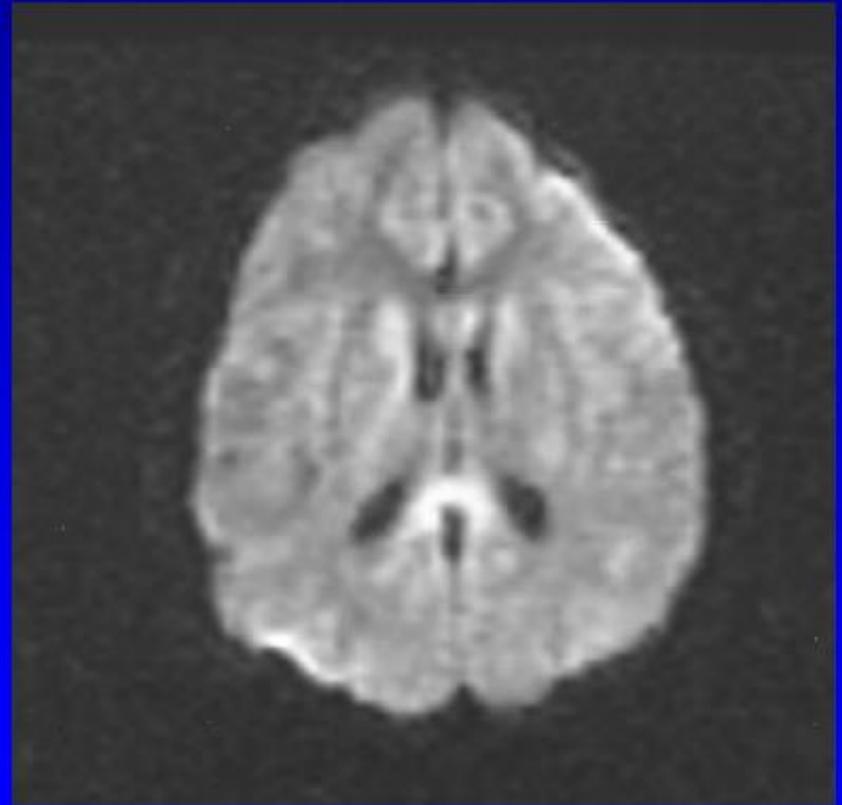
DIFFUSION WEIGHTED IMAGING

DAI

FLAIR



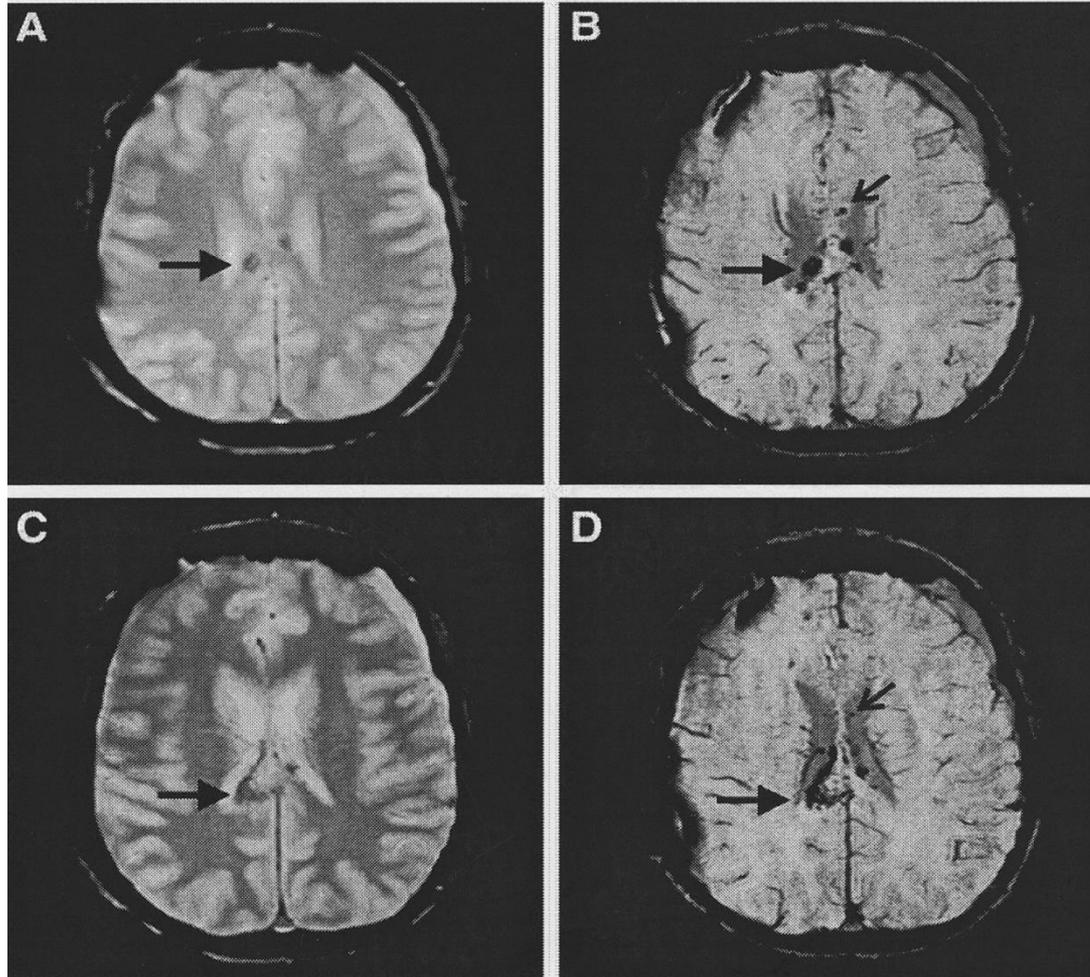
Diffusion Weighted Image



Gradient Echo and Susceptibility Weighted Images

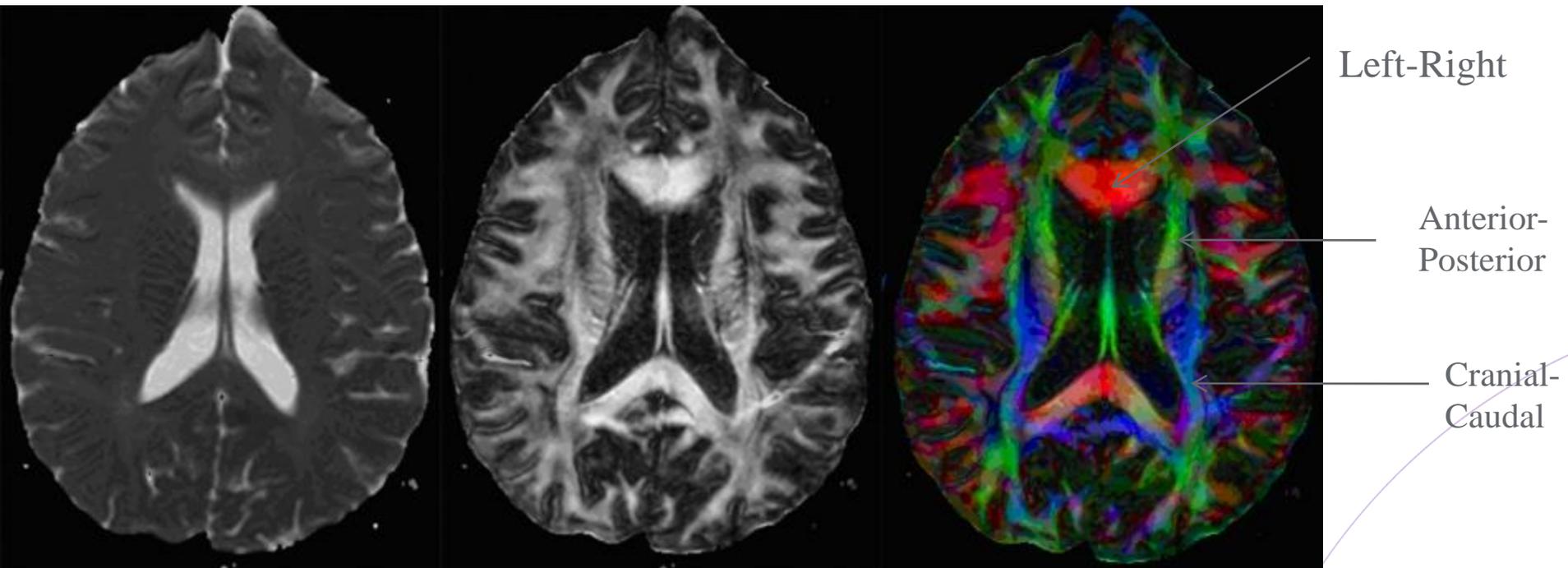
Gradient Echo

Susceptibility Weighted



Tong KA, et al:Radiology 2003;27:332-9

Diffusion Tensor Imaging



Magnetic Resonance Spectroscopy

- Assesses the relative or absolute concentrations of various molecules
 - N-acetyl aspartic acid (NAA)
 - Neuronal marker
 - Lower NAA levels reflect
 - Neuronal loss (predominant neuronal location)
 - Metabolic dysfunction (synthesized in mitochondria)
 - Myelin repair (? Role as acetyl donor in lipid synthesis)

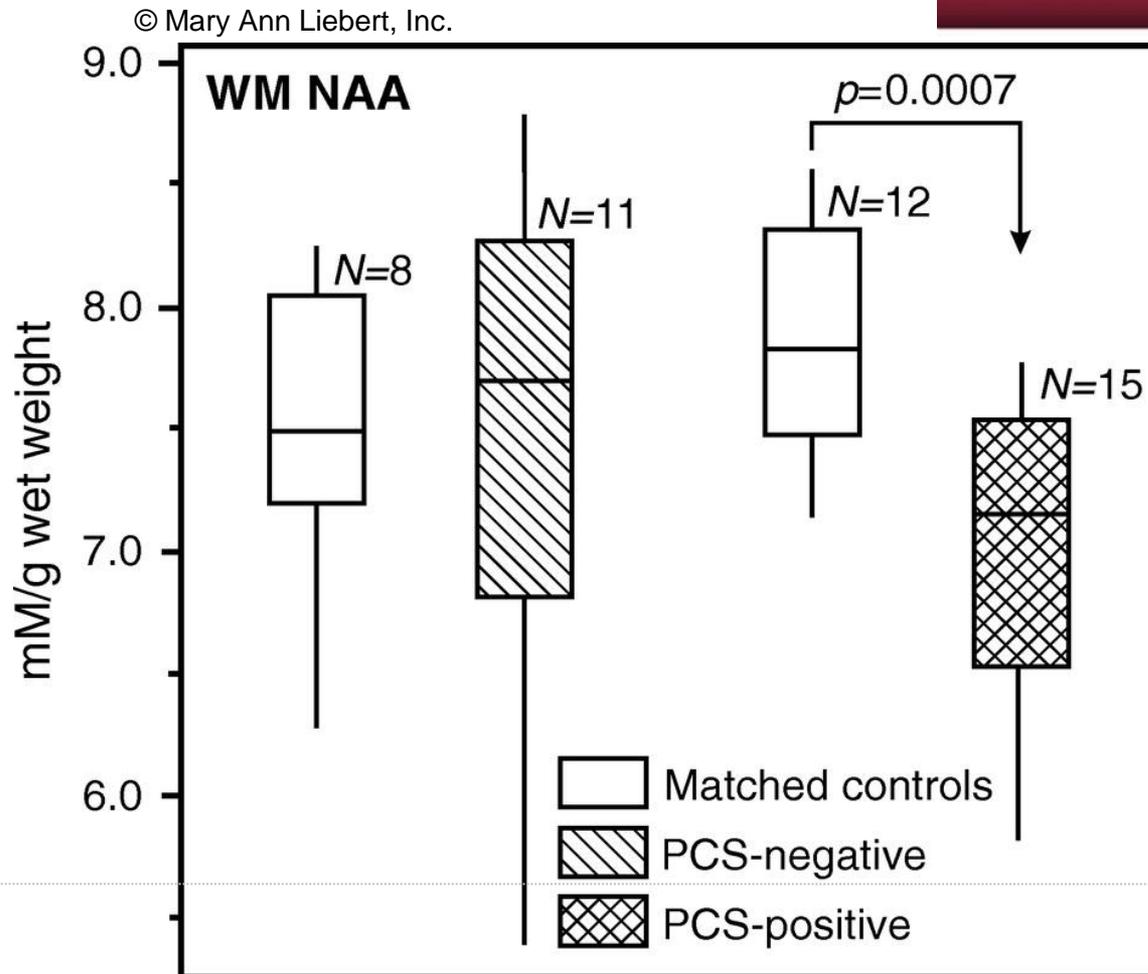
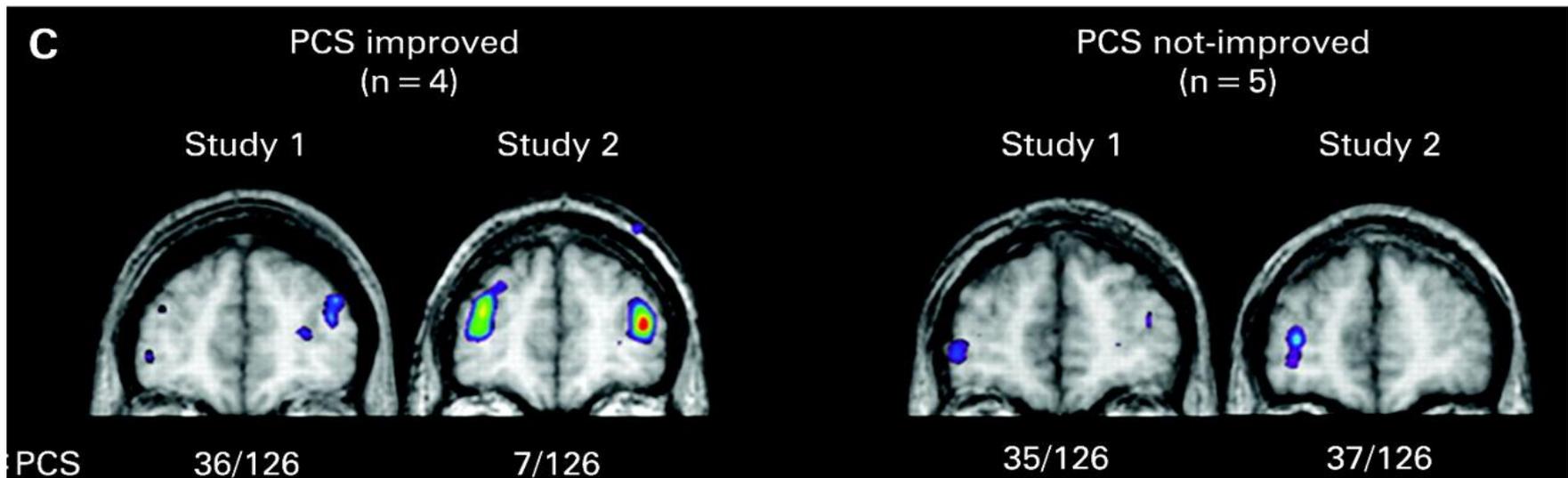
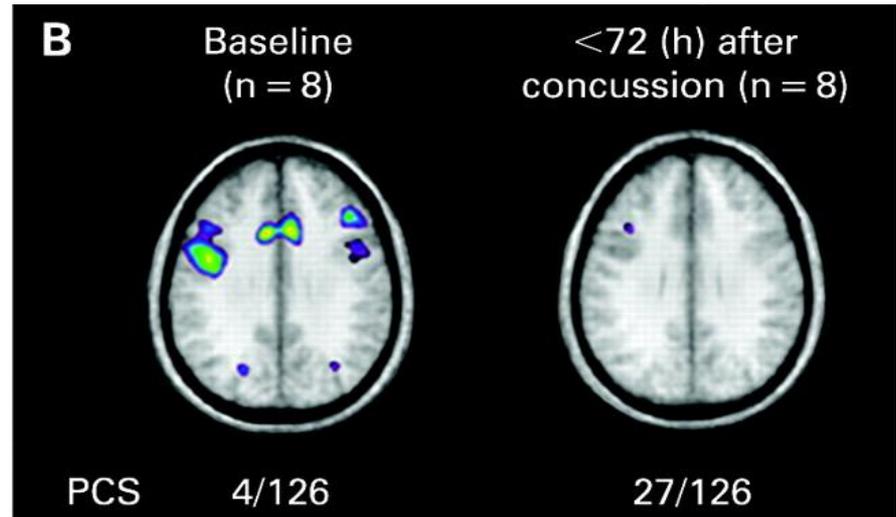
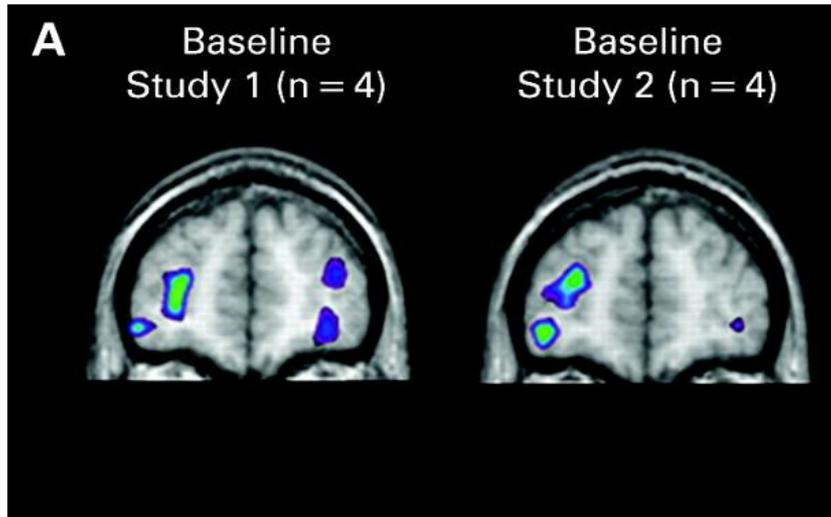


FIG. 1. Box plots displaying 25%, median and 75% (box) and 95% (whiskers) of the *N*-acetylaspartate (NAA) concentrations distributions in the white matter of post-concussive symptoms (PCS)-negative and PCS-positive mild traumatic brain injury patients, compared with their age- and gender-matched controls. Note that a highly significant ($p < 0.001$) NAA deficit is observed only in the PCS-positive cohort (124 × 105 mm; 300 × 300 DPI).

Functional MRI (fMRI)

- Images function by detecting the different magnetic properties of oxy- and deoxyhemoglobin
 - Blood Oxygen Level Difference (BOLD)
- Lack of radiation permits many images
- Good spatial and temporal resolution
 - Better than PET or SPECT
- Non-invasive

Functional MRI Utility Following Concussion



fcMRI: Connectivity

- Resting State fMRI
 - Assessment of BOLD during resting state
 - Permits assessment of connectivity between spatially distinct cerebral regions
 - Regions (neurons) that wire together, fire together

Conclusions

- CT/Standard MRI remain mainstay of clinical neuroimaging
- Newer assessments opening window to enhanced understanding

Thank you!

