

Neuroimaging Workshop — Faculty

Morning Session (9:00 – 11:00 AM)

- Sairah Bashir, MD — *Introduction to CT and MRI*
- Abhi Jain, MD — *Framework & Key Neuroimaging Pathologies*
- Usaama Khan, MD — *CTA / CTP Essentials*

Afternoon Session (12:30 – 2:00 PM)

- Carmel Armon, MD — *MRI Overview & Core Disease Concepts*
- Monika Ambrus, MD — *High-Yield Neuroimaging CT Case Review*

Introduction to CT and MRI

Black , white and Shades of Gray

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On the Brain

Butter Yellow—A Soft Hue With Neurological Implications

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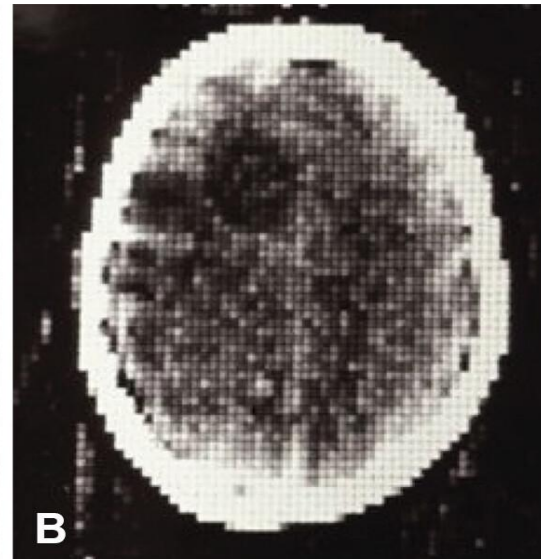
Agenda

- Introduction
- Brief History of CT and MRI
- CT and MRI Principles
- Review common sequences
- Approach to CT and MRI

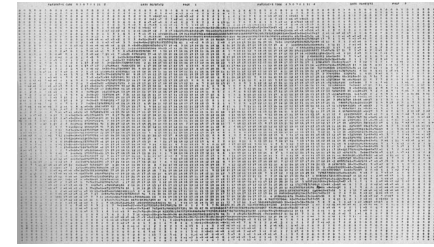
History of CT Scan

First CT scan (1971)

- Revealed a frontal lobe tumor in a 41-year-old woman
- First image took 9 days of data + 2.5 hours reconstruction



History of CT Scan

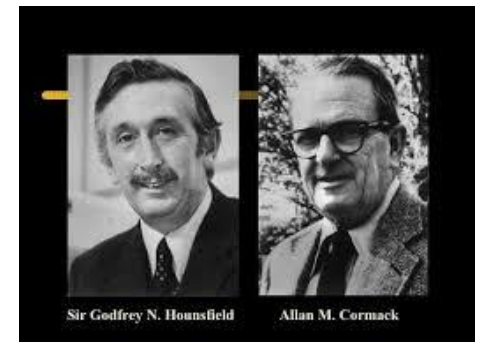


-Built by a music company: EMI--the label behind the Beatles

*Beatles' success helped fund CT innovation

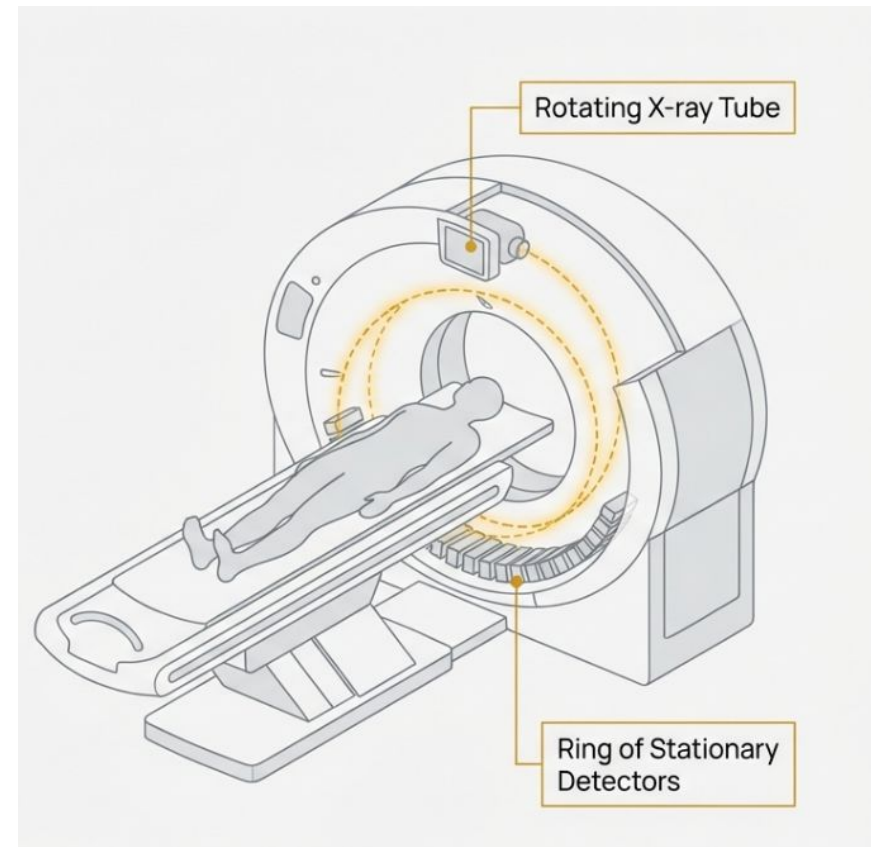
-Oldendorf known as the “Thomas Edison of medical device innovation”

-1979 Nobel Prize in Medicine awarded to Hounsfield & Cormack



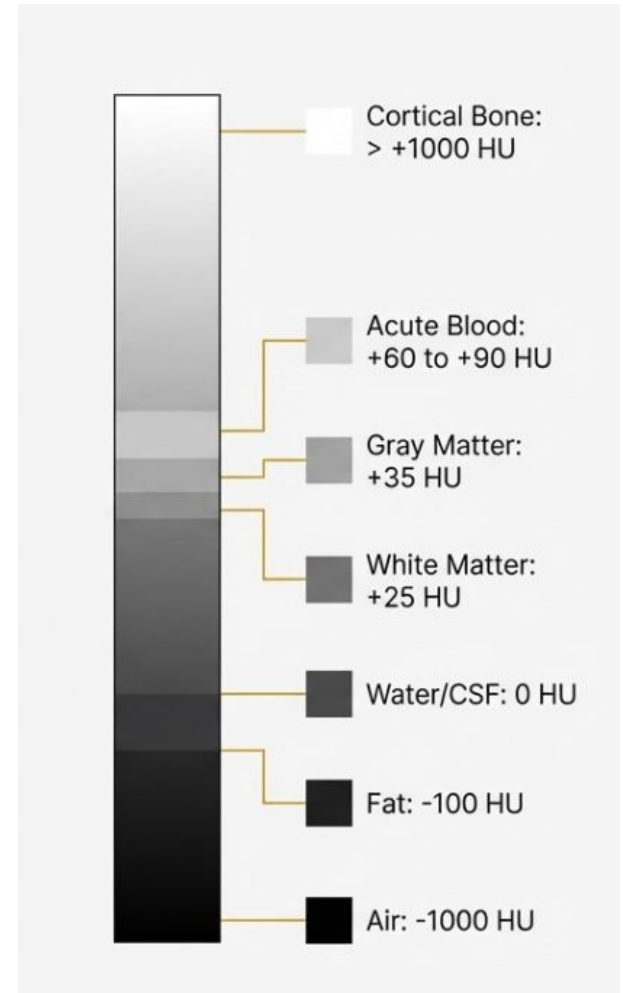
CT Physical Principles

- Rotating X-ray tube + stationary detectors in gantry
- Table moves → helical acquisition
- Photons attenuated differently by tissues
- Reconstruction into voxels with attenuation values (Hounsfield Units)



Hounsfield Units (HU)

- Bone $> +1000$ HU
- Acute blood $\approx 60\text{--}90$ HU
- Soft tissue $\approx 20\text{--}40$ HU
- Water = 0 HU (reference)
- Fat ≈ -100 HU
- Air ≈ -1000 HU



Seeing the Brain's Anatomy in Shades of Gray

On a CT, these HU values are translated into a grayscale image. Hyperdense (whiter) structures have high HU values, while hypodense (darker) structures have low HU values. Gray matter (~35 HU) appears slightly brighter than white matter (~25 HU) because it contains more cellular elements (neurons), while white matter contains more water and myelinated axons, lowering its density.

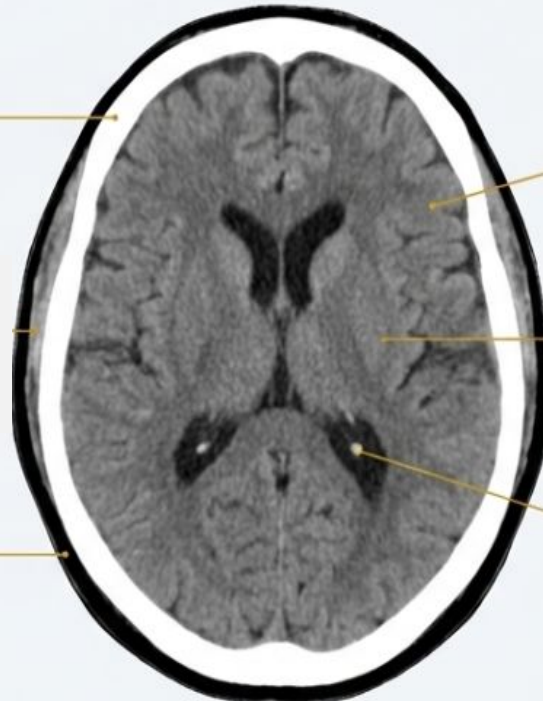
Skull:
Hyperdense, >+500 HU

Gray Matter:
Gray, ~35 HU

White Matter:
Dark Gray, ~25 HU

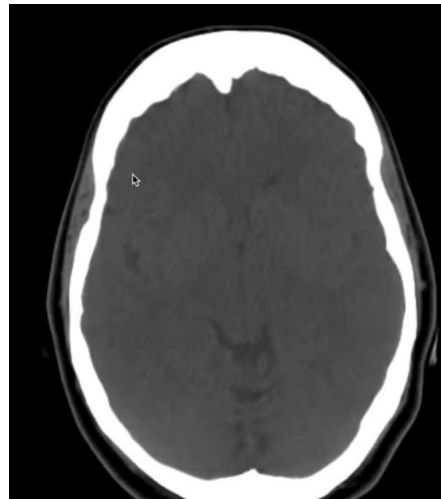
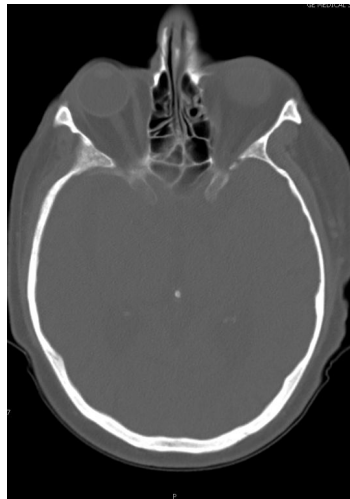
Air outside skull:
Pure Black, -1000 HU

CSF in Ventricles:
Black, ~0 HU



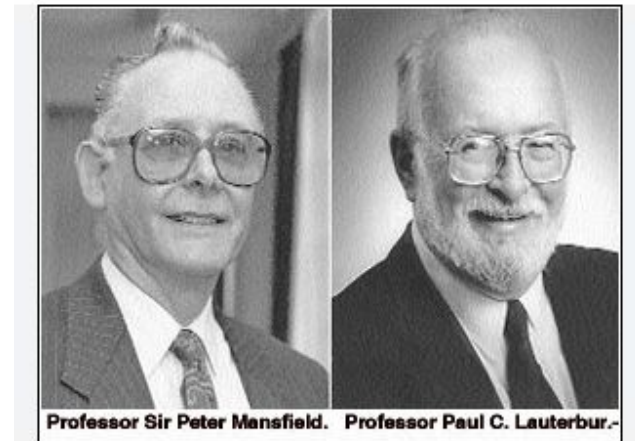
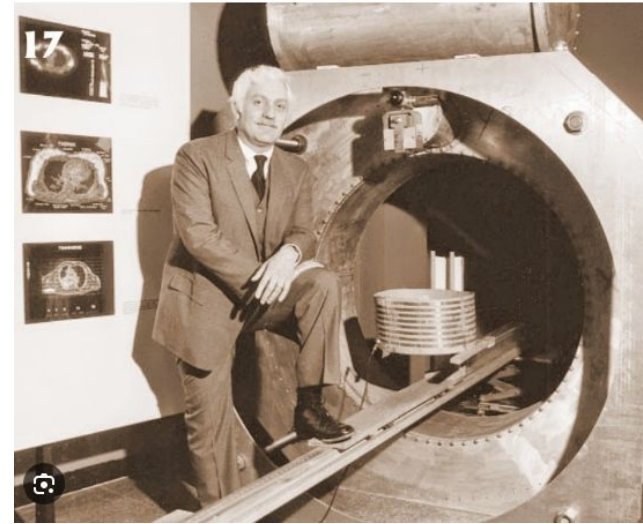
Common Windows

- Brain window: soft tissue contrast
- Bone window: detect fractures
- Subdural window: detect small SDH under skull
- Stroke window: enhance gray–white contrast



History of MRI

- 1930s: NMR discovered; Bloch and Purcell showed atoms respond to magnetic fields
- 1971: Raymond Damadian proposed using magnetic resonance to detect disease
- Built first MRI machine (“Indomitable”)
- 1977: First full-body human MRI scan performed
- MRI quickly evolved into a key diagnostic tool for brain, spine, joints, and cancer
- 2003: Nobel Prize awarded to Lauterbur & Mansfield for MRI discoveries



MRI physics

- MRI uses magnetic field and radiowaves, unlike CT
- Body is mostly water, which contains Hydrogen atoms
- Each Hydrogen atom has a proton that spins and behaves like a magnet
- MRI uses that proton behavior to create images

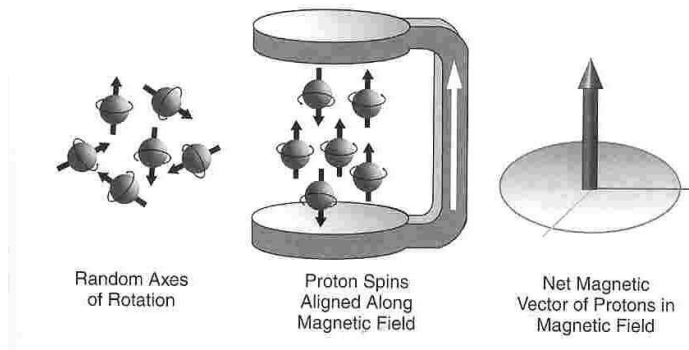


Figure 2-2

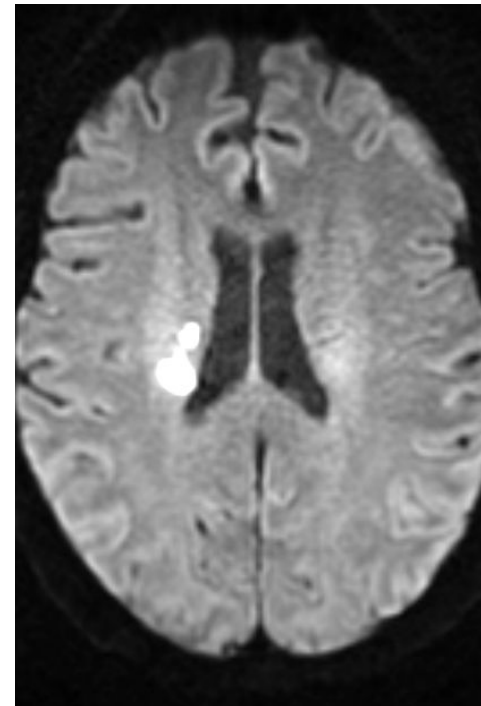
Proton rotational axis in the absence of a magnetic field (*left*) is random. In the presence of a magnetic field (*middle*), there is a net excess of protons aligned with the direction of the main magnetic field. This produces longitudinal magnetization (*right*).

MRI: Sequences Overview

- Diffusion Weighted Imaging (DWI & ADC)
- T1-weighted imaging
- T2-weighted imaging
- FLAIR
- GRE & SWI
- Post-contrast T1

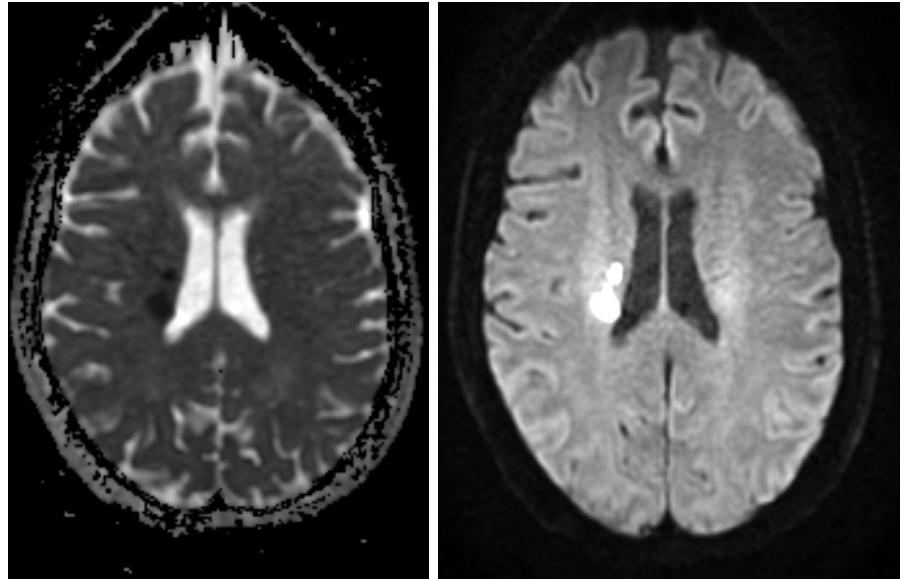
Diffusion Weighted Imaging (DWI)

- Part of every routine brain MRI
- Includes B0 and B1000 images
- High signal suggests restricted diffusion
- Useful for acute infarct & hypercellular tumors



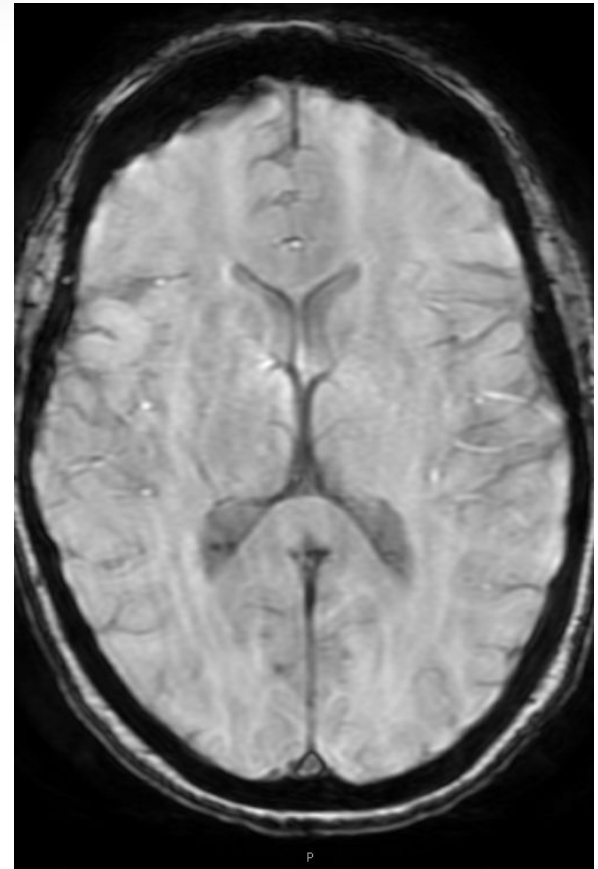
ADC Map

- Quantitative map derived from DWI
- Units: mm^2/s
- Restricted diffusion: low ADC
- T2 shine-through: high ADC with high DWI



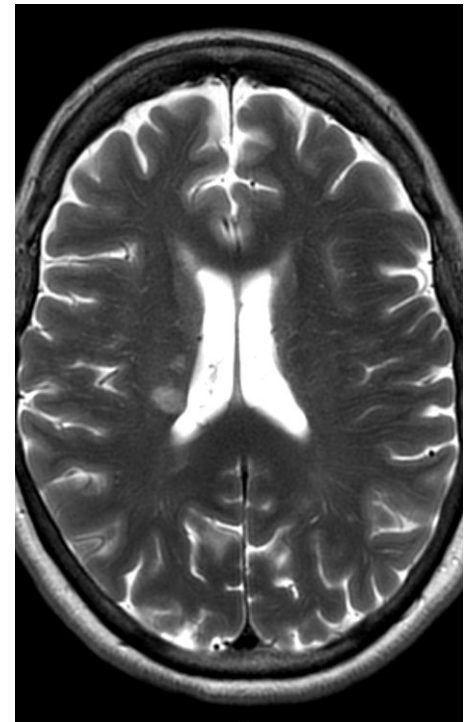
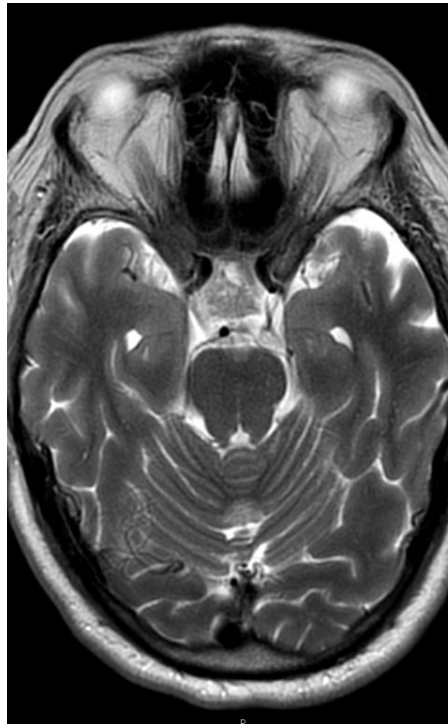
GRE / SWI

- Detect hemorrhage or calcification
- Useful for microbleeds and trauma
- SWI has enhanced susceptibility contrast



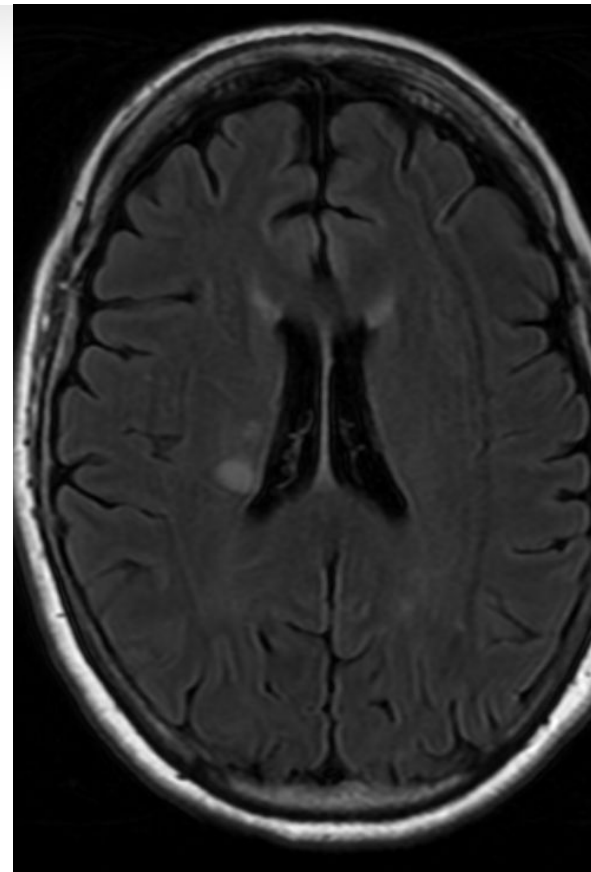
T2-Weighted Imaging

- - CSF is bright
- - Good for ventricles and CSF spaces
- - Edema = T2 bright
- - Assess flow voids (vessels appear dark)



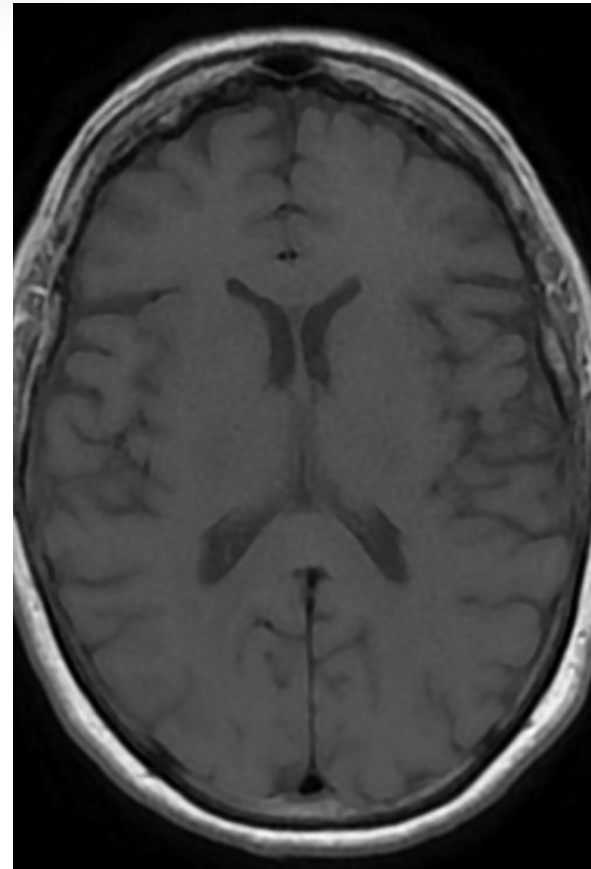
T2 FLAIR

- CSF signal is nulled
- Enhances parenchymal edema visibility
- Assess sulci for blood or inflammation
- Useful alternative when no T2 available



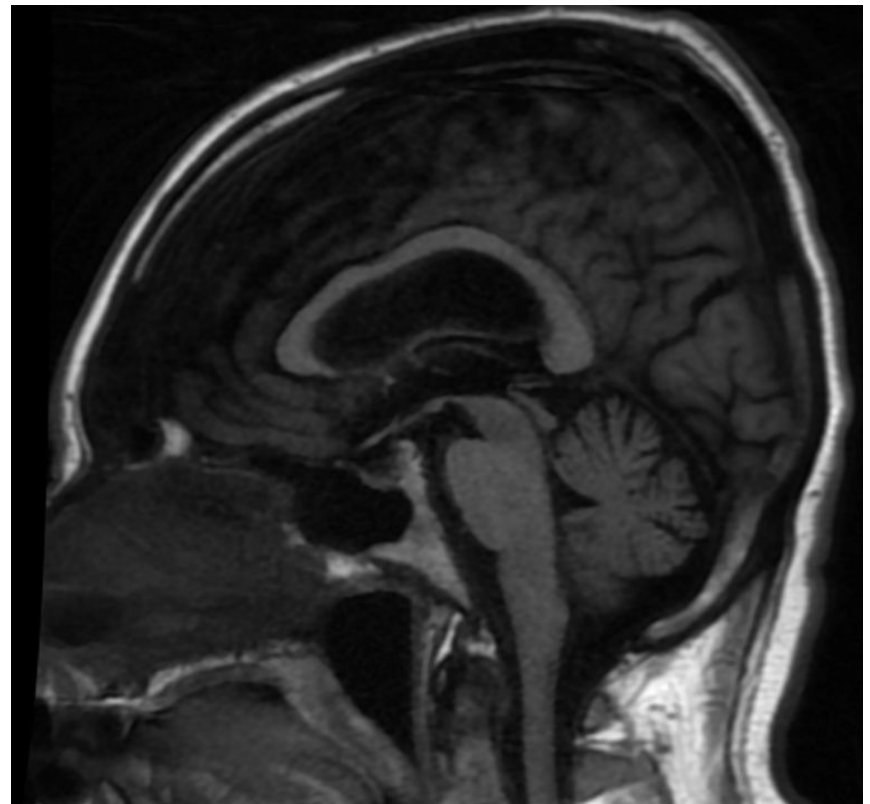
T1-Weighted Imaging

- Gray matter = gray, white matter = white
- CSF is dark
- Excellent for midline structures
- Can be 2D or 3D volumetric



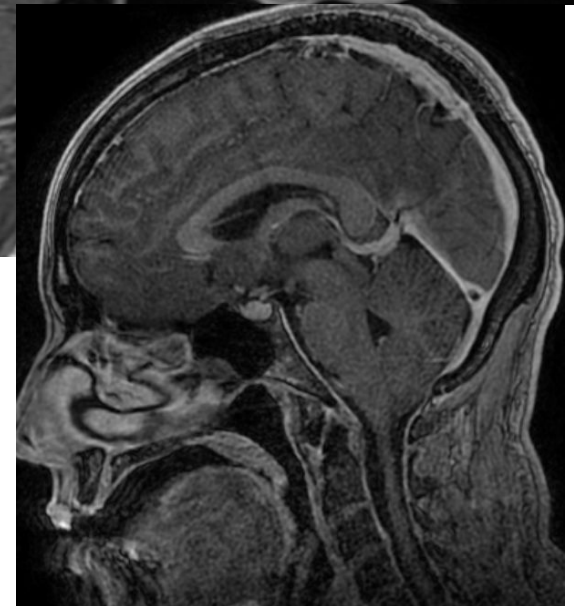
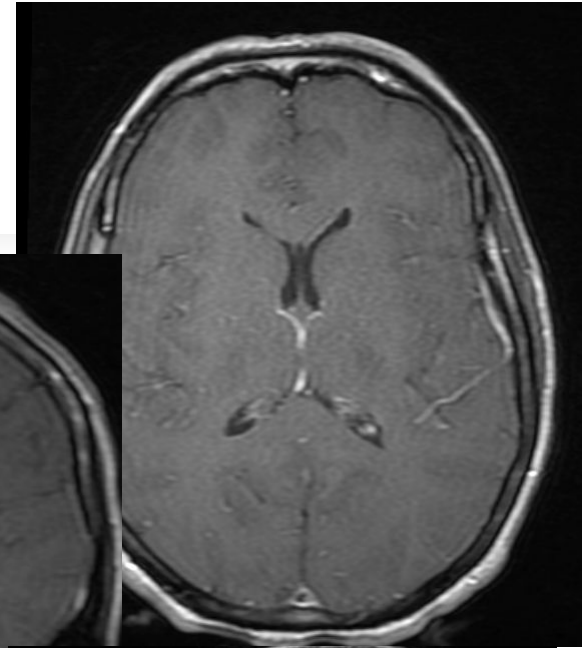
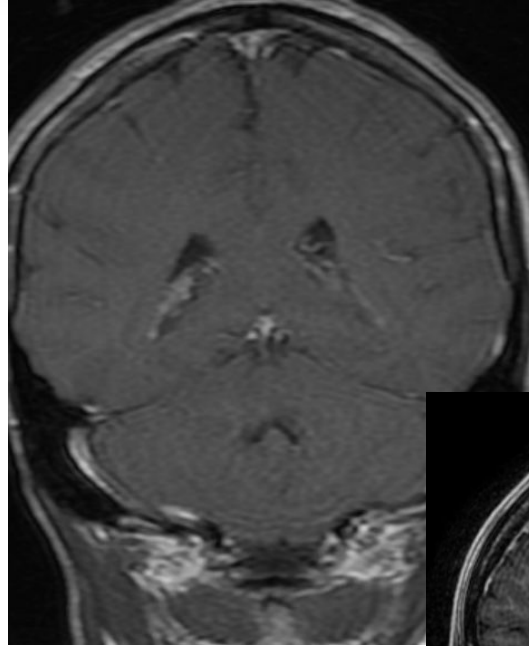
Sagittal t1

- Great for structural orientation
- brainstem, cerebellum, ventricles, and corpus callosum, CMJ, Pituitary



Post-Contrast T1

- Gadolinium leaks when BBB disrupted
- T1 shortening = enhancement
- Compare pre- and post- images
- Vessels may enhance depending on protocol



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