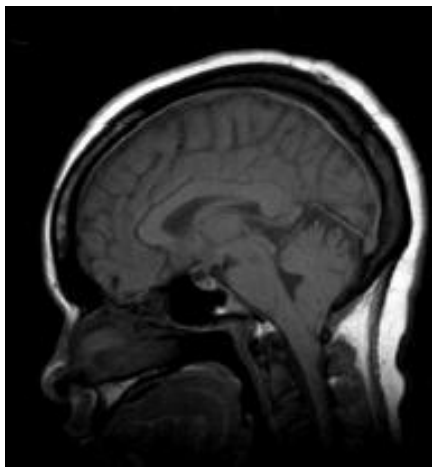
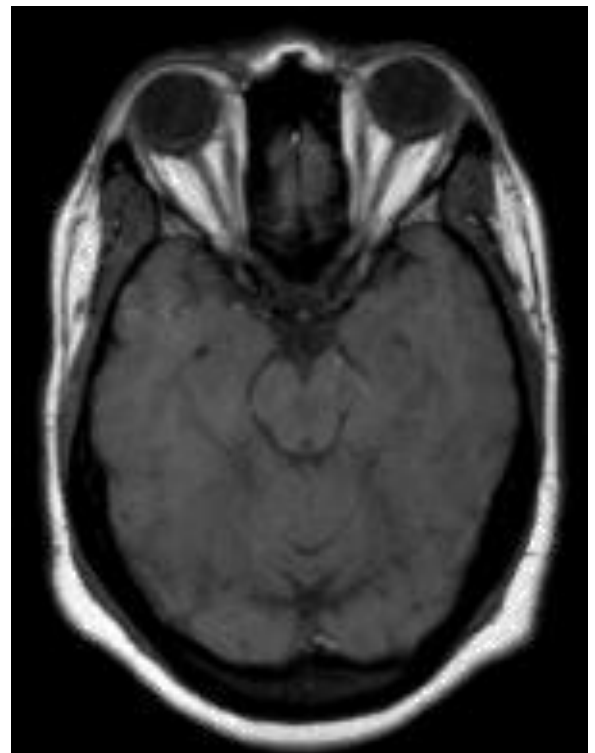
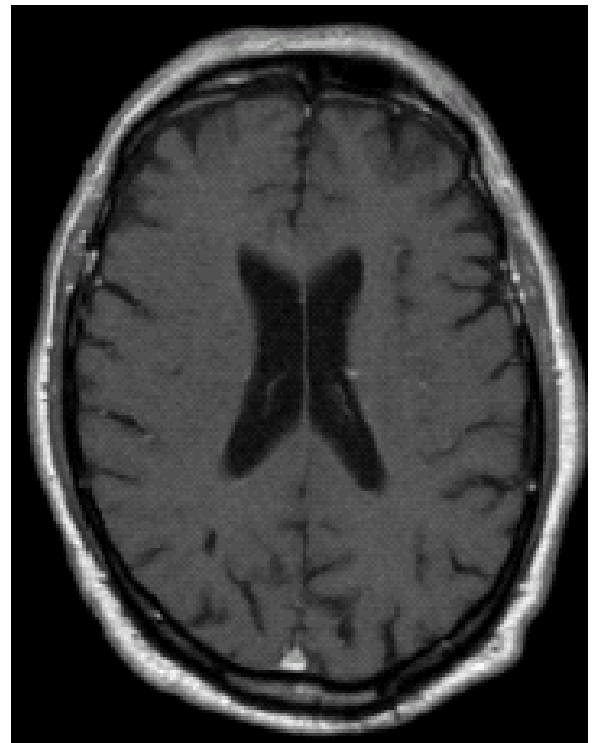


MRI for Neurology

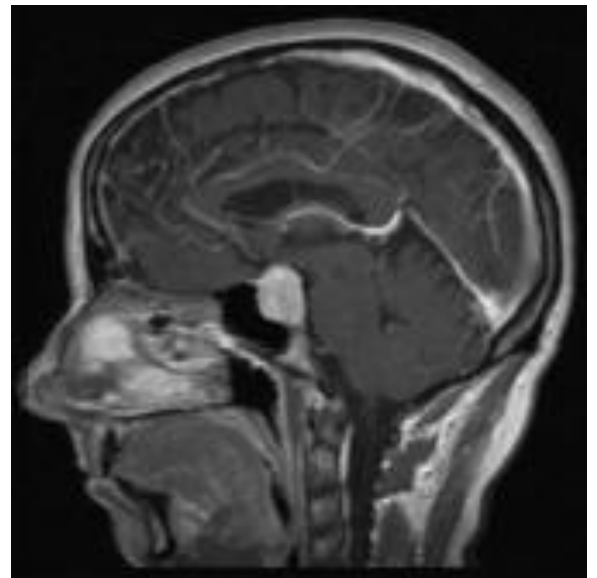
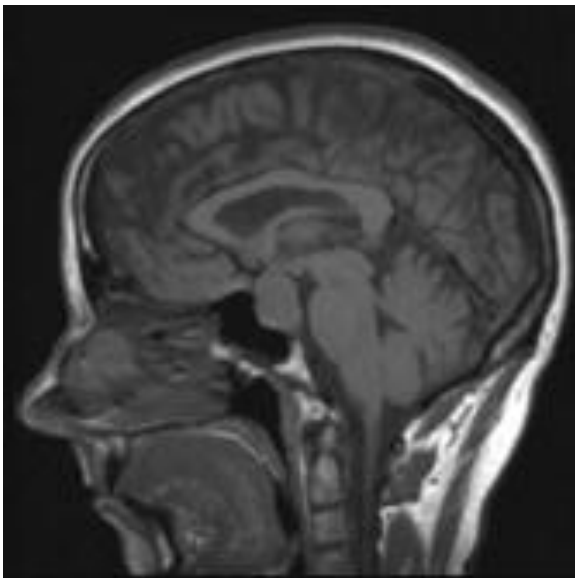
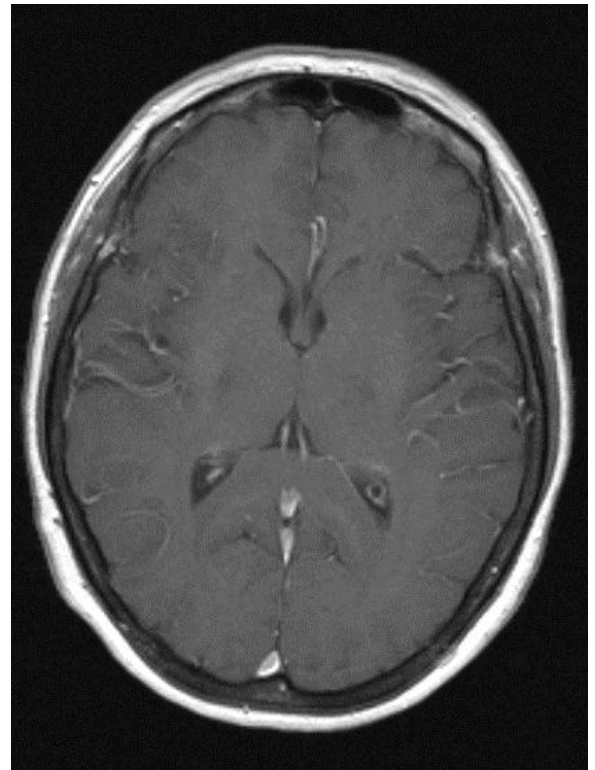
T1-weighted images (T1)

- Black on T1 (no water or fat protons)
 - Air
 - Calcium
 - Dense bone
- Dark on T1 (long T1)
 - CSF
 - Edema
 - Most lesions
- Grey on T1
 - White matter, gray matter
- Bright on T1 (short T1)
 - Fat
 - Blood (methemoglobin)
 - Gadolinium (Gd, contrast)
- Useful for:
 - Borders between brain and CSF (e.g., sulci, ventricles, cysts)
 - Not very sensitive to lesions
 - *Pre-contrast image
- Recognition
 - Repeated in multiple orientations
 - Looks like CT:
 - Ventricles dark
 - Scalp bright
 - Orbits: bright; globes: black
 - Vessels: normally not seen
- Sample Codes:
 - Stroke_BJC/T1_TRA
 - Stroke_BJC/T1_SAG
 - Stroke_BJC/T1_COR



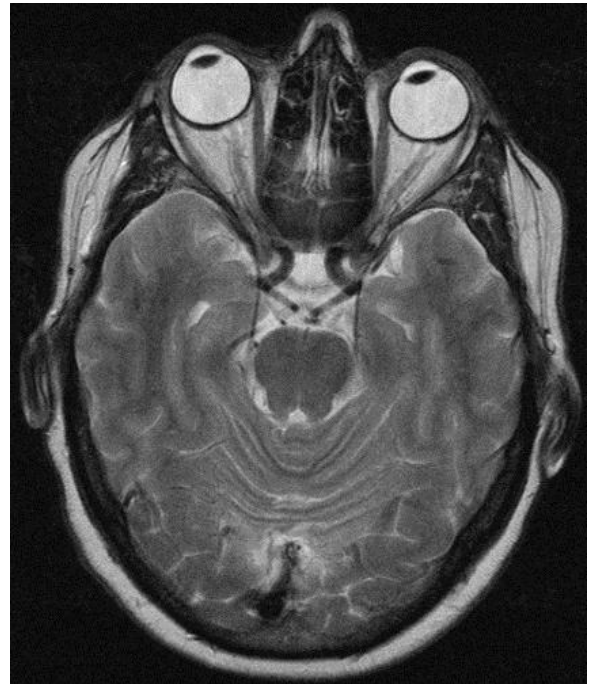
T1-weighted images with Gd contrast

- Sensitive to presence of vascular or extravascular Gd
- Useful for visualization of:
 - Normal vessels
 - Vascular changes
 - Disruption of blood-brain barrier
- Look for: Bright on Gd and NOT bright on non-contrast
- Recognition
 - Displayed after non-enhanced images (usually performed last)
 - Like non-contrast T1 but with bright arteries and veins
- Sample Codes:
 - Stroke_BJC/T1_TRA_SE_contr
 - Stroke_BJC/T1_SAG_SE_contr
 - Stroke_BJC/T1_COR_SE_contr



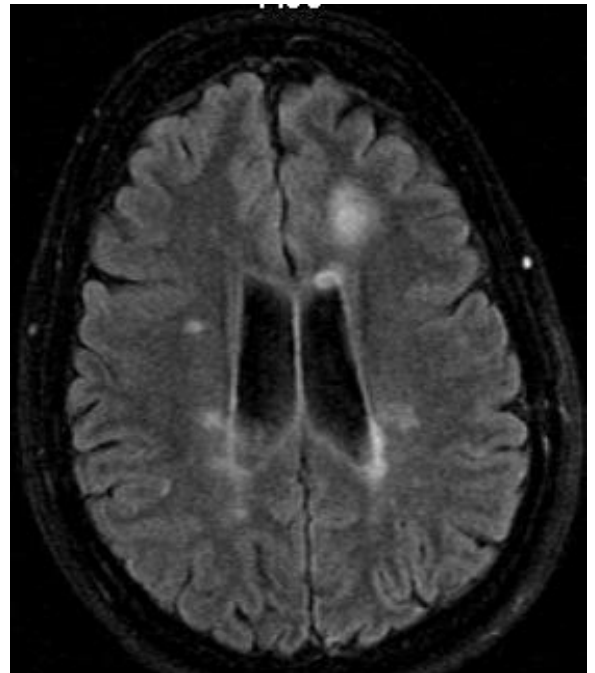
T2-weighted images (T2)

- Black on T2 (no protons)
 - Air
 - Calcium
 - Dense bone
 - Flow
- Dark on T2 (long T2)
 - White matter
 - Gray Matter
- Bright on T2 (short T2)
 - CSF
 - Blood (except deoxyhemoglobin)
 - Edema
 - Most lesions
- Useful for:
 - Brain anatomy (shows CSF spaces)
 - Most brain lesions
 - But can't distinguish lesions from CSF (ventricles, sulci)
- Recognition
 - CSF (ventricles, cisterns, sulci): bright
 - Scalp: bright
 - Eyes: bright
 - Vessels: black (flow void)
- Sample codes:
 - Stroke_BJC/T2_TRA_TSE



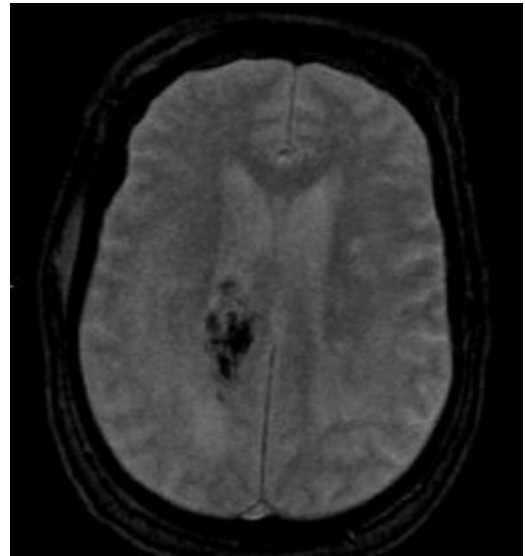
FLAIR (Fluid Attenuated Inversion Recovery)

- Same as T2 except free CSF (ventricles, cisterns, sulci) is suppressed (black)
- Most pathology is **BRIGHT**
- Useful for:
 - Same as T2
 - Most lesions
 - Especially good for lesions near ventricles or sulci (MS)
 - Sometimes improves gray/white distinction
- Recognition
 - Superficially resembles T1
 - Bright pathology
 - Often bright areas around ventricles
- Sample codes:
 - Stroke_BJC/T2_TRA_TFLAIR



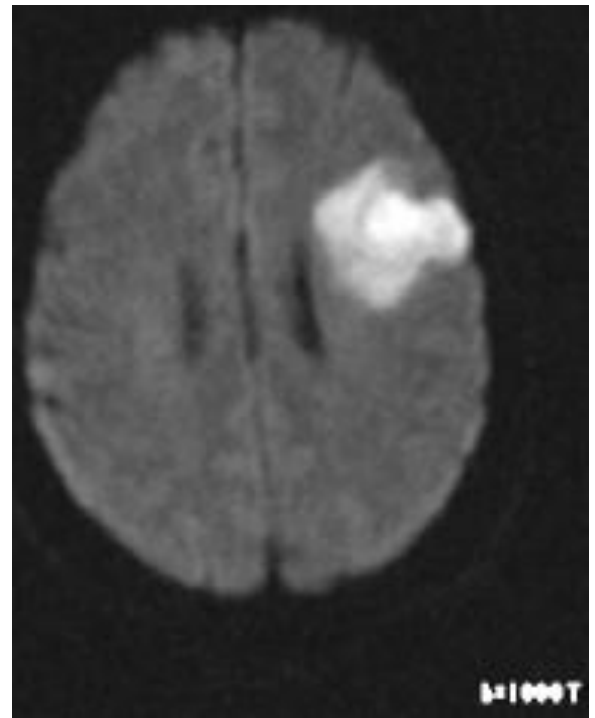
T2* (T2-star, or SWI)

- Form of T2-weighted image which is susceptible to *iron or calcium*
- Blood, bone, calcium appear *dark*
- Area of blood often appears much larger than reality (“blooming”)
- Useful for:
 - Identification of early hemorrhage
- Look for: **DARK** only
- Recognition:
 - Like T2 except
 - Cranium, scalp are dark or absent
 - Dark areas near frontal and temporal bones
 - Hemorrhage is darker than brain
- Sample codes:
 - Stroke_BJC/ EPI_T2_STAR



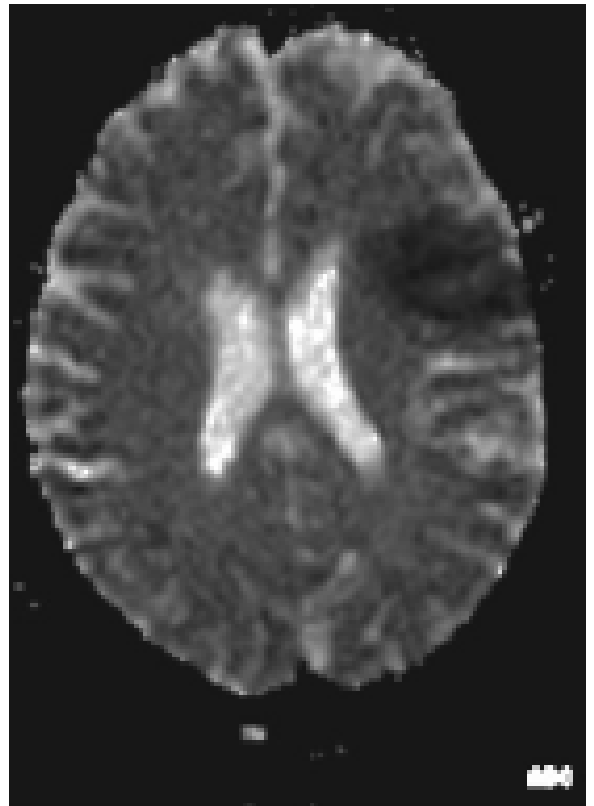
Diffusion-weighted image (DWI)

- Sensitive to passive diffusion of water
 - May be related to portion of intracellular vs extracellular water
 - Image is average of diffusion tensors in 3 dimensions
- Areas of restricted diffusion are *bright*
- High T2 signal is also bright (“T2 shine-through”; see ADC below)
- Restricted diffusion occurs in cytotoxic edema:
 - Ischemia (possibly within minutes)
 - Seizures
 - Abscess
 - Not other structural lesions such as tumors, vasogenic edema
- Look for: **BRIGHT** only
- Recognition
 - Some marked b=900T or b=1000T at bottom, others marked DIFF-TRACE, etc
 - Usually the completed DWI sequence (20 images) appears *after* many other sequences
 - Low-resolution image (typically 20 slices)
 - *Ignore other sequences:*
 - b=0, b=50, b=1000P, b=1000Q, b=1000R, b=1000S
- Sample codes:
 - Stroke_BJC/DWI_TRACE_TRA or
 - TRAN EP2D DIFF



Apparent Diffusion Coefficient (ADC Map)

- Contains actual data relevant to diffusion image
- Areas of restricted diffusion are *dark*
- Useful for:
 - Excluding T2-shine through
 - Real restricted diffusion is bright on DWI, dark on ADC
- Look for: **DARK** only
- Recognition
 - Images marked ADC
 - Grainy dark images
- Sample codes:
 - Stroke_BJC/DW_ADC_TRA



Infarction in CT Imaging of the Brain in Acute Stroke

- Infarction: focal hypodense area, in cortical, subcortical, or deep gray or white matter, following vascular territory, or watershed distribution. Early subtle findings include obscuration of gray/white matter contrast and effacement of sulci, or "insular ribbon."
- Hemorrhage: hyperdense image in white or deep gray matter, with or without involvement of cortical surface (40 to 90 HU). Petechial refers to scattered hyperdense points, coalescing to form irregularly hyperdense areas with hypodense interruptions. Hematoma refers to a solid, homogeneously hyperdense image.
- Hyperdense image in major intracranial artery: suggestive of vascular embolic material.
- Calcification: hyperdense image within or attached to vessel wall (>120 HU).
- Incidental: silent infarct, subdural collection, tumor, giant aneurysm, arteriovenous malformation.

Infarction in MRI of the Brain in Acute Stroke

- Acute: Subtle low signal (hypointense) on T1, often difficult to see at this stage, and high signal (hyperintense) on spin density and/or T2-weighted and proton density-weighted images starting 8 h after onset; should follow vascular distribution. Mass effect maximal at 24 h, sometimes starting 2 h after onset, even in the absence of parenchymal signal changes. No parenchymal enhancement with paramagnetic contrast agent. Territorial intravascular paramagnetic contrast enhancement of "slow-flow" arteries in hyperacute infarcts; at 48 h, parenchymal and meningeal enhancement can be expected.
- Subacute (1 wk or older): Low signal on T1, high signal on T2-weighted images. Follows vascular distribution. Revascularization and blood-brain barrier breakdown may cause parenchymal enhancement with contrast agents.
- Old (several weeks to years): Low signal on T1, high signal on T2. Mass effect disappears after 1 mo. Loss of tissue with large infarcts. Parenchymal enhancement fades after several months.

Hemorrhage in Brain CT/MRI

	Age	CT	T1-weighted MRI	T2-weighted MRI	Explanation for susceptibility effects on MRI	Mnemonic for T1/T2
Hyperacute	<~8 hours	hyperdense	iso- to hypointense	hyperintense	oxyhemoglobin	ibby
Acute	~8-72 hours	hyperdense	iso- to hypointense	hypointense	deoxyhemoglobin	iddy
Early Subacute	~3-7 days	hyperdense	hyperintense	hypointense	intracellular methemoglobin	biddy
Late Subacute	~1 wk-months	isodense	hyperintense	hyperintense/ hypointense rim	free methemoglobin/ hemosiderin rim	baby
Chronic	months-years	hypodense	hypointense	hypointense	hemosiderin, ferritin	doodoo

If we wanted to extend the mnemonic to include the hyperacute stage, it would be **ibby iddy biddy baby doodoo** (but that kind of ruins the mnemonic). [**b** stands for bright or hyperintense, **d** stands for dark or hypointense, and **i** stands for iso-intense.]

Sources:

Table modified by Allyson Zazulia, MD (2009).

[Practice Guidelines for the Use of Imaging in Transient Ischemic Attacks and Acute Stroke.](#)

A Report of the Stroke Council, American Heart Association (1997)