

Neuroradiology for Advanced Practice Providers



CORA FIX, PA-C

August 2022

Objectives

- Understand the indications for contrast for brain and spine imaging.
- Be able to recommend the appropriate type of imaging based on patient complaint or physical exam findings
- Describe basic patterns of disease on imaging

My Goals for you

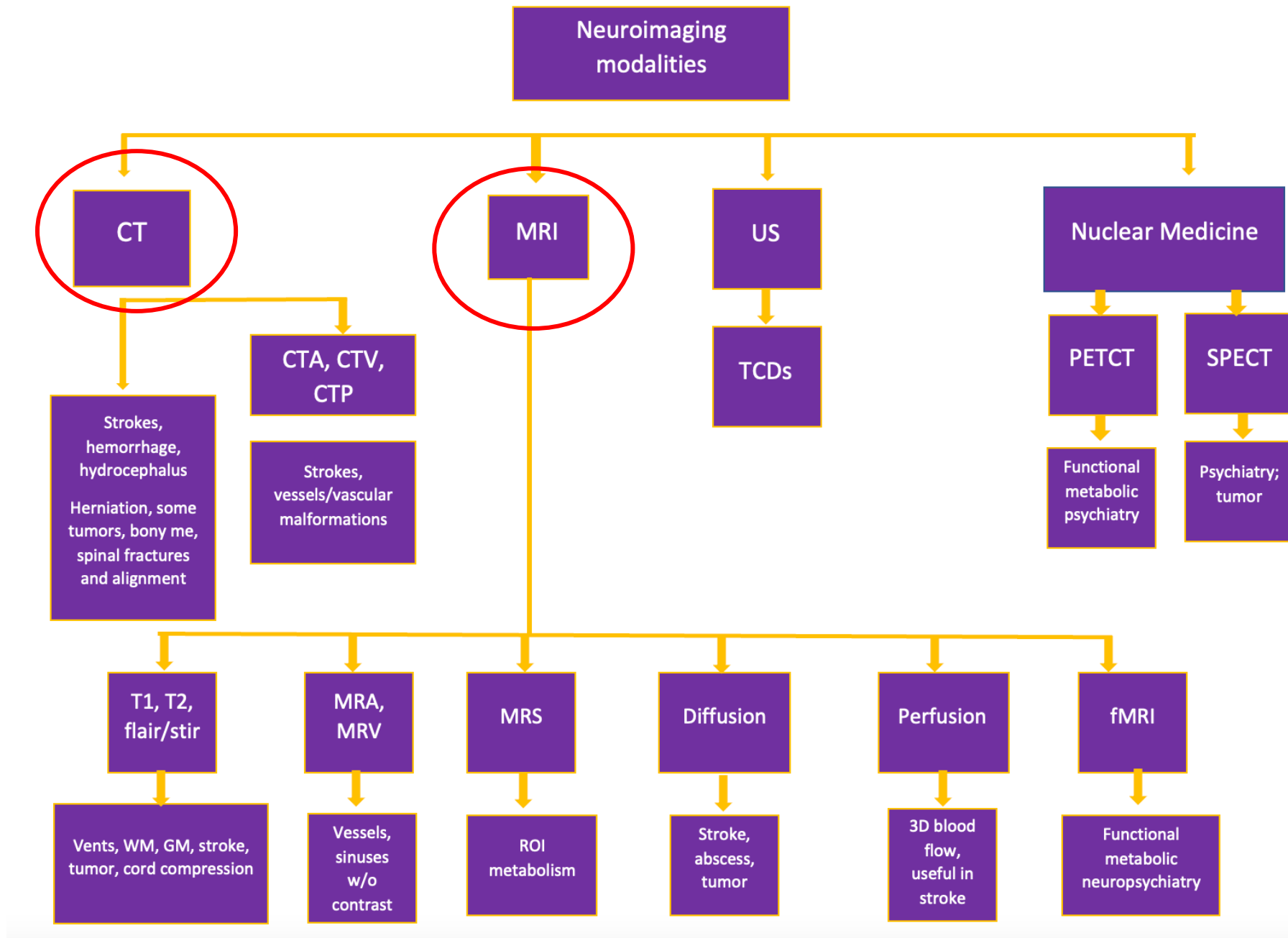
- Personally review neuroimaging you order
- Incorporate image review into patient encounters
- Develop a systematic approach to ordering and reviewing neuroimaging
- Feel more confident discussing imaging findings with radiology and specialty colleagues

Why not just look at the read?

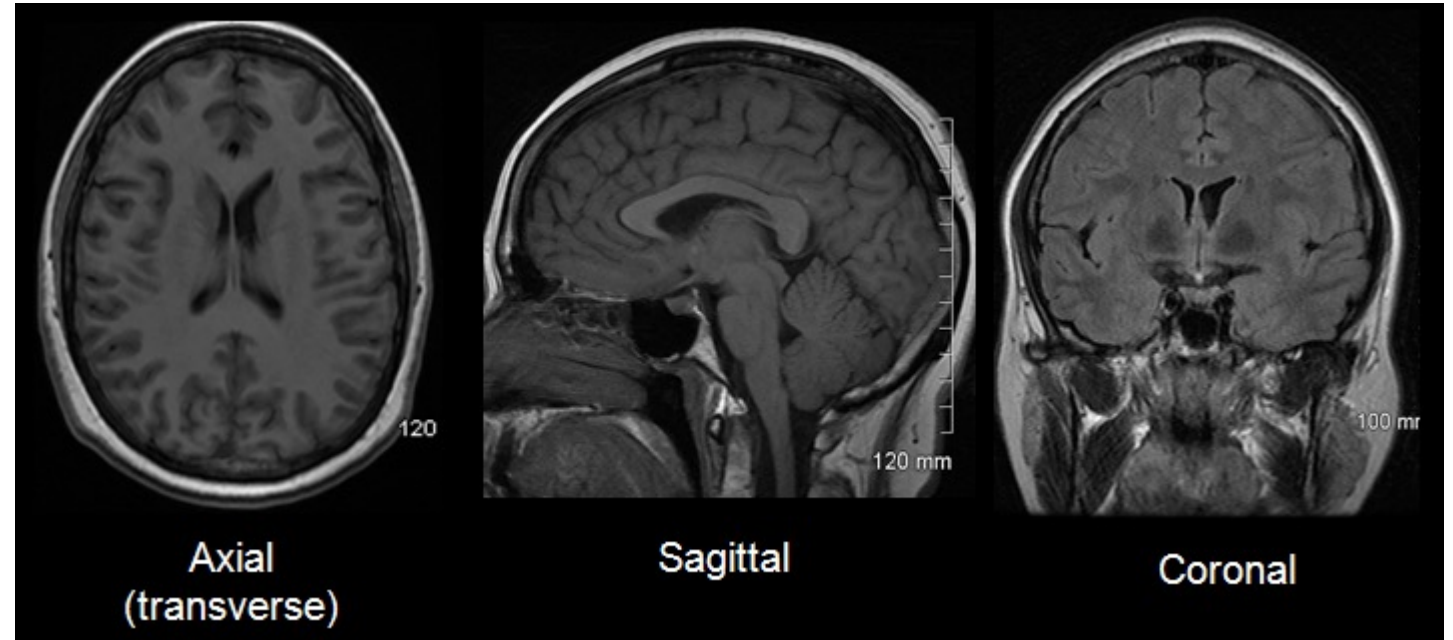
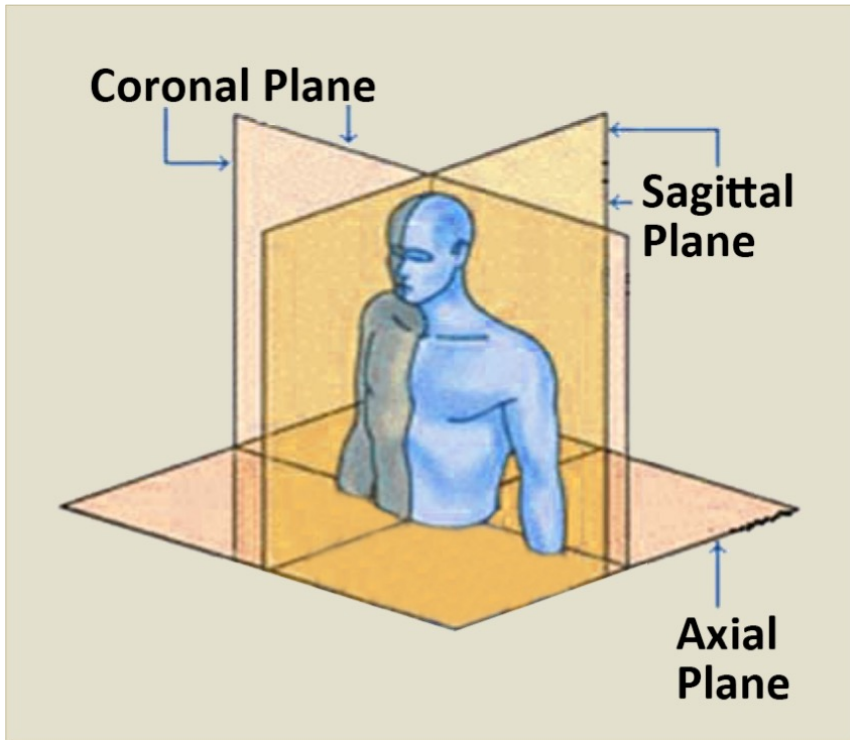
A picture is worth 1,000 words

- Radiologists are Human
- Quickly look for the glaring positives
- Improved patient understanding and satisfaction
- Drew T, Võ ML, Wolfe JM. The invisible gorilla strikes again: sustained inattentional blindness in expert observers. *Psychol Sci*. 2013 Sep;24(9):1848-53. doi: 10.1177/0956797613479386. Epub 2013 Jul 17. PMID: 23863753; PMCID: PMC3964612.





Basics



R



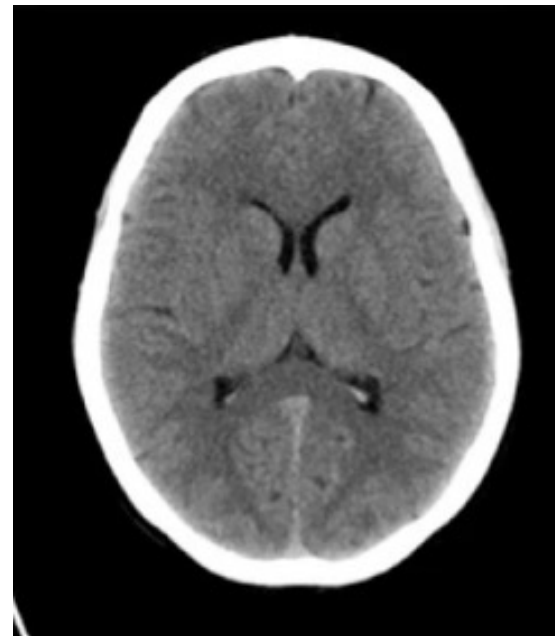
L

COMPUTED TOMOGRAPHY (CT)

Advantages: Cheap, fast (<10min). Great for uncooperative patients, excellent for bones/blood.

Disadvantages: Radiation, Inferior to MRI in resolution and contrast. Not useful in spinal cord imaging.

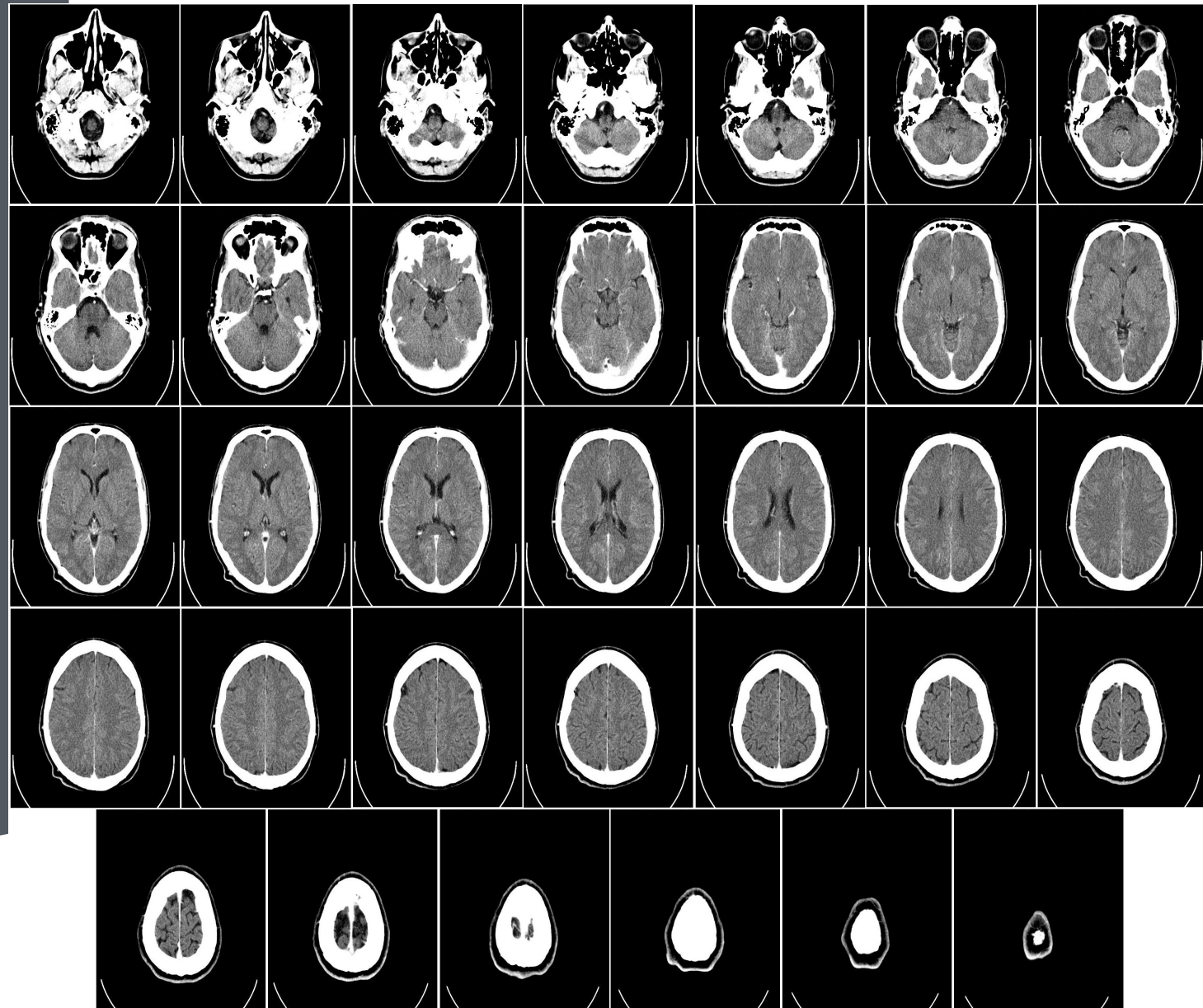
Tissue	Appears	Term
Bone Acute blood	Bright/white	Hyperdense
Gasses & liquids Tumor, Infarct	Dark/black	Hypodense
Soft tissue/brain	grey	isodense



Case courtesy of Bruno Di Muzio, Radiopaedia.org, rID: 46533

APPROACH TO LOOKING AT CT HEAD

- Start at the bottom or top and slowly scroll through, looking at:
 - Brain- Look for symmetry, gray white differentiation, shift, gyri/sulci, hypodensity
 - CSF: Subarachnoid space and Ventricles: look for compression/shift. Hydrocephalus (first evident in temporal horns). Basal cisterns
 - Blood- Evaluate for hemorrhage (bright acute, isodense 1-2 weeks, hypodense 2-3 weeks)
 - Soft tissues and Bone- evaluate for fractures/mets



When to choose CT

Does your differential include

- Bleed
- Trauma
- Stroke
- Hydrocephalus
- Fracture



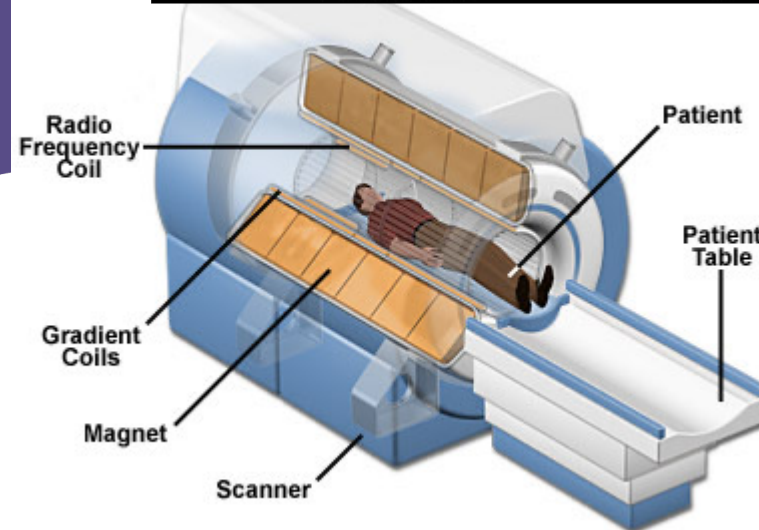
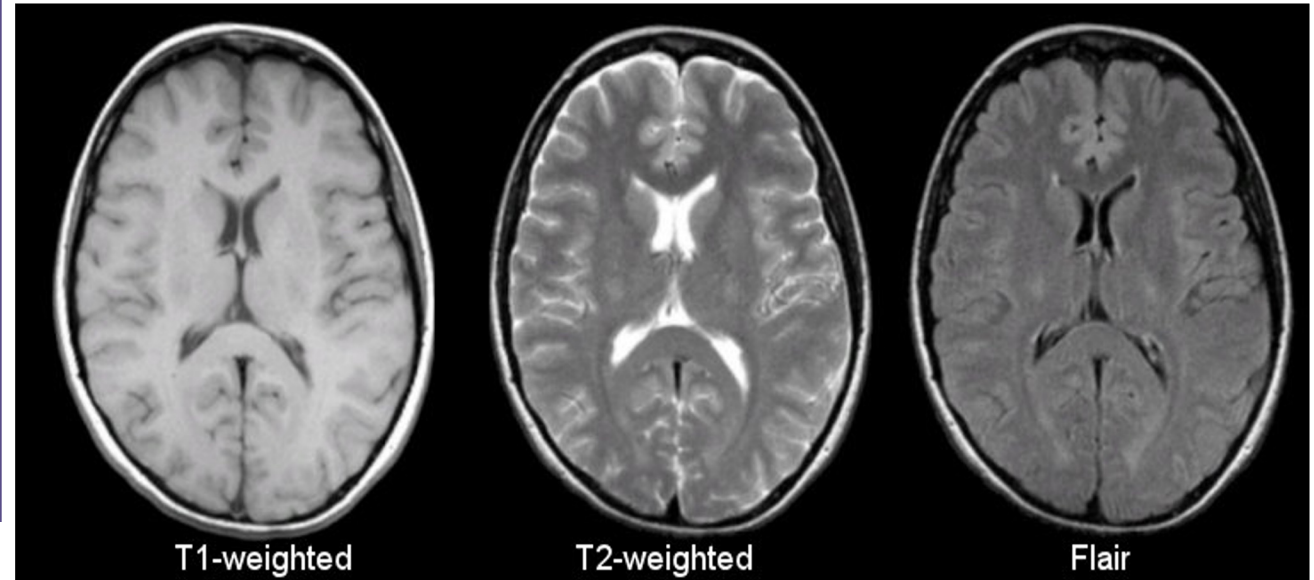
MAGNETIC RESONANCE IMAGING (MRI)

Advantages: No radiation

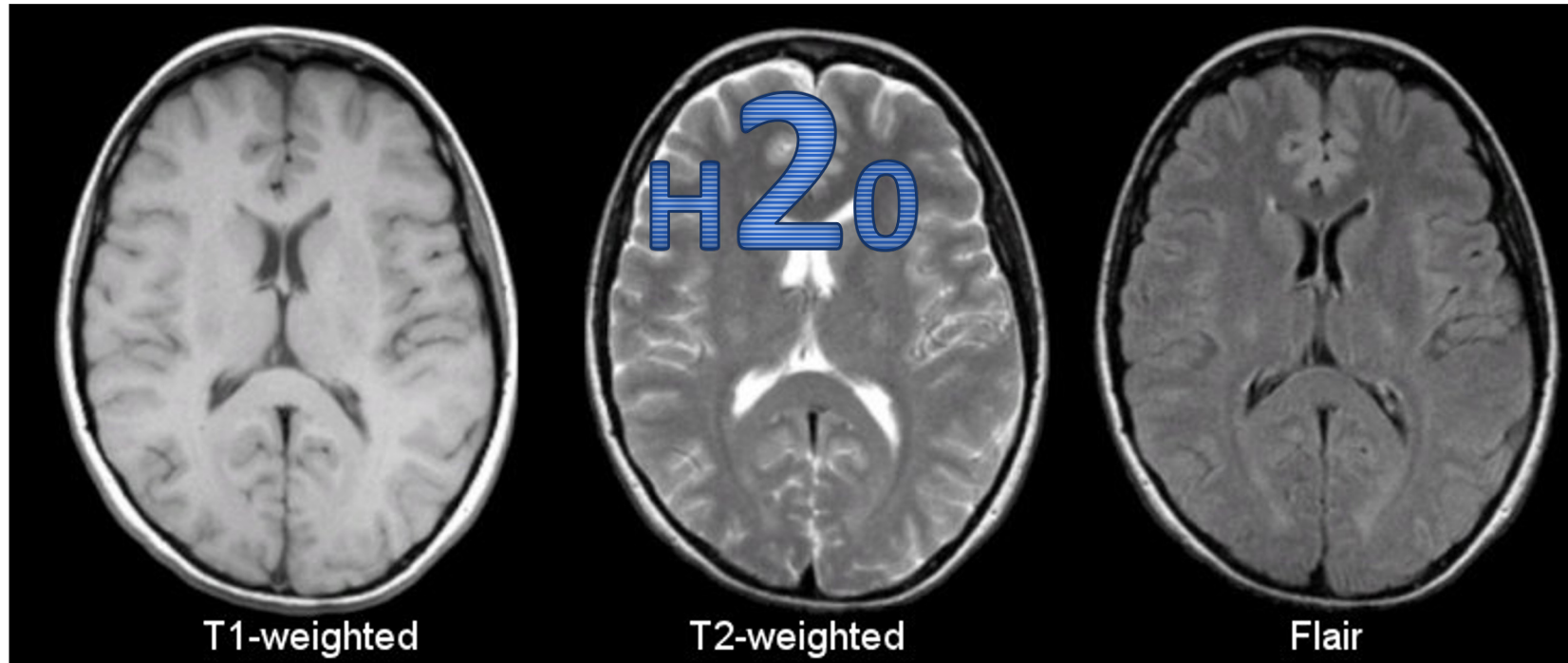
Better contrast resolution, better stroke detection, better at identifying and characterizing tumors. Much better for spine

Disadvantages: Time, \$, Claustrophobia, not compatible with pacemaker, ICD, must be protocolled

Differences in tissue contrast are due to differences in signal intensity of different tissues and the MRI sequence



Know which sequence you are looking at and what “normal” looks like



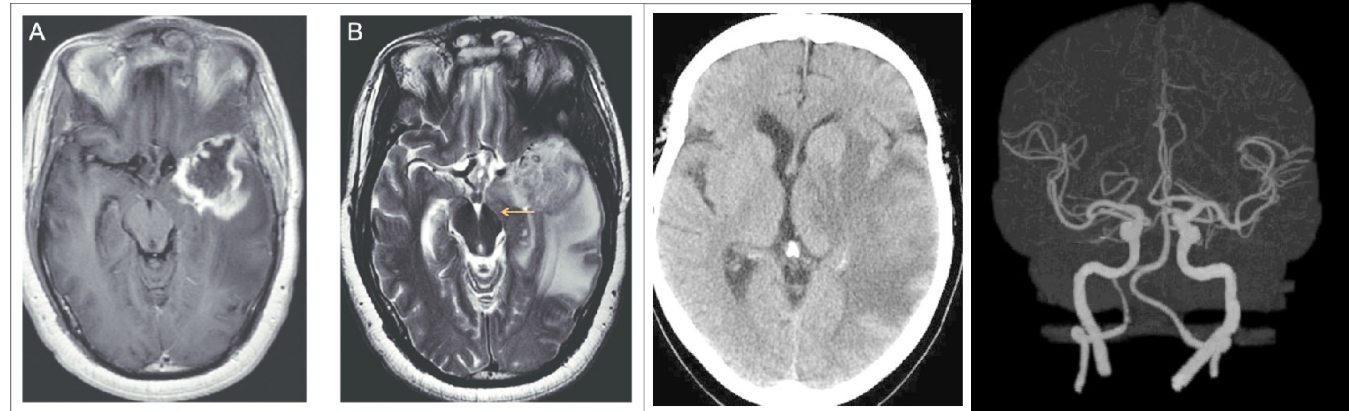
Tissue	T1	T2	FLAIR
CSF	Dark	Bright	Dark
White matter	Light	Dark grey	Dark grey
Cortex	Grey	Light grey	Light grey
Inflammation	Dark	Bright	Bright
Fat (w/in marrow)	Bright	Light	light

WHEN DO I NEED CONTRAST?

Healthy capillaries keep contrast agents in the blood stream. When capillaries are abnormal or leaky (cancer and infection), contrast material will diffuse into the abnormal tissue and the tissue will “enhance”

MRI = Gadolinium

CT= Iodinated



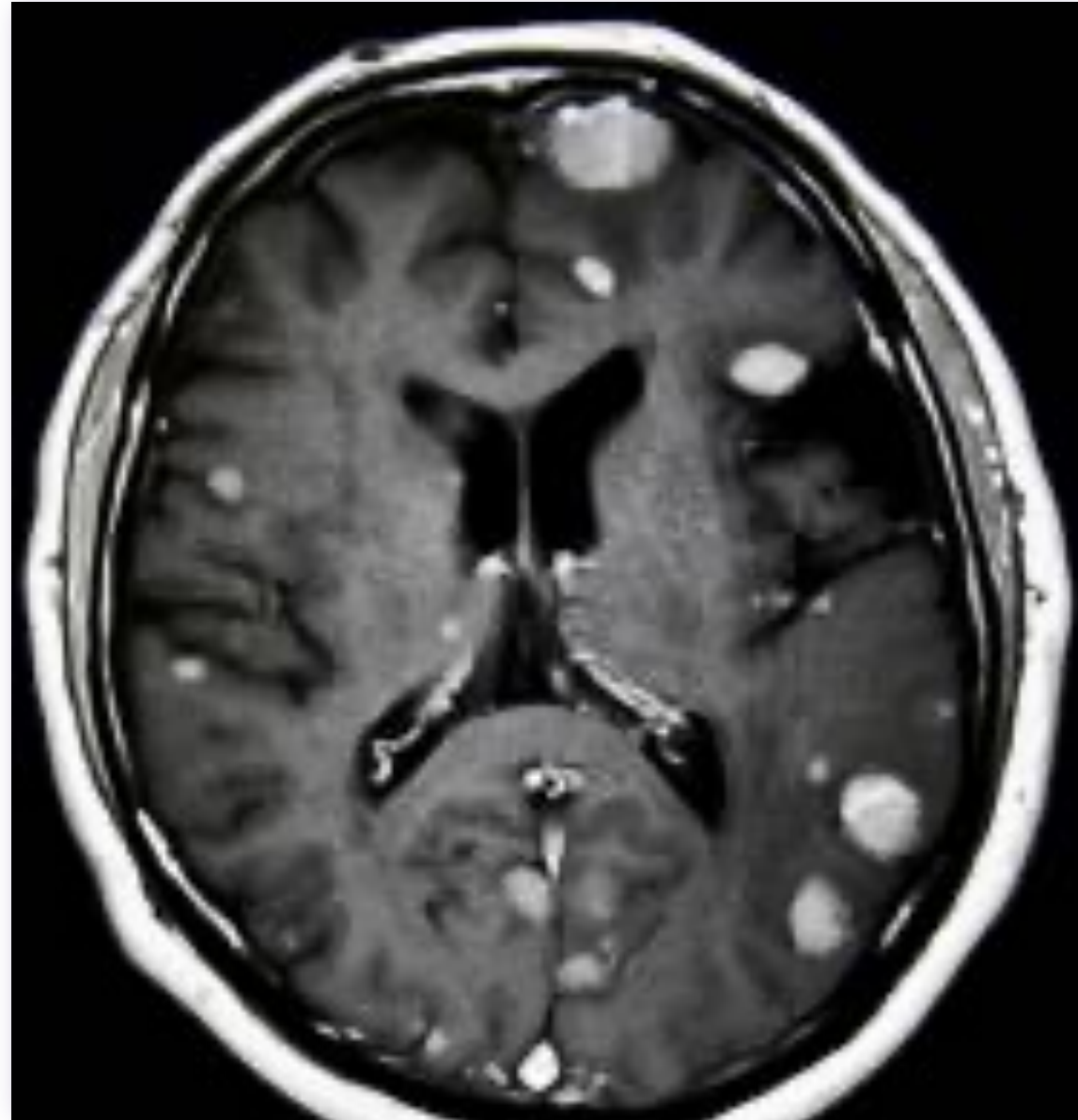
Which MRI sequence best depicts the abnormality

- T2 – Water and fluid containing tissue is bright. Fat and bone dark. **Good for looking for edema, demyelination, infarction, chronic hemorrhage**
- T1- Water and fluid containing tissue dark, fat /bone bright. **Best for anatomic details grey/white matter**
- T1 + GAD- Best to identify **tumor, leptomeningeal involvement, infection**
- FLAIR- Fluid attenuating Inversion Recovery- Free water dark, edematous tissue bright. **GOOD for looking at vasogenic edema (BRAIN), demyelination, infarction**
- STIR (Short Tau Inversion Recovery) suppresses signal coming from fatty tissues – so **ONLY WATER** is bright and good for looking for **marrow edema in spine**
- DWI- Designed to detect spontaneous water movement. Restricted (bright) in ischemic brain. Best **early stroke detection, abscess**

Brain metastasis/tumor

Order: MRI brain w/wo contrast

- FLAIR to look for swelling
- T1 + Gd to look for enhancing lesions



Leptomeningeal metastasis

Order: MRI w/o contrast, include any deficits in imaging order

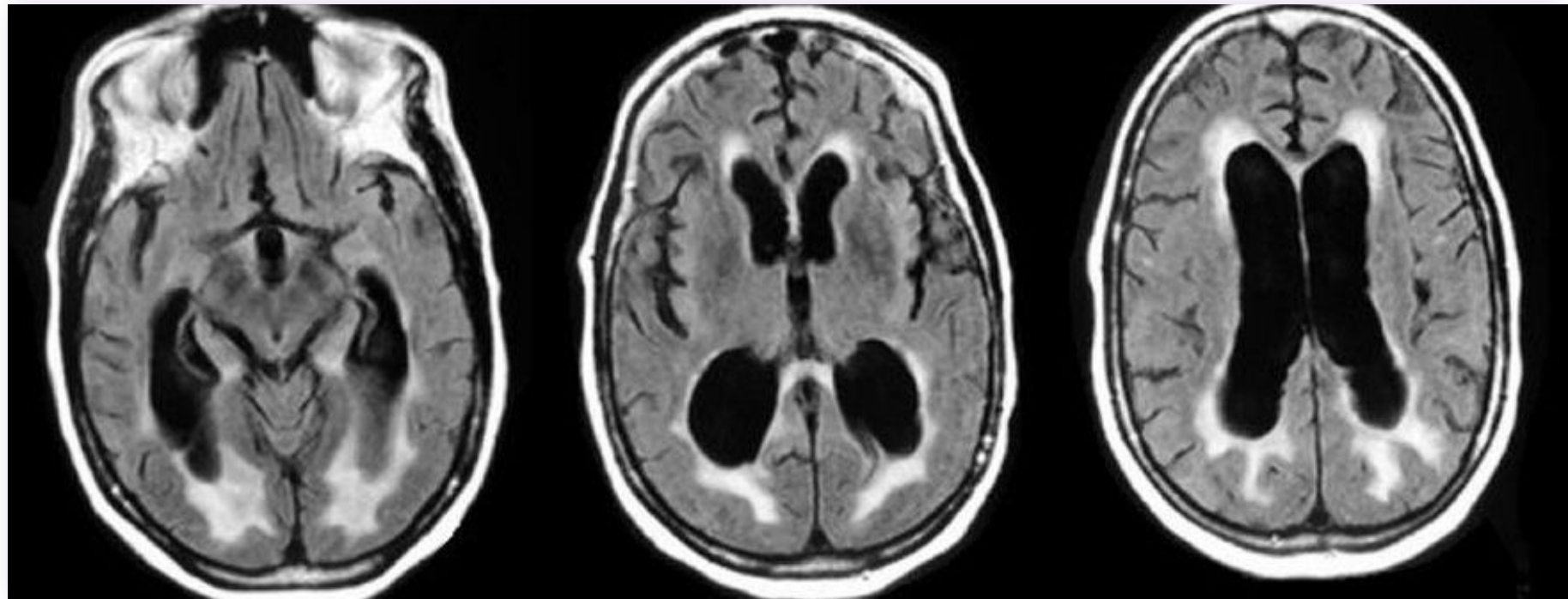
- **T1+ Gad:** Leptomeningeal enhancement in a “sugar coated” appearance
- Case courtesy of Assoc Prof Frank Gaillard, [Radiopaedia.org](https://radiopaedia.org/?lang=us). From the case <https://radiopaedia.org/cases/44859?lang=us> ID: 44859



Hydrocephalus

Order: CTH +/- MRI brain w/wo

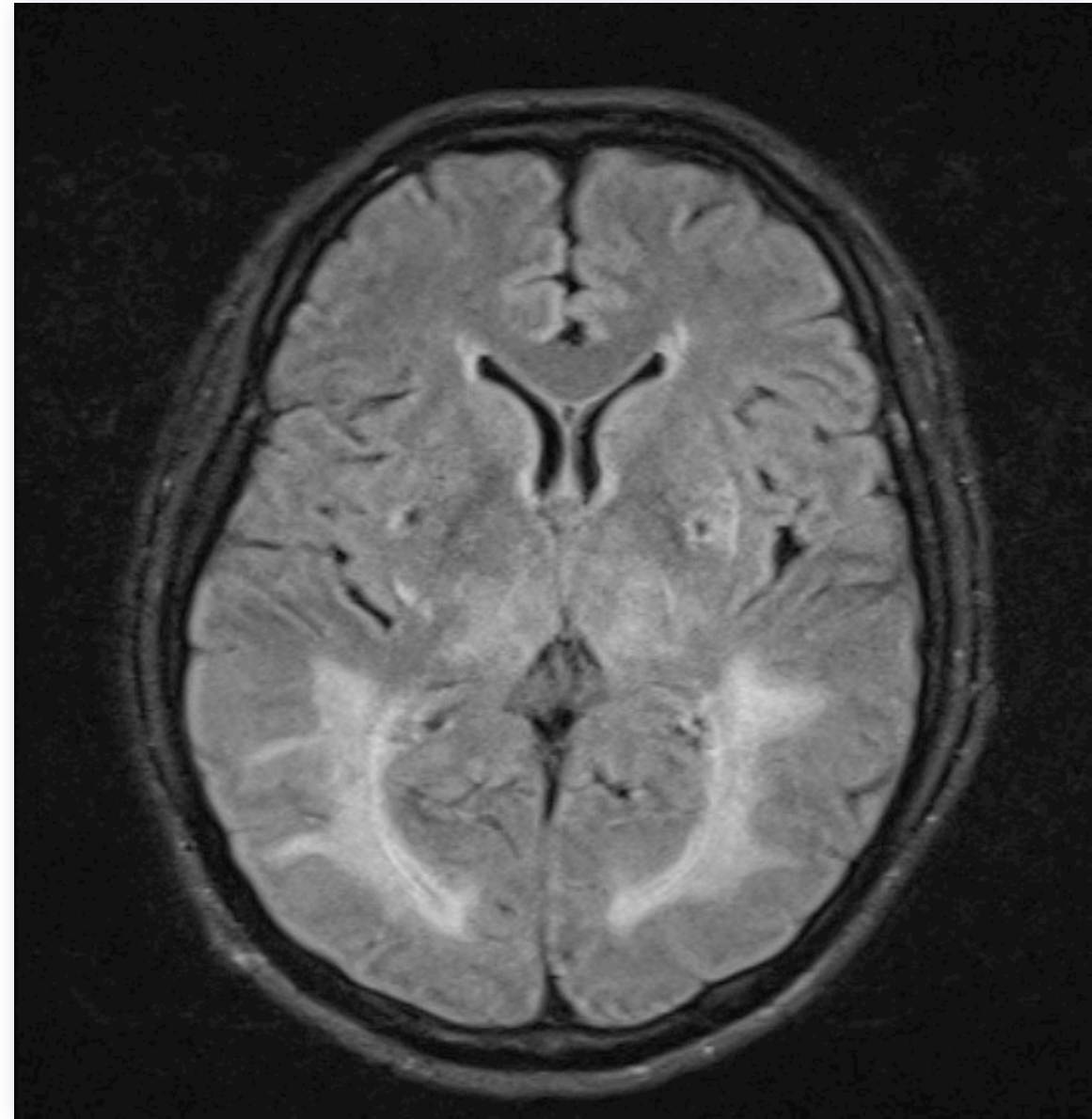
- Any sequence to look at ventricle size, gyri and sulci
- **FLAIR** to look for subependymal edema
- **T1+ Gad** to look for obstructing tumors and leptomeningeal enhancement



PRES: posterior reversible leukencephalopathy syndrome

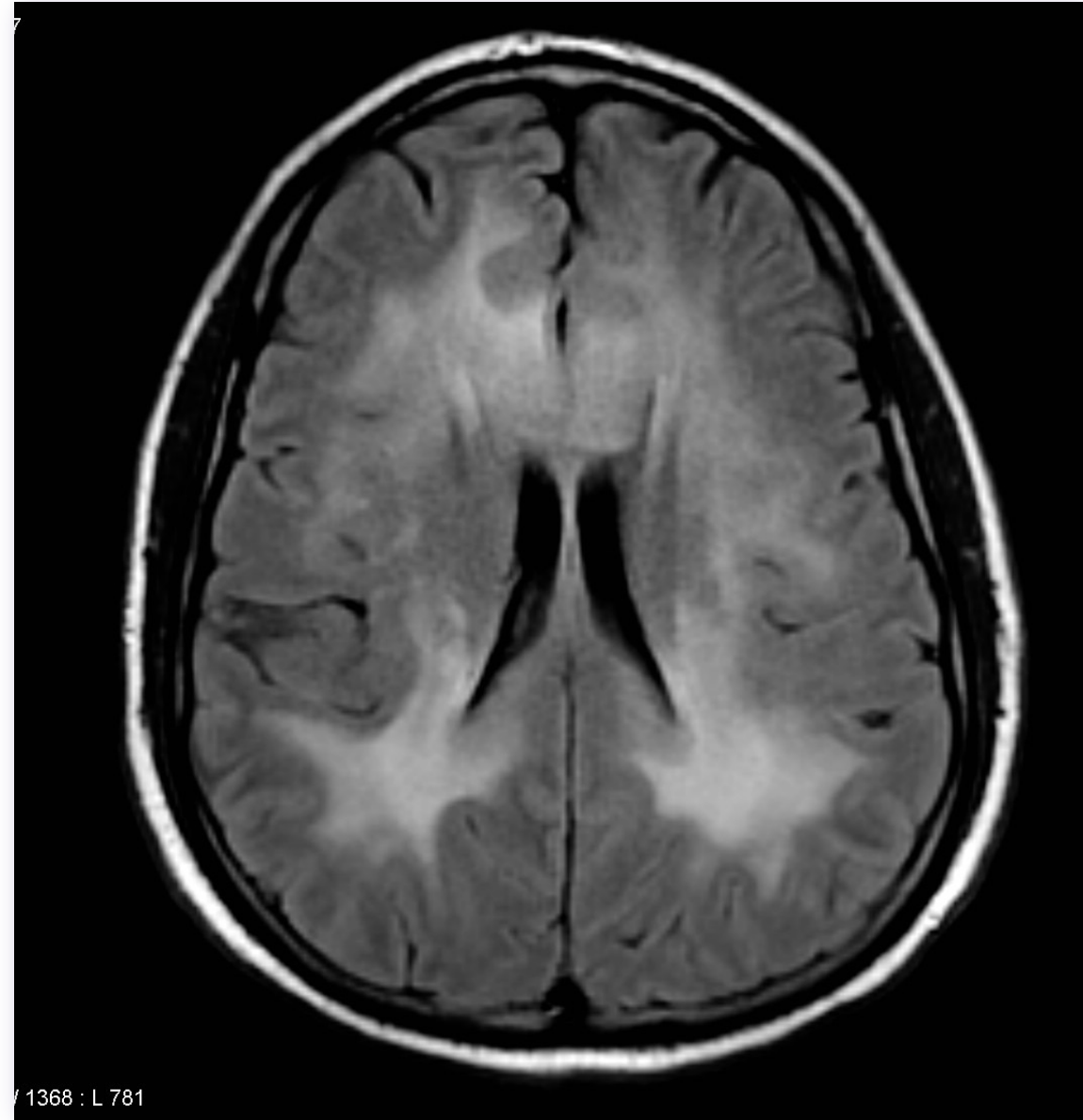
- **T2 and FLAIR**: Bilateral vasogenic edema in occipital and parietal regions

Case courtesy of Dr Ian Bickle, Radiopaedia.org. From the case radiopaedia.org/cases/30870



Leukoencephalopathy

- **FLAIR:** confluent and symmetric white matter changes (bright), and may involve the corpus callosum as well, particularly the splenium
- Case courtesy of Assoc Prof Frank Gaillard, Radiopaedia.org. From the case rID: 4438

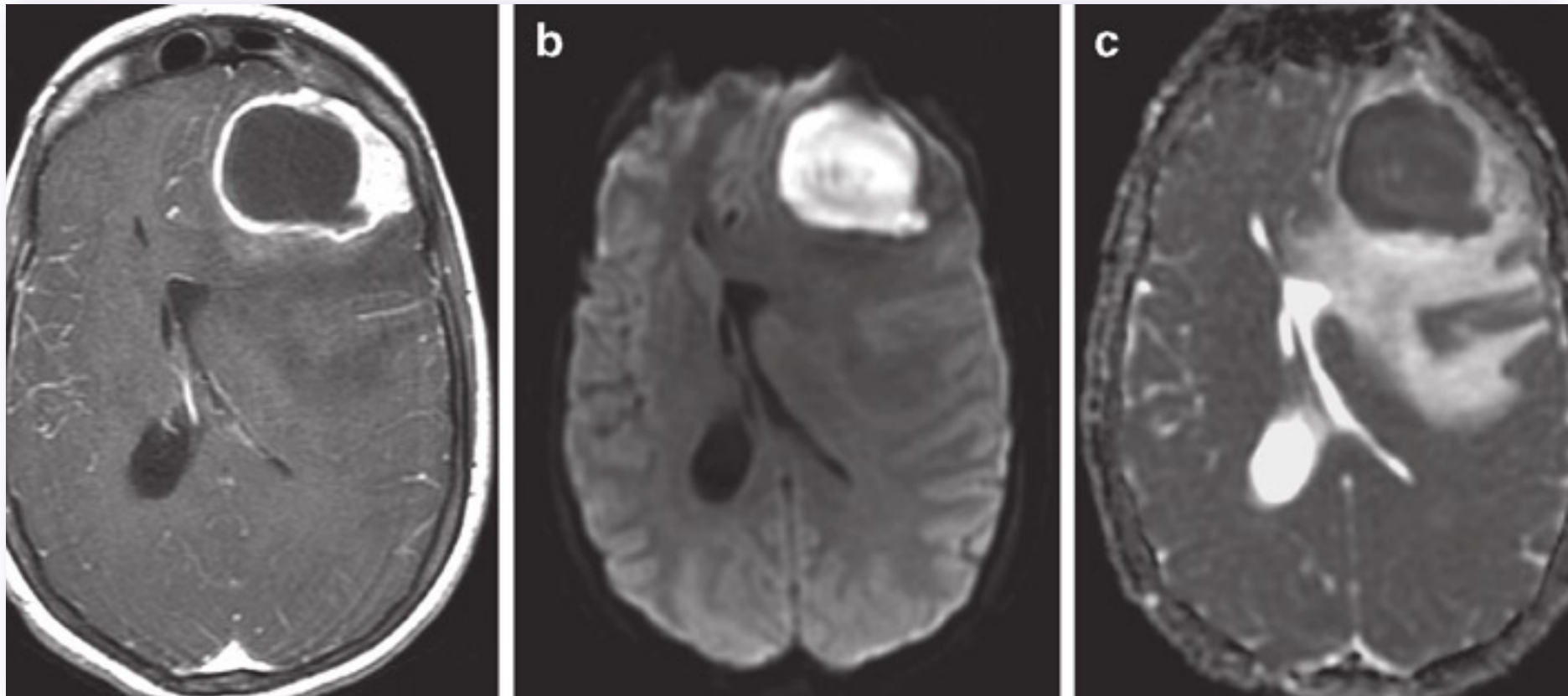


1368 : L 781

Abscess

Order: MRI w/wo contrast

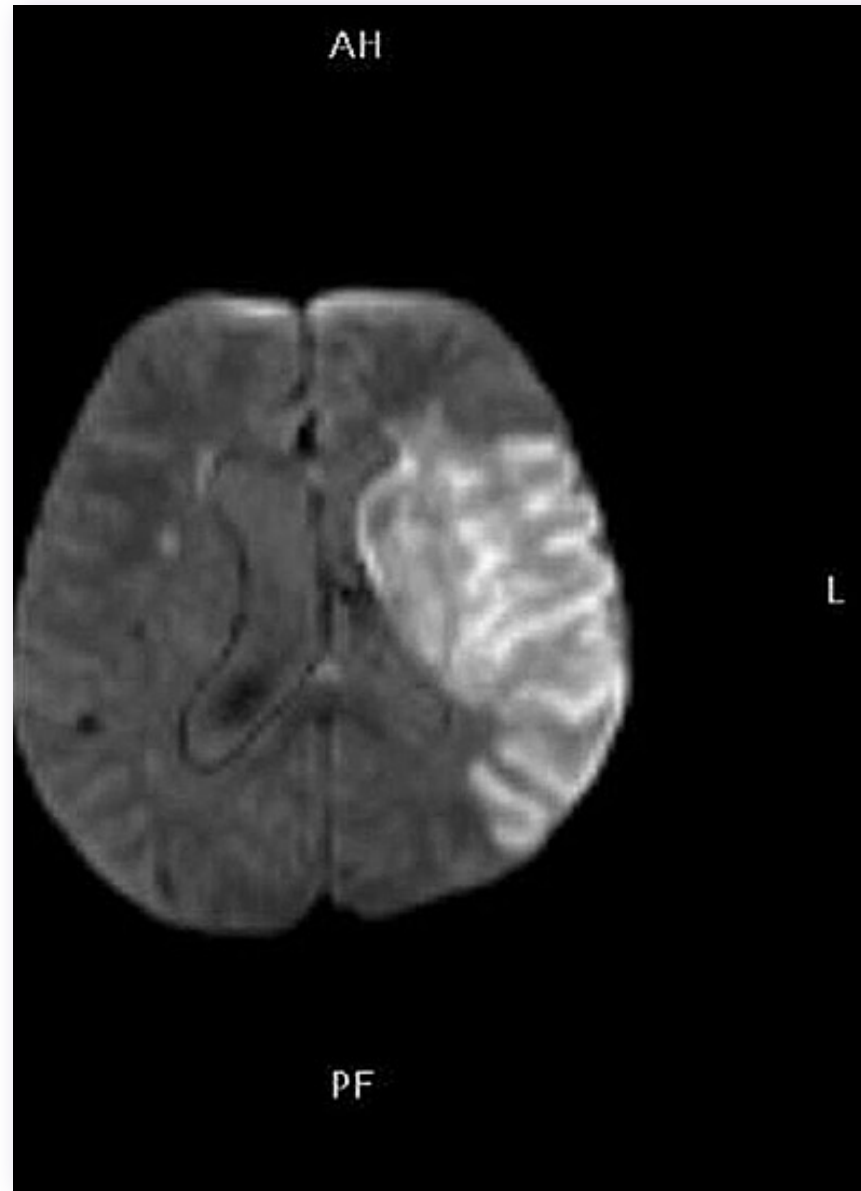
- **T1 + Gad:** Rim enhancing lesion
- **DWI + ADC:** Look for restricted diffusion (bright) on DWI and corresponding hypoattenuation on ADC



Stroke

Order:
CTH CTA,
MRI brain w/o contrast

- **DWI:** Look for areas of restricted diffusion (bright)
- **ADC:** Look for dark area which corresponds to the bright region on DWI



APPROACH TO SPINE

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Ordering and reviewing spine imaging

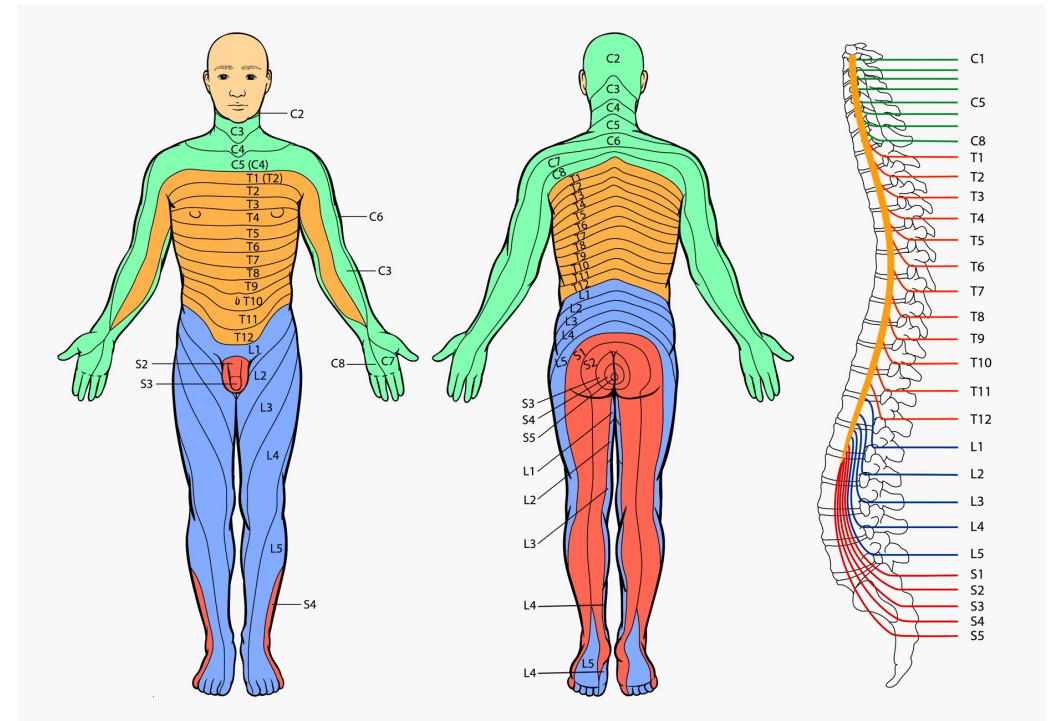
Upper vs. lower motor neuron causes of weakness

Cord compression/injury

- May present with bilateral weakness and ataxia (unable to tandem). May also have paresthesias, dysesthesias, pain
- Muscle tone: decreased early, increased later.
- Abnormal reflexes: Present
- Reflexes: Increased. Check for clonus

Peripheral/spinal nerve injury:

- May present with weakness in spinal distribution, stocking and glove numbness/tingling paresthesias, radicular pain, impaired balance
- Muscle tone: Decreased. Look for asymmetric atrophy
- Abnormal reflexes: absent
- Reflexes: Decreased or absent



APPROACH TO VIEWING SPINE IMAGING

1. Create 2 vertical series
2. Make each vertical series a 1x1 viewing layout
3. Pull T2 sagittal to one series and T2 axial in other
4. add all cutlines
5. Scroll through sagittal and find the corresponding axial imaging using the cutlines.



Worklist [Navigation icons] 0.0 [Navigation icons] [Navigation icons]

MRI C T L SPINE WO ... 12/4/2017 17:13:13 6 series

SAG STIR C/TSP 15 images

SAG T1 C/T 15 images

SAG STIR T/L 16 images

SAG T1 T/L 16 images

AX T2 CT im052214 48 images

AX T2 TL im052214 48 images

Se:501 Im:11 [H] BANERJEE, SOMA 12/4/2017 17:13:13 Study Time:17:13:13

T8 T9 T10 T11 T12 L1 L2 L3 L4 L5 S1

[A] [F] [P] [R] [L]

SAG STIR T/L C575 W1119

AX T2 TL im052214 C397 W771

Patient info Exam info Report OrthoView



Herniated Disc



Cauda Equina Syndrome & Spinal Cord Compression

- CT and Xray CANNOT assess cord or cauda equina compression! Order MRI

Case courtesy of Dr Ashutosh Gandhi, [Radiopaedia.org](https://radiopaedia.org/?lang=us). From the case [RID: 19758](https://radiopaedia.org/cases/19758?lang=us)

Case courtesy of Dr Ian Bickle, [Radiopaedia.org](https://radiopaedia.org/?lang=us). From the case [RID: 25701](https://radiopaedia.org/cases/25701?lang=us)



Other useful imaging tests

- Catheter based angiogram**- Performed by IR, gold standard for diagnosis of cerebrovascular abnormalities (aneurysm, AVM, acute stroke).
- CT angiogram**- After catheter based angiogram, the most sensitive test for detecting neurovascular abnormalities. Involves contrast so kidney function must be acceptable.
- MR Angiogram** - MR based angiogram slightly less sensitive than CTA but doesn't use contrast so good option for neurovascular evaluation in patient's with impaired kidney function.
- FMRI**- functional MRI measures brain activity by detecting changes associated with blood flow. Can be used for brain mapping prior to neurosurgery or assess effects of stroke, trauma or neurodegenerative disease on brain function
- MR spectroscopy**- allows tissue to be interrogated for the presence and concentration of various metabolites. Sometimes used to differentiate radiation necrosis vs. tumor
- EMG**- Electromyography is an electrodiagnostic medicine technique for evaluating and recording the electrical activity produced by skeletal muscles. Mostly helpful for diagnosing the cause of weakness (peripheral neuropathy vs. radiculopathy vs. myelopathy)
- EEG**- electroencephalogram is a test that records the electrical signals of the brain. Used to help diagnose seizures and sleep disorders
- CT myelogram**: IR procedure done to image spinal cord and cauda equina if MRI spine is contraindicated

Case #1

77 yo right hand dominant M w/ history of metastatic melanoma. Called 911 after developing acute onset of left arm weakness.

- T: 36.2 °C
- BP: 170/90
- HR: 80
- RR: 18
- SpO2: 99 % Room air

EXAM:

CV: RRR, no murmur. No LE edema.

Resp: CTAB, full sentences on RA

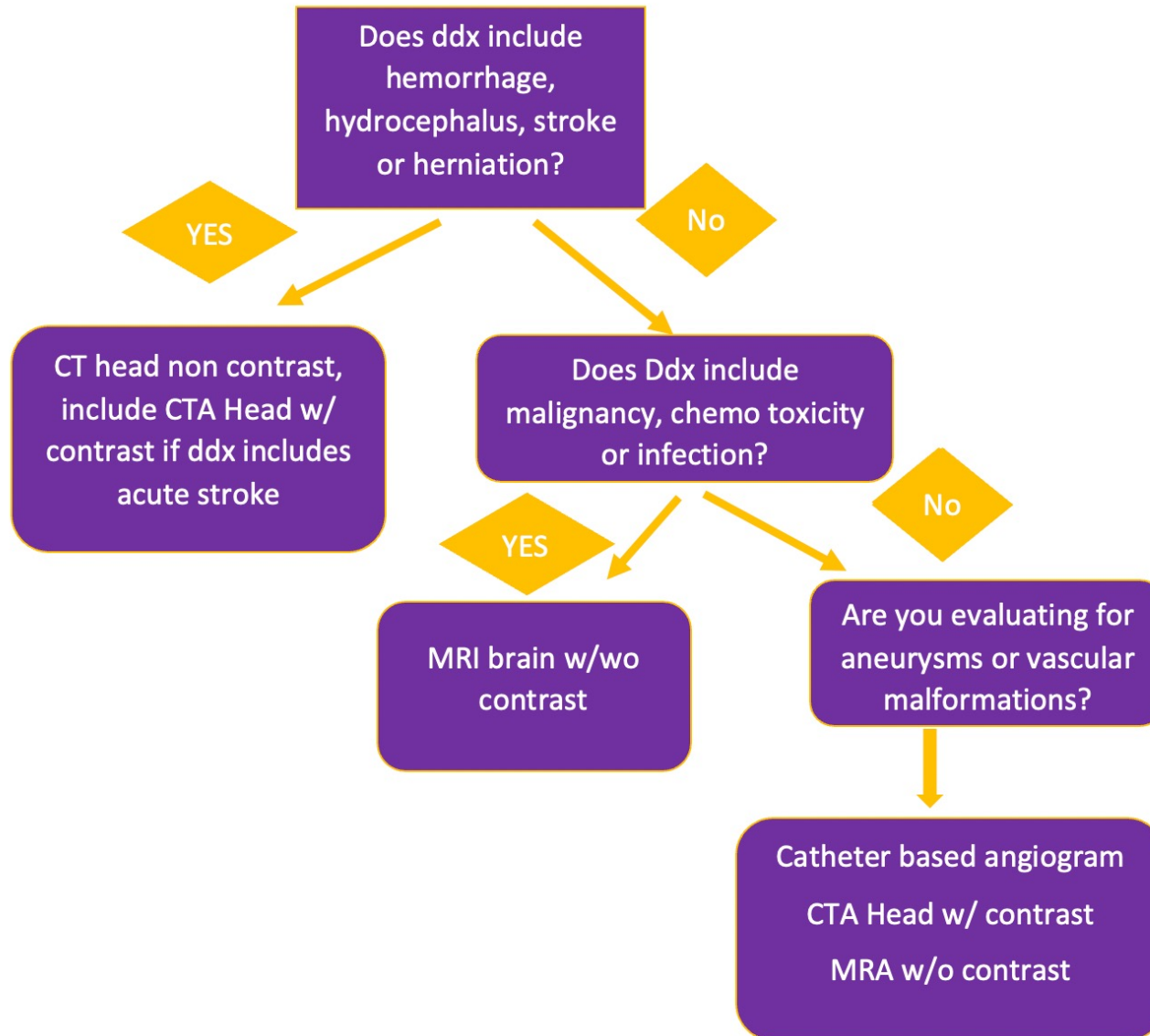
GI: NABT. Soft, nondistended, nontender

Musk: No warm/tender/swollen/red joints.

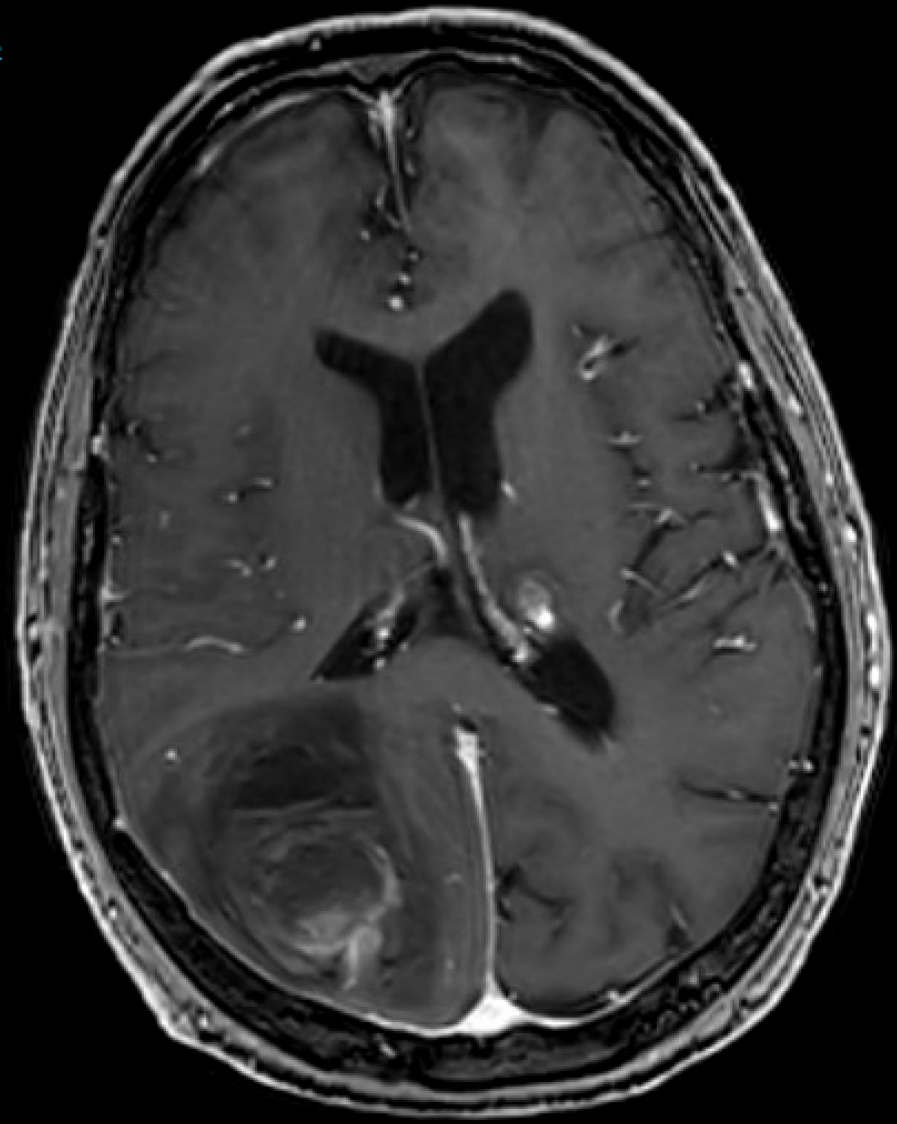
Skin: No rashes. Warm and dry.

Neuro: Alert and oriented x 3. CN Mild L facial droop, other wise CN grossly intact, LUE flaccid paralysis with distal sparing (able to squeeze fingers), subjective numbness on RUE, B/L LE 5/5 motor.

Putting it all together



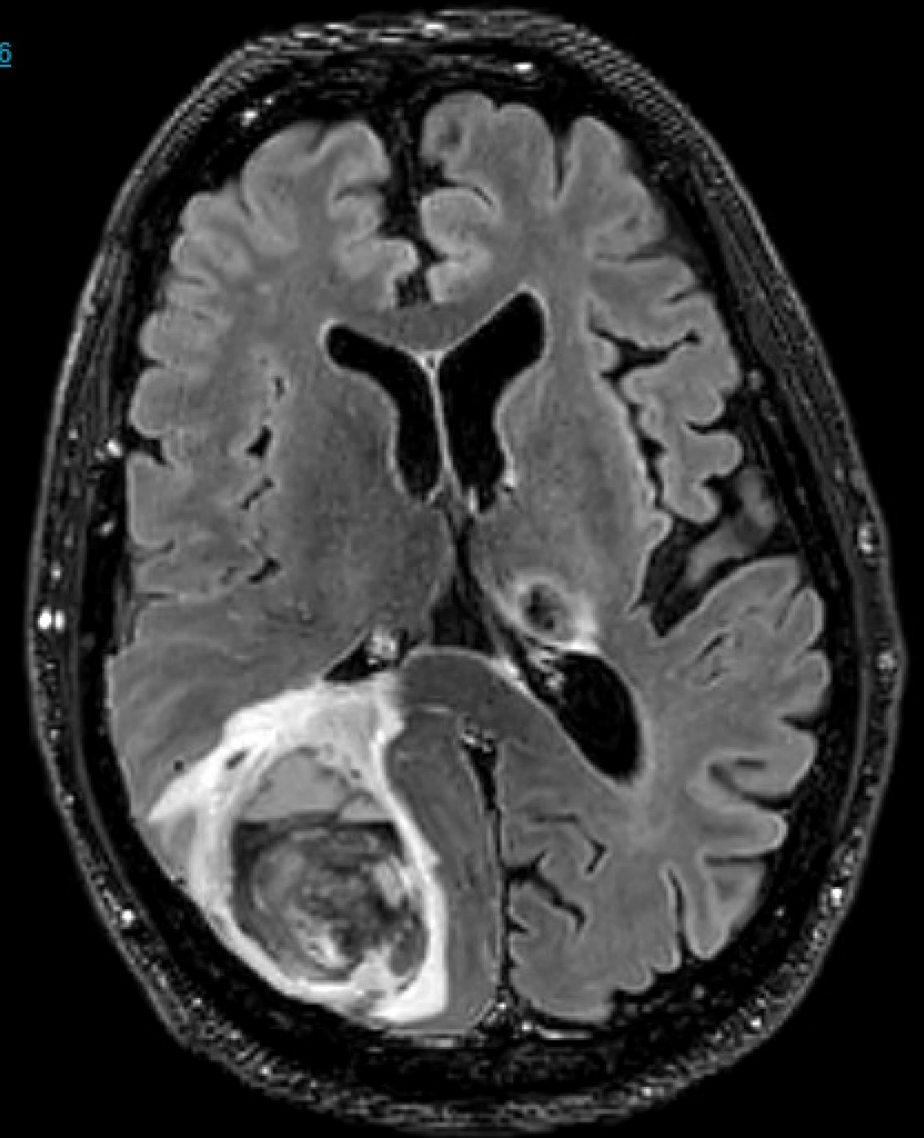
Se: 901
Im: 107/196
Fast Scroll



RPF

LAH

Se: 601
Im: 103/196



RPF

5
LAH
cm

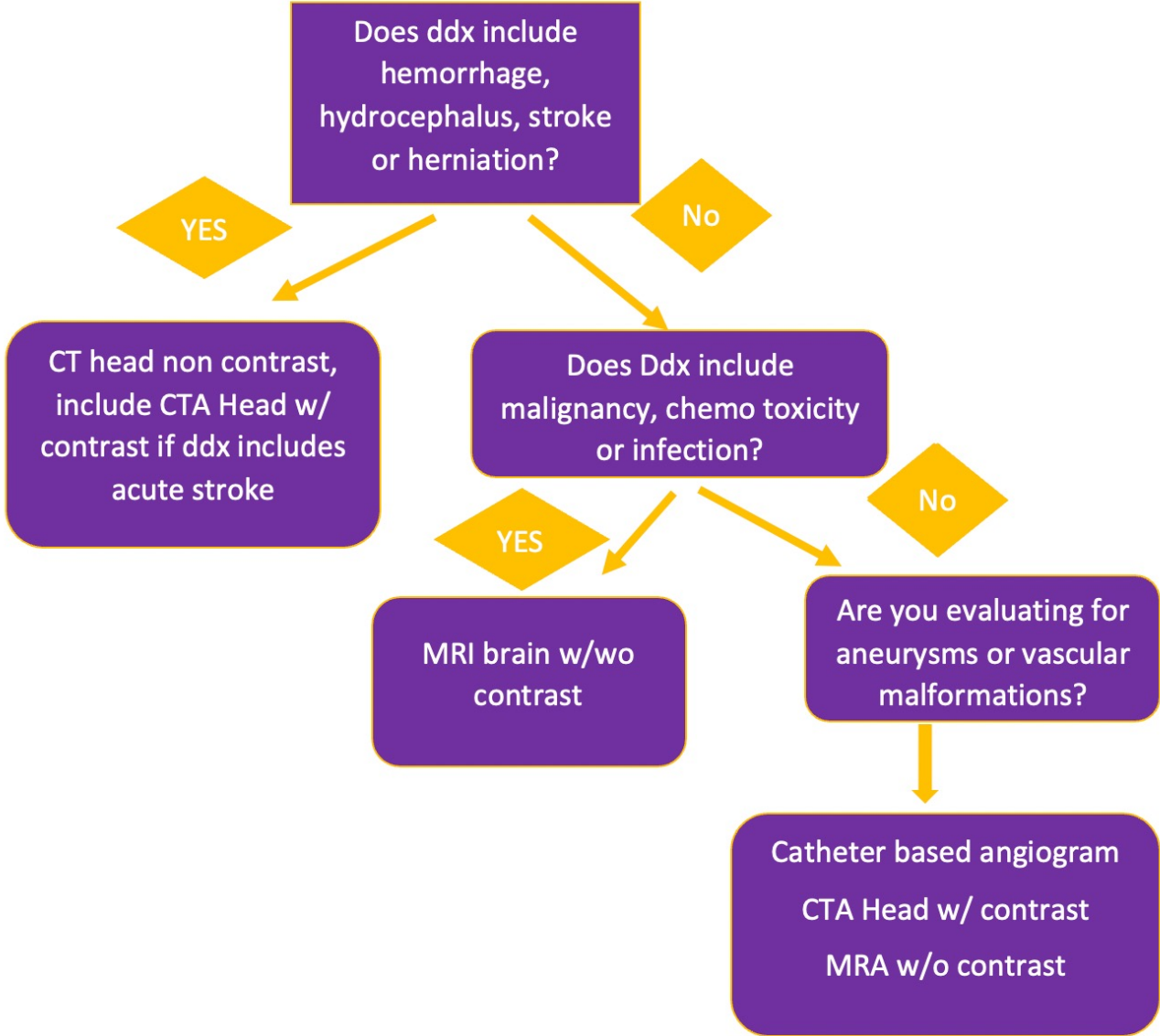
Case #2

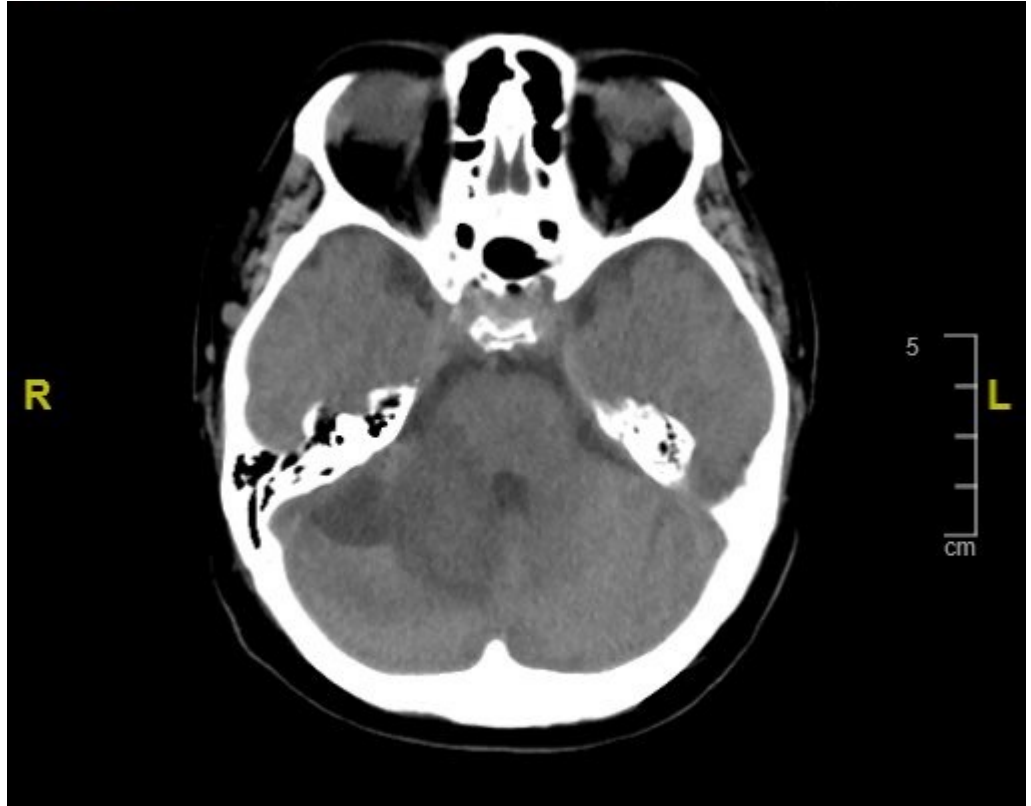
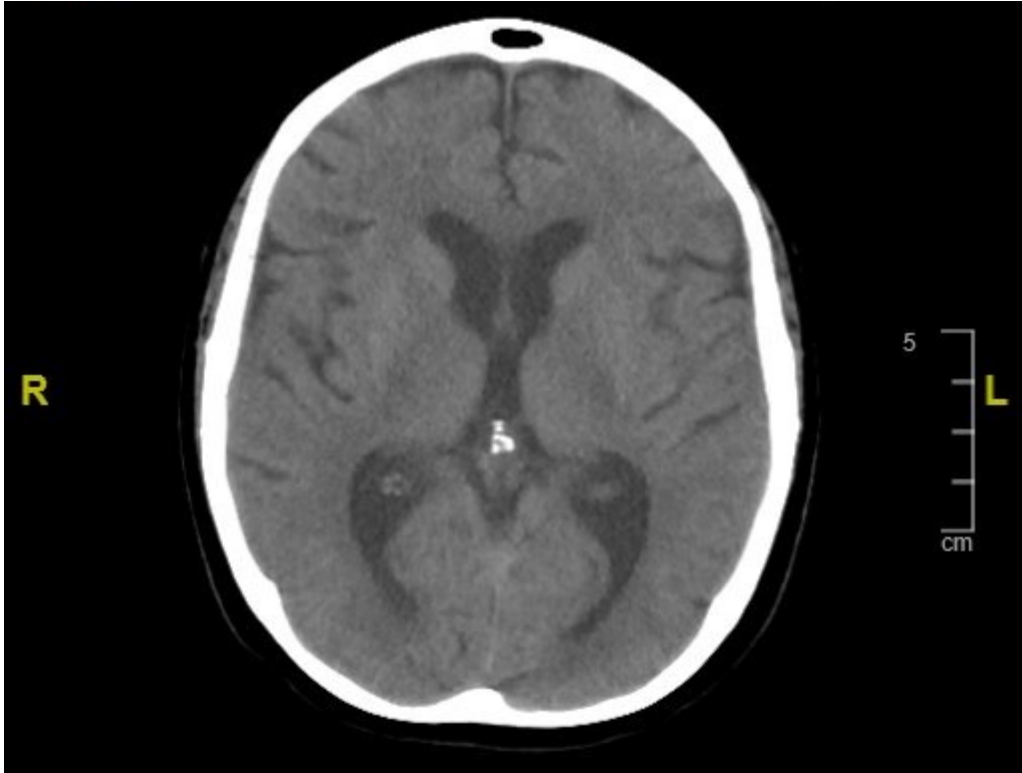
61-year-old female with history significant for metastatic breast cancer, DVT on Xarelto, and insulin dependent diabetes. Presents with complaint of diplopia/blurry vision and worsening balance. She has migraine headaches for which she takes sumatriptan and reports increased frequency and intensity of headaches.

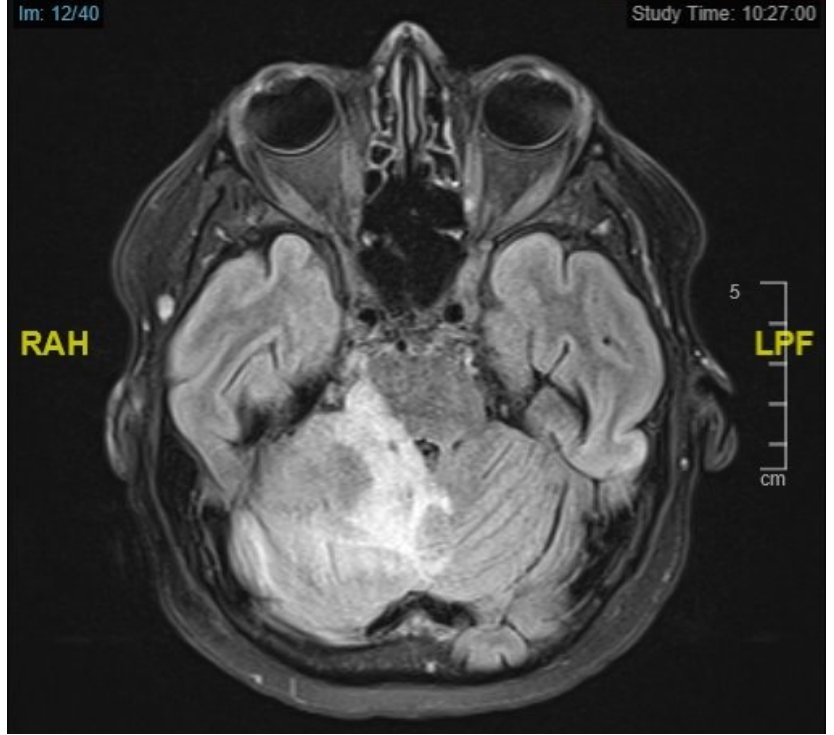
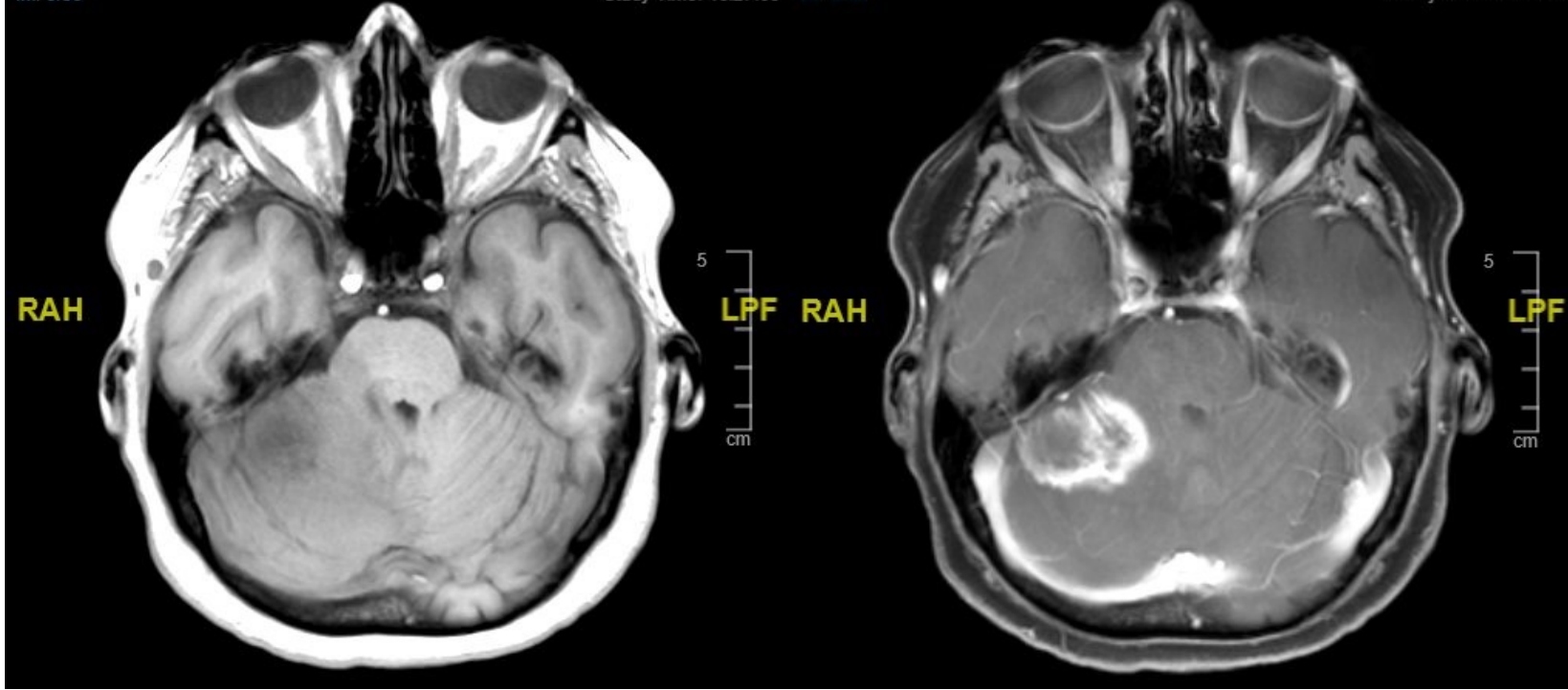
ON EXAM

- mild anisocoria otherwise CN II-XII intact.
- endorses double vision with binocular vision which resolves with covering one eye. Dysmetria is evident of FTN testing R>L.
- Strength testing 5/5 throughout. Sensation intact to light touch. 2+ patellar DTRs, toes down going.
- . Gait is wide based and she is unable to tandem.

Putting it all together







Case #3

- 66-year-old man with metastatic prostate cancer, hypertension and CAD presents to clinic with back pain and worsening LE weakness past few weeks. He had a foley placed in the setting of hip fracture and failed his voiding trial this week.
- PMHX significant for T3-T6 PSIF, T3-T5 laminectomies for tumor debulking 3 months earlier followed by chemoradiation. Had a GLF with hip fracture and ORIF one month prior to presentation.

On exam:

- Strength. 5/5 except R Dorsiflexion and EHL 3/5, R plantar flexion 4/5, L plantar flexion and dorsiflexion 4/5.
- Sensation: Diminished sensation over toes and dorsum of feet bilaterally

• Reflexes:	Right	Left
Patellar	1+	1+
Achilles	Absent	Absent
Babinski's	Negative	Negative
Clonus	Absent	Absent

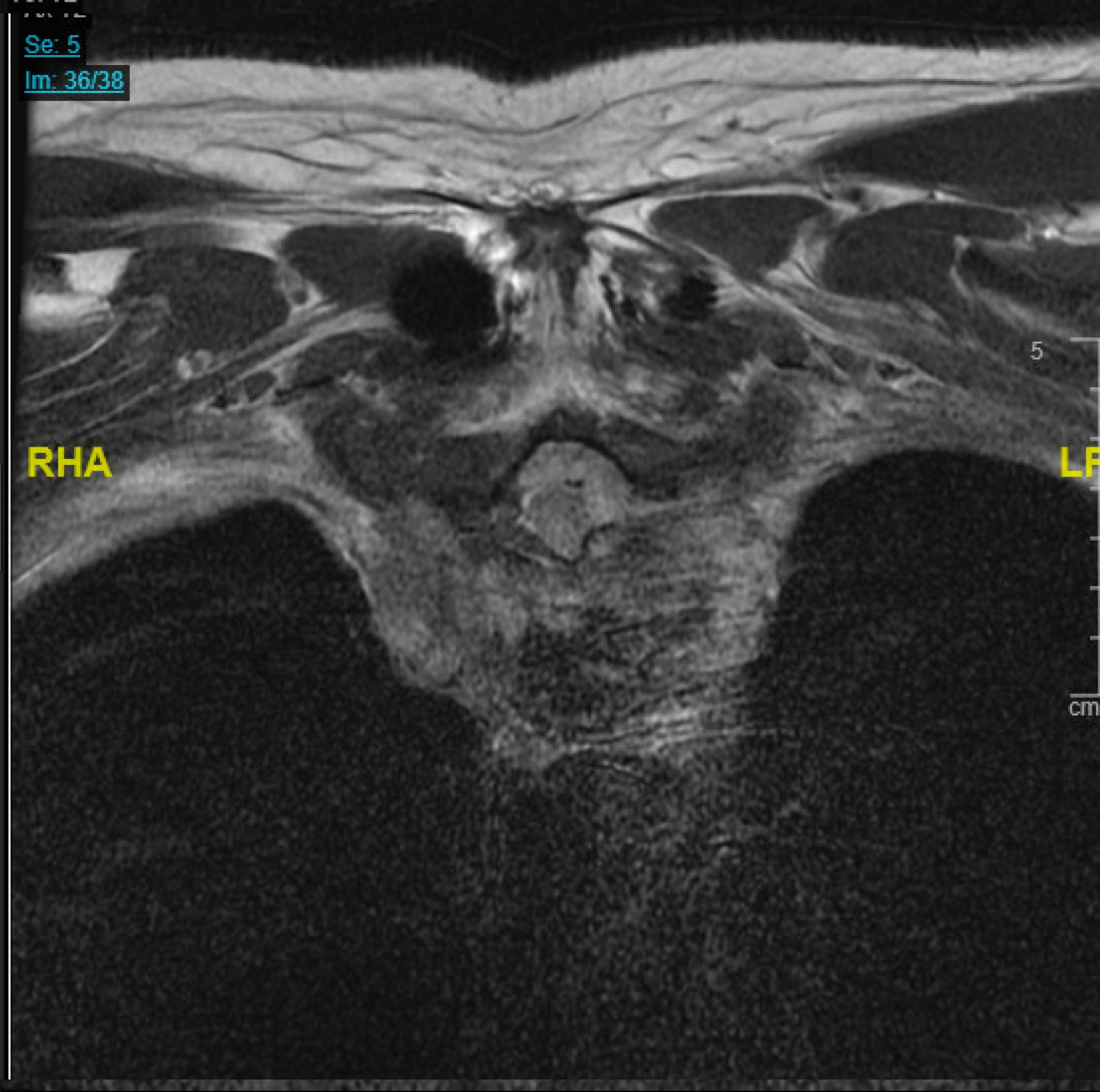
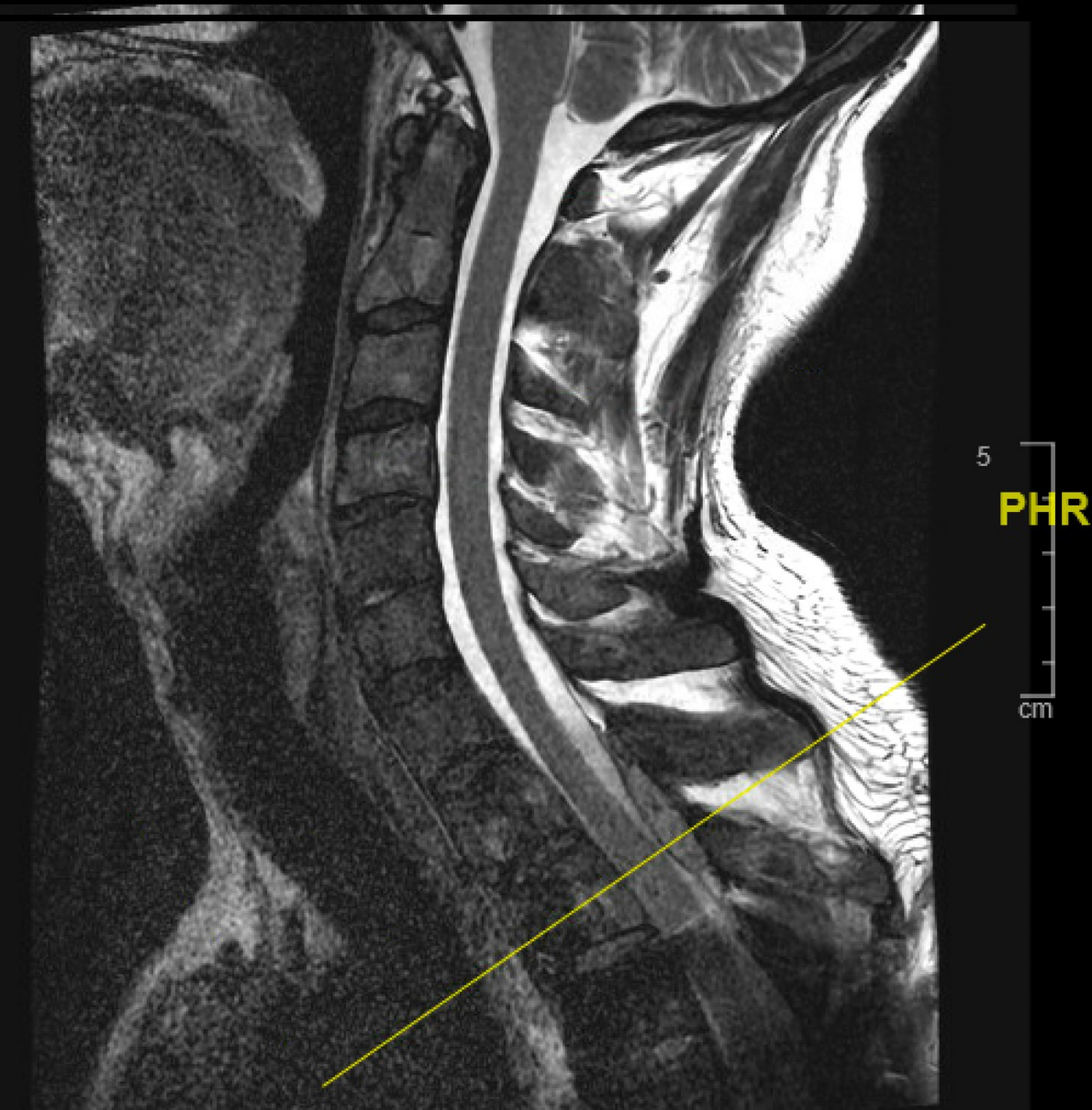
Thinking through spine

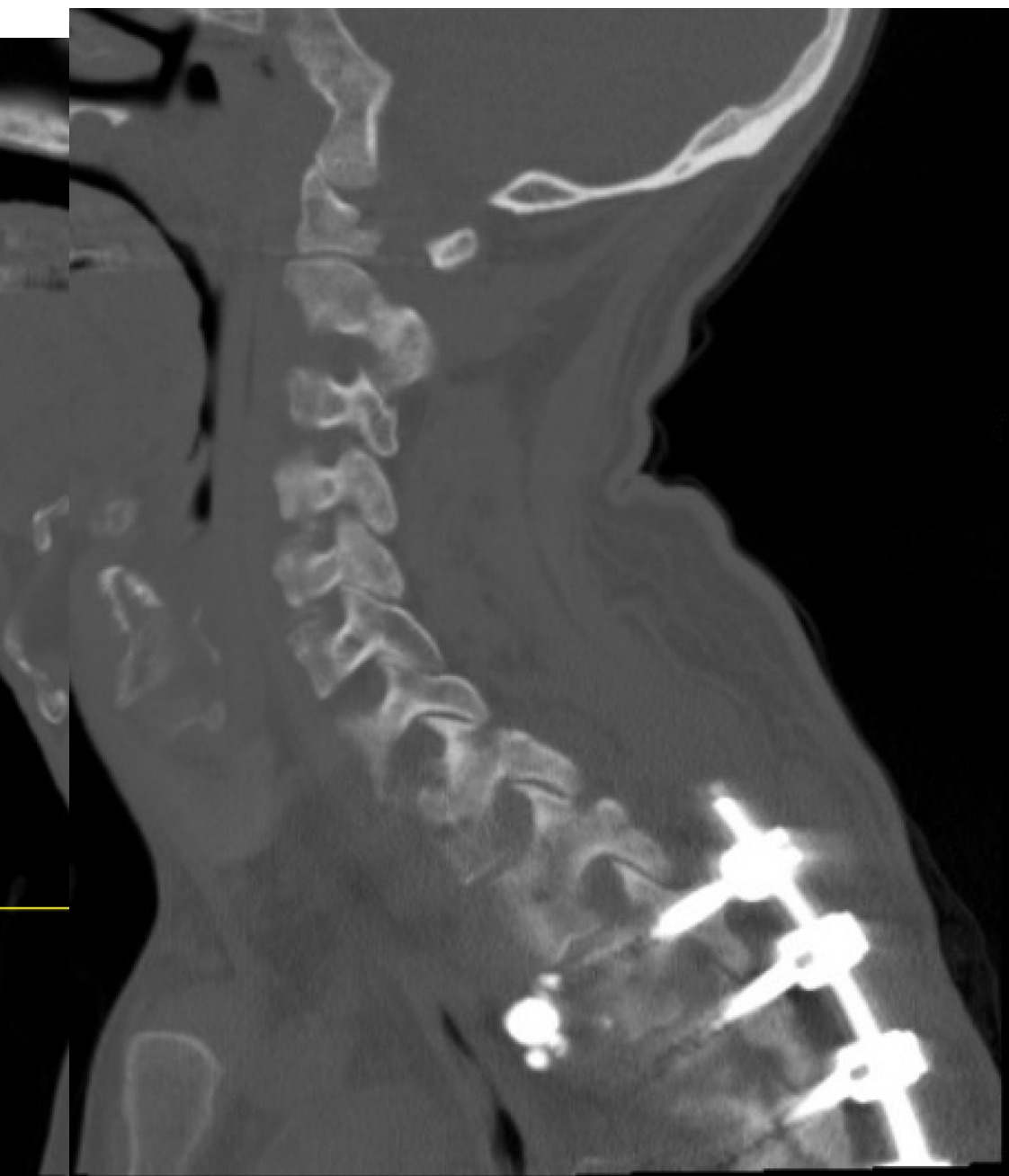
In the setting of new neurologic deficits

- Am I worried about spinal cord or cauda equina compression? If yes => urgent MRI (add w/wo contrast if you are concerned for metastasis or infection)
 - Can I reliably determine the level of the deficit or is there a known lesion to direct imaging? If no, image more rather than less of the spine
- Am I worried about hardware failure with cord or spinal nerve compression? => CT w/o contrast + MRI w/o contrast

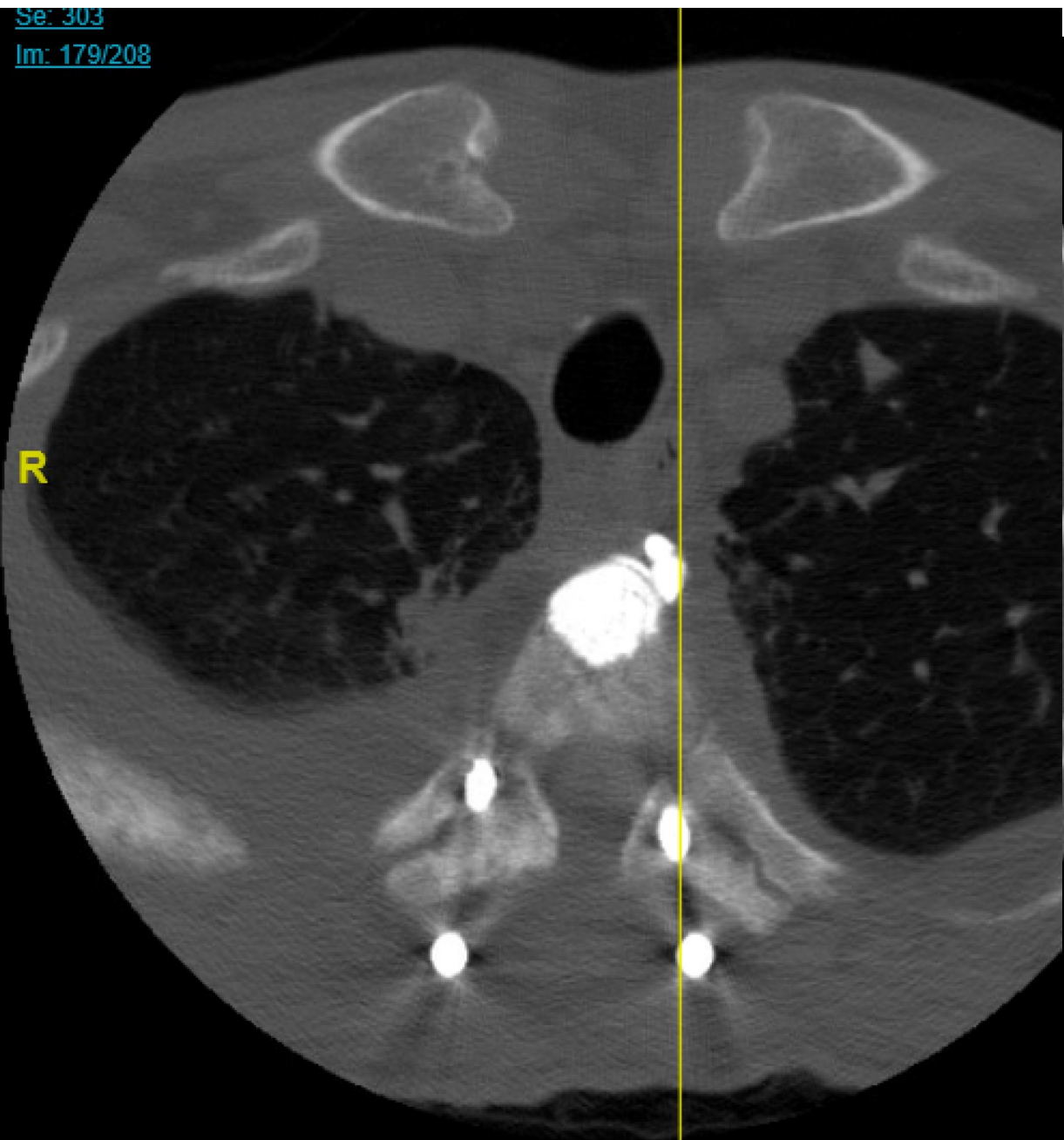
In the setting of pain but no neurologic deficits

- Am I worried about fracture or painful metastasis but no radicular symptoms are present?
CT w/ contrast or MRI





P



R

Se: 303
Im: 179/208

1.12

ST: 1.250000 mm

Pearls

- Develop a systematic approach to reviewing imaging, do it the same way every time
- Compare old imaging when possible
- When you get comfortable, start showing patients their imaging
- For spine, look for signs of myelopathy and consider imaging MORE of the spine unless you are certain of the level of the deficit
- Be as clear as possible in detailing your differential/clinical concern when ordering imaging
- If in doubt, don't hesitate to discuss with radiology

Useful tools

- https://www.radiologymasterclass.co.uk/tutorials/ct/ct_brain_anatomy/ct_brain_anatomy_start
- Radiopaedia: <https://radiopaedia.org>

QUESTIONS?

