Imaging of Brain Tumors and Other Masses

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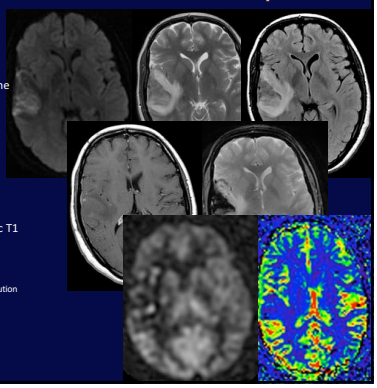
Role of Imaging

- Initial work-up
  - Mass versus non-mass
  - Reasonable imaging differential diagnosis
- Biopsy and pre-surgical planning
- Immediate post-op imaging
  - Residual tumor
  - Post-surgical infarcts
- Longer term follow-up
  - Recurrence
  - Radiation effects

MRI Protocol: Unknown Mass Workup

- DWI
  - Helpful to evaluate for cellularity
  - Key to diagnosing abscess
  - DTI may help surgical planning; not routine
- T2 and/or T2 FLAIR
  - Signal intensity of mass
  - Flow voids
  - Edema
- Gradient echo
  - hemorrhage, calcification
- T1 pre- and post-contrast
  - At least 1 plane pre- to assess for intrinsic T1 hyperintensity (hemorrhage, etc.)
  - Same plane post-contrast
  - 3D imaging in separate plane
    - SPGR lower conspicuity, but higher spatial resolution
    - Now using 3D T1 FSE (CUBE)
- Perfusion Imaging
  - ASL: CBF, vascular shunting
  - Bolus contrast PWI relative CBV

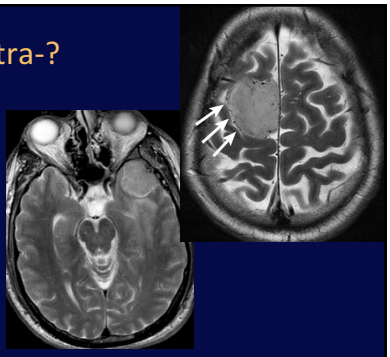


Initial Work-up

- Adult versus pediatric
- Intra- versus extra-axial localization is key!

Intra- versus Extra-?

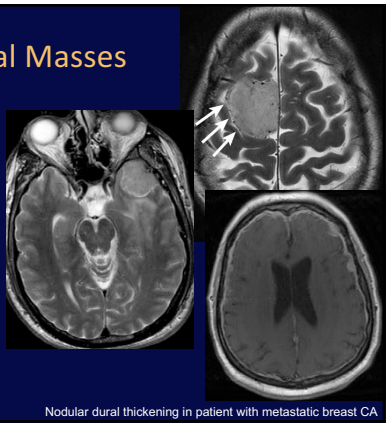
- Broad dural base
- Cleft sign
  - CSF between mass and rest of brain
- Vessels at the edge of the mass
  - Inward buckling of cortex



Ddx for Extra-axial Masses

- Meningioma
- Metastases

- Less common:
  - Hemangiopericytoma
  - Lymphoma
  - Sarcoid



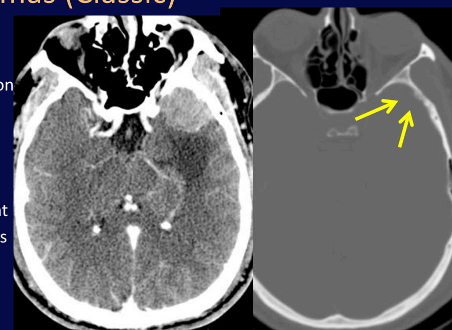
Nodular dural thickening in patient with metastatic breast CA

Meningiomas

- Most frequently diagnosed primary brain tumor
- Demographics
  - Woman:Men 2:1
  - NF2, prior radiation
- Grading
  - Most are WHO Grade 1 (90-95%)
  - Atypical meningiomas (Grade 2) (5%)
  - Malignant/anaplastic meningioma (Grade 3) (1-2%)
- No imaging features to distinguish grade

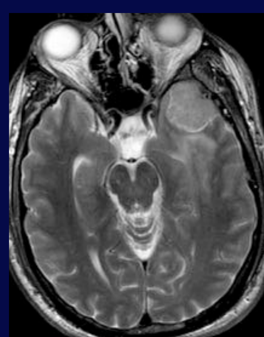
Meningiomas (Classic)

- CT
  - Hard to see on noncontrast
  - Hyperdense
  - +/- edema
  - Avid enhancement
  - Bony changes



Meningiomas (Classic)

- MRI
  - Extra-axial
  - Cleft sign
  - Low to medium T2 signal
  - Reduced DWI
  - Avid contrast enhancement
    - Uniform or spoke-wheel
    - +/- dural tail
  - Usually high perfusion
    - Both CBV and CBF
    - Unless calcified



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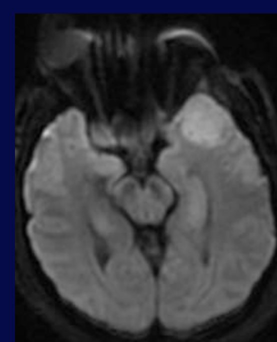

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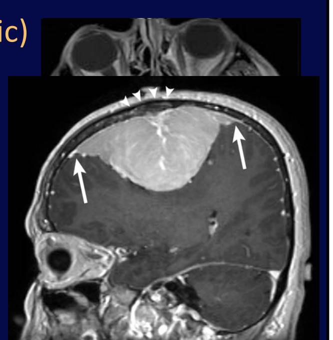

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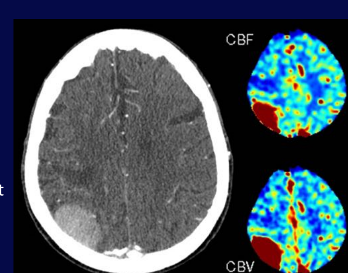
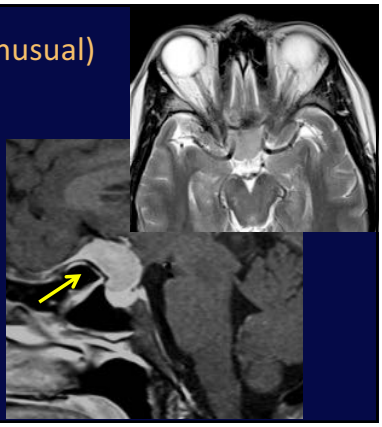


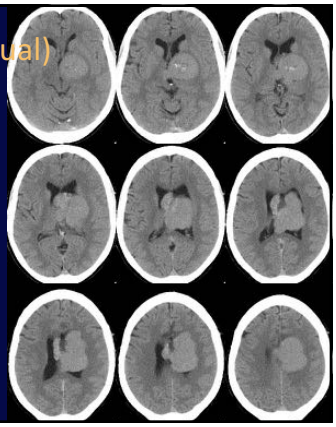
Meningiomas (Unusual)

- Tuberculum sella
  - Mimicking pituitary adenoma
  - Low on T2
  - Pneumosinus dilitans
  - No sella enlargement
  - Normal pituitary seen



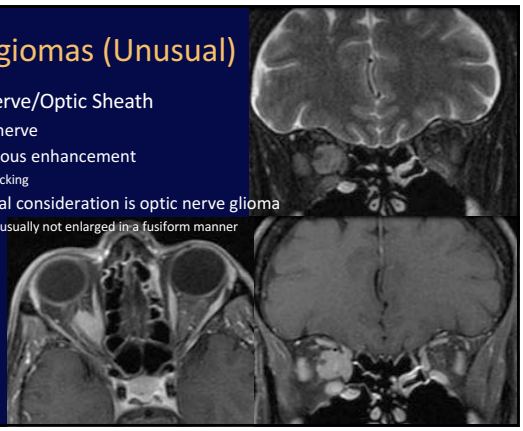
Meningiomas (Unusual)

- Intraventricular
  - 2-5% of meningiomas
  - Still most common adult intraventricular mass
  - Lateral ventricle trigone > third ventricle > fourth ventricle
  - Usually T2 low
  - Distinguishes from other lateral ventricle neoplasms, esp CPP



Meningiomas (Unusual)

- Optic Nerve/Optic Sheath
- Iso T2 to nerve
- Homogenous enhancement
  - Tram tracking
- Differential consideration is optic nerve glioma
  - Nerve is usually not enlarged in a fusiform manner

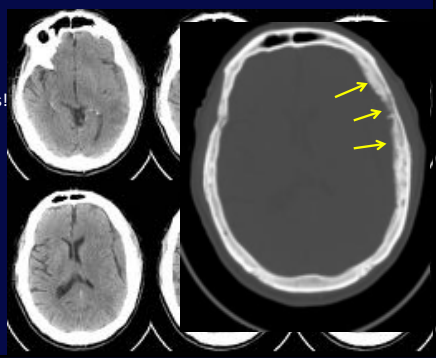


Dural Metastases

- Distinguish from SDH on noncon CT?
- Typical entities
  - Breast CA
  - Prostate CA
  - Melanoma
- Oddballs
  - Esthesioneuroblastoma

R/o Subdural Hematoma

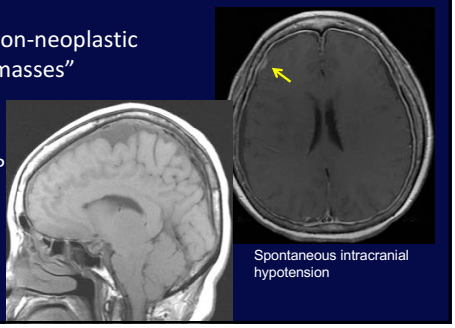
- Be careful!
- Check bone windows!



Prostate Cancer, no trauma

Ddx for Extra-axial "Masses"

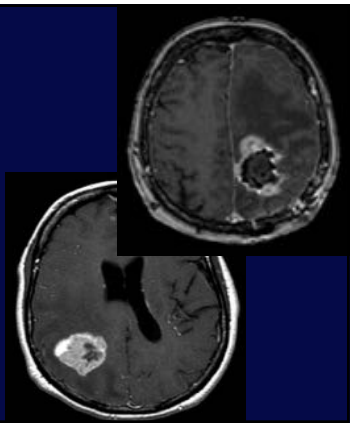
- Remember non-neoplastic extra-axial "masses"
  - Sarcoid
  - TB
  - SIH / Post LP



Spontaneous intracranial hypotension

Intra-axial Lesions

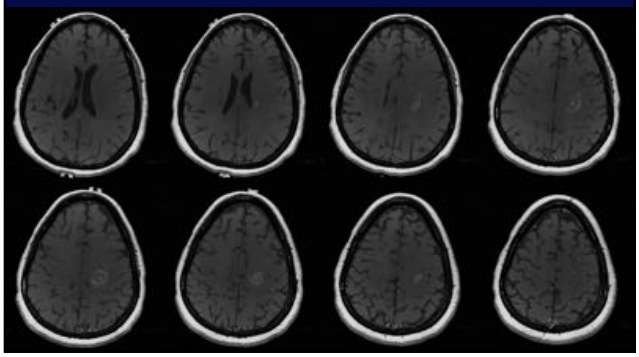
- Wide range of potential diagnoses
  - MAGIC DR, ring-enhancing
  - Non-enhancing "masses"
  - Tumor mimics
- Key role of mass effect
- Neoplastic or not?
- Does it need a biopsy?



MAGIC DR (L): Ring-enhancing Lesions

- Metastasis
- Abscess
- Glioma
- Infarction (Subacute)
- Contusion
- Demyelinating
- Radiation
- ?treated Lymphoma

45 yo woman with history of chest wall sarcoma



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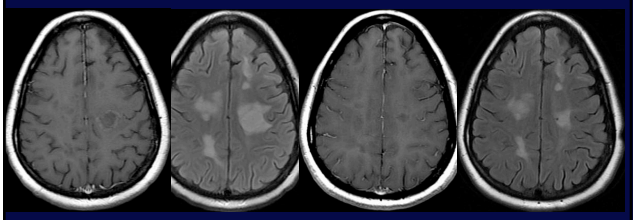
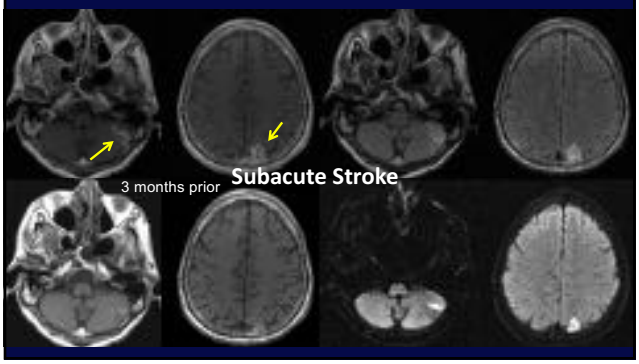


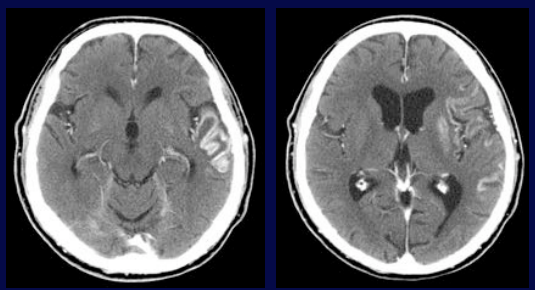
1 month post-biospy 2 months post-biospy

Tumefactive Demyelination

49 yo man with brain lesions, AMS

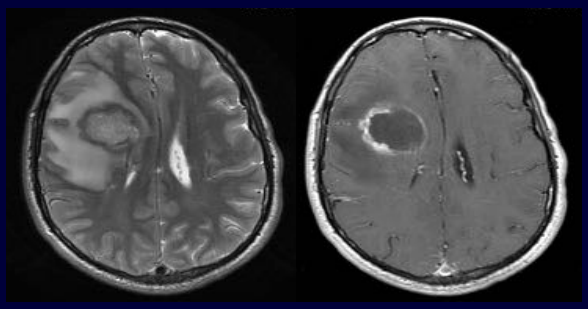


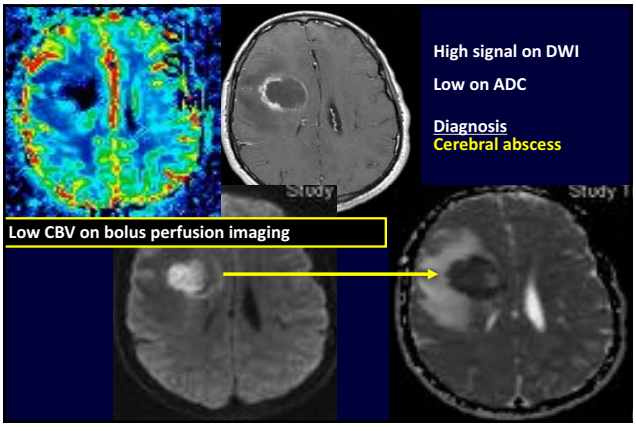
Subacute Stroke – Classic



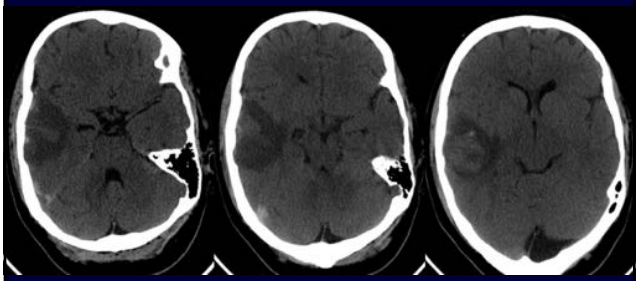
Gyral enhancement; no mass effect

Ring enhancing brain lesion





22 yo woman, mass lesion in the right temporal lobe



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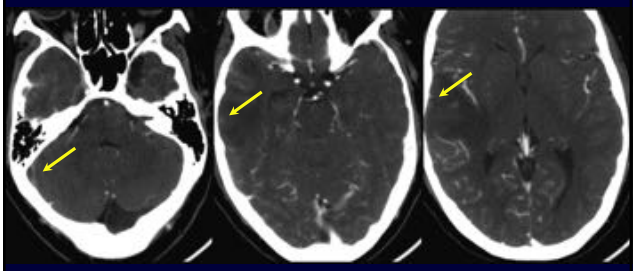


Thrombosis of the vein of Labbe and sigmoid sinus

Most Common Brain Mass Mimics

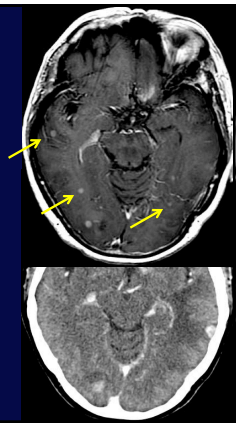
- Ring-enhancing masses
  - Abscess
  - Tumefactive demyelination
  - Subacute stroke
  - Venous sinus thrombosis

So it's a tumor…

- Grading
  - Perfusion/spectroscopy demonstrates ability to grade tumors based on metabolism and hemodynamics
  - Primarily of academic interest
    - Patient will have bx, and path is still gold standard
    - May help guide biopsy location
- Primary vs. metastasis
  - Solitary brain nodule in an adult
    - 50-50 split between primary glial neoplasm and metastasis
    - Big impact on therapy
      - Must find the primary!
      - Brain surgery vs. radiation vs. palliative care

Met Versus Primary

- Multiplicity
- Mets almost always enhance
  - So if not enhancing, unlikely to be met, unless treated in past?
  - MR much more sensitive than CT



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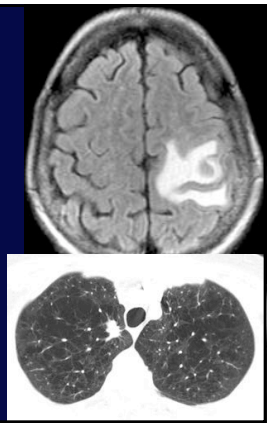
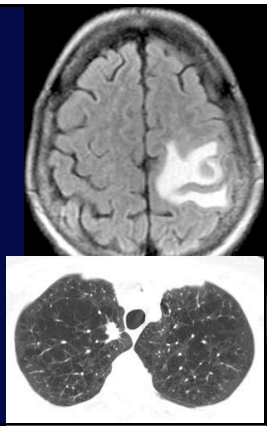
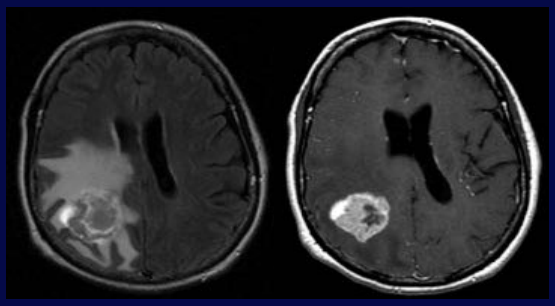


Met Versus Primary

- Multiplicity
- Mets almost always enhance
  - So if not enhancing, unlikely to be met, unless treated in past?
  - MR much more sensitive than CT
- Discrete border between edema and mass
- Tend to have lower CBF
  - Exceptions
  - Renal Cell Carcinoma
  - Hemangioblastoma
  - Esthesioneuroblastoma
- Bolus contrast perfusion versus time curve

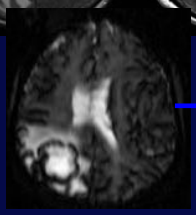


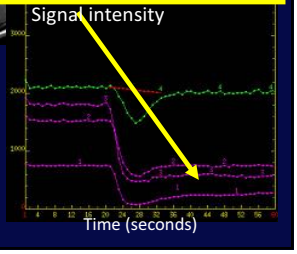
Metastasis or Primary?

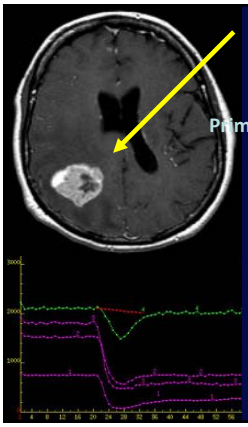


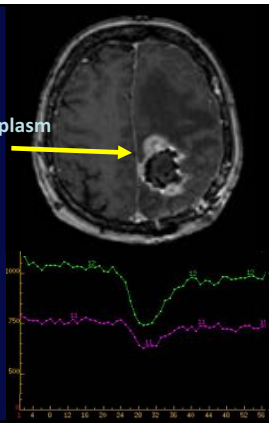
Dynamic curve shows minimal washout of contrast

In setting of intraparenchymal lesion, suggests "non-brain" capillary bed, usually metastasis.









Primary Neoplasms: High-grade versus Low-grade?

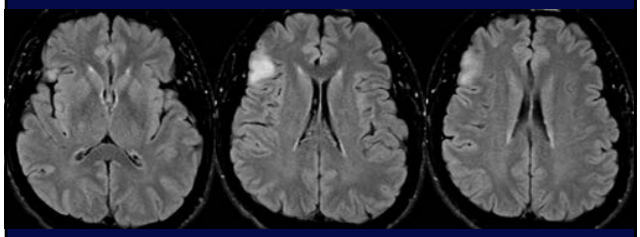
- Astrocytomas and Oligodendrogliomas
- Grade 3-4 versus Grade 1-2
- Prognosis (months-years vs. years-decades)
- Keys are
  - Increasing enhancement
  - Significantly increasing mass effect
  - Advanced techniques (perfusion, spectroscopy)
- Gold-standard is still biopsy

2016 World Health Organization

- Histology + molecular parameters are incorporated
- Major restructuring for diffuse gliomas and embryonal tumors (medulloblastoma)
- New entities (anaplastic PXA, diffuse leptomeningeal, glioneuronal tumor)
- Deletion of older tumors
- Gliomatosis cerebri is a pattern of spread, PNET

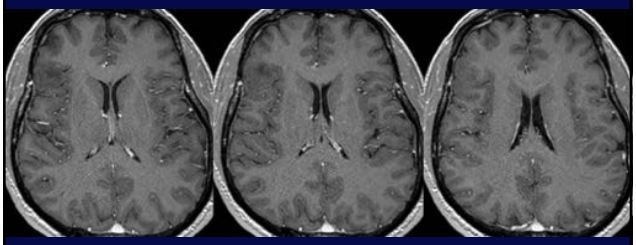
Louis et al., Acta Neuropath 2016

54 yo man with seizure



T2 bright abnormality with subtle mass effect

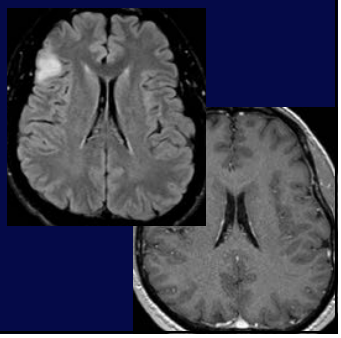
54 yo man with seizure



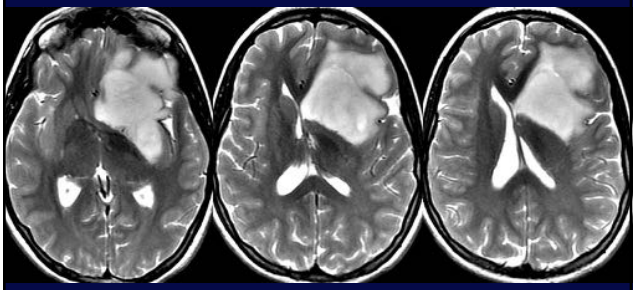
No significant enhancement

Low-Grade Diffuse Astrocytoma

- Most commonly presents with seizure in young (20-45 yrs)
- Grades 1 and 2 usually indistinguishable
- Mass-like T2 signal abnormality
- No enhancement*
- Usually slow growth
  - 6-10 yrs to degenerate to anaplastic astrocytoma/GBM

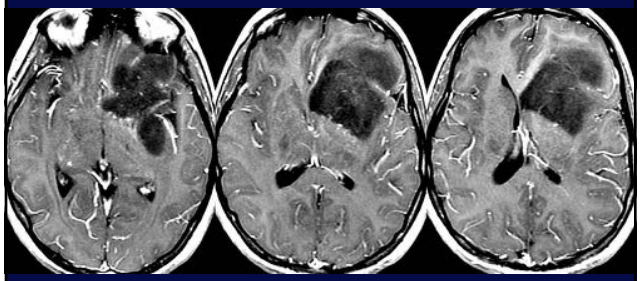


18 yo presenting with seizure



T2 bright abnormality with significant mass effect

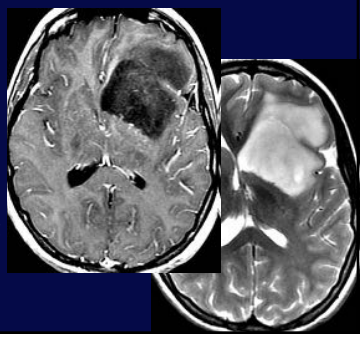
18 yo presenting with seizure



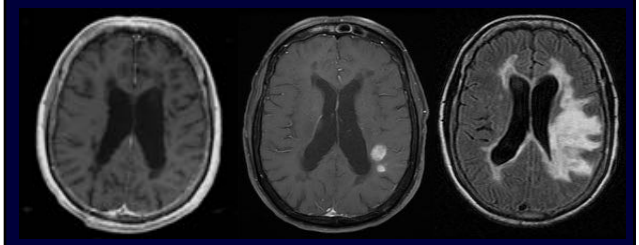
Mild patchy enhancement

Anaplastic Astrocytoma

- Most commonly evolves from prior LGG (75%)
- Grade 3
- Mass-like T2 signal abnormality
- Minimal enhancement
- May see increased CBF, CBV on perfusion imaging
- More rapid growth
  - 2-5 yrs median survival



67 yo woman - History of MS



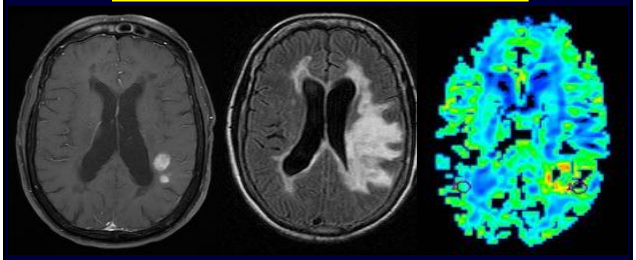
6 months prior

Current

New enhancing white matter lesions

High flow suggests neoplasm

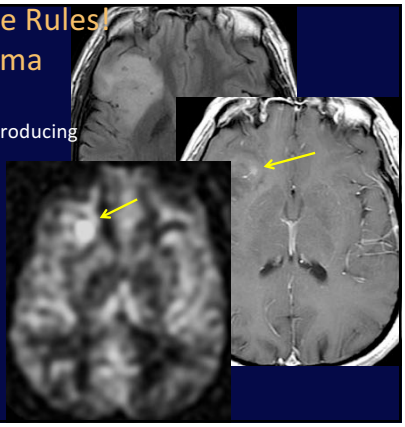
Final dx: GBM



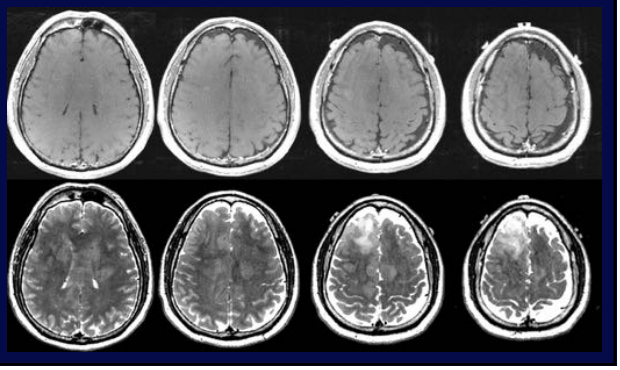
rCBV

Exceptions to the Rules: Oligodendroglioma

- Tumor of the myelin producing oligodendrocytes
- Often cortically-based
- Often calcified
- Grade 2 (Low grade)
- 50% enhance
- Have high CBV, CBF
- 1p 19q deletion
  - Good prognosis

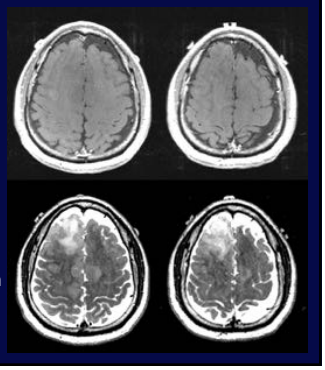


64 yo man with AMS



Exceptions to the Rules!
Gliomatosis Cerebri

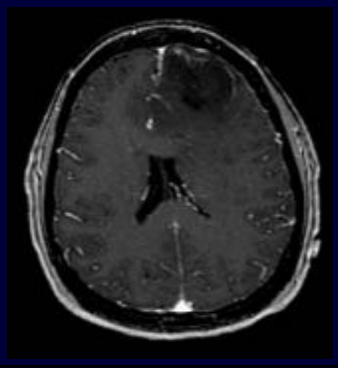
- 2007 WHO Grades 2-4
- Peak incidence 40-50 yrs
- Diffusely infiltrative
- Involves 3 or more lobes
- Minimal to no enhancement
  - despite higher grade
  - and poor prognosis
- 2016 WHO classified as growth pattern



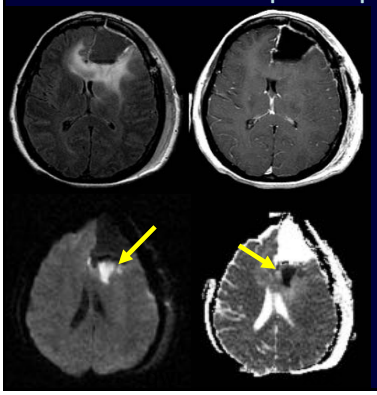
Immediate Post-op Tumor Imaging

- Within 48 hrs to avoid enhancing granulation tissue
- Abnormal enhancement presumed to represent residual tumor
  - Enhancing tumors only, of course…
- Serves as baseline for future studies
- DWI to image post-surgical ischemic injury
  - Prognosis
  - Sub-acute infarcts may enhance during follow-up imaging

51 yo woman, pre-op anaplastic astrocytoma



Immediate post-op (< 48 hrs)



No enhancing tumor

"Post-surgical change"

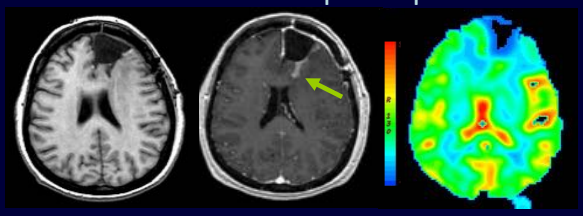
High signal on DWI

Low on ADC

"Post-surgical injury"

Really infarct

One month post-op



T1 pre T1 post rCBV

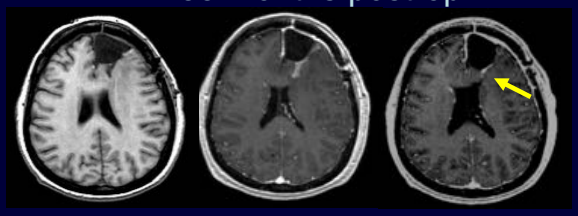
? Suspicious enhancement

? Recurrent tumor

No elevated CBV

Subacute infarct

Three months post-op



T1 pre T1 post T1 post

1 month 3 months

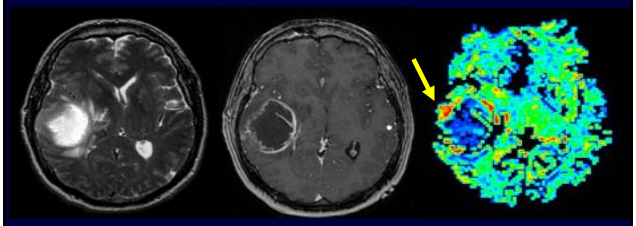
Resolving enhancement after sub-acute ACA infarct

Subacute infarct

Post-op brain tumor evaluation

- What does new enhancing tissue mean?
  - Subacute infarct
  - Recurrent tumor
  - Radiation necrosis
  - Pseudoprogression

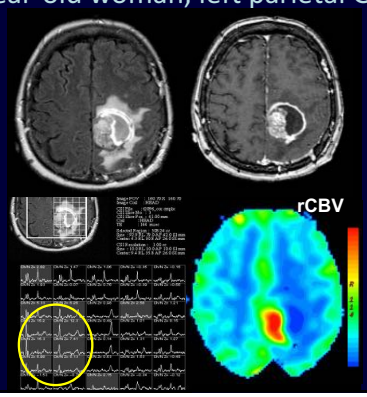
51 year-old woman with GBM
s/p prior resection, XRT, and chemotherapy



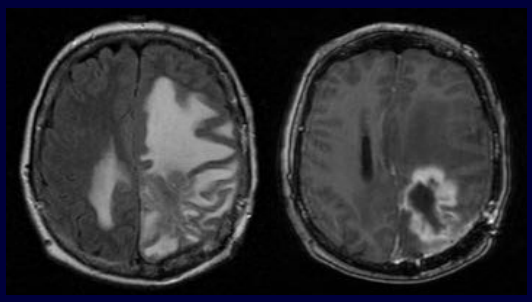
New enhancement around cavity | CBV

Recurrent GBM

56 year-old woman, left parietal GBM

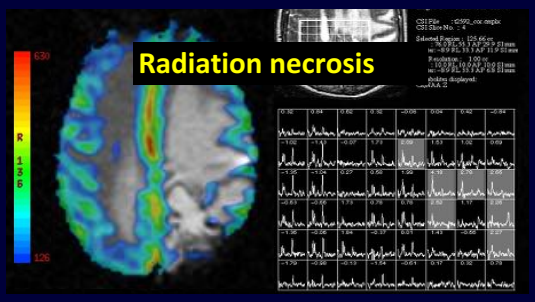


1 yr later, s/p resection, chemo, XRT



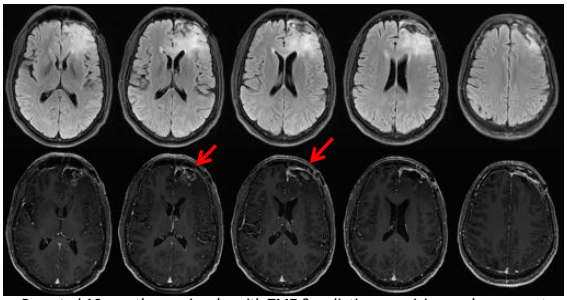
New enhancement, mass effect - worrisome for tumor recurrence

1 yr later, s/p resection, chemo, XRT



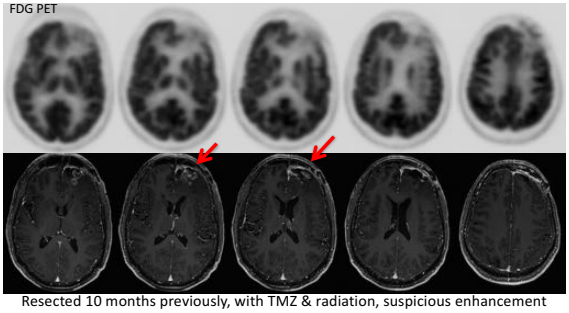
CBV | 1H-MRS

40 yo man, anaplastic oligodendroglioma (IDH mt, 1p/19q co-deleted)



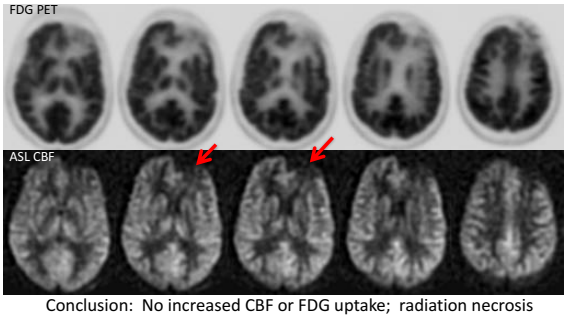
Resected 10 months previously, with TMZ & radiation, suspicious enhancement

40 yo man, anaplastic oligodendroglioma (IDH mt, 1p/19q co-deleted)



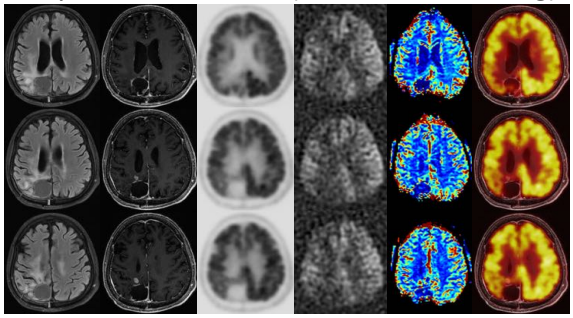
Resected 10 months previously, with TMZ & radiation, suspicious enhancement

40 yo man, anaplastic oligodendroglioma (IDH mt, 1p/19q co-deleted)



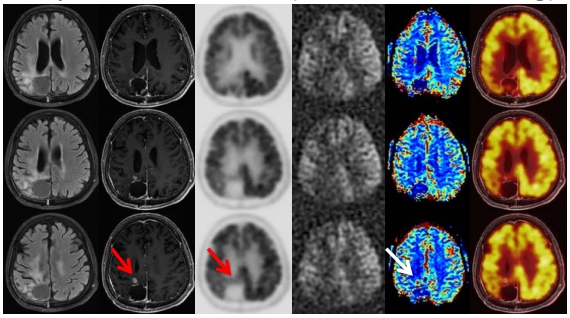
Conclusion: No increased CBF or FDG uptake; radiation necrosis

72 yo man with GBM (IDH WT, MGMT neg)



Resected 2 yrs prior, 8 cycles TMZ, radiation, Optune/TTF 1 yr prior, increasing enhancing nodule

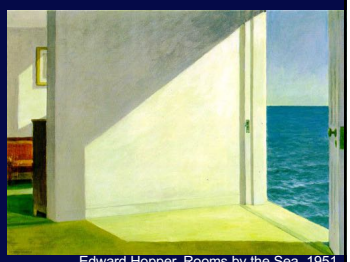
72 yo man with GBM (IDH WT, MGMT neg)



Increased FDG, CBV superiorly suggests tumor recurrence

Take Home Messages

- Extra-axial versus intra-axial
- Extra-axial most likely meningiomas
  - But be aware of other entities
- Intra-axial
  - Not all enhancement is tumor
  - Mass effect is key
  - Can make good guess at primary versus metastatic lesion
  - Biopsy guidance
- Imaging useful in tumor follow-up
  - Early post-op imaging very helpful
- Perfusion/MRS/PET helpful for distinguishing radiation necrosis from recurrent tumor.
- ***Thanks for your attention!***



Edward Hopper, Rooms by the Sea, 1951

gregz@stanford.edu