• Overview of common pediatric tumors

• Medulloblastoma
• Ependymoma
• Pilocytic Astrocytoma

• Anatomic imaging
• Diffusion Weighted Imaging (DWI)
• Dynamic Susceptibility Contrast (DSC)
  • Perfusion Imaging
• Magnetic Resonance Spectroscopy (MRS)

• How does advanced tumor imaging affect patient care? (Is it useful?)
**Pediatric Brain Tumor Epidemiology**

- 2.5 – 4 per 100,000 children per year
- 20% of all childhood malignancies
- 2nd only to acute lymphoblastic leukemia

- 54-70% of all childhood brain tumors occur in the posterior fossa
  - Medulloblastoma – 18% of all childhood brain tumors
    - Most common malignant pediatric brain tumor
  - Astrocytomas – most common childhood brain tumor (25% of all childhood brain tumors)
  - Ependymoma – third most common childhood brain tumor (10% of all childhood brain tumors)

**Hydrocephalus from tumor**

- Enlarged Head
- Setting Sun eyes
- Tense fontanelle

**Medulloblastoma**

- Enlarged Head
- Setting Sun eyes
- Tense fontanelle
Medulloblastoma

Pilocytic Astrocytoma
- World Health Organization (WHO) grade I

Pilocytic Astrocytoma
- World Health Organization (WHO) grade I
Pilocytic Astrocytoma

Ependymoma

WHO grade I
WHO grade II
WHO grade IV

Ependymoma

Ependymoma

Ependymoma

Ependymoma
Comparison

- CT

Medulloblastoma  Pilocytic astrocytoma  Ependymoma

- T2

Medulloblastoma  Pilocytic astrocytoma  Ependymoma

Comparison

- T1 + C

Medulloblastoma  Pilocytic astrocytoma  Ependymoma

DWI

- A linear pulsed field gradient is applied, dephasing spins
- A second pulse applied in the same direction at opposite magnitude rephases the spins of the molecule only if it has not moved, thus the more Brownian motion, the more signal loss

\[ \frac{S}{S_0} = e^{-2\gamma^2\delta^2(D-\delta/3)D} = e^{-bD} \]

DWI in tumors

- Apparent diffusion coefficient (ADC) – map of the diffusion “D” coefficient
- Excludes increased signal on DWI from T2 “shine through”

Neuroepithelial Tumors  ADC µm²/ms

- WHO grade I, Dysembryoplastic Neuroepithelial Tumor  2.546±0.135
- WHO grade I, Pilocytic Astrocytoma  1.659±0.260
- WHO grade II, Diffuse Astrocytoma  1.530±0.148
- WHO grade II, Oligodendroglioma  1.455
- WHO grade II, Ependymoma  1.230±0.119
- WHO grade III, Anaplastic Astrocytoma  1.245±0.153
- WHO grade III, Anaplastic Oligodendroglioma  1.222±0.093
- WHO grade III, Anaplastic Ependymoma  1.103±0.101
- WHO grade IV, Glioblastoma  1.079±0.154
- WHO grade IV, PNET  0.835±0.122
- WHO grade IV, Medulloblastoma  0.66±0.15

Other Brain Tumors  ADC µm²/ms

- Craniopharyngioma  1.572±0.210
- Schwannoma  1.384±0.140
- Epidermoid  1.263±0.174
- Germ Cell Tumor  1.189±0.175
- Metastatic Tumor  1.149±0.192
- Pituitary Adenoma  1.121±0.202
- Typical Meningioma  1.17±0.21
- Atypical/Malignant Meningioma  0.75±0.21
- Malignant Lymphoma  0.725±0.192

**DWI**
- Medulloblastoma – decreased ADC
- Pilocytic astrocytoma – increased ADC
- Ependymoma – mostly increased ADC

**Comparison**
- ADC

**Perfusion Imaging**
- **DSC**
  - First pass bolus imaging of contrast
  - Gadolinium
  - Heavy metal chelate with paramagnetic effect.
  - T2* effect
    - Faster T2 (transverse) decay due to field inhomogeneity
    - Signal dropout on GRE seen adjacent to paramagnetic substances
    - Echo Planar Imaging (EPI) is commonly used for measuring susceptibility perfusion
Perfusion Imaging

- Technique
  - At least 22 g peripheral iv
  - 5 cc/s power injector
  - 0.1 mmol/kg multihance
  - 32 ml total with NS
  - 20 sec delay for injection after scanning starts
    - If 24g iv in neonates, decrease to 3-4 cc/s

- rCBV – ratio between the CBV of the highest perfusing portion of the tumor divided by CBV of normal white matter

- Grading from perfusion
  - Increased CBV as measured by perfusion imaging should correlate with more aggressive tumors
  - This allows grading prior to histopathology
  - Directs biopsy toward the most aggressive part of the tumor so tumors are not undergraded
  - Increased CBV values should correlate with decreased survival outcome


- rCBV of 1.75 is the cutoff between high grade and low grade glial tumors (astrocytomas)
- rCBV thresholds have yet to be established in the pediatric population
Perfusion Imaging

- Medulloblastoma
  - High grade
  - HOT!

- Ependymoma
  - Typically WHO grade II
  - Lukewarm.

- Pilocytic Astrocytoma
  - Low grade
  - Cold! (sort of.)
  - rCBV ratios important

- Perfusion Imaging
  - Low grade group – rCBV 2.2
  - Medulloblastomas – rCBV 3.7
  - (p=0.028)

- Perfusion Imaging
  - Very little in the literature on perfusion imaging in pediatric population
  - Initial results based on rCBV of 9 pilocytics and 2 ependymomas vs. 5 medulloblastomas
  - Low grade group – rCBV 2.2
  - Medulloblastomas – rCBV 3.7
  - (p=0.028)
Protons in different biological metabolites have different chemical shifts from a reference chemical.

- Decreased N-acetyl acetate – indicating a decrease in neuronal elements
- Increased Choline – a marker of cell membranes, indicating increased mitosis
- Presence of lactate – anaerobic respiration - rapidly growing tumors outgrow its blood supply and get central necrosis.

MRS in brain neoplasm

Voxel placement of MR spectroscopy.
MRS
- Single voxel technique
  - Pros
    - Better signal to noise
    - Better peaks, can isolate more metabolites
    - Quantify ratios
  - Cons
    - Time consuming to run multiple single voxels
    - Placement is more critical

- Multivoxel technique
  - Pros
    - Faster
    - Covers larger area
    - Placement important but less critical
  - Cons
    - Decreased signal to noise
    - Done at long echo with only 3-4 major metabolites

Placement is critical!
MRS
- Placement of voxel is very important
  - Do not place in the center of a necrotic tumor, or areas of hemorrhage
  - Do place in enhancing portions and solid portions
  - Do get a normal contralateral comparison
  - Ask your friendly radiologist if in doubt

MRS
- Medulloblastomas

MRS
- Pilocytic Astrocytoma

MRS
- Ependymoma
MRS

- Qualitatively similar – lactate, low NAA and high choline
- However, if single voxel is performed you can get ratios

Summary

- DWI/ ADC improves recognition in distinguishing high grade medulloblastomas from low grade ependymomas and pilocytic astrocytomas

MRS

- Qualitatively similar – lactate, low NAA and high choline
- However, if single voxel is performed you can get ratios

Summary

- Perfusion
  - Differentiate high vs low grade tumors based on blood supply
  - Can guide biopsy
  - Can be useful for recurrence vs. radiation necrosis

Summary

- Spectroscopy
  - With quantitative ratios – can separate the high grade medulloblastomas from low grade
