Imaging of Pediatric Epilepsy

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Epilepsy: Nonacute Situation

- MR is the study of choice
- Tailor MR study to suspected epileptogenic zone
  - Temporal lobe
  - Extratemporal

MRI

- Sensitivity in detecting brain damage varies depending upon:
  - Age of baby at time of scan (FCD difficult to detect 5-18 months of age)
  - Scanner (magnetic field and gradient) strength
  - Sequences obtained
  - Section thickness
  - Signal to noise
  - Expertise of interpreter ("You see what you look for, you look for what you know")

Magnetic Resonance Imaging is the Technique of Choice for the Imaging Evaluation of Pediatric Epilepsy...

However, MRI is most useful when the semiology and EEG findings have been communicated.
Causes of Pediatric Epilepsy

- Brain Malformations
- Brain Injuries
  - Vascular
  - Perinatal Ischemia/Trauma
  - Postnatal Trauma
  - Infection
- Mesial Temporal Sclerosis
- Vascular Malformations
- Neoplasms
- Metabolic
- “Idiopathic”

Malformations of Cortical Development

- Constitute 20-50% of pediatric epilepsy cases being evaluated for surgery

- Classification:
  - 1. Malformations secondary to abnormal stem cell production/differentiation or apoptosis
  - 2. Malformations secondary to abnormal neuronal migration
  - 3. Malformations secondary to abnormal late migration/cortical organization
Classification: Malformations of Cortical Development

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Focal Cortical Dysplasia Palmini Classification

- Minor Malformations of Cortical Development (mMCD)
  - mMCD Type I - ectopically placed neurons in Layer 1
  - mMCD Type II - microscopic heterotopia outside Layer 1
- FCD Type I - Dyslamination of Cerebral Cortex
  - Type Ia - dyslamination
  - Type Ib - dyslamination plus giant/immature neurons
- FCD Type II - dysmorphic neurons +/- balloon cells
  - Type IIa - dysmorphic neurons without BC
  - Type IIb - dysmorphic neurons with BC

**Images:**
- GW blurring Mild inc T2 Dx: mMCD
- SPGR Normal
- FSE Parallel Imaging Dx: FCD1a
9 yo with refractory epilepsy localized to right parietal lobe
Dx: FCD Type 1
Blurring of GWJ

23 yo woman with hx of partial complex sz since age 4 yrs. Now with worsening control.
FCD Type 1.

FCD type II A

12 mo with FCD2
Focal Transmantle Dysplasia (FCD2b)

25 y.o. with intractable epilepsy. Which lesion to resect?

- MRI --> Large dot - eloquent cortex
- Small dots - spikes

Patient: multiple epileptogenic foci, extensive resection necessary

Localization of Eloquent Cortex

- Magnetic Source Imaging (MSI, MEG) - extra machine
- fMRI (Bold)
- DTI (only sensorimotor)
Localization of Epileptogenic Focus

- FDG Positron Emission Tomography (PET)
- fMRI (BOLD)
- Magnetoencephalography (MEG, also called MSI)
- MR Spectroscopy - Research Only
- Diffusion Tensor Imaging - Research

Frontal Lobe: Cortical Dysplasia

Magnetic Source Imaging (MSI)

MEG interictal spike foci coregistered with axial SPGR images

Magnetoencephalography (MEG)

Simultaneous recording of 275 MEG channels and 128 EEG channels
Use of fMRI (BOLD) in Pediatric Epilepsy
Courtesy Graeme Jackson

Functional Localization of Epileptogenic Focus

- Requires specialized tools (MR compatible EEG, EEG leads for fMRI or separate machine for MEG, PET)
- fMRI requires dedicated MRI scanner
  - Accuracy not determined in large series

Malformations of Cortical Development

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41 yo with partial complex epilepsy
**Subcortical Heterotopia**

- **CLINICAL:**
  - Variable age at presentation
  - Epilepsy in >80%
  - Focal neurological deficits in >70%
  - Intellect: normal to mild retardation
- **IMAGING:**
  - Heterotopic mass extending from ventricle into white matter
  - Small ipsilateral hemisphere with reduced white matter
  - Callosal hypogenesis/agenesis in ~70%
  - Dysplastic basal ganglia

3 year old boy with epilepsy

37 year old woman with partial complex epilepsy
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**Polymicrogyria**

- A malformation characterized by multiple small gyri separated by shallow sulci
- Causes: *in utero* injury, mutations, ??
- May be diffuse, multifocal asymmetrical, bilateral and symmetrical, or very localized
- Much variability in histology
- Much variability in Imaging appearance
22 yo woman with Partial complex seizures
Dx: PMG

3 month old with infantile spasms

18 month old with congenital hemiplegia, seizures

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7 month old with early had preference and sz

Utility of High Resolution images in assessing epilepsy

14 year old girl with seizures, obtundation, fever
Dx: viral cerebritis

2 year old girl with new onset of Seizures
Dx: Cysticercosis vs. TB
Increased diffusion, lactate, alanine, and valine on MRS give dx of cysticercosis

Lesions Resulting from Epilepsy or Epilepsy Rx

- Cortical edema
- Subcortical watershed edema (PRES)
- Splenium lesions from AED’s
  - Phenobarbital, Dilantin, Carbamazepine

7 year old girl with new onset seizures

MRS, TE=26ms
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S/P GTCS earlier that day
Diffusion: interstitial edema (PRES) implies no permanent injury

6 year old girl with partial complex epilepsy
Small, hyperintense right hippocampus
Dx: Mesial Temporal Sclerosis
Dual Pathology
• Development of hippocampal sclerosis with other epileptogenic lesion
  – Heterotopia, AVM, FCD, DNT are most common
• MTS is caused by seizures
• Inciting lesion is always located in temporal lobe
• Often, both lesions (inciting lesion and sclerotic hippocampus) must be removed for seizure control

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• **Vascular Disorders/Malformations**
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Sturge Weber Syndrome

- Characterized by angiomas of the face, ocular choroid, and leptomeninges
- Patients manifest epilepsy, hemiparesis, hemianopsia, mental retardation
- Pathophysiology is probably cortical injury secondary to chronic venous hypertension; angioma impairs venous drainage from the cortex in affected areas
If you know it’s there and you can’t find it....look harder!
(but you need to know where to look...)
Dx: Transmantle Cavernoma
Very vascular and epileptogenic lesion

Vascular Malformations: Parameters Predictive of Epilepsy
1. Cortical location
2. Feeding by MCA
3. Cortical location of feeding vessel
4. Absence of aneurysms
5. Presence of varix/varices in venous drainage
Ref: Turjman et al, AJNR 1995;16:345-350

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30 year old woman with partial epilepsy
Imaging at 1.5T
Extracranial cyst? Tumor?
Dysembryoplastic Neuroepithelial Tumor (DNT)

- Benign multilobular cortical tumor
- Causes epilepsy; age at onset 1-19 yrs
- Often epilepsy of long duration
- Complete resection is curative
- Most common in temporal, frontal lobes

3T MRI
Dx: DNET

Dx: Hypothalamic Hamartoma

6 year old girl with epilepsy, precocious puberty.
Dx: Hypothalamic Hamartoma
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Conclusions

- MR is the imaging study of choice for pediatric epilepsy
- To maximize value of MR, good communication is as critical as proper technique -- 3 planes, thin sections, high contrast
- If partial epilepsy with well localized focus, other techniques may be useful -- PET, MEG, MRS