Pediatric Body MRI

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Objectives

- Identify the challenges of imaging pediatric patients.
- Determine the advantages & disadvantages of scanner strength.
- Discuss the various safety concerns involved in pediatric imaging.
- Understand the basis for appropriate coil selection.
- List and understand the most useful pulse sequences.
- Become familiar with the use of specific contrast agents.

Pediatric Challenges

- Anatomical
- Developmental
- Physiological
- Behavioral

ALARA

- As
- Low
- As
- Reasonably
- Achievable

Pediatric Challenges

Anatomical Challenges:
- Average neonate brain 25% that of adult
- Structures and blood vessels smaller than adult
- Decrease FOV and SLT equals decreased SNR, CNR, and image quality
- 3T significantly improves all factors

Developmental Challenges:
- Tissues undergo changes through infancy and puberty
- Primarily brain, bone, and cartilage
- Requires Sr, SNR, and CNR for subtle changes
**Pediatric Challenges**

**Physiological Challenges:**
- Rates much higher in infants and children
  - Normal infant heart rate ~ 140/min
  - Normal adult heart rate ~ 60-100/min
  - Normal infant respiratory rate ~ 40/min
  - Normal adult respiratory rate ~ 15-20/min
- Inability to perform breath-hold sequences

**Behavioral Challenges:**
- Lack of understanding and cooperation
  - May require sedation or GA (inherent risks, slow & costly)
- Techniques (pediatric swaddling devices, timing feeds, etc.)
- Greater success with shorter scan times (higher field strengths with improved temporal resolution)

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**Scanner Selection**

**3 Tesla (Higher Field Strength) Advantages:**
- SNR increase
- Improved spatial resolution
- Improved temporal resolution
- Longer T1 tissue times

**3 Tesla (Higher Field Strength) Disadvantages:**
- Chemical shift increase
- Susceptibility (T2*) increase
- SAR increase
- Longer T2 tissue times
- Longer T1 tissue times

* Increased BW and decreased FA reduce most disadvantages

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**High Field Strength**

**Potential 3T Improvements**

<table>
<thead>
<tr>
<th>Factor</th>
<th>CNS</th>
<th>MSK</th>
<th>CVS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SNR</td>
<td>DWI, DTI, fMRI</td>
<td>Peds joints &amp; cartilage</td>
<td>Temporal resolution</td>
</tr>
<tr>
<td>Longer T1</td>
<td>MRA</td>
<td>MRA</td>
<td>MRA, ASL, tagging</td>
</tr>
<tr>
<td>Susceptibility</td>
<td>fMRI, SWI</td>
<td>Calcification detection</td>
<td>BOLD</td>
</tr>
<tr>
<td>Chemical shift</td>
<td>MRS</td>
<td>MRS &amp; FS</td>
<td>MRS</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Application</th>
<th>Examples of disease processes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neonate</td>
<td>All structures</td>
</tr>
<tr>
<td>CNS</td>
<td>Brain, IAC, CN, Brachial Plexus</td>
</tr>
<tr>
<td>Abdomen</td>
<td>Biliary Tree</td>
</tr>
<tr>
<td>MSK</td>
<td>Small joints Polartopathy</td>
</tr>
<tr>
<td>MR Angio</td>
<td>Vascular Malformation CHD</td>
</tr>
<tr>
<td>Whole Body</td>
<td>Neuroblastoma, lymphoma, leukemia, sarcoma, oncologic, osteomyelitis &amp; polyarthritis</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>@ 3T</th>
<th>Effects</th>
<th>Compensation</th>
<th>Trade-off</th>
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</thead>
<tbody>
<tr>
<td>T1 times</td>
<td>ETI contrast</td>
<td>ETI Parallel imaging &amp; MT sequences</td>
<td>Repetition time</td>
</tr>
<tr>
<td>Chemical shift</td>
<td>Artifact @ fat interfaces</td>
<td>Double refocus BW</td>
<td>SNR increase</td>
</tr>
<tr>
<td>SAR</td>
<td>BOLD</td>
<td>SAR reduction Fat &amp; MT saturation</td>
<td>ETL - ESR</td>
</tr>
<tr>
<td>Magnetic susceptibility</td>
<td>Image distortion</td>
<td>Fat &amp; MT saturation</td>
<td>T1 - ESR</td>
</tr>
<tr>
<td>SNR</td>
<td>BOLD</td>
<td>SNR reduction</td>
<td>ETL - ESR</td>
</tr>
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1.5T vs. 3T

Safety Concerns

Reducing SAR @ 3T
- Use transmit-receive coils
- Reduce the number of sections
- Reduce the FA
- Increase the TR of GRE sequences
- Decrease the ETL
- Add a delay between sequences
- Use parallel imaging techniques or sequences that have FA modulation

Coil Selection
- Newer generation phased-array coils with higher, smaller channels ~ 32 for improved SNR

Safety Concerns

SAR Limits and Ways to Reduce SAR

- FDA limits
  - 4 W/kg for the whole body for 15 min
  - 3 W/kg averaged over the head for 10 min
  - 8 W/kg in any gram of tissue in the head or torso for 5 min
  - 12 W/kg in any gram of tissue in the extremities for 5 min

- Ways to reduce SAR
  - Increase TR, decrease flip angle, decrease number of sections
  - Use parallel imaging, which reduces ETL
  - Intersperse gradient-echo and spin-echo sequences
  - Minimize the saturation band
  - Make sure the patient is changed into a loose hospital gown for better heat dissipation
  - The bore fan should be on
  - The room temperature should be cool

Note:—FDA = U.S. Food and Drug Administration, TR = repetition time.
*FDA limits for SAR are such that radiofrequency exposure should elevate core body temperature by ≤1°C.
**Pulse Sequences**

- Same sequences as used in adult studies
  - Utilize techniques to reduce scan time and/or motion artifacts
- Prioritize sequences
- SSFSE
  - Single-shot, half-Fourier rapid acquisitions for T2W (HASTE)
- Fast GRE sequences for T1W & T2W (VIBE)
- 3D Sequences (SPACE)

**Contrast Agents**

- Magnevist and Prohance are non-specific agents for the liver
- Multihance – high relaxivity agent
  - Standard dose (0.1mmol/kg)
  - Arterial/portal/venous/delayed sequences

**Contrast Agents**

- Gadoxetate Disodium (Eovist; Bayer HealthCare Pharmaceuticals, Wayne, NJ, USA)
  - ~ 50% biliary excretion
  - Eovist specifically for liver exams (0.025mmol/kg) (high relaxivity agent)
  - Hepatocyte parenchymal phase of contrast enhancement beginning ~ 15 min following injection to ~ 60 min.

- Gadofosveset Trisodium (Ablavar; Lantheus Medical Imaging, North Billerica, MA, USA)
  - Immediate dynamic imaging used for MRA
  - Steady-state imaging ~ 7 min to ~ 60 min

**Specialized Pediatric Techniques**

- 6y/o Enterography

6y/o Enterography
<table>
<thead>
<tr>
<th>6y/o Urography</th>
<th>3y/o Triggered</th>
</tr>
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<tbody>
<tr>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
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**Conclusion**

- Radiation awareness
- Pediatric challenges
- Scanner options
- Safety concerns
- Coil selection
- Pulse sequences
- Contrast agents
- Techniques to promote cooperation