Neonatal Brain MR Protocols

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Sonography has been an important part of care in the neonate, particularly the high risk and unstable premature.
Neonatal Ultrasound

- Late 1970’s
  - Anterior fontanelle window to brain
  - Excellent premature infants
- 1980’s
  - Noninvasive
  - No sedation
  - Radiation free
  - Fast
  - Bedside
  - Low cost
  - Doppler flow
Indications for Head Ultrasound

- Hemorrhage
- Ventriculomegaly
- Ischemia
- CNS malformations
- Infection
- Masses
- Vascular abnormalities
Ultrasound Limitations

- Small field of view

- Contrast
  - Anoxic brain injury

- Functional information
Neonatal Imaging: CT

- Transportation
- Radiation
- Limitation in contrast
Obtain sonogram as initial study. If lack of concordance with clinical, MR should be considered

A.J. Barkovich
Pediatric Neuroimaging
Neonatal MRI

- Late 1980s and early 1990s
  - Superior soft tissue contrast
  - Multiple planes
  - Variable field of view
  - Higher imaging techniques
    - Diffusion
    - Spectroscopy
    - Functional
    - Volumetry
    - Arterial spin labeling (ASL)
MRI Difficulties

- Stability of neonate
  - Personnel
  - Monitoring
    - Thermoregulation
- Time
  - Preparation
- Transportation

- Sedation
  - Time
  - Risk
- MRI safety
  - Contraindications
  - Acoustic noise
- Imaging
  - Sequences
  - Coils
Stability of the Neonate: Monitoring

- MR compatible
  - Pulse oximeter
  - EKG leads
  - Ventilator
  - Infusion pumps or extension tubing
  - Life support
    - Resuscitation bag
    - Crash cart
- Blankets/sheets for warmth
Time for Preparation

- Undressed to diaper
- Transfer to MR compatible equipment
- Ear protection
- Warming blankets

- Time
  - Critically ill
    - 1 hour
  - Stable
    - 30 minutes

Challenges of Transportation

- Temperature regulation
- Intensive monitoring
- Support apparatus
  - Respiratory
- Time for transport
- Time to wait for imaging
- Exposure to infection/noise
Transportation

- MR compatible incubator

Commercial unit built by Lammers

Motion
Sedation of the Neonate

- Neuronal cell death after neonatal exposure sedatives/anesthetics

- Chloral hydrate
  - >12 hours increased sedation
  - Increased bradycardia events

  Allaegaert K et al. Paediatr Anaesth 2008; 18(12):1270-1
Lack of Sedation

• Fed 30-60 minutes before the scan started
  – Held/rocked
  – SweetEase or a small amount of formula at time of scan

• Immobilization
  – Swaddle blankets/linens and tape
  – VacFix/Medvac bag
    • 10% failure rate

• Medication
  – 0.1 mg/kg midazolam X2 through the IV
MRI Safety

- Gadolinium
  - Off label, due to immature kidney function
  - Gadavist
- Hearing
  - Mimi ear muffs and ear plugs
    - Uninterrupted sleep < 45 dBA
    - Prevent physiologic distress < 65dBA
    - Hearing Loss > 85 dBA
- MR compatibility
  - Wand
- Specific Absorption rate
  - 3W/Kg for 10 minute period
MRI Timing

- < 24 hours falsely negative
- 1-2 weeks ideal
- >2 weeks chronic
  - Pattern may be more difficult
Technical Considerations

- Coils
  - Smallest coil
    - Adult knee
    - Neonatal head coil

Wardray Premise
Imaging

- Infant brain—92-95% water
  - Decreases over the first 2 years to 80-85%

- Imaging
  - Increase T1 and T2 relaxation times
    - T1 imaging TR 500-850 (T1 Flair 2200 msec)
    - T2 imaging TR 3500-5000
  - Diffusion higher ADC values
    - B value 800 and 1000 sec/mm²
Myelination

- **T1** – increased glycolipids
  - 6-8 months
- **T2** – decreased free water molecules
  - 6-18 months
Normal Myelination in Neonate

- T1 myelination in weeks
  - 24-28 - Dorsal brainstem
  - 28 - Subthalami and ventrolateral nucleus
  - 36-37 - Posterior limb internal capsule (T2-40)
  - 38-40 - Corticospinal central coronal radiate and perirolandic white matter
MRI 40 Weeks
Germinal Matrix Involution in Weeks

- 27- VZ (ependymal)
- 34/36 -SVZ (subependymal)
  - 33
    - Roof temporal horns
    - Lateral occipital horn
  - 36
    - ganglionic eminence
  - Postnatal
    - frontal periventricular
Normal Germinal Matrix
Sulcation

16 w
- Interhemispheric
- Sylvian

22-25 w
- Parietooccipital
- Callosal
- Calcarine
- Cingulate

26-28 w
- Central (26)
- Precentral (27)
- Superior Temporal
- Marginal
- Postcentral (28)

29-34 w
- Superior frontal
- Inferior frontal
- Inferior temporal

>30 w
- Secondary
- Tertiary
Subdural in Newborns

- 46%
- Supratentorial (posterior cranium)
- Infratentorial
- < 3mm
- Resolve 1 month

Rooks VJ. Prevalence and Evolution of Intracranial Hemorrhage in Asymptomatic Term Infants. AJNR. 2008; 29: 1082-89
Susceptibility Weighted Imaging (SWI)
MRA/MRV
Spectroscopy

2.02 ppm - N-acetyl-aspartate - neuronal marker

3.23 ppm - Choline - cell membrane

3.02 ppm - Creatine - cellular energy

3.56 ppm Myo-inositol - hormonal and enzymatic regulation, glial

1.33 ppm - Lactate - anaerobic

2.1/2.5 ppm Glutamine/Glutamate - excitatory and detox

.8, 1.2, 1.5 ppm - Lipids
Spectroscopy

- Potential Pitfalls
  - NAA low in newborn
    - Adult at 2.5 years
  - Lactate varies with maturity
    - Term BG Lac/NAA .25
    - Absent few months
  - Variable different regions
  - Do not include CSF
  - Solvent for phenobarbital 1.15 ppm
    - Porpan 1,2 diol
High lactate and low NAA poor outcome
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<th>Mach. #</th>
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<tr>
<td>NA</td>
<td>7</td>
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<tr>
<td>Cr</td>
<td>10</td>
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<td>RMS Noise</td>
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<td>Cr SNR</td>
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Voxel Location

R/L A/P S/I
Ctr L14.1 A63.5 S24.5
Dim 15.0 15.0 15.0

R/L A/P S/I
Ctr L13.4 A45.5 S24.5
Dim 15.0 15.0 15.0
Conclusion

- Brain MRI adjunct
- Communication/preparation
- Monitoring/sedation
- Imaging amended
- Know what is normal