Magnetic Resonance Imaging of the fetus

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MR as an Imaging Tool

- **Nuclear Magnetic Resonance Spectroscopy**
  - Known for a long time in the chemistry lab

- Idea of Medical Imaging arose in 1980’s
Basic Principals of MRI

How does Magnetic Resonance Imaging work?

- Certain nuclei act like tiny magnets
  - $^1$H imaging

- By using a large external magnetic field and radio waves - manipulate magnetic properties to determine relative concentration and position of $^1$H within tissue
Basic Principals of MRI

- **Strong magnetic field**
  - 0.3 -> 3 Tesla
    - 1 Tesla = 10,000 Gauss
    - Earth’s magnetic field 0.3 - 0.7 Gauss
    - Refrigerator magnet 100 Gauss
  - Aligns protons with field creating strong vector
Basic Principals of MRI

- Superimposed a variable magnetic field (gradient)
- Introduce energy (radio waves)
  - Frequency just below FM radio
- Some protons absorb energy
- Turn off radio waves and listen for return frequency as proton release energy (relaxation time)
Basic Principals of MRI

- Two separate characteristics of protons that are recorded (T1 and T2)
- Numerous applications (sequences) to enhance and display differences in these characteristics
- First clinical applications 1980
Magnetic Resonance Fetal Imaging

- Then- first described in 1983
  - Conventional spin echo technique
  - Required maternal and/or fetal sedation

- Now- advances in hardware/software allow an image to be obtained in milliseconds
  - Effectively freezing fetal motion
MR Fetal Imaging- T2 Sequences

- Single shot fast spin echo (SSFSE)
- HASTE *half-Fourier single-shot turbo spin echo*
  - Imaging blurring
  - High RF deposition- heating
  - Low SNR

- Workhorse
  - anatomy
MR Fetal Imaging- T1 Sequences

- FLASH *fast low angle shot*
  - Relatively slow (20 sec) without high performance gradients

- Liver, thyroid and meconium
- Hemorrhage
- Lipomas
MR Fetal Imaging-Additional Sequences

- TruFISP
  - Alternative T2 weighted sequence (white blood)
- Diffusion Weighted Imaging
  - Hypoxic-ischemic injury
- Echo planar imaging
  - Calcifications and blood products
MR Fetal Imaging - Timing of exam

- Late 2\textsuperscript{nd} trimester onward
- Avoid first trimester - effects not studied
MR Fetal Imaging- Adjunct to US

- Ultrasound remains the primary screening modality
  - But may be limited by
    - Small field of view
    - Poor penetration through the ossified skull
    - Lack of acoustic window with oligohydramnios
    - Fetal position- particularly in late pregnancy
    - Nonspecific appearance of certain abnormalities
    - Beam attenuation of maternal adipose tissue
MR Fetal Imaging - Advantages

- Superior contrast resolution
- Better visualization of CNS structures
- Large field of view
- True multiplanar imaging
- Relative operator independence
MR Fetal Imaging- Adjunct to US

- Confirm diagnosis/offer alternative diagnosis
- Identify additional abnormalities
- Patient counseling/pregnancy management
- Problem solver
MR Fetal Imaging - Indications

- CNS abnormality
- Neck/Chest/Abdominal Mass
- Lung hypoplasia
- Renal/GU abnormality
- Spine/Sacroccocygeal teratoma
MR Fetal Imaging- CNS

- Fetal MRI of the CNS is particularly helpful
  - Etiology of ventriculomegaly
  - Evaluation of posterior fossa collections
  - Evaluation of mylination/migration abnormalities
  - Documentation/extent of hemorrhage or ischemia
MR Fetal Imaging- CNS

  - MRI lead to a change in diagnosis 26/44 (40%)

  - Additional information 64%
  - Change in diagnosis 28%
  - Alter timing/mode of delivery 11%
Aquaductal Stenosis
Hydranencephaly
Dandy Walker Malformation
Arachnoid Cyst
MR Fetal Imaging- Non CNS

- **Airway/ thoracic abnormalities**
  - Obstructing neck mass
  - Lung Hypoplasia
  - CDH: document position of the fetal liver
    - Liver “up” vs. “down”; mortality 57% vs. 7%
  - Chest masses
    - CCAM
    - Sequestration
    - Bronchogenic cyst
Fetal lung hypoplasia

- Lung volume
  - Vs. Gestational age
  - Vs. Fetal size
  - Vs. predicted volume
- Signal intensity
Low-intensity fetal lungs on MRI may suggest the diagnosis of pulmonary hypoplasia


- Concept of lung-to-liver intensity ratio
  - Value <2 suggests hypoplasia in fetuses after 26 weeks
Lung = 90
Liver = 91
Ratio = 0.99
Achondroplasia

coronal chest anterior to posterior
coronal chest anterior to posterior cont.
axial chest with grossly normal signal intensity within the lungs
Congenital Diaphragmatic Hernia
MR Fetal Imaging - Non CNS

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    - Chest masses
      - CCAM
      - Sequestration
      - Bronchogenic cyst
  - Chest Wall
MR Fetal Imaging- Non CNS

- Abdominal masses
- GI/GU anomalies
- Sacrococcygeal teratoma
- TTTS
Renal dysgenesis
oligohydramnios
Twin-To-Twin Transfusion Syndrome
MR fetal Imaging- Cutting Edge

- Evaluation of the placenta
- Ungated fetal cardiac cine – Echoplanar imaging
- Assessment of nutritional status by evaluation of adipose tissue
MR fetal Imaging- Cutting Edge

- **Functional MR**
  - 33+ weeks
  - Brain oxygenation

- **MR spectroscopy**
  - Lactate in Brain
  - Myelin in Brain
  - Lecithin in amniotic fluid and/or lung parenchyma → lung maturity
MR Fetal Imaging - Conclusions

- Useful Adjunct to ultrasound
  - Any CNS anomaly
  - Any chest mass

- Problem solver
  - Abdominal/pelvic lesions

- Surgical planning