Magnetic Resonance Imaging of the fetus

John A. Cassese M.D.
Assistant Professor
Departments of Diagnostic Imaging and Pediatrics
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
  - $^1\text{H}$ imaging

- By using a large external magnetic field and radio waves - manipulate magnetic properties to determine relative concentration and position of $^1\text{H}$ 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)
CREATING REFINED ANATOMICAL IMAGES
Within the metallic cocoon of an MRI scanner, the patient is surrounded by four electromagnetic coils and the components of a transciever.

Scanner
Uses electromagnets and radio signals to produce cross-sectional images.

Y Coil
Creates varying magnetic field from top to bottom across scanning tube.

Z Coil
Creates varying magnetic field from head to toe within scanning tube.

Transciever
Sends radio signals to protons and receives signals from them.

X Coil
Creates varying magnetic field from left to right across scanning tube.

Main Coil
Surrounds patient with uniform magnetic field.

Patient
Wears loose clothing; must empty pockets of metallic objects that could prove harmful if moved by magnetic force.
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** \textit{fast low angle shot}
  - Relatively slow (20 sec) without high performance gradients

- Hemorrhage
- Calcification
- Lipomas
MR Fetal Imaging- Diffusion Weighted Imaging Sequences

- Distinction between water moving freely or in a restricted way

- Hypoxic-ischemic injury
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
    - Reverberation artifact
    - Poor penetration through the ossified skull
    - Oligohydramnios
    - Fetal position- particularly in late pregnancy
    - Nonspecific appearance of certain abnormalities
MR Fetal Imaging- Advantages

- Superior contrast resolution
- Better visualization of CNS structures
- Large field of view
- True multiplanar imaging
- Non-ionizing radiation
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
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
MR Fetal Imaging- Non CNS

- 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

Shigeko Kuwashima, et al. (Pediatr Radiol. 2001;31:669-672.)

• 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

- **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
  - 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