THE ROLE OF FETAL MRI IN PRENATAL DIAGNOSIS

Dr. Ashley Robinson
- Clinical Associate Professor of Radiology
  Weill-Cornell Medical College
- Department of Radiology
  Sidra Medical and Research Center
Disclosure statement

• None
Utility

• US remains primary modality
• MRI useful secondary modality to confirm or exclude abnormalities
  – “Utility of MR is inversely proportional to utility of preceding US”
• MRI can demonstrate additional subtle abnormalities not seen by US that may alter outcome
  – Especially for brain / spine
  – Precise depiction of abnormalities in multiple planes
Utility

• Counselling
• Planning:
  – delivery
  – postnatal therapy
• Avoid postnatal studies which require sedation
Advantages of US

• Accessible
• Cheap
• Real-time “live” scanning
• Instantaneous availability of images and interpretation
Disadvantages of US

- Small FOV
- Limited soft tissue contrast
- Maternal body habitus
- Oligohydramnios
- Ossification
- Fetal position
Advantages of MRI

• Not limited by
  – Fetal position
  – Overlying maternal bone
  – Overlying fetal bone
  – Obesity
  – Oligohydramnios

No skull shadow

Good soft tissue contrast
Advantages of MRI

- Excellent tissue contrast with different sequences
  - blood, fat, meconium, cartilage
- Large field of view is easier to get overview
Advantages of MRI

• Multiplanar visualization of all organs
Disadvantages of MRI

- Technical challenges
  - Motion artifacts & limited number of fast sequences
  - Need short scan time – typically 15 seconds
  - Motion artifact
    - moving fetus
    - maternal breathing
      » especially for fetal parts under diaphragm e.g. head if breech
      » breathhold limited to about 20-25 seconds
- Interpretation
  - Small structures – little signal to create images
    - Tend to need thicker slices
  - MR has lower resolution than US
When to do it

- **Gestational age**
  - 12-16 weeks – not in first trimester due to
    - risk to organogenesis
    - Some organs not developed e.g.:
      - brain – continues to change throughout pregnancy
      - Cerebellum – not fully formed sometimes until 24 weeks
  - Too much motion – lots of amniotic fluid
  - 17-24 weeks – *most useful* – especially if TOP being considered
  - 24-40 weeks – improved spatial resolution
    - Better for cortical abnormalities
    - Better for specialized techniques due to less motion
  - Repeat – helpful to watch development particularly brain
When not to do it

• Contraindications to MRI
  – Absolute
    • All safety-related
      » metallic foreign bodies
        » accidental
        » Implanted
  – Relative
    • (not without prior US)
    • Some tattoos
    • permanent makeup
    • Claustrophobia
When not to do it

- Contraindications to MRI
  - Relative
    - Gadolinium (contrast medium)
      - Potentially toxic to fetus
        » Re-circulation via urine into amniotic fluid & fetal GI tract
      - Can be used if delivery imminent
        » E.g. if assessing for placental invasion
WHY

• Neuro
  – Brain / posterior fossa
    • Congenital
    • Acquired brain injury
      – Destructive
      – Disruptive
      – Both can give same appearance
  – Spine
  – Face / orbits
22-23 weeks

Parieto-occipital fissure (P) - seen on medial aspect of posterior cortex on axial view.

Parieto-occipital fissure also seen on coronal view of posterior cortex.
24-25 weeks

Calcarine fissure (C) - seen on medial aspect of posterior cortex

Calcarine fissure also seen on parasagittal view through of medial cortex - also shows parieto-occipital fissure.
Rolandic (central) sulcus (R) - seen on superolateral aspect of cortex on axial view

Rolandic sulcus often better seen on parasagittal view

26-27 weeks
29 weeks

Superior temporal sulcus (T)
- seen on lateral aspect of cortex on coronal view
- appears at 29 (27-32) weeks
- Sylvian fissure also seen

29 week fetus with no Sylvian fissure or other fissures that should be seen by this stage
Plus abnormal lamination

Lissencephaly
Posterior fossa / brainstem

Prenatal ultrasound

- Cerebello-pontine hypoplasia
- Micro-lissencephaly (tubulinopathy) - primitive Z-shaped brainstem
- Congenital muscular dystrophy - Z-shaped brainstem
- Vermian hypoplasia (Dandy-Walker) - Outcome variable
- Wolf-Hirshhorn syndrome - vermian hypoplasia with additional anomalies
- Mild vermian hypoplasia - Deaf but otherwise normal outcome
- Blake's pouch cyst - Normal outcome expected

Findings and/or postnatal imaging

Prenatal magnetic resonance imaging
WHY

• Neuro
  – Brain
    • Congenital
    • Acquired brain injury
      – Destructive
      – Disruptive
      – Both can give same appearance
  – Spine
  – Face / orbits
• callosal dysgenesis
• Cystic malformation of posterior fossa
• female
• (guess the diagnosis?)
Aicardi syndrome

- microphthalmia
- Porencephalic cyst
- heterotopias
- & vertebral segmentation anomaly
WHY

• Neuro
  – Brain
    • Congenital
    • Acquired brain injury
      – Destructive
      – Disruptive
      – Both can give same appearance
  – Spine
  – Face / orbits
WHY

- Neuro
  - Brain
    - Congenital
    - Acquired brain injury
      - Destructive
      - Disruptive
      - Both can give same appearance
  - Spine
  - Face / orbits
Thoracic cystic mass

Thoracic cystic mass

Segmentation anomaly
Thoracic cystic mass
Neurenteric cyst
WHY

• Neuro
  – Brain
    • Congenital
    • Acquired brain injury
      – Destructive
      – Disruptive
      – Both can give same appearance
  – Spine
  – Face / orbits
25 weeks gestation
US findings

- Diaphragmatic hernia
  - Diaphragm only seen anteriorly
  - Stomach up
- Cataracts
- Delayed ocular biometry
- & Cardiac anomalies
  (unknown at time of MRI)
30 weeks gestation additional MR findings

- Normal brain
- Microphthalmia
- & Anophthalmia
Matthew-Wood Syndrome

- Died at birth
- Unilobated lungs, pulmonary hypoplasia
- Diaphragmatic hernia
- Hypoplastic heart
- & Absent globes with hypoplastic optic nerves
Matthew-Wood Syndrome

• A.K.A.:
  – Spear
  – PMD
    • Pulmonary hypoplasia
    • Microphthalmia
    • Diaphragmatic hernia
  – PDAC
    • Pulmonary hypoplasia
    • Diaphragmatic hernia
    • Anophthalmia
    • Cardiac anomaly
WHY

• Body
  – Neck
  – Chest
    • Lungs
    • cardiac
  – Abdomen/pelvis
    • GI
    • GU
  – MSK – skeletal dysplasias
    • Black bone MRI
    • CT
WHY

- Body
  - Neck
  - Chest
    - Lungs
    - cardiac
  - Abdomen/pelvis
    - GI
    - GU
- MSK – skeletal dysplasias
  - Black bone MRI
  - CT
WHY

• Body
  – Neck
  – Chest
    • Lungs
    • cardiac
  – Abdomen/pelvis
    • GI
    • GU
  – MSK – skeletal dysplasias
    • Black bone MRI
    • CT
Lungs

Normal diaphragms

CHAOS
Lung hypoplasia

- Congenital diaphragmatic hernia
- Lung volumetry
- Pulmonary hypoplasia secondary to oligohydramnios
WHY

• Body
  – Neck
  – Chest
    • Lungs
    • cardiac
  – Abdomen/pelvis
    • GI
    • GU
  – MSK – skeletal dysplasias
    • Black bone MRI
    • CT
Esophageal atresia

Normal stomach

No stomach but dilated esophagus
WHY

• Body
  – Neck
  – Chest
    • Lungs
    • cardiac
  – Abdomen/pelvis
    • GI
    • GU
  – MSK – skeletal dysplasias
    • Black bone MRI
    • CT
Oligohydramnios, neither kidney present, adrenals are clearly seen however

No uterus between bladder and rectum
Useful if ambiguous genitalia
WHY

- Body
  - Neck
  - Chest
    - Lungs
    - cardiac
  - Abdomen/pelvis
    - GI
    - GU
- **MSK** – skeletal dysplasias
  - Black bone MRI
  - CT
WHY

SWI
skull base anatomy

Fetal CT

3D printing
WHY

- Placenta
  - Accreta
  - The only potential indication for gadolinium contrast

Placenta accreta
Placenta increta
Placenta percreta

Invaded into myometrium
Invaded through serosa
What specific techniques

- MR volumetry
- DWI
- DTI
- T1 meconium colonography
- SWI blood/calcification
- Spectroscopy
- Motion
What specific techniques

- MR volumetry
- DWI
- DTI
- T1 meconium colonography
- SWI blood/calcification
- Spectroscopy
- Motion
Volumetry

- e.g. lungs in CDH
- Observed:expected volume ratio
- Reliably predicts:
  - Mortality
  - Need for ECMO
  - Chronic lung disease

Lung volumetry
What specific techniques

• MR volumetry
• DWI
• DTI
• T1 meconium colonography
• SWI blood/calcification
• Spectroscopy
• Motion
DWI
Diffusion Weighted Imaging

Focal infarct in TTTS
What specific techniques

- MR volumetry
- DWI
- DTI
- T1 meconium colonography
- SWI blood/calcification
- Spectroscopy
- Motion
DTI
Diffusion Tensor Imaging

Coloured according to fibre direction
What specific techniques

- MR volumetry
- DWI
- DTI
- T1 meconium colonography
- SWI blood/calcification
- Spectroscopy
- Motion
T1 meconium colonography

• Meconium is high signal on T1
• Useful for:
  – Bowel atresias
    • Meconium doesn’t reach rectum
  – Cloacal anomalies
    • Signal lost when mixes with urine
What specific techniques

- MR volumetry
- DWI
- DTI
- T1 meconium colonography
- SWI blood/calcification
- Spectroscopy
- Motion
SWI
Susceptibility Weighted Imaging

Fetal intraventricular hemorrhage

Hemosiderin staining
What specific techniques

• MR volumetry
• DWI
• DTI
• T1 meconium colonography
• SWI blood/calcification
• Spectroscopy
• Motion
Pyruvate dehydrogenase deficiency

Cysts in basal ganglia

Lactate doublet
What
specific techniques

- MR volumetry
- DWI
- DTI
- T1 meconium colonography
- SWI blood/calcification
- Spectroscopy
- Motion
TRUFISP for flow

Umbilical arteries

Cardiac flow
Summary

- US always before MRI
- MRI is complementary
- Can help if US difficult because of:
  - Oligohydramnios
  - Ossification
  - Obesity
- MRI can confirm and often give more specific diagnosis
- MRI can help with planning delivery
- Some exciting new techniques

- “Utility of MR is inversely proportional to utility of preceding US”