Fetal and neonatal functional imaging: challenges and solutions

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Conflicts of Interest

I have no documented financial relationships to disclose or Conflicts of Interest (COIs) to resolve.
Objectives

1) Learn about the challenge of fetal and neonatal imaging.

2) Learn about practical solutions to these problems.
Outline

1) Background

2) Fetal imaging

3) Neonatal imaging
Outline

1) Background

2) Fetal imaging

3) Neonatal imaging
Why imaging in the fetal and neonatal period?

1) The brain grows rapidly during this period!

- The brain 2x in size in 3 months!
- Start of the 3rd trimester
- End of the neonatal period

**Graph:**
- **X-axis:** Gestational Age (weeks)
- **Y-axis:** Intracranial volume (mm³)
- Data points indicating brain growth from approximately 150,000 mm³ to 500,000 mm³ between 29-43 weeks of gestation.
Why imaging in the fetal and neonatal period?

1) The brain grows rapidly during this period!

- Early 3rd trimester
- Middle 3rd trimester
- 1 day old baby

2x in size but 3x in weight
Why imaging in the fetal and neonatal period?

1) The brain grows rapidly during this period!
Why imaging in the fetal and neonatal period?

1) The brain grows rapidly during this period!

2) Fetal origins of disorders
   1) For example: link between ASD and maternal immune response during pregnancy

3) Early interventions
   1) Which individuals? Which treatments?
   2) Behavioral measures can be limited at these ages
   3) Imaging potentially could help in informing treatment options
What can we ferret out?
Outline

1) Background

2) Fetal imaging

3) Neonatal imaging
Challenges of fetal imaging

Focus on the two major concerns for research:
1) Safety
2) Motion
Safety of fetal imaging: concerns

1) Exposure of the fetus to the static magnetic field

2) Tissue heating
   1) Caused by excitatory radiofrequency energy
   2) Measured as specific absorption rate (SAR)

3) Acoustic exposure
   1) MRIs are loud
Exposure of the fetus to the static magnetic field

1) Preclinical models
   1) Possible effects early in 1\textsuperscript{st} trimester
   2) No effects during late 2\textsuperscript{nd}-3\textsuperscript{rd} trimester

2) Routinely image preterm babies at similar ages (late 2\textsuperscript{nd}-3\textsuperscript{rd} trimester)
Safety of fetal imaging: research

Tissue heating

1) The FDA has standard for SAR
   1) But no specific for pregnant women/fetuses

2) Fetal model in the pig
   1) Temperature changes well below FDA range
Safety of fetal imaging: research

Acoustic exposure

1) Measured sound attenuation in the body
   1) Natural attenuation offers large protection

2) New “quieter” MRI
Safety of fetal imaging: research

Retrospective studies

1) Review long-term outcomes of fetuses receiving clinical MRI (n=1,500-5,000)

1) No adverse outcomes associate with fetal MRI
Safety of fetal imaging: solutions

What we do:

1) Image during 3\textsuperscript{rd} trimester when it is safest
2) Scan is <45 minutes to limit exposure
3) Keep SAR to a minimum
4) Use latest scanners/sequences
Fetal motion: concerns
Fetal motion: research

\[ \mathcal{H} = \begin{bmatrix} I_{xx} & I_{xy} & I_{xz} \\ I_{yx} & I_{yy} & I_{yz} \\ I_{zx} & I_{zy} & I_{zz} \end{bmatrix} \]

\[ \mu(t) = \frac{\left( \sum_x w(x, t) I(x, t) \right)}{\left( \sum_x w(x, t) \right)} \]
Fetal motion: solutions
Outline

1) Background

2) Fetal imaging

3) Neonatal imaging
Challenges of neonatal imaging

Focus on the two major concerns for research:
1) Safety
2) Subject compliance
Safety of neonatal imaging: concerns

1) Acoustic exposure
   1) MRIs are loud

2) Overall health
   1) No long-term health concerns
   2) But, neonates cannot tell you what is wrong
      1) For example, are they cold?
Safety of neonatal imaging: solutions

Acoustic exposure

1) Many layers of ear protection
Overall health

1) Physiological monitoring
   1) Heart rate
   2) O² saturation
   3) Temperature
Subject compliance: concerns

1) Neonates like to sleep and be comfortable
   1) If not, they will cry!
Subject compliance: solutions

Neonates like to sleep and be comfortable

1) Feed, burp, swaddle method
   1) Quickly puts most to sleep
2) MRI safe vacuum swaddler
Conclusions

Our goals with fetal/neonatal imaging:

1) Safety acquire data in fetuses and neonates
2) Be able to analyze the data
3) Learn about brain development and its alterations in developmental disorders
4) (Hopefully!) Help inform clinical decisions
Many thanks!

Questions/Comments