

# Fetal and neonatal functional imaging: challenges and solutions

Dustin Scheinost, Ph.D.

Assistant Professor of Radiology & Biomedical Imaging  
and in the Child Study Center  
Yale School of Medicine, New Haven, CT



# 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

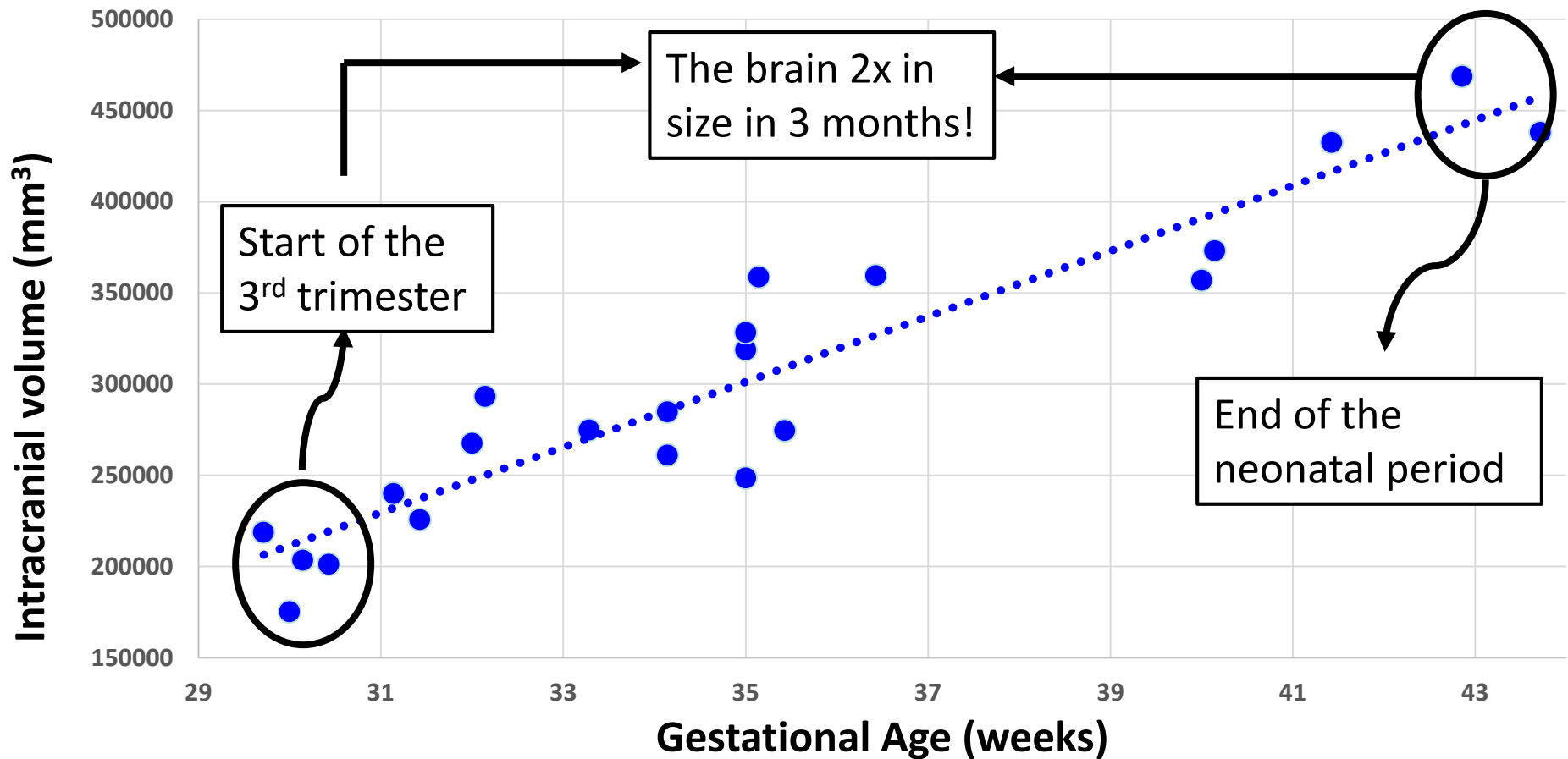
- 1) Background
- 2) Fetal imaging
- 3) Neonatal imaging

# 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!



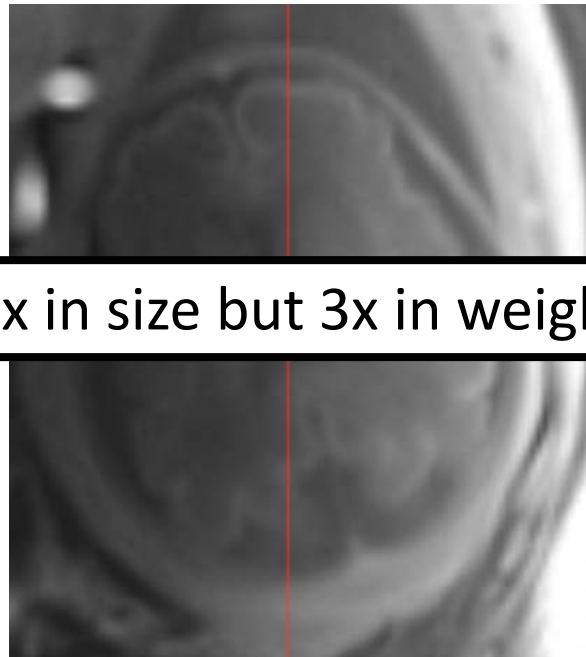
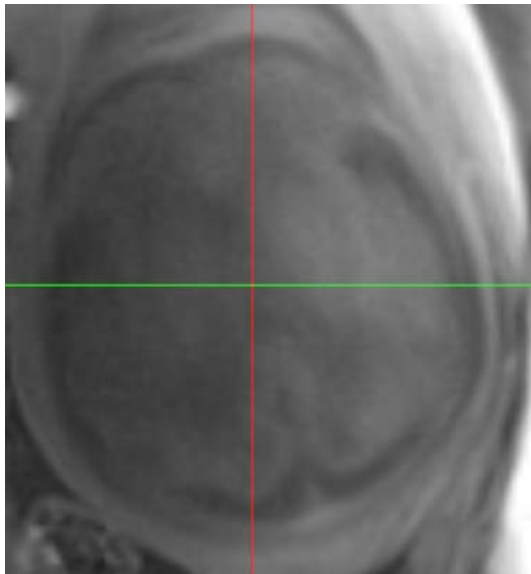
# Why imaging in the fetal and neonatal period?

1) The brain grows rapidly during this period!

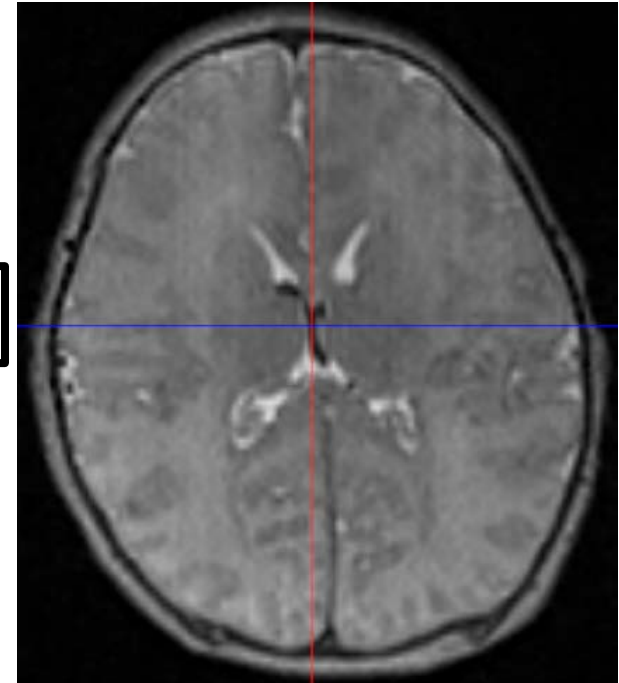
Early 3<sup>rd</sup>  
trimester

Middle 3<sup>rd</sup>  
trimester

1 day old  
baby

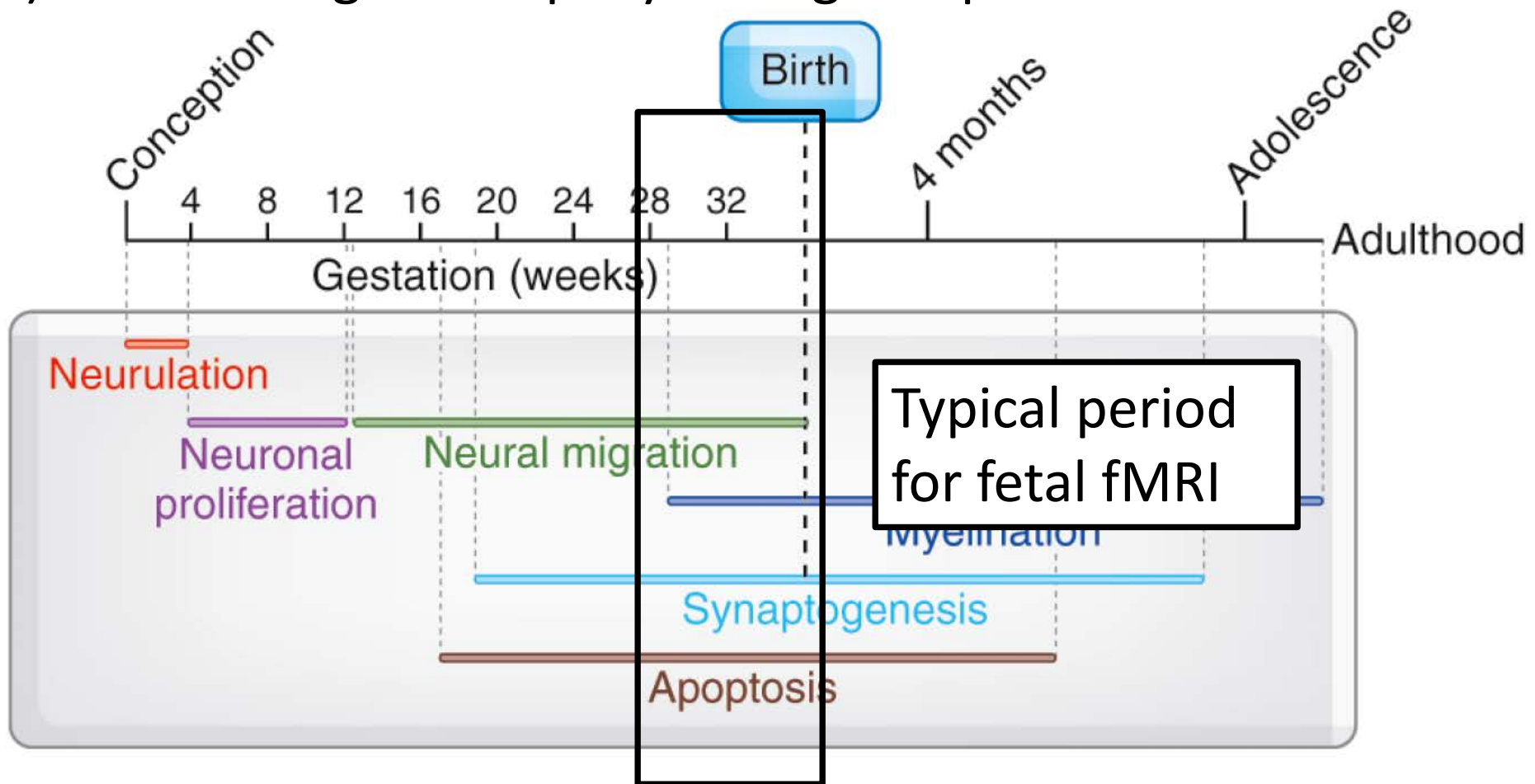


2x in size but 3x in weight



# Why imaging in the fetal and neonatal period?

1) The brain grows rapidly during this period!

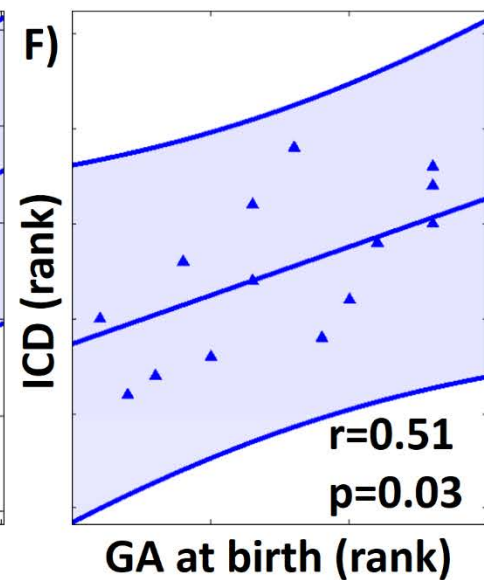
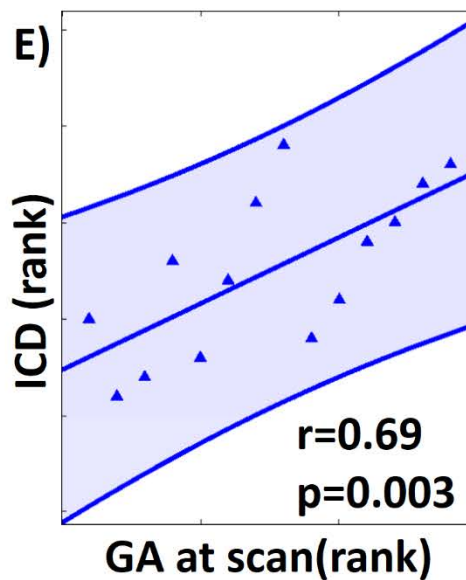
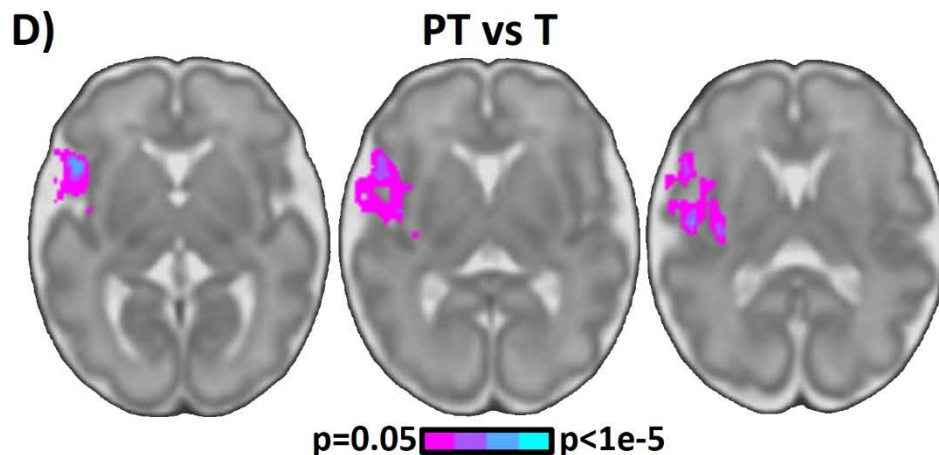
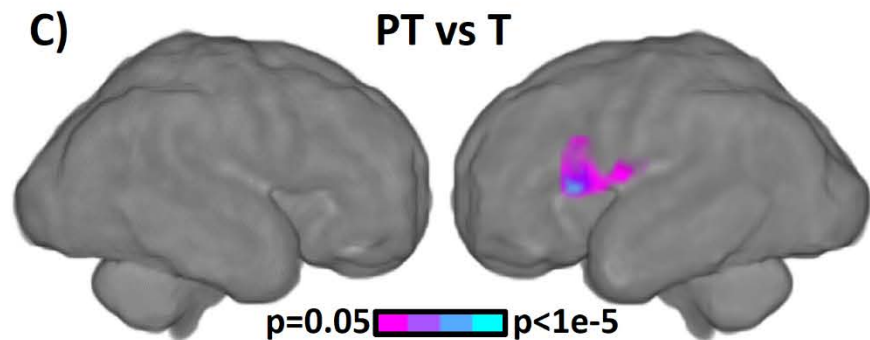
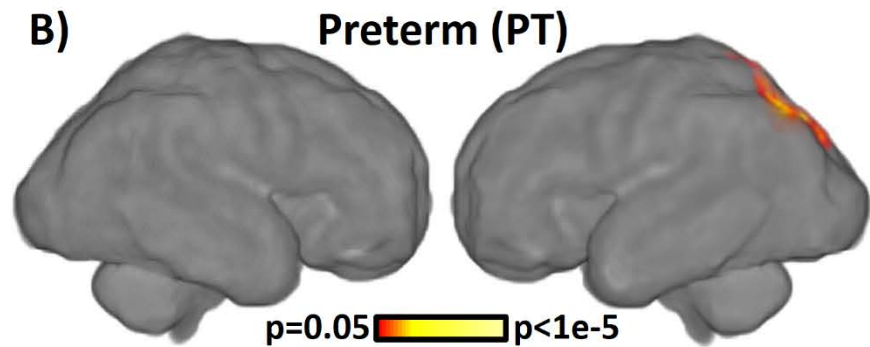
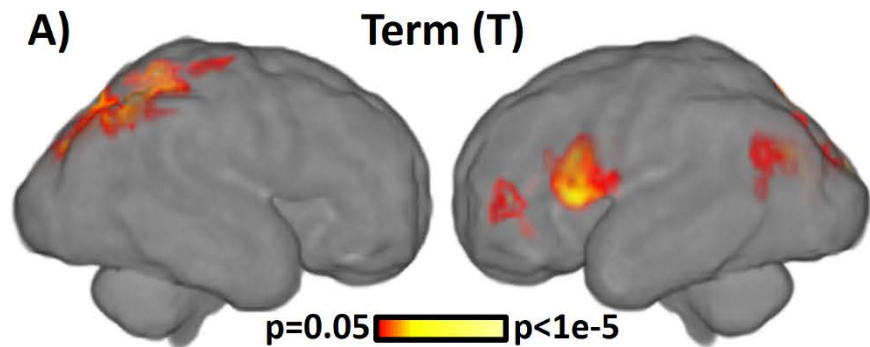




# Why imaging in the fetal and neonatal period?

- 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?



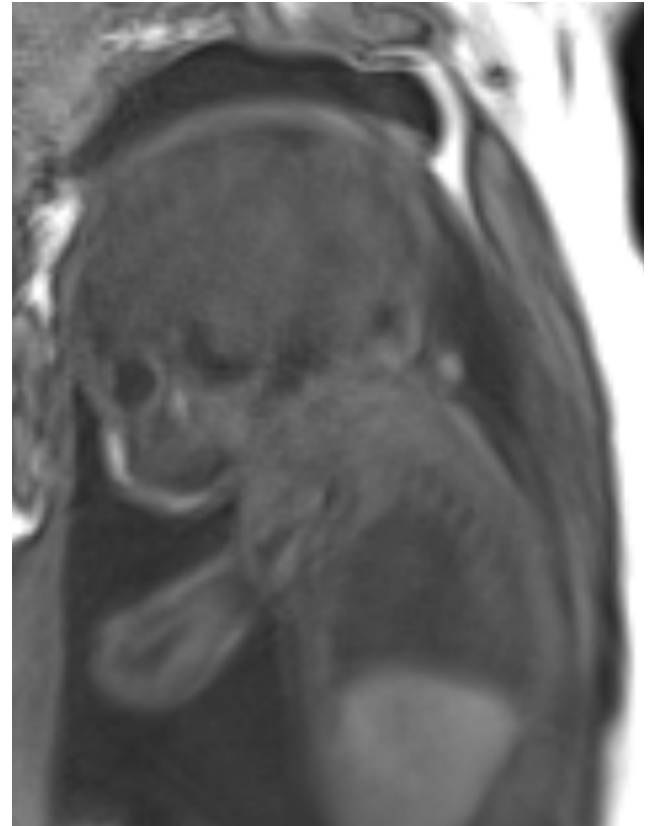
# Outline

- 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

# Safety of fetal imaging: research

Exposure of the fetus to the static magnetic field

1) Preclinical models

1) Possible effects early in 1<sup>st</sup> trimester

2) No effects during late 2<sup>nd</sup>-3<sup>rd</sup> trimester

2) Routinely image preterm babies at similar ages  
(late 2<sup>nd</sup>-3<sup>rd</sup> 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

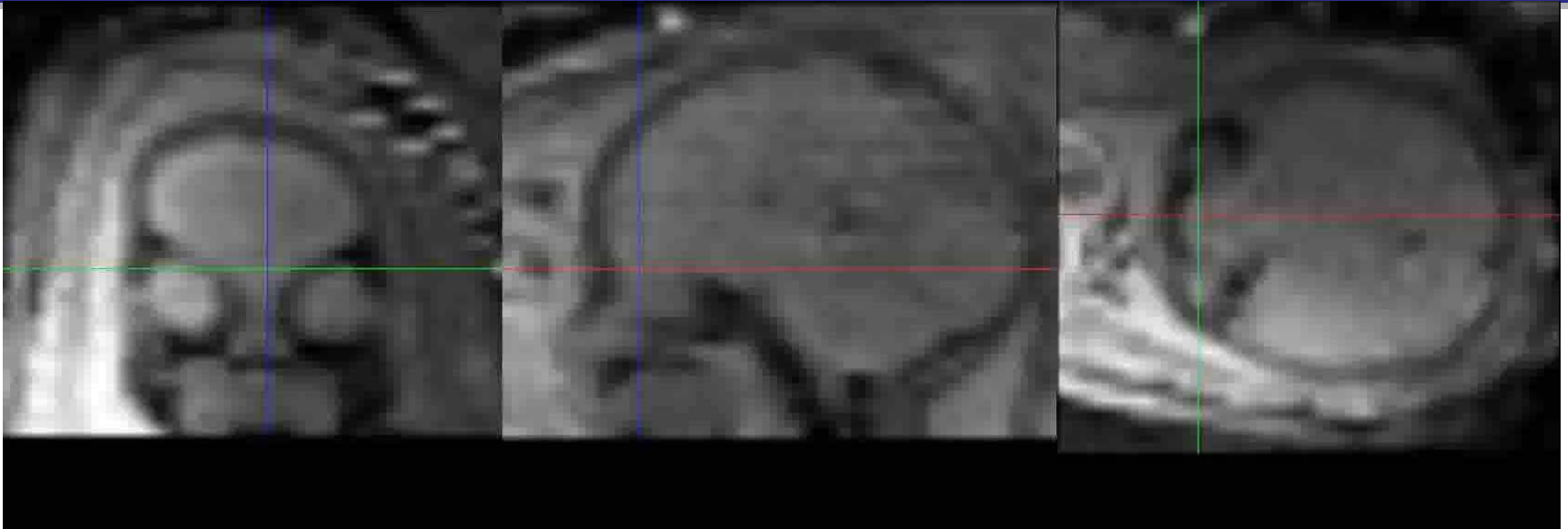
- 1) Review long-term outcomes of fetuses receiving clinical MRI (n=1,500-5,000)
  - 1) No adverse outcomes associate with fetal MRI

# Safety of fetal imaging: solutions

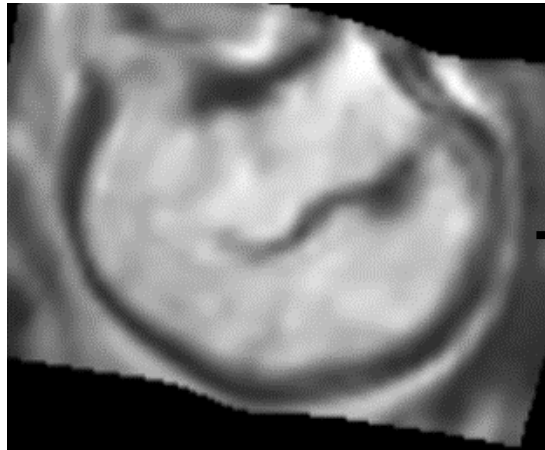
What we do:

- 1) Image during 3<sup>rd</sup> trimester when it is safest
- 2) Scan is <45 minutes to limit exposure
- 3) Keep SAR to a minimum
- 4) Use latest scanners/sequences

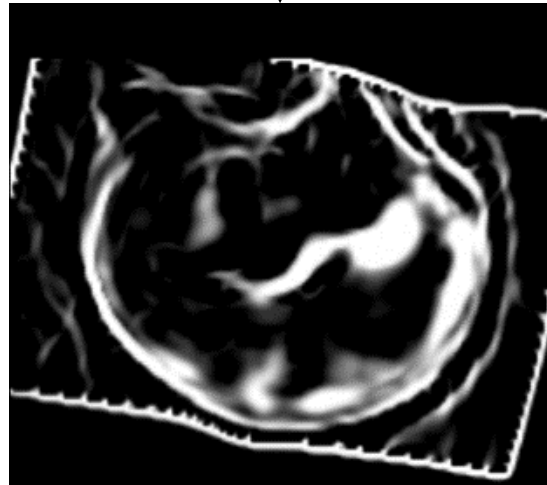
# Fetal motion: concerns



# Fetal motion: research

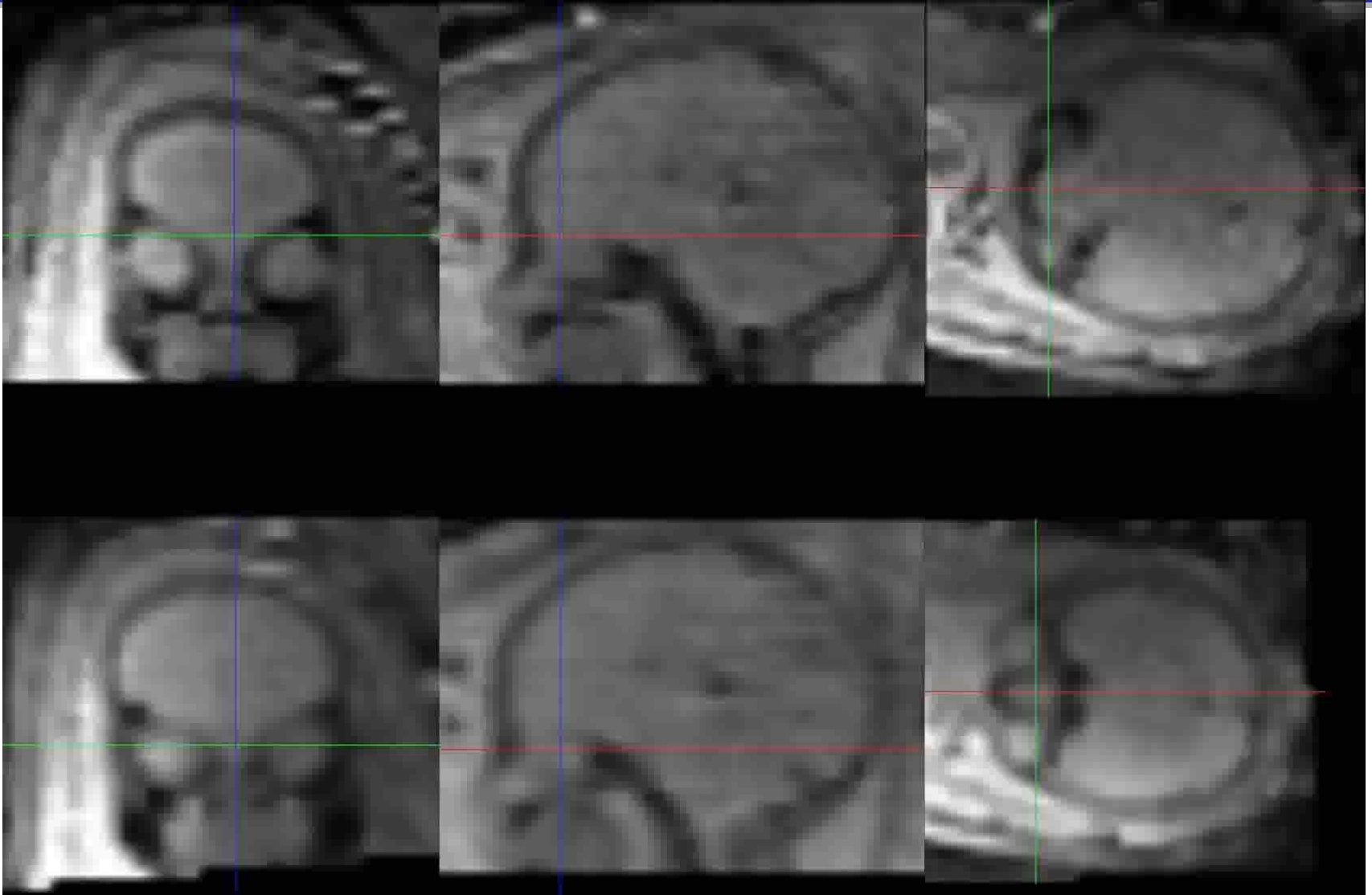


$$\mathcal{H} = \begin{bmatrix} I_{xx} & I_{xy} & I_{xz} \\ I_{yx} & I_{yy} & I_{yz} \\ I_{zx} & I_{zy} & I_{zz} \end{bmatrix}$$



$$\mu(t) = (\sum_x w(x, t) I(x, t)) / (\sum_x w(x, t))$$

# 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



# Safety of neonatal imaging: solutions

## Overall health

### 1) Physiological monitoring

- 1) Heart rate
- 2) O<sup>2</sup> 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

