Introduction

- According to the CDC, there were 3,664,292 births registered in the US in 2021, and 10.49% of these births were pre-term [1].
- Pregnancy is a protected environment and changes in maternal anatomy at mid-gestational timepoints are poorly understood.
- Humans and Rhesus Macaques have very comparable reproductive anatomies [2].

Purpose: Assess the shape, structure, and composition of the NHP uterus and cervix through four gestational timepoints.

Methods

Gestational timepoints: nonpregnant (NP, n=3), early 2nd trimester (E2, n=3), early 3rd (E3, n=3), and late 3rd (L3, n=7).

1. Composition - Hydration
Hydration levels were found by dehydrated samples for each monkey by lyophilization (freeze-dry) and was calculated using the following equation:

\[
\text{Hydration (\%)} = \frac{\text{Wet weight} - \text{Dry weight}}{\text{Wet weight}}
\]

2. Size - Uterine Volume
A parametric model of the human uterus was used to implement macaque measurements and find the volumes of all the uterine cavities using Solidworks.

3. Size - Uterine Wall Thickness
Uterine wall measurements were taken from imaging with a dissecting microscope and a spatial calibration Matlab code and compared to measurements from ultrasound images.

4. Shape - Cervix Model
Ultrasound Measurements → Solidworks profiles → Solidworks model

Results

Figure 1: Hydration for each uterine layer throughout gestation

- Significant decrease in hydration from endometrium-decidua to perimem
- On a tissue layer basis, no change in hydration occurs as a result of pregnancy at all gestational timepoints

Figure 2: Supine uterine volumes throughout gestation

- Uterine cavity volumes in the supine position demonstrated a positive linear correlation with respect to gestational age

Figure 3: Uterine wall thicknesses measured from dissecting microscope (DM) and ultrasound (US) images

- Uterine wall thicknesses vary depending on the method of measurement
- Wall thickness does not change in pregnancy

Figure 4: Meshed model of NP monkey cervix

- First ever high-fidelity 3D NHP cervix model
- Uses include computational modeling of ultrasound wave propagation and cervical stress throughout pregnancy

Conclusion

The results of this study demonstrate that, although the uterus exhibits dramatic structural changes throughout gestation, uterine wall thickness and hydration do not seem to be impacted by pregnancy. Further, modeling the distinctive and interesting shape of the NHP cervix allows for the enables many computational simulations to assess biomechanical changes to the cervix in pregnancy.

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References