Multiparametric QUS Analysis for Placental Tissue Characterization

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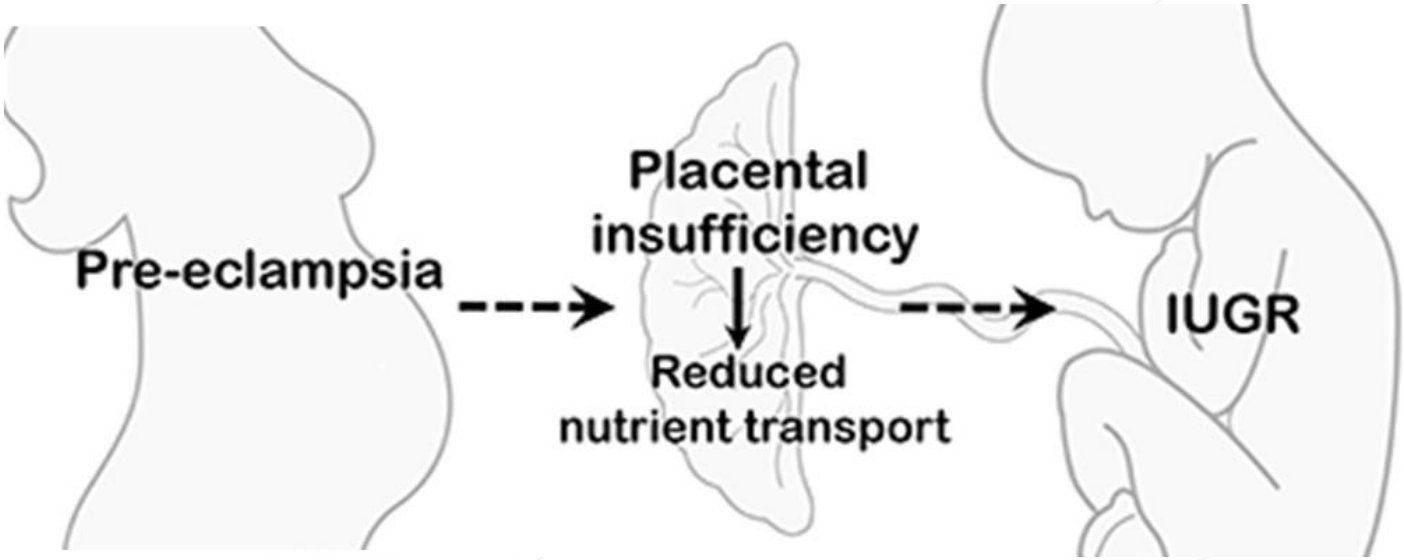
This year, over 300,000 women will die in childbirth.

3 million babies will die during the first month of their life.

Placenta: The Missing Link



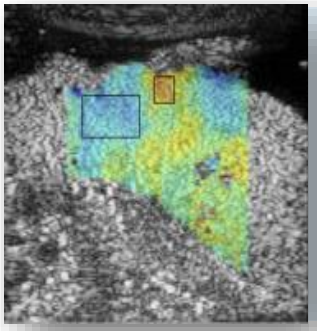
in every 5 maternal death occurs due to preeclampsia.

of total neonatal death occurs due to IUGR and pre-term birth

A Quantifiable Measure of Placental Health:

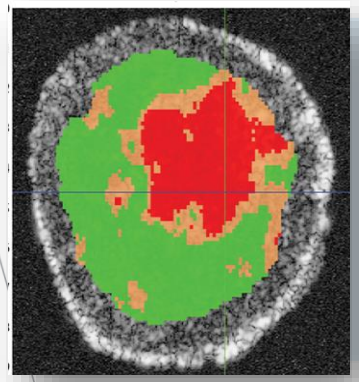
to detect and monitor pregnancy related diseases

QUS Analysis for Placenta Characterization



Shear Wave Speed

- Promising results for differentiating placentas in normal pregnancy and complicated pregnancy in last few years [Sugitani'13, Cimsit'15, Abeysekera'17].



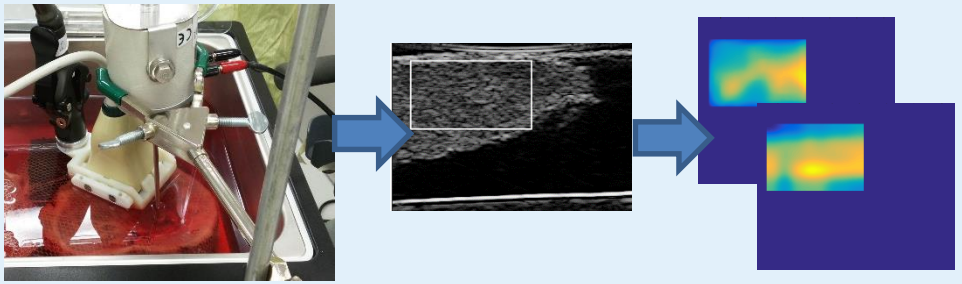
Attenuation Coefficient Estimate (ACE)

- Successful tissue characterization for liver, breast, myocardial tissue, and more recently cervix.
- No work focussed on placental tissue characterization.

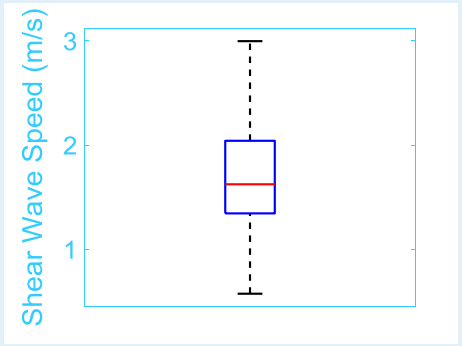
Images from [McAleavey'16, Oelze'16]

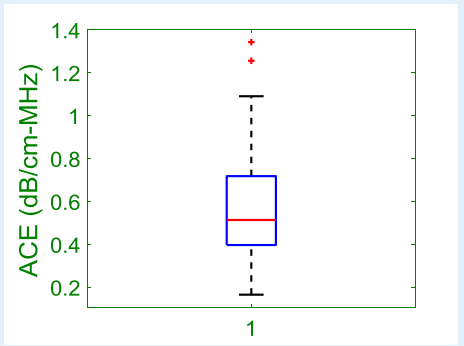
Objective

- Simultaneous measurement of the QUS parameters: Shear wave speed and Attenuation Coefficient Estimate.



- Establish baseline measurements.

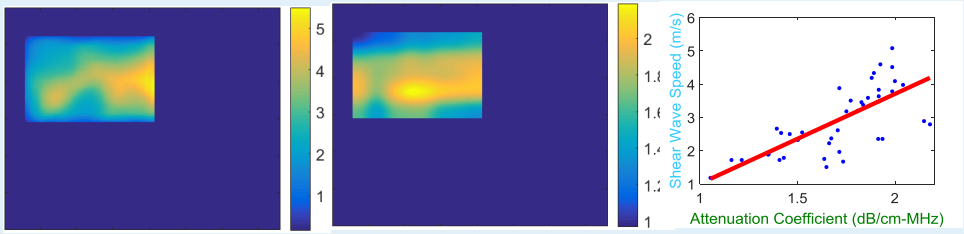




- Investigate spatial correlation between the QUS parameters.

Shear wave speed

Attenuation Coefficient Estimate



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Data Acquisition

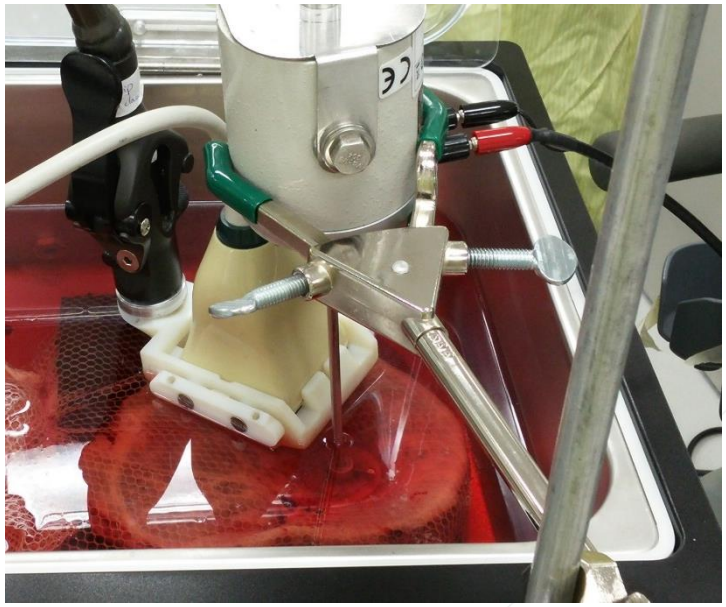


Figure: Data acquisition from a placenta sample using SWAVE (Shear Wave Absolute Vibro-Elastography) method [Abeysekera'17].

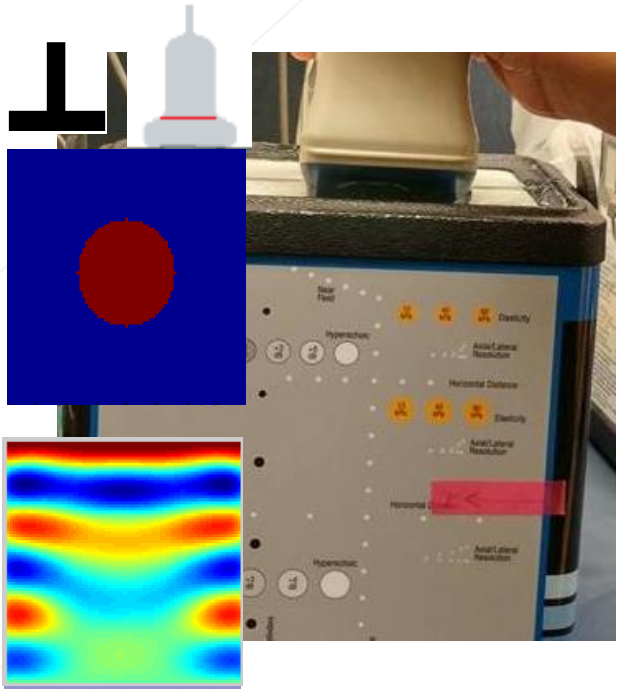
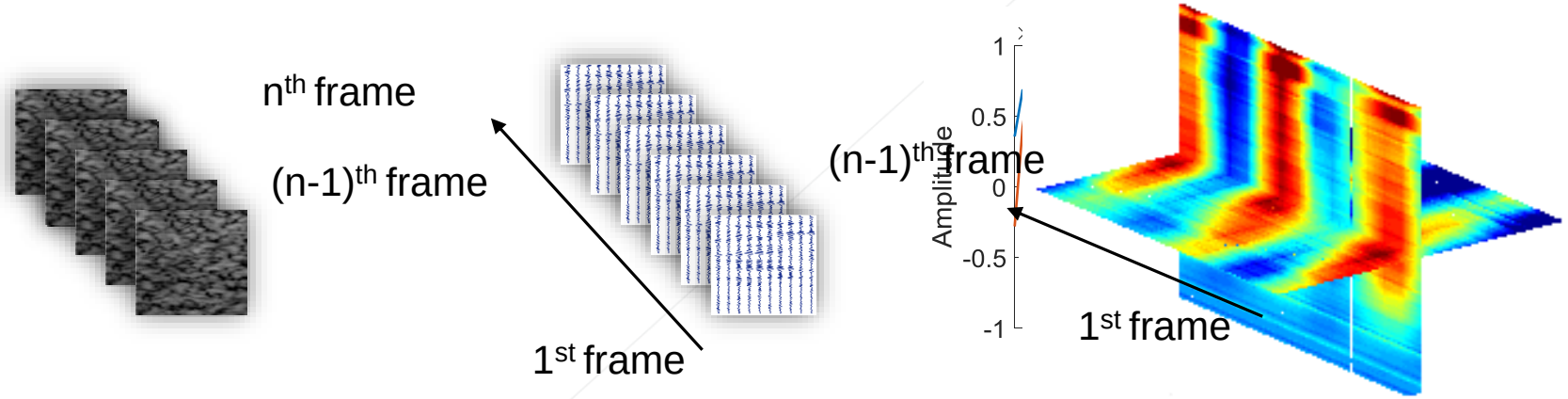


Figure: Data acquisition from the reference phantom.

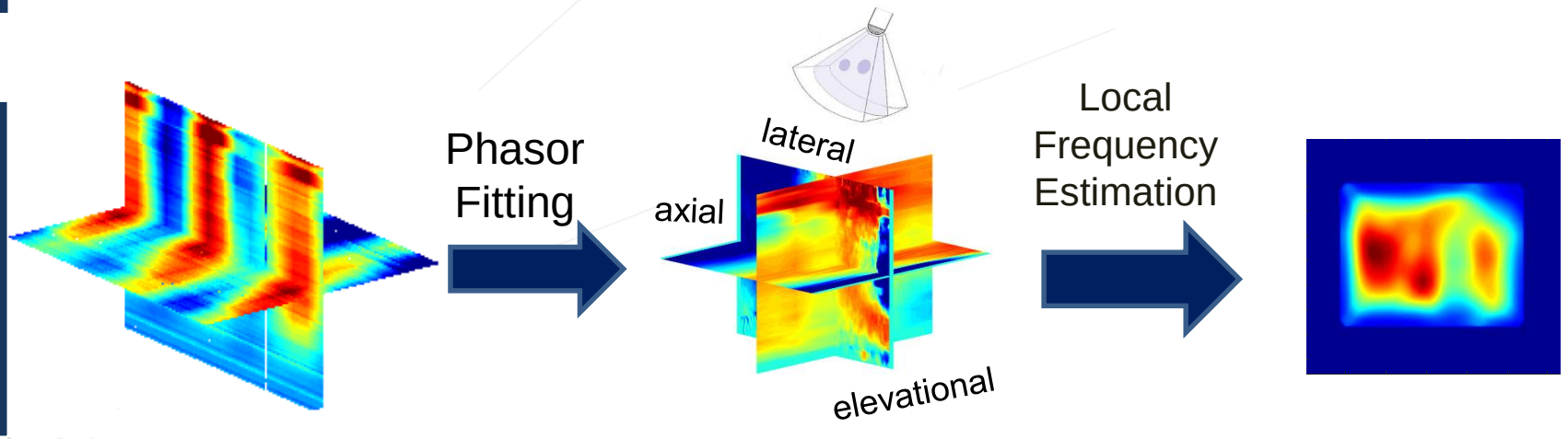
QUS Parameter Estimation

SWAVE: Shear Wave Speed Estimation

Displacement Measurement



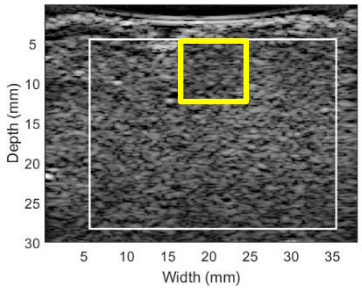
Elasticity Measurement



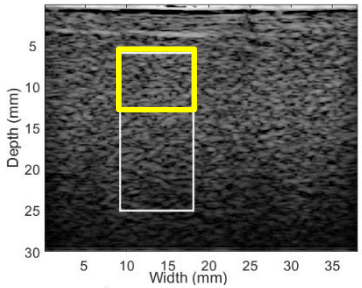
QUS Parameter Estimation

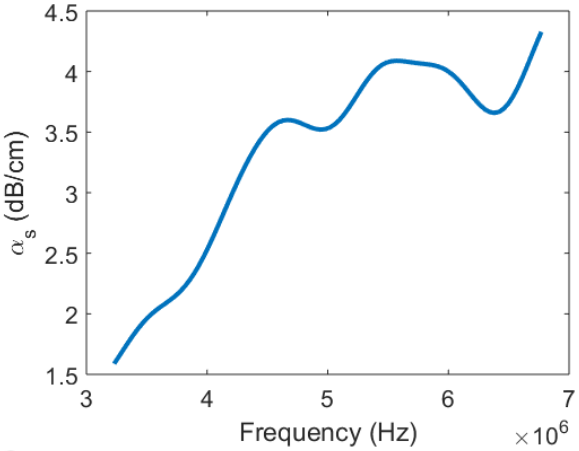
Attenuation Coefficient Estimate

Tissue Sample



Reference Phantom





$$\alpha_s(f) = \alpha_r(f) - \frac{1}{4}\left(\frac{\partial\left(RS(f,z)\right)}{\partial(z)}\right)$$

$$RS(f,z) = \ln\left(\frac{S_s(f,z)}{S_r(f,z)}\right)$$

$$\alpha_s(f) = \beta_s f$$

β_s= Attenuation Coefficient Estimate

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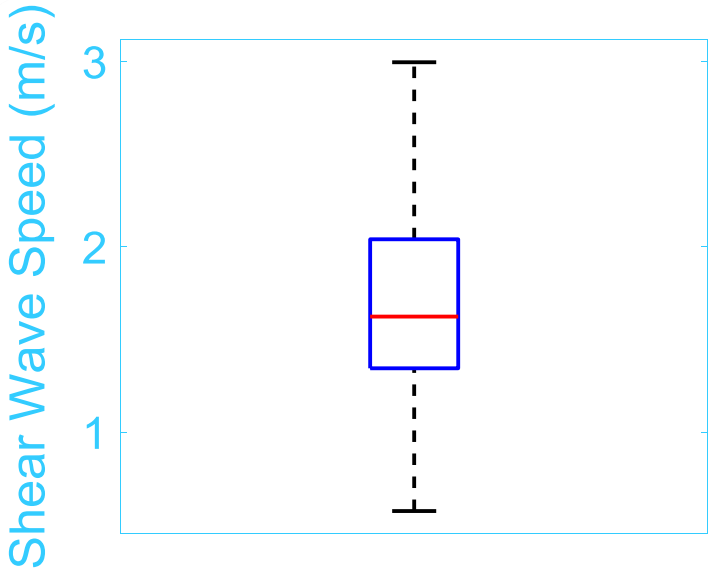
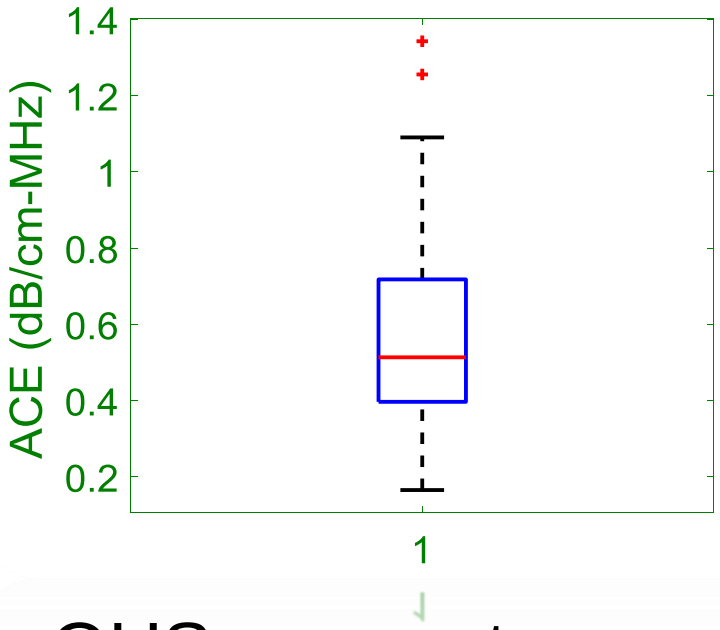
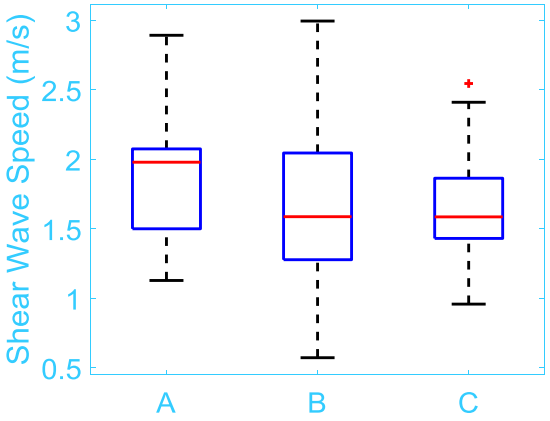
QUS Results: Baseline Measurement





Baseline values for the QUS parameters:
Quantifiable Measures of Placental Health

QUS Results: Variation among Sub-classes



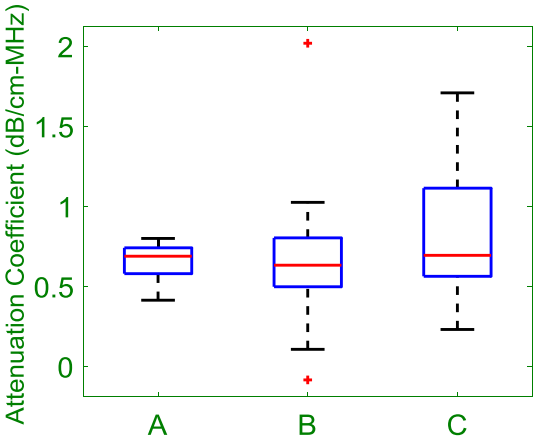


Table: Description of ex-*vivo* placenta dataset.

Sub-classes	Description
A (n = 13)	No appreciable abnormalities
B (n = 30)	Abnormalities that did not reach a diagnostic threshold
C (n = 16)	Abnormalities passing one or more diagnostic thresholds

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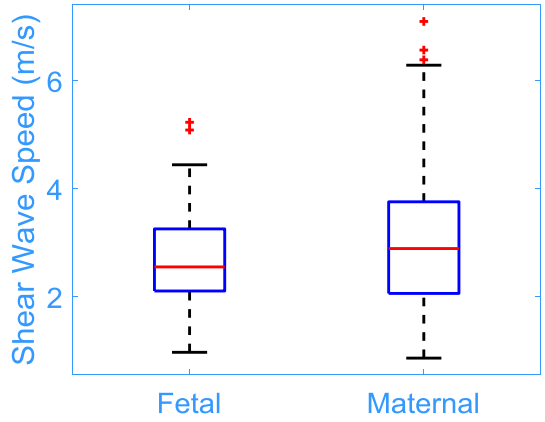
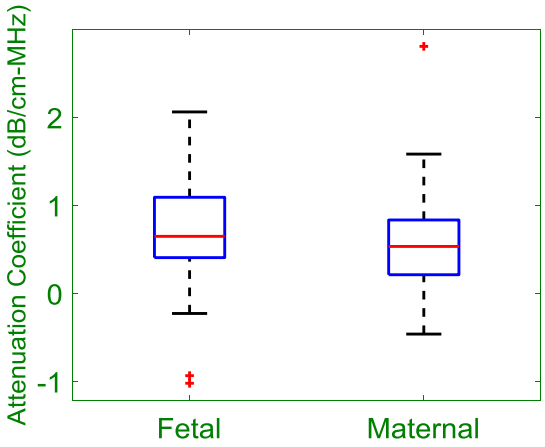
QUS Results: Spatial Variation

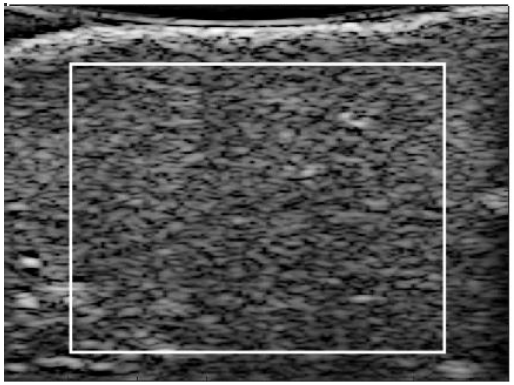
Fetal Surface

Maternal Surface

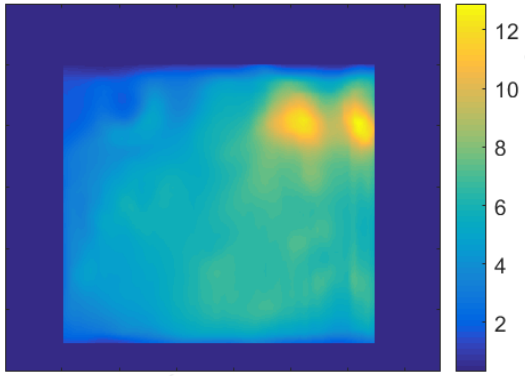




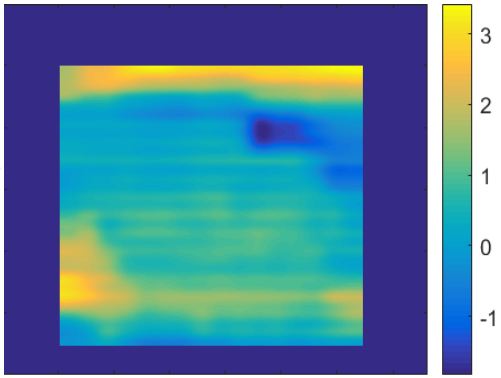
QUS Results: Spatial Correlation

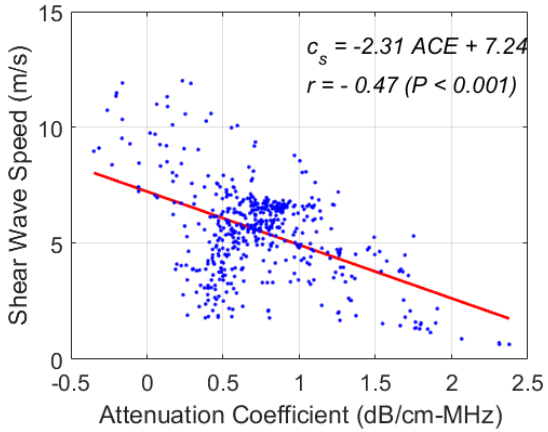


Shear wave speed



Attenuation Coefficient Estimate





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Conclusion

- Quantifiable measures of placental health.
- First large-scale study to report the baseline values for attenuation coefficient estimation and shear wave speed based on 59 placentas.
- Future work: compare attenuation coefficient estimate and shear wave speed between normal and diseased placentas (n = 10/60).

Thank you