A simulation based approach for shear wave attenuation quantification in transverse isotropic tissues: preliminary results

2022 IEEE IUS
International Ultrasonics Symposium
Venice, Italy || October 10-13, 2022

Eliana Budelli[1], Javier Brum[2], Patricia Lema[1], Carlos Negreira[2]
[1] Instituto de Ingeniería Química, Facultad de Ingeniería - Universidad de la República, Montevideo, Uruguay.
[2] Laboratorio de Acústica Ultrasonora, Instituto de Física, Facultad de Ciencias - Universidad de la República, Montevideo, Uruguay.

INTRODUCTION

Shear wave velocity (SWV) and attenuation (SWA) are related to the mechanical properties of tissue given by its storage and loss moduli. To estimate the mechanical properties of tissue, SWA should be corrected by diffraction effects induced by the shear wave source. In this work we address this problem to provide a full mechanical characterization of transverse isotropic tissue (TIT) .

Caused by mechanical properties of the tissue

$SWA_{observed} = SWA_{visc} + SWA_{diff}$

Observed in experiments

Obtained when simulating propagation in purely elastic media

METHODS

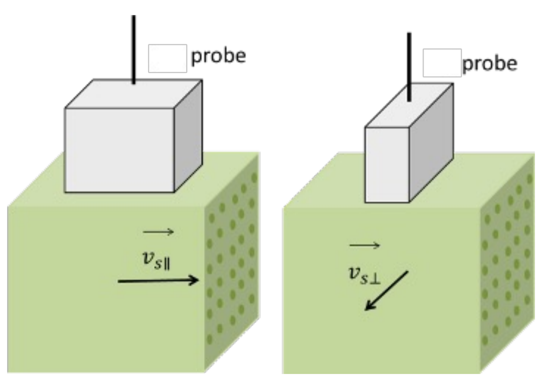
Experimental measurements in transverse isotropic tissue (TIT) → SWV SWA observed

Simulation of purely elastic TIT: SWA diffraction

SWA corrected ↔ SWA visc

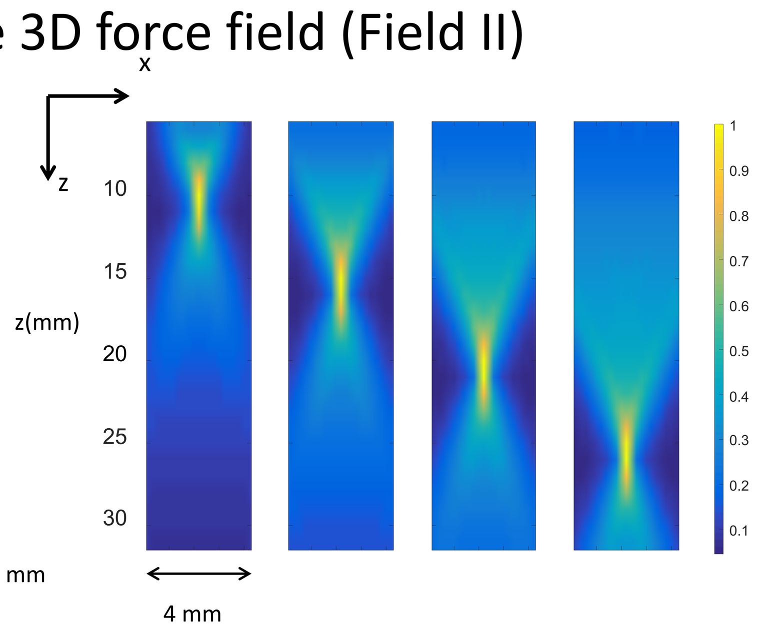
Experiments ↔ Simulation

- Meat sample ("peceto")
  - Probe parallel to fibers
  - Probe perpendicular to fibers



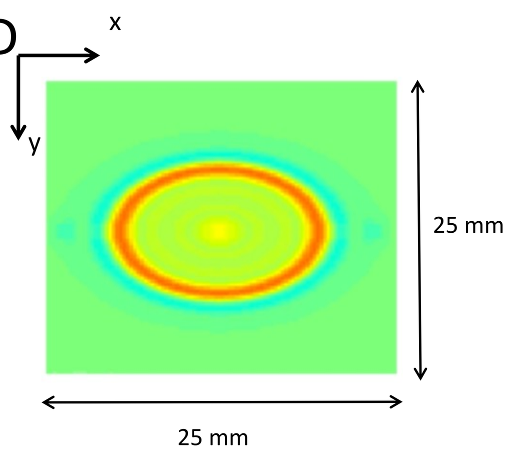
- Shear wave elastography
  - Verasonics Vantage system, 7 MHz probe
  - Push sequence
    - 10, 15, 20 and 25 mm
    - 150 µs duration
  - Tracking
    - Plane wave 5 kHz

Simulation of the 3D force field (Field II)



Simulation of the 3D Displacement field (Green's functions algorithm)

- 1 voxel of the pressure spot = 1 punctual source
- Summation of the contribution of all of the punctual sources



$$\boldsymbol{U}(\vec{r}_2,\omega) = \int_{\Pi_S} U_{zz}(\vec{r},\vec{r}_2,\omega)dr^3$$

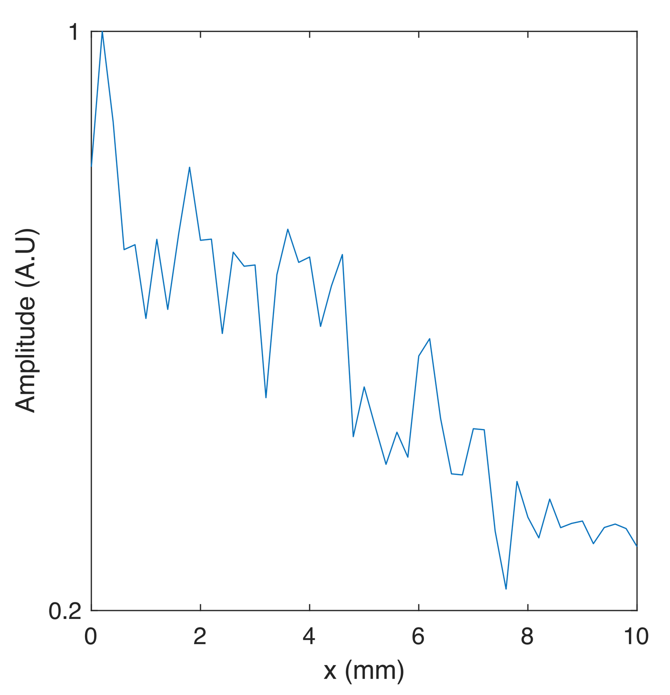
$$\boldsymbol{U}(\vec{r}_2,\omega) = \sum_{l=1}^{N} F(l) * G_{zz}^{exact}(\vec{r}_2,\omega)$$

RESULTS

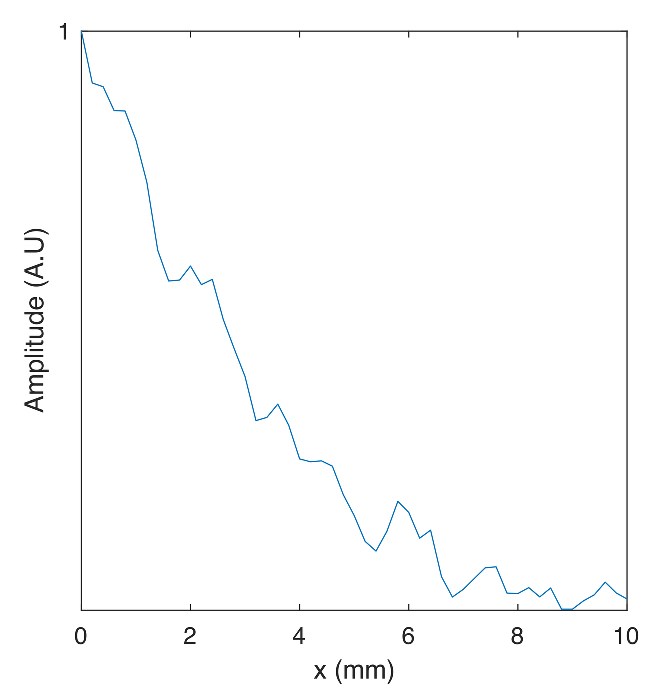
SHEAR WAVE VELOCITY AT 100 Hz	
SWV//	4.5 ±0.7 m/s
SWV⊥	3.2 ±0.3m/s

SHEAR WAVE ATTENUATION AT 100 Hz		
	Before correction	After correction
α//	89±14 Np/m	68±14 Np/m
α⊥	135±20 Np/m	112±20 Np/m

∥



⊥



Experiments

Simulation

SHEAR WAVE ATTENUATION AT 100 Hz	
SWA diff //	21 Np/m
SWA diff ⊥	23 Np/m

CONCLUSIONS

The methodology presented allowed diffraction correction in TIT, which avoids overestimation of the SWA. Future work will address the possibility of obtaining an analytical correction for SWA in TIT. Applications in sports medicine and food industry are also envisaged.

This work was funded by:
Agencia Nacional de Investigación e Innovación - ANII - FMV_1_2019_1_155527
Espacio Interdisciplinario – Universidad de la República