009 DEVELOPMENT OF AN EXPERIMENTALLY VALIDATED NUMERICAL TOOL TO ASSESS THE ACCURACY OF SHEAR WAVE ELASTOGRAPHY.

Annette Caenen[1], Darya Shcherbakova[1], Benedict Verhegghe[1], Clément Papadacci[2], Mathieu Pernot[2], Patrick Segers[1], Abigail Swillens[1].*

[1]Ghent University, Ghent, BELGIUM; [2]Institut Langevin, Paris, FRANCE.

Background: There is increasing interest to apply shear wave elastography (SWE) in arteries for the purpose of cardiovascular risk assessment. However, the artery's thin wall (typically < shear wavelength), multi-layered configuration and anisotropic tissue properties induce complex wave phenomena, complicating the link between the measured shear wave (SW) characteristics and the true arterial tissue properties.

Aims: To assess the accuracy and robustness of SWE for assessment of arterial stiffness, a flexible testing ground for SWE in variably complex conditions is needed. For this purpose, we built a 3D finite element (FE) model with its numerical settings validated and optimized according to SWE measurements performed in a bounded visco-elastic medium. This modeling strategy has been previously demonstrated by [1] and [2], but in bulky media.

Methods: We modeled the SWE-experiment we conducted on a thin (4.35 mm) gelatin-agar phantom (setup illustrated in fig.A) in the FE-software Abaqus (Providence, RI, USA). The FE-model required two inputs: (i) the employed acoustic radiation force (ARF), obtained by modeling the ultrasonic excitation from the Aixplorer system (SuperSonic Imagine, France) in the ultrasound simulation software Focus (Michigan state university, MI, USA), and (ii) the phantom's visco-elastic material properties, determined by using a uniaxial mechanical test bench. Furthermore, these mechanical tests served as a ground truth for the Young's modulus derived from the SWE experiments. To validate the numerical framework, we compared the experimental and numerical shear wave speed (SWS) obtained by tracking the SW front via the peak tissue velocity.

Results: Fig. B depicts the axial tissue velocity in the middle of the phantom (dashed line in fig. A) versus time, both for experiment and simulation, used to derive the SWS. An SWS of 4.58m/s is obtained in the simulation, matching well the 4.63 m/s of the experiment. This corresponded to an E-modulus of 62.9kPa (simulation) and 64.3kPa (experiment), deviating 9% from mechanical testing (E=68.1kPa). The simulated displacement field caused by the ARF excitation is illustrated in fig. C.

Conclusions: The developed numerical framework reproduces the obtained experimental data and provides a solid basis for the further exploration of the complex link between tissue geometry/material properties and SW propagation in (diseased) arteries.

References: [1] Palmeri et al, Ultrason. Ferroelectr. Freq. Control IEEE Trans. On, 52:1699–1712, 2005.
[2] Lee et al, Int. J. Numer. Methods Biomed. Eng., 28:678–696, 2012.