

INVESTIGATING THE ACCURACY OF MATERIAL CHARACTERIZATION ALGORITHMS FOR MYOCARDIAL SHEAR WAVE ELASTOGRAPHY IN CHILDREN

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Abstract

Shear wave elastography (SWE) is a promising ultrasonic (US) diagnostic tool in pediatric cardiology. In SWE, a vibration source is induced locally in the cardiac muscle tissue, radiating shear waves of which the propagation speed is related to tissue stiffness. However, performance of SWE in the myocardium is to be investigated as tissue characterization is challenged by SW dispersion, caused by the complex heart geometry and anisotropic material. Hence, we investigated the robustness of SWE in a generic model of the left ventricle (LV).

Keyword(s): biomechanics – medical imaging

1. INTRODUCTION

SWE is a technique which can successfully derive bulk tissue stiffness from the group speed of SW's induced by an acoustic radiation force as excited by an US probe. However, in a thin, curved myocardium, the propagation speed will depend on frequency (i.e. dispersion), and group speed based algorithms are no longer valid. To study the effect of ventricular geometry on the accuracy of stiffness estimation and SW physics, we considered experimentally and numerically a generic LV model for 10-15 year olds.

2. MATERIALS AND METHODS

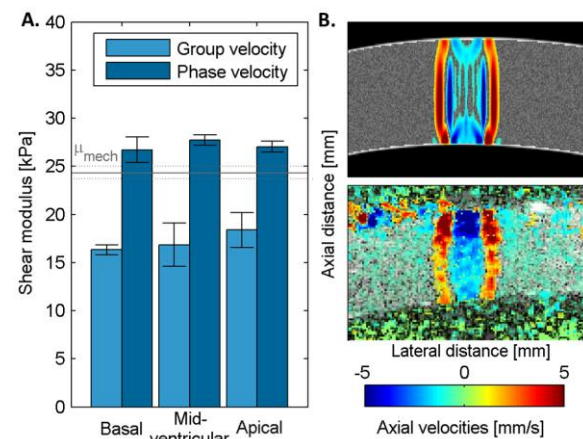
Experimental model: A phantom equivalent of the LV was created in 10% polyvinyl alcohol PVA (freeze-thawed once). SWE-experiments were performed on different zones (basal/mid-ventricular/apical) of the submerged phantom. The resulting data of these experiments were processed with a group and phase speed analysis, of which the estimated stiffness was compared to the mechanically measured shear modulus μ_{mech} of the PVA-material.

Numerical model: The SWE-experiment was numerically replicated by using a finite element (FE)-based approach previously developed [1].

3. RESULTS AND DISCUSSION

Fig. A demonstrates that group speed analysis systematically underestimates μ_{mech} with -32.9%, -30.8% and -24.5%, while phase speed analysis slightly overestimates μ_{mech} with +9.7%, +13.9 and +11.1% for basal, mid-ventricular and apical zone. Fig. B shows a good correspondence between the axial velocity pattern of simulation (top) and measurement (bottom) at $t=0.72$ ms.

In conclusion, our experiments showed that phase speed analysis provided a better tissue stiffness estimate than group speed. On the other hand, numerical modeling gave insights in factors influencing dispersion and allowed visualization of SW's in 3D. However, to assure correct stiffness estimation in patient-specific geometries and anisotropic materials, development of a more robust algorithm is desirable, where we foresee a crucial role of FE-modeling to better understand the complex SW pattern.



References

- [1] Caenen et al, IEEE-TUFFC, 62(3), 439-450, 2015.