Ultrasound time-harmonic elastography of the heart with temporal resolution and real-time feedback to enable stiffness measurements in systole and diastole

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Theme: Mechanics

Previous work in BIOQIC has pushed the boundaries of ultrasound-based time-harmonic elastography (THE) of the heart. In particular, we have developed an ultrasound scanner connected to a vibratory bed that for the first time reliably measures the stiffness of the heart in the anterior wall of the left ventricle (see Figure). This unique device is currently being tested and validated in healthy volunteers under cardiac stress and in patients with cardiac AMT amyloidosis and diastolic dysfunction. For the next cohort, we propose to develop a cardiac THE that allows i) time-resolved measurement of stiffness values in diastole and systole and ii) providing real-time feedback to the operator. Both developments are crucial for clinical implementation, since stiffness values can so far only be derived in relatively quiescent phases of the heart, whereas systole still remains a blind spot of cardiac THE and even diastolic measurements in patients with high heart rates are limited. Furthermore, the real-time display of the obtained shear wave velocity maps (elastograms) would allow the operator to compensate for measurement errors due to transducer deposition, patient movement, or respiration. This would greatly improve the consistency and accuracy of the method. The proposed development of time-resolved cardiac THE requires a completely new concept of data preprocessing, including automatic unwrapping, AI-based motion estimation, and principal component analysis of harmonic motion components. These steps will be first implemented and tested on a state-of-the-art parallel transmission-acquisition research platform and later compiled on a clinical B-mode scanner to facilitate clinical translation. Following these developments, we anticipate that cardiac THE will be ready to undergo the certification processes as a medical device and to be used in large-scale clinical research in multicenter studies.

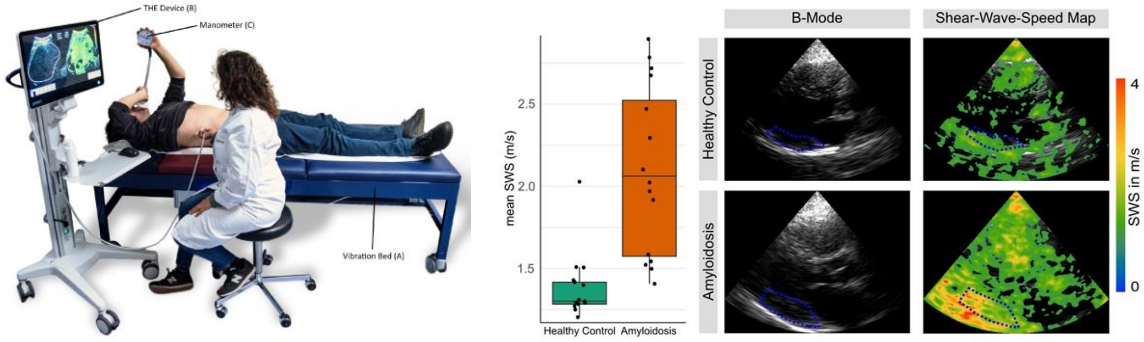

Figure: BIOQIC development of cardiac THE. Left panel: integrated THE scanner, here for application in the liver, right panel: preliminary data in healthy volunteers and patients with AMT amyloidosis.

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