

# Three-dimensional velocity estimation of natural mechanical waves in the myocardium

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## Background, Motivation, and Objective

Mechanical wave (MW) propagation depends on the local tissue properties. Considering the anisotropic characteristics of the myocardium, the MW velocity and direction is expected to be three-dimensional and complex in nature. Hence, velocity estimation using a 1D M-mode approach may be insufficient and depend on the 2D view. In this work, we investigate the 3D propagation of naturally occurring mechanical waves *in vivo*, and evaluate 1D, 2D, and 3D MW velocity estimation in this context.

## Statement of Contribution/Methods

A clinical system (GE E95, GEVU, Norway) was used to sequentially acquire high quality (HQ) and high framerate 3D (HFR, 832Hz) volumes of the left ventricle (LV). An AI-based pipeline provided rapid automated analysis consisting of 3D segmentation and standard view / anatomical M-mode extraction. Mechanical wave imaging (MWI) was done using both clutter filter wave imaging (CFWI) and tissue doppler imaging (TDI) for N=5 healthy and N=8 aortic stenosis patients. 1D velocities were estimated using regression analysis on the position of maximum intensity in the M-mode, while 2D and 3D vector velocities were estimated based on the gradient of the time-of-flight maps generated from a specific event (e.g., atrial kick). A method comparison was done by averaging the available information in a 2D slice for each method, in addition to the full myocardial mask, with an aim to estimate the global average mechanical wave velocity in the myocardium. The comparison pipeline is summarized in Fig. A.

## Results/Discussion

Our pipeline could visualize the 3D propagation of the mechanical waves, showing the origin and propagation of the atrial kick (AK) and aortic valve closure (AVC) events. We could observe that the 1D method is sensitive to the wave direction while the 3D gradient method better captured the velocity of the wave (Fig. B, artifactual M-mode). Results from the gradient method were on average aligned with the M-mode while having less variation and outliers, which confirms the validity and efficacy of this approach (Fig. C). All approaches were here able to separate patient and healthy cases. In future work we will conduct a large cohort analysis aiming to elucidate the potential and limitations of 3D MWI, and the ability to quantify both global and focal fibrosis in the myocardium.

