3D myocardial elastography with coherent compounding of diverging waves

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Background, Motivation and Objective

3D cardiac strain imaging allows for the characterization of contraction abnormalities of the full heart. However, 3D echocardiography typically suffers from low temporal resolution (usually 20-30 volumes/s), which decreases frame-to-frame correlation and corresponding displacement and strain estimation accuracy. Coherent compounding of unfocused waves can achieve high temporal and spatial resolution. In addition, myocardial elastography can improve motion tracking by using radiofrequency instead of envelope signals. The objective of this study is to show the feasibility of 3D myocardial elastography using high volume rate ultrasound imaging with coherent compounding in humans in vivo.

Statement of Contribution/Methods

A 32x32-element array, with 3-MHz center frequency and connected to four synchronized Verasonics Vantage 256 systems was used for 3D myocardial elastography. Ultrasound radiofrequency channel data were acquired at a volume rate of 4900 Hz using coherent compounding 16 diverging waves, entailing a compounded volume rate of approximately 306 Hz at an imaging depth of 140 mm in two healthy volunteers (26 & 27 y.o.). Each diverging wave was transmitted from a virtual source located behind the transducer and using a 16x16 moving sub-aperture array. A standard delay-and-sum method implemented on a GPU was used for 3D image reconstruction in a 90°x90° pyramidal grid. Inter-volume axial and lateral displacements were estimated using 1-D normalized cross-correlation in a 2D (axial and lateral) search. Inter-volume axial and lateral strains were also estimated with a least-squares estimator. Inter-volume axial and lateral strains were accumulated over systole.

Results/Discussion

End-systolic left ventricular axial strain shows was tensile in the anterior and inferior region and compressive in the lateral and septal regions. End-systolic lateral larger positive strains occurred in the lateral and septal regions than in the anterior and inferior regions. Axial and lateral strain variation along the left ventricular axis could be observed due 3D imaging. Better strain estimation was found in the axial than in the lateral direction. This study showed that 3D myocardial elastography in humans in vivo is feasible with coherent compounding and has potential to better locate and characterize regions with contractile abnormalities.

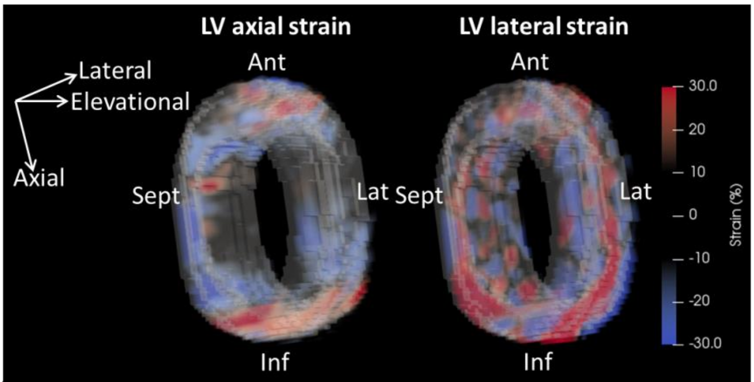

Figure 1: End-systolic left ventricular (LV) 3D axial and lateral strain in a healthy volunteer. Positive strains are in red and negative strains are in blue. Positive axial strains are mainly observed in the anterior (Ant) and inferior (Inf) regions and positive lateral strains in the septal (sept) and lateral (lat) regions, indicating radial thickening during contraction.