Single-Heartbeat Myocardial Elastography in human subjects with Coronary Artery Disease

Julien Grondin[1], Alok Gambhir[2], Stan Okrasinski[1], Ethan Bunting[1] and Elisa Konofagou[1,3]

[1]Department of Biomedical Engineering, Columbia University, New York, NY
[2]Department of Medicine, Columbia University, New York, NY
[3]Department of Radiology, Columbia University, New York, NY

Email: jlg2216@columbia.edu

Background, Motivation and Objective:
Myocardial Elastography (ME) is a technique that can image 2-D myocardial strains *in vivo*. Prior studies have shown that ME can detect abnormal function of coronary artery disease (CAD) patients and identify the territories affected by occluded arteries. However, the previous method required RF frame acquisition using ECG gating with long breath–holding times and/or ECG-gating related artifacts. In this study, the entire field of view was acquired at high temporal resolution during a single heartbeat for CAD patients. The objective of this study was to evaluate the performance of ME in detecting and characterizing abnormal myocardial function in CAD patients using high frame-rate and single-heartbeat data acquisition.

Statement of Contribution/Methods:

In this study, one normal and seven CAD human subjects were imaged in order to assess the performance of single-heartbeat ME. The patients also underwent coronary angiography and were scanned with ME on the same day as their catheterization procedure. Occlusion superior to 40% measured by angiography was detected in five patients in right coronary artery (RCA), four patients in left circumflex (LCX) and six patients in left anterior descending (LAD). An unfocused transmit sequence was used to acquire transthoracic images in short- axis view using a Verasonics ultrasound system and a P4-2 probe at 2.5 MHz center frequency. Channel data were acquired during 2s at 2000 frames per second and ECG was acquired synchronously. The RF data were reconstructed on a 90° field of view at 20 MHz sampling frequency. Incremental axial and lateral displacements were estimated using normalized 1-D cross-correlation (window size: 5.9 mm, 90% overlap) and then accumulated during systole. Axial and lateral cumulative strains were computed by applying a least-squares estimator using a Savitzky-Golay filter on the axial and lateral cumulative displacements (kernel size: 6.6mm) before converting to radial and circumferential cumulative strains.

Results/Discussion/Conclusions:

The average radial end-systolic cumulative strain in the normal myocardium was 9.8%, 7.5% and 4.9% in the regions perfused by RCA, LCX and LAD, respectively. The average radial end-systolic cumulative strain in occluded regions in CAD patients were $-3.6\pm5.9\%$ in RCA, $-2.7\pm3.1\%$ in LCX and $1.0\pm2.8\%$ in LAD. The relative variation of strain between the normal and the CAD subjects was 137% in RCA, 136% in LCX and 80% in LAD. These preliminary

clinical findings indicate the potential of ME to noninvasively, at high frame rates and within a single heartbeat differentiate CAD-affected from normal left-ventricular myocardium in all regions perfused by coronaries.