Radiofrequency-based Speckle Tracking Echocardiography Using a Newly Developed Prototype Ultrasound System for Evaluation of Myocardial Strain and Strain Rate

University of Michigan Cardiovascular Center

Theodore J. Kolias[1], Matthew O'Donnell[2], Nicole M. Kline[1], Lingling Zhang[1], James D. Hamilton[3]

[1]University of Michigan, Ann Arbor, MI; [2]University of Washington, Seattle, WA; [3]Pixel Velocity/Epsilon Imaging Inc., Ann Arbor, MI

Abstract

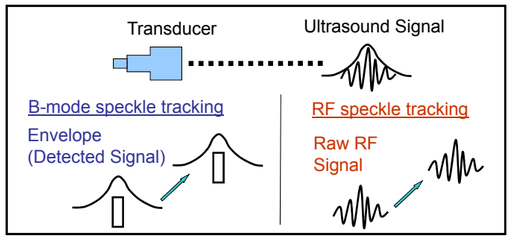
Introduction: Current commercially available 2D speckle tracking techniques operate at relatively low speckle tracking frame rates (< 100 frames/sec) and utilize only the processed 2D B-mode data rather than the raw radiofrequency (RF) ultrasound data. We have developed a prototype RF-based speckle tracking echocardiography system that operates at high speckle tracking frame rates (> 500 frames/sec), with an effective temporal resolution of 60 to 150 frames/sec. This prototype uses the raw RF data (including the signal phase information) to improve tracking quality.
Methods: 24 human subjects (10 normal and 14 with known CAD) underwent imaging with the prototype system. Longitudinal end-systolic strain (ε), peak systolic strain rate (sSR), and peak early diastolic strain rate (dSR) were measured in each of 18 segments derived from 3 standard apical views. Global ε, sSR, and dSR were also calculated for each subject by averaging the 18 segments. Narrow sector imaging was also compared to full sector imaging. *Results*: ε, sSR, and dSR could be obtained in 94%, 92%, and 92% of segments, respectively. Among normal subjects, the mean ε, sSR, and dSR varied significantly by segment, with the lowest values found in the apical segments of the anterior, anteroseptal, and lateral walls. Subjects with CAD had significantly lower global ε (-8.3 ± 3.0% vs. -16.5 ± 2.2%, p < 0.001), sSR (-0.53 ± 0.19 s-1 vs. -1.11 ± 0.17 s-1, p < 0.001), and dSR (0.61 ± 0.23 s-1 vs. 1.58 ± 0.31 s-1, p < 0.001) compared to normal subjects. Among subjects with CAD, segments with an abnormal wall motion score (WMS) had significantly lower ε compared to those with a normal WMS (-6.3 ± 5.5% vs. -9.9 ± 7.0%, p = 0.009), and a trend toward lower sSR (p = 0.076). In addition, the mean ε, sSR, and dSR of normal segments from patients with CAD were significantly lower than those from normal subjects (p < 0.001 for each parameter). Narrow sector imaging did not improve the results.
Conclusions: Radiofrequency-based speckle tracking echocardiography using the new prototype is feasible and allows for evaluation of myocardial strain and strain rate. This new prototype can successfully detect abnormalities secondary to CAD, and has significant potential to improve the echocardiographic assessment of myocardial deformation.

Disclosure Information

The following relationships exist related to this presentation:
This project was supported by a research grant from Pixel Velocity/ Epsilon Imaging, Inc.
T.J. Kolias - Pixel Velocity Inc. (Research grants & consulting),
M. O'Donnell - Pixel Velocity Inc. (Consulting), N.M. Kline - None,
L. Zhang - None, J.D. Hamilton - Pixel Velocity Inc. (Employee).

Introduction

- Current commercially available 2D speckle tracking techniques operate at relatively low speckle tracking frame rates (< 100 frames/sec) and utilize only the processed B-mode data.
- We have developed a prototype RF-based speckle tracking ultrasound system for measurement of strain and strain rate, which:
  a) Can operate at high speckle tracking frame rates (> 500 frames/sec), with an effective temporal resolution of 60 to 70 (up to 150) frames/s.
  b) Uses the raw RF data (including the signal phase information) to optimize tracking quality.



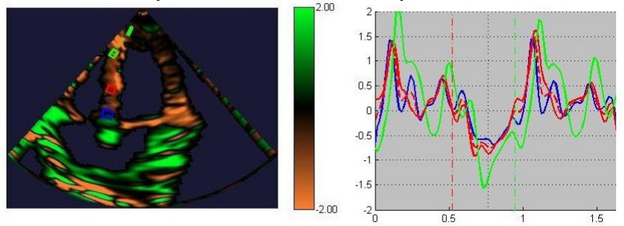
- The goal of this study was to evaluate the ability of the prototype system to measure strain and strain rate in normal subjects and patients with coronary artery disease (CAD).

Methods

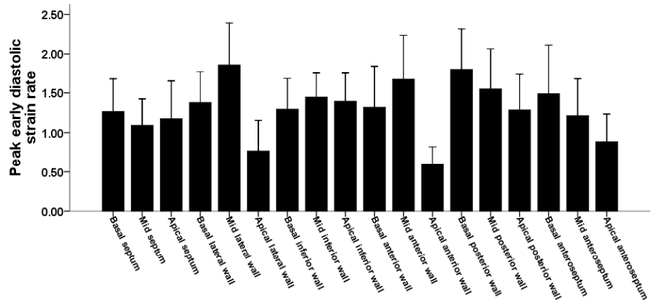
- 24 human subjects (14 with known CAD and 10 normal without known CAD) underwent imaging with the prototype system.
- Longitudinal end-systolic strain, peak systolic strain rate (SR), and peak early diastolic SR were measured in 18 segments derived from 3 standard apical views. Global strain, systolic SR, and diastolic SR were also calculated for each subject by averaging the 18 segments.
- Patients with CAD also underwent wall motion score assessment on a standard echo obtained within 2 days of the prototype echocardiogram.
- Strain and SR (Lagrangian) were initially obtained using a reference length set at end-systole (data in abstract); these were subsequently converted to make the reference length at end-diastole (all other data).

Results

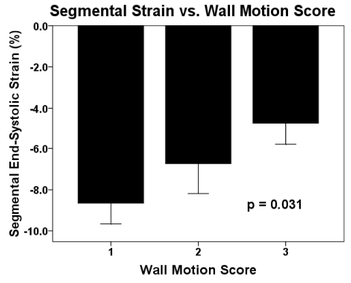
Example of a Strain Rate Color Map and Curves



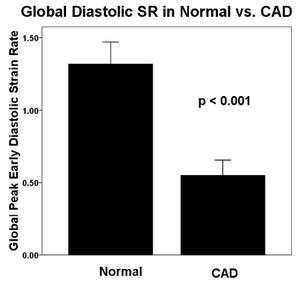
Variation in Strain Rate by Segment in Normal Subjects



Segmental Strain vs. Wall Motion Score



Global Diastolic SR in Normal vs. CAD



Results

Strain and Strain Rate in Normal Subjects and Patients with Coronary Artery Disease

	End-systolic strain (%)	Peak systolic strain rate (s^{-1})	Peak early diastolic strain rate (s^{-1})
a) Normal subjects (global)	-13.6 ± 1.5	-0.93 ± 0.15	1.32 ± 0.24
b) Patients with CAD (global)	-7.3 ± 2.5	-0.48 ± 0.16	0.55 ± 0.20
p value (a vs. b)	< 0.001	< 0.001	< 0.001
c) Segments with normal WMS in CAD patients	-8.6 ± 5.7	-0.53 ± 0.39	0.59 ± 0.40
p value (a vs. c)	< 0.001	< 0.001	< 0.001

Percent of Segments in which Strain and Strain Rate Could Be Measured

	End-systolic strain	Peak systolic strain rate	Peak early diastolic strain rate
% of Segments (n=432)	95%	94%	93%

Conclusions

- Radiofrequency-based speckle tracking echocardiography using the new prototype is feasible, and allows for evaluation of myocardial strain and strain rate.
- This new prototype can successfully detect abnormalities in myocardial deformation secondary to coronary artery disease.
- This new technology has significant potential to improve the echocardiographic assessment of myocardial deformation.