Initial Human Study of a Prototype Radiofrequency-based Speckle Tracking Echocardiography System for Assessment of Myocardial Deformation

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 Inc., Ann Arbor, MI

ABSTRACT

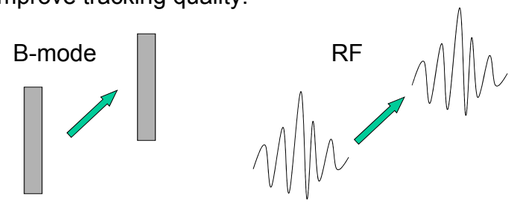
Background: Myocardial deformation assessed by 2D speckle tracking allows evaluation of regional strain in any direction within the 2D plane. Algorithms using speckle tracking depend on correlating ultrasound speckles from frame to frame and tracking their motion. The quality of the tracking is critical to the accuracy of the measurement, but is not assessable during imaging in real time using current commercial systems. Furthermore, current commercial speckle tracking algorithms are based on the processed 2D B-mode image, rather than the raw radiofrequency (RF) data, and therefore much information is lost, including the signal phase information which significantly improves tracking quality.
Methods: We have developed a prototype RF-based speckle tracking echocardiography system (Pixel Velocity Inc.) that operates at a high frame rate (100 frames/sec) and provides real time simultaneous 2D B-mode images as well as images of the tracking correlation magnitudes, which we term DQI (data quality index) images. These allow the sonographer to adjust the image to optimize tracking prior to capturing and storing the RF data, which is then used to calculate velocity, strain, and strain rate. In this study, we demonstrated the feasibility of this technique in 13 pts (7 normal and 6 with CAD). In each pt, after images were optimized and stored, longitudinal strain and tracking quality (DQI) were measured at end-systole in 18 segments from 3 standard apical views.
Results: Strain and DQI were obtained in 221 out of 234 segments (94%). The mean DQI of all segments was 0.52 ± 0.19, and the mean strain was -0.09 ± 0.08. Repeated measures ANOVA using SPSS linear mixed model procedure with Bonferroni adjustment revealed no significant differences in DQI between the 6 segments in the apical 4 chamber view or between the 6 segments in the apical long axis view. In contrast, the DQI values of the segments in the apical 2 chamber view were significantly different ($p < 0.001$), with worse tracking in the basal anterior (0.44 ± 0.21) and mid anterior (0.35 ± 0.23) wall segments.
Conclusions: RF-based speckle tracking with real time DQI display is feasible in humans, and can be used to guide data acquisition. The quality of tracking varies among myocardial segments and should be considered when evaluating myocardial deformation using speckle tracking.

DISCLOSURE INFORMATION

The following relationships exist related to this presentation:
This project was supported by an NIH-SBIR grant (Direct sponsor: Pixel Velocity Inc., Prime sponsor: NIH).
T.J. Kolias – Pixel Velocity Inc. (Research grant and consulting), M. O'Donnell – Pixel Velocity Inc. (Consulting), N.M. Kline – None, L. Zhang - None, J.D. Hamilton – Pixel Velocity Inc. (Employee).

INTRODUCTION

- Myocardial deformation assessed by 2D speckle tracking allows evaluation of regional strain
- Depends on correlating ultrasound speckles from frame to frame and tracking their motion
- Quality of tracking is critical to accuracy, but is not assessable in real time with current systems
- Current speckle tracking algorithms are based on the processed 2D B-mode image, rather than the raw radiofrequency (RF) data, resulting in loss of signal phase information which could significantly improve tracking quality:

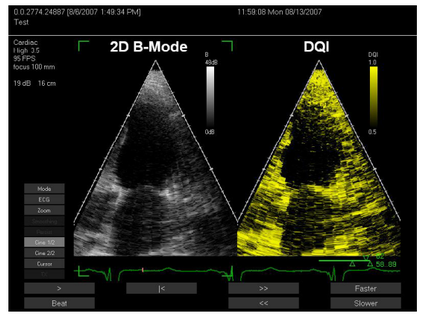


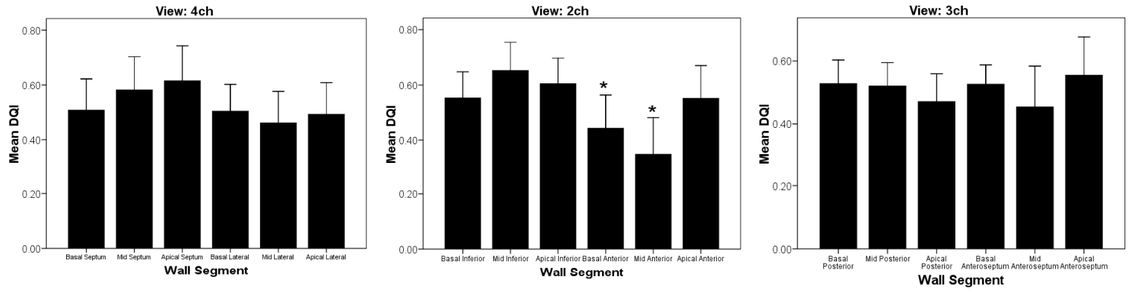
METHODS

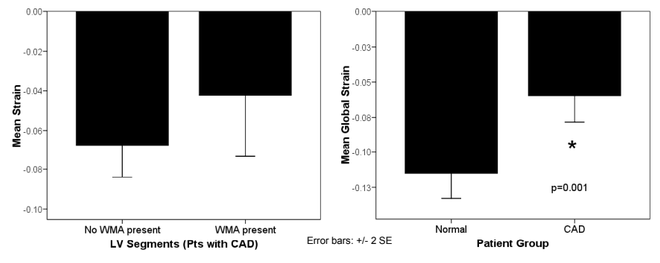
- We have developed a prototype RF-based speckle tracking echocardiography system
  - •Operates at high frame rate (100 frames/sec)
  - •Real time display of B-mode and tracking correlation magnitudes (data quality images or DQI), allowing sonographer to adjust image
- Feasibility demonstrated in 13 patients (7 normal and 6 with CAD)
- Longitudinal strain and DQI were measured in 18 segments from 3 standard apical views (ap4, ap2, and ap3 chamber views)

RESULTS

- Strain and DQI were obtained in 221 out of 234 segments (94%)
- No significant differences in DQI between the segments in the ap4, or between the segments in the ap3 chamber views
- DQI values of segments in the ap2 chamber view varied significantly ($p<0.001$)
- Mean strain of segments with wall motion abnormalities (WMA) was less than segments without WMA, but was not significant
- Global longitudinal strain (average of 18 segments) was significantly less in patients with vs. without CAD ($p=0.001$)







CONCLUSIONS

- RF-based speckle tracking with real time DQI display is feasible in humans, and can be used to guide data acquisition
- The quality of tracking varies among myocardial segments and should be considered when evaluating myocardial deformation using speckle tracking