A New Speckle Tracking Method For The Assessment of Myocardial Strain: Validation In An Animal Model of Ischemia-Reperfusion

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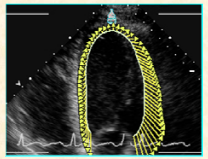
Introduction

- Quantification of regional myocardial function is crucial in the diagnosis of ischemic heart diseases.
- Myocardial strain, originally derived from tissue Doppler imaging, is a valuable tool in the assessment of left ventricular regional contraction; however, is limited by angle dependency.
- Recently, 2-dimensional strain measurement from grayscale images has been introduced based on speckle tracking. Speckle tracking is a method in which ultrasound speckles within the image are tracked and strain is determined from the displacement of speckles in relation to each other, therefore it is angle independent.
- The aim of this study was to validate a new speckle tracking echocardiography method, Velocity Vector Imaging (VVI), against sonomicrometry in an animal model of ischemia-reperfusion.



An example of VVI application, showing the tracking of endocardial motion, yellow arrows representing the direction and the amplitude of the motion.

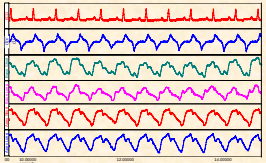
Methods

Experimental Protocol

- Seven mongrel dogs were anesthetized, intubated and mechanically ventilated.
- A sternotomy was performed and the heart was suspended in a pericardial cradle, following necessary instrumentations.
- Inotropic state and regional myocardial function altered by various interventions: dobutamine, left anterior descending (LAD) artery occlusion for 15 minutes, reperfusion for 1 hour, followed by dobutamine and esmolol infusion.

Sonomicrometry Measurements

- Myocardial strain by sonomicrometry (SM) was measured in basal and apical regions of the left ventricular (LV) anterolateral wall using two pairs of ultrasonic crystals in each region attached to the myocardium.
- Longitudinal and circumferential dimensions were measured by the use of SM crystals and strain was calculated as; strain = (L-L0)/L0, where L0 is the segment length at the onset of QRS and L is the segment length at the time of peak – dp/dt.



Data obtained from SM crystal pairs is analyzed by a data acquisition software (AcqKnowledge 3.7.2, BioPac system, Inc.) as shown in the figure.

Velocity Vector Imaging

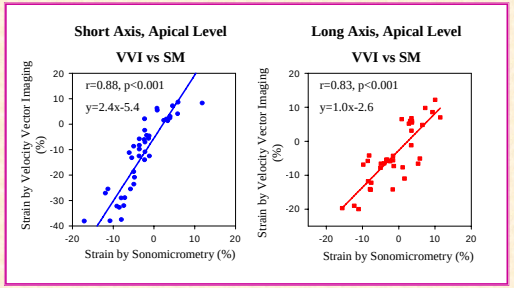
- An Acuson Sequia 512 (Siemens, Mountainview, CA) ultrasound system was used to acquire images from both short and long-axis views of the LV at the basal and apical levels where SM crystals were located.
- Images were analyzed off-line using the new software (Axius™, VVI, Siemens, Mountainview, CA) which provides 2D velocity, strain and strain rate by automatic endocardial border and speckle tracking throughout the cardiac cycle following one reliable manually drawn endocardial tracing.
- Strain was obtained by comparing displacement of the speckles in relation to each other along the endocardial contour.
- From short axis views circumferential strain values were recorded where the crystal pairs were located. Longitudinal strain curves were obtained by placing the sample volume on the apical and basal segments at long-axis views.

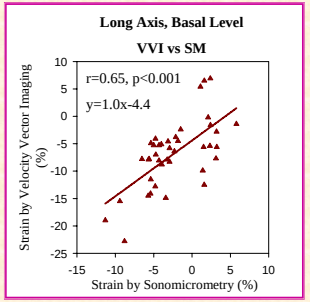
❖ Short axis view at baseline representing normal contraction and strain pattern by VVI.

❖ Short axis view during LAD occlusion showing dyskinetic motion resulting in positive strain pattern by VVI.

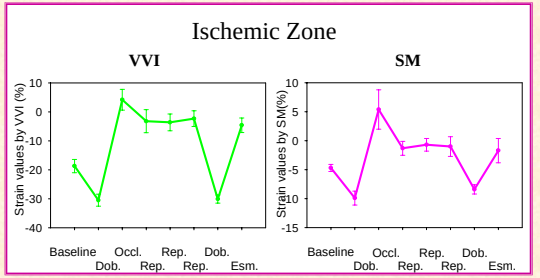
Results

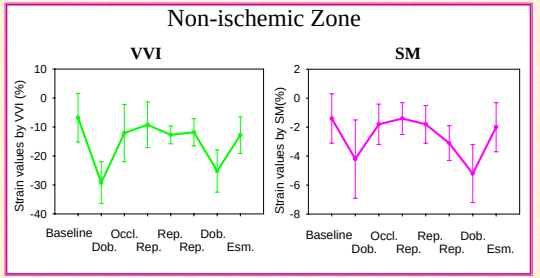
- Eight different hemodynamic and inotropic state were tested for strain. One of the 7 animals died during coronary occlusion.
- Strain values obtained at the apical ischemic segments both from short axis and long axis views correlated well with VVI and SM (r=0.88, p<0.001 and r=0.83, p<0.001, respectively).





- Regression analysis for the measurement of strain at basal non-ischemic segments from long-axis views indicated a significant correlation between VVI and SM methods (r=0.65, p<0.001).





Dob = dobutamine; occl = occlusion; rep = reperfusion (15, 30, 60 min); esm = esmolol

- Changes in strain induced by ischemia-reperfusion and additional pharmacological interventions could be tracked well with VVI with a trend parallel to SM data.
- Absolute values for strain by VVI were generally smaller than by SM, mostly because of difference between endocardial (VVI) and intramyocardial (SM) measurements.

Conclusions

- A new speckle tracking echocardiography, Velocity Vector Imaging, can quantify regional myocardial function.
- VVI provides accurate and angle-independent measurements of strain under different pathophysiologic conditions.
- This method promises to be a clinical tool to quantify regional function from apical and short axis views that is automated and easy to use.