Velocity Vector Imaging as a new approach for cardiac magnetic resonance: Comparison with echocardiography

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• Cardiac magnetic resonance (CMR) is a powerful tool to quantify left ventricular (LV) function, however previous strain methods have usually required complicated and time-consuming tagging.

• Velocity vector imaging (VVI) is a novel quantitative technique that has been applied previous to speckle tracking echocardiography (Echo).
OBJECTIVE

- To test the hypothesis that VVI can be applied to routine CMR DICOM images to quantify cardiac function similar to Echo.
METHODS

- Consecutive 51 subjects with suspected heart failure who had both CMR and echocardiography
  - Age $53 \pm 15$ years
  - 33 male (65%)
- Standard Echocardiography (Echo)
  - Echocardiography was performed with either a Vivid 7 (GE Vingmed, Horten, Norway) or an iE33 (Philips Medical Systems, Andover, Mass).
• Velocity Vector Imaging by Echo

• Echocardiographic images were used from the parasternal short-axis view, mid-LV level using the papillary muscles as an internal anatomic landmark.

• VVI was measured from routine DICOM data sets using a software (2D Cardiac Performance Analysis©, TomTec, Germany).

• A region of interest was manually placed on endocardial and epicardial borders.
Cardiac magnetic resonance (CMR)

- CMR was performed on a 1.5 Tesla scanner (Siemens, Germany).
- The scanning parameters were as follows: echo time (TE) 1.8ms, repetition time (TR) 3.6ms, spatial resolution $1.8 \times 1.5\text{mm}^2$, slice thickness 6mm, temporal resolution of 30 frames per RR-interval.
- Ejection fraction was calculated by assessment of the volumes of the endocardial contours in diastole and systole of the short-axis images using Argus Viewer (Siemens, Germany).
• **Velocity Vector Imaging by CMR**

- CMR images were selected from the digital DICOM data set to correspond to the mid-LV short axis plane using papillary muscles as an internal anatomic landmark.

- VVI was measured from Routine digital DICOM data sets using the novel software (2D Cardiac Performance Analysis Analysis MR®, TomTec, Germany).

- A region of interest was manually placed on endocardial and epicardial borders.
• Patients were divided as those having systolic dysfunction (LVEF<50%: Group 1) or having normal systolic function (LVEF≥50%: Group 2).
Velocity Vector Imaging by Echo

Normal systolic function patient (EF=60%)

Echo (VVI)

Radial Velocity by Echo

Velocity (cm/s)

Time (ms)

ECG

Average Velocity

Anterior

Ant-Sep

Posterior

Inferior

Lateral

Septal
Velocity Vector Imaging by CMR

Normal systolic function patient (EF=60%)
Velocity Vector Imaging by Echo

Systolic dysfunction patient (EF=17%)
Velocity Vector Imaging by CMR

Systolic dysfunction patient (EF=17%)
RESULTS

• Imaging data were suitable for quantitative analysis in 100% (51/51) of CMR images and 90% (47/51) of echo images.
• Patients Data

◆ Group 1: **Systolic dysfunction patients (LVEF < 50%)**
  • 22 patients
    • 6 ischemic cardiomyopathy
    • 16 non-ischemic cardiomyopathy

◆ Group 2: **Normal systolic function patients (LVEF ≥ 50%)**
  • 29 patients
    • 5 ischemic heart disease
    • 3 hypertrophic cardiomyopathy
    • 1 hypertensive heart disease
    • 6 paroxysmal atrial fibrillation
    • 14 non-cardiac disease
Comparison Between the Groups by Echo and CMR

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<thead>
<tr>
<th></th>
<th>Group1</th>
<th>Group2</th>
<th>Echo</th>
<th>Group1</th>
<th>Group2</th>
<th>CMR</th>
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</thead>
<tbody>
<tr>
<td>Average Velocity (cm/s)</td>
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<td></td>
<td>1.84 ± 0.7</td>
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<td>2.92 ± 0.86</td>
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<td>1.94 ± 0.87</td>
<td>3.75 ± 0.91</td>
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* p<0.001 vs Group1  † p<0.001 vs Echo
Variability of Average Velocity Between CMR and Echo

- Average Velocity by Echo (cm/s) vs. Average Velocity by CMR (cm/s)
- Mean of Average Velocity (cm/s)
- $r = 0.76$
- $p < 0.001$

- Average Velocity by Echo - CMR (cm/s)
- Mean: -0.5
- +1.96 SD: 1.1
- -1.96 SD: -2.1
CONCLUSIONS

• A novel simple VVI software approach can be applied to CMR to quantify myocardial function, and compares favorably with similar strain measures by speckle tracking Echo.

• VVI by CMR has potential for clinical applications.