Global left ventricular circumferential strain is a marker for both systolic and diastolic myocardial function

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• Circumferential strain by cardiac magnetic resonance (CMR) is a powerful tool to quantify left ventricular (LV) function; however previous strain methods have required sophisticated and time-consuming tagging.
OBJECTIVE

- To test the hypothesis that global circumferential strain (GCS) by CMR imaging or speckle tracking echo (ST-Echo) is a combined marker of either systolic or diastolic myocardial dysfunction.
METHODS

- Consecutive 51 subjects with suspected heart failure who had both CMR and echocardiography
  - Age 53±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).
• Strain measurements by Echo

• Echocardiographic images were used from the apical 4 and 2 chamber and long axis views, and parasternal short axis view mid-LV level using the papillary muscles as an internal anatomic landmark.

• Strain was analyzed 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).
Strain measurements by CMR

- CMR images were selected from the digital DICOM data set using the similar LV images to ECHO as an internal anatomic landmark.
- Strain was analyzed 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.
METHODS

- The mitral inflow to annular velocity ratio (E/E’) estimated filling pressures

- Systolic dysfunction was defined as LVEF<50% and diastolic dysfunction was defined as E/E’≥12

- Patients were divided into two groups:
  - **Group1** - having evidence of either systolic or diastolic function (E/E´≥12 or LVEF<50%)
  - **Group2** - having no evidence of myocardial dysfunction (E/E´<12 and LVEF≥50%)
Longitudinal Strain by Echo

Normal myocardial function patient (EF=60%, E/E’=9)

Echo

Longitudinal Strain by Echo

ECG

Strain (%)

Time (ms)

Basal-Septal
Mid-Septal
Apical-Septal
Apical Lateral
Mid-Lateral
Basal-Lateral
Average (Global Longitudinal Strain)
Longitudinal Strain by CMR

Normal myocardial function patient (EF=60%, E/E’=9)
Radial Strain by Echo

Normal myocardial function patient (EF=56%, E/E’=8)

Echo

Radial Strain by Echo

ECG

Time (ms)

Strain (%)

Anterior
Ant-Sep
Posterior
Inferior
Septal
Average
(GLOBAL RADIAL STRAIN)

100ms

GRS
Radial Strain by CMR

Normal myocardial function patient (EF=56%, E/E’=8)
Circumferential Strain by Echo

Normal myocardial function patient (EF=60%, E/E’=6)

Echo

Circumferential Strain by Echo

ECG

Time (ms)

Strain (%)

100ms

GCS

Ant-Sep

Anterior

Lateral

Posterior

Inferior

Septal

Average (Global Circumferential Strain)
Circumferential Strain by CMR

Normal myocardial function patient (EF=60%, E/E’=6)

CMR

Circumferential Strain by CMR

ECG

Strain (%)

0

-10

-20

-30

Time (ms)

100ms

Ant-Sep  Anterior  Lateral
Posterior  Inferior  Septal
Average  (Global Circumferential Strain)
RESULTS

- Imaging data were suitable for quantitative analysis in 100% (51/51) of CMR images and 90% (47/51) of echo images.
### RESULTS

**Patients Data**

<table>
<thead>
<tr>
<th>Group 1 (n=27): having evidence of either systolic or diastolic function</th>
<th>22 patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>EF&lt;50% and E/E’≥12 or E/E’&lt;12</td>
<td></td>
</tr>
<tr>
<td>5 patients</td>
<td>EF≥50% and E/E’≥12</td>
</tr>
</tbody>
</table>

- 6 ischemic cardiomyopathy
- 16 non-ischemic cardiomyopathy

- 1 hypertrophic cardiomyopathy
- 2 paroxysmal atrial fibrillation
- 2 non-cardiac disease

<table>
<thead>
<tr>
<th>Group 2 (n=24): having no evidence of myocardial dysfunction</th>
<th>24 patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>EF≥50% and E/E’&lt;12</td>
<td></td>
</tr>
</tbody>
</table>

- 5 ischemic heart disease
- 1 hypertensive heart disease
- 2 hypertrophic cardiomyopathy
- 4 paroxysmal atrial fibrillation
- 12 non-cardiac disease
## Comparison Between the Groups

<table>
<thead>
<tr>
<th></th>
<th>Group1 (n=27)</th>
<th>Group2 (n=24)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age, yrs</strong></td>
<td>57±14</td>
<td>50±15</td>
<td>0.1</td>
</tr>
<tr>
<td><strong>Gender (Male), n (%)</strong></td>
<td>19 (70%)</td>
<td>14 (58%)</td>
<td>0.5</td>
</tr>
<tr>
<td><strong>EF, %</strong></td>
<td>38±17</td>
<td>62±6</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>E/E’</strong></td>
<td>14±5</td>
<td>8±2</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>Echo</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Global Longitudinal Strain</td>
<td>-10.7±4.2</td>
<td>-16.7±3.6</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Global Radial Strain</td>
<td>17.4±11.3</td>
<td>29.5±16.7</td>
<td>0.005</td>
</tr>
<tr>
<td>Global Circumferential Strain</td>
<td>-14.7±8.0</td>
<td>-27.1±8.2</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>Cardiac MR</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Global Longitudinal Strain</td>
<td>-13.8±5.8</td>
<td>-22.2±3.8</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Global Radial Strain</td>
<td>16.9±9.1</td>
<td>27.7±14.6</td>
<td>0.003</td>
</tr>
<tr>
<td>Global Circumferential Strain</td>
<td>-13.0±6.1</td>
<td>-27.7±6.1</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>
Variability of Global Longitudinal Strain Between CMR and ECHO

GLS by Echo speckle tracking (%) vs. GLS by CMR (%)

- Scatter plot showing a positive correlation with a red line indicating the trend.
- Pearson's correlation coefficient ($r = 0.68$)
- Statistical significance: $p < 0.0001$

Mean GLS (%): 4.3

Mean GLS ± 1.96 SD:
- Lower bound: -5.4
- Upper bound: 14.1
Variability of Global Radial Strain Between CMR and ECHO

GRS by Echo speckle tracking (%)

GRS by CMR (%)

Mean GRS (%)

GRS by Echo - CMR (%)

$p < 0.05$

$r = 0.37$
Variability of Global Circumferential Strain Between CMR and Echo

\[ r = 0.85 \]
\[ p < 0.0001 \]
ROC Analyses of GLS, GRS and GCS for Predicting Myocardial Dysfunction by Echo and CMR

**Echo-GLS**
- $AUC = 0.88$
- Cut off: $-13.3\%$
- Sensitivity: $79\%$
- Specificity: $83\%$

**Echo-GRS**
- $AUC = 0.77$
- Cut off: $20.4\%$
- Sensitivity: $73\%$
- Specificity: $77\%$

**Echo-GCS**
- $AUC = 0.85$
- Cut off: $-16.4\%$
- Sensitivity: $69\%$
- Specificity: $96\%$

**CMR-GLS**
- $AUC = 0.88$
- Cut off: $-16.3\%$
- Sensitivity: $71\%$
- Specificity: $100\%$

**CMR-GRS**
- $AUC = 0.76$
- Cut off: $15.7\%$
- Sensitivity: $56\%$
- Specificity: $88\%$

**CMR-GCS**
- $AUC = 0.96$
- Cut off: $-18.4\%$
- Sensitivity: $88\%$
- Specificity: $100\%$
CONCLUSIONS

• GCS appears to be the most sensitive non-invasive method to detect either systolic or diastolic myocardial dysfunction in patients with suspected HF, and has promise for future clinical applications.