How to apply new echocardiographic methods in management of heart failure

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Conflicts of interest

• There are no conflicts of interest to disclose
Evaluation of Left Ventricular Function

☑ Systolic function
☑ Diastolic function
Which methods?

✓ Myocardial velocities by tissue Doppler echocardiography

✓ Myocardial strain by speckle tracking echocardiography
Myocardial velocities by tissue Doppler

![Myocardial velocities](image)

Blood velocities

Myocardial velocities

Otto A. Smiseth 2013
LV early-diastolic lengthening velocity (e’)

Myocardial velocities (cm/s)

ECG

Smiseth 2013
Determinants of LV lengthening velocity (e’)

LV relaxation

Decay in active fibre force

Restoring forces

Analogous to a compressed spring which recoils passively.

LV lengthening load

Left atrial pressure represents a force which pushes blood into the ventricle, thereby causing LV lengthening.

Based upon Opdahl/Smiseth et al., Circulation. 2009;119:2578-2586.
Transmitral flow velocity
Mitral annulus velocity
E/e' ratio
Tricuspid regurgitation velocity
Pulmonary venous flow velocity
Natriuretic peptides
Cardiac structural changes

Diastolic Dysfunction

Normal
Mild
Moderate
Severe

Increasing E/e’ ratio
E/e’ > 15 is consistent with elevated LV filling pressure

Normal values virtually excludes heart failure
Elevated in most patients with diastolic heart failure, but not sufficient stand alone evidence
Enlarged left atrium and LV hypertrophy supports the diagnosis diastolic heart failure

Smiseth et al., European Cardiology 2012
What is "strain"?

End-systole

End-diastole

0

-20

%  

Time

OA Smiseth, 2013
Strain methodologies

Dimension crystals
(experimental studies)

Systolic strain = \( \frac{L - L_0}{L_0} \)

MRI-tissue tagging

Tissue Doppler

Speckle tracking
Speckle tracking
Speckle tracking echocardiography

Longitudinal Strain

2013/03/01-11:36:37
4CH, single wall
Frame = 13

Courtesy of Thomas Helle-Valle
Strain by speckle tracking echocardiography
Global Systolic Strain

Global strain = average of all segmental strain values

Modified from Ola Gjesdal
Global Strain in a Normal Heart

Global strain = average of all segmental strain values

Global strain = -20 %
Normal ranges of global left ventricular longitudinal strain

A meta-analysis: 2,597 subjects from 24 studies.

Reported normal values of GLS varied from -15.9% to -22.1% (mean, -19.7%; 95% CI, -20.4% to -18.9%).

Global Strain - LAD Infarct

Global strain = average of all segmental strain values

Global strain = -9 %
“Global longitudinal strain measurement by 2DS was superior to EF and WMSI for the prediction of outcome and may become the optimal method for assessment of global LV systolic function. Guidelines incorporating measures of LV function may need to be revised to incorporate global longitudinal strain in light of this finding.”

Twisting motion
Determinants of LV untwisting rate
Important features of the strain trace

- Peak strain
- Post-systolic shortening
Distribution of circumferential strain in the ischemic LV

Courtesy of Thomas Helle-Valle
Post-systolic shortening in ischemic myocardium

- echo / scintigraphy
- stress response

strain [%]

ECG

Case 1

61 yr. old male

Previously healthy

Admitted after midnight, general discomfort and nausea

ECG non-conclusive
Tissue Doppler velocities (cm/s)

- Septum
- LV lateral wall
- LV inferior wall
- LV anterior wall
Strain
2 chamber

Strain curves 2 chamber (%)
Stenosis (90%) RCA

Speckle strain (%) 2ch
Case 2
Case 2

20 yr. old male

Chest pain.

Hypotensive

Suspected pulmonary embolism, confirmed by CT

I.v. thrombolysis
ACUTE PULMONARY EMBOLISM

**BASELINE**

**THROMBOLYSIS**

Strain Doppler (%)
Case 3

19 yr. old male

Fainted shortly after a soccer match
TISSUE DOPPLER

RIGHT VENTRICULAR FREE WALL

LEFT VENTRICULAR FREE WALL
Doppler strain RV free wall
# Arrhythmogenic right ventricular cardiomyopathy and subclinical right ventricular dysfunction

<table>
<thead>
<tr>
<th></th>
<th>Healthy individuals (n = 40)</th>
<th>Asymptomatic mutation carriers (n = 27)</th>
<th>ARVC patients with arrhythmia (n = 42)</th>
<th>P-value (Kruskal-Wallis)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LVEF (%)</td>
<td>64(61.65)</td>
<td>61(60.65)</td>
<td>60(55.67)</td>
<td>0.16</td>
</tr>
<tr>
<td>LVGLS (%)</td>
<td>-22(-21,-24)</td>
<td>-20(-18,-21)*</td>
<td>-17(-16,-19)*</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>RV strain (%)</td>
<td>-25(-23,-27)</td>
<td>-22(-20,-24)*</td>
<td>-19(-16,-21)*</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>LV dispersion (ms)</td>
<td>20(16,25)</td>
<td>38(33,49)*</td>
<td>60(48,70)*</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>RV dispersion (ms)</td>
<td>13(9,19)</td>
<td>35(23,47)*</td>
<td>52(41,63)*</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>PSAX RVOT (mm)</td>
<td>28(26,30)</td>
<td>27(26,28)</td>
<td>31(29,37)*</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>RVED area (cm²)</td>
<td>22(20,24)</td>
<td>24(22,27)</td>
<td>29(25,36)*</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>RVES area (cm²)</td>
<td>12(11,14)</td>
<td>14(12,15)</td>
<td>18(15,25)*</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>RVFAC (%)</td>
<td>44(39,48)</td>
<td>43(40,48)</td>
<td>38(27,43)*</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

*P < 0.001 compared with healthy individuals.

**P < 0.01 compared with asymptomatic mutation carriers.
Case 4

• 50 yr. old male

• Highly active in sports

• No symptoms

• Referred due to SD in younger brother
Case 4

• Echo: Bordeline LV

• Normal ECG and Holter

• Normal exercise stress test

• Normal scintigraphy
Slightly dilated LV, 6.2 cm
Tissue Doppler velocities (cm/s)

Septum

LV free wall
2D speckle strain (%)
Conclusions

- LV lengthening velocity (e’) by tissue Doppler should be used in evaluation of diastolic function.

- Global LV strain appear to be a sensitive measure of LV systolic function, but added clinical value not yet proven.

- In selected patients strain is clinically useful
  - In CAD
  - In CMP
  - In subclinical heart disease