Beginner’s Guide to Strain: What should be in your lab in 2018

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Disclosures

- None
Strain Imaging*

Quantitative

Magnitude

Degree of myocardial deformation

Direction

Cardiac axes of myocardial motion

* AKA: speckle tracking echocardiography (STE), 2D strain, myocardial deformation, or cardiac mechanics

Strain \approx \text{Deformation}

Strain = \text{Deformation resulting from applied force}
Calculation of Strain

Strain can be Positive

\[ \text{Strain} = \frac{L_1 - L_0}{L_0} \times 100 \]

where:
- \( L_1 \) = length at a given point in time
- \( L_0 \) = baseline length

\[ \text{Strain} = \frac{8 - 5}{5} \times 100 = +60\% \]
Strain can be Negative

\[ \text{Strain} = \frac{L_1 - L_0}{L_0} \times 100 \]

\[ = \frac{6 - 8}{8} \times 100 \]

\[ = -25\% \]

- \( L_1 \): length at a given point in time
- \( L_0 \): baseline length

2D Strain Principles

Unique acoustic speckles
Direction of Motion

<table>
<thead>
<tr>
<th>Direction</th>
<th>Longitudinal</th>
<th>Radial</th>
<th>Circumferential</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systole (Diastole)</td>
<td>Shortening = -ve (Lengthening = +ve)</td>
<td>Thickening = +ve (Thinning = -ve)</td>
<td>Shortening = -ve (Lengthening = +ve)</td>
</tr>
</tbody>
</table>

Most Common Clinical Application

Global Longitudinal Strain (GLS) of LV

<table>
<thead>
<tr>
<th>APLAX</th>
<th>AP-4ch</th>
<th>AP-2ch</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="APLAX.png" alt="Image" /></td>
<td><img src="AP-4ch.png" alt="Image" /></td>
<td><img src="AP-2ch.png" alt="Image" /></td>
</tr>
</tbody>
</table>
Display of GLS (Quad Format)

- Colour-encoded ROI (Parametric preview)
- Segmental/regional strain curves
- Curved anatomical Colour M-mode
- Peak segmental Strain map

Display of GLS (Bull’s Eye Plot)

Peak Systolic Strain
GLS -20%

Blue = +ve (lengthening)
Red = -ve (shortening)
Requirements for Strain Imaging

Caveat #1: Variability

Same Image

Software 1: GLS 21.2%

Software 2: GLS 16.7%

Images courtesy Prof. Jens-Uwe Voigt, University Hospital Gastroesophagus, Catholic University Leuven, Belgium
Caveat #1: Variability

Because of intervendor and intersoftware variability …… serial assessment of GLS in individual patients should be performed using the same vendor’s equipment and the same software


Caveat #2: Normal Values

GLS

<table>
<thead>
<tr>
<th>vendor</th>
<th>Software</th>
<th>n</th>
<th>Mean</th>
<th>SD</th>
<th>LLN</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Varying</td>
<td>Meta-analysis</td>
<td>2597</td>
<td>−19.7%</td>
<td>NA</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td>GE</td>
<td>Echocor</td>
<td>247</td>
<td>−21.5%</td>
<td>2.0%</td>
<td>−18%</td>
<td>31</td>
</tr>
<tr>
<td>GE</td>
<td>Echocor</td>
<td>207</td>
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<td>1.6%</td>
<td>−18%</td>
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</tr>
<tr>
<td>GE</td>
<td>Echocor</td>
<td>131</td>
<td>−21.2%</td>
<td>2.4%</td>
<td>−17%</td>
<td></td>
</tr>
<tr>
<td>GE</td>
<td>Echocor</td>
<td>257</td>
<td>−21.2%</td>
<td>2.4%</td>
<td>−17%</td>
<td></td>
</tr>
<tr>
<td>Philips</td>
<td>QLAB 7.1</td>
<td>330</td>
<td>−18.9%</td>
<td>2.5%</td>
<td>−14%</td>
<td>32</td>
</tr>
<tr>
<td>Toshiba</td>
<td>Ultra Extend</td>
<td>337</td>
<td>−19.9%</td>
<td>2.4%</td>
<td>−15%</td>
<td>32</td>
</tr>
<tr>
<td>Siemens</td>
<td>VVI</td>
<td>116</td>
<td>−19.8%</td>
<td>4.6%</td>
<td>−11%</td>
<td>197</td>
</tr>
<tr>
<td>Siemens</td>
<td>VVI</td>
<td>82</td>
<td>−17.3%</td>
<td>2.3%</td>
<td>−13%</td>
<td>198</td>
</tr>
<tr>
<td>Exacte</td>
<td>Mylab 50</td>
<td>30</td>
<td>−19.5%</td>
<td>3.1%</td>
<td>−13%</td>
<td>199</td>
</tr>
</tbody>
</table>

LLN: Lower limit of normal range.
*T. Kouznetsova and J. Stokseth, Department of Cardiology, Catholic University Leuven, personal communication.
†P. Barbier, University Milano, personal communication.

Caveat #2: Normal Values

"..... peak GLS in the range of -20% can be expected in a healthy person, and the lower the absolute value of strain is below this value, the more likely it is to be abnormal"


Caveat #3: Image Quality

Optimal for Strain

Suboptimal for Strain
Caveat #3: Image Quality

“When regional tracking is suboptimal in more than two myocardial segments in a single view, the calculation of GLS should be avoided.”


Caveat #4: Learning Curve

There is a significant learning curve associated with LV strain analysis. We recommend a minimum of 50 studies for training to achieve competency in GLS analysis.

Clinical Applications

- Diastolic function
- Atrial function
- AF risk
- Embolic risk in PAF

- HF
- CTRCD
- Valve disease
- LV "hypertrophy"
- IHD/CAD
- CRT
- Diastolic function

"Simplified" Clinical Applications

- Pattern Recognition
- Subclinical Dysfunction
- Regional variation
Hypertrophic CM: GLS severely decreased
Hypertensive Heart: GLS mildly decreased
Athlete’s Heart: GLS normal or increased

GLS Differentiates LVH Aetiology

- Athlete’s Heart: GLS normal or increased
- Hypertensive Heart: GLS mildly decreased
- Hypertrophic CM: GLS severely decreased

Key messages:
- Longitudinal strain is significantly attenuated in patients with hypertrophic cardiomyopathy (HCM) compared with other variant forms of left ventricular hypertrophy (LVH).

Afonso L, ..... Abraham TP. BMJ Open 2012;2:e001390
GLS in CTRCD*

Expert Consensus for Multimodality Imaging Evaluation of Adult Patients during and after Cancer Therapy: A Report from the American Society of Echocardiography and the European Association of Cardiovascular Imaging

* Cancer Therapeutics–Related Cardiac Dysfunction

GLS Detects Early Subclinical Myocardial Dysfunction before LVEF

- Drop of 10 points to LVEF <53%
- Relative drop of GLS as compared to baseline
  - < 8%
  - > 15%
- No evidence of subclinical LV dysfunction
- Subclinical LV dysfunction*

* The data supporting the initiation of cardioprotection for the treatment of subclinical LV dysfunction is limited.

Case Example

Baseline

3 Months Tratzusamab

GLS [21.6%]
EF 64%

GLS [17.8%]
EF 62%

* Clinically significant > 15%

Images courtesy Ada Lo, Royal Brisbane & Women's Hospital

Regional Variation or Mechanical Dispersion*

Normal

Abnormal

* Mechanical dispersion (MD) = standard deviation of time from ECG Q/R to peak strain

Mechanical Dispersion in Aortic Stenosis

Klaeboe, LG, J Am Soc Echocardiogr 2017 30, 727–735

Summary #1

Strain measures myocardial deformation

Most common clinical application is GLS [LV]

Normal GLS [LV] >20%

Fastidious attention to detail + learning curve
Summary #2

Simplified Clinical Applications

- Pattern Recognition
  - Bull's eye plot
- Subclinical Dysfunction
  - Averaged GLS value
- Regional Variation
  - Strain curve shape

Summary #3

PAST

NOW

LVH
Heart Failure
Cardiotoxicity
Aortic stenosis
IHD

FUTURE

Diastolic function
Regional variation
RV strain
LA strain
References & Further Reading

- Blessberger H, Binder T. NON-invasive imaging: Two dimensional speckle tracking echocardiography: basic principles. Heart. 2010 May;96(9):716-22

References & Further Reading

- EACVI free webinar: How and why to measure LV myocardial strain: https://www.youtube.com/watch?v=ipmZG5H78T6&feature=youtu.be