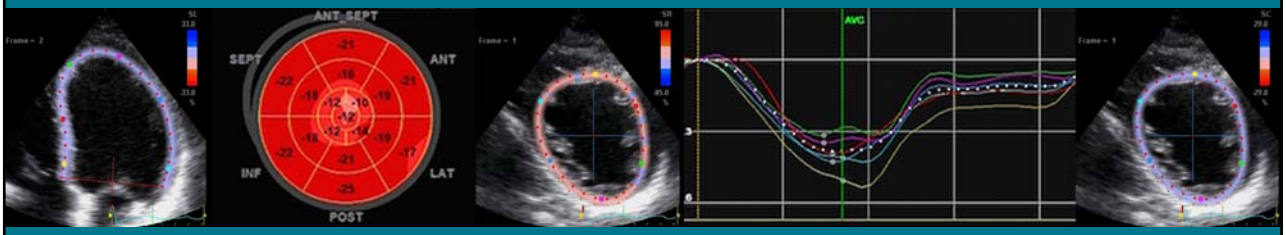
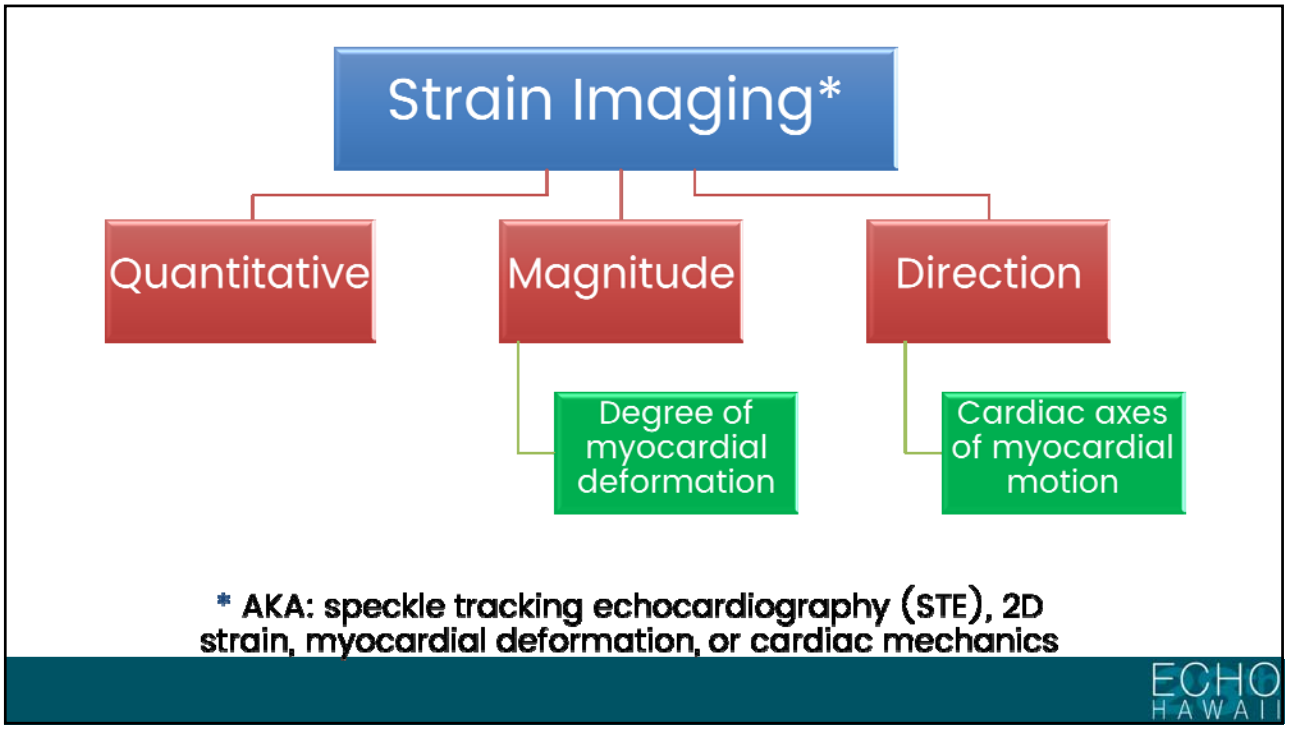
Beginner's Guide to Strain:
What should be in your lab in 2018

Bonita Anderson
DMU (Cardiac), MApplSc (Med Ultrasound), ACS, AMS, FASE



Disclosures

- None



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

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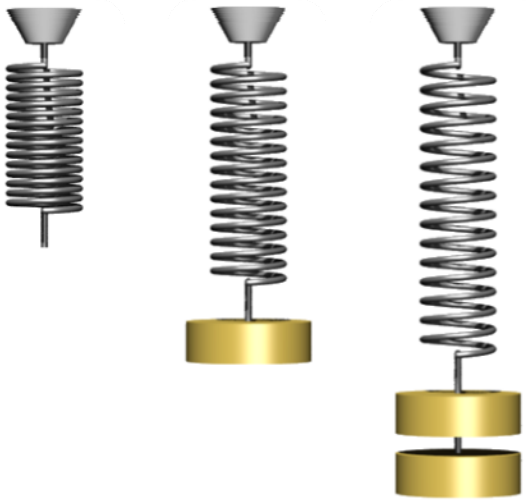
Strain ≈ Deformation



Strain = Deformation resulting from applied force

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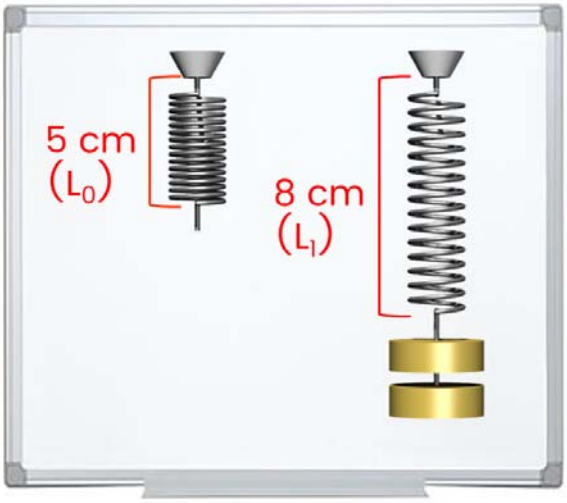
Calculation of Strain

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

L_1 = length at a given point in time
L_0 = baseline length

Strain can be Positive



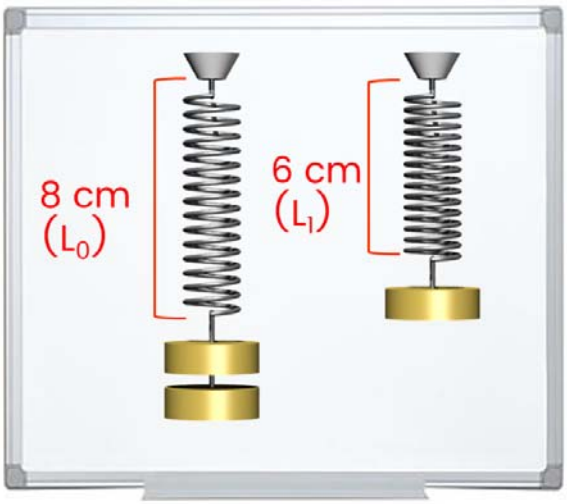
$$\text{Strain} = \frac{L_1 - L_0}{L_0} \times 100$$

$$= \frac{8 - 5}{5} \times 100$$

$$= +60\%$$

L_1 = length at a given point in time
L_0 = baseline length

Strain can be Negative



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

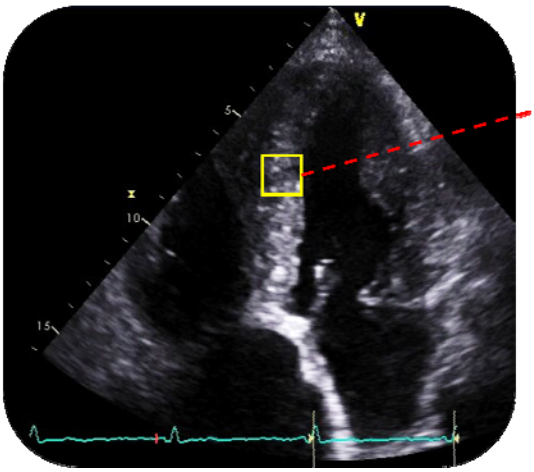
$$= \frac{6 - 8}{8} \times 100$$

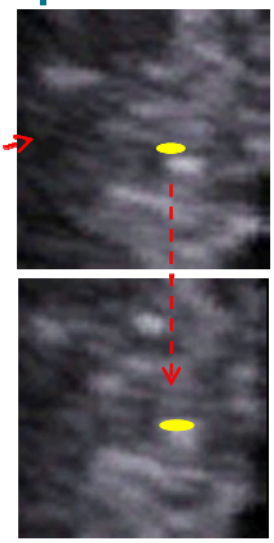
$$= -25\%$$

L_1 = length at a given point in time
L_0 = baseline length

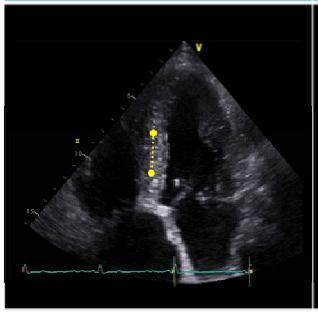
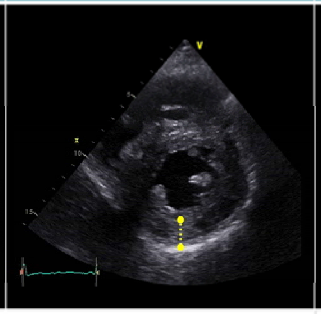
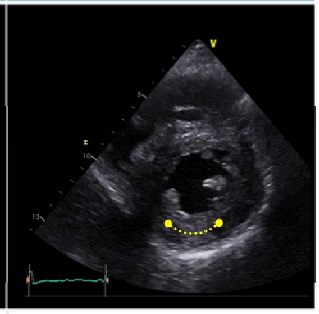
2D Strain Principles

Unique acoustic speckles





Direction of Motion

Direction	Longitudinal	Radial	Circumferential
			
Systole	Shortening = -ve	Thickening = +ve	Shortening = -ve
(Diastole)	(Lengthening = +ve)	(Thinning = -ve)	(Lengthening = +ve)

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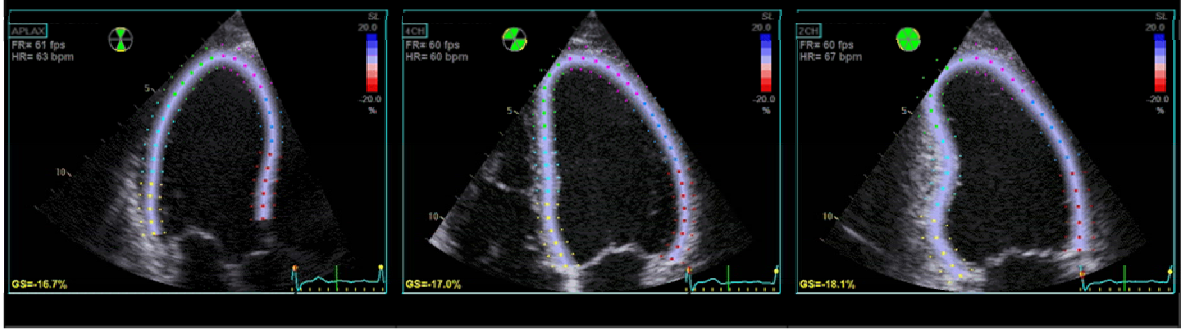
Most Common Clinical Application

Global Longitudinal Strain (GLS) of LV

APLAX AP-4ch AP-2ch



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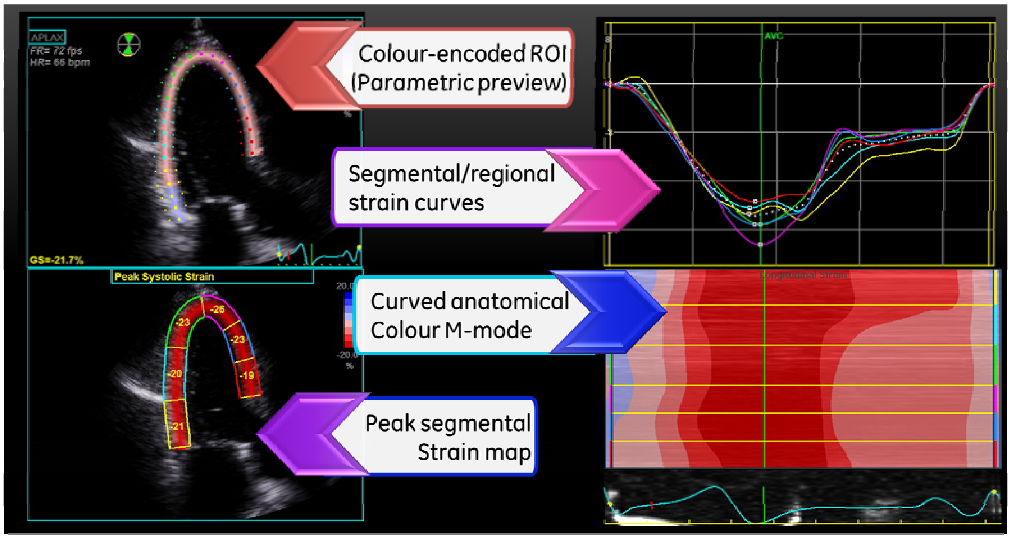
Display of GLS (Quad Format)



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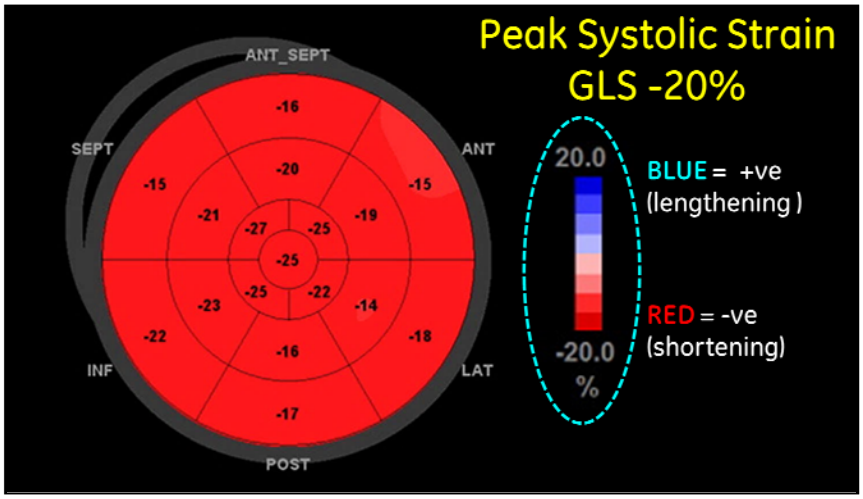
Display of GLS (Bull's Eye Plot)



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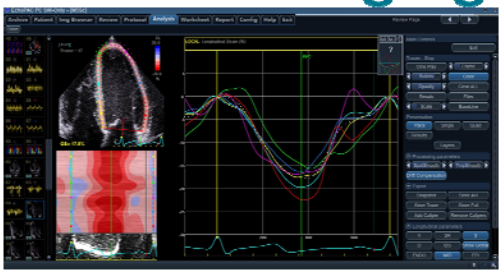
Requirements for Strain Imaging



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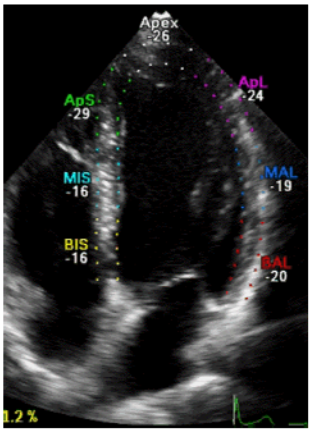
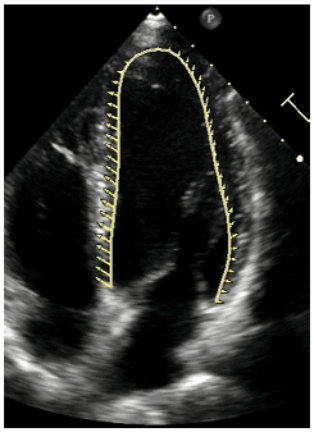
Caveat #1: Variability

Same Image

Software 1; GLS 21.2%



Software 2; GLS 16.7%



Images courtesy Prof Jens-Uwe Voigt, University Hospital Gasthuisberg, Catholic University Leuven, Belgium

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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

Lang RM, et al. J Am Soc Echocardiogr 2015;28:1-39

Caveat #2: Normal Values

GLS

Supplemental Table 6 Normal LV strain values from meta-analysis and individual recent publications using specific vendors' equipment and software

vendor	Software	n	Mean	SD	LLN	Reference
Varying	Meta-analysis	2597	−19.7%		NA	26
GE	EchoPAC BT 12	247	−21.5%	2.0%	−18%	31
	EchoPAC BT 12	207	−21.2%	1.6%	−18%	*
	EchoPAC BT 12	131	−21.2%	2.4%	−17%	†
	EchoPAC 110.1.3	333	−21.3%	2.1%	−17%	32
Philips	QLAB 7.1	330	−18.9%	2.5%	−14%	32
Toshiba	Ultra Extend	337	−19.9%	2.4%	−15%	32
Siemens	VVI	116	−19.8	4.6	−11%	197
	VVI	82	−17.3	2.3	−13%	198
Esaote	Mylab 50	30	−19.5	3.1	−13%	199

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

Lang RM, et al. J Am Soc Echocardiogr 2015;28:1-39

Caveat #2: Normal Values

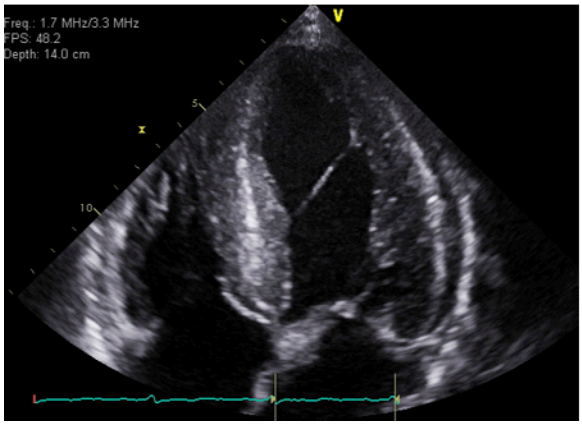
“

….. 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

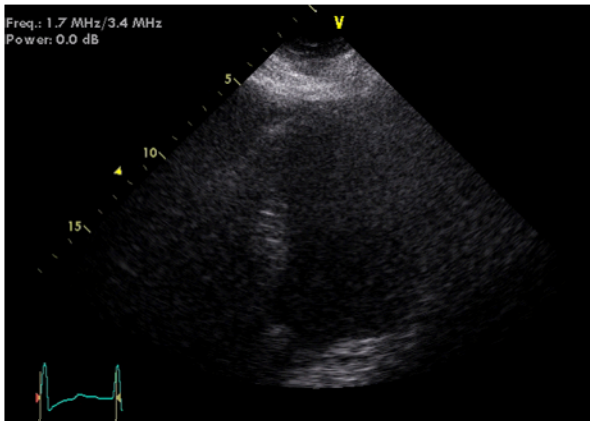
Lang RM, et al. J Am Soc Echocardiogr 2015;28:1-39

Caveat #3: Image Quality

Optimal for Strain



Suboptimal for Strain



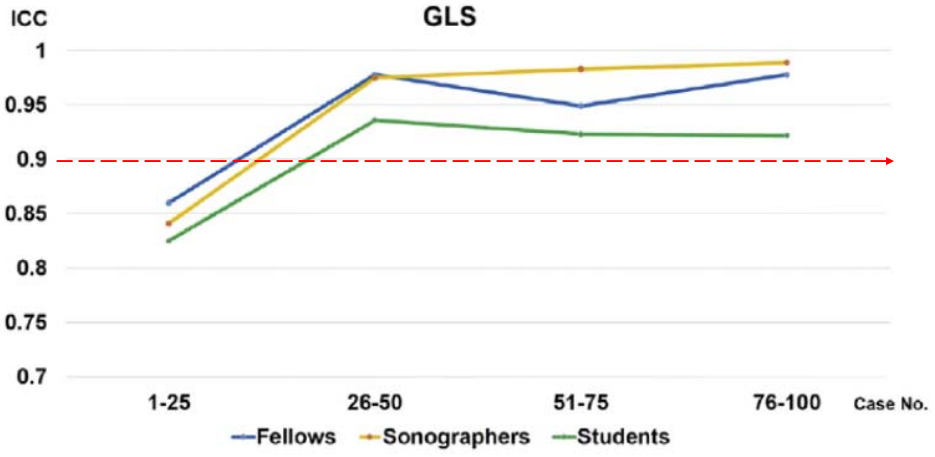
Caveat #3: Image Quality

“

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

Lang RM, et al. J Am Soc Echocardiogr 2015;28:1-39

Caveat #4: Learning Curve



Chan J, et al. J Am Soc Echocardiogr 2017; 11:1081-1090

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*

Chan J, et al. J Am Soc Echocardiogr 2017; 11:1081-1090

JACC: CARDIOVASCULAR IMAGING
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IMAGING VIGNETTE

Practical Guidance in Echocardiographic Assessment of Global Longitudinal Strain

Kazuaki Negishi, MD, PhD,* Tomoko Negishi, MD,* Koji Kurosawa, MD, PhD,† Krasimira Hristova, MD,‡ Bogdan A. Popescu, MD, PhD,§ Dragos Vinereanu, MD, PhD,§ Satoshi Yuda, MD, PhD,‖ Thomas H. Marwick, MBBS, PhD, MPH*

FIGURE 1 Steps for Myocardial Strain Measurement

- Step 1: Acquisition/Selection of appropriate image(s)
- Step 2: Assessment of adequacy for strain measurement
- Step 3: Detection/marking of fiducial landmarks (annulus and apex)
- Step 4: Tracing of the endocardial border
- Step 5: Adjustment of ROI width (avoid the pericardium)
- Step 6: Evaluation of tracking quality
- Step 7: Repeat steps 5 and 6, until adequate tracking is achieved.

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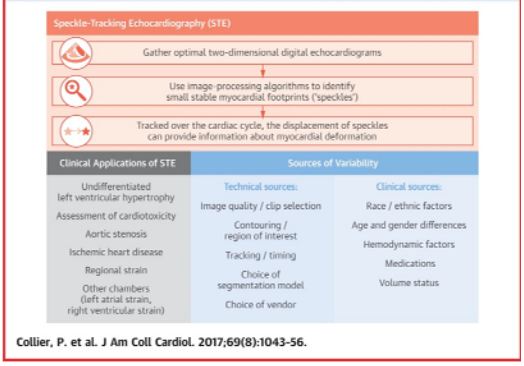
THE PRESENT AND FUTURE

REVIEW TOPIC OF THE WEEK

A Test in Context: Myocardial Strain Measured by Speckle-Tracking Echocardiography

Patrick Collier, MD, PhD, Dermot Phelan, MD, PhD, Allan Klein, MD

CENTRAL ILLUSTRATION: Speckle-Tracking Strain: Clinical Utility and Future Directions



Collier, P. et al. J Am Coll Cardiol. 2017;69(8):1043-56.

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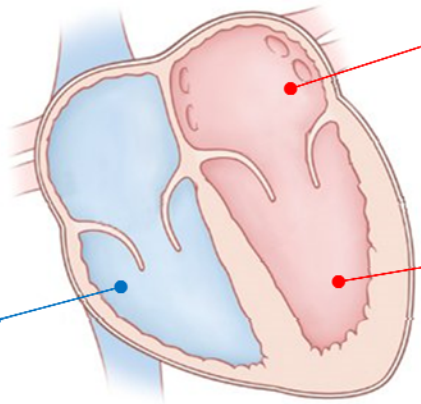
Clinical Applications

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



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

- PHTn
- CHD
- ARVD

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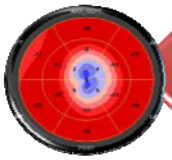
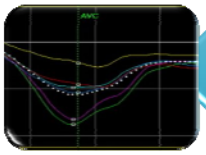
"Simplified" Clinical Applications



Pattern Recognition

Subclinical Dysfunction



Regional variation

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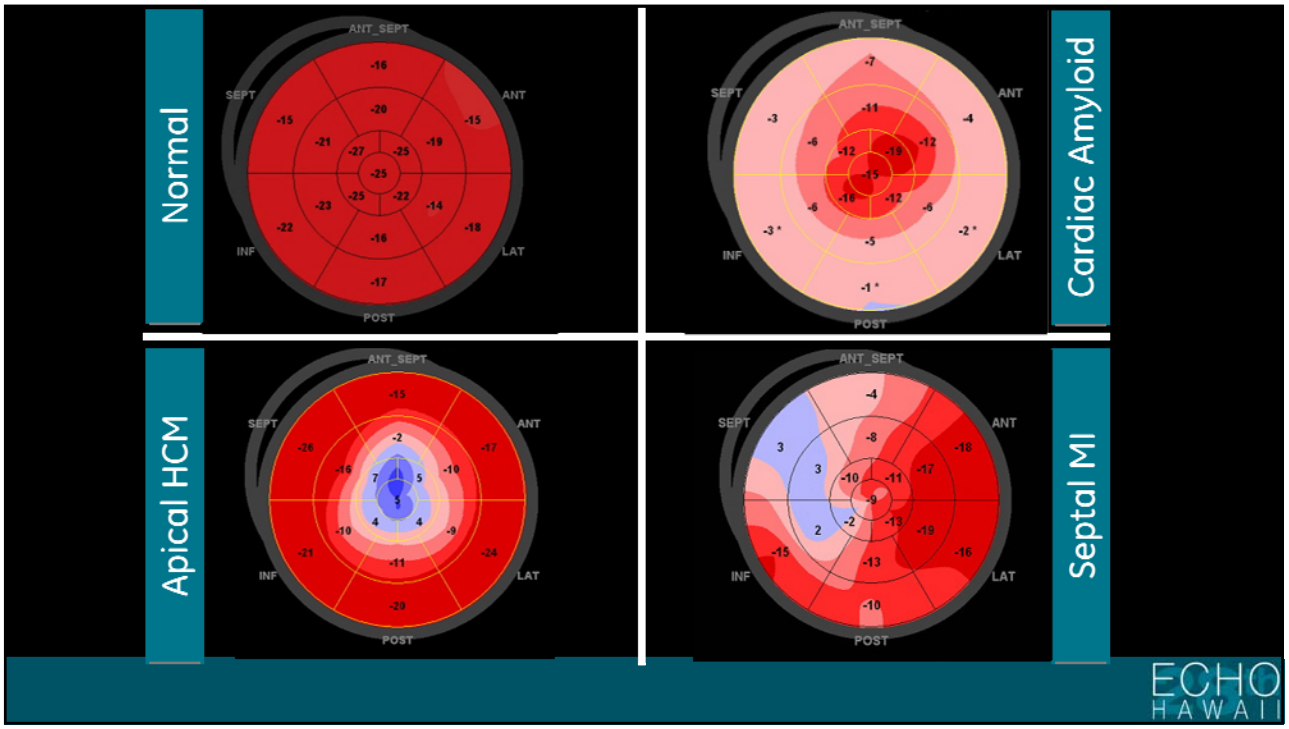
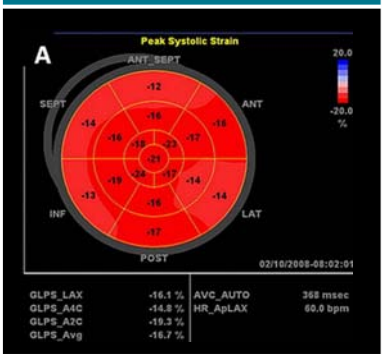
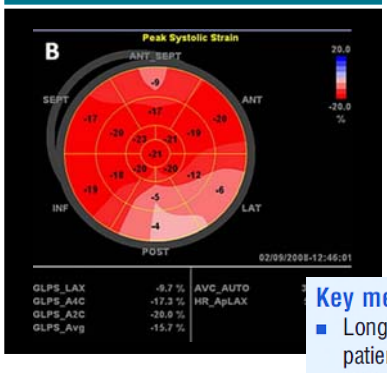


GLS Differentiates LVH Aetiology

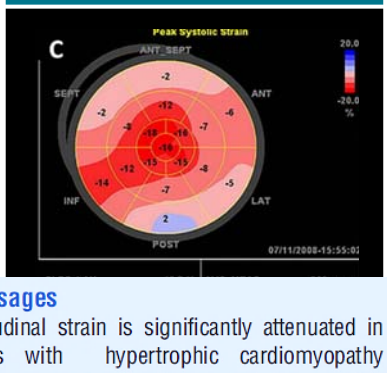
Athlete's Heart
GLS normal or increased



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

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GLS in CTRCD*

EXPERT CONSENSUS STATEMENT

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

Juan Carlos Plana, MD, FASE, Chair, Maurizio Galderisi, MD, FESC, Co-Chair, Ana Barac, MD, PhD, Michael S. Ewer, MD, JD, Bonnie Ky, MD, FASE, Marielle Scherrer-Crosbie, MD, PhD, FASE, Javier Ganame, MD, PhD, FASE, Igal A. Sebag, MD, FASE, Deborah A. Agler, RCT, RDCS, FASE, Luigi P. Badano, MD, PhD, FESC, Jose Banchs, MD, FASE, Daniela Cardinale, MD, PhD, FESC, Joseph Carver, MD, Manuel Cerqueira, MD, Jeanne M. DeCara, MD, FASE, Thor Edvardsen, MD, PhD, FESC, Scott D. Flamm, MD, MBA, Thomas Force, MD, Brian P. Griffin, MD, Guy Jerusalem, MD, PhD, Jennifer E. Liu, MD, FASE, Andreia Magalhães, MD, Thomas Marwick, MBBS, PhD, MPH, Liza Y. Sanchez, RCS, FASE, Rosa Sicari, MD, PhD, FESC, Hector R. Villarraga, MD, FASE, and Patrizio Lancellotti, MD, PhD, FESC, *Cleveland, Ohio; Naples, Padua, Milan, and Pisa, Italy; Washington, District of Columbia; Houston, Texas; Philadelphia, Pennsylvania; Boston, Massachusetts; Hamilton, Ontario and Montreal, Quebec, Canada; Chicago, Illinois; Oslo, Norway; Liege, Belgium; New York, New York; Lisbon, Portugal; Hobart, Australia; Rochester, Minnesota*

(J Am Soc Echocardiogr 2014;27:911-39.)

Keywords: Chemotherapy, Doxorubicin, Trastuzumab, Left ventricular dysfunction, Three-dimensional echocardiography, Early detection, Strain, Biomarkers

*** Cancer Therapeutics–Related Cardiac Dysfunction**

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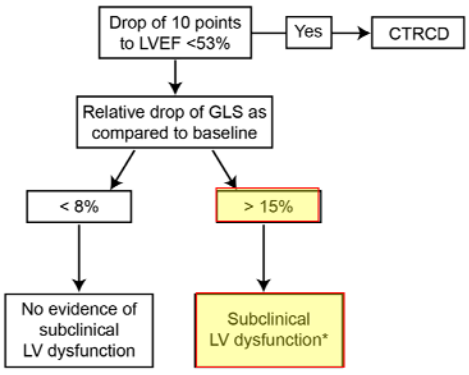
GLS Detects Early Subclinical Myocardial Dysfunction before LVEF



a relative % reduction in the GLS of > 15% from baseline identifies sub-clinical LV dysfunction

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

Plana JC, et al. J Am Soc Echocardiogr 2014;27:911-39

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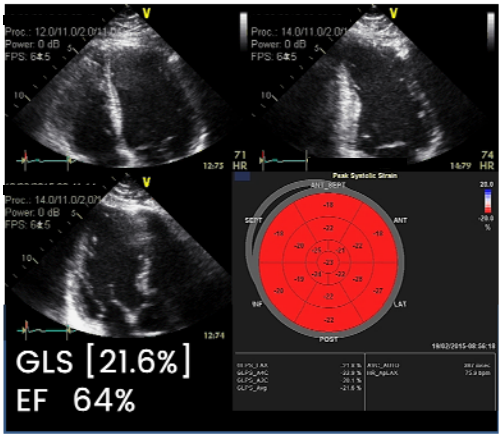
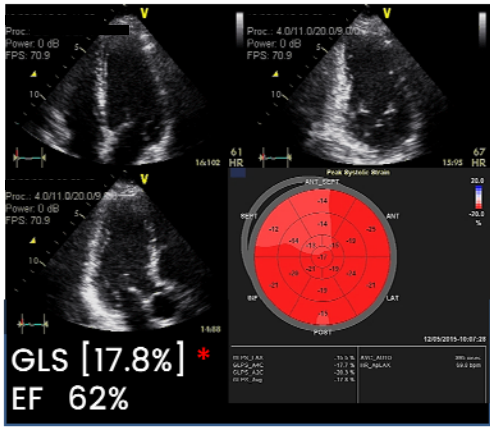
Case Example

Baseline



3 Months Tratzusamab



* Clinically significant > 15%

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

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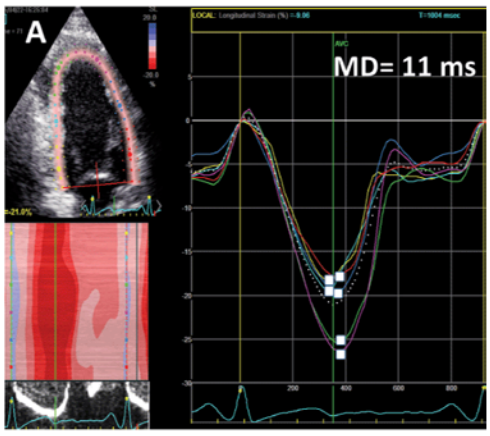
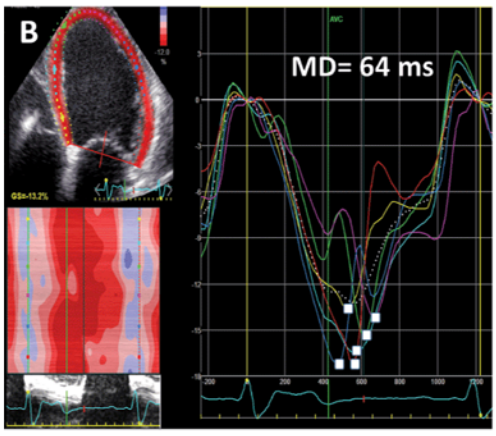
Regional Variation or Mechanical Dispersion*

Normal



Abnormal



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

Mirea O, Duchenne J and Voigt JU. F1000Research 2016, 5:787

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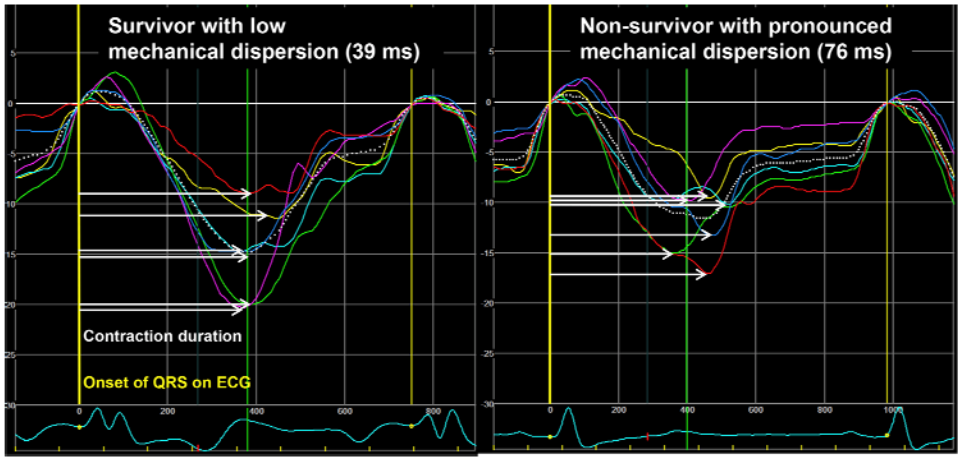
Mechanical Dispersion in Aortic Stenosis



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

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Summary #1

Strain measures myocardial deformation

Most common clinical application is GLS [LV]

Normal GLS [LV] >20%

Fastidious attention to detail + learning curve

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Summary #2

Simplified Clinical Applications

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

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Summary #3

LVH
Heart Failure
Cardiotoxicity
Aortic stenosis
IHD

Diastolic function
Regional variation
RV strain
LA strain

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References & Further Reading

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- **EACVI free webinar: How and why to measure LV myocardial strain:** https://www.youtube.com/watch?v=ipmZXGF9HT4&feature=youtu.be

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