Quantitating Ventricular Function With Echocardiography: How do you use LV Strain in Daily Practice?

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Houston Methodist
DeBakey Heart & Vascular Center

Disclosures: nothing to disclose

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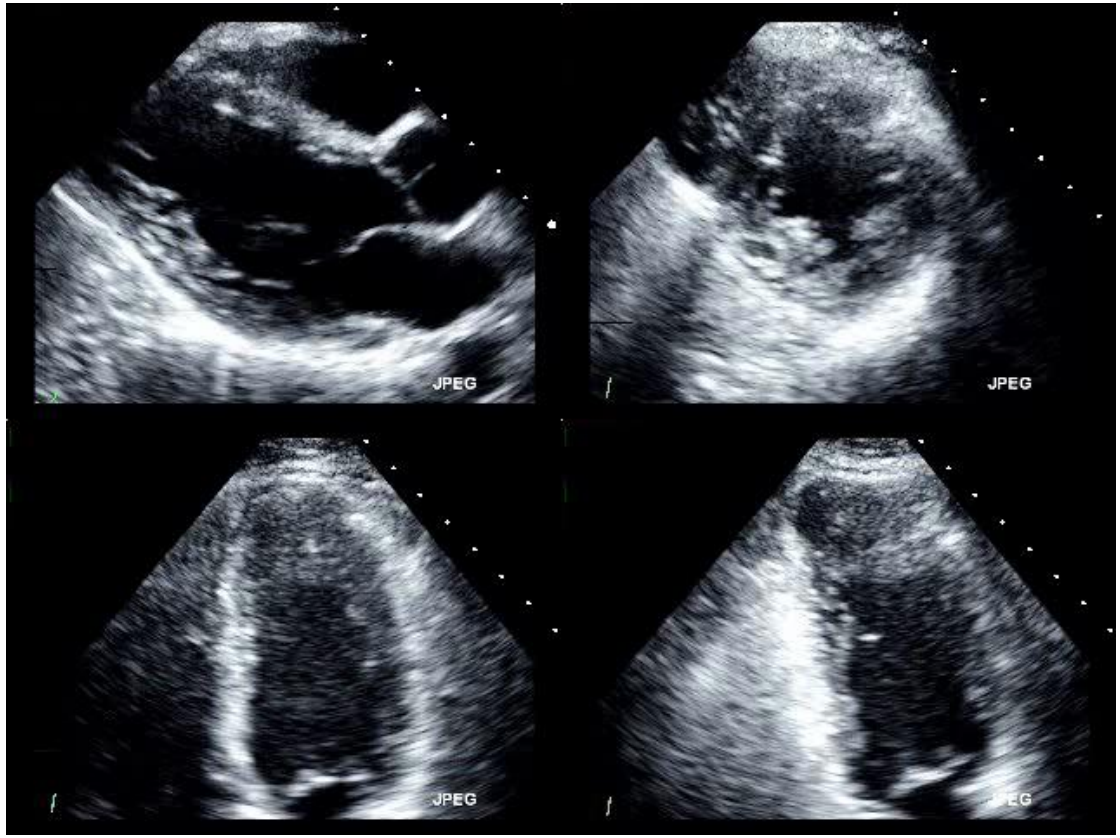
Evaluation of LV Function

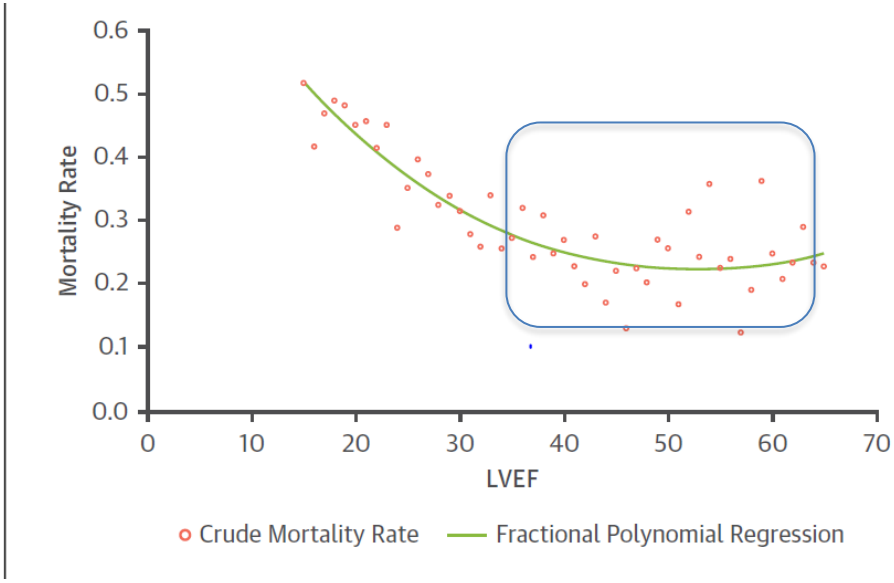


- Represents ~60-80% of clinical indication for an echocardiogram
- For 5 decades EF has been the main parameter of systolic LV function

EF = (EDV – ESV) / EDV

Assessment of LV function: limitations of Ejection Fraction

- Measurement (or estimate) variability with TTE
  - Best with CMR
- Influenced directly by preload and inversely by afterload
- It is a measure of pump function rather than myocardial function
  - A variety of heart conditions with preserved EF have been shown to have myocardial dysfunction and poor outcomes (EX: HFpEF, chronic MR)
- Variable outcomes seen in the range between 35 and 50%



Potter E, JACC 2018

Myocardial Deformation by 2D-Speckle Tracking: Strain Imaging

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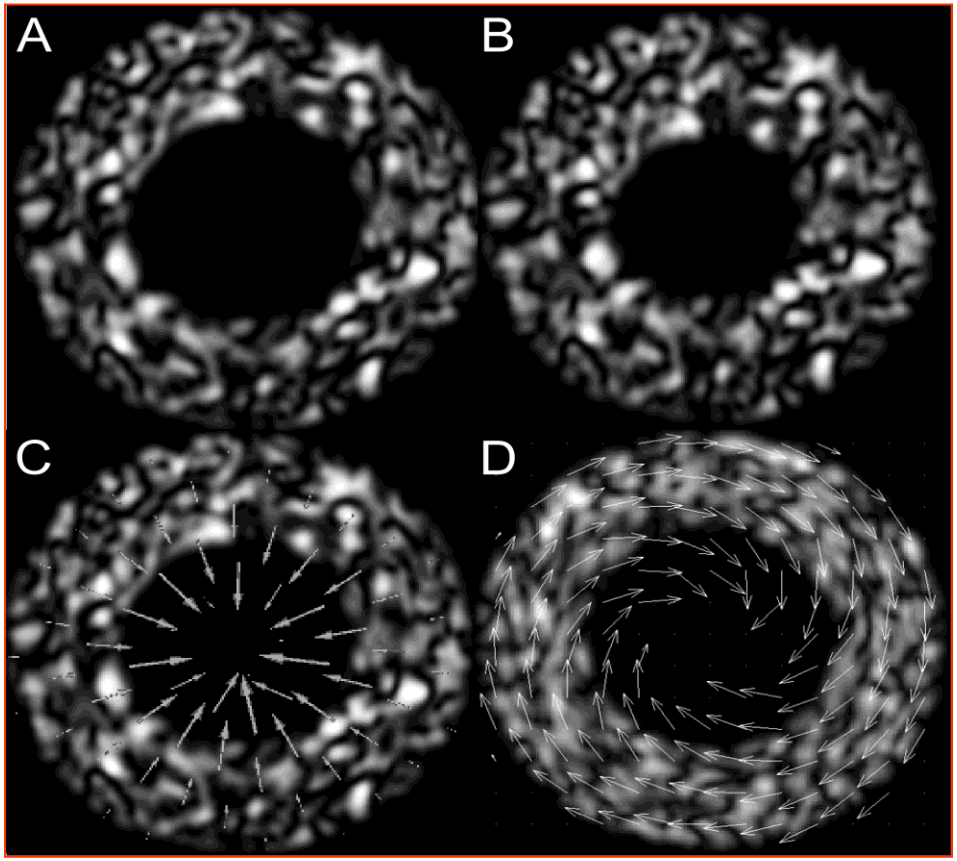
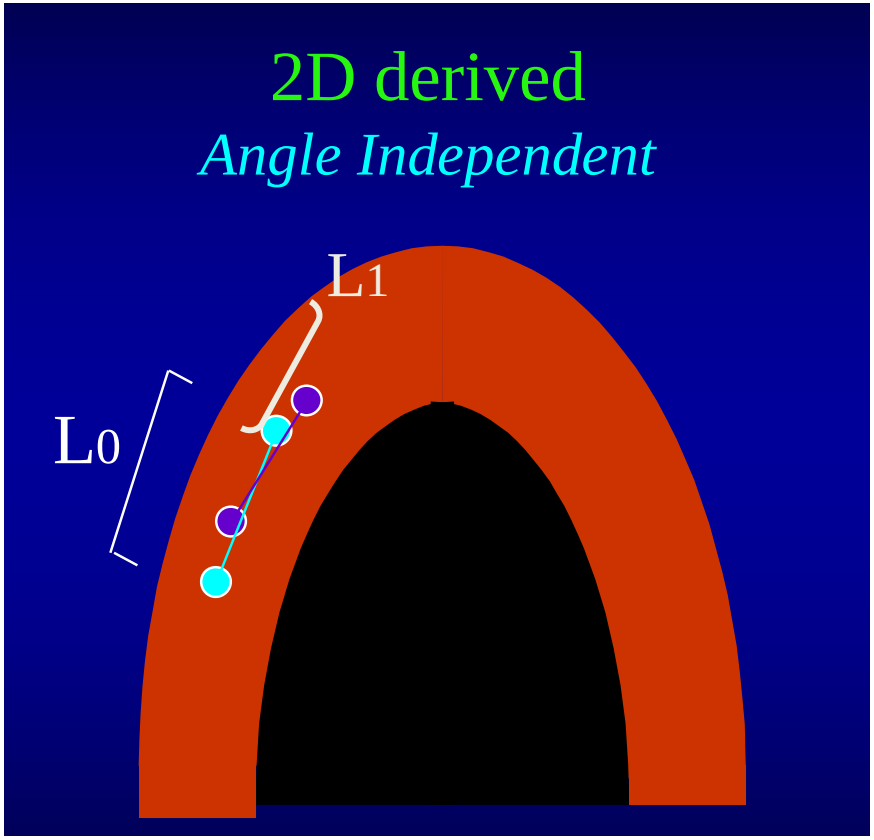
An attempt to assess myocardial function separate from pump function



(Arrow length proportional to deformation)



Strain = $\Delta L/Lo$

Strain rate = $(\Delta L/Lo)/t$

Ventricular Mechanics

Helix and Loops and Mechanical Activation

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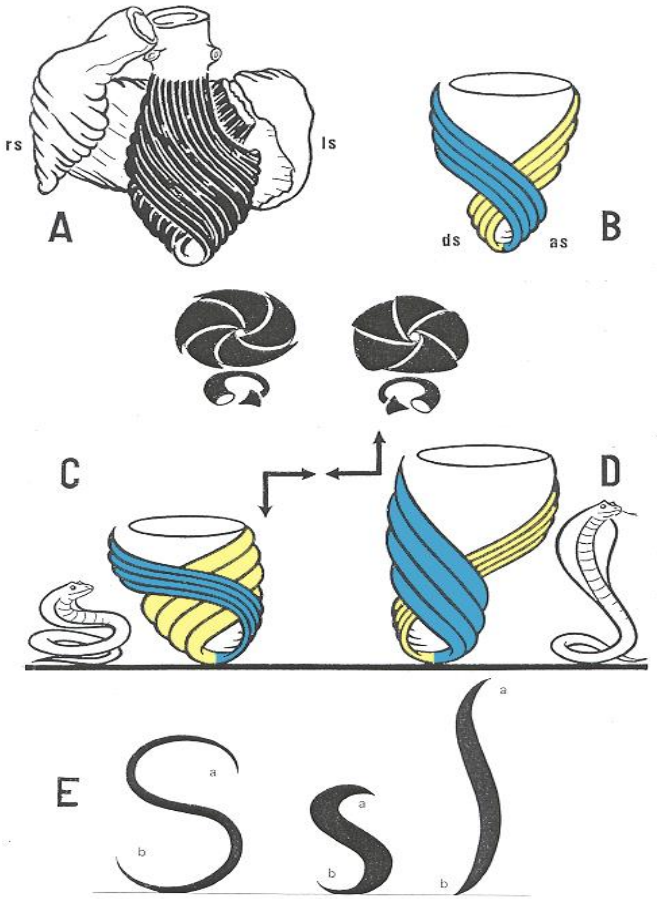

Manel Ballester-Rodés, Spain and Jagat Narula, Irvine

Myocardial Deformation/Strain by Speckle Trackinga

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Delgado V, et al. JACC 2008

Radial Strain

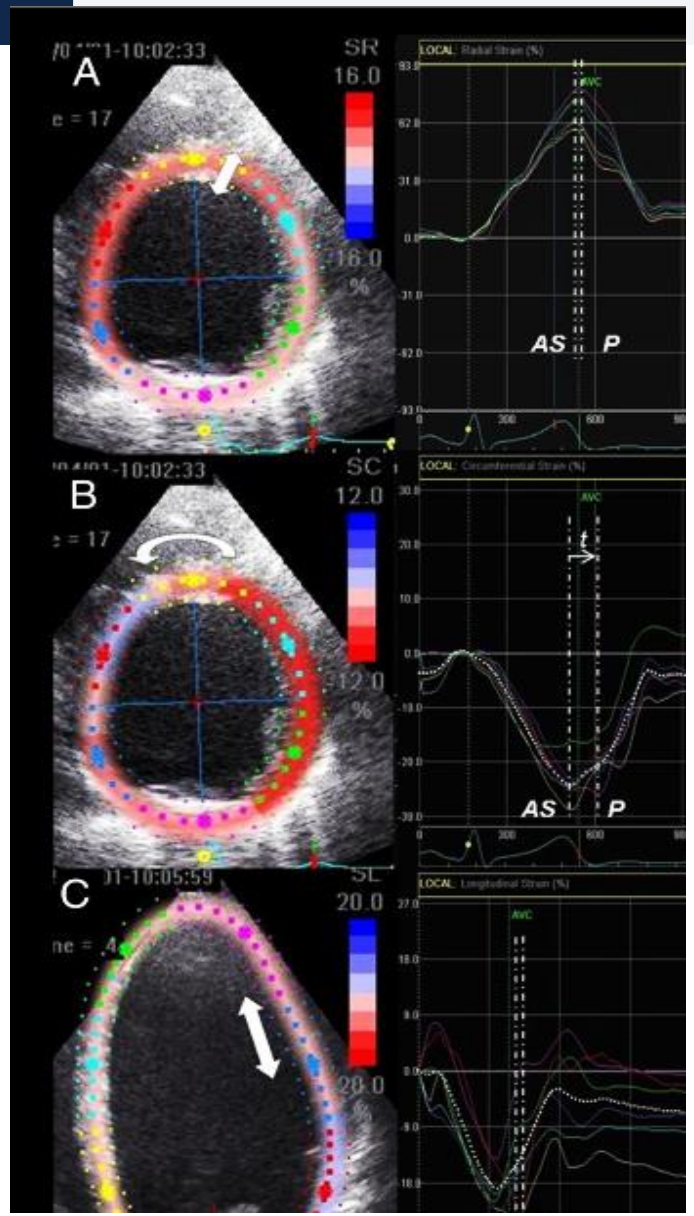
-a measurement of segmental myocardial thickening

Circumferential Strain

-a measurement of segmental myocardial circumferential shortening

Longitudinal Strain

-a measurement of segmental myocardial longitudinal shortening



Speckle Tracking - Strain

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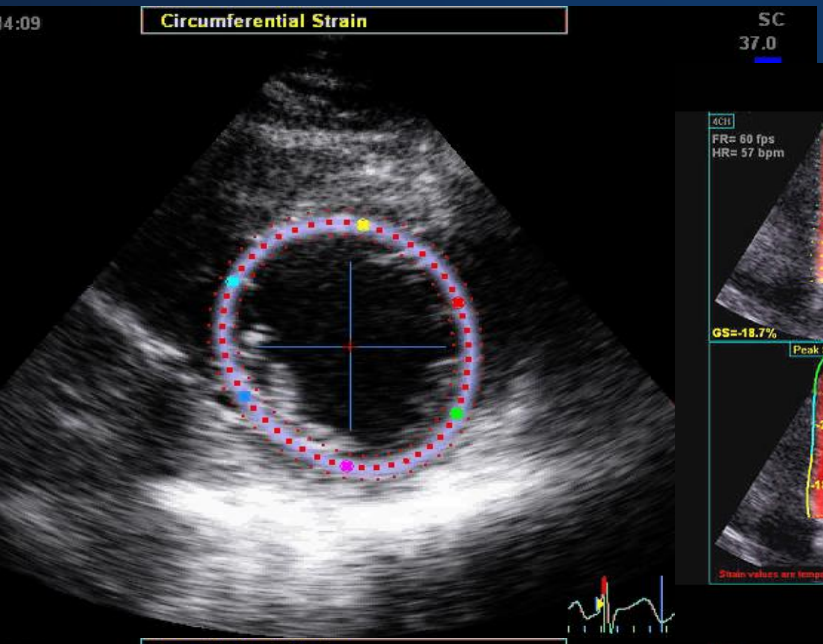

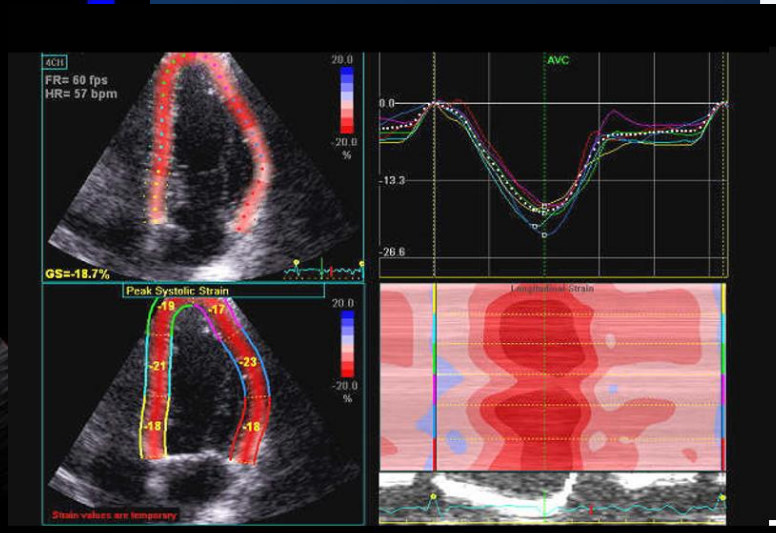

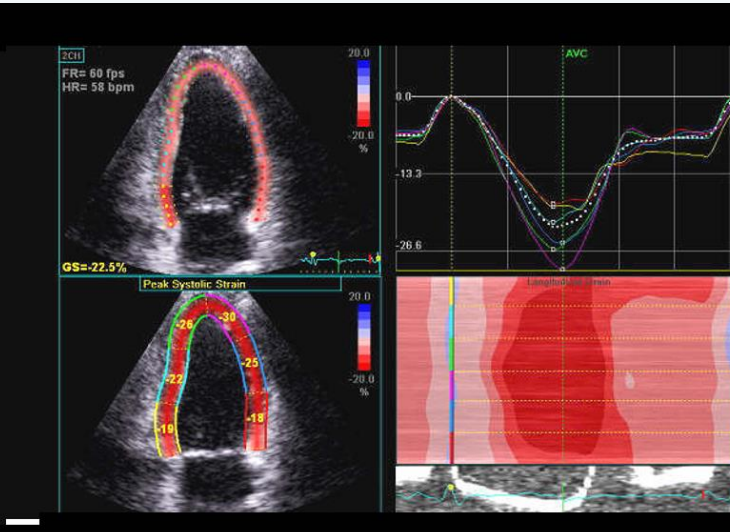

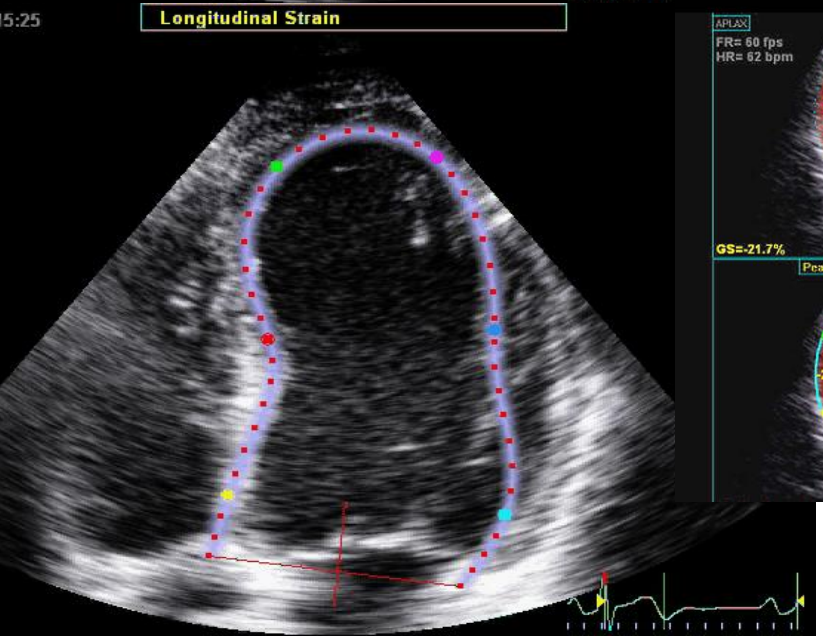

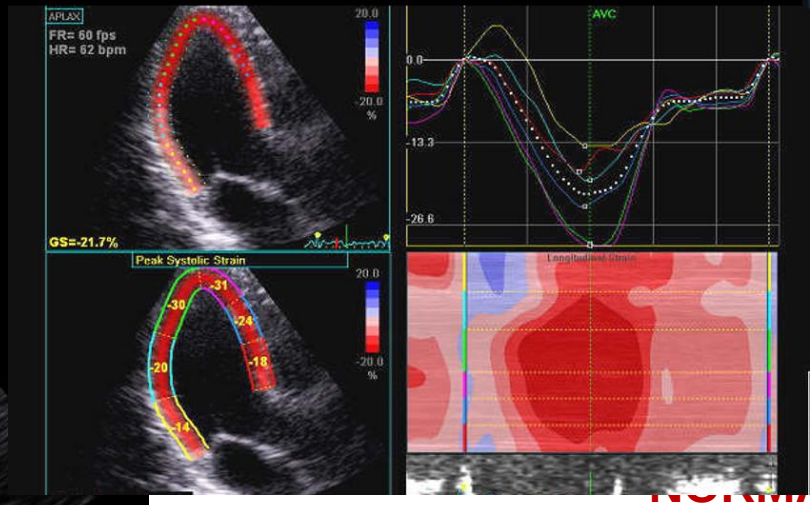

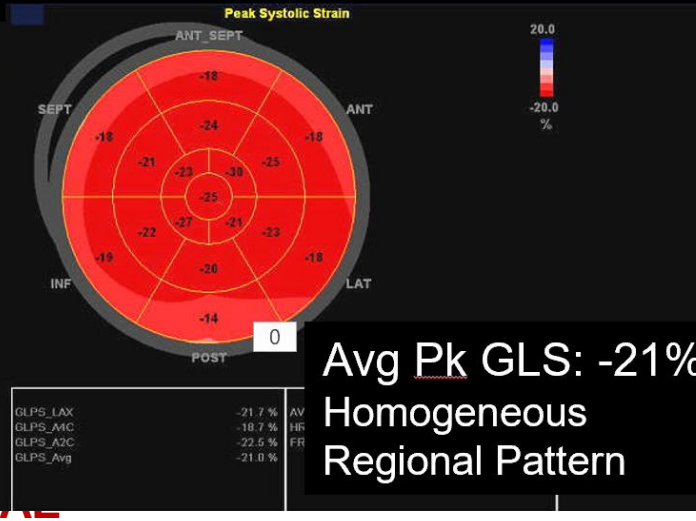

Avg Pk GLS: -21%
Homogeneous
Regional Pattern

NORMAL

Speckle Tracking - Strain

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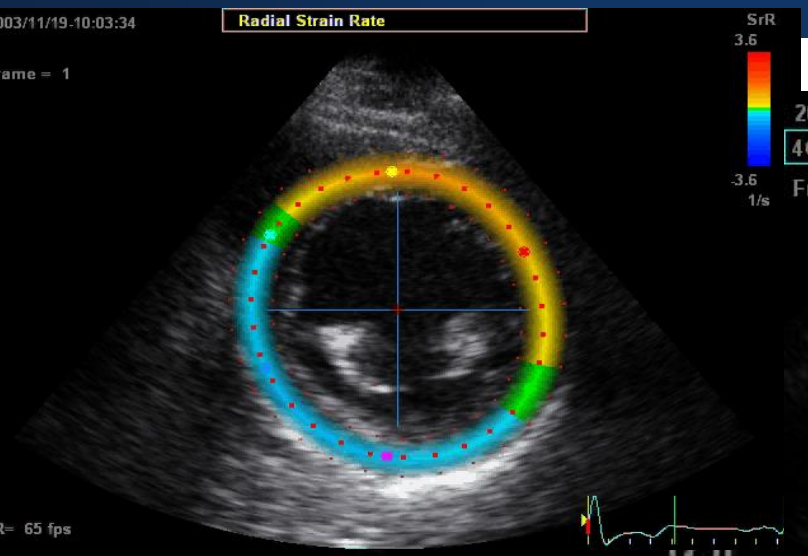

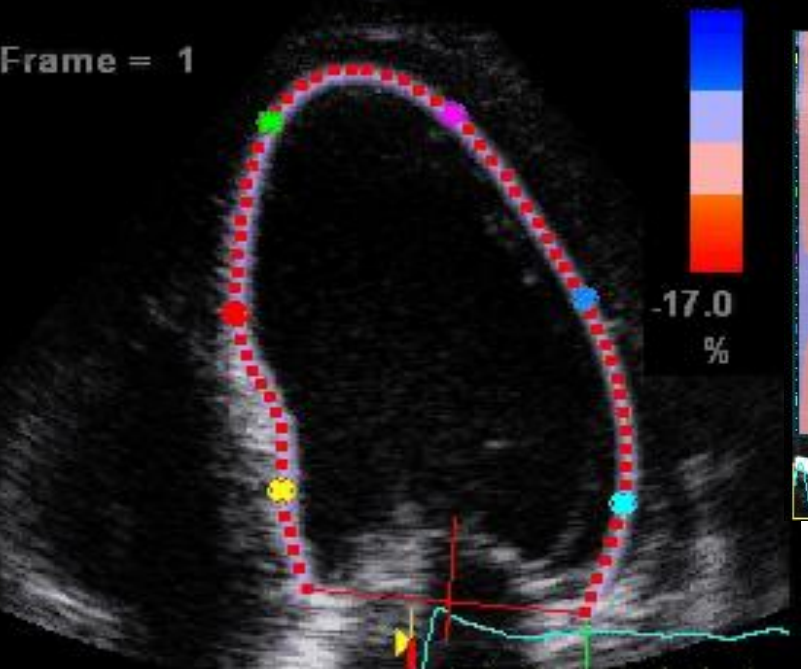

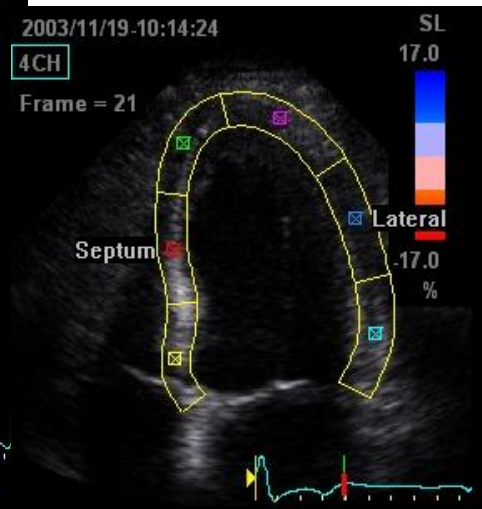

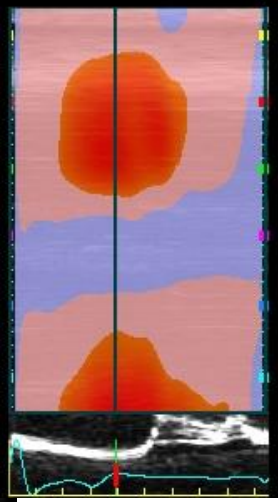

ABNORMAL

FULL TEXT ARTICLE

Normal Global Longitudinal Strain

Nicholas D'Elia BMSci (Hons) MBBS, GDip, Stefano Caselli MD, PhD, Wojciech Kosmala MD, PhD, Patrizio Lancellotti MD, PhD, Daniel Morris MD, Denisa Muraru MD, PhD, Masaaki Takeuchi MD, PhD, Annemien van den Bosch MD, PhD, Roderick W.J. van Grootel MS, Hector Villarraga MD and Thomas H. Marwick MBBS, PhD, MPH

JACC: Cardiovascular Imaging, 2020-01-01, Volume 13, Issue 1, Pages 167-169, Copyright © 2020 American College of Cardiology Foundation

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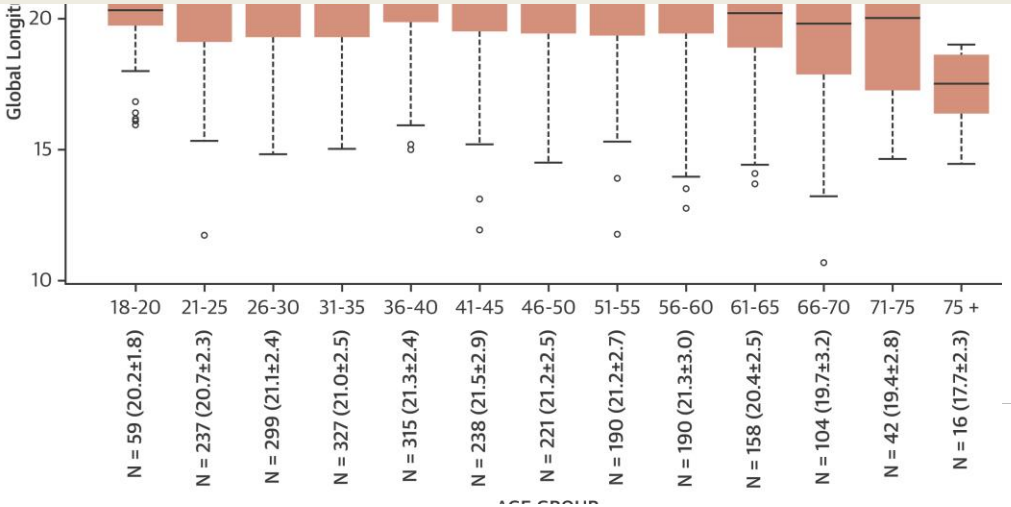
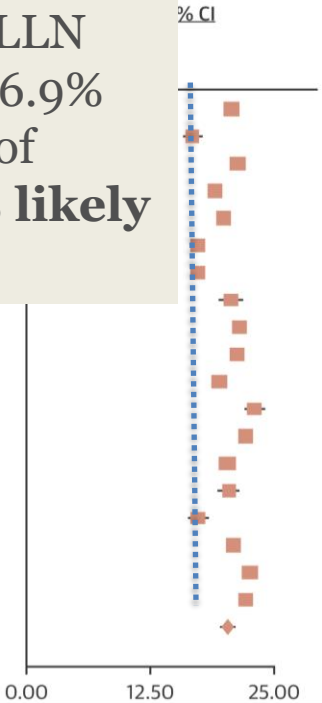
Normal values for Average Peak GLS: variation by vendors (n = 2396)

The **normal range for GLS varied between the vendors**, with **TomTec** presenting the **highest** values (n = 644; 22.1% [20.1, 23.8] , LLN 18.0%), **followed by GE** (n = 1,013; 21.%2 [19.9, 22.8], LLN 18.2%), **Toshiba** (n = 278; 19.9% [18.3, 21.5], LLN 15.8%), **Philips** (n = 379; 19.6% [18.1, 21.3], LLN 15.5%), and **Siemens** (n = 82; 16.9% [16.0, 18.8], LLN 14.0%), differences being statistically significant (1-way analysis of variance p < 0.01). **Regardless of vendor or clinical covariate, a GLS <16% likely indicates significant myocardial dysfunction.**



Kockabay	21.500	0.127	0.016	21.251	21.749
Moris	21.230	0.113	0.013	21.009	21.451
Caselli	19.400	0.325	0.106	18.762	20.038
Charfeddi	22.990	0.519	0.269	21.973	24.007
Cheng	22.000	0.147	0.022	21.712	22.288
Cheng	20.200	0.166	0.028	19.874	20.526
Cong	20.340	0.542	0.294	19.277	21.403
Eun	17.300	0.539	0.290	16.245	18.355
Menting	20.800	0.161	0.026	20.485	21.115
Sugimoto	22.500	0.115	0.013	22.274	22.726
Kotwica	22.000	0.372	0.138	21.271	22.729
	20.166	0.348	0.121	19.484	20.848



Potential Applications of Peak Average GLS in Routine Clinical Practice

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- Detection of subclinical LV dysfunction in a variety of diseases
- Objective assessment of global and regional function
- Regional patterns associated with myocardial diseases
- Better prediction of serious CV outcomes
  - lower values (without the - sign), worse prognosis

45M with severe hypertension and ESRF

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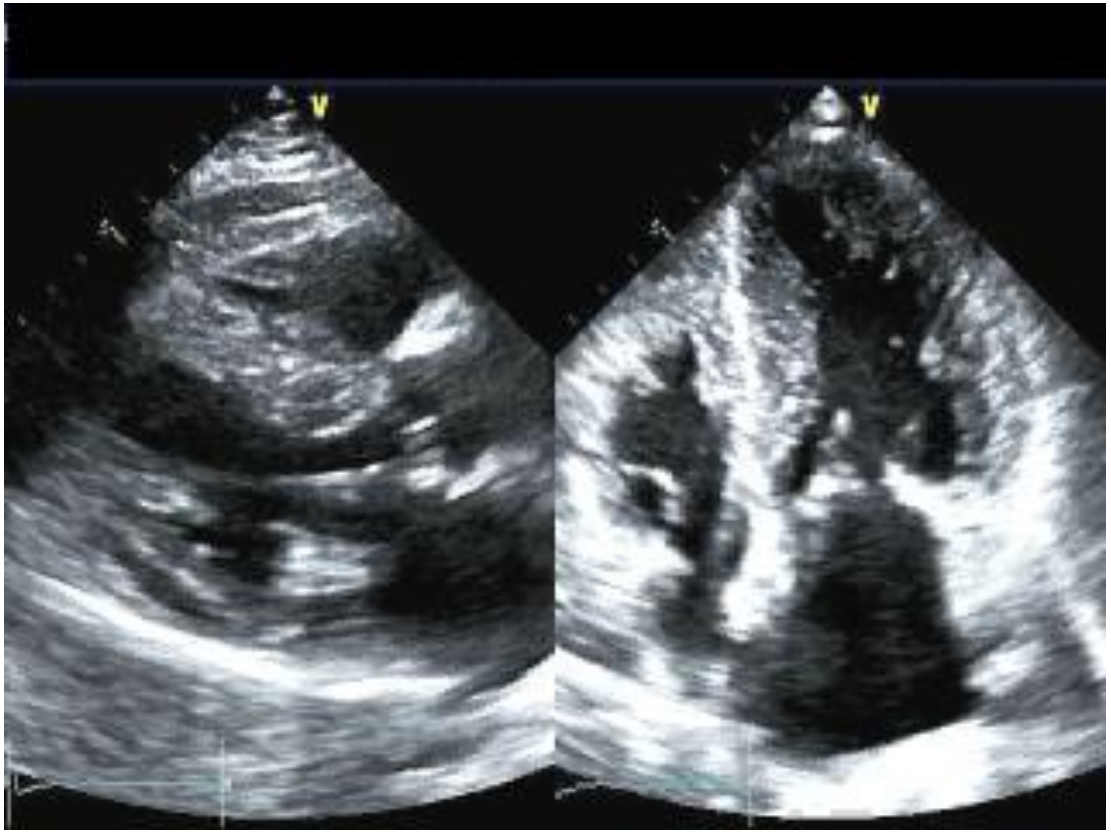

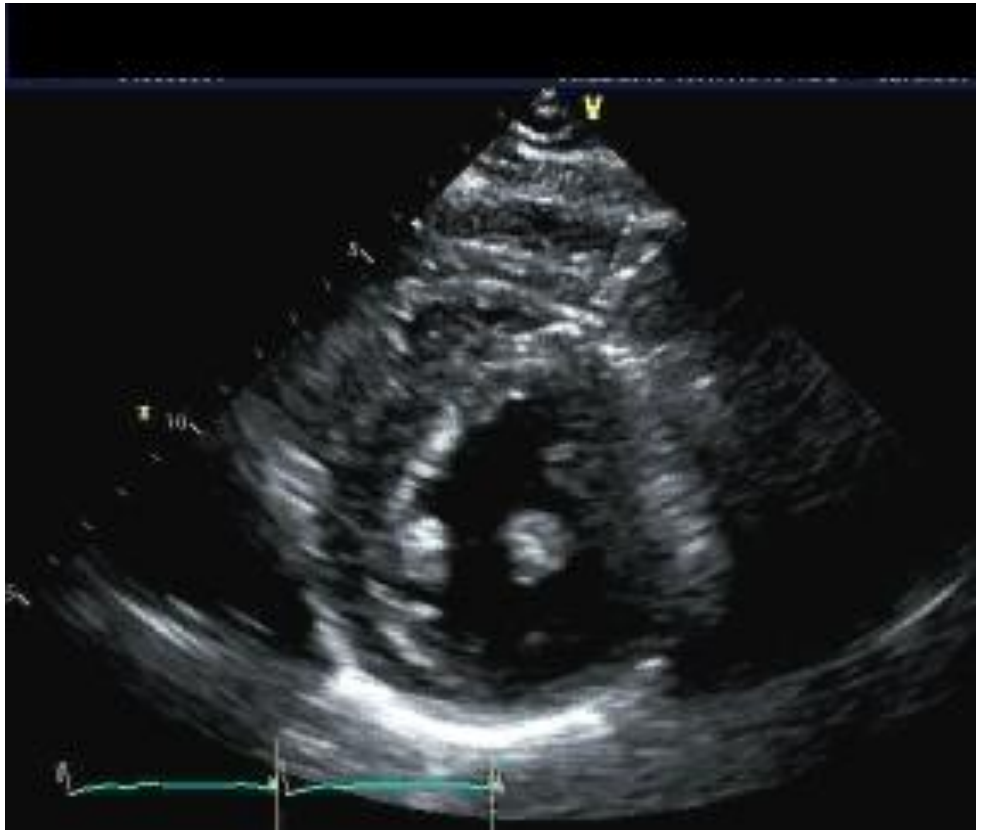

LVEF > 75%; Cavity Obliteration

45M with severe hypertension and ESRF

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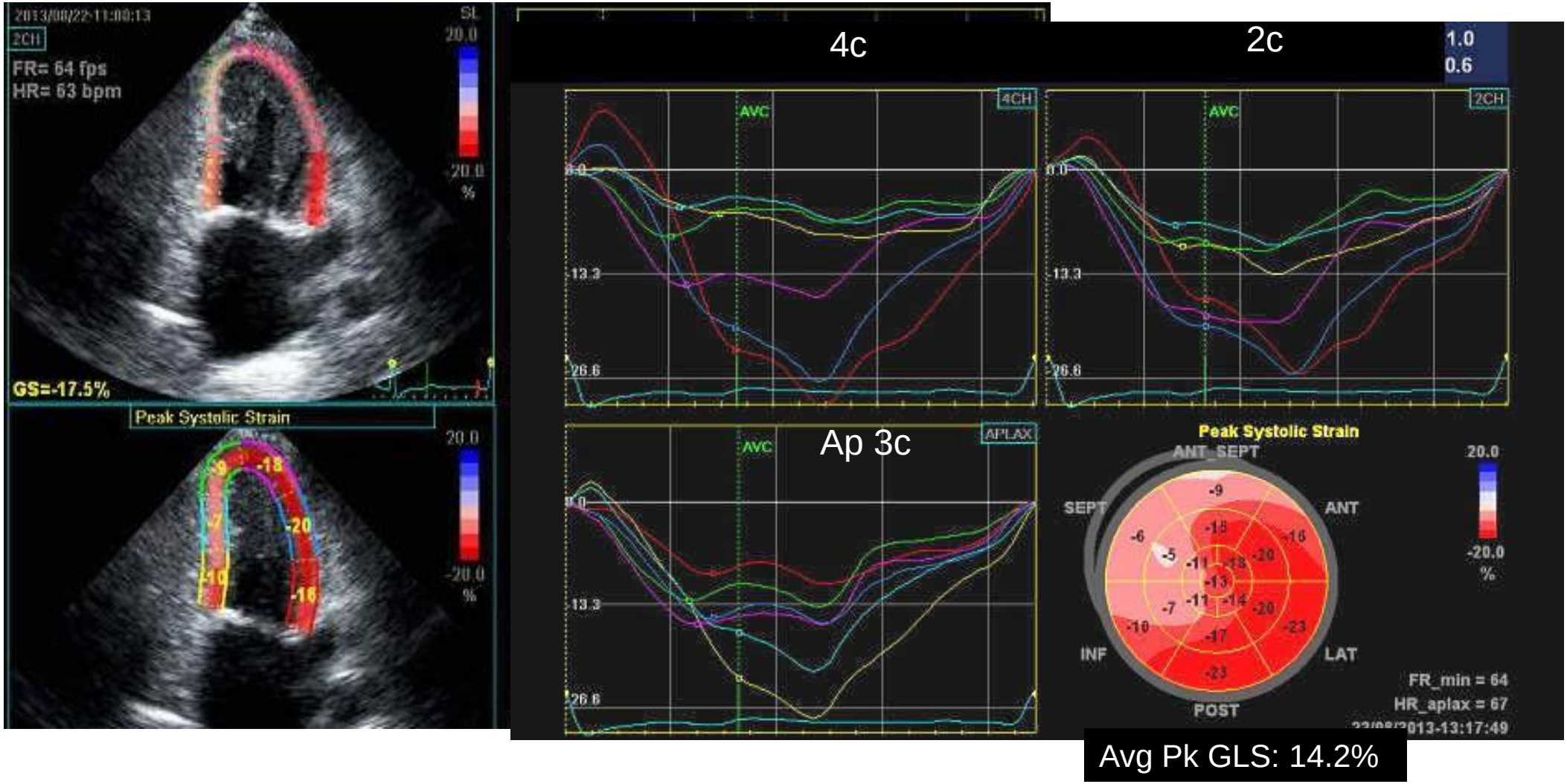

Avg Pk GLS: 14.2%

Current studies in progress looking at GLS outcome prediction in patients with ESRF

Potential Applications of Peak Average Global Longitudinal Strain

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- Detection of subclinical LV dysfunction
  - hypertension
  - HCM
  - diabetes
  - acute transplant rejection
  - Valvular lesions: MR, AR, AS
  - Sepsis
  - HFpEF

- The list is growing

Use of Strain Imaging for regional function

Concordance with the eye: multiple WMAs

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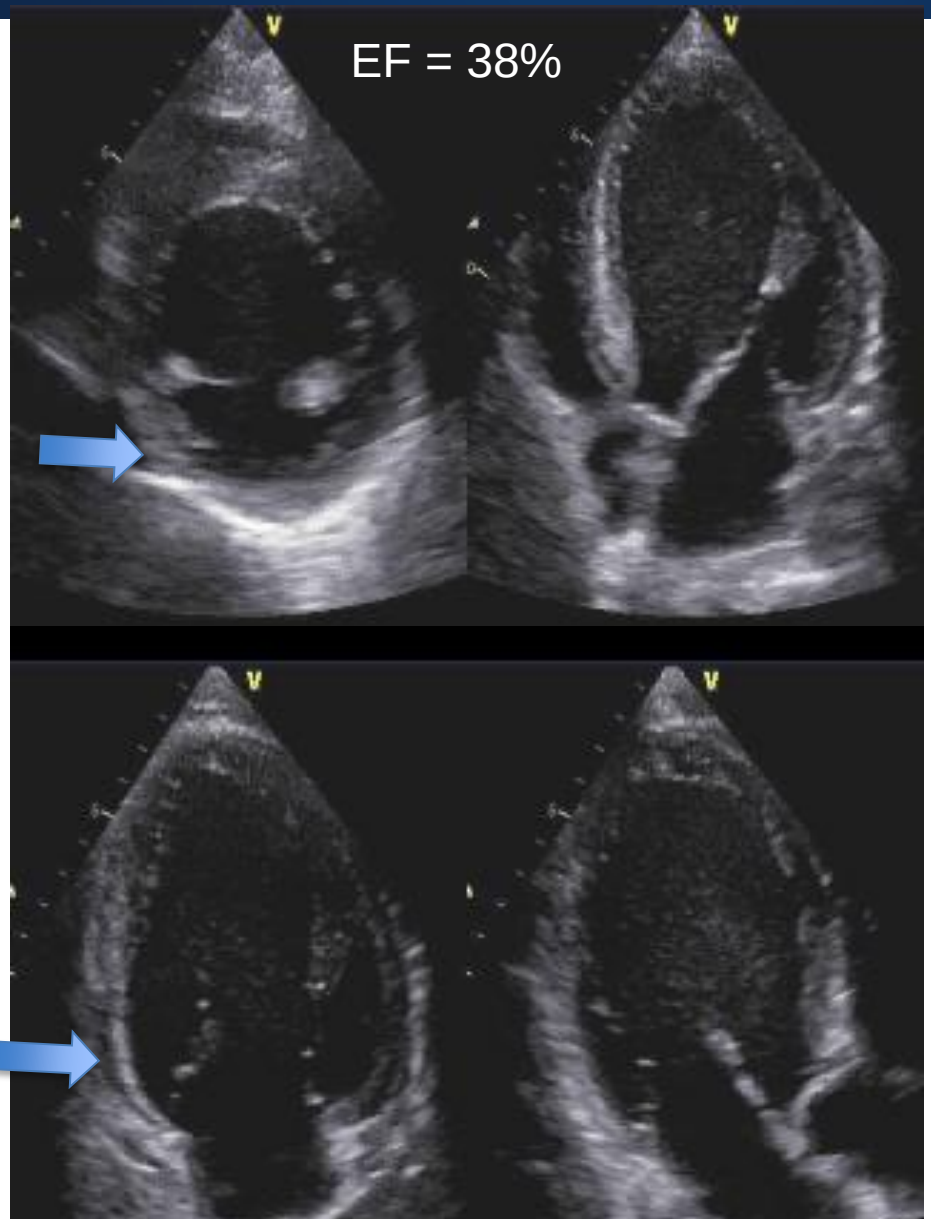

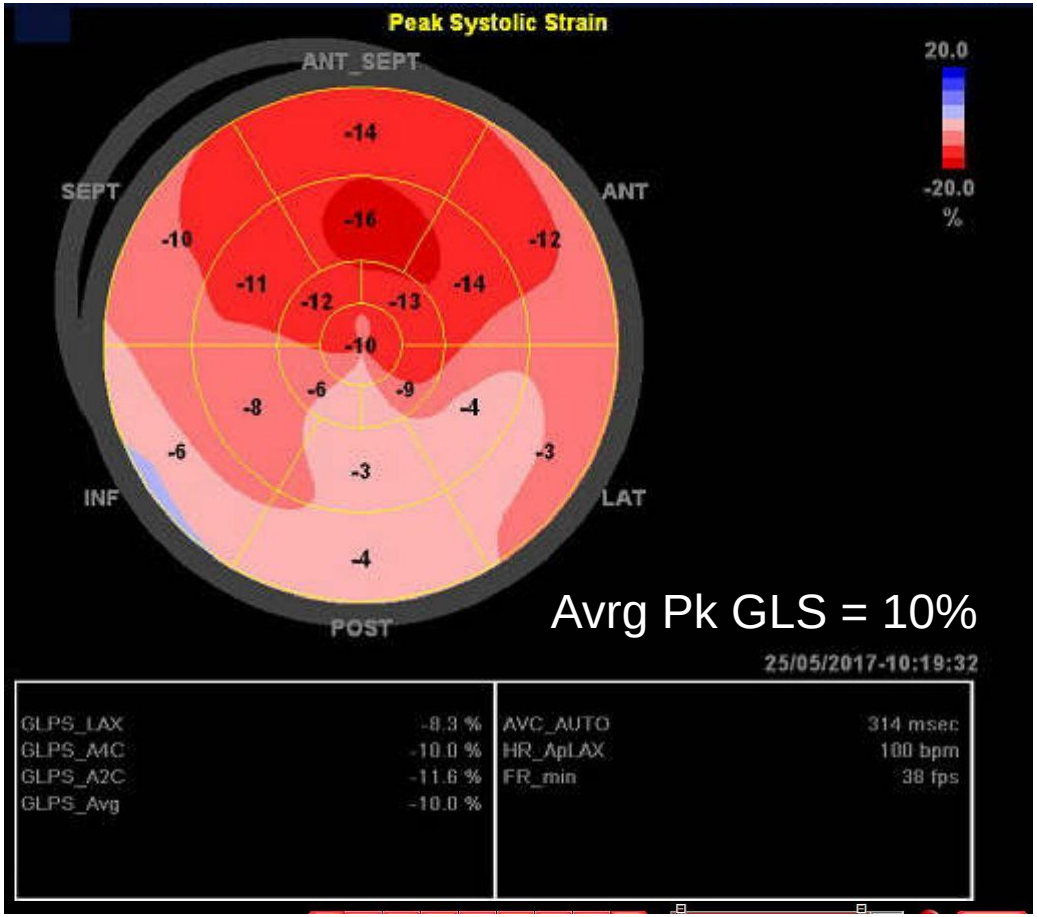

Use of Strain Imaging to Detect RWMAs

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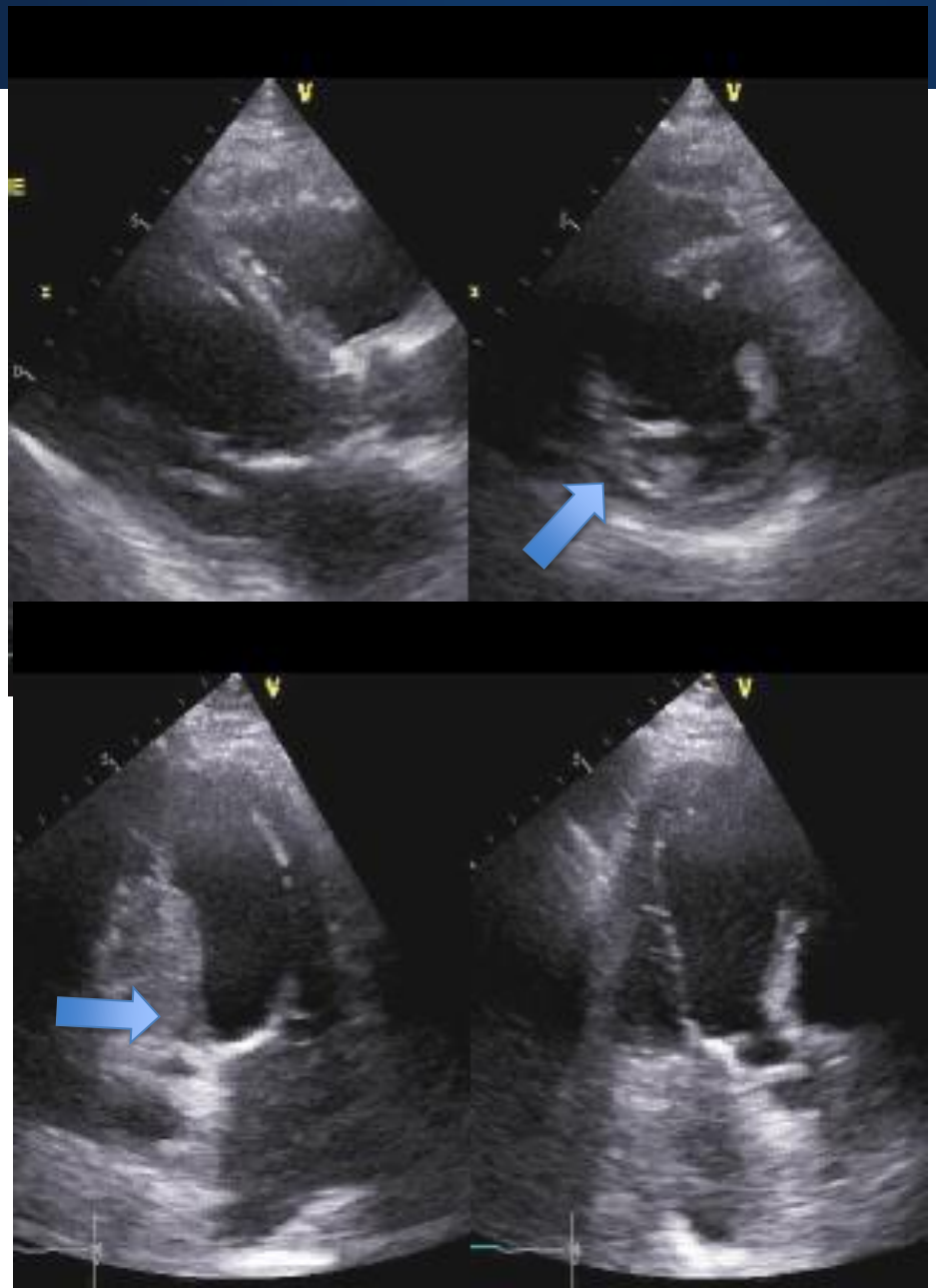

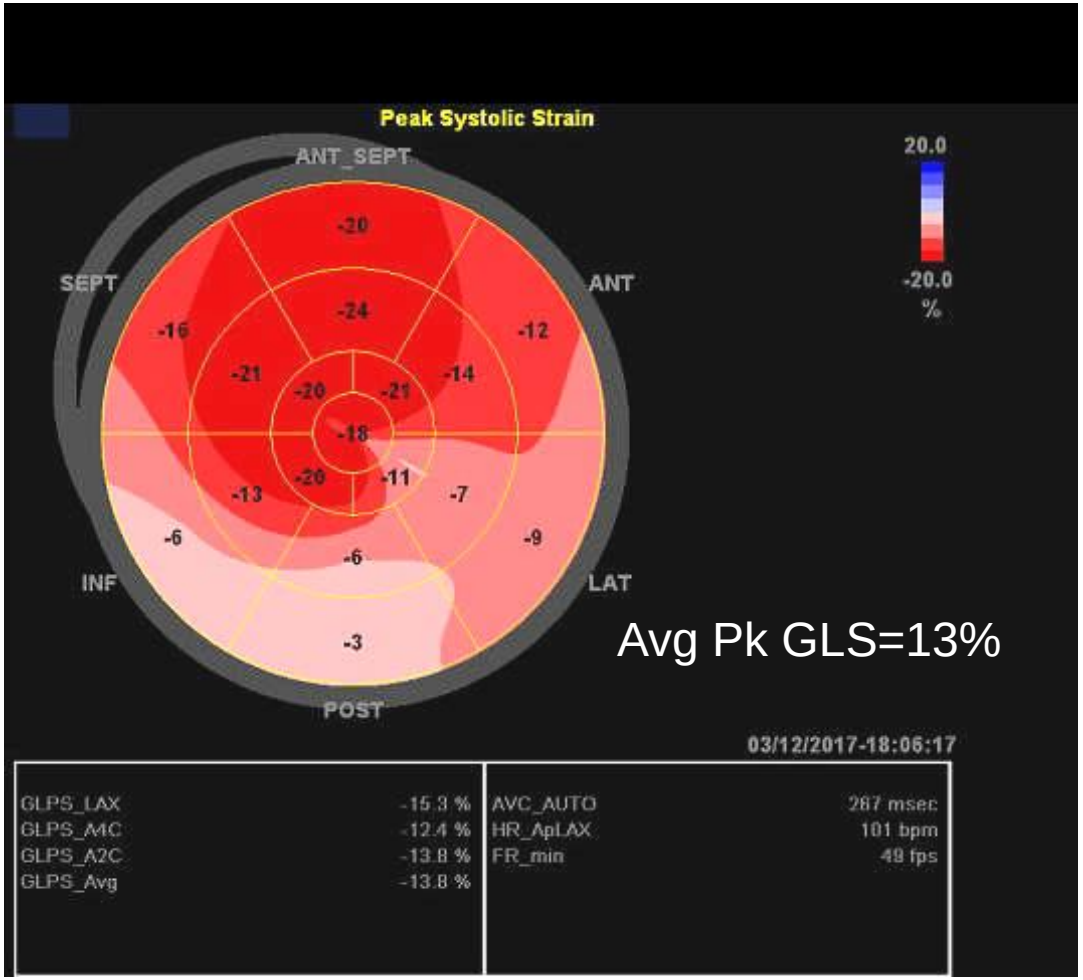

Avg Pk GLS=13%

Use of Strain Imaging to Detect RWMAs

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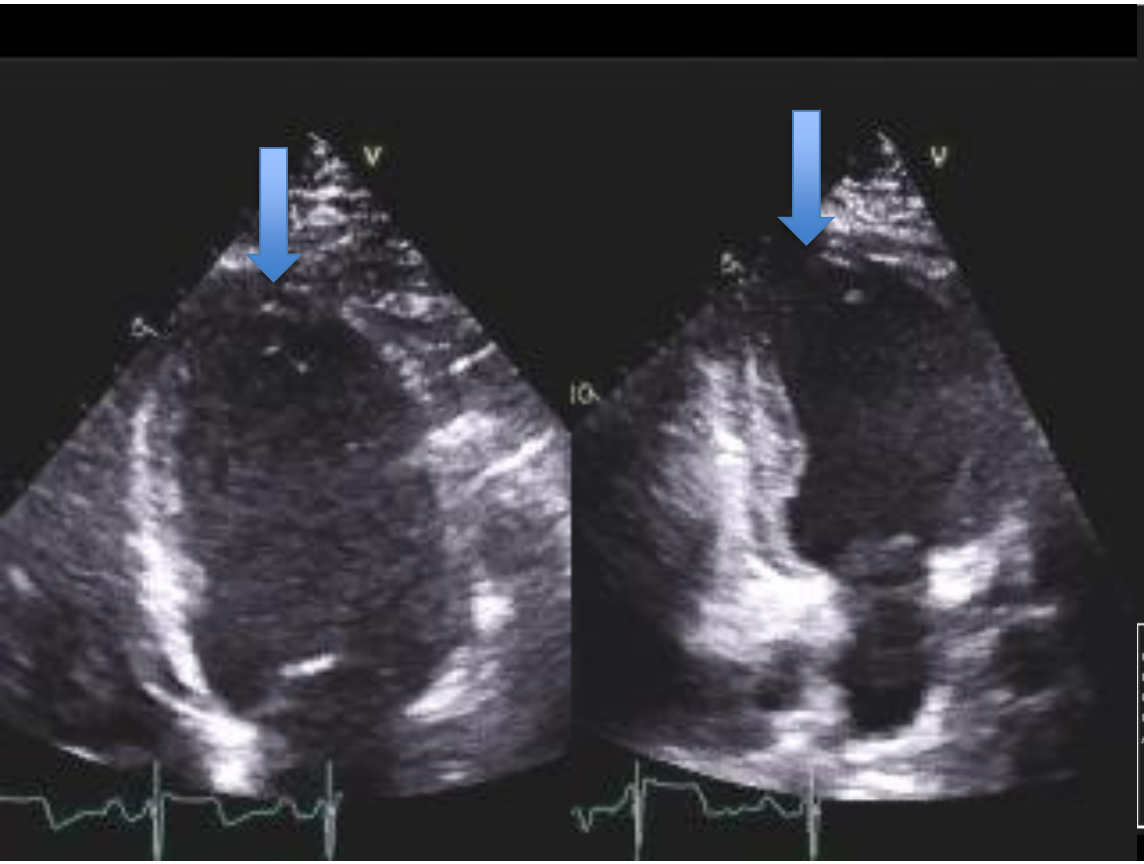

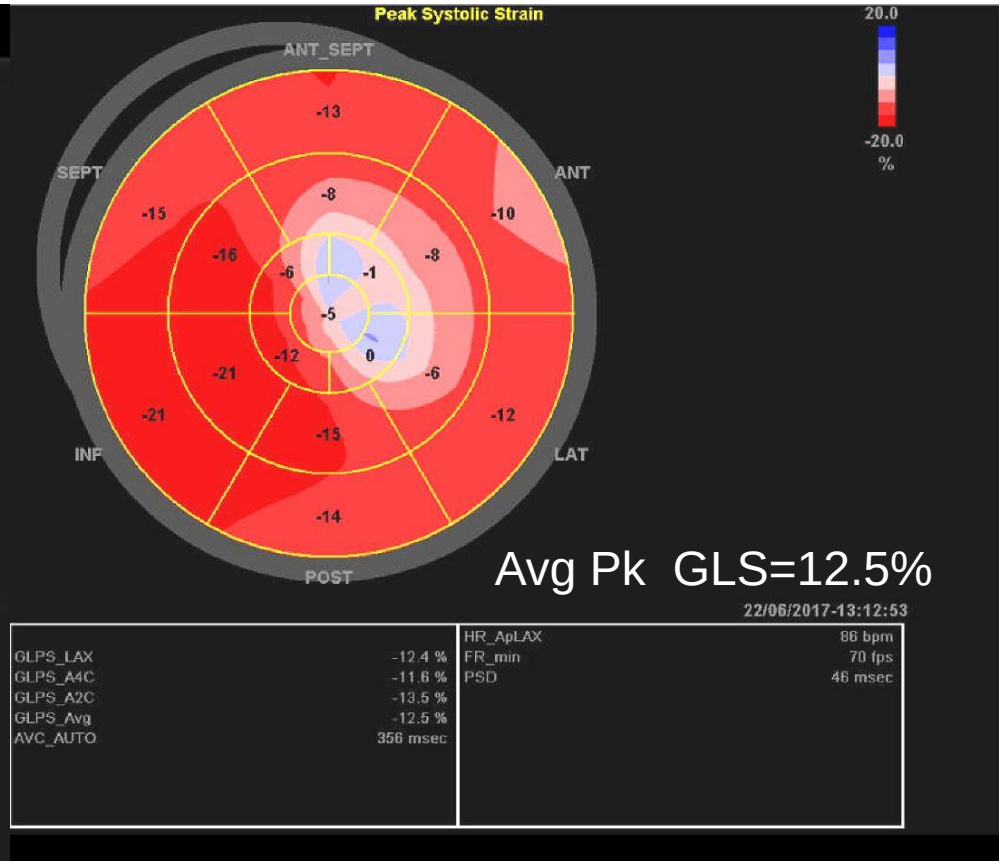

54 F with a ? Hx of an old MI

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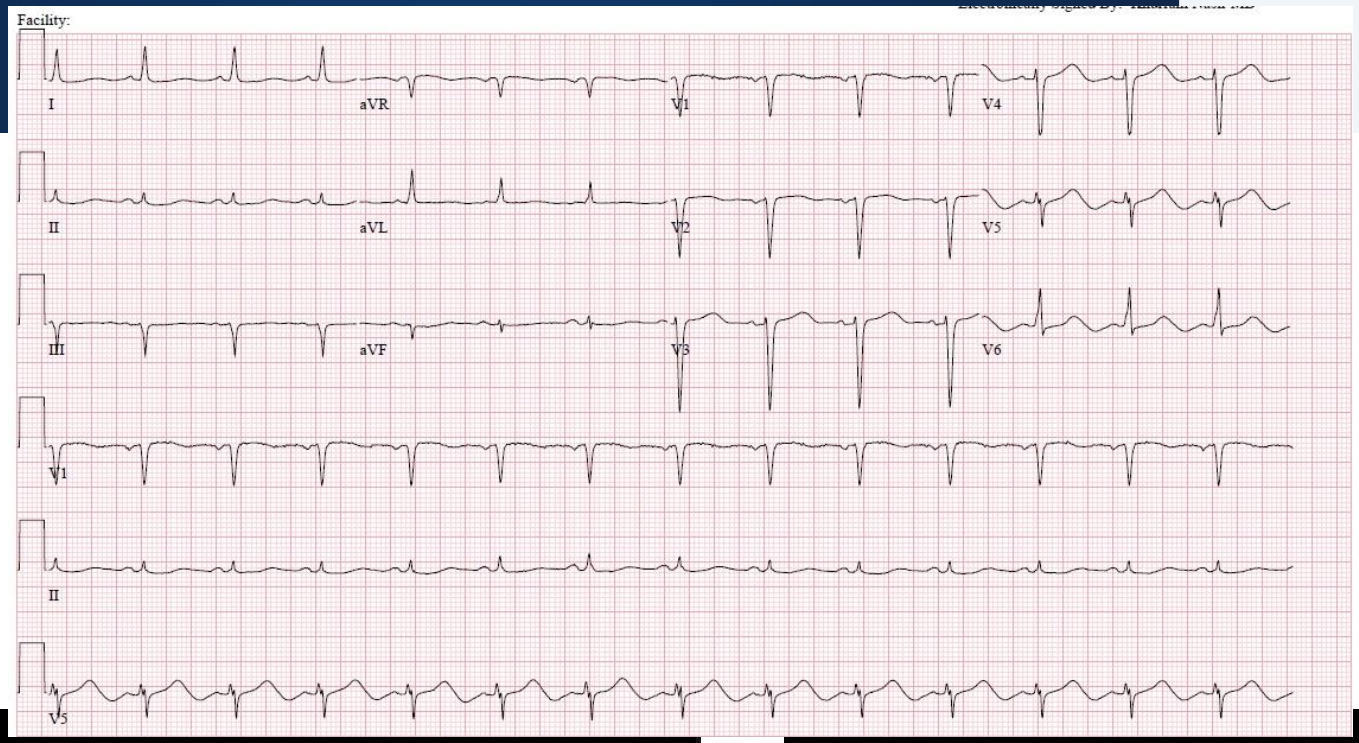

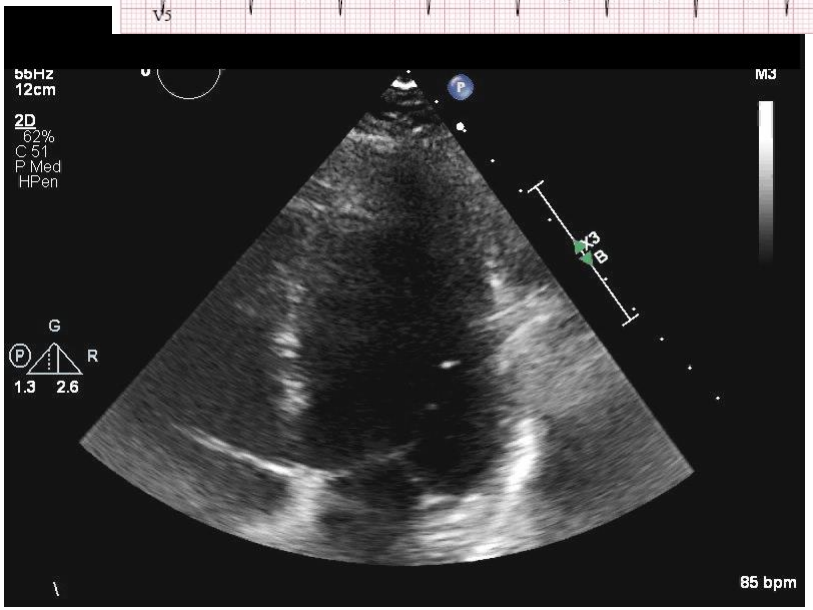

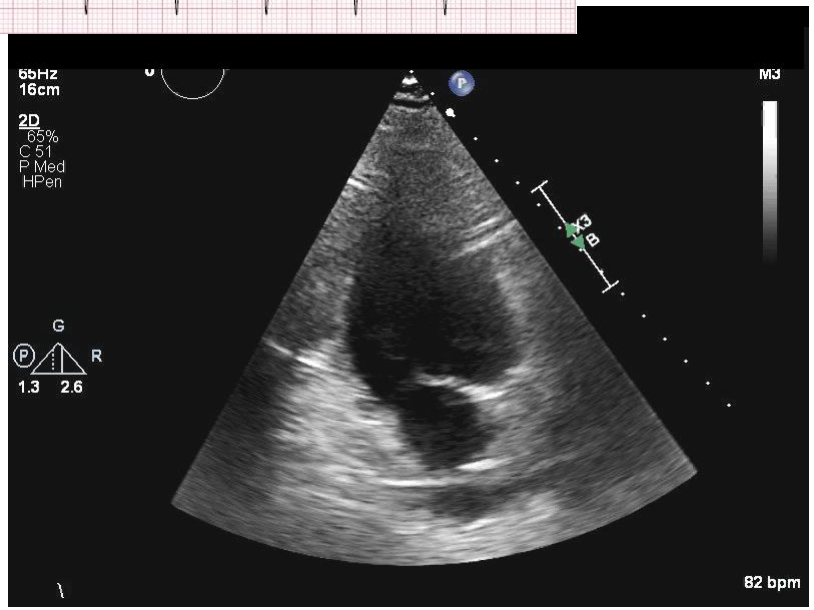

54 F with a ? Hx of an old MI

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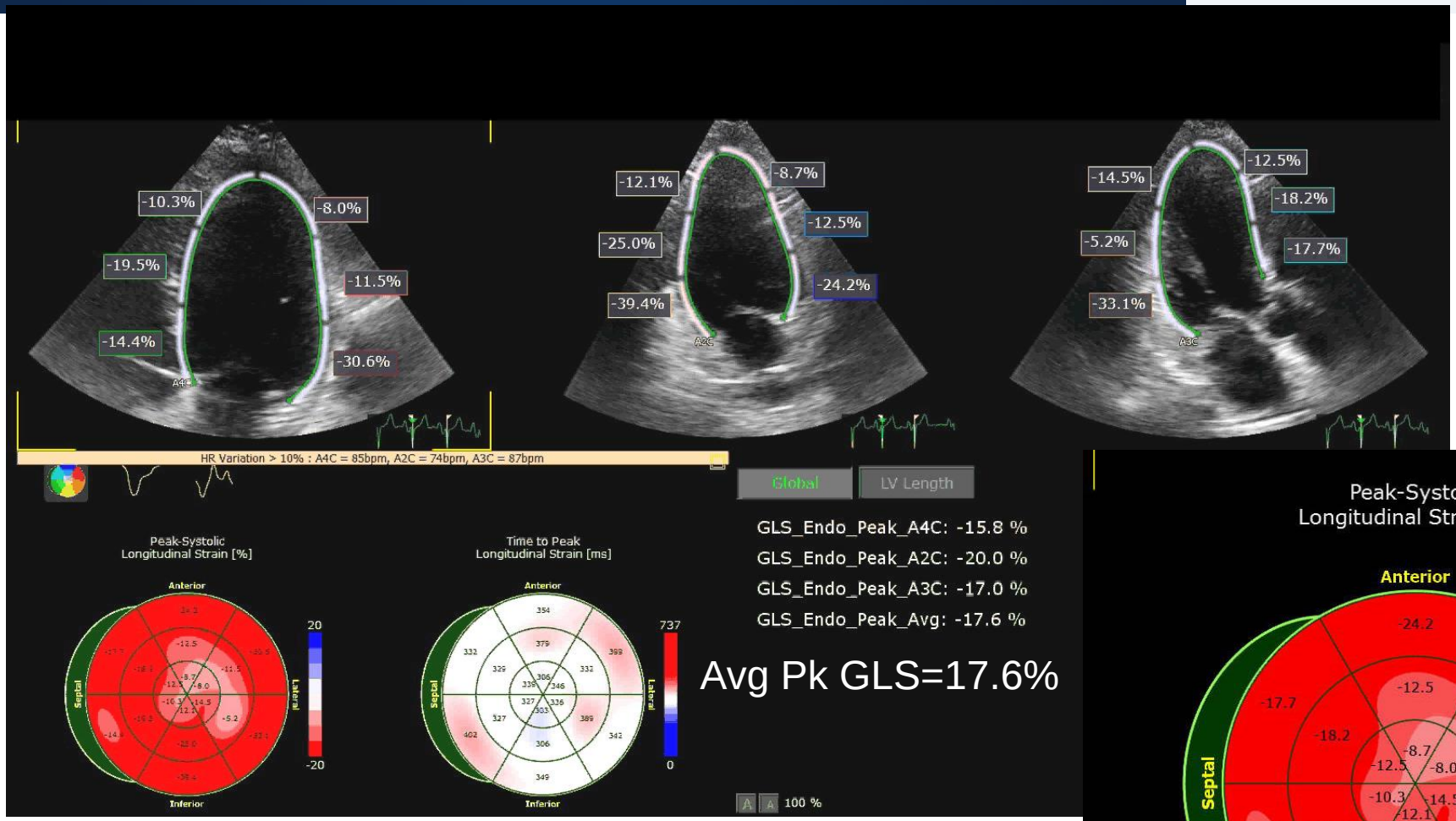

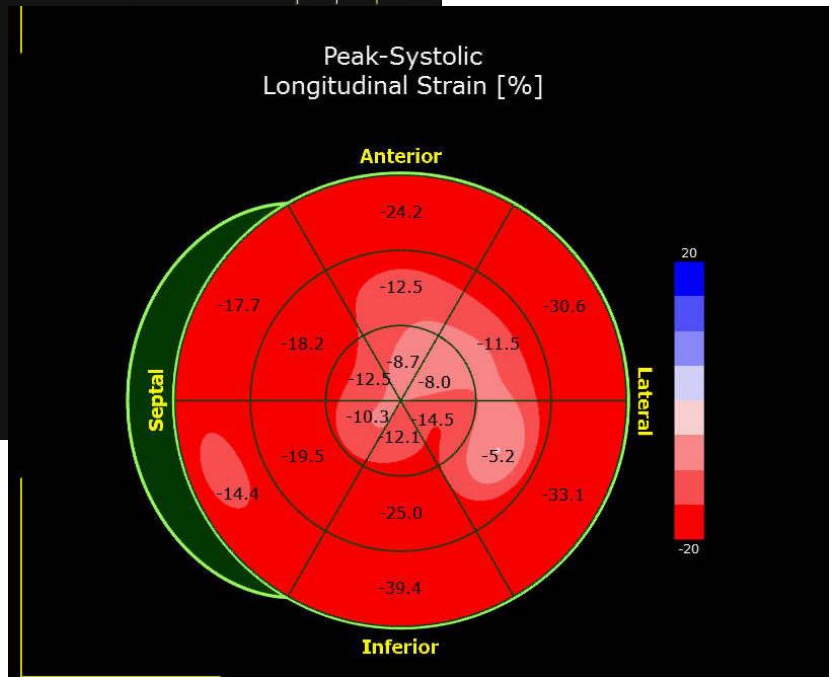

54 F with a ? Hx of an old MI

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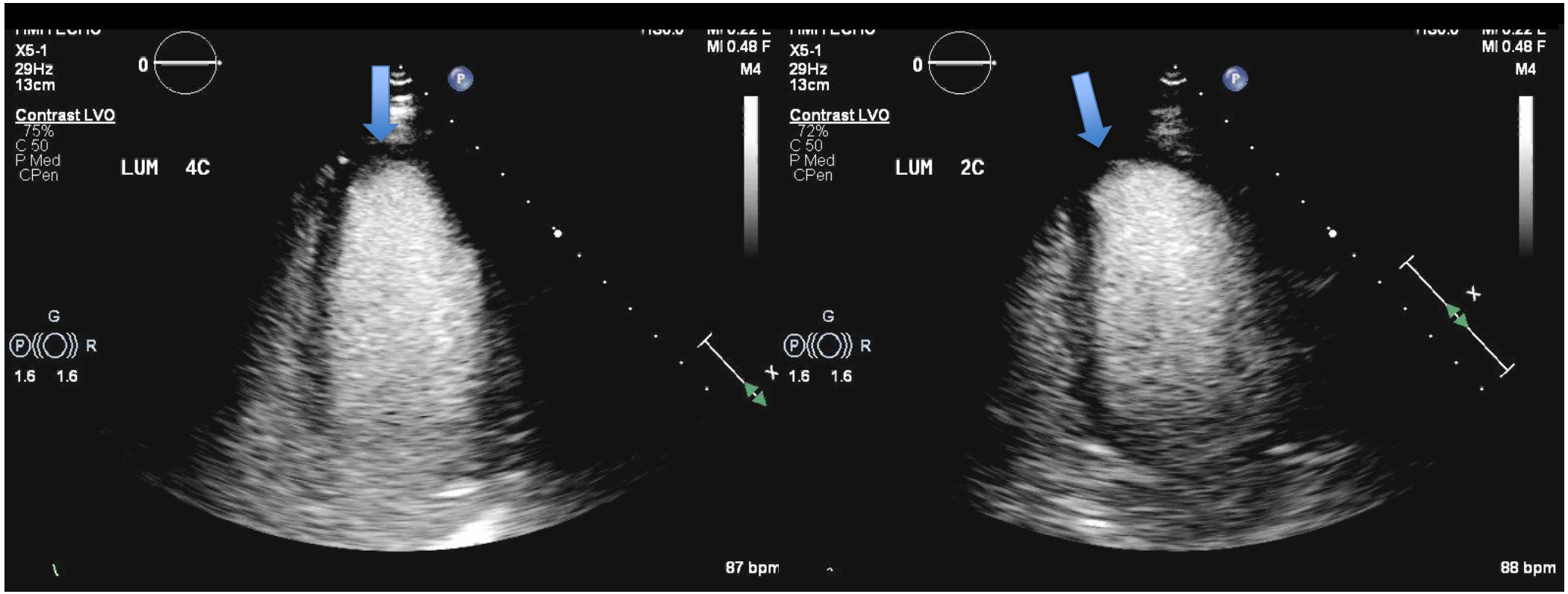
Contrast Given



4C

2C

Regional Patterns in Myocardial Diseases

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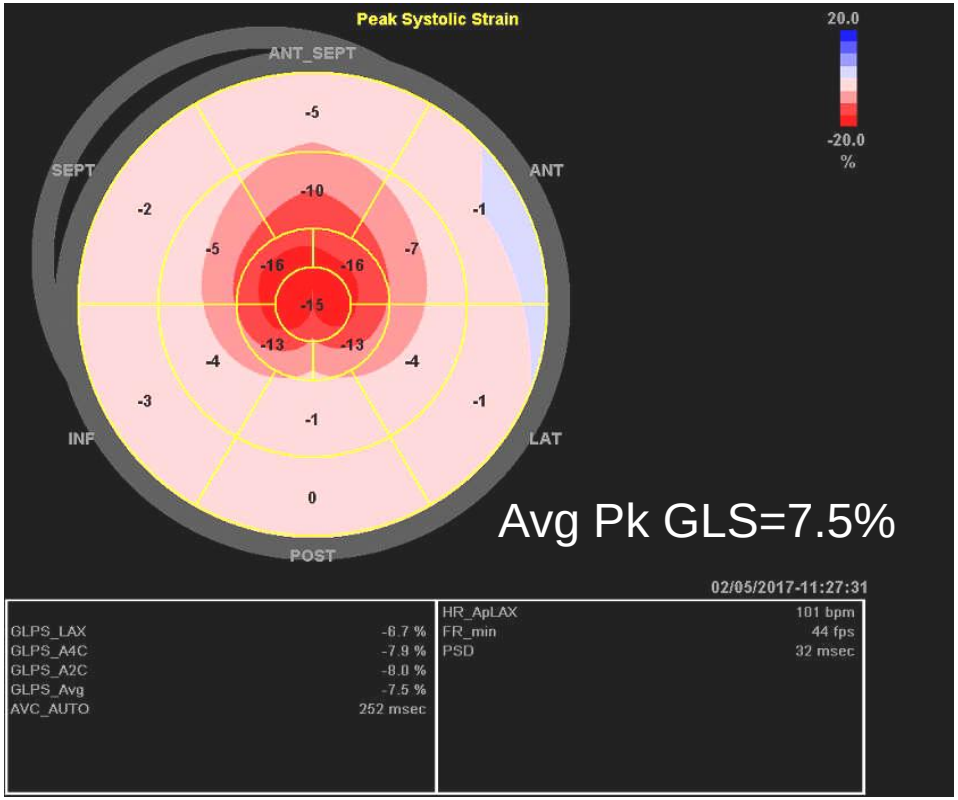
- Normal coronary angio

Apical Sparring



κ Light Chain 135 mg/L [3.3 – 19.4 ng/mL]
λ Light Chain 63.8 mg/L [5.7 – 26.3 mg/L]
κ / λ2.11 [0.26 – 1.65]
Acute presentation of cardiac light chain amyloidosis

79F with recent chest pain

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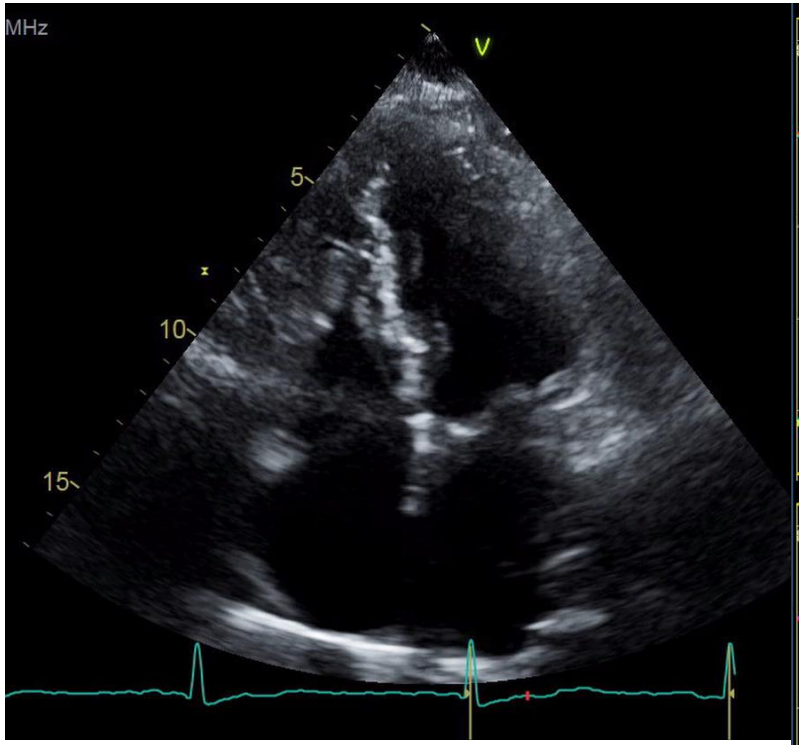

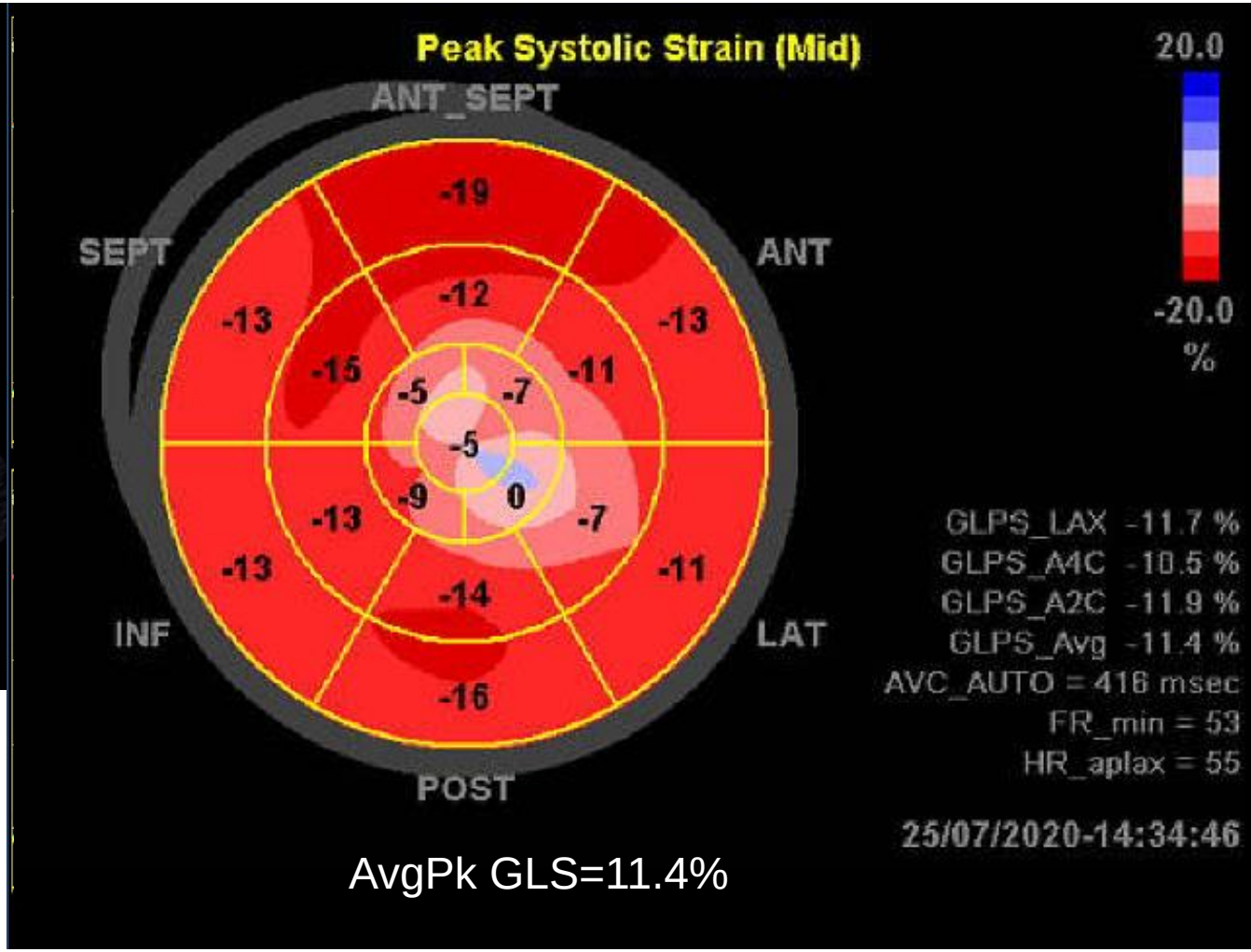

AvgPk GLS=11.4%

79F with recent chest pain

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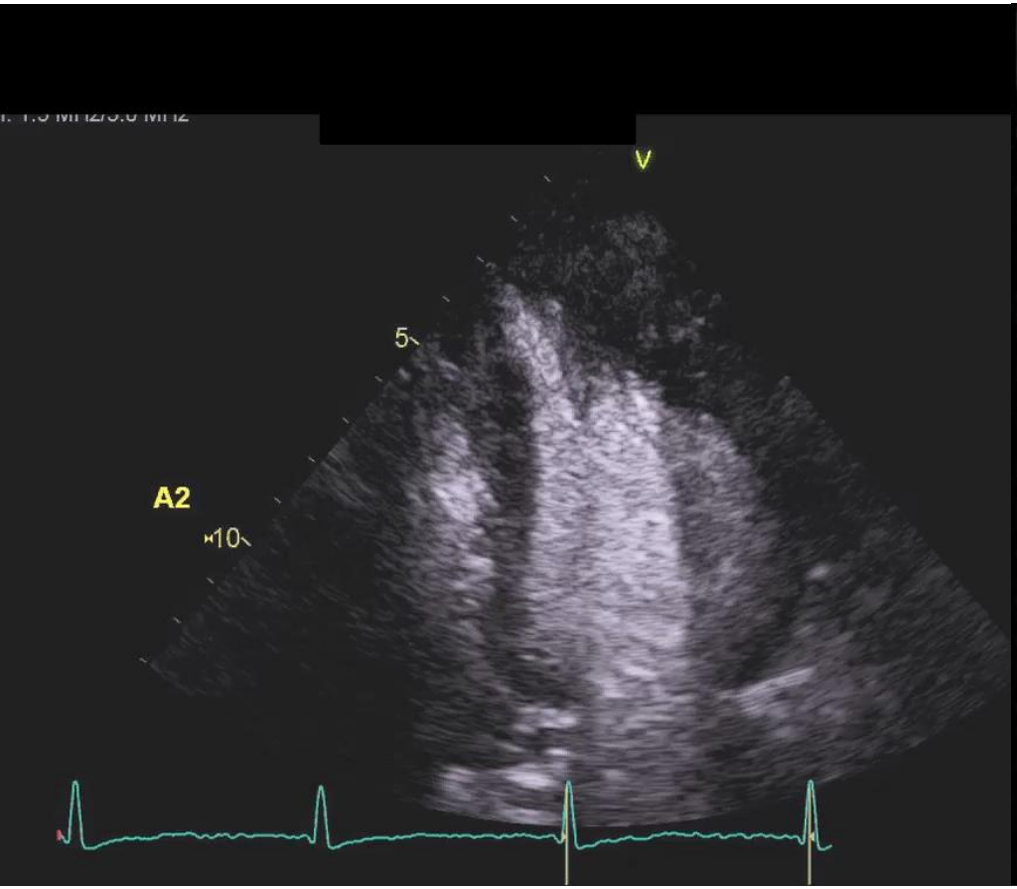
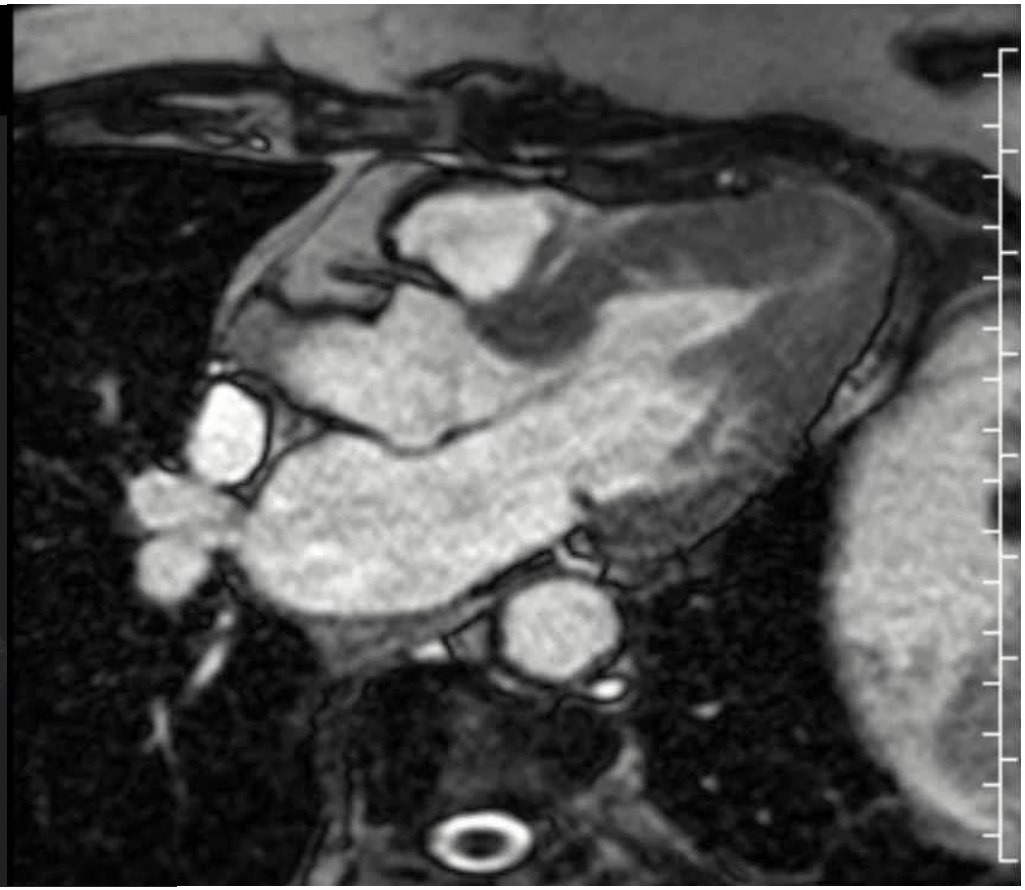
Contrast Echo



CMR



DX: Apical HCM

Potential Applications of Peak Average GLS in Routine Clinical Practice

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- Detection of subclinical LV dysfunction in a variety of diseases
- Objective assessment of global and regional function
- Regional patterns associated with myocardial diseases
- Better prediction of serious CV outcomes
  - lower values (without the - sign), worse prognosis

Early Detection and Prediction of Cardiotoxicity in Chemotherapy

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http://dx.doi.org/10.1016/j.jacc.2014.01.073

STATE-OF-THE-ART PAPERS

ASE/EACVImaging consensus document *(Plana, JC, JASE 2014)* recommendations:

a relative change in GLS less than 8% is not meaningful, whereas **a change greater than 15% is likely to indicate subclinical LV dysfunction**

Paaladinesh Thavendiranathan, MD,*† Frédéric Poulin, MD,* Ki-Dong Lim, MD,*
Juan Carlos Plana, MD,‡ Anna Woo, MD,* Thomas H. Marwick, MD§

Toronto, Ontario, Canada; Cleveland, Ohio; and Hobart, Australia

A 10-15% reduction on Pk Avrg GLS appears to be the most useful parameter for prediction of a >5% fall in EF during chemotherapy

Value of GLS in Predicting Cancer Therapy Related Cardiac Dysfunction (>5% EF drop)

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- Meta-analysis *(Oikonomou E, et.al. JAMA cardiol Aug 2019)*
  - **a ≥10-15% drop in GLS with chemotherapy had varying sensitivity and specificity for CTRCD**
  - **absolute GLS values** during treatment also have **comparable prognostic value for detecting CTRCD**
    - The threshold active treatment absolute GLS value to identify risk has been variable in the literature, with most studies suggesting a value between 18.0% and 19.0% (median, 18.0%)
  - **Baseline GLS may also flag patients at risk of CTRCD**, possibly through detection of preexisting subclinical dysfunction, which may be aggravated by chemotherapy

More studies are needed

Global Longitudinal Strain to Predict Mortality in Patients With Acute Heart Failure (HRpEF and HFrEF Combined)

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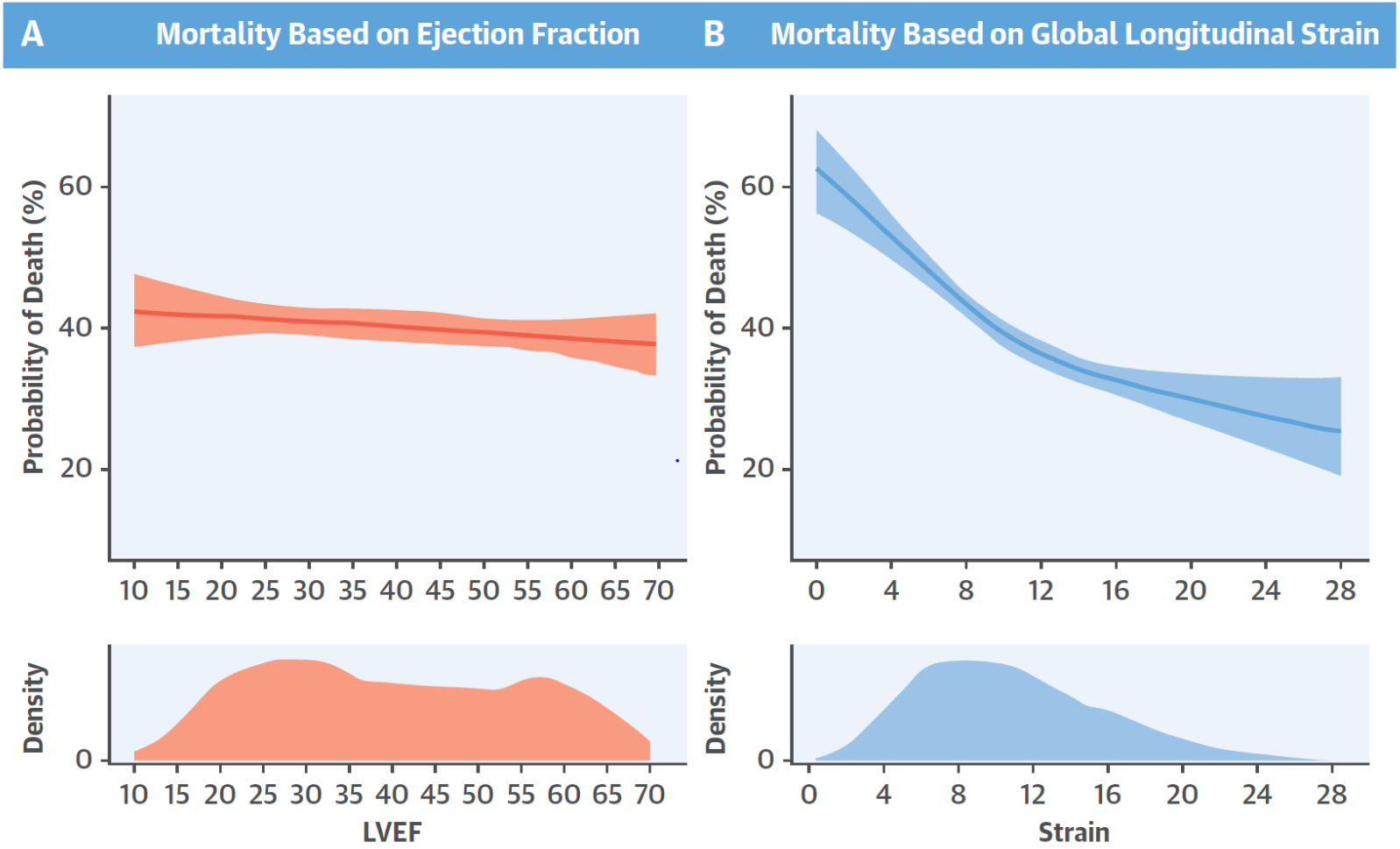
Jin Joo Park, MD, PhD,[a] Jun-Bean Park, MD, PhD,[b] Jae-Hyeong Park, MD, PhD,[c] Goo-Yeong Cho, MD, PhD[a]

JACC 71: 2018

N=4312

5-year All-cause Mortality



Journal of the American Heart Association
Volume 11, Issue 6, 15 March 2022
https://doi.org/10.1161/JAHA.121.024505

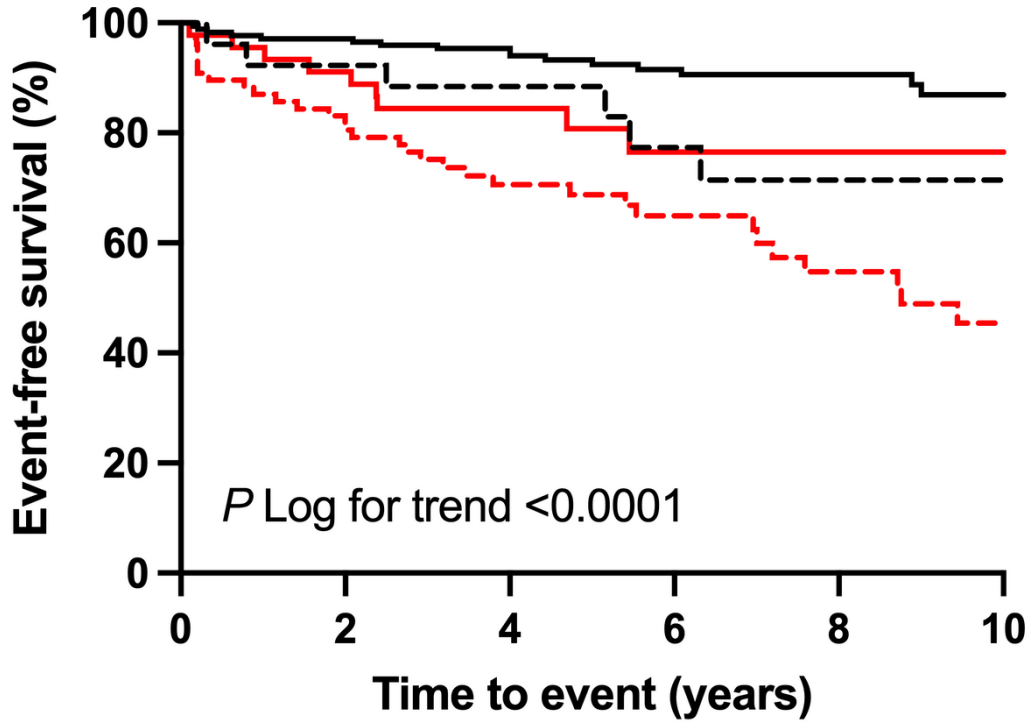
ORIGINAL RESEARCH

Global Longitudinal Strain is Incremental to Left Ventricular Ejection Fraction for the Prediction of Outcome in Optimally Treated Dilated Cardiomyopathy Patients

Anne G. Raafs, MD † ; Andrea Boscutti, MD † ; Michiel T. H. M. Henkens, MD ; Wout W. A.

March 2022

A total of 323 patients with DCM (66% men, age 55±14 years) under optimal Rx for HF were included.



Number at risk

LVEF >40% and GLS better than -13%	175	168	139	94	64	38	*P*=0.026
LVEF >40% and GLS worse than -13%	26	24	17	13	7	3	
LVEF <40% and GLS better than -13%	45	41	28	15	13	11	*P*=0.030
LVEF <40% and GLS worse than -13%	77	63	43	30	20	13	

JAMA Cardiology | Original Investigation

Association of Left Ventricular Global Longitudinal Strain With Asymptomatic Severe Aortic Stenosis

Natural Course and Prognostic Value

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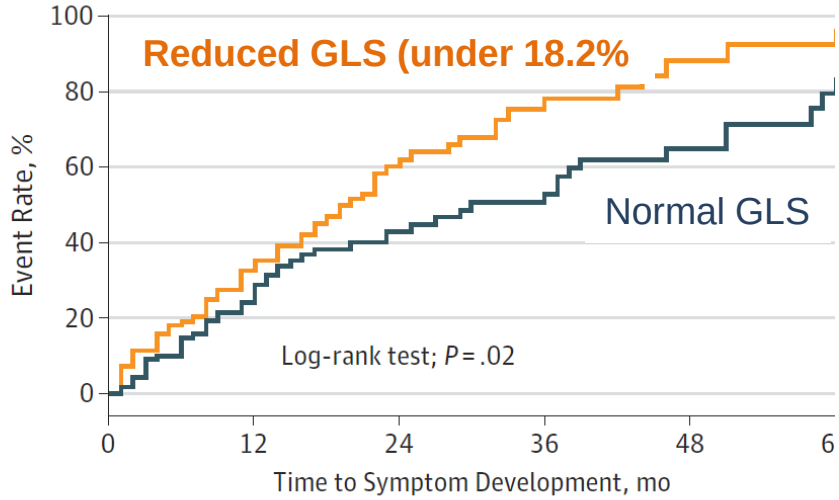
Development and Intervention in Patients With Asymptomatic Aortic Stenosis

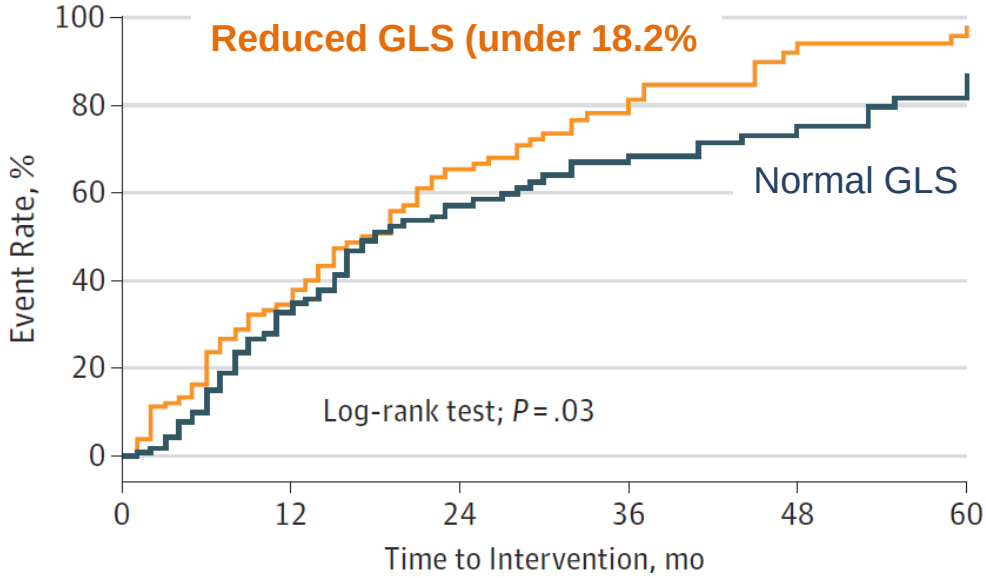
Symptoms development



No. at risk

LV GLS >−18.2%	102	52	22	9	3	
LV GLS ≤−18.2%	118	60	33	22	12	

Intervention



JAMA Aug 2018

FULL TEXT ARTICLE

Left Ventricular Global Longitudinal Strain in Patients with Moderate Aortic Stenosis

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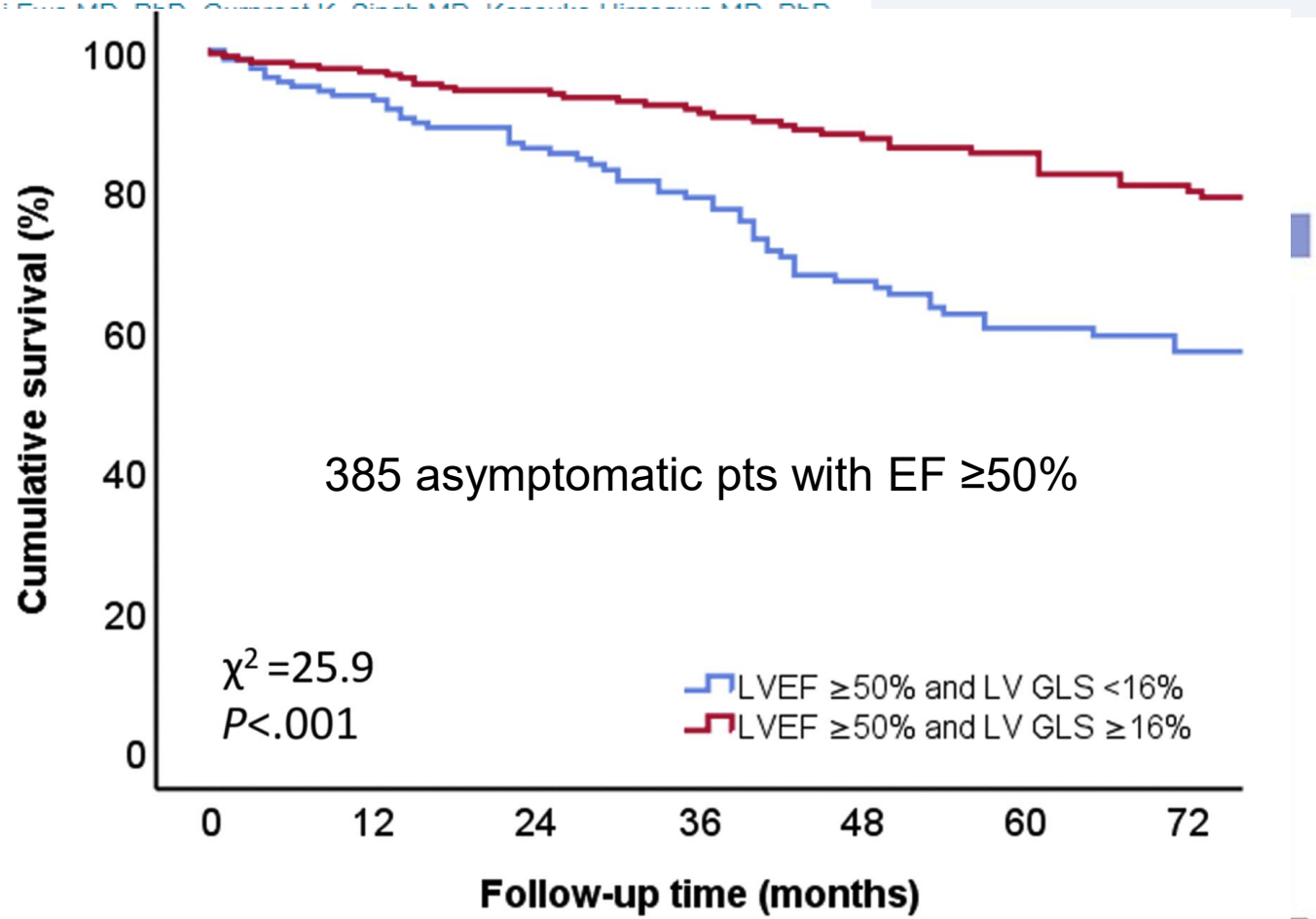

Number at risk							
LVEF ≥50% and LV GLS <16%	156	143	115	95	72	56	49
LVEF ≥50% and LV GLS ≥16%	229	222	189	156	134	112	93

FULL TEXT ARTICLE

Left Ventricular Global Longitudinal Strain in Patients with Moderate Aortic Stenosis

Jan Stassen MD, Stephan M. Pio MD, See Hooi Ewe MD, PhD, Gurpreet K. Singh MD, Kensuke Hirasawa MD, PhD, Steele C. Butcher MD, MPhil, David J. Cohen MD, MSc, Philippe Généreux MD, PhD, Martin B. Leon MD, PhD, Nina Ajmone Marsan MD, PhD, Victoria Delgado MD, PhD and Jeroen J. Bax MD, PhD

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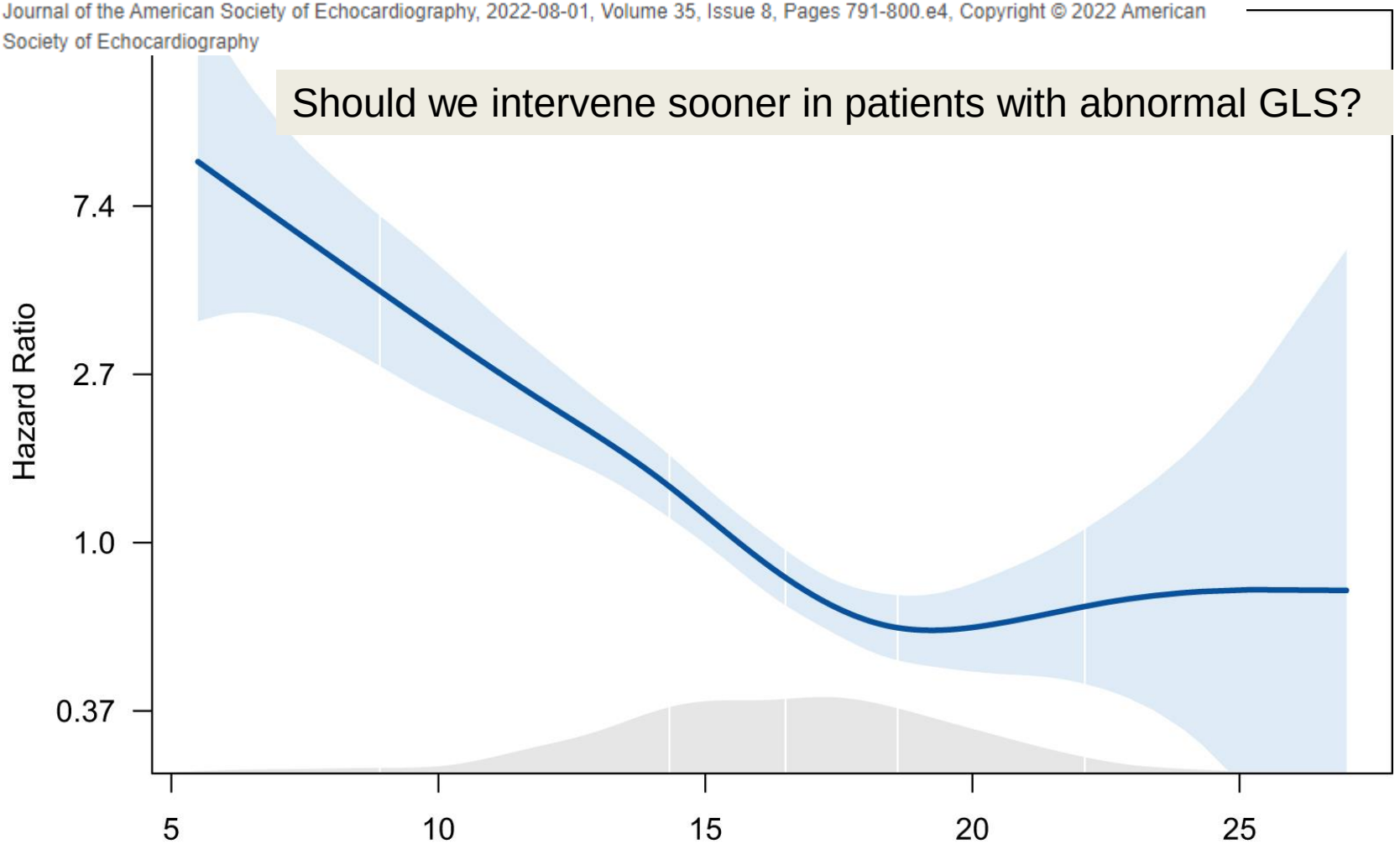
Should we intervene sooner in patients with abnormal GLS?



Strain Echocardiography and Functional Capacity in Asymptomatic Primary Mitral Regurgitation With Preserved Ejection Fraction

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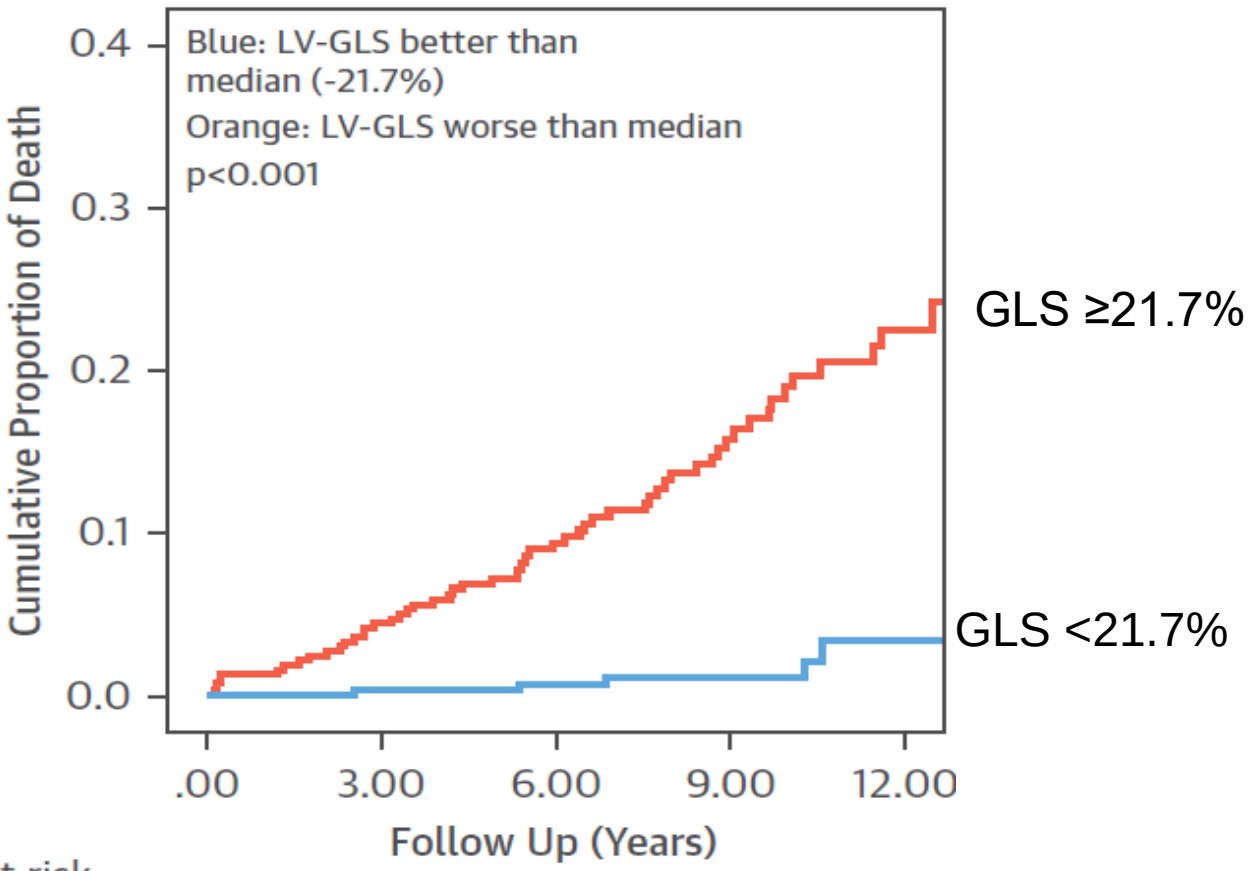
JACC 2016

Amgad Mentias, MD, Peyman
Tomislav Mihaljevic, MD, Rak
Richard A. Grimm, DO, Brian



Numbers at risk

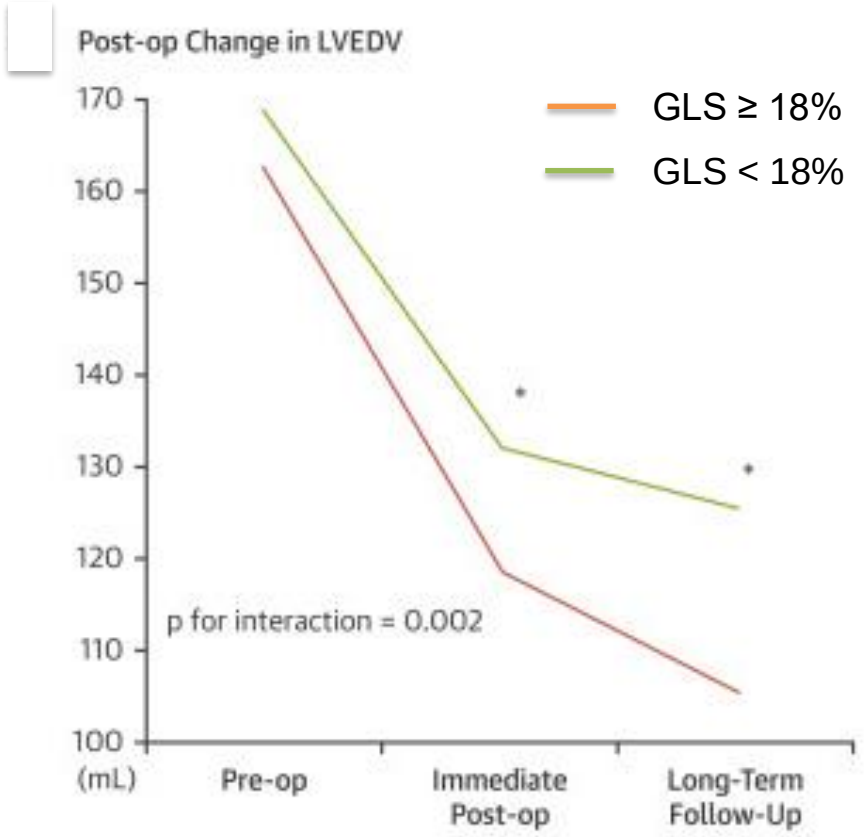
Resting LV-GLS					
Better than median	370	367	238	131	61
Worse than median	367	350	261	181	80

FULL TEXT ARTICLE

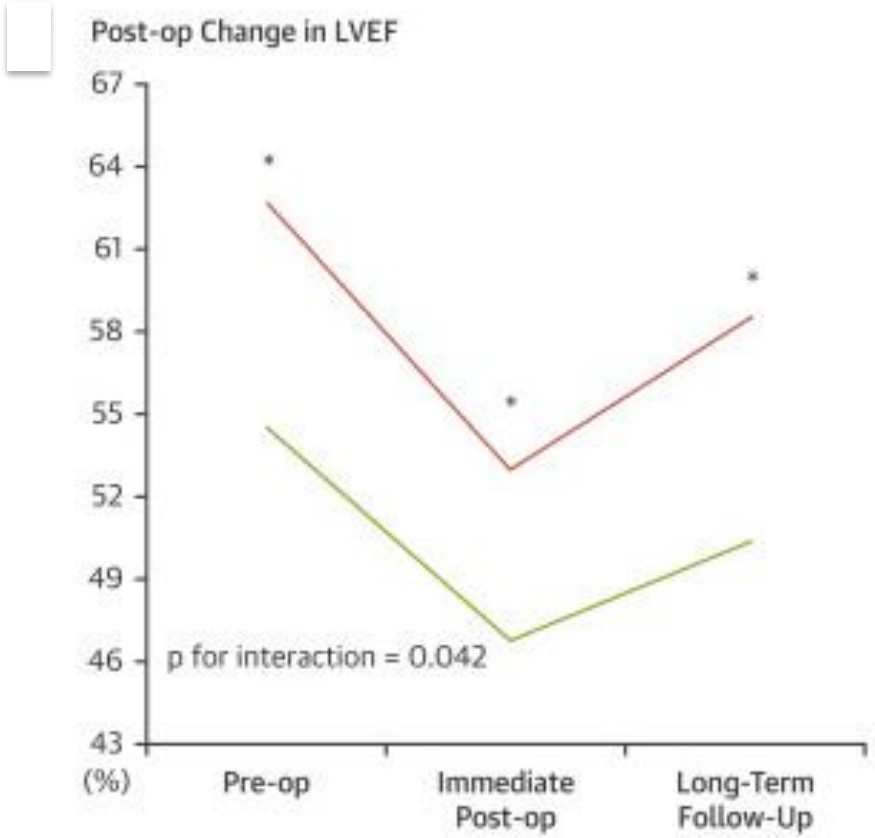
Myocardial Strain in Prediction of Outcomes After Surgery for Severe Mitral Regurgitation

Hyue Mee Kim MD, Goo-Yeong Cho MD, PhD, In-Chang Hwang MD, Hong-Mi Choi MD, Jun-Bean Park MD, PhD, Yeonyee E. Yoon MD and Hyung-Kwan Kim MD, PhD

JACC: Cardiovascular Imaging, 2018-09-01, Volume 11, Issue 9, Pages 1235-1244, Copyright © 2018 American College of Cardiology Foundation



GLS ≤-18.1%	162.7 ± 51.5	118.7 ± 42.4	105.6 ± 33.2
GLS >-18.1%	168.7 ± 59.7	132.1 ± 46.6	125.7 ± 45.4



GLS ≤-18.1%	62.7 ± 6.2	53.0 ± 9.9	58.5 ± 7.2
GLS >-18.1%	54.5 ± 9.0	46.8 ± 11.2	50.4 ± 9.6

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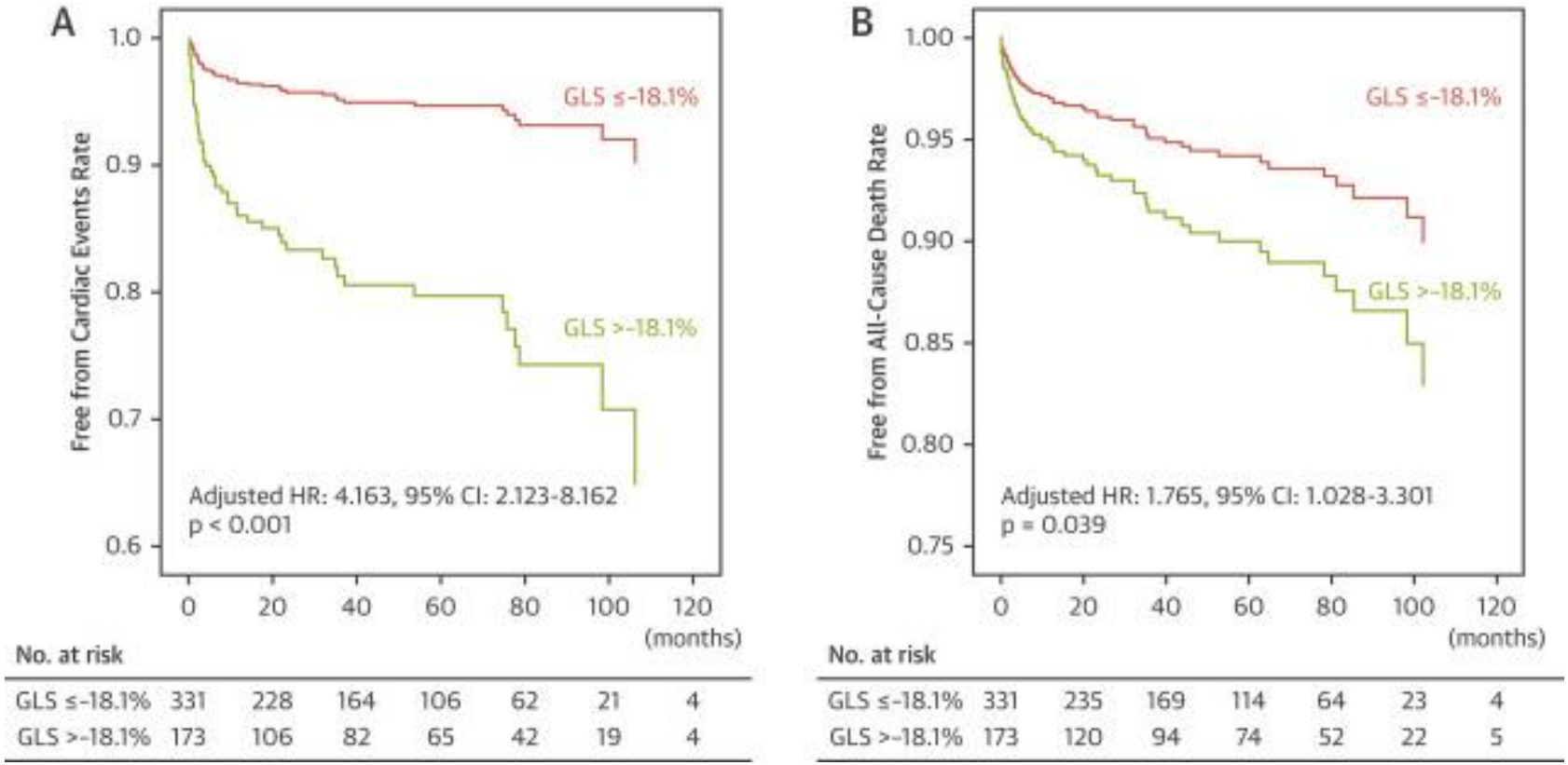

Risk-Adjusted Event-Free Survival According to GLS
Event-free survival curves are shown according to the GLS (−18.1%), adjusted for significant univariate predictors. **(A)** Event-free survival curve for cardiac events. **(B)** Event-free survival curve for all-cause death.

J Intensive Care. 2022; 10: 29.
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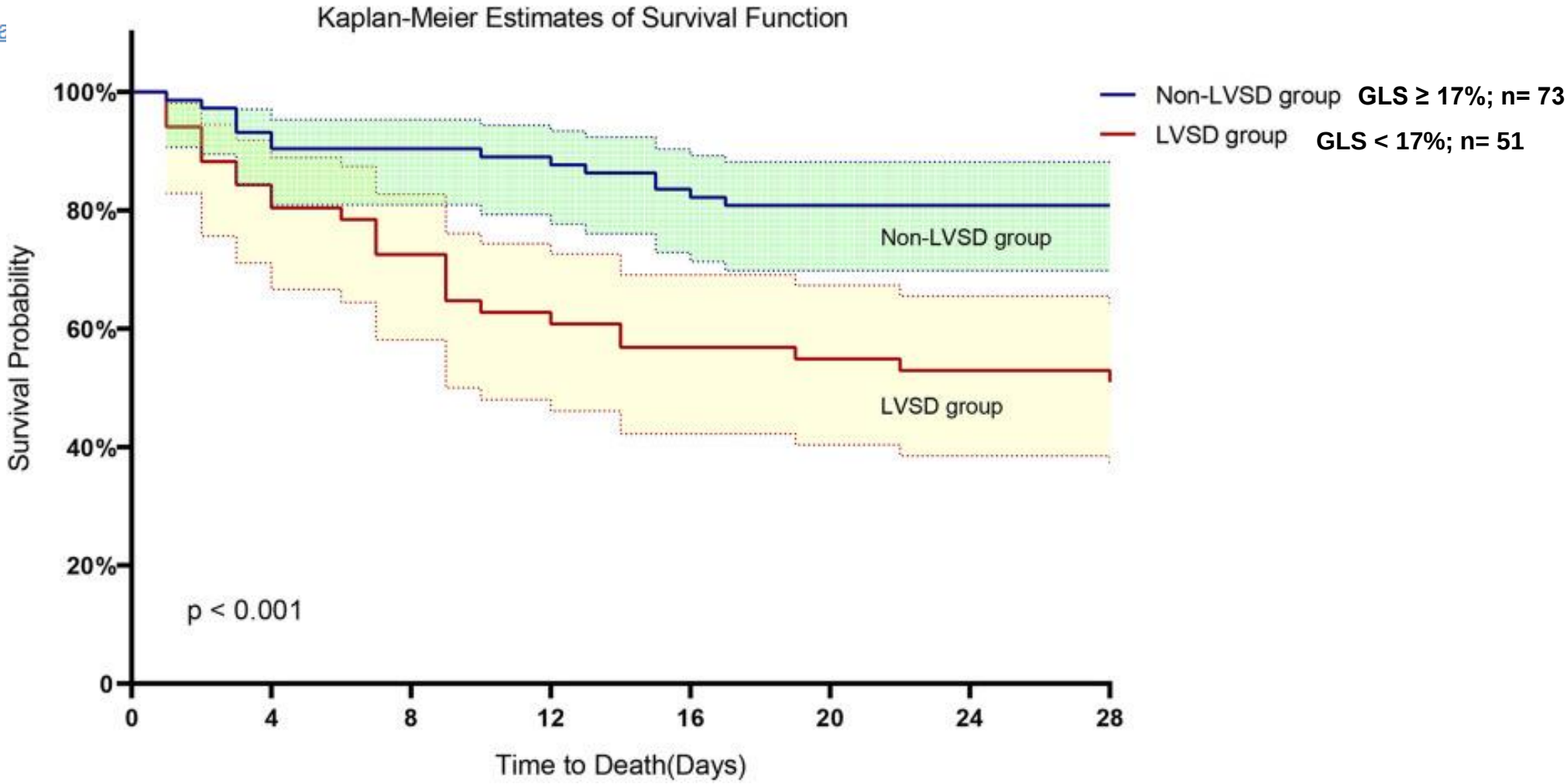
PMCID: PMC9199206
PMID: 35706065

Construction of a predictive model and prognosis of left ventricular systolic dysfunction in patients with sepsis based on the diagnosis using left ventricular global longitudinal strain

Jia



Limitations of Strain Imaging

- Quality of image alters accuracy
  - contrast cannot be used

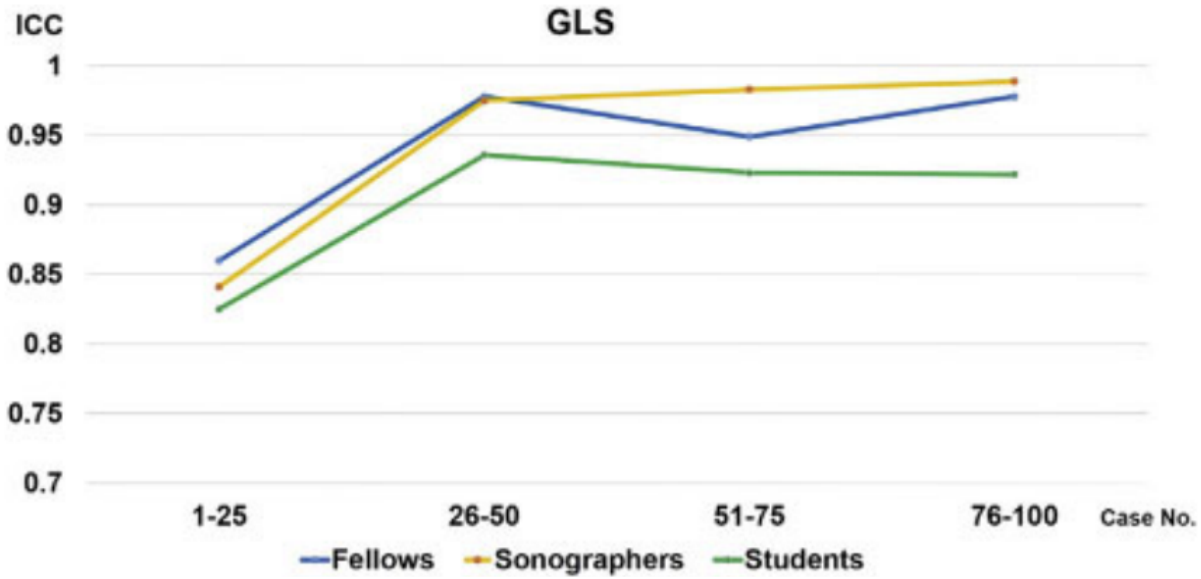


Figure 1 GLS Learning curve. ICC of each group compared with expert over consecutive quartiles of 25 cases.

Chang J, JASE Nov 2017

Limitations of Strain Imaging

- Quality of image alters accuracy
  - contrast cannot be used
- Strain is an index of myocardial fiber shortening and thus, it is also influenced by changes in loading conditions
  - Consider BP at time of imaging
- Inaccurate results may be incorrectly accepted
  - How does one know that an abnormal result is real in a patient with an otherwise normal echocardiogram?
- **Clinical limitation:** how do we treat an asymptomatic patient with normal LVEF who has abnormal global or regional strain

Predicting Outcome

- Regional strain may help in the detection of regional abnormalities in CAD and selective cardiomyopathies
- Reduction of GLS in cancer patients receiving cardio-toxic agents can predict a drop in EF but the GLS thresholds are still under validation
- GLS provides a **better prediction of CV events and mortality than EF**, in patients with HF, valvular lesions and sepsis.
- Stay tune as new treatment guidelines apply e GLS data to patient management

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Thanks