Myocardial Imaging

Tissue Doppler and Strain Imaging

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mayo

DISCLOSURE

Relevant Financial Relationship(s)

None

Off Label Usage

None

When obtaining a pulsed wave tissue Doppler signal you should?

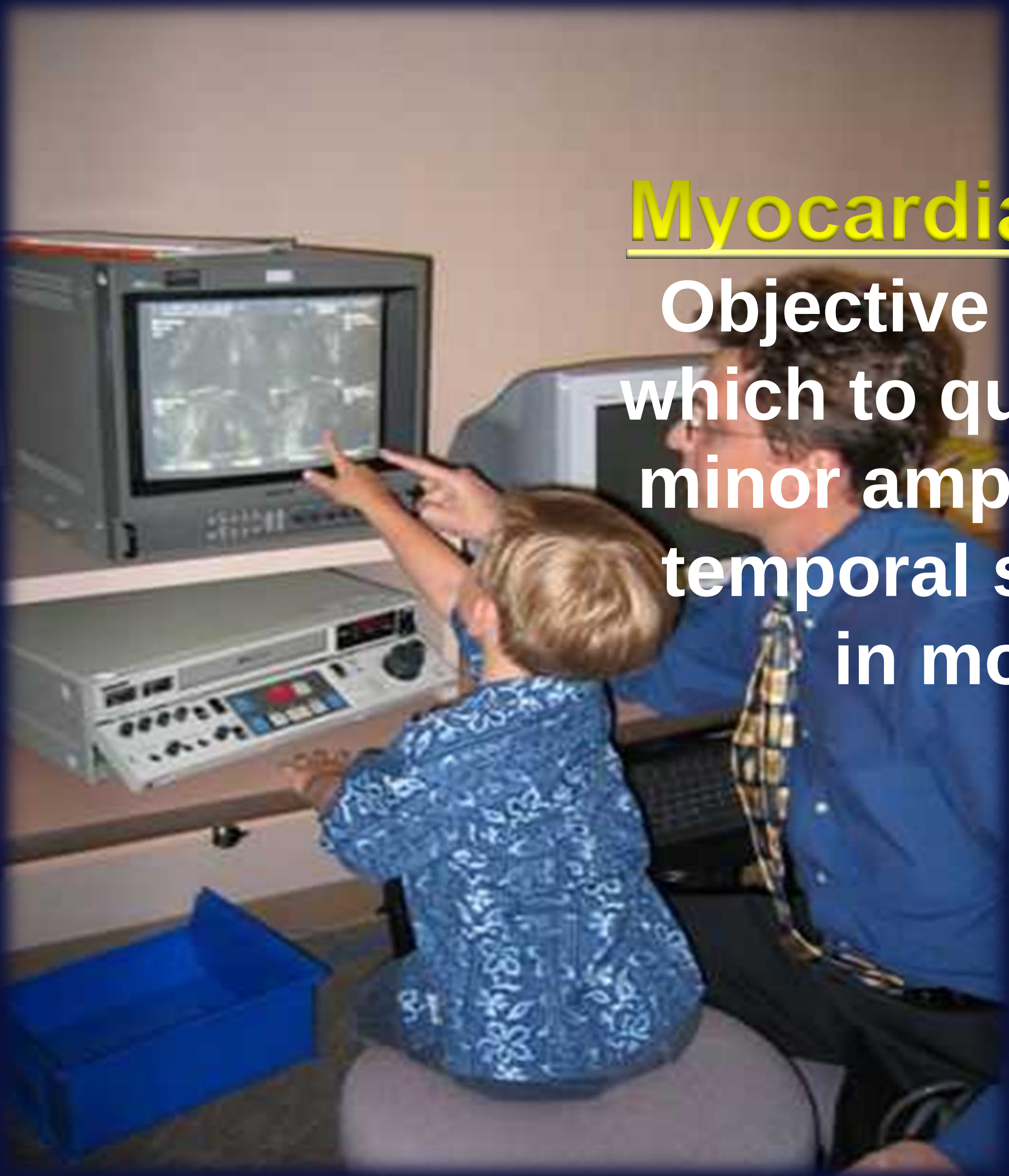
a. Turn the wall filters on and turn down the receiver gain.
b. Turn the wall filters off and turn up the receiver gain.
c. Turn the wall filters off and turn down the receiver gain.
d. Turn the wall filters on and turn up the receiver gain.

With “speckle tracking” myocardial imaging:

a. You measure strain along the axis of the ultrasound beam.
b. Velocity and strain measurements are measured from standard gray-scale images.
c. Myocardial velocity measurements are not influenced by translational or tethering motion as they are when obtained by pulsed wave tissue Doppler imaging.
d. You can measure longitudinal but not circumferential or radial strain.

Compared to pulsed wave tissue Doppler the myocardial velocities obtained by color tissue Doppler are?

a. Higher
b. Lower
c. The same



Myocardial Imaging

Objective way with which to quantify the minor amplitude and temporal subtleties in motion

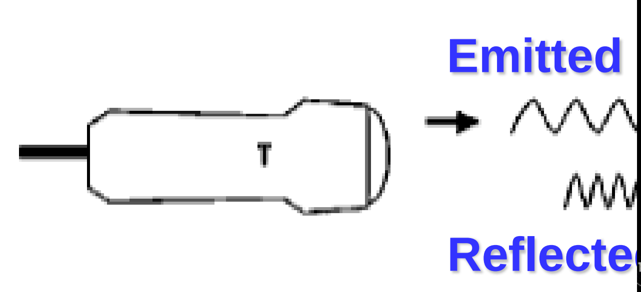
Objectives

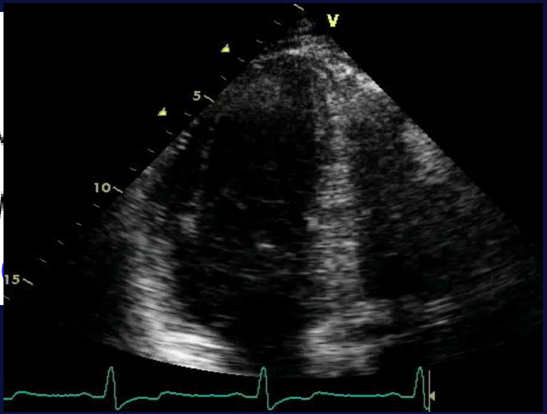
1. What is myocardial imaging?
2. Potential Clinical Applications
3. Impediments to widespread clinical adoption.

How Do We Obtain a Velocity?

Christian Andreas Doppler
1803 - 1853

Positive Frequency Shift



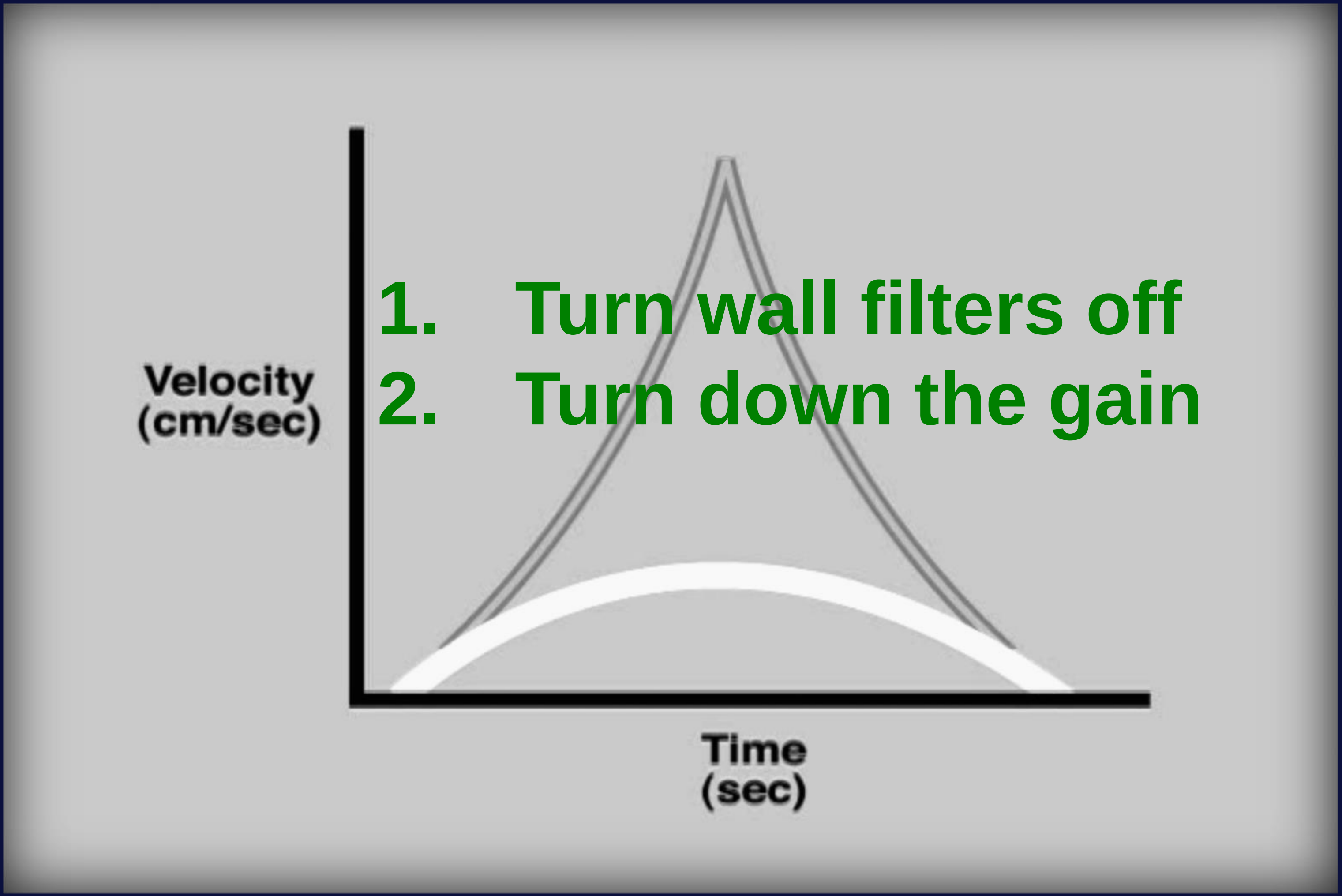


$$(f_r - f_o) = 2 f_o \, v \, (\cos\theta) / c$$

C= average speed of sound in tissue (1540m/sec)

Doppler:

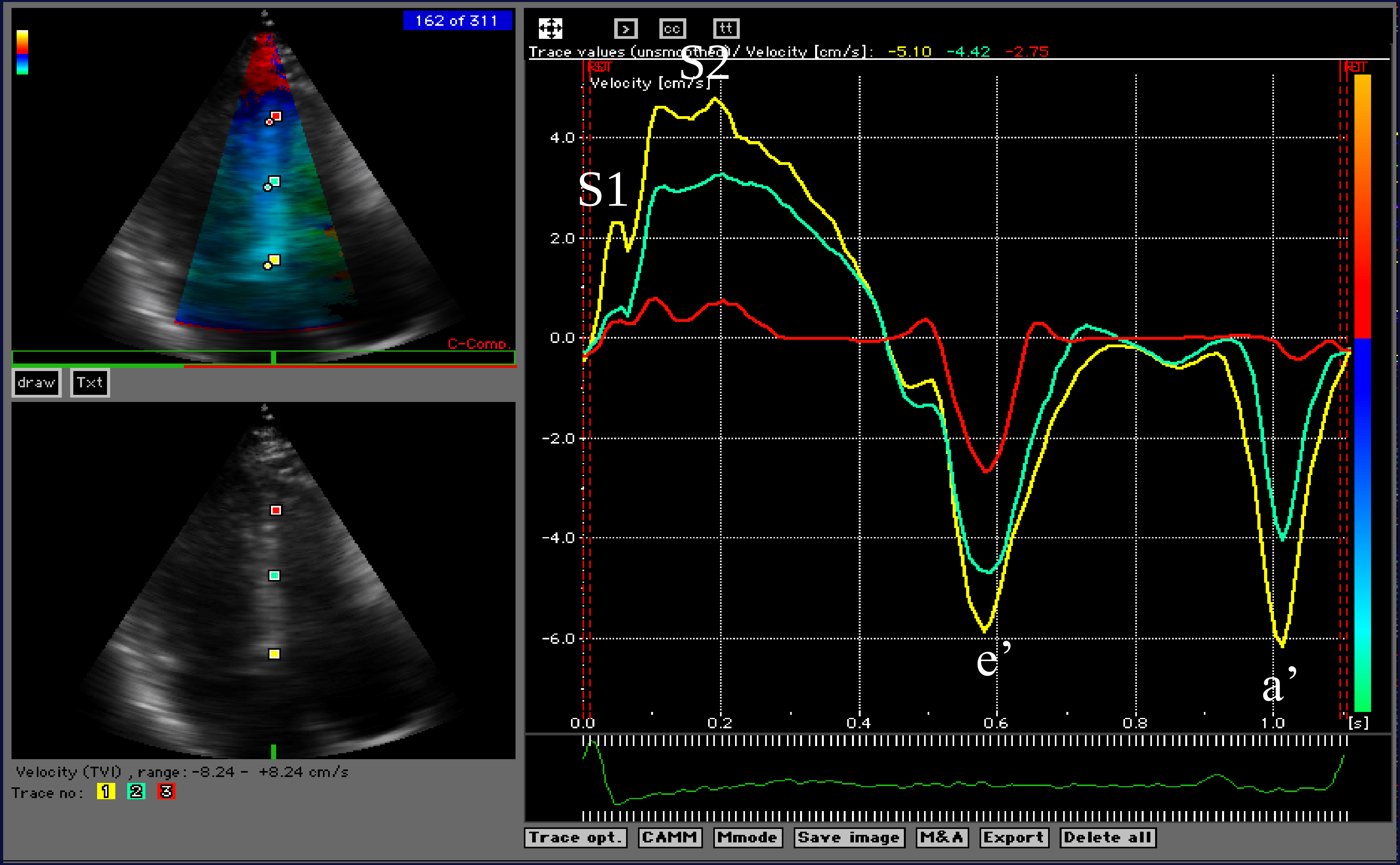
Doppler Tissue Imaging



1. Turn wall filters off
2. Turn down the gain

Doppler Tissue Imaging

Septal Myocardial Velocity Traces

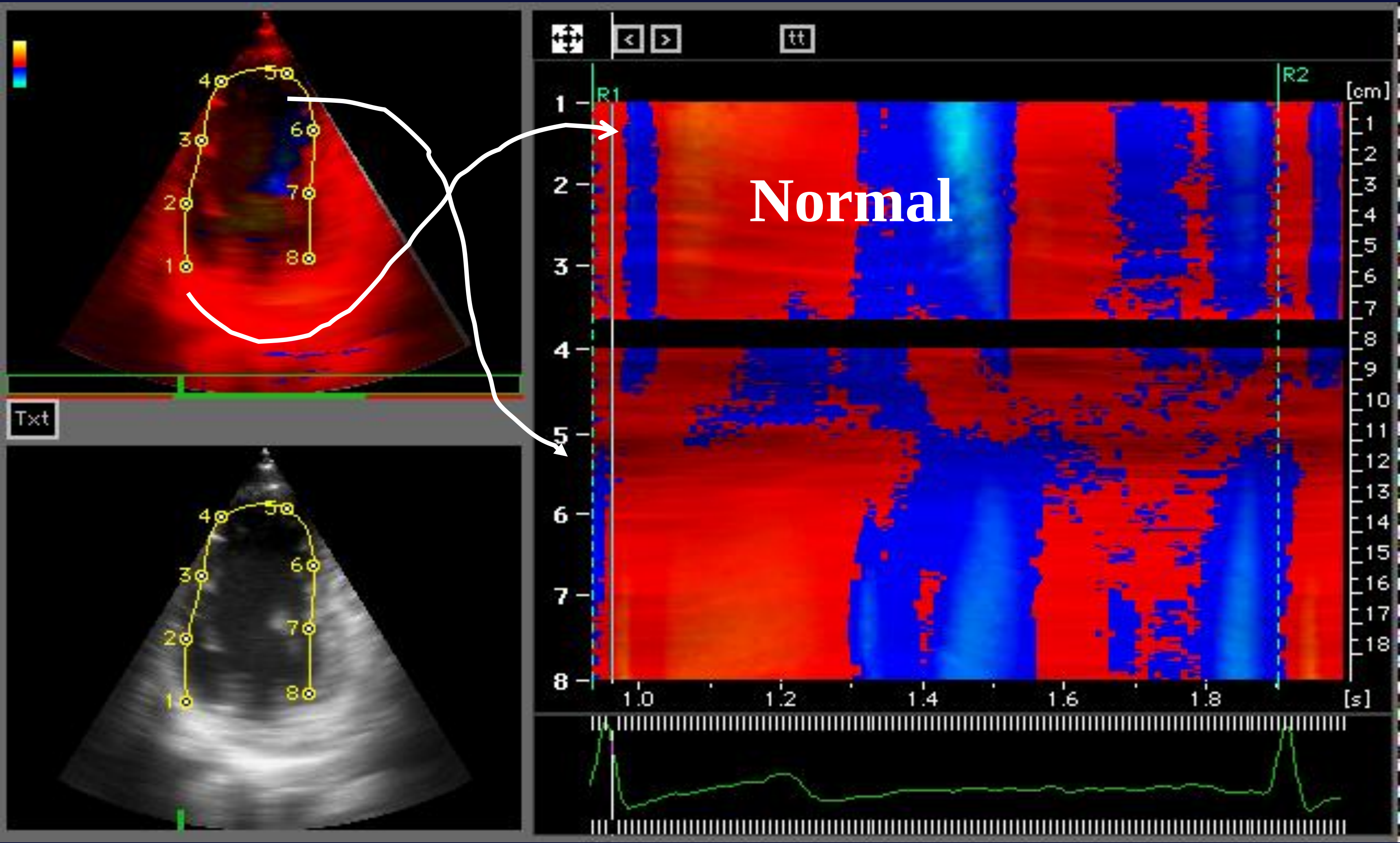


Trace values (unsmoothed) / Velocity [cm/s]: -5.10 -4.42 -2.75

Velocity (TVI) , range: -8.24 - +8.24 cm/s

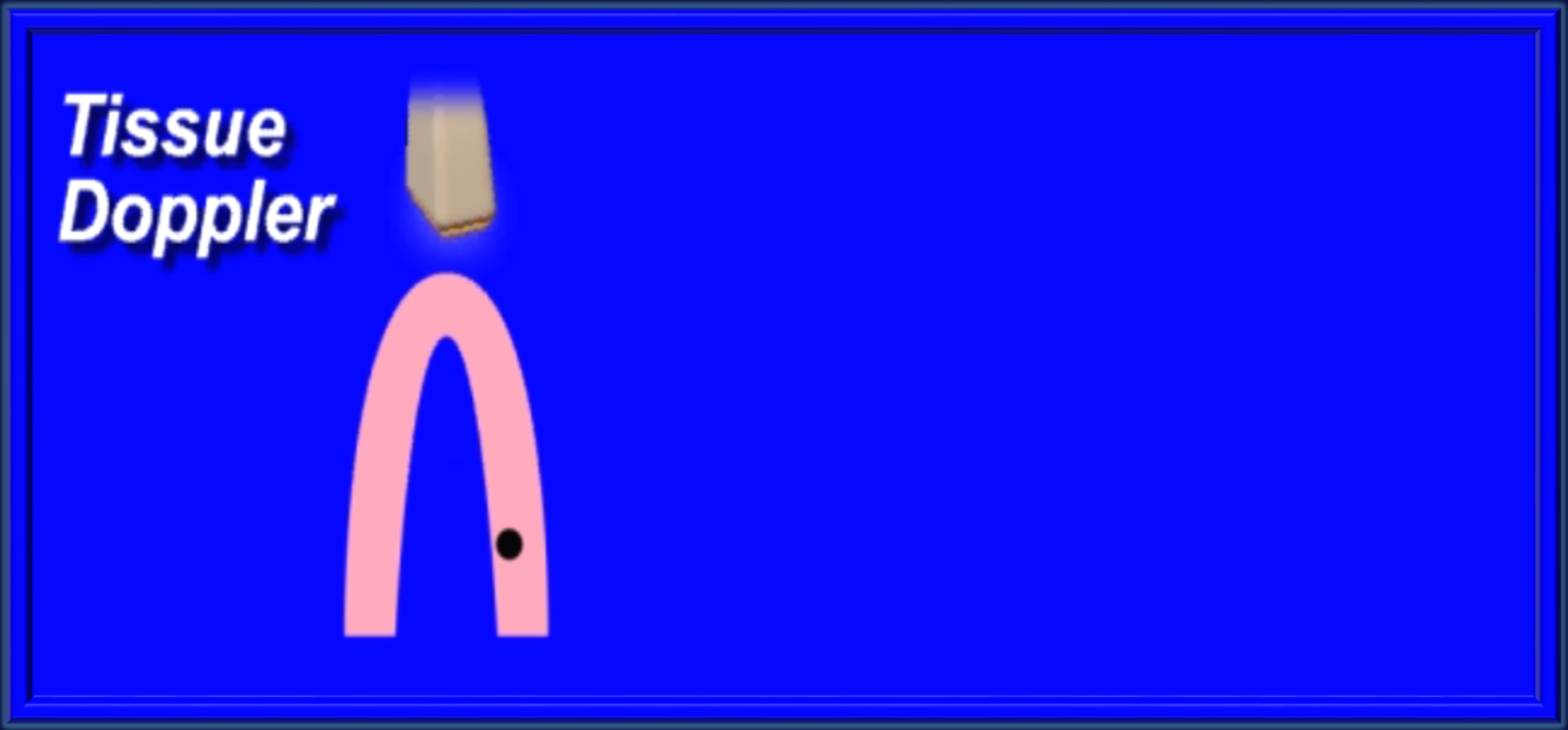
Trace no: 1 2 3

Curved M-mode : TVI



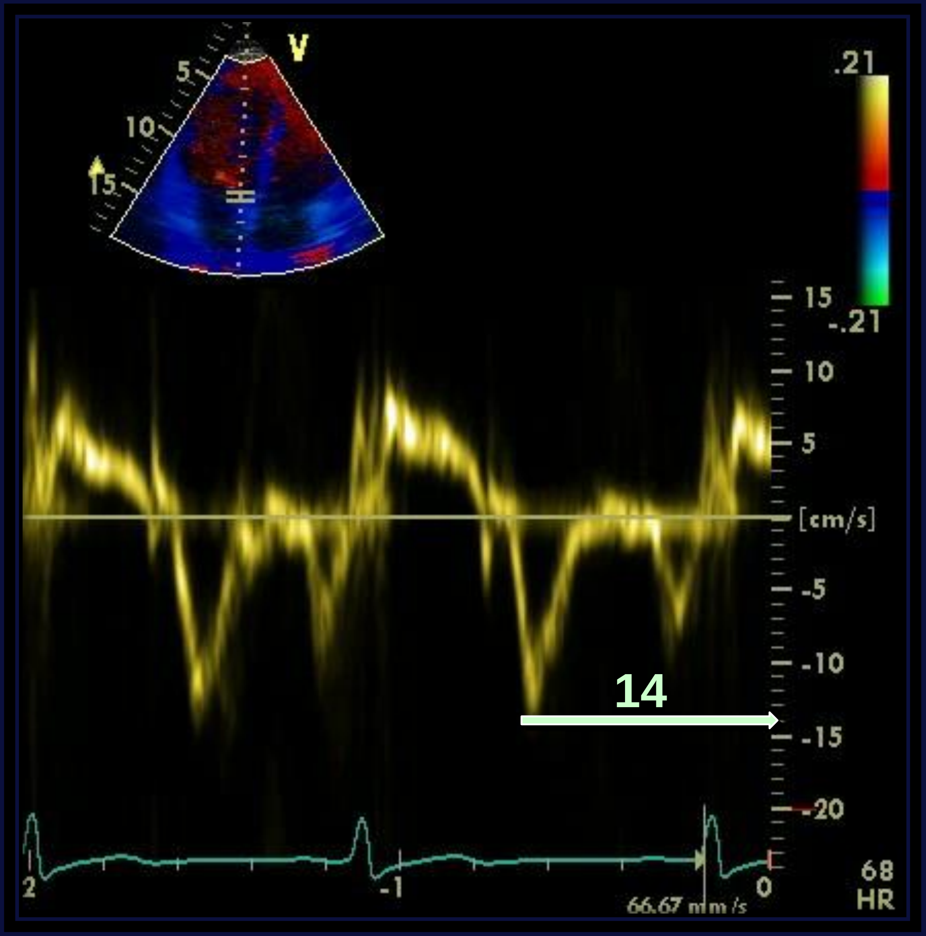
Goal

To Detect Regional Wall Motion



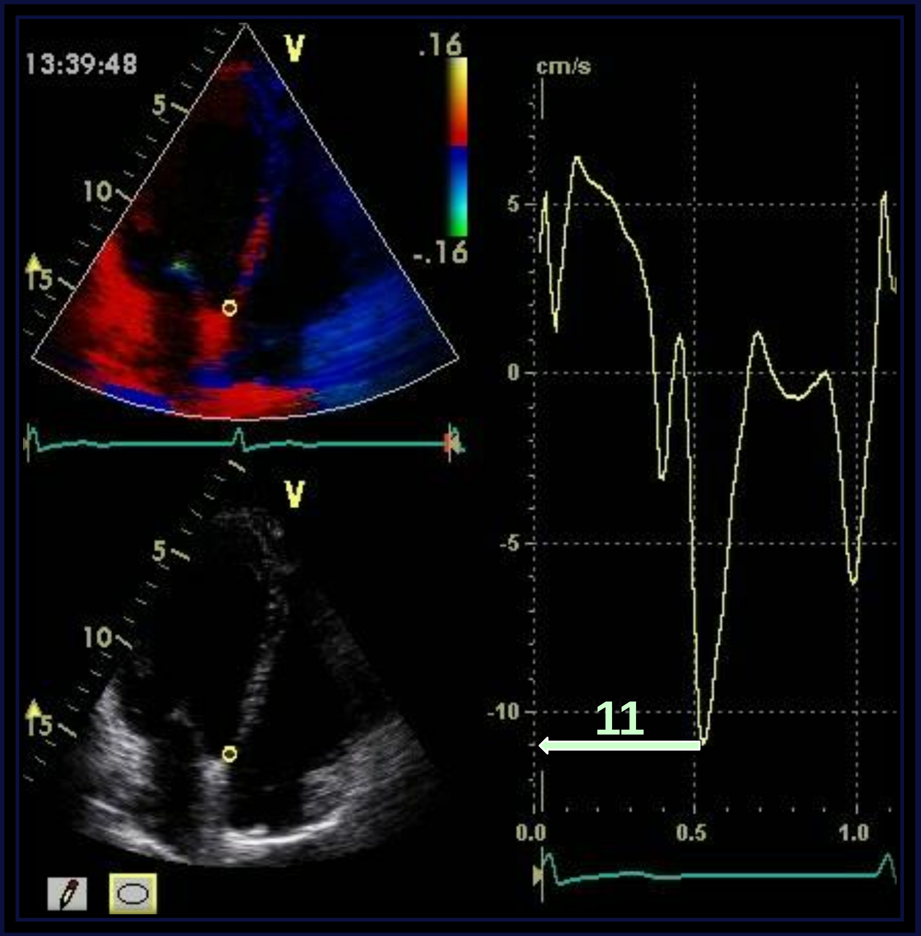
Pulsed TD

Peak Velocities



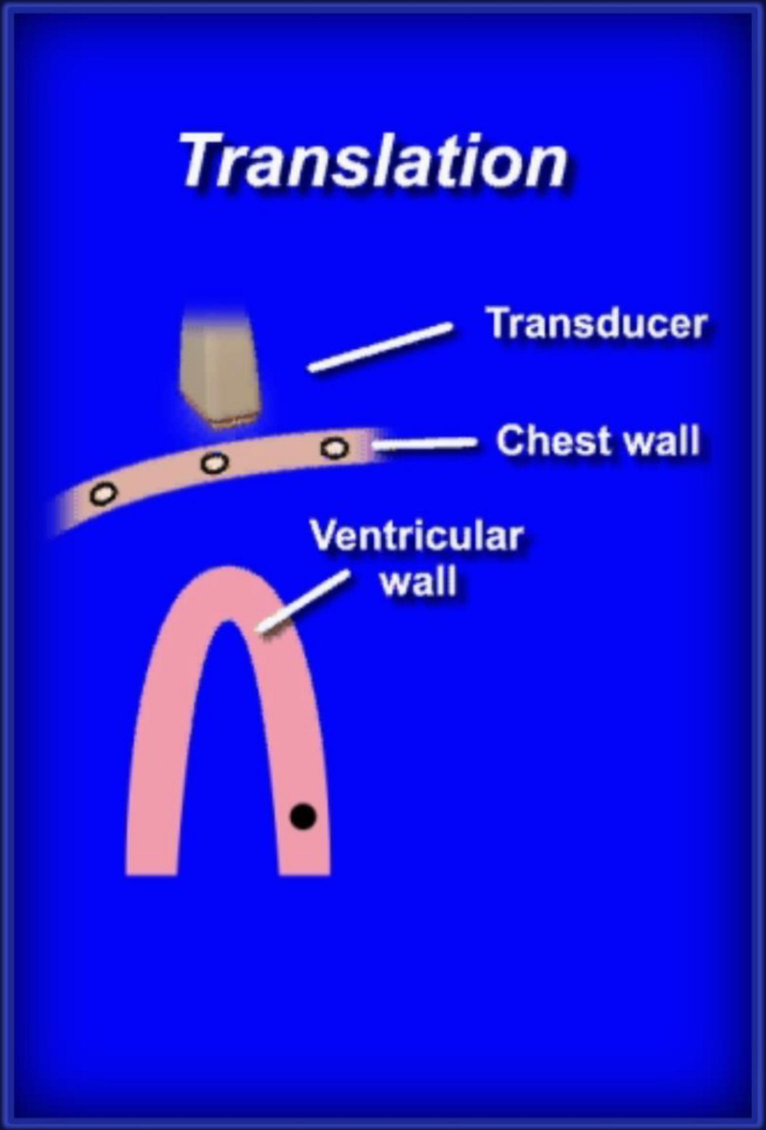
Color TD

Mean Velocities

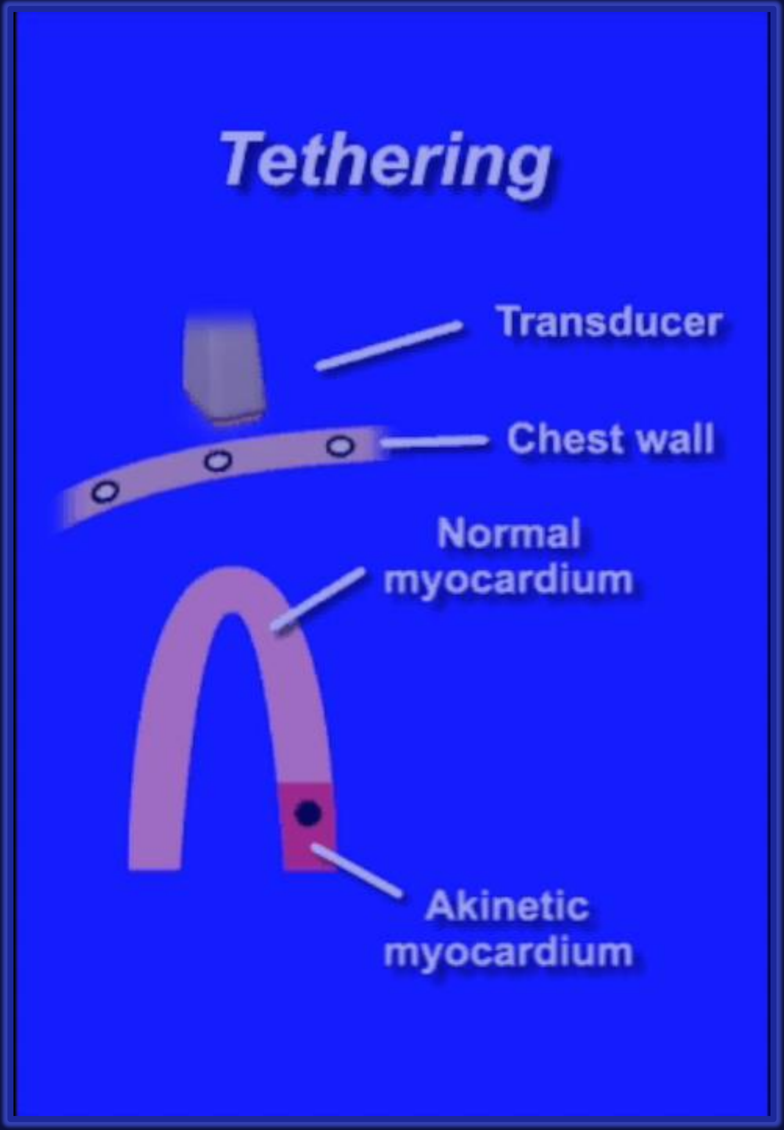


Pitfall (Velocity Analysis)

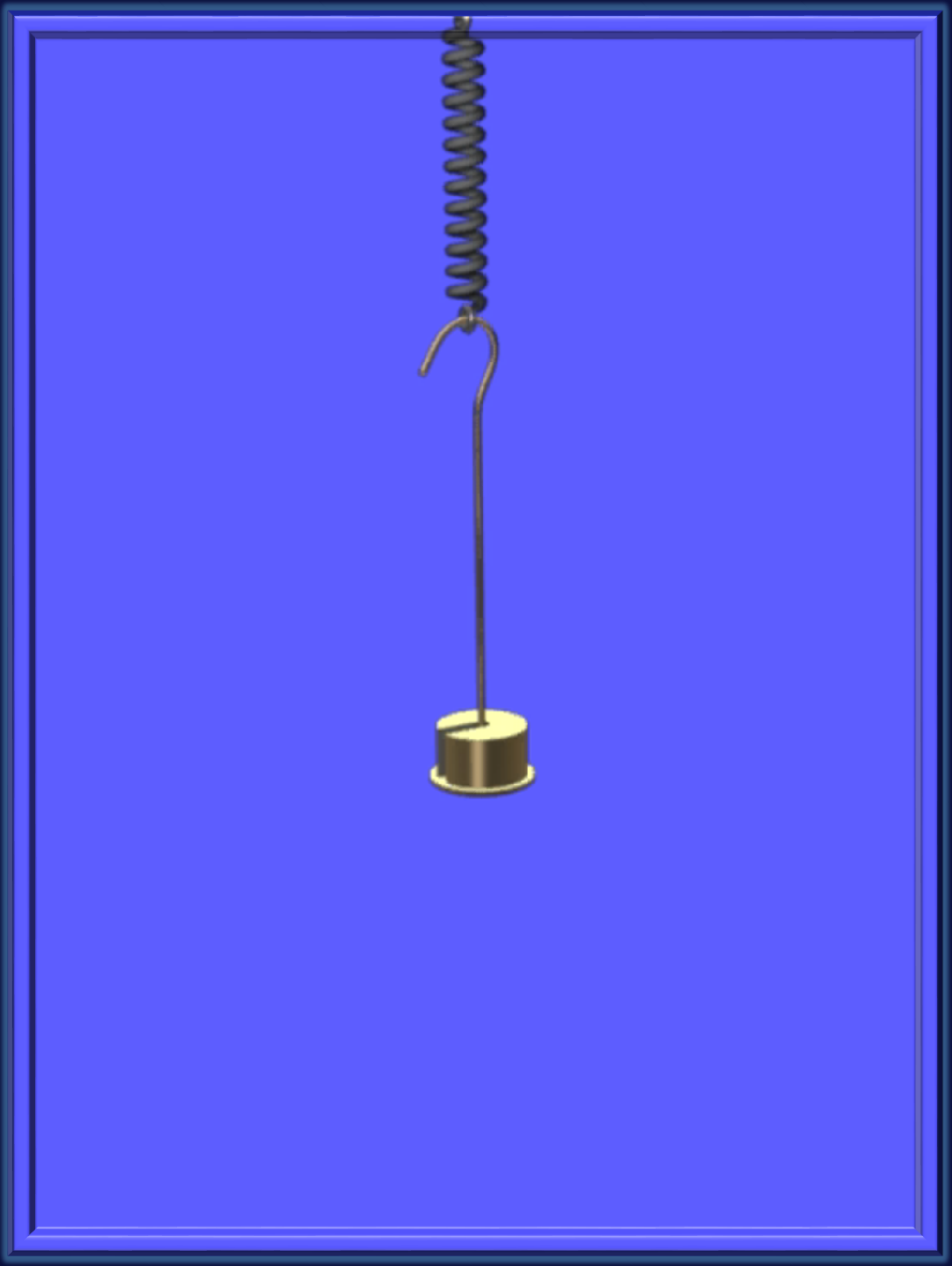
Translation and Tethering



Translation



Tethering



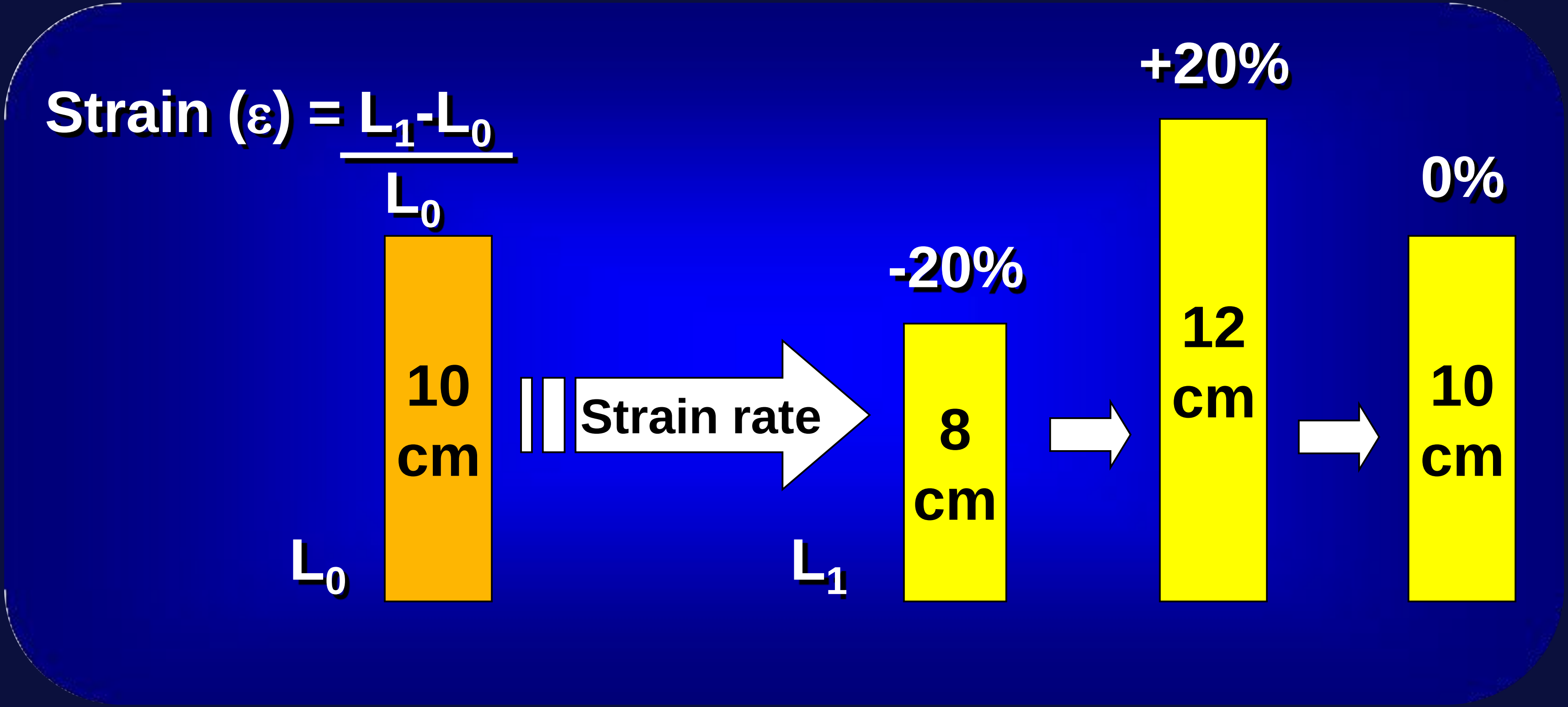
Strain = deformation resulting from applied force

Stress = force

Courtesy of Ted Abraham

Myocardial strain

Used to describe elastic properties of cardiac muscle (Mirsky and Parmley: Circ Res, 1973)



Strain (ε) = $\frac{L_1-L_0}{L_0}$

L_0 **10 cm**

Strain rate

-20% L_1 **8 cm**

+20% **12 cm**

0% **10 cm**

Strain rate:

Rate of deformation

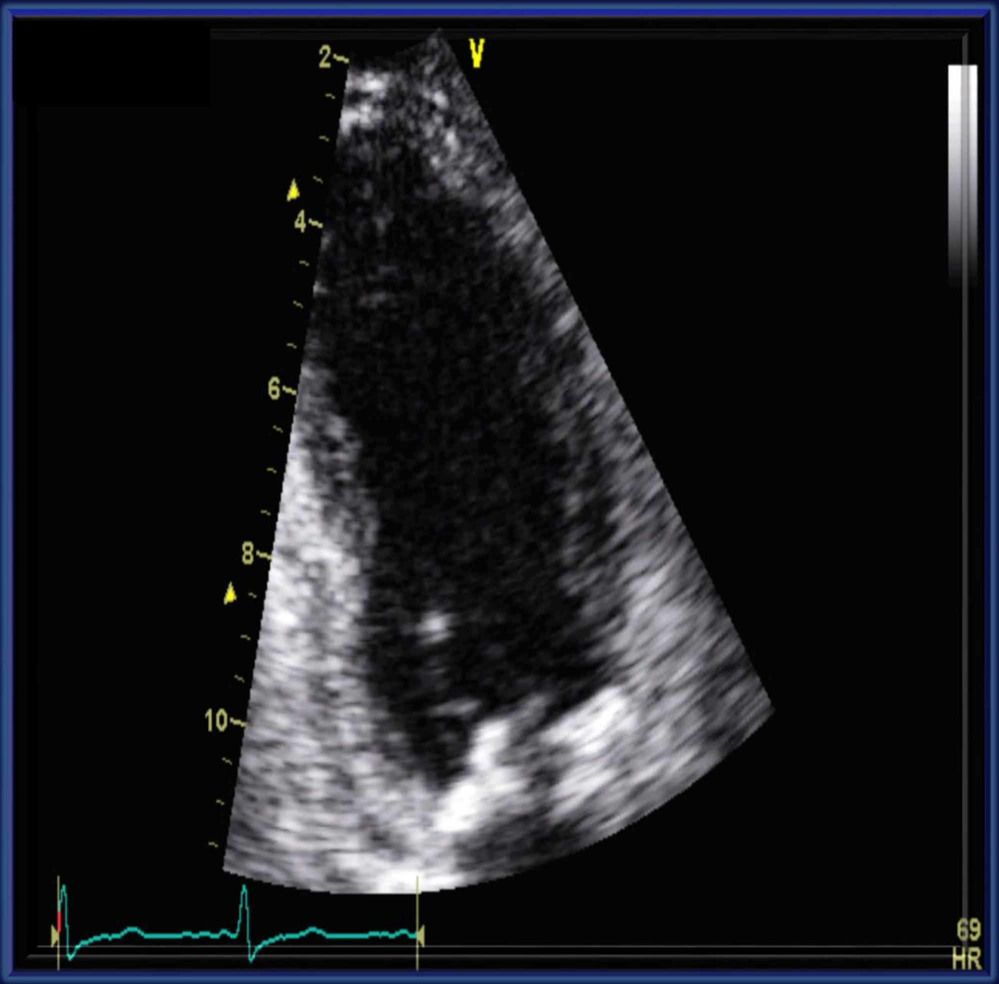
High strain rate

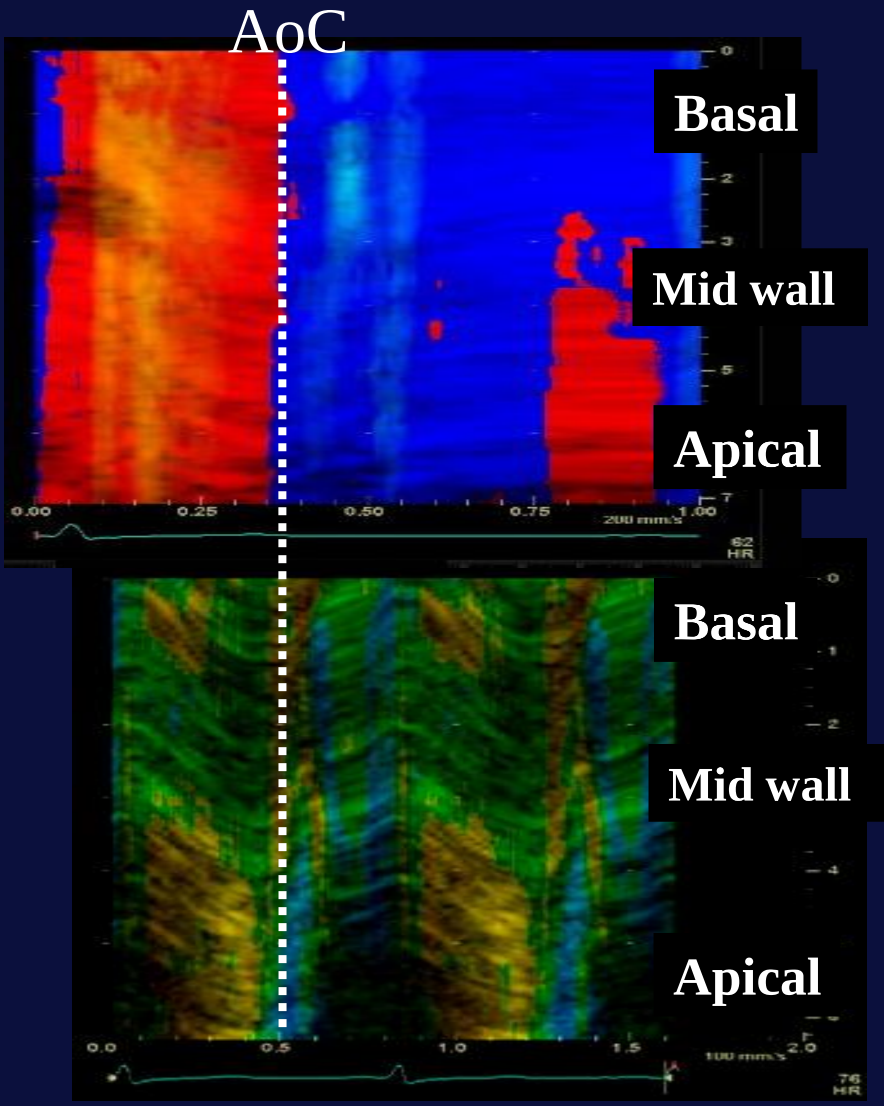
Low strain rate

Equal strain

Courtesy of Andreas Heimdal

Strain rate vs. Tissue Doppler





Feature “Speckle” Tracking

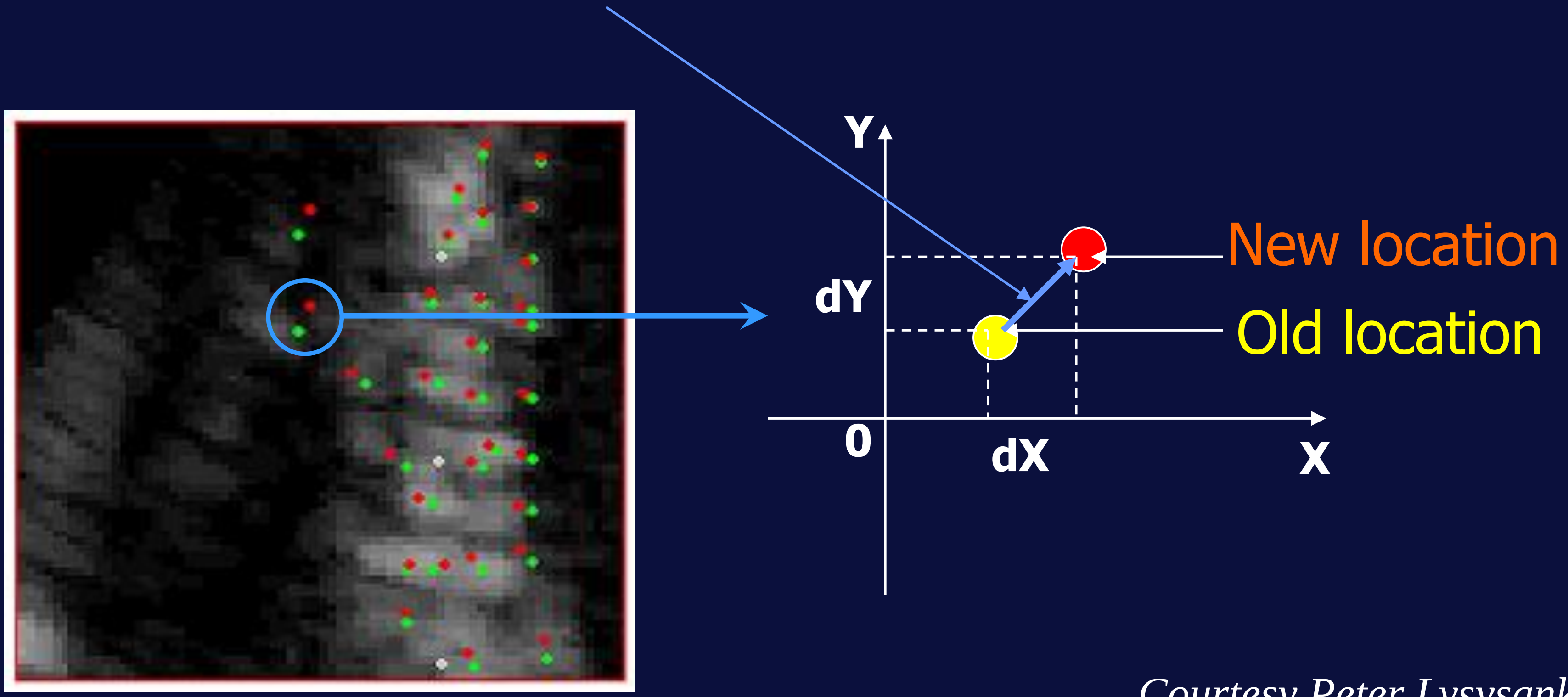
Doppler

Movement of the myocardium relative to the sample volume fixed in space

Acoustic pattern tracking
Speckle Tracking

Velocity is estimated as a shift of each object divided by time between successive frames (or multiplied by Frame Rate)-->

2D vector: (Vx, Vy) = (dX, dY) * FR



Courtesy Peter Lysysanksy

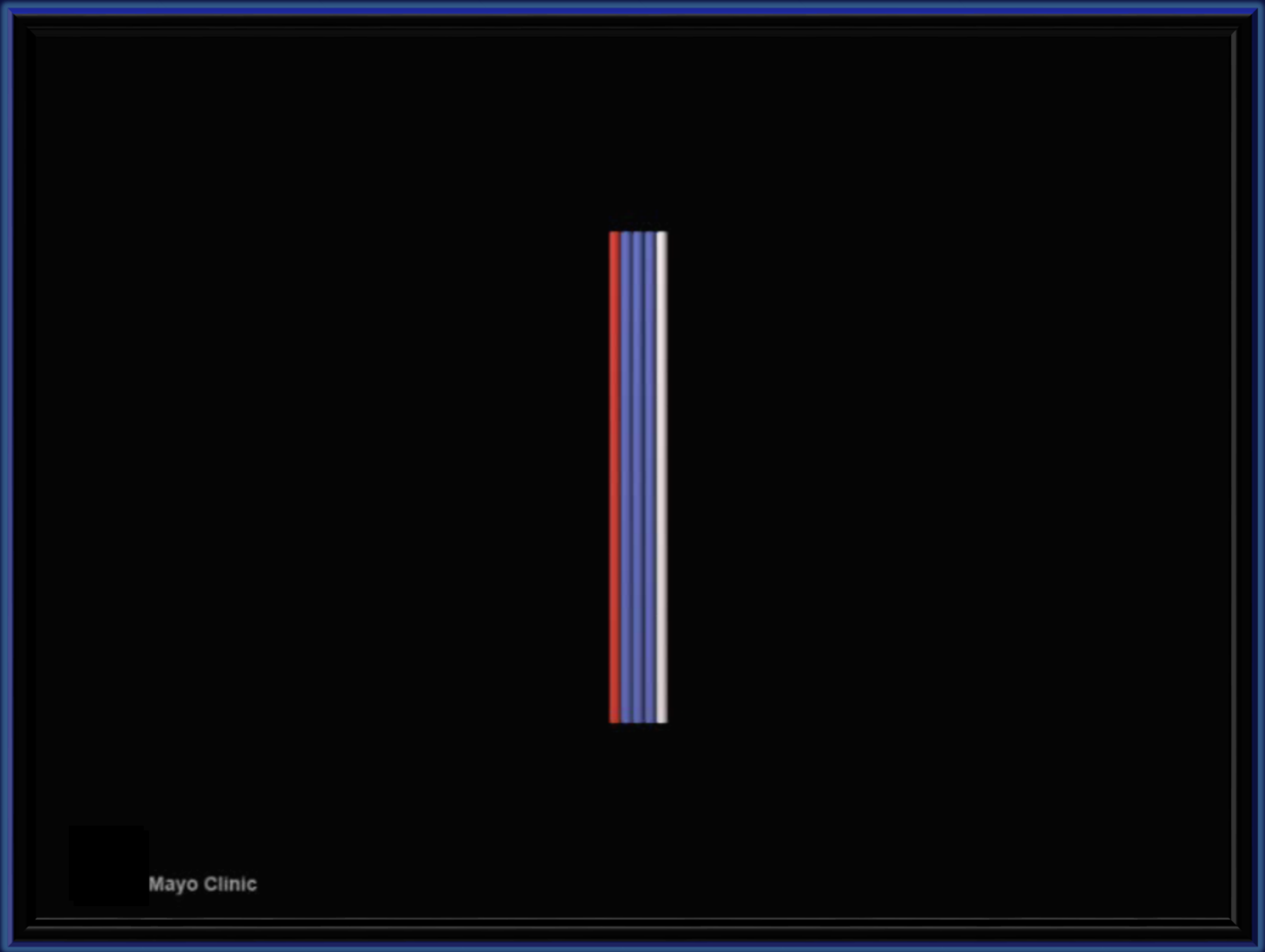
Doppler Independent Techniques (Speckle Tracking)

Potential Advantage?

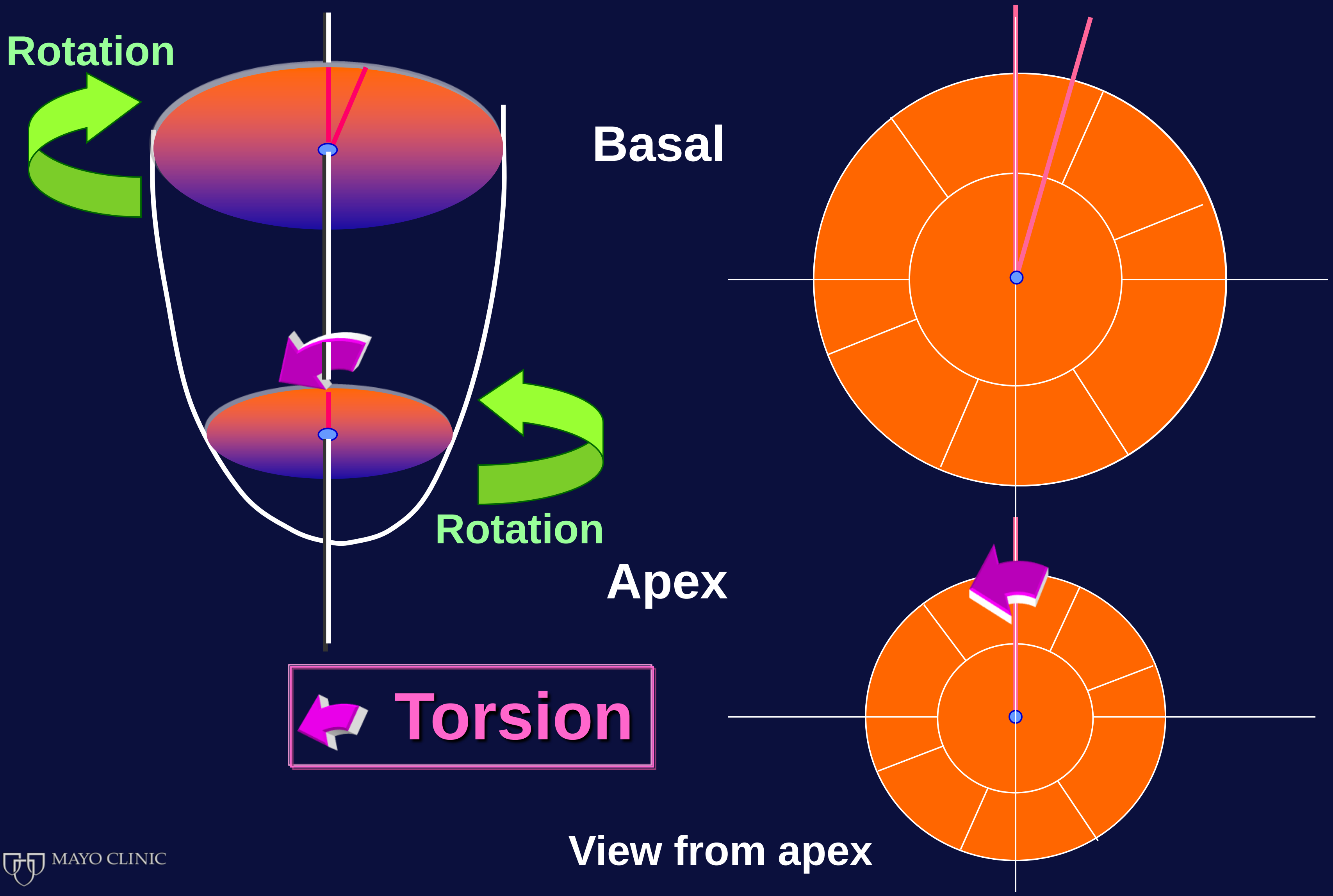
- Signal noise
- Speckle tracking by principle is angle independent
- Gray scale (standard views)
- Monitor strain in two rather than one dimension
- Minimal user input
- Assessment of rotation: derived from circumferential strain at different levels in the heart (NO fixed sample volume)

Myocardial Mechanics

Rotation/Twist/Torsion



Rotation and Torsion



Rotation

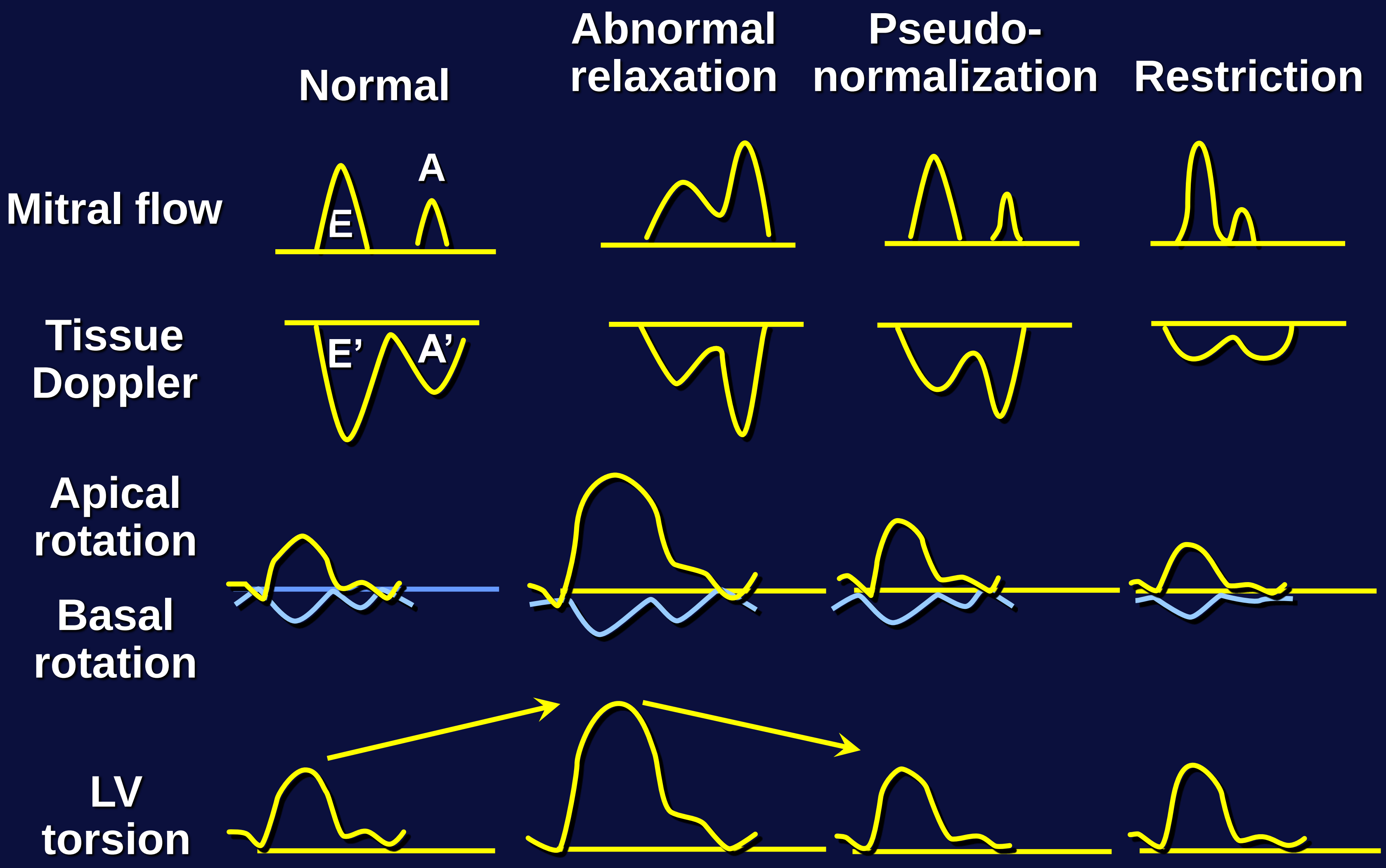
Basal

Rotation

Apex

Torsion

View from apex



Normal

Abnormal relaxation

Pseudo-normalization

Restriction

Mitral flow

Tissue Doppler

Apical rotation

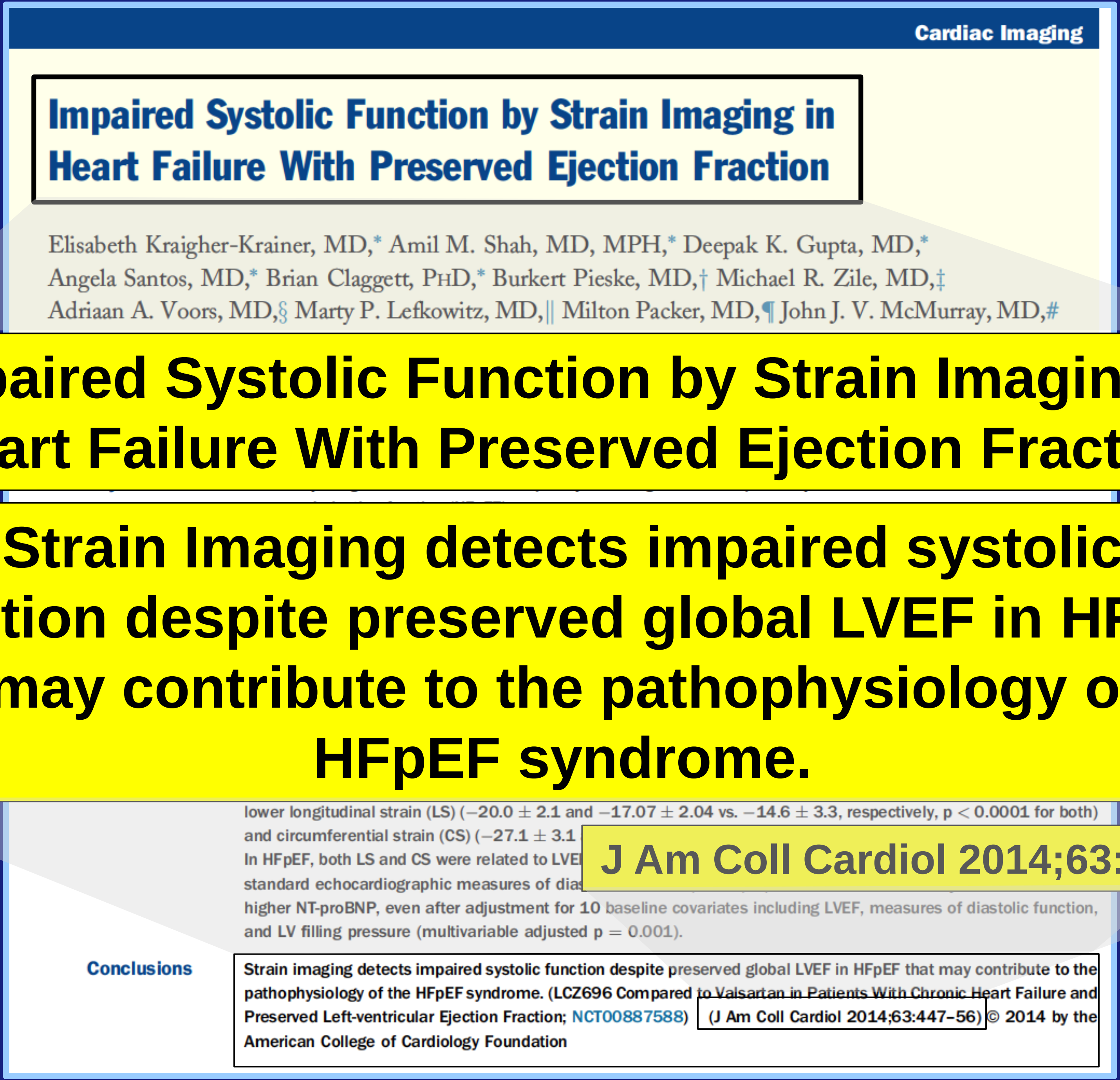
Basal rotation

LV torsion

Park et al: J Am Soc Echo Cardiogr 21:1129, 2008

Objective #2

Potential Clinical Applications



Cardiac Imaging

Impaired Systolic Function by Strain Imaging in Heart Failure With Preserved Ejection Fraction

Elisabeth Kraigher-Krainer, MD,* Amil M. Shah, MD, MPH,* Deepak K. Gupta, MD,*
Angela Santos, MD,* Brian Claggett, PHD,* Burkert Pieske, MD,† Michael R. Zile, MD,‡
Adriaan A. Voors, MD,§ Marty P. Lefkowitz, MD,|| Milton Packer, MD,¶ John J. V. McMurray, MD,#

lower longitudinal strain (LS) (−20.0 ± 2.1 and −17.07 ± 2.04 vs. −14.6 ± 3.3, respectively, $p < 0.0001$ for both)
and circumferential strain (CS) (−27.1 ± 3.1
In HFpEF, both LS and CS were related to LVE
standard echocardiographic measures of dias
higher NT-proBNP, even after adjustment for 10 baseline covariates including LVEF, measures of diastolic function, and LV filling pressure (multivariable adjusted $p = 0.001$).

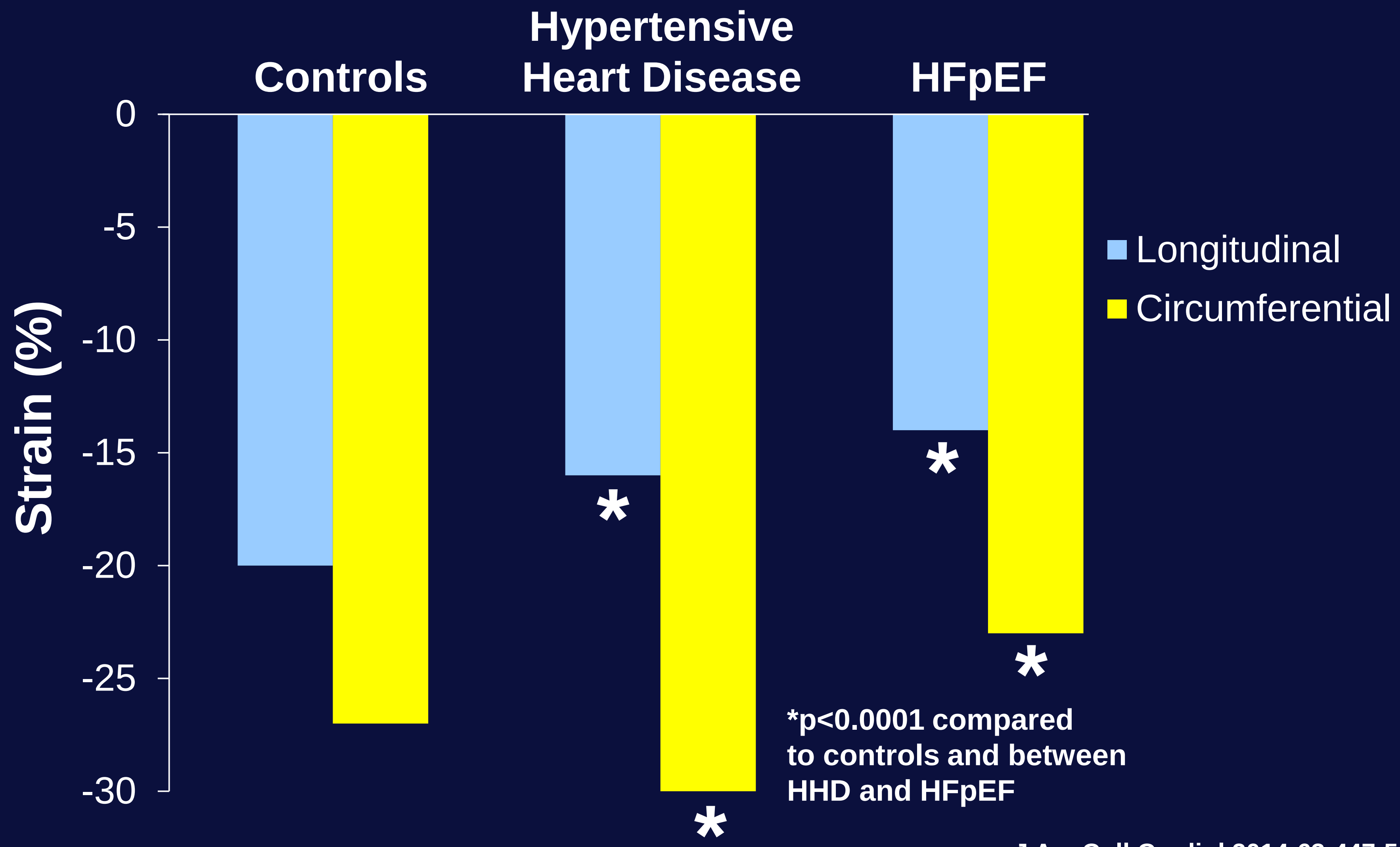
Conclusions Strain imaging detects impaired systolic function despite preserved global LVEF in HFpEF that may contribute to the pathophysiology of the HFpEF syndrome. (LCZ696 Compared to Valsartan in Patients With Chronic Heart Failure and Preserved Left-ventricular Ejection Fraction; NCT00887588) (J Am Coll Cardiol 2014;63:447–56) © 2014 by the American College of Cardiology Foundation

Impaired Systolic Function by Strain Imaging in Heart Failure With Preserved Ejection Fraction

Strain Imaging detects impaired systolic function despite preserved global LVEF in HFpEF that may contribute to the pathophysiology of the HFpEF syndrome.

J Am Coll Cardiol 2014;63:447-56

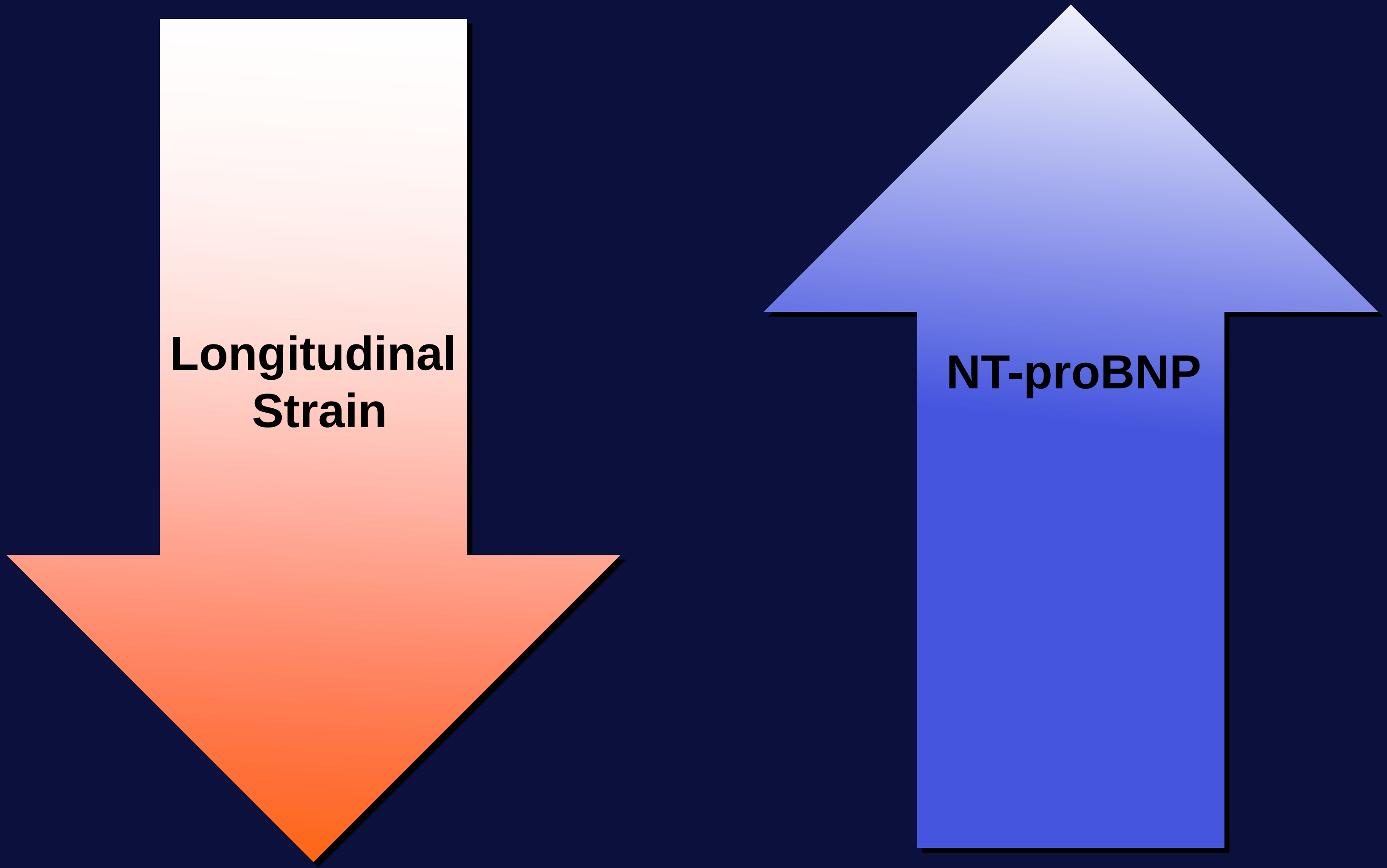
Average Longitudinal and Circumferential Systolic Strain



*p<0.0001 compared to controls and between HHD and HFpEF

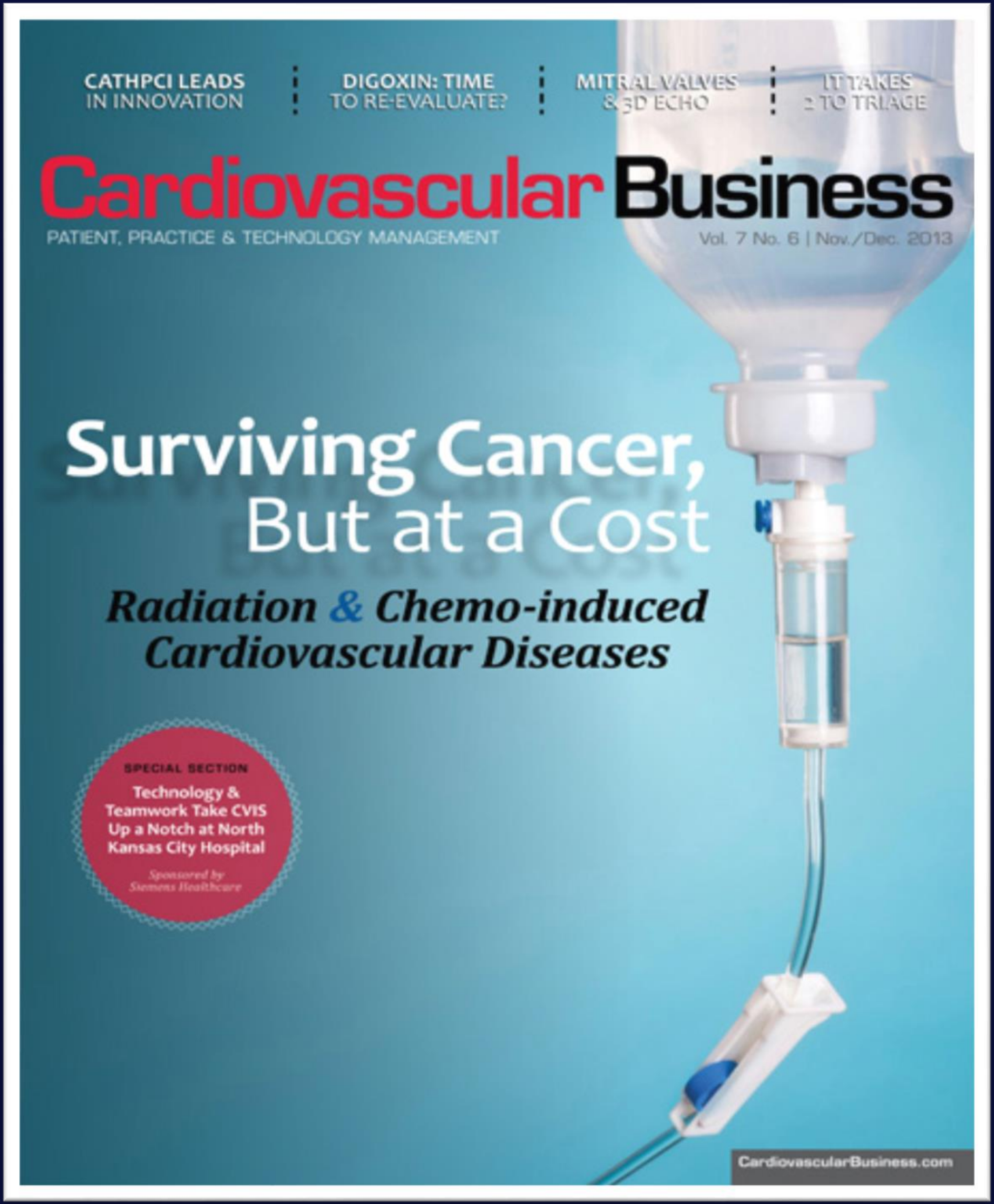
J Am Coll Cardiol 2014;63:447-56

Association of Longitudinal Systolic Strain and NT-proBNP



Longitudinal Strain

NT-proBNP



CATHPCI LEADS IN INNOVATION

DIGOXIN: TIME TO RE-EVALUATE?

MITRAL VALVES & 3D ECHO

IT TAKES 2 TO TRIAGE

Cardiovascular Business

PATIENT, PRACTICE & TECHNOLOGY MANAGEMENT

Vol. 7 No. 6 | Nov./Dec. 2013

Surviving Cancer, But at a Cost

Radiation & Chemo-induced Cardiovascular Diseases

SPECIAL SECTION

Technology & Teamwork Take CVIS Up a Notch at North Kansas City Hospital

Sponsored by Siemens Healthcare

CardiovascularBusiness.com

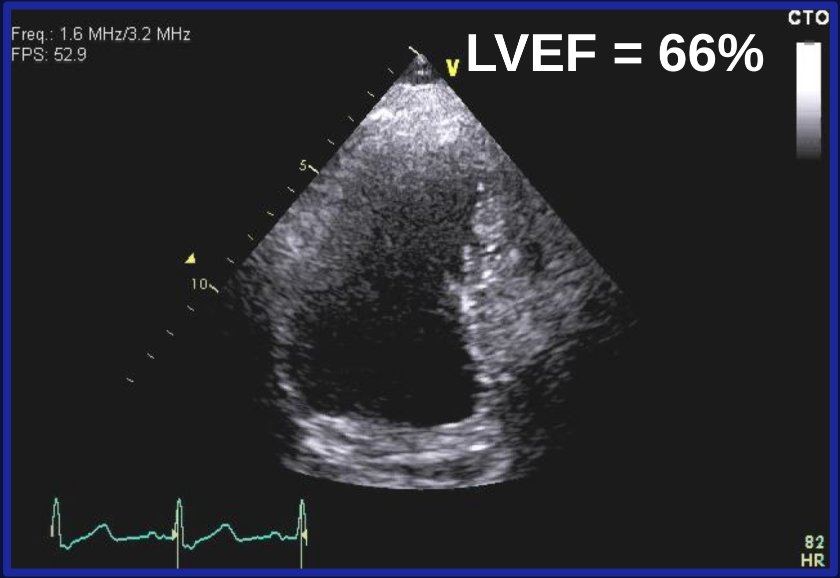
Cardio-Oncology

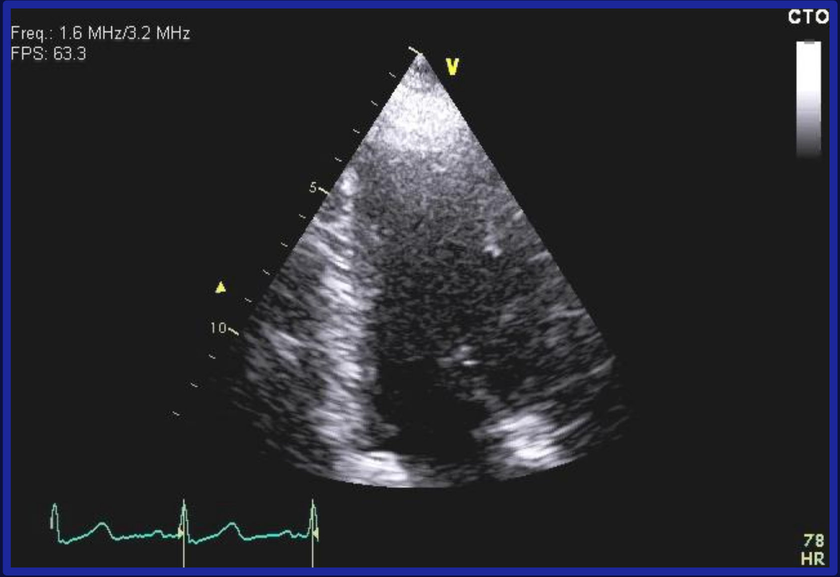
"The difficulty when dealing with cardiology side effects is that they can often mask themselves as normal effects from the cancer treatment itself..."

Case

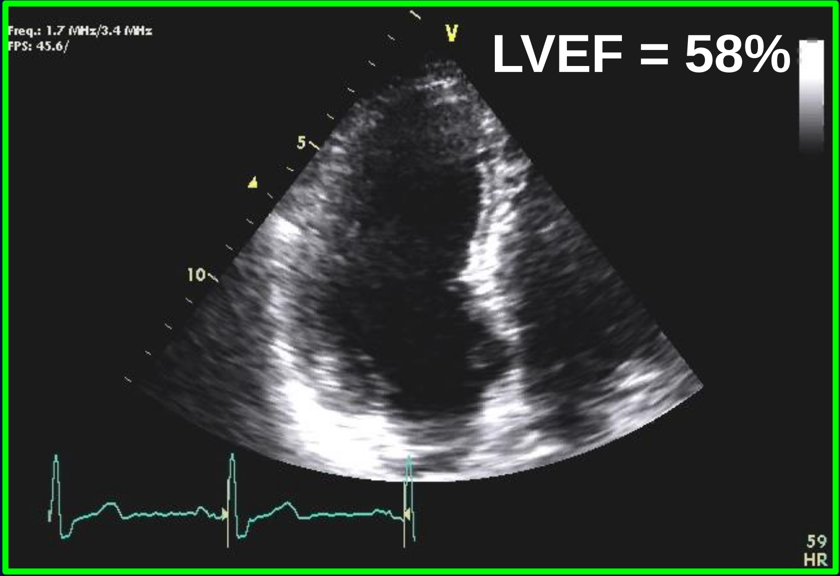
- 76 year old male
- CMML/MDS with associated myeloid sarcoma skin lesions
- Experimental Chemotherapy ABT-348

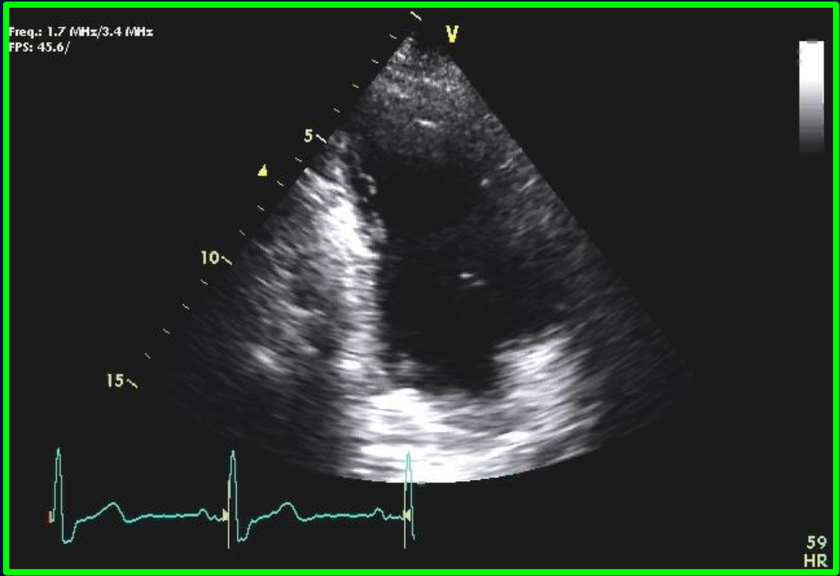
Baseline


LVEF = 66%



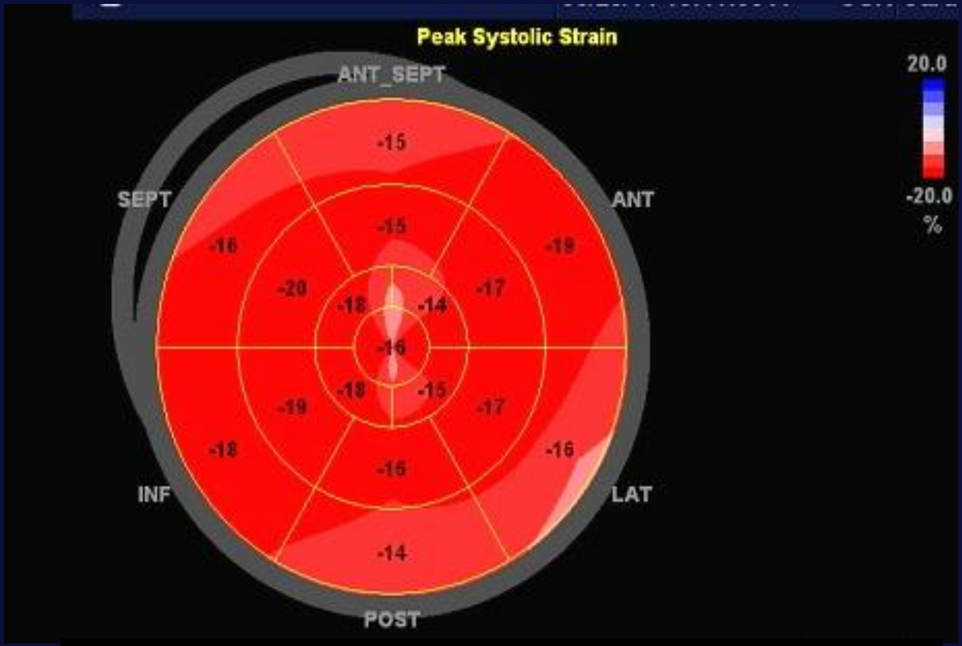
2 Months


LVEF = 58%



Baseline

LVEF = 66%

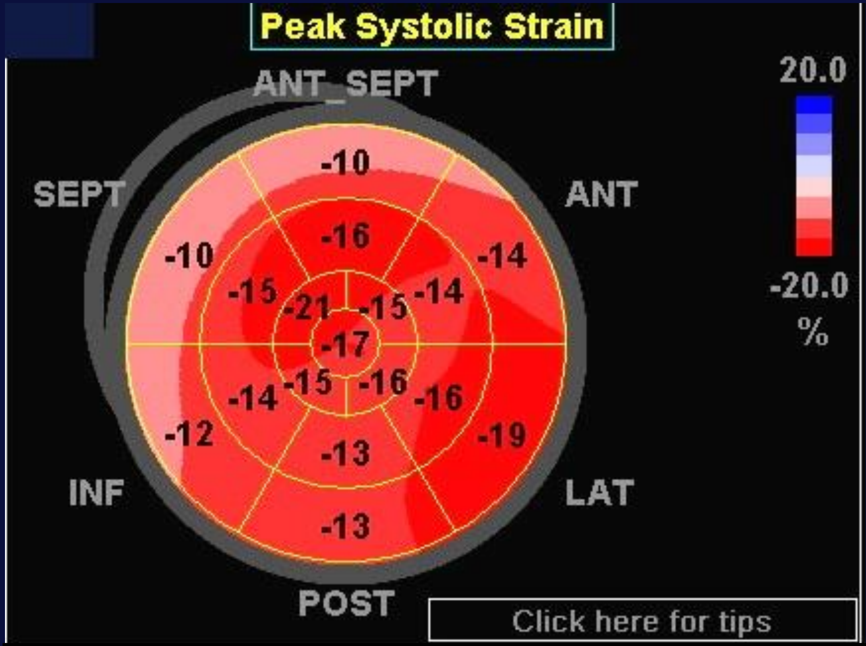


GLPSS Avg = -17.8%

Troponin T = 0.02

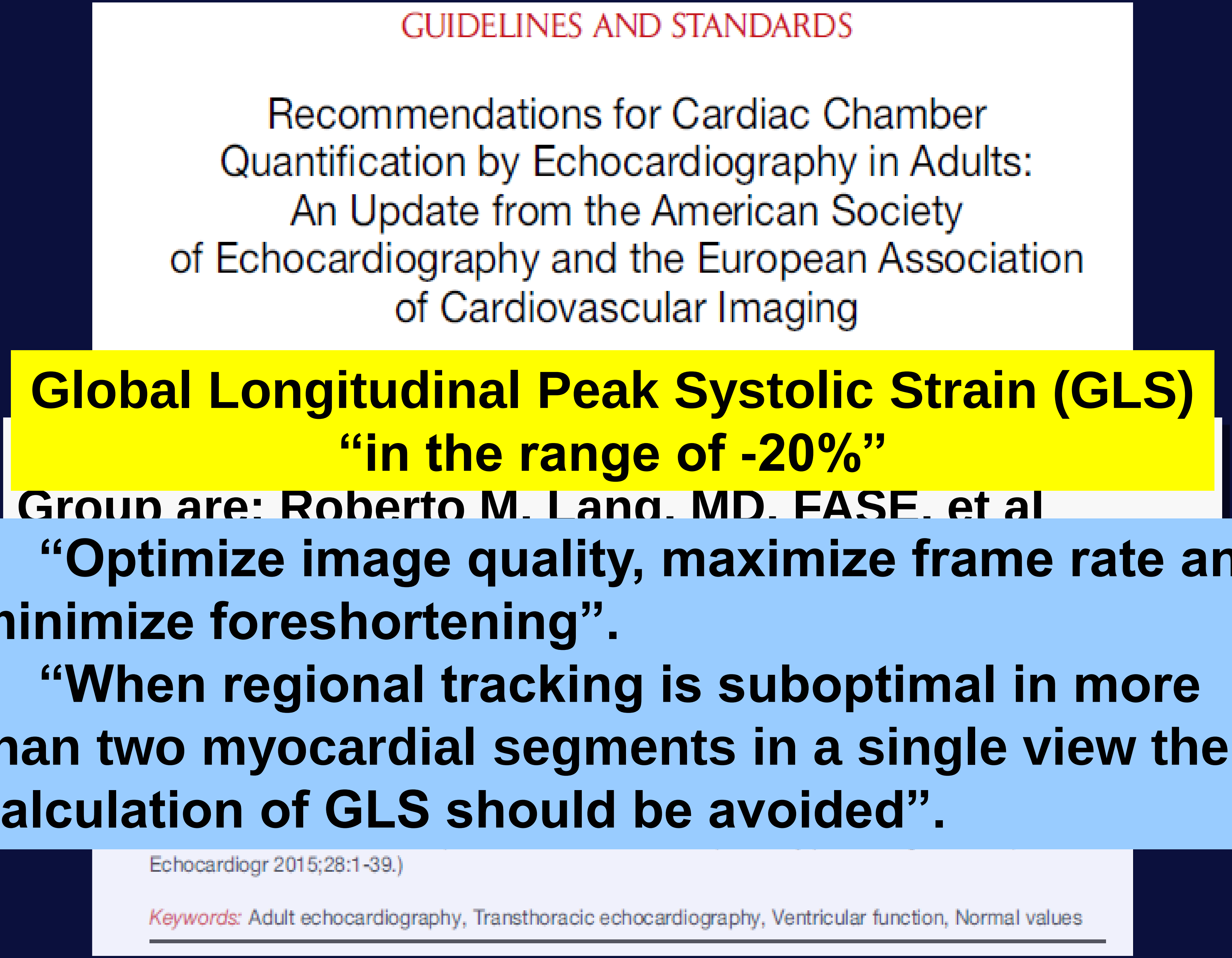
2 Months

LVEF = 58%



GLPSS Avg = -14.3%

Troponin T = 0.03



GUIDELINES AND STANDARDS

Recommendations for Cardiac Chamber Quantification by Echocardiography in Adults: An Update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging

Global Longitudinal Peak Systolic Strain (GLS)
“in the range of -20%”

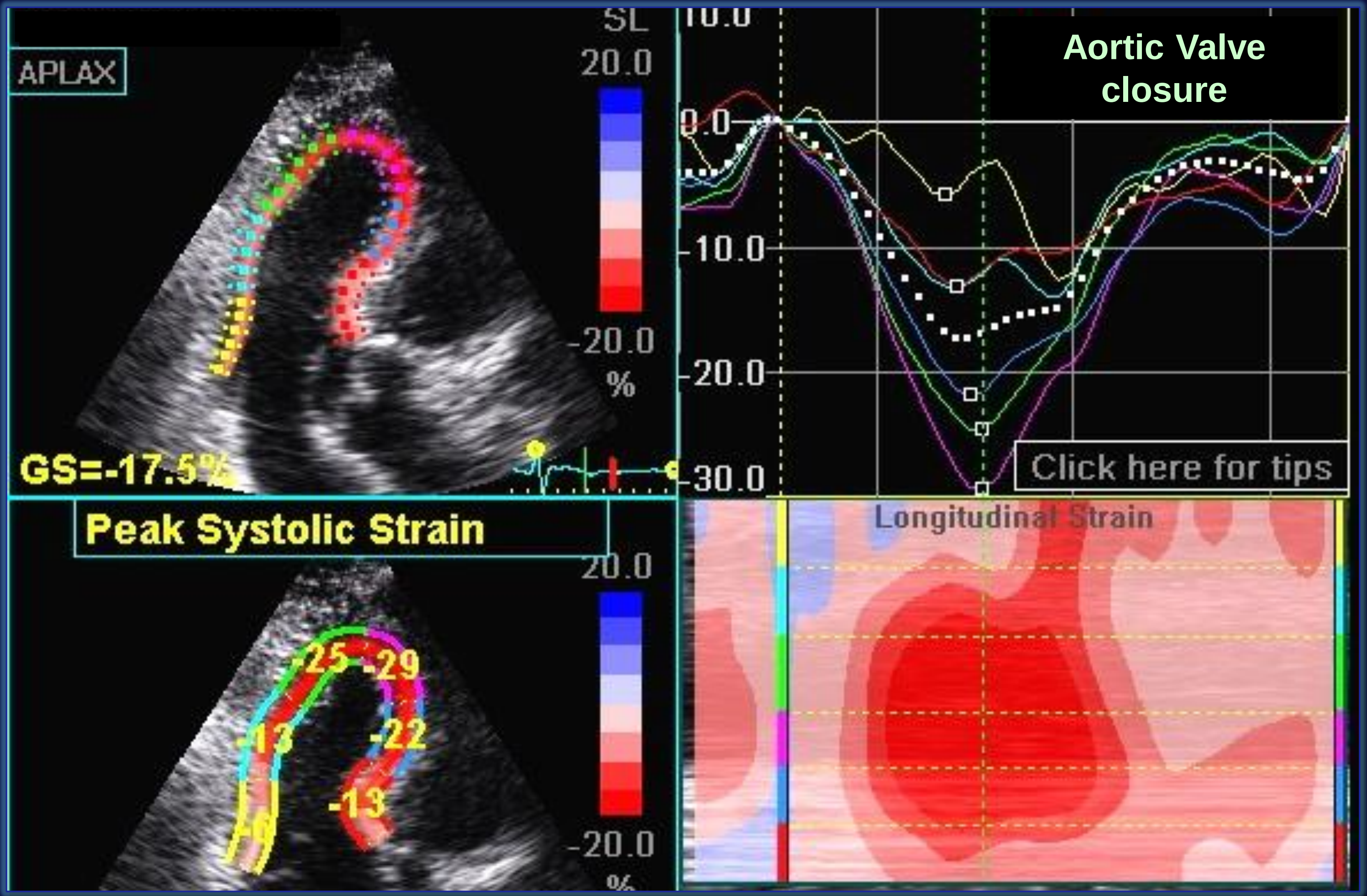
Group are: Roberto M. Lang, MD, FASE, et al

- **“Optimize image quality, maximize frame rate and minimize foreshortening”.**
- **“When regional tracking is suboptimal in more than two myocardial segments in a single view the calculation of GLS should be avoided”.**

Echocardiogr 2015;28:1-39.)

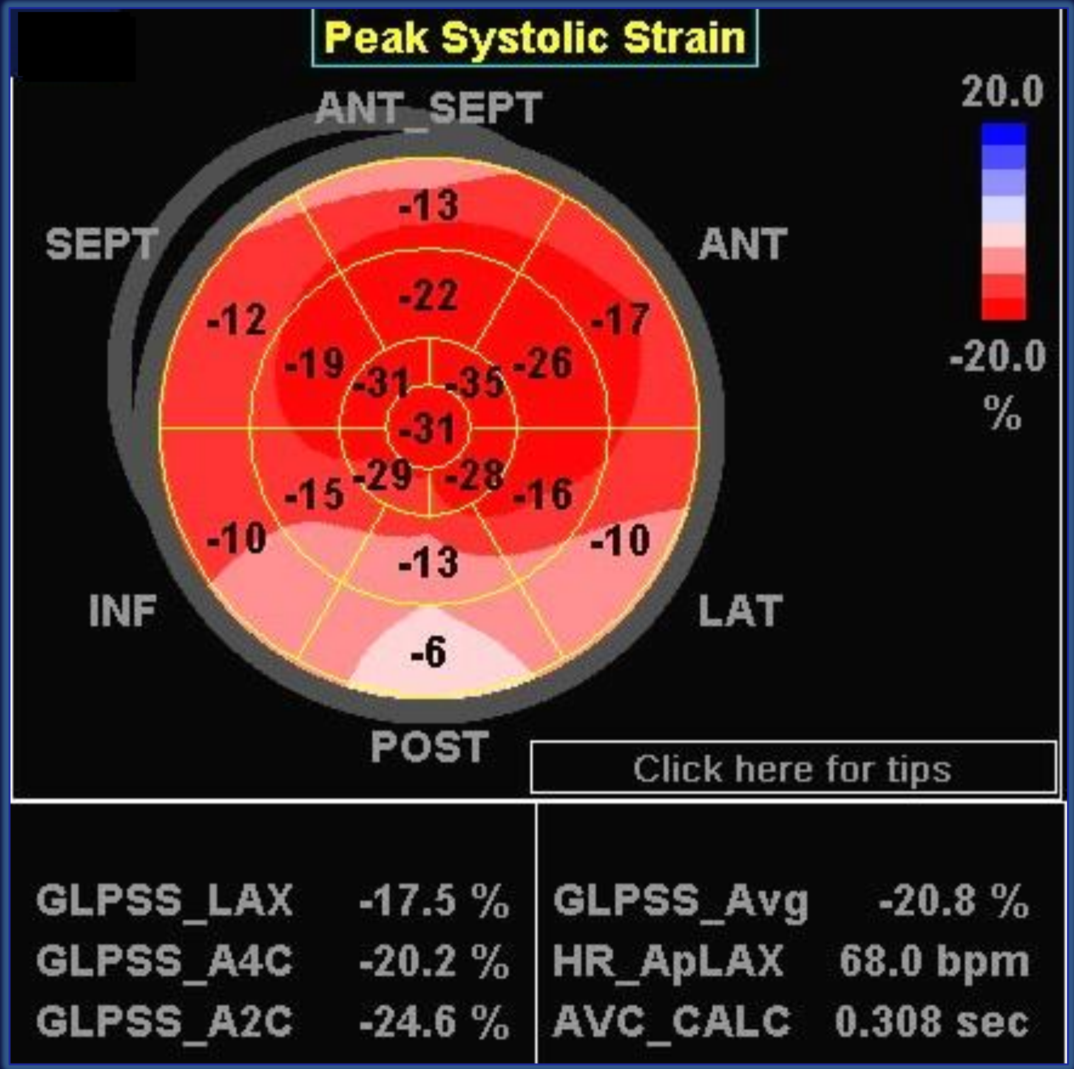
Keywords: Adult echocardiography, Transthoracic echocardiography, Ventricular function, Normal values

Timing: Peak Systole?



Aortic Valve closure

Global Longitudinal Peak Systolic Strain

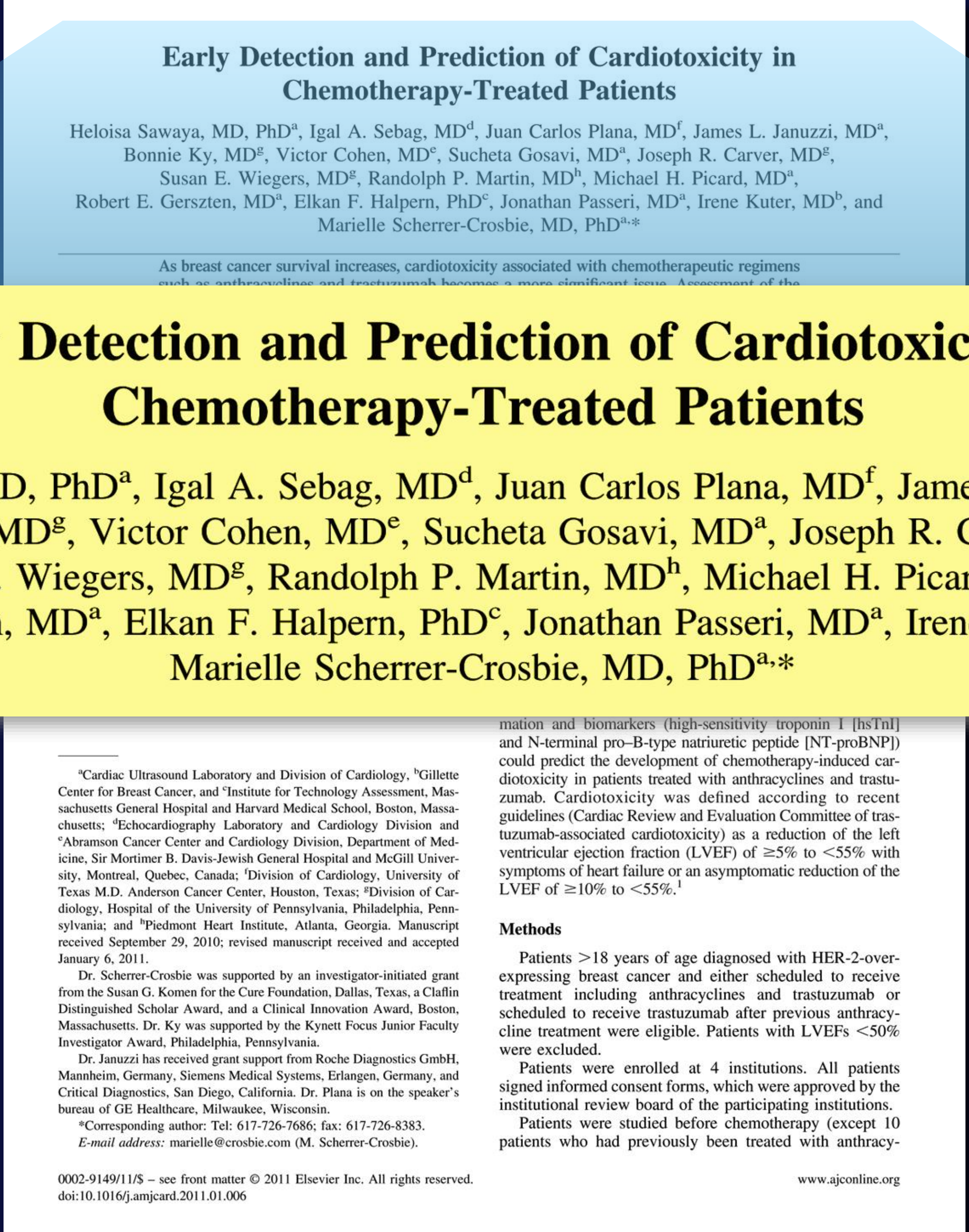

[redacted]

Peak Systolic Strain

GLPSS_LAX	-17.5 %	GLPSS_Avg	-20.8 %
GLPSS_A4C	-20.2 %	HR_ApLAX	68.0 bpm
GLPSS_A2C	-24.6 %	AVC_CALC	0.308 sec

Early Detection and Prediction of Cardiotoxicity in Chemotherapy-Treated Patients

Heloisa Sawaya, MD, PhD[a], Igal A. Sebag, MD[d], Juan Carlos Plana, MD[f], James L. Januzzi, MD[a],
Bonnie Ky, MD[g], Victor Cohen, MD[e], Sucheta Gosavi, MD[a], Joseph R. Carver, MD[g],
Susan E. Wiegers, MD[g], Randolph P. Martin, MD[h], Michael H. Picard, MD[a],
Robert E. Gerszten, MD[a], Elkan F. Halpern, PhD[c], Jonathan Passeri, MD[a], Irene Kuter, MD[b], and
Marielle Scherrer-Crosbie, MD, PhD[a,*]



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Chemotherapy-Treated Patients

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Robert E. Gerszten, MD[a], Elkan F. Halpern, PhD[c], Jonathan Passeri, MD[a], Irene Kuter, MD[b], and
Marielle Scherrer-Crosbie, MD, PhD[a,*]

As breast cancer survival increases, cardiotoxicity associated with chemotherapeutic regimens such as anthracyclines and trastuzumab becomes a more significant issue. Assessment of the

mation and biomarkers (high-sensitivity troponin I [hsTnI] and N-terminal pro–B-type natriuretic peptide [NT-proBNP]) could predict the development of chemotherapy-induced cardiotoxicity in patients treated with anthracyclines and trastuzumab. Cardiotoxicity was defined according to recent guidelines (Cardiac Review and Evaluation Committee of trastuzumab-associated cardiotoxicity) as a reduction of the left ventricular ejection fraction (LVEF) of ≥5% to <55% with symptoms of heart failure or an asymptomatic reduction of the LVEF of ≥10% to <55%.[1]

Methods

Patients >18 years of age diagnosed with HER-2-overexpressing breast cancer and either scheduled to receive treatment including anthracyclines and trastuzumab or scheduled to receive trastuzumab after previous anthracycline treatment were eligible. Patients with LVEFs <50% were excluded.

Patients were enrolled at 4 institutions. All patients signed informed consent forms, which were approved by the institutional review board of the participating institutions.

Patients were studied before chemotherapy (except 10 patients who had previously been treated with anthracy-

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[a]Cardiac Ultrasound Laboratory and Division of Cardiology, [b]Gillette Center for Breast Cancer, and [c]Institute for Technology Assessment, Massachusetts General Hospital and Harvard Medical School, Boston, Massachusetts; [d]Echocardiography Laboratory and Cardiology Division and [e]Abramson Cancer Center and Cardiology Division, Department of Medicine, Sir Mortimer B. Davis-Jewish General Hospital and McGill University, Montreal, Quebec, Canada; [f]Division of Cardiology, University of Texas M.D. Anderson Cancer Center, Houston, Texas; [g]Division of Cardiology, Hospital of the University of Pennsylvania, Philadelphia, Pennsylvania; and [h]Piedmont Heart Institute, Atlanta, Georgia. Manuscript received September 29, 2010; revised manuscript received and accepted January 6, 2011.

Dr. Scherrer-Crosbie was supported by an investigator-initiated grant from the Susan G. Komen for the Cure Foundation, Dallas, Texas, a Claflin Distinguished Scholar Award, and a Clinical Innovation Award, Boston, Massachusetts. Dr. Ky was supported by the Kynett Focus Junior Faculty Investigator Award, Philadelphia, Pennsylvania.

Dr. Januzzi has received grant support from Roche Diagnostics GmbH, Mannheim, Germany, Siemens Medical Systems, Erlangen, Germany, and Critical Diagnostics, San Diego, California. Dr. Plana is on the speaker's bureau of GE Healthcare, Milwaukee, Wisconsin.

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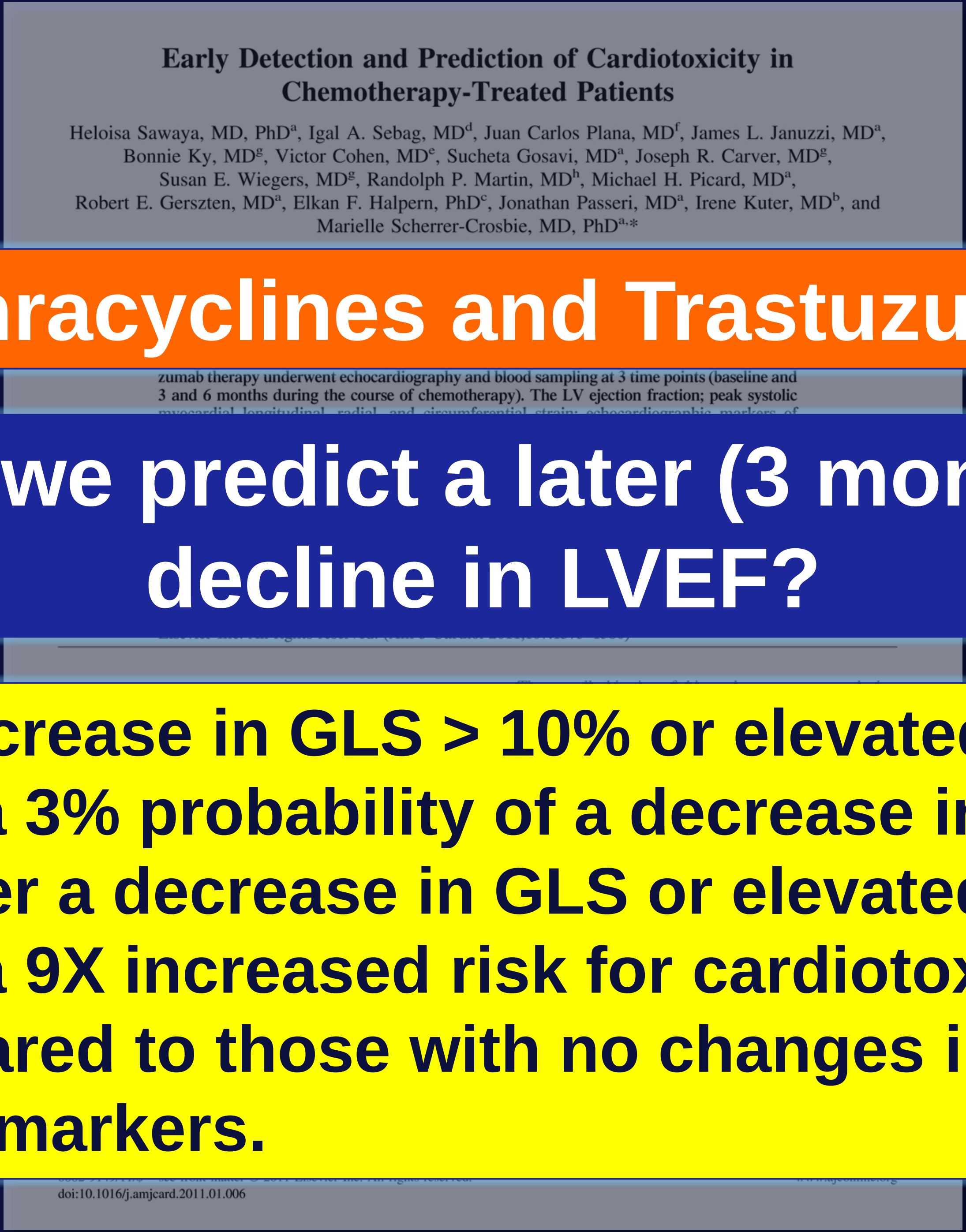
doi:10.1016/j.amjcard.2011.01.006



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zumab therapy underwent echocardiography and blood sampling at 3 time points (baseline and 3 and 6 months during the course of chemotherapy). The LV ejection fraction; peak systolic

doi:10.1016/j.amjcard.2011.01.006

Anthracyclines and Trastuzumab

Can we predict a later (3 months) decline in LVEF?

- **No decrease in GLS > 10% or elevated hsTnI have a 3% probability of a decrease in LVEF.**
- **If either a decrease in GLS or elevated hsTnI have a 9X increased risk for cardiotoxicity compared to those with no changes in either of these markers.**

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

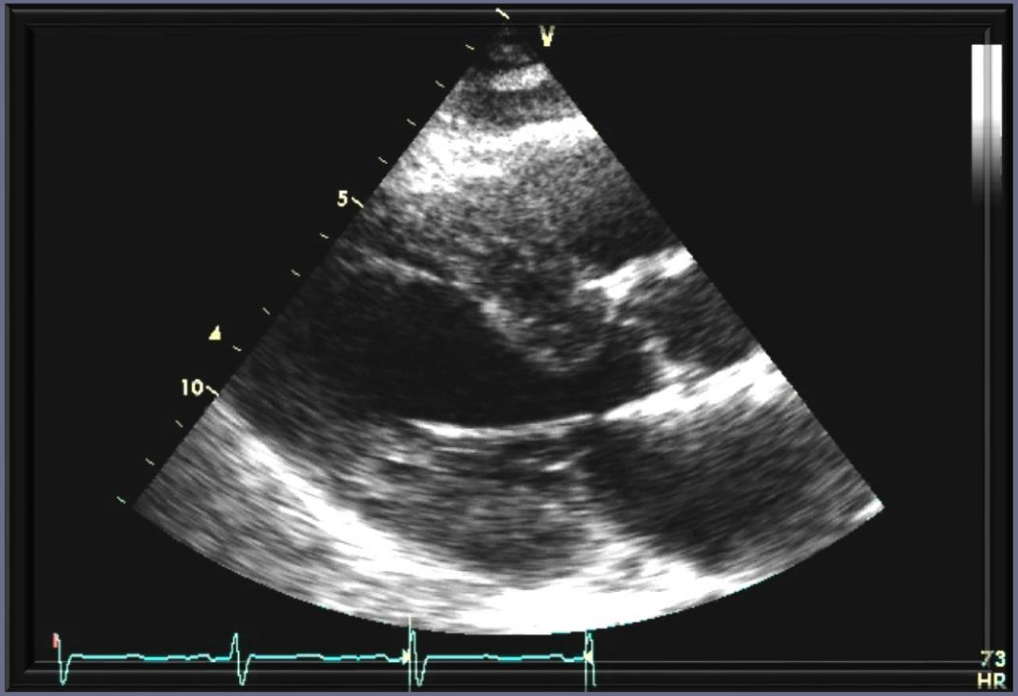
- CRTCD if decrease in LVEF >10% to a value <53%

- GLS is the optimal parameter of deformation for the early detection of subclinical LV dysfunction.
- In patients with available baseline strain measurements, a relative percentage reduction of GLS of <8% from baseline appears not to be meaningful, and those >15% from baseline are very likely to be abnormal.

baseline

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

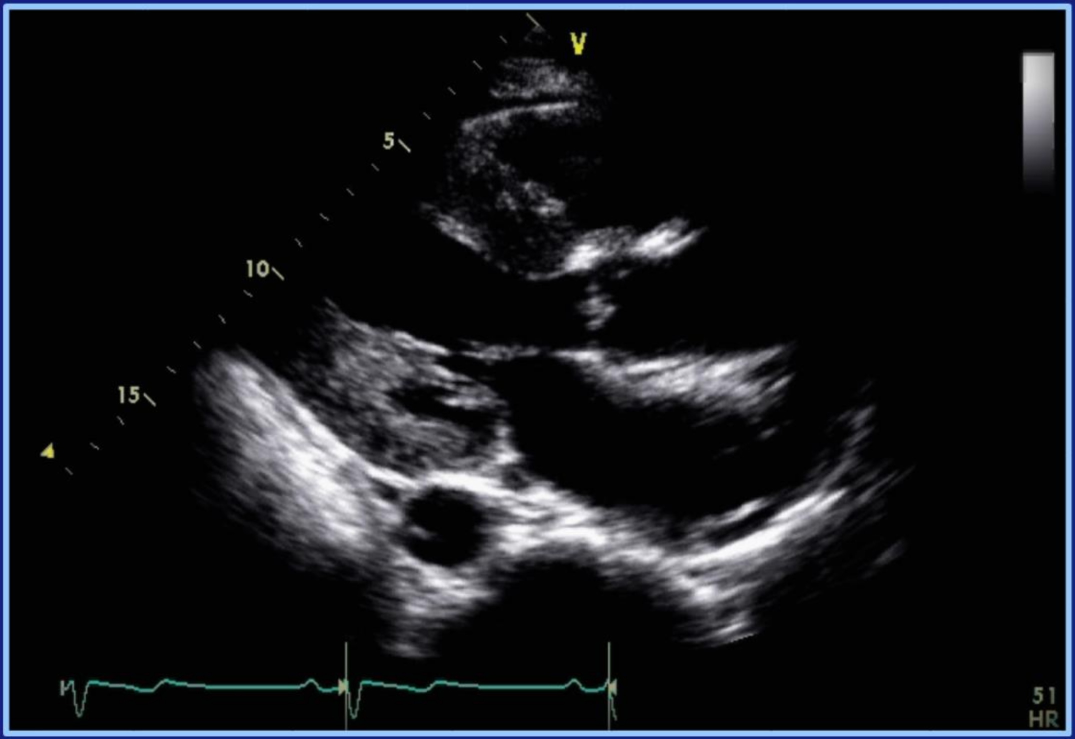
Thick Walls, Why?



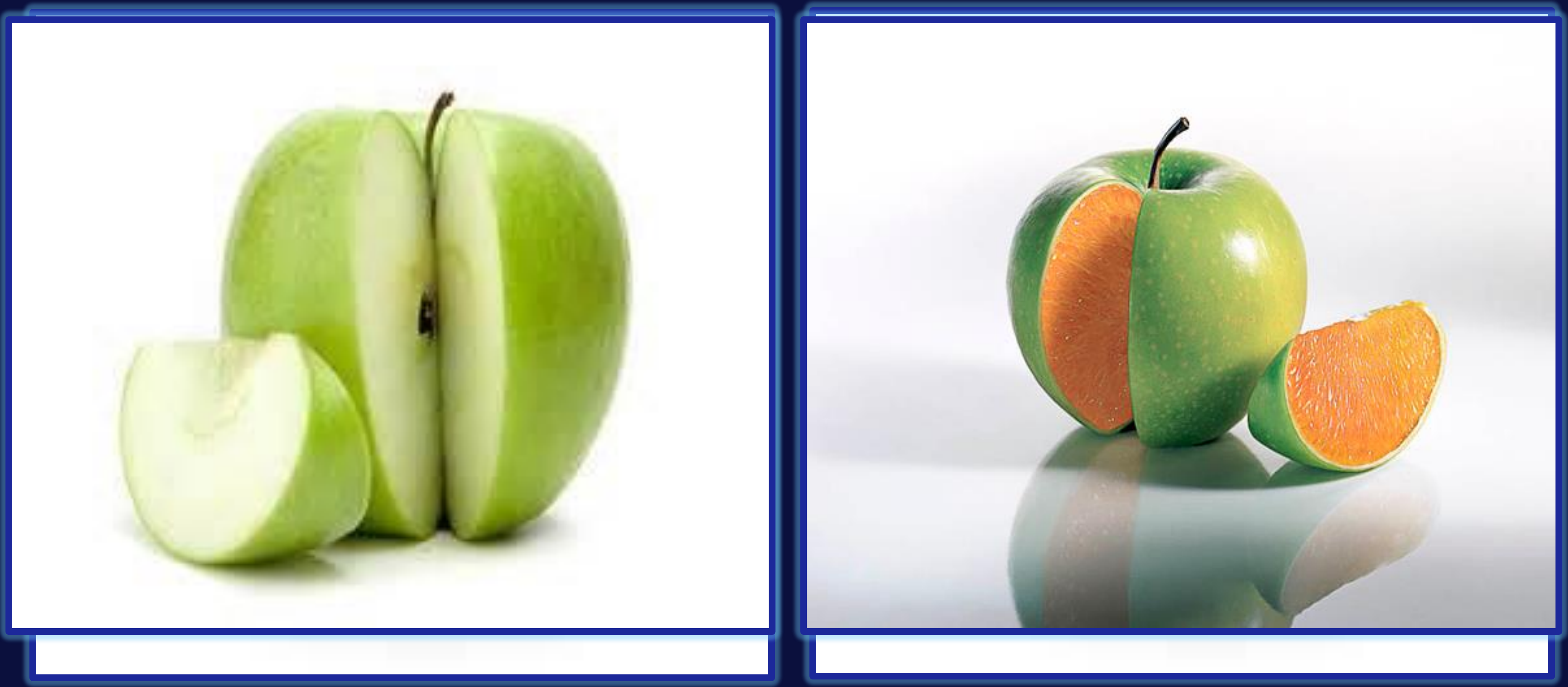
- Athlete
- HTN
- HCM
- Infiltrative
  - -amyloid
- Storage
  - -Fabry

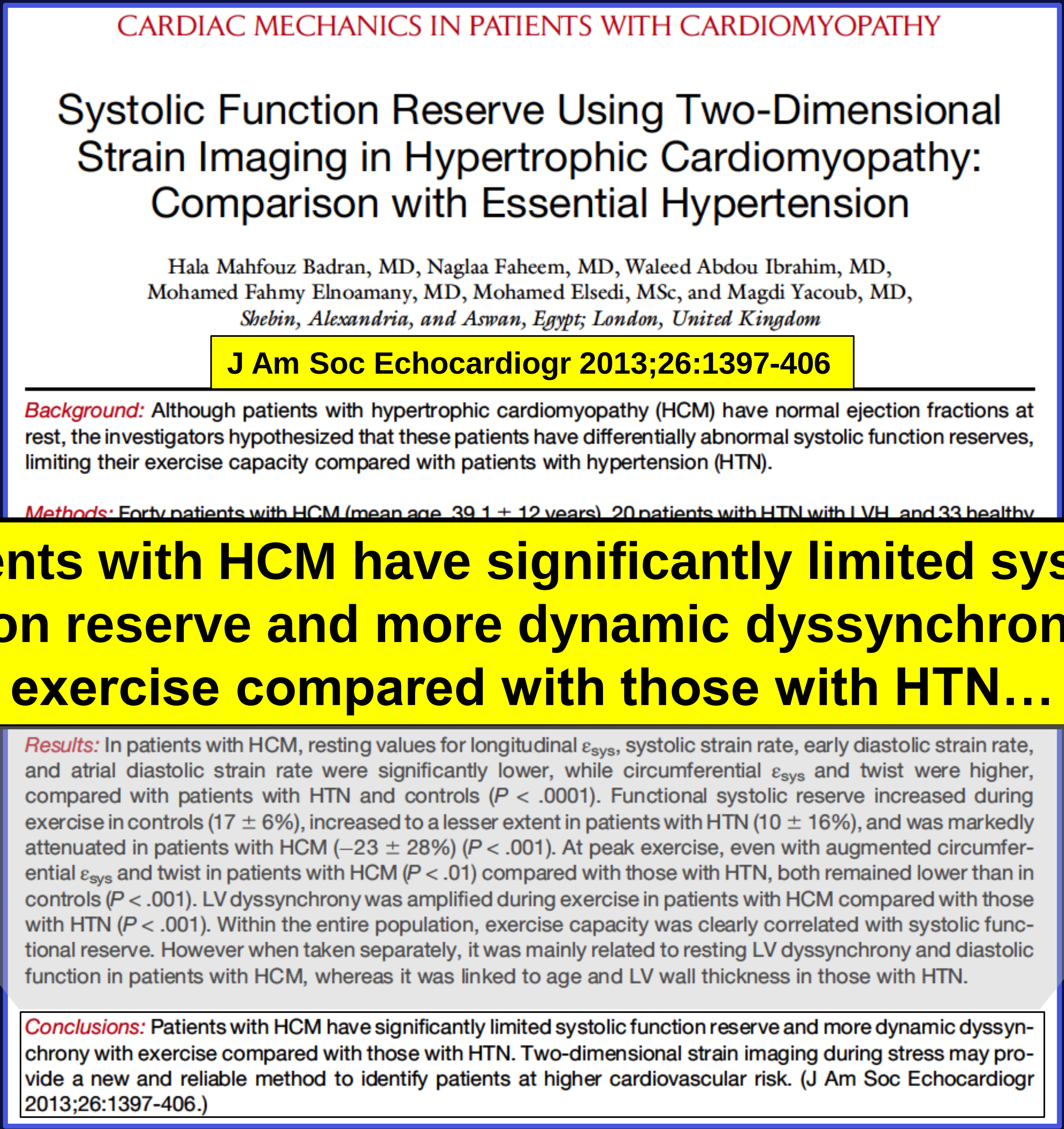
HTN or HCM?

The Thinker
Auguste Rodin



Are They Really The Same?





CARDIAC MECHANICS IN PATIENTS WITH CARDIOMYOPATHY

Systolic Function Reserve Using Two-Dimensional Strain Imaging in Hypertrophic Cardiomyopathy: Comparison with Essential Hypertension

Hala Mahfouz Badran, MD, Naglaa Faheem, MD, Waleed Abdou Ibrahim, MD,
Mohamed Fahmy Elnoamany, MD, Mohamed Elsedi, MSc, and Magdi Yacoub, MD,
Shebin, Alexandria, and Aswan, Egypt; London, United Kingdom

J Am Soc Echocardiogr 2013;26:1397-406

Background: Although patients with hypertrophic cardiomyopathy (HCM) have normal ejection fractions at rest, the investigators hypothesized that these patients have differentially abnormal systolic function reserves, limiting their exercise capacity compared with patients with hypertension (HTN).

Methods: Forty patients with HCM (mean age, 39.1 ± 12 years), 20 patients with HTN with LVH, and 33 healthy

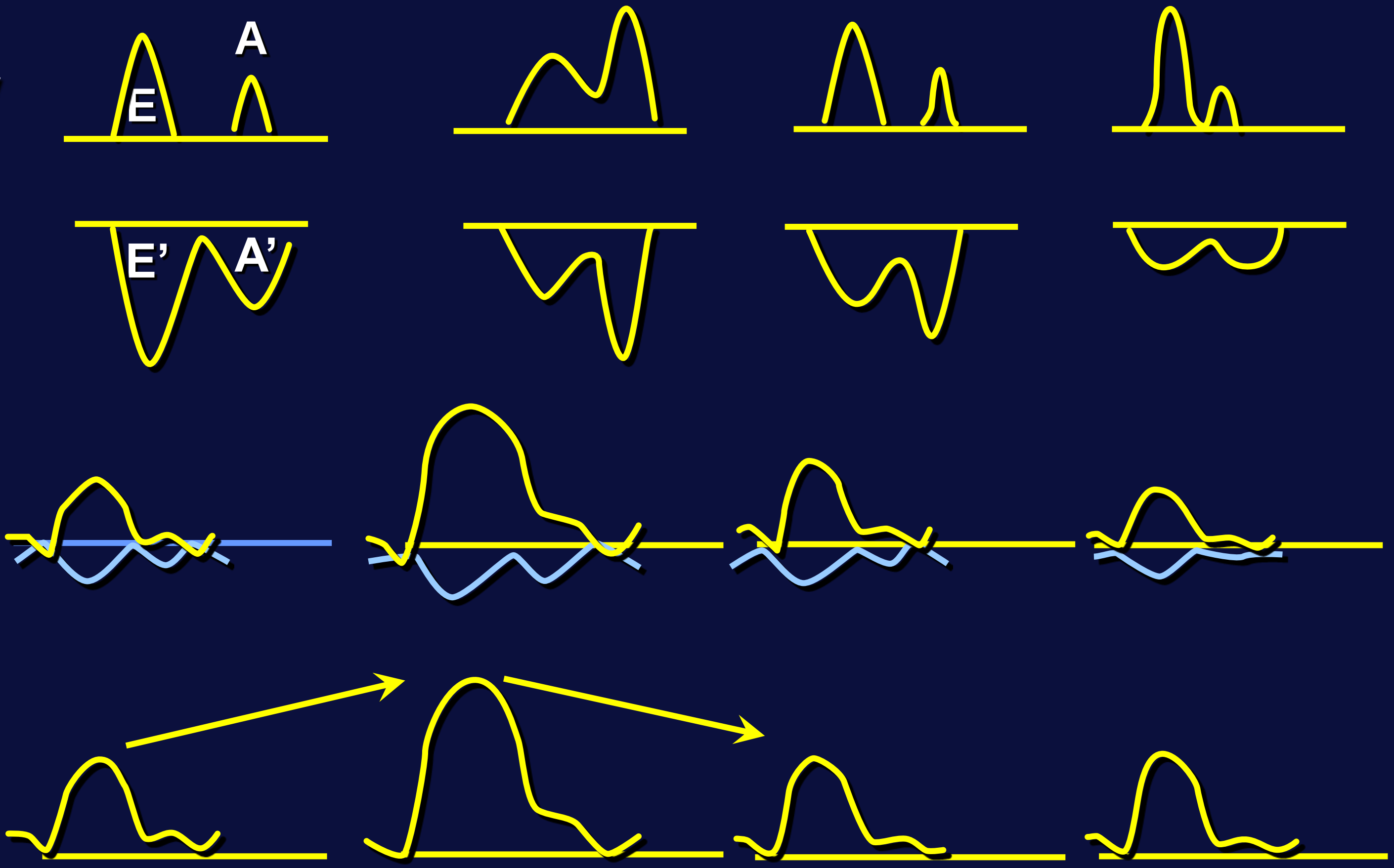
Patients with HCM have significantly limited systolic function reserve and more dynamic dyssynchrony with exercise compared with those with HTN…

Results: In patients with HCM, resting values for longitudinal ε_{sys}, systolic strain rate, early diastolic strain rate, and atrial diastolic strain rate were significantly lower, while circumferential ε_{sys} and twist were higher, compared with patients with HTN and controls ($P < .0001$). Functional systolic reserve increased during exercise in controls (17 ± 6%), increased to a lesser extent in patients with HTN (10 ± 16%), and was markedly attenuated in patients with HCM (–23 ± 28%) ($P < .001$). At peak exercise, even with augmented circumferential ε_{sys} and twist in patients with HCM ($P < .01$) compared with those with HTN, both remained lower than in controls ($P < .001$). LV dyssynchrony was amplified during exercise in patients with HCM compared with those with HTN ($P < .001$). Within the entire population, exercise capacity was clearly correlated with systolic functional reserve. However when taken separately, it was mainly related to resting LV dyssynchrony and diastolic function in patients with HCM, whereas it was linked to age and LV wall thickness in those with HTN.

Conclusions: Patients with HCM have significantly limited systolic function reserve and more dynamic dyssynchrony with exercise compared with those with HTN. Two-dimensional strain imaging during stress may provide a new and reliable method to identify patients at higher cardiovascular risk. (J Am Soc Echocardiogr 2013;26:1397-406.)

HTN or HCM?

	Controls	HTN	HCM
Rest Strain (%)	-18.5 ± 2.0	-15.5 ± 3.7*	-13.5 ± 5.6**
Exercise Strain (%)	-23.1± 2.7	-17.7 ± 2.4*	-11.8 ± 4.9**
Rest TTP-SD (msec)	28 ± 7.5	28 ± 12.7	52 ± 28.9**
Exercise TTP-SD (msec)	20.9 ± 12	30 ± 20*	60 ± 37**



Normal

Abnormal relaxation

Pseudo-normalization

Restriction

Mitral flow

Tissue Doppler

Apical rotation

Basal rotation

LV torsion

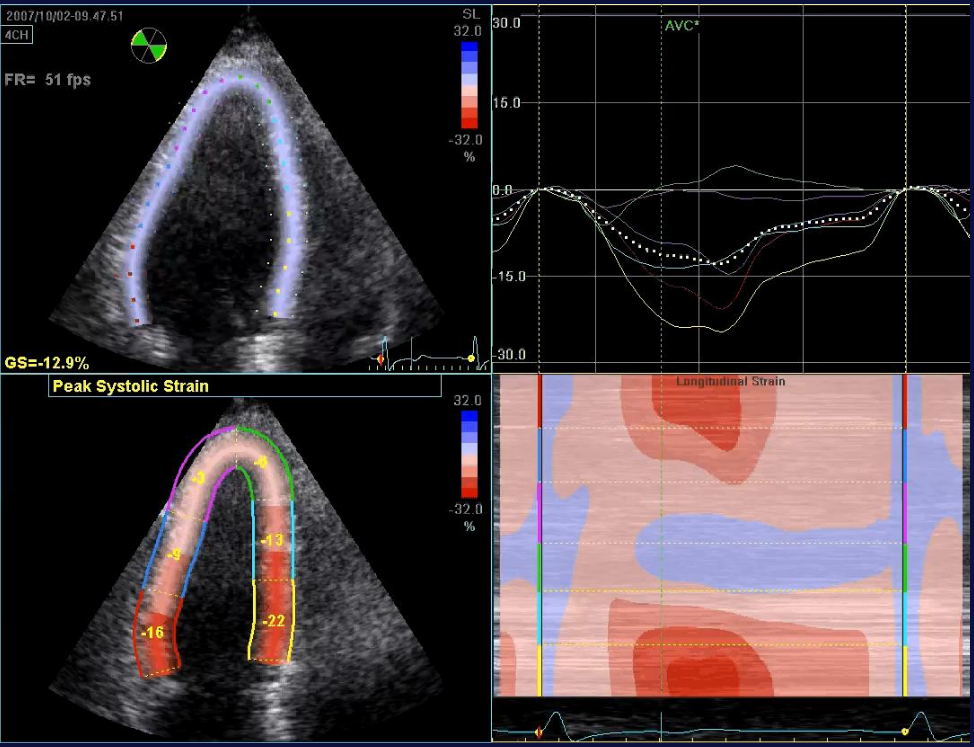
Park et al: J Am Soc Echo Cardiogr 21:1129, 2008

HTN or HCM?

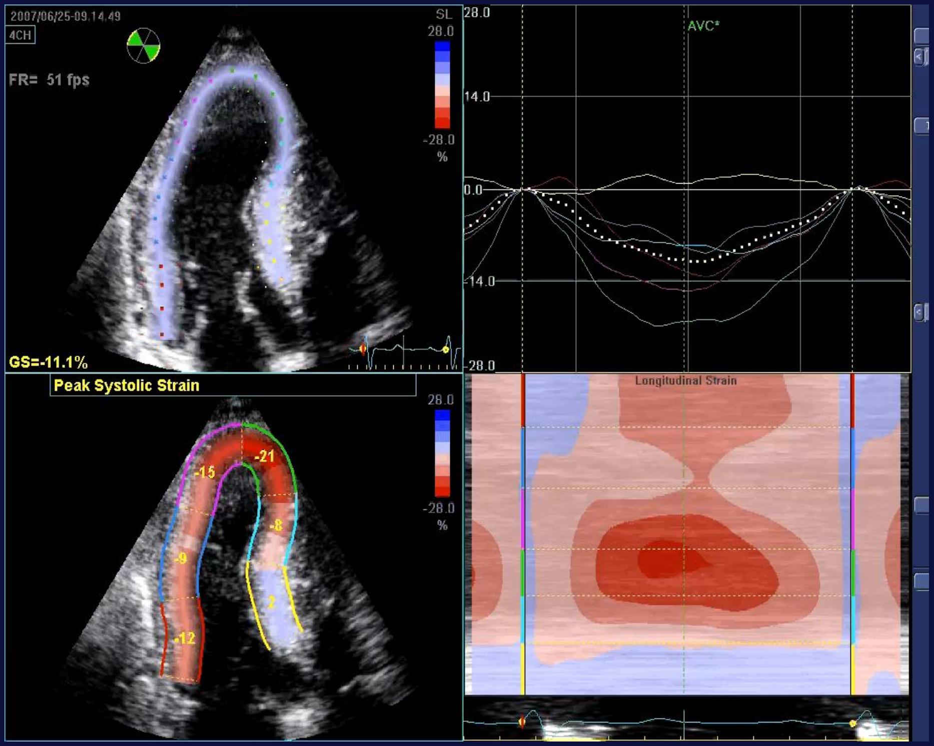
	Controls	HTN	HCM
Rest Circumferential Strain (%)	-19.3 ± 2.5	-23.9 ± 2.9*	-22.8 ± 3.4**
▲Circumferential Strain Exercise (%)	5.3± 1.2	1.7 ± 2.1*	2.3± 3.0**
Septal Thickness (mm)	9.6 ± 2.0	17.8 ± 4.4*	26.0 ± 6.0**

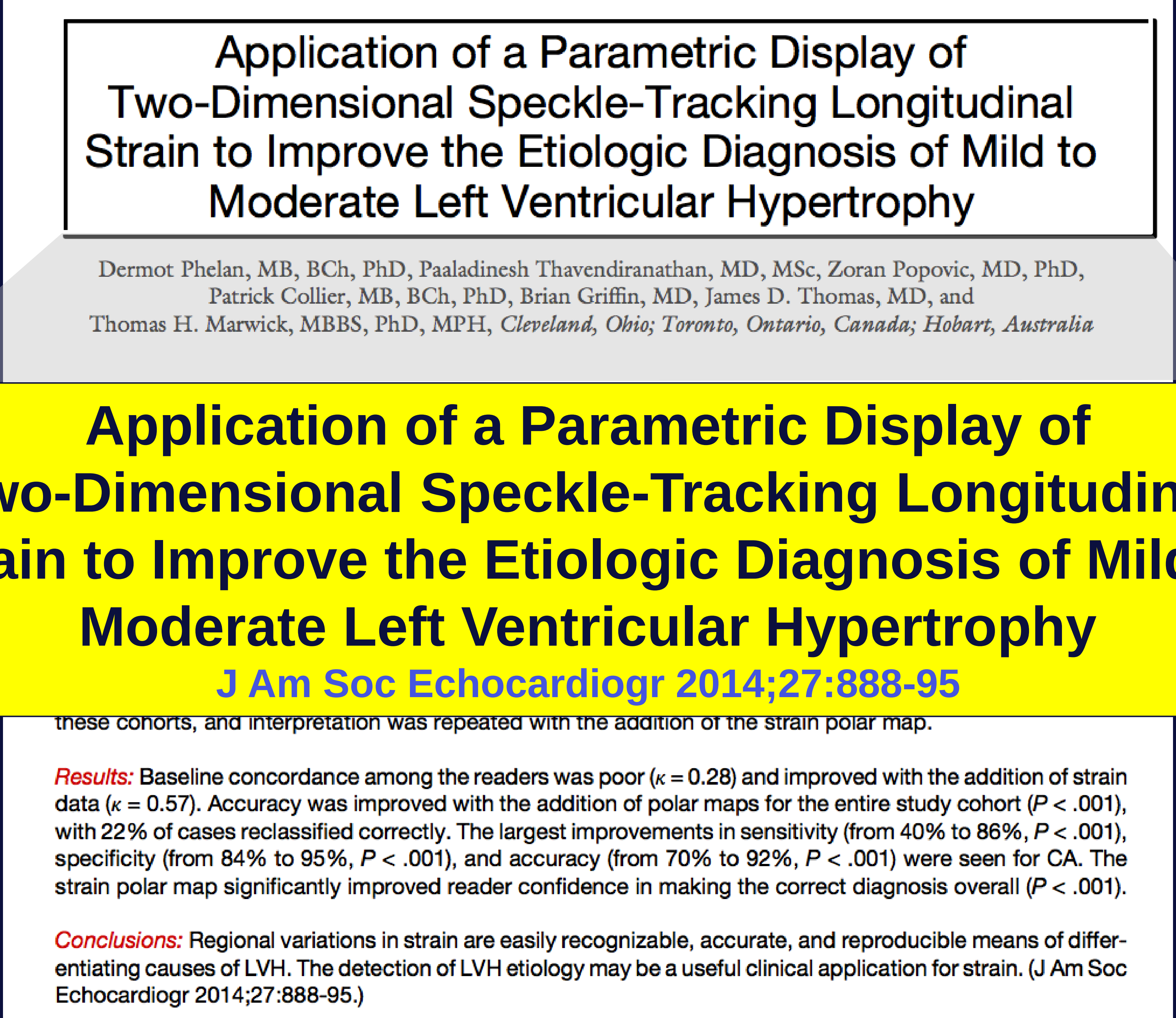
Identify "Regionality" of Myocardial Motion

Apical HCM



Septal HCM





Application of a Parametric Display of
Two-Dimensional Speckle-Tracking Longitudinal
Strain to Improve the Etiologic Diagnosis of Mild to
Moderate Left Ventricular Hypertrophy

Dermot Phelan, MB, BCh, PhD, Paaladinesh Thavendiranathan, MD, MSc, Zoran Popovic, MD, PhD,
Patrick Collier, MB, BCh, PhD, Brian Griffin, MD, James D. Thomas, MD, and
Thomas H. Marwick, MBBS, PhD, MPH, *Cleveland, Ohio; Toronto, Ontario, Canada; Hobart, Australia*

Application of a Parametric Display of Two-Dimensional Speckle-Tracking Longitudinal Strain to Improve the Etiologic Diagnosis of Mild to Moderate Left Ventricular Hypertrophy

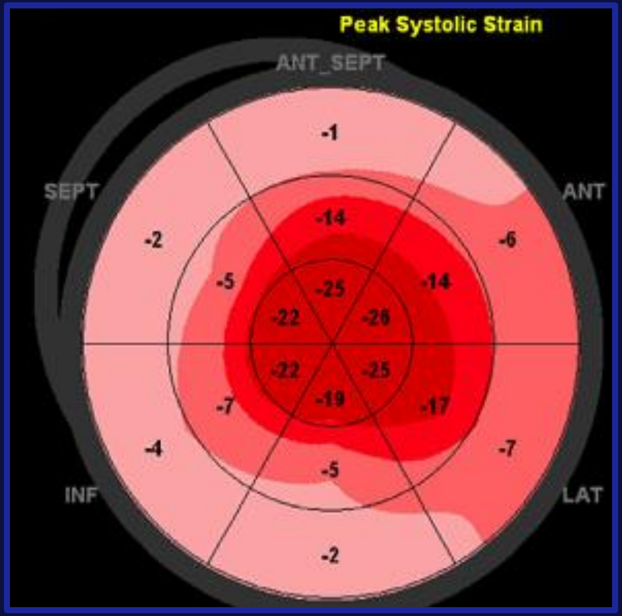
J Am Soc Echocardiogr 2014;27:888-95

these cohorts, and interpretation was repeated with the addition of the strain polar map.

Results: Baseline concordance among the readers was poor ($\kappa = 0.28$) and improved with the addition of strain data ($\kappa = 0.57$). Accuracy was improved with the addition of polar maps for the entire study cohort ($P < .001$), with 22% of cases reclassified correctly. The largest improvements in sensitivity (from 40% to 86%, $P < .001$), specificity (from 84% to 95%, $P < .001$), and accuracy (from 70% to 92%, $P < .001$) were seen for CA. The strain polar map significantly improved reader confidence in making the correct diagnosis overall ($P < .001$).

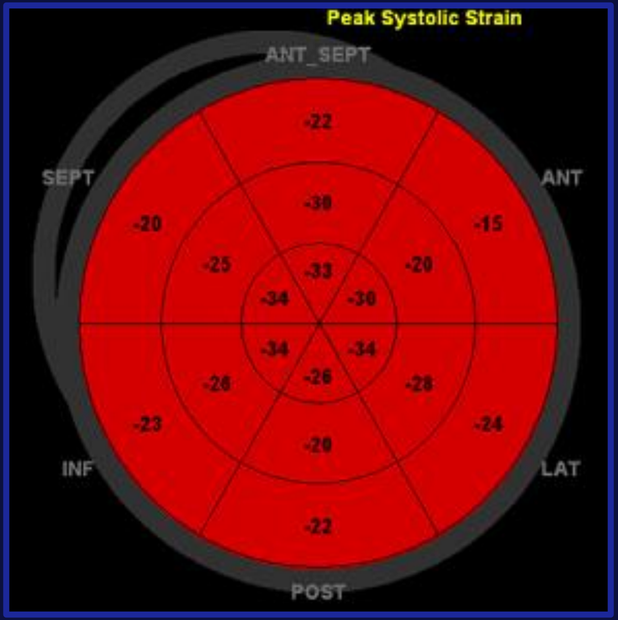
Conclusions: Regional variations in strain are easily recognizable, accurate, and reproducible means of differentiating causes of LVH. The detection of LVH etiology may be a useful clinical application for strain. (J Am Soc Echocardiogr 2014;27:888-95.)

Cardiac Amyloidosis



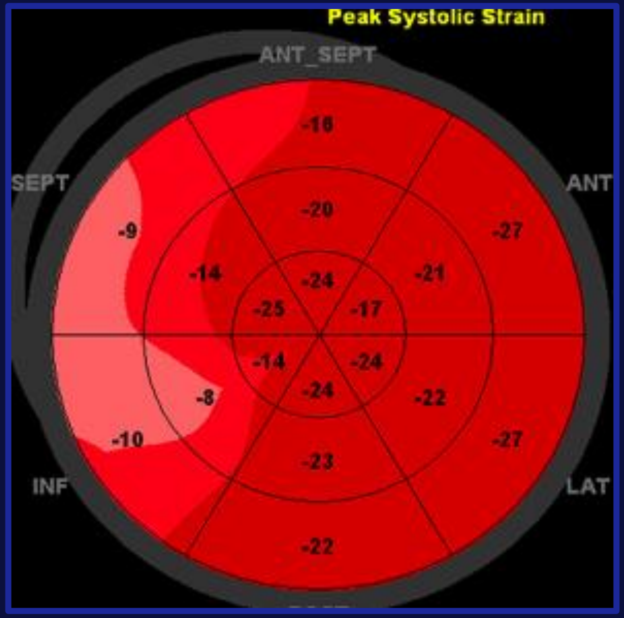
14mm

Hypertensive Heart Disease



14mm

Hypertrophic Cardiomyopathy

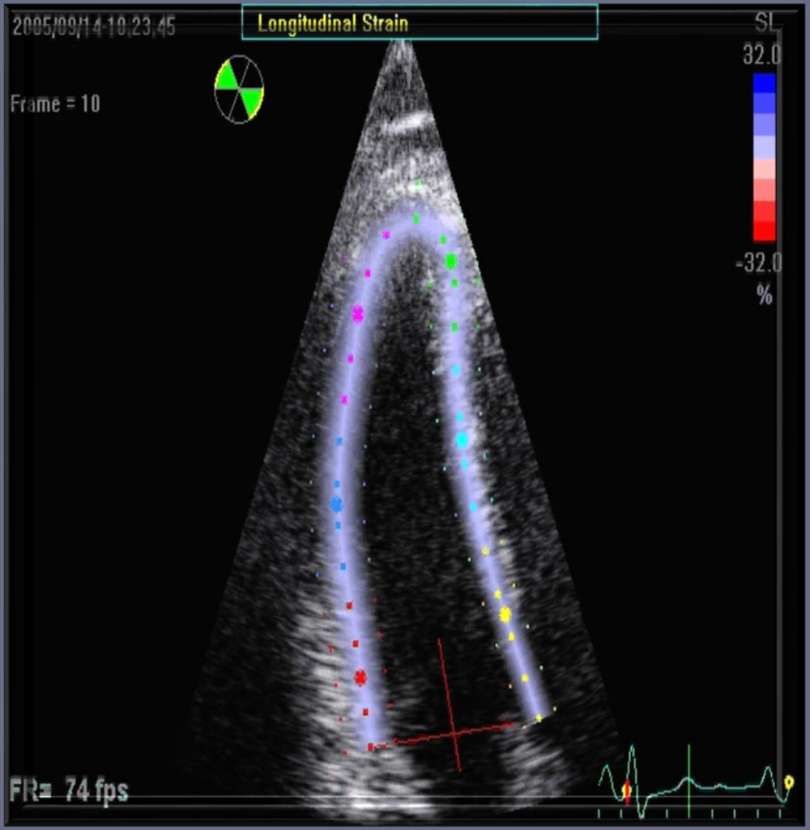


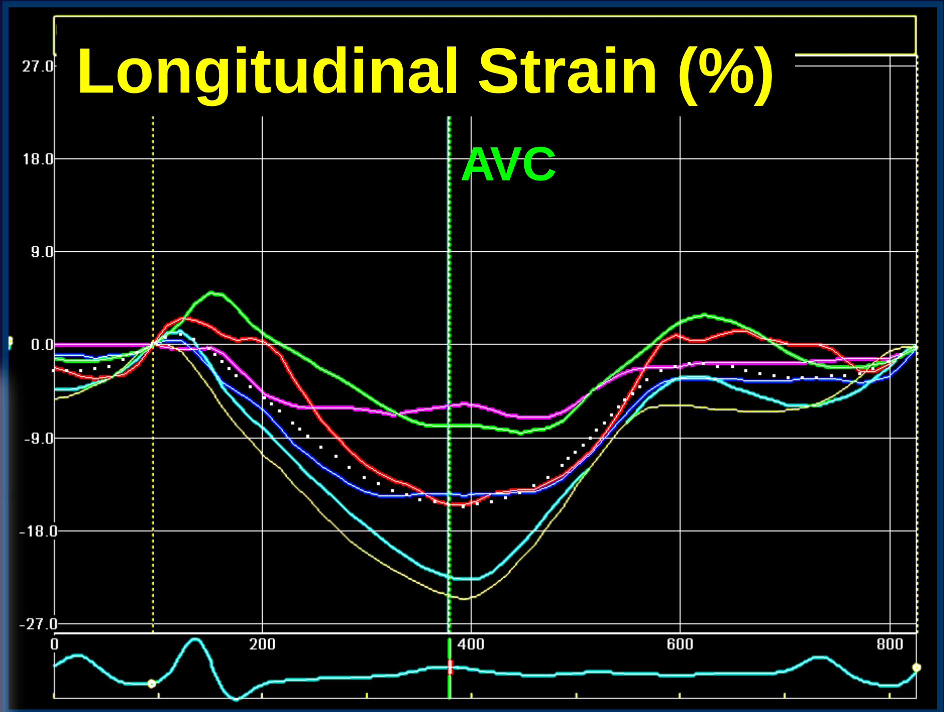
13mm

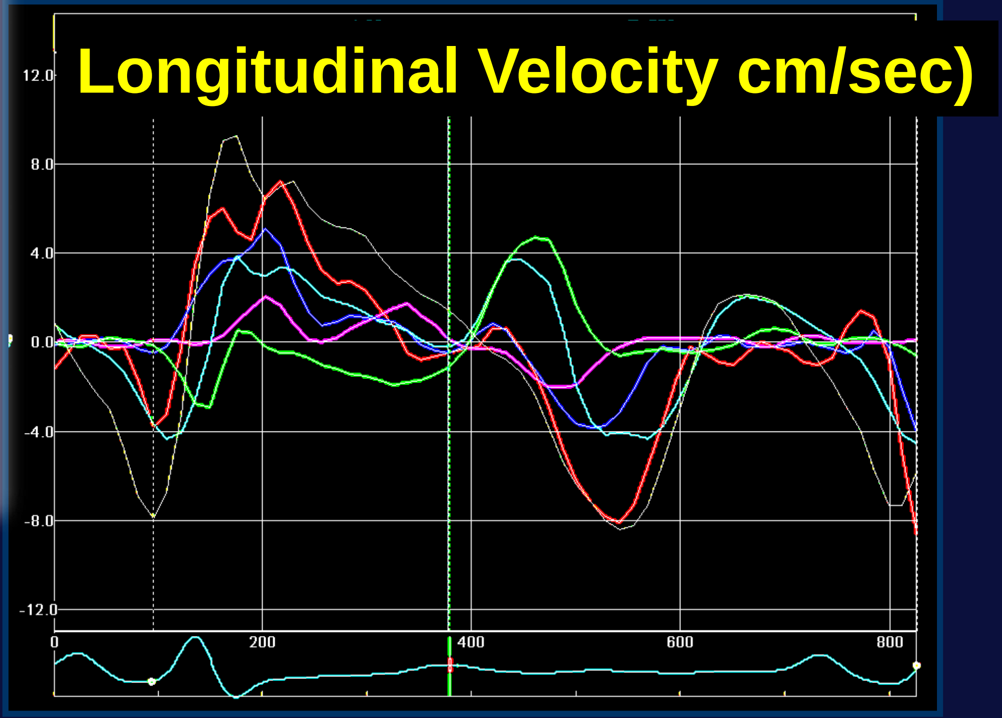
Mean Wall Left Ventricular Thickness

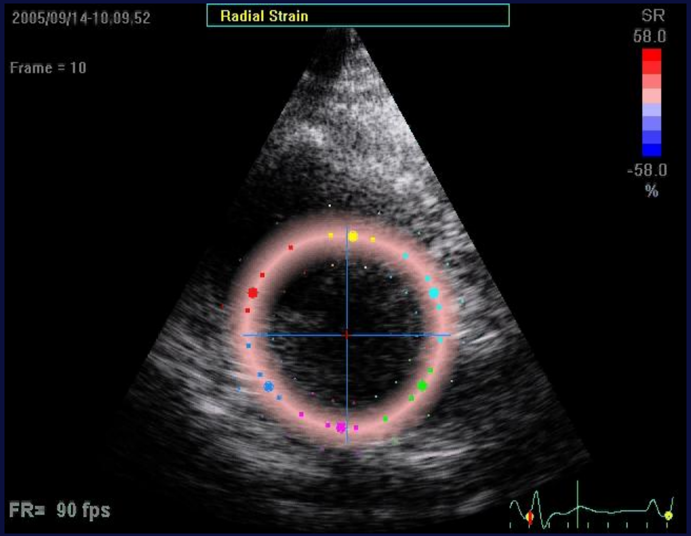
Pattern Recognition

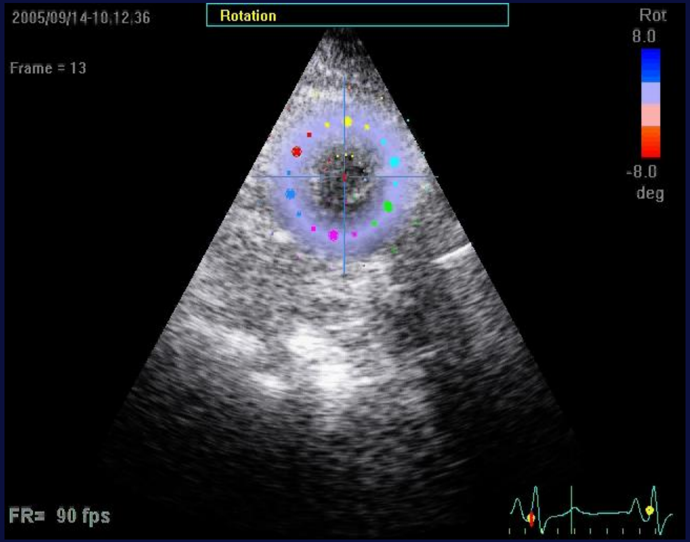
Constrictive Pericarditis

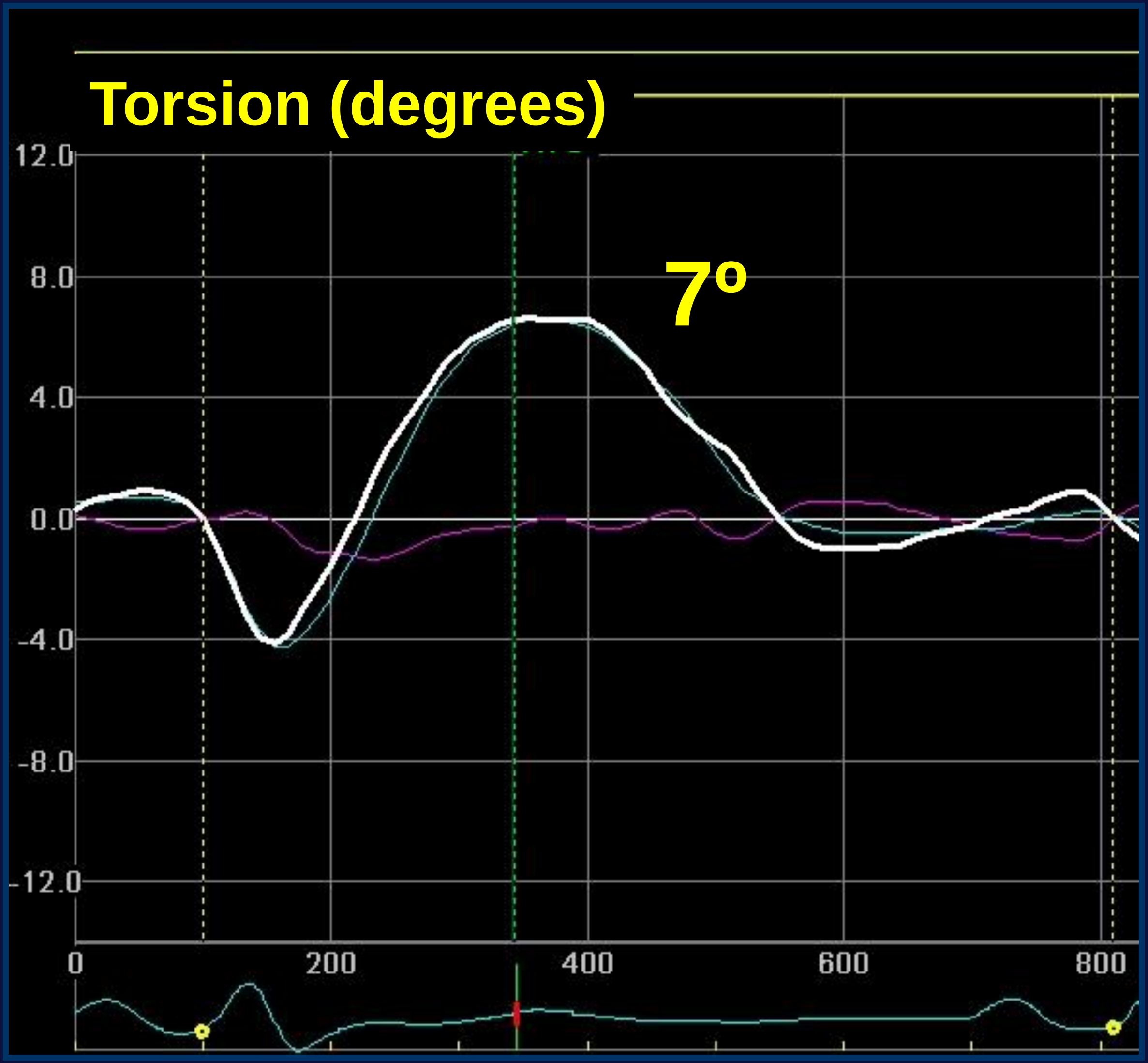



Longitudinal Strain (%)


Longitudinal Velocity cm/sec)

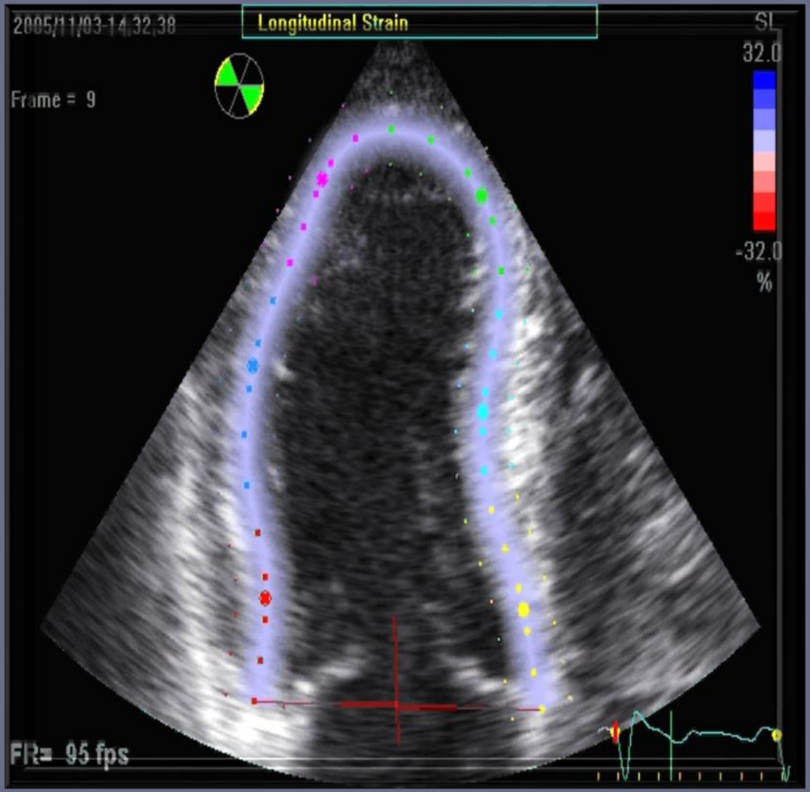


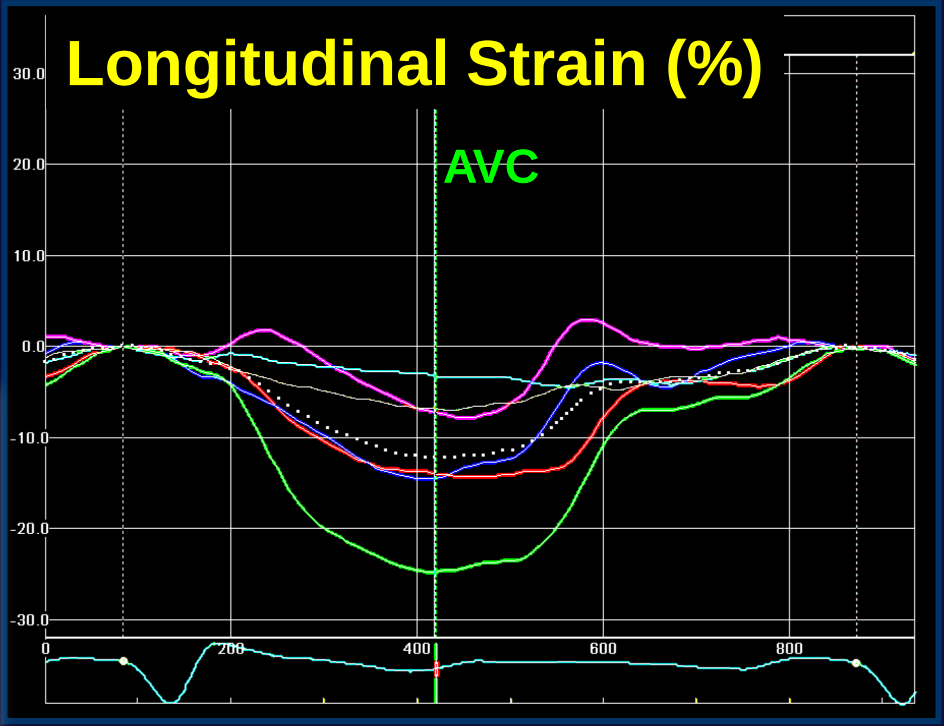



Torsion (degrees)

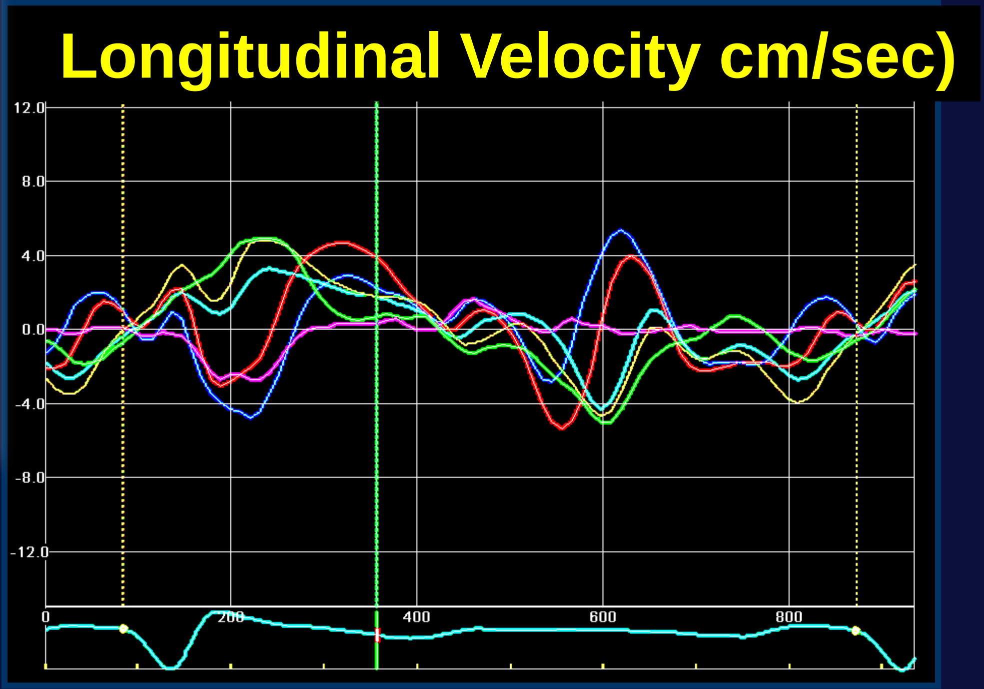
7º

Amyloidosis

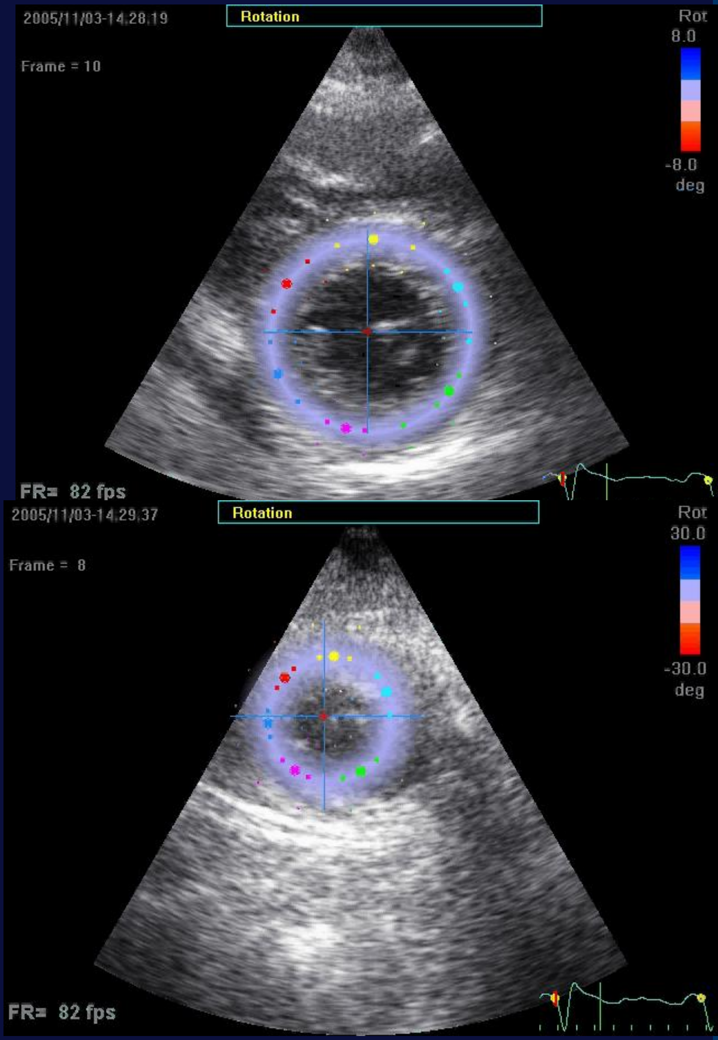


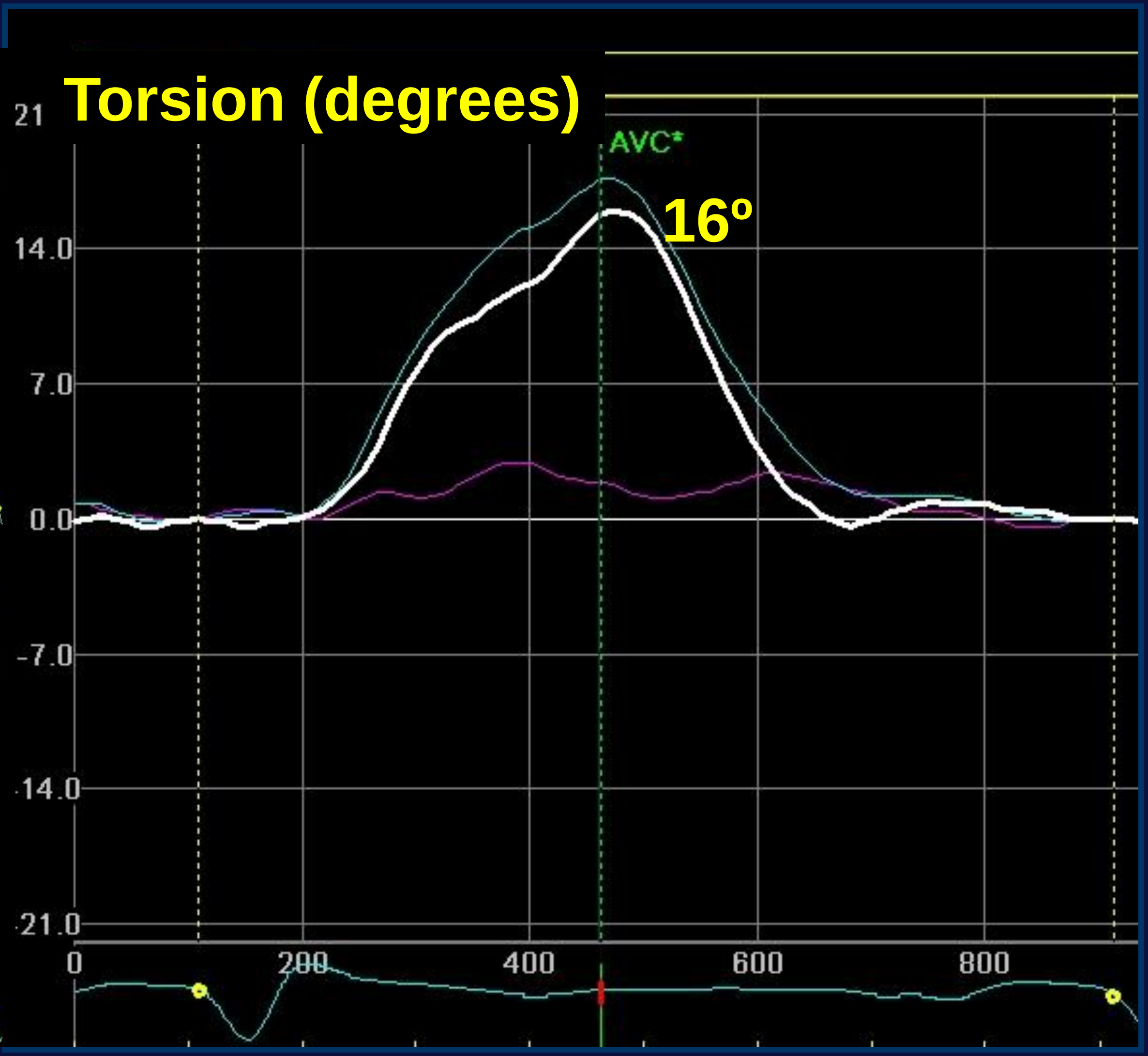


Longitudinal Strain (%)



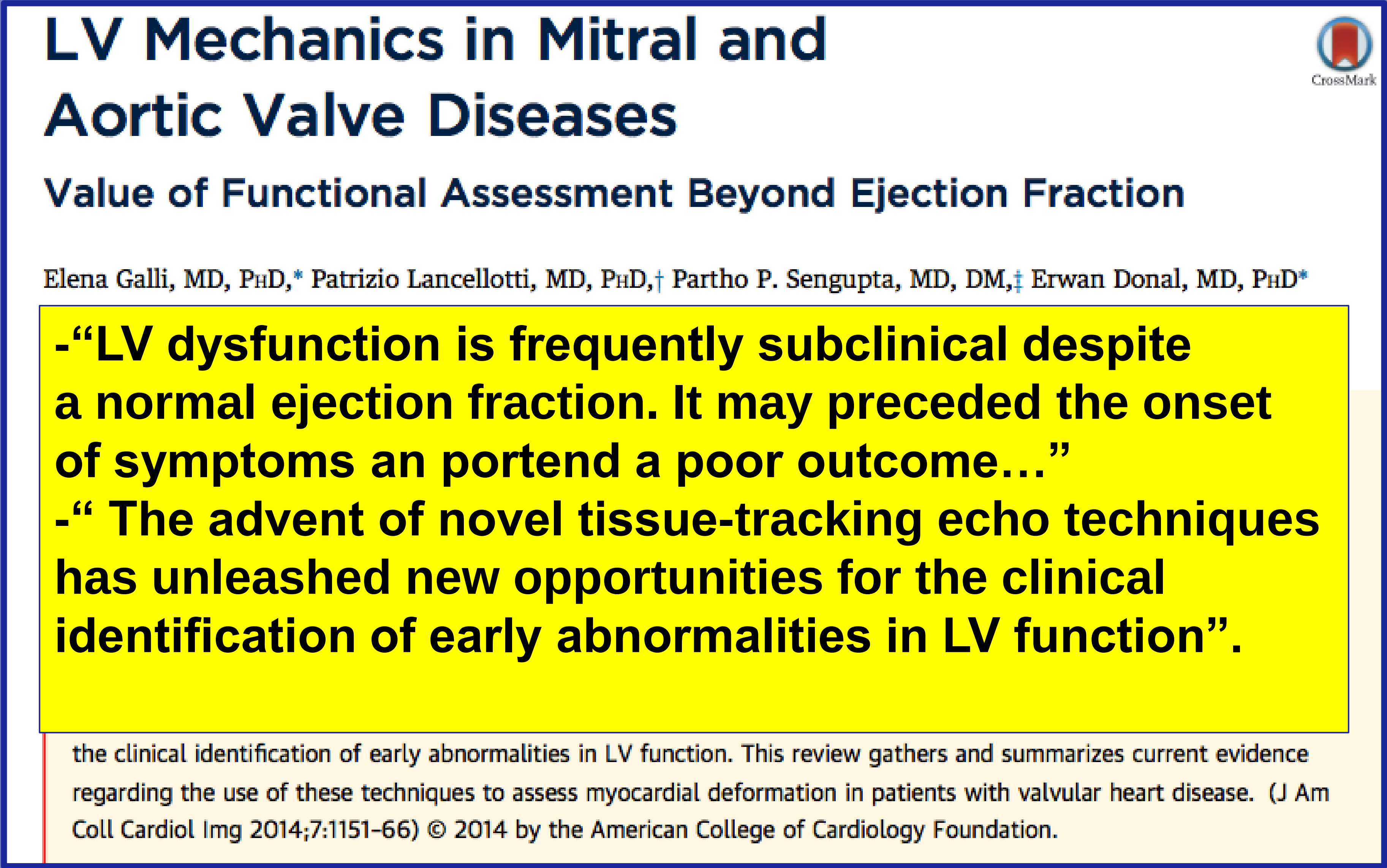
Longitudinal Velocity cm/sec)





Torsion (degrees)

16º



LV Mechanics in Mitral and Aortic Valve Diseases

Value of Functional Assessment Beyond Ejection Fraction

Elena Galli, MD, PhD,* Patrizio Lancellotti, MD, PhD,† Partho P. Sengupta, MD, DM,‡ Erwan Donal, MD, PhD*

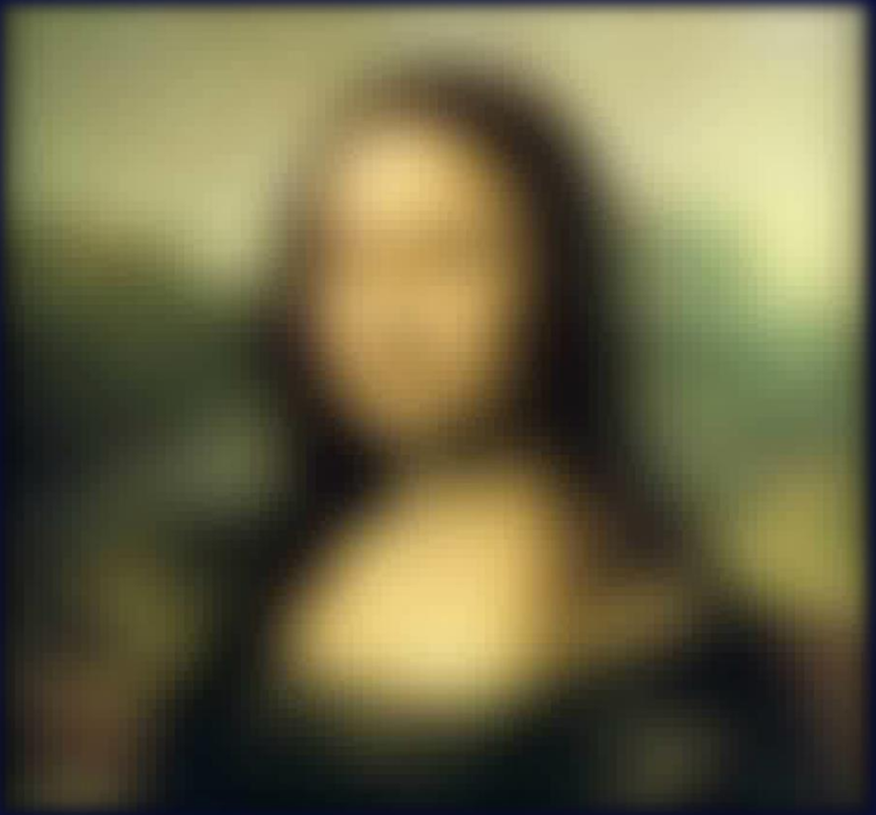
-“LV dysfunction is frequently subclinical despite a normal ejection fraction. It may preceded the onset of symptoms an portend a poor outcome…”

-“ The advent of novel tissue-tracking echo techniques has unleashed new opportunities for the clinical identification of early abnormalities in LV function”.

the clinical identification of early abnormalities in LV function. This review gathers and summarizes current evidence regarding the use of these techniques to assess myocardial deformation in patients with valvular heart disease. (J Am Coll Cardiol Img 2014;7:1151–66) © 2014 by the American College of Cardiology Foundation.

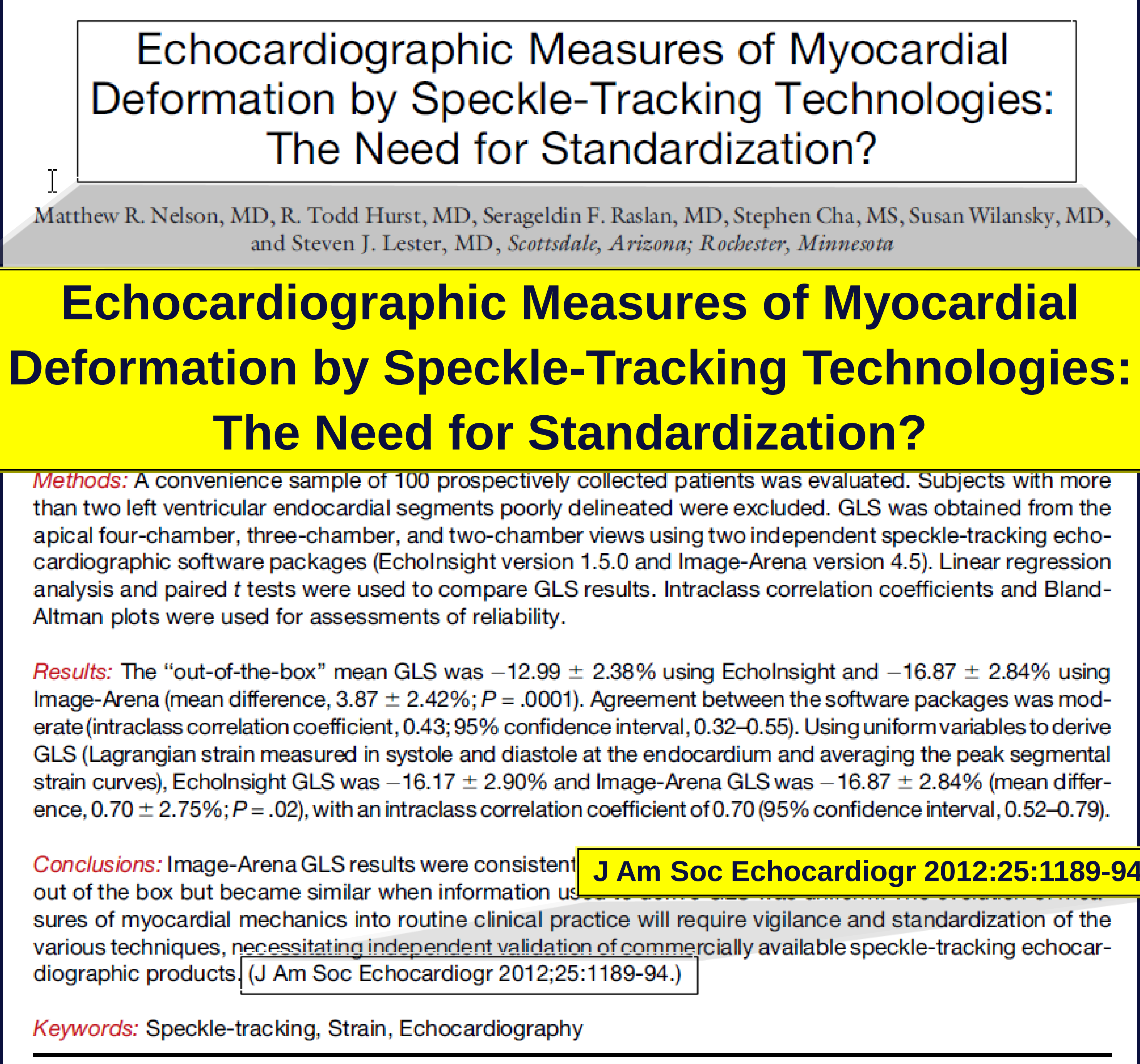
Objective #3

Impediments to Clinical Adoption?



1. Standardization
2. Workflow

Echocardiographic Measures of Myocardial Deformation by Speckle-Tracking Technologies: The Need for Standardization?



Echocardiographic Measures of Myocardial Deformation by Speckle-Tracking Technologies: The Need for Standardization?

Matthew R. Nelson, MD, R. Todd Hurst, MD, Serageldin F. Raslan, MD, Stephen Cha, MS, Susan Wilansky, MD, and Steven J. Lester, MD, *Scottsdale, Arizona; Rochester, Minnesota*

Methods: A convenience sample of 100 prospectively collected patients was evaluated. Subjects with more than two left ventricular endocardial segments poorly delineated were excluded. GLS was obtained from the apical four-chamber, three-chamber, and two-chamber views using two independent speckle-tracking echocardiographic software packages (EchoInsight version 1.5.0 and Image-Arena version 4.5). Linear regression analysis and paired *t* tests were used to compare GLS results. Intraclass correlation coefficients and Bland-Altman plots were used for assessments of reliability.

Results: The "out-of-the-box" mean GLS was −12.99 ± 2.38% using EchoInsight and −16.87 ± 2.84% using Image-Arena (mean difference, 3.87 ± 2.42%; *P* = .0001). Agreement between the software packages was moderate (intraclass correlation coefficient, 0.43; 95% confidence interval, 0.32–0.55). Using uniform variables to derive GLS (Lagrangian strain measured in systole and diastole at the endocardium and averaging the peak segmental strain curves), EchoInsight GLS was −16.17 ± 2.90% and Image-Arena GLS was −16.87 ± 2.84% (mean difference, 0.70 ± 2.75%; *P* = .02), with an intraclass correlation coefficient of 0.70 (95% confidence interval, 0.52–0.79).

Conclusions: Image-Arena GLS results were consistent

out of the box but became similar when information us

sures of myocardial mechanics into routine clinical practice will require vigilance and standardization of the various techniques, necessitating independent validation of commercially available speckle-tracking echocardiographic products. (J Am Soc Echocardiogr 2012;25:1189-94.)

J Am Soc Echocardiogr 2012:25:1189-94

Keywords: Speckle-tracking, Strain, Echocardiography

Image Arena

2D Speckle Tracking

EchoInsight

(GE Vivid™ 7)

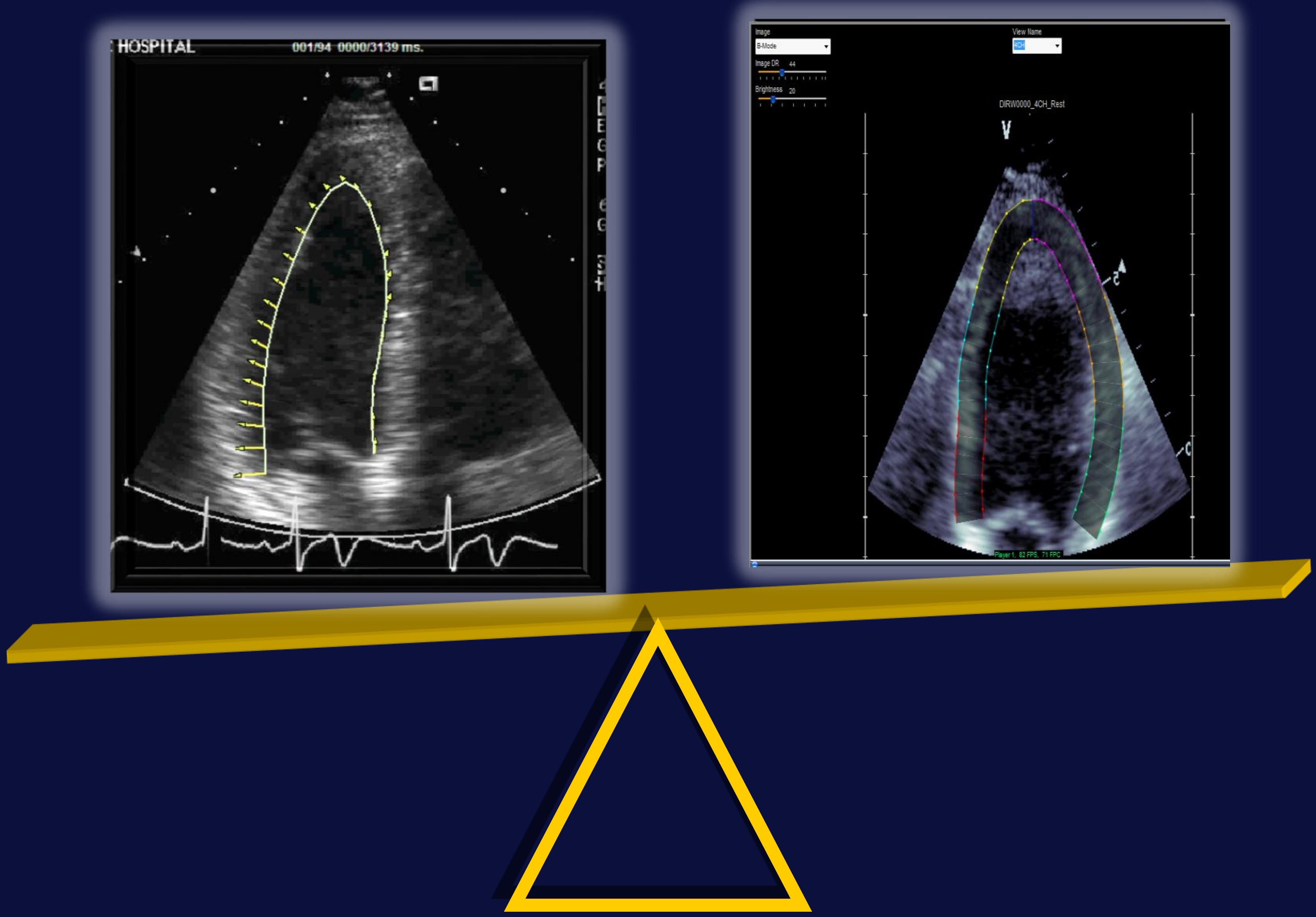
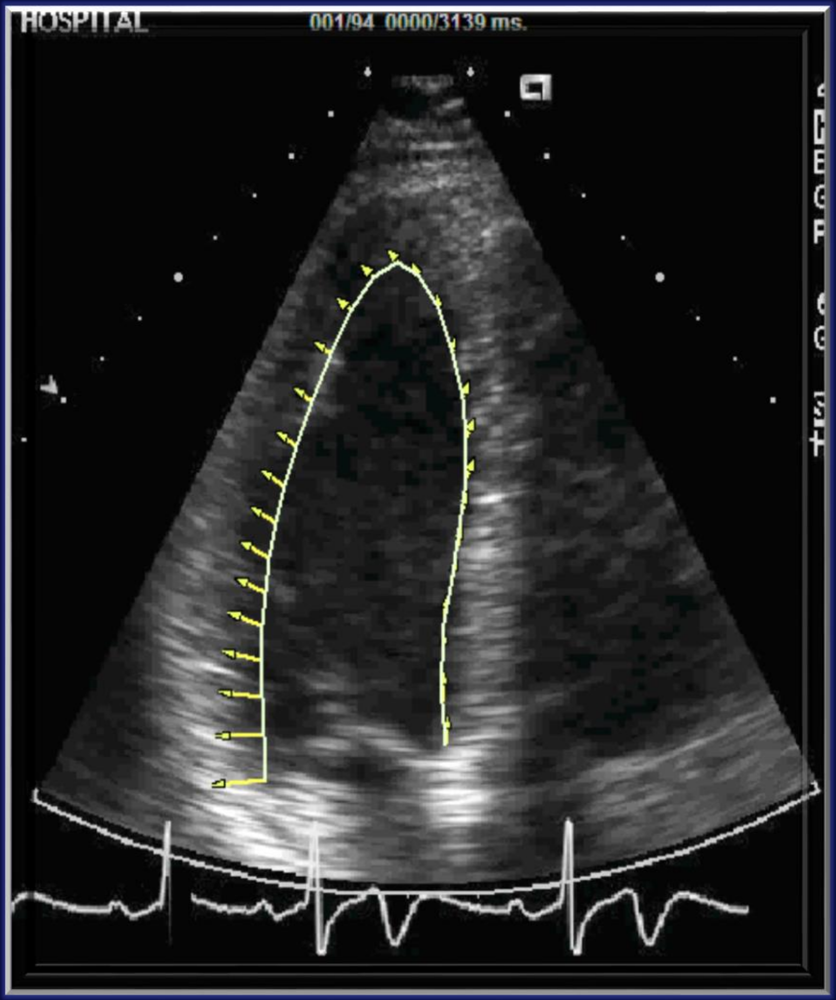


Image: B-Mode
Image DR 44
Brightness 20
View Name: 4CH

Image Area

EchoInsight

GLS -16.87 ± 2.84% vs -12.99 ± 2.38%; p=0.0001



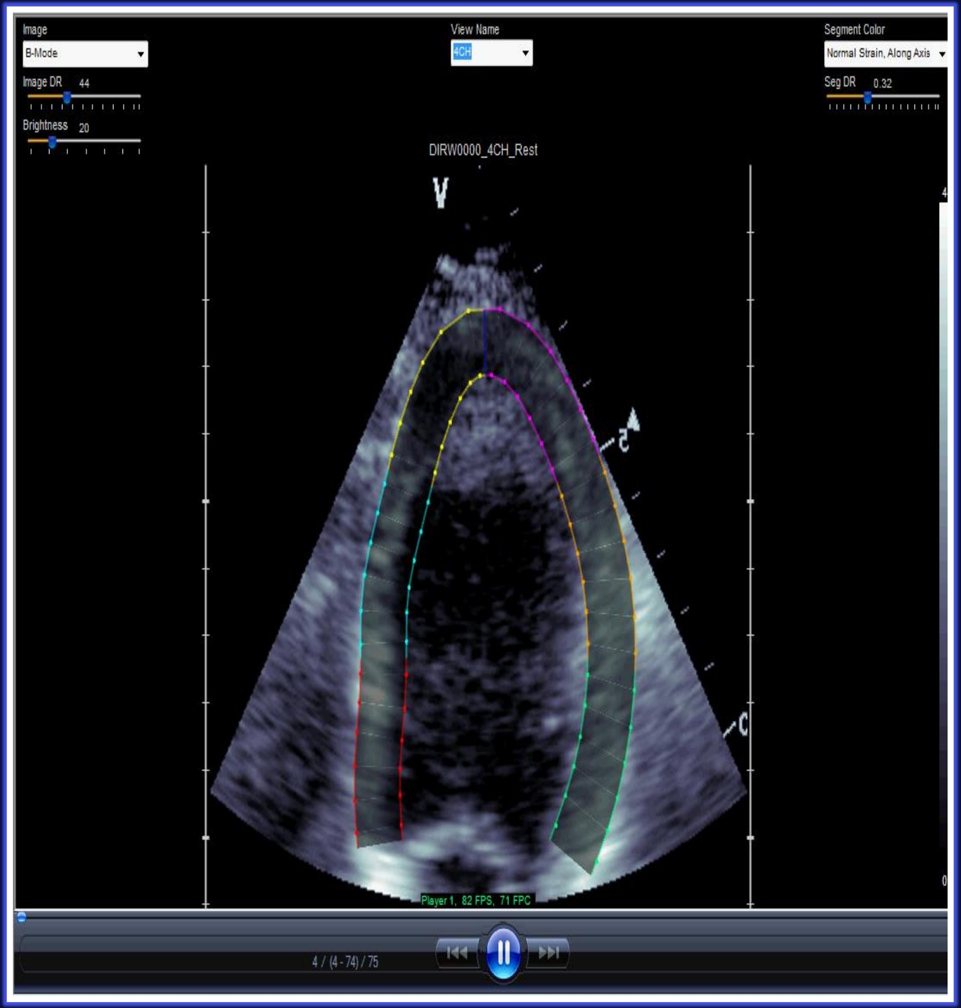


Image: B-Mode

View Name: 4CH

Segment Color: Normal Strain, Along Axis

Image DR 44

Brightness 20

Seg DR 0.32

DIRW0000_4CH_Rest

Player 1, 82 FPS, 71 FPC

4 / (4 - 74) / 75

Need For Standardization

	Endocardium		Endocardium/Epicardium	
	Natural	Lagrangian	Natural	Lagrangian
Average of peaks				
Systole	-14.63±2.48†	-15.79±2.86†	-13.42± 2.22†	-14.39±2.53†
Systole/ diastole	-14.96±2.50†	-16.17±2.90*	-13.70± 2.24†	-14.71±2.57†
Peak of ave				
Systole	-13.93±2.66†	-14.99±3.04†	-12.96± 2.43†	-13.86±2.75†
Systole/ diastole	-13.99±2.61†	-15.05±2.99†	-12.99± 2.38†	-13.91±2.69†

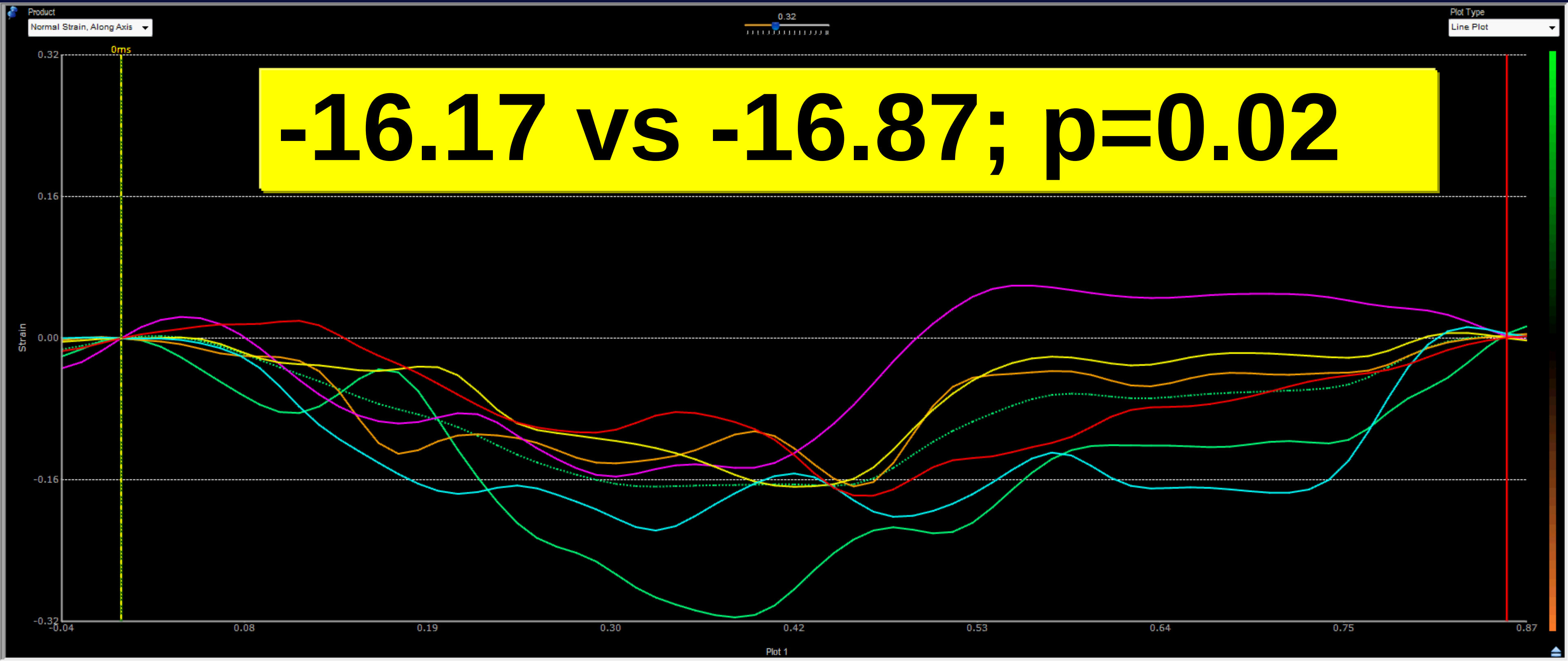
-16.17 vs -16.87; p=0.02

*Significant difference (P<.05) compared with Image-Arena GLS

†Significant difference (P<.001) compared with Image-Arena GLS

- J Am Soc Echocardiogr 2012:25:1189-94

Average of Peaks or Peak of the Average?

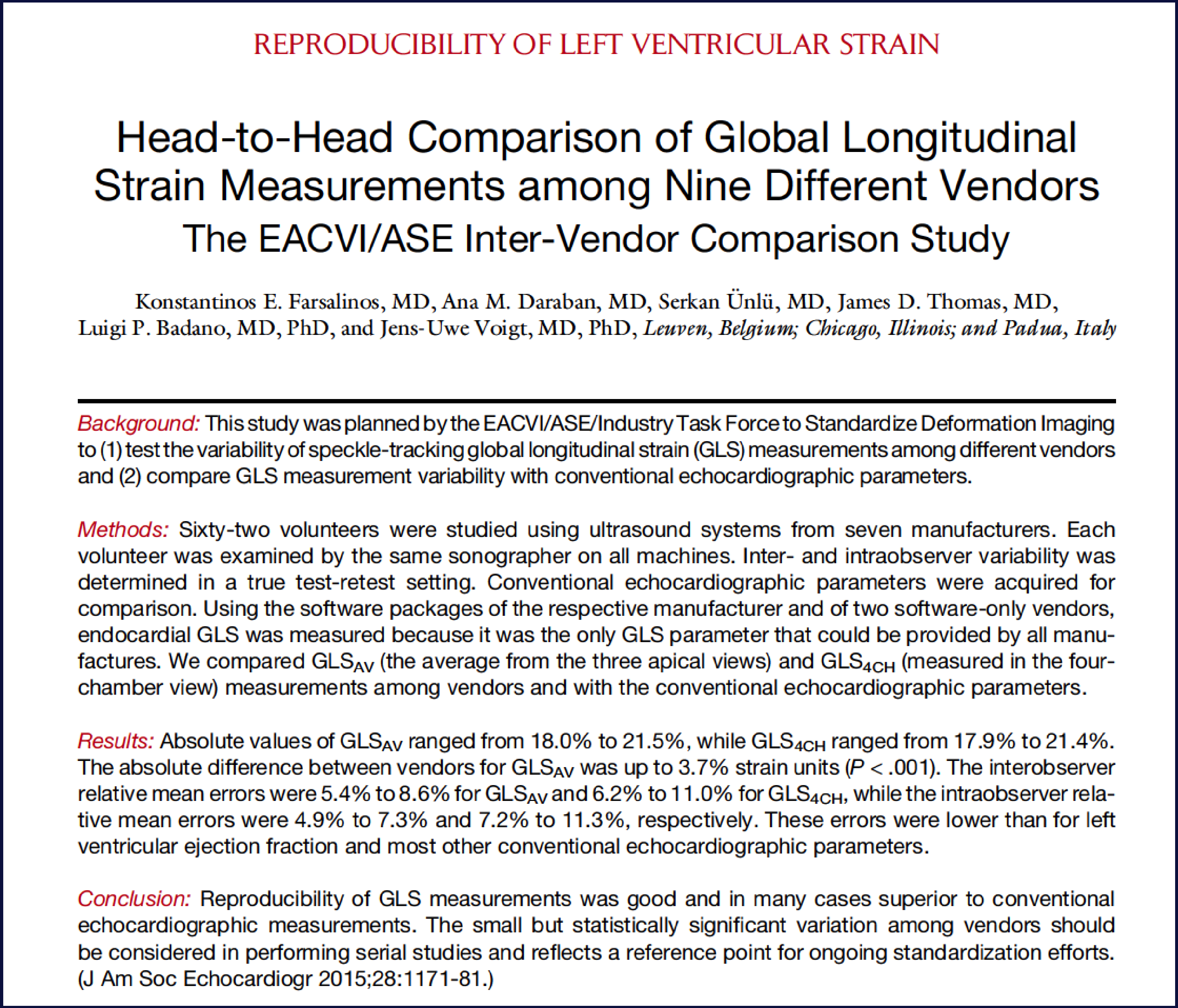


Product
Normal Strain, Along Axis

Plot Type
Line Plot

-16.17 vs -16.87; p=0.02

Scaling and Adaptive Scaling?



REPRODUCIBILITY OF LEFT VENTRICULAR STRAIN

Head-to-Head Comparison of Global Longitudinal Strain Measurements among Nine Different Vendors

The EACVI/ASE Inter-Vendor Comparison Study

Konstantinos E. Farsalinos, MD, Ana M. Daraban, MD, Serkan Ünlü, MD, James D. Thomas, MD,
Luigi P. Badano, MD, PhD, and Jens-Uwe Voigt, MD, PhD, *Leuven, Belgium; Chicago, Illinois; and Padua, Italy*

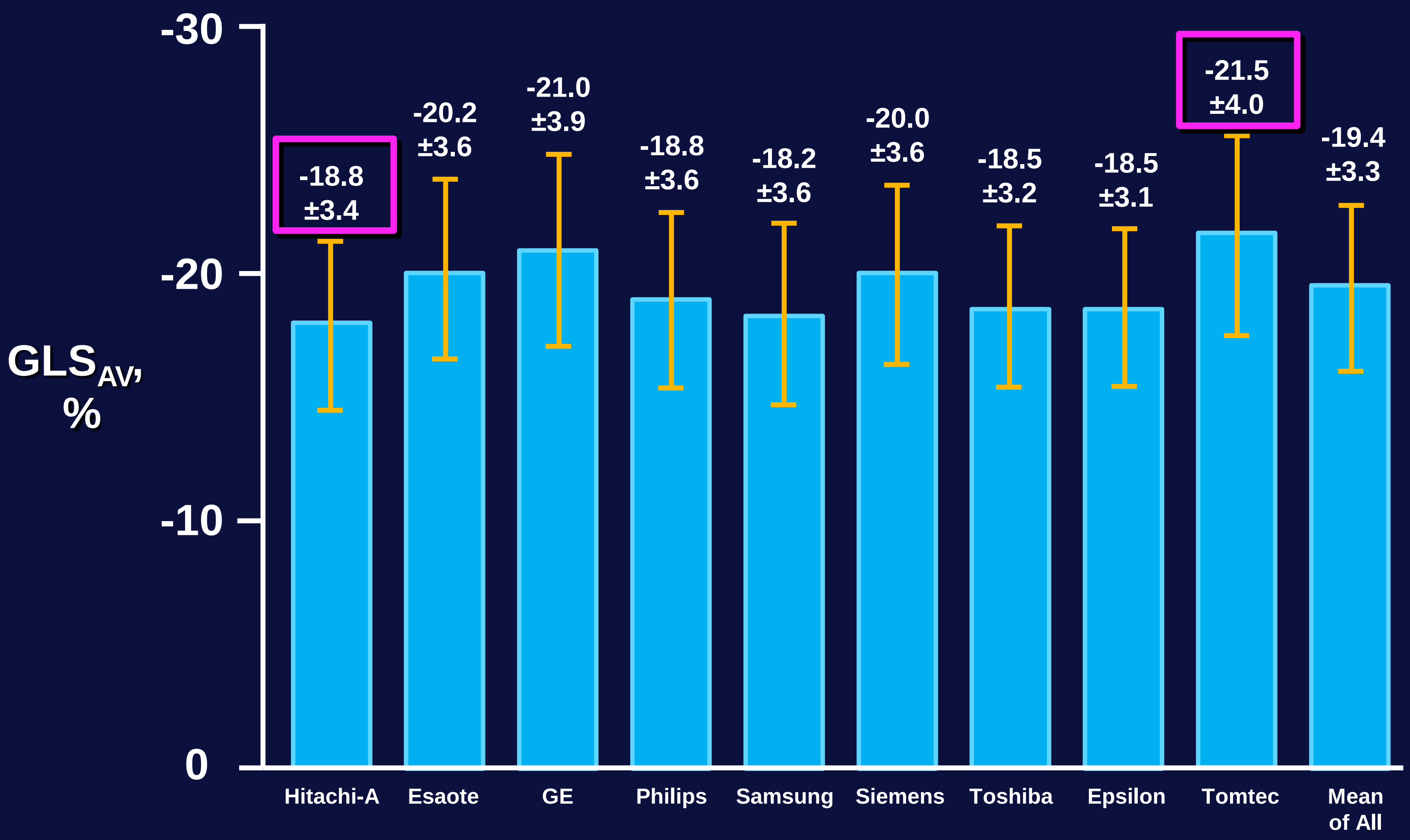
Background: This study was planned by the EACVI/ASE/Industry Task Force to Standardize Deformation Imaging to (1) test the variability of speckle-tracking global longitudinal strain (GLS) measurements among different vendors and (2) compare GLS measurement variability with conventional echocardiographic parameters.

Methods: Sixty-two volunteers were studied using ultrasound systems from seven manufacturers. Each volunteer was examined by the same sonographer on all machines. Inter- and intraobserver variability was determined in a true test-retest setting. Conventional echocardiographic parameters were acquired for comparison. Using the software packages of the respective manufacturer and of two software-only vendors, endocardial GLS was measured because it was the only GLS parameter that could be provided by all manufactures. We compared GLS_{AV} (the average from the three apical views) and GLS_{4CH} (measured in the four-chamber view) measurements among vendors and with the conventional echocardiographic parameters.

Results: Absolute values of GLS_{AV} ranged from 18.0% to 21.5%, while GLS_{4CH} ranged from 17.9% to 21.4%. The absolute difference between vendors for GLS_{AV} was up to 3.7% strain units ($P < .001$). The interobserver relative mean errors were 5.4% to 8.6% for GLS_{AV} and 6.2% to 11.0% for GLS_{4CH}, while the intraobserver relative mean errors were 4.9% to 7.3% and 7.2% to 11.3%, respectively. These errors were lower than for left ventricular ejection fraction and most other conventional echocardiographic parameters.

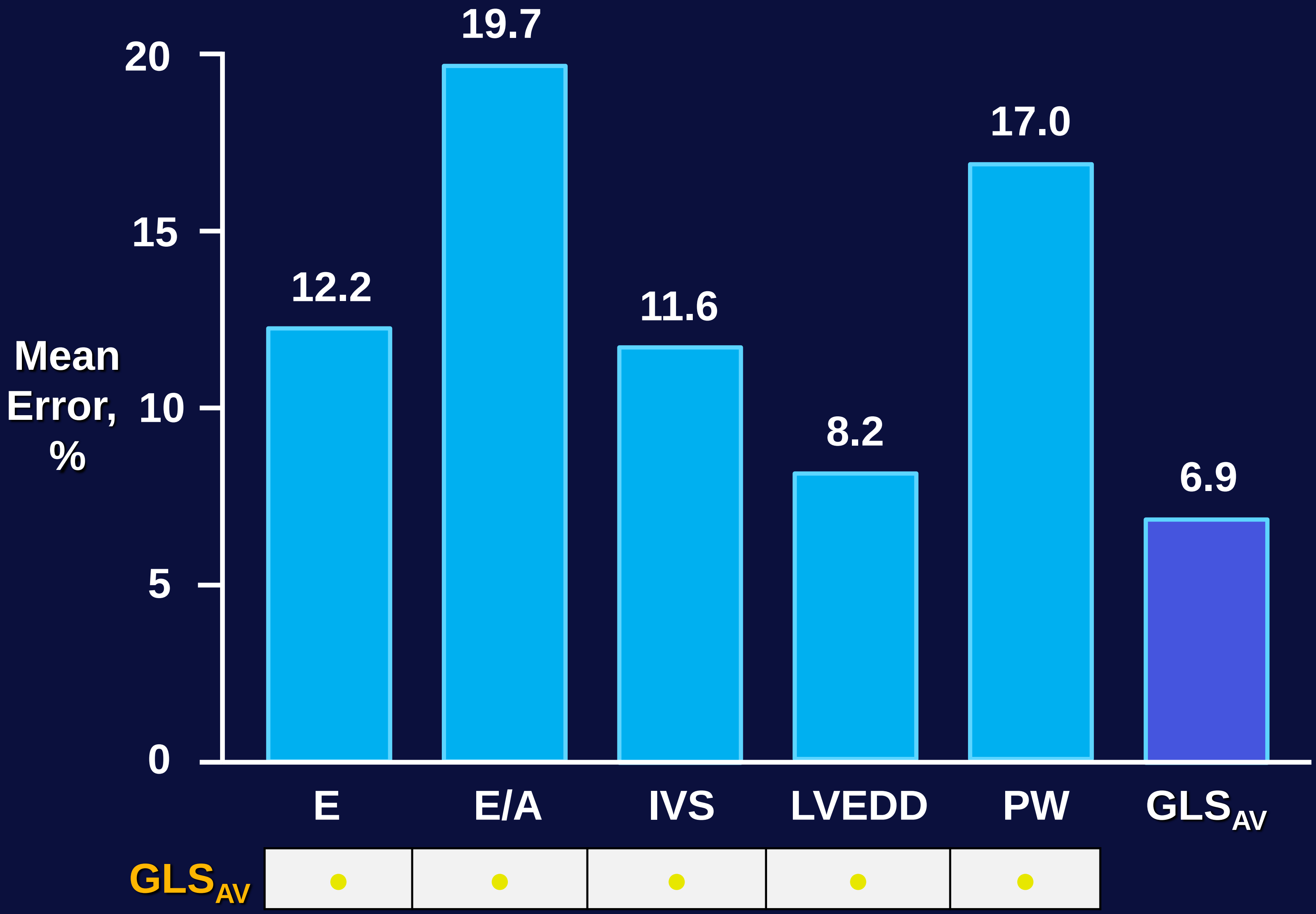
Conclusion: Reproducibility of GLS measurements was good and in many cases superior to conventional echocardiographic measurements. The small but statistically significant variation among vendors should be considered in performing serial studies and reflects a reference point for ongoing standardization efforts.
(J Am Soc Echocardiogr 2015;28:1171-81.)

Global Longitudinal Strain Among Various Vendors



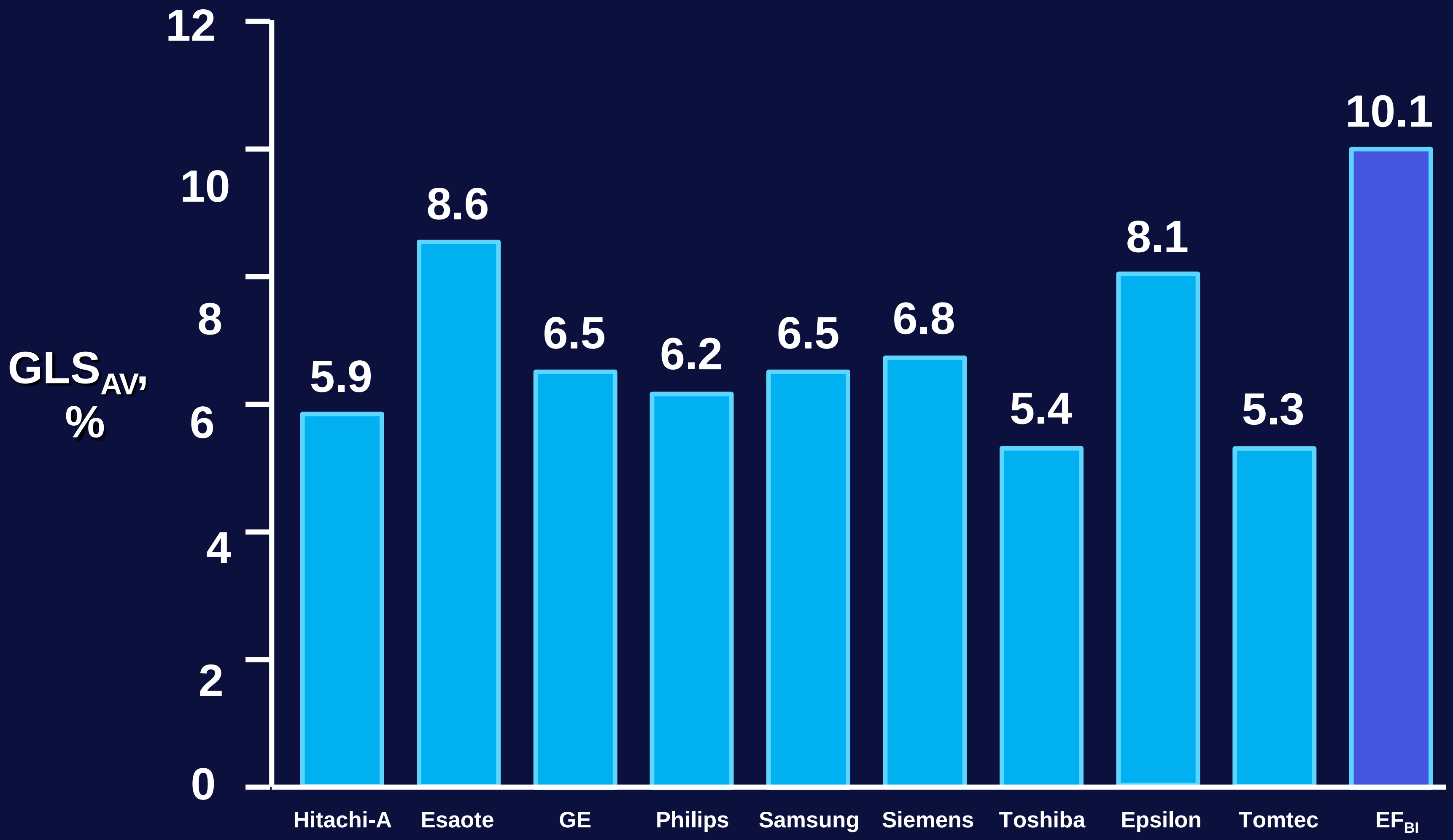
Farsalinos et al. J Am Soc Echocardiogr 2015;28:1171-81

Mean Error in Measurements

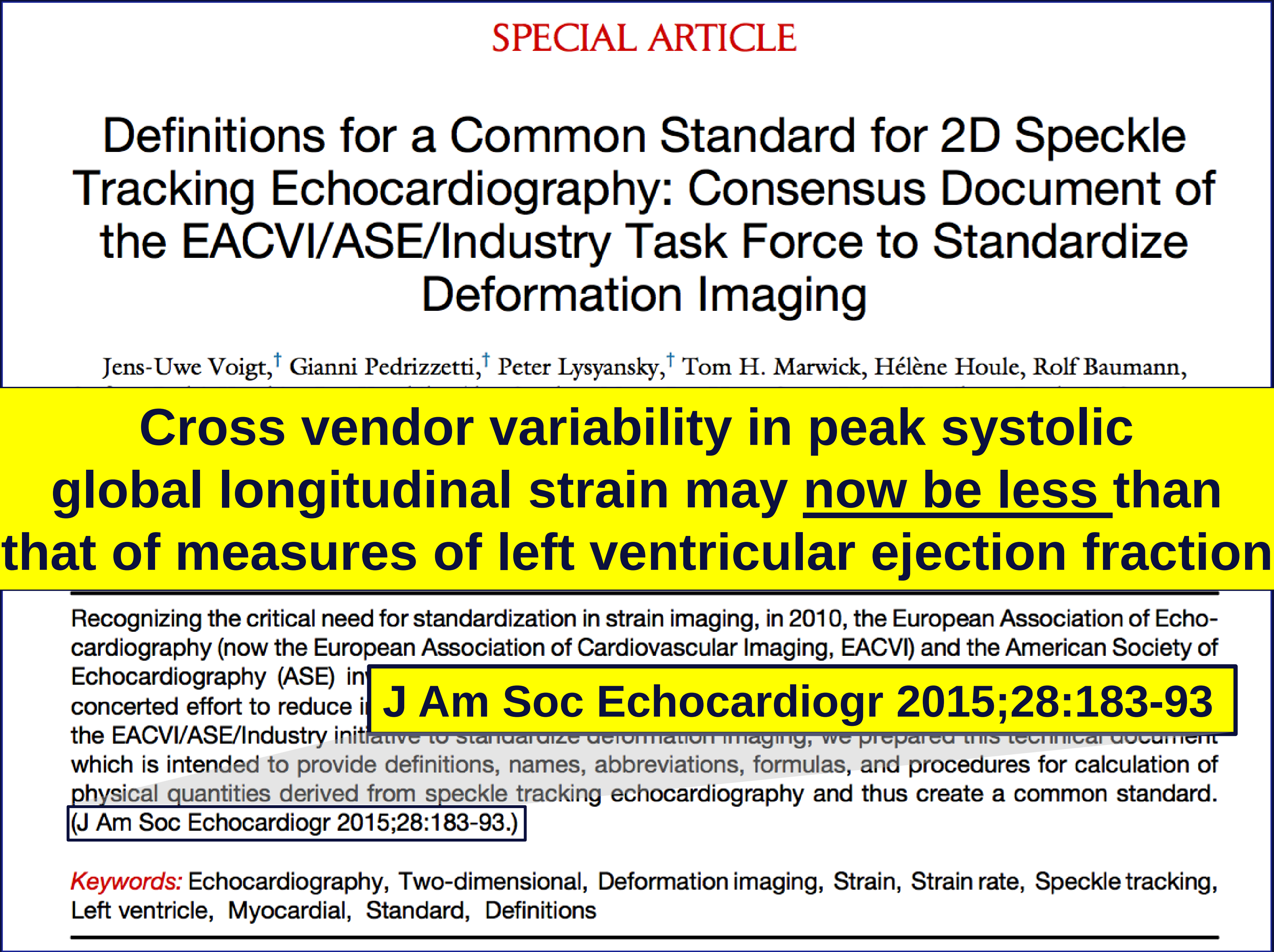


Farsalinos et al. J Am Soc Echocardiogr 2015;28:1171-81

Interobserver Relative Mean Errors



Farsalinos et al. J Am Soc Echocardiogr 2015;28:1171-81



SPECIAL ARTICLE

Definitions for a Common Standard for 2D Speckle Tracking Echocardiography: Consensus Document of the EACVI/ASE/Industry Task Force to Standardize Deformation Imaging

Jens-Uwe Voigt,[†] Gianni Pedrizzetti,[†] Peter Lysyansky,[†] Tom H. Marwick, Hélène Houle, Rolf Baumann,

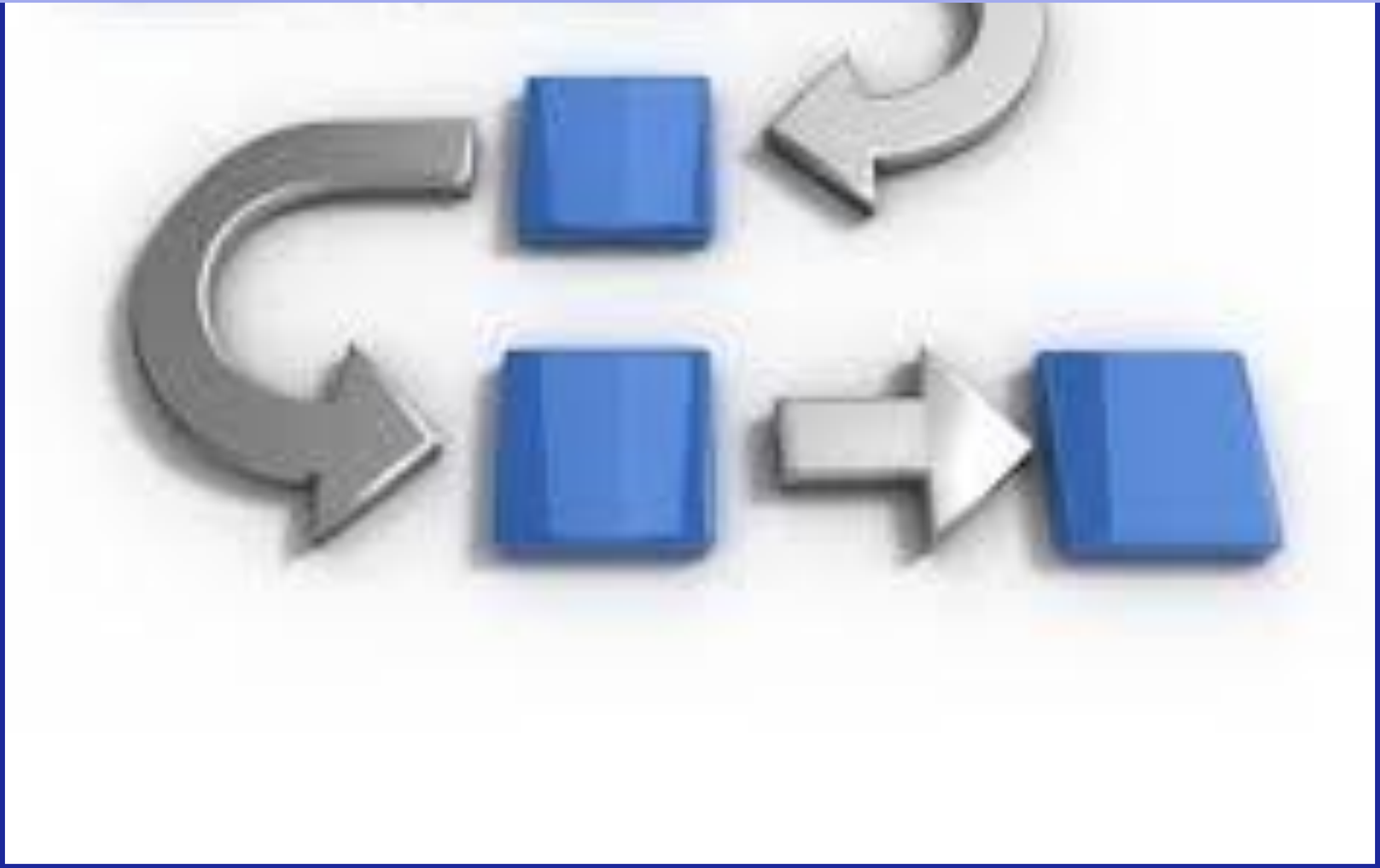
Cross vendor variability in peak systolic global longitudinal strain may <u>now be less</u> than that of measures of left ventricular ejection fraction

Recognizing the critical need for standardization in strain imaging, in 2010, the European Association of Echocardiography (now the European Association of Cardiovascular Imaging, EACVI) and the American Society of Echocardiography (ASE) in
concerted effort to reduce i
the EACVI/ASE/Industry initiative to standardize deformation imaging, we prepared this technical document which is intended to provide definitions, names, abbreviations, formulas, and procedures for calculation of physical quantities derived from speckle tracking echocardiography and thus create a common standard. (J Am Soc Echocardiogr 2015;28:183-93.)

J Am Soc Echocardiogr 2015;28:183-93

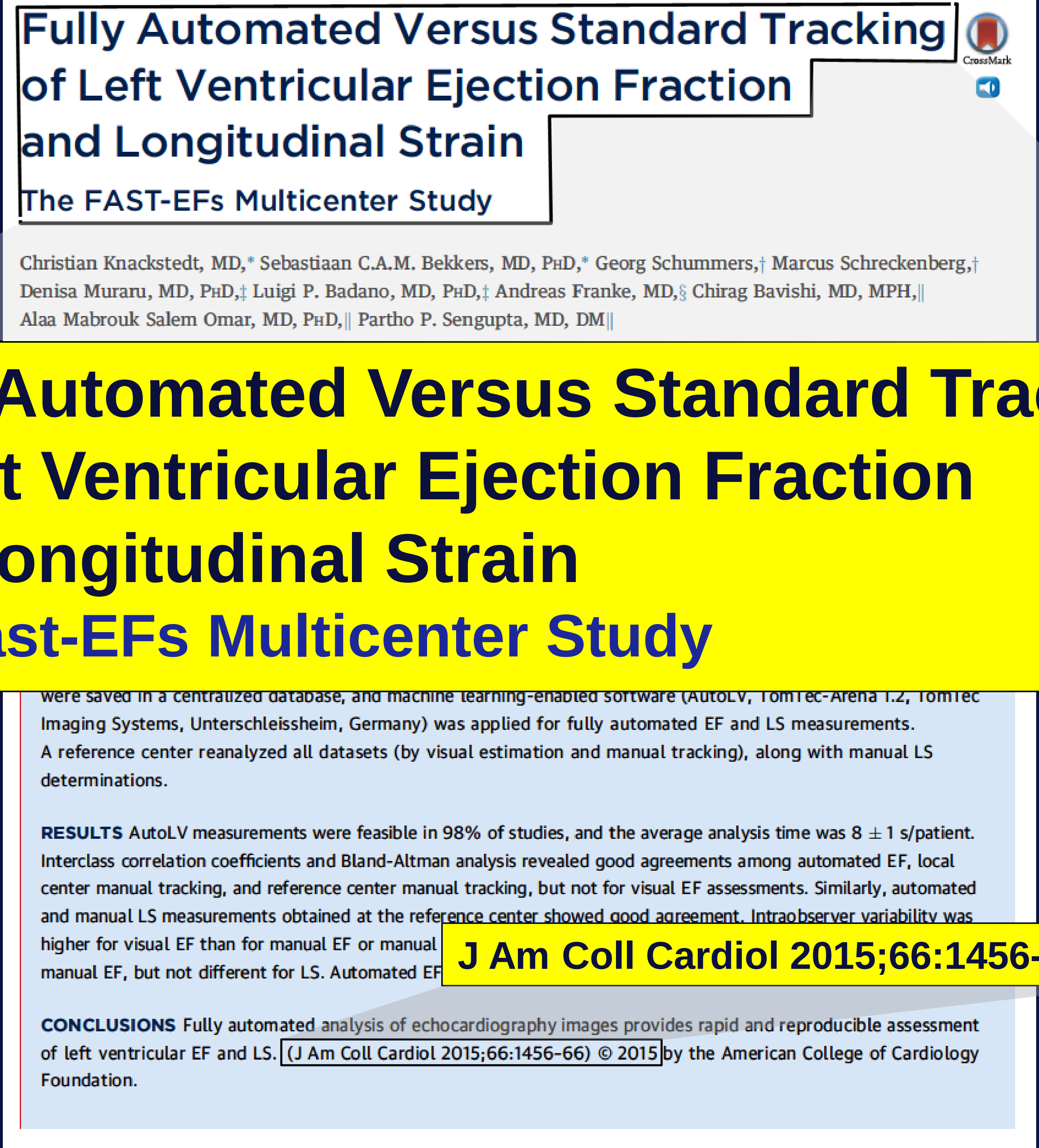
Keywords: Echocardiography, Two-dimensional, Deformation imaging, Strain, Strain rate, Speckle tracking, Left ventricle, Myocardial, Standard, Definitions

Any innovation in imaging must be paralleled or exceeded by an innovation in workflow.



Fully Automated Versus Standard Tracking of Left Ventricular Ejection Fraction and Longitudinal Strain

The Fast-EFs Multicenter Study



Fully Automated Versus Standard Tracking of Left Ventricular Ejection Fraction and Longitudinal Strain

The FAST-EFs Multicenter Study

Christian Knackstedt, MD,[*] Sebastiaan C.A.M. Bekkers, MD, PhD,[*] Georg Schummers,[†] Marcus Schreckenberg,[†] Denisa Muraru, MD, PhD,[‡] Luigi P. Badano, MD, PhD,[‡] Andreas Franke, MD,[§] Chirag Bavishi, MD, MPH,[||] Alaa Mabrouk Salem Omar, MD, PhD,[||] Partho P. Sengupta, MD, DM[||]

were saved in a centralized database, and machine learning-enabled software (AutoLV, TomTec-Arena 1.2, TomTec Imaging Systems, Unterschleissheim, Germany) was applied for fully automated EF and LS measurements. A reference center reanalyzed all datasets (by visual estimation and manual tracking), along with manual LS determinations.

RESULTS AutoLV measurements were feasible in 98% of studies, and the average analysis time was 8 ± 1 s/patient. Interclass correlation coefficients and Bland-Altman analysis revealed good agreements among automated EF, local center manual tracking, and reference center manual tracking, but not for visual EF assessments. Similarly, automated and manual LS measurements obtained at the reference center showed good agreement. Intraobserver variability was higher for visual EF than for manual EF or manual manual EF, but not different for LS. Automated EF

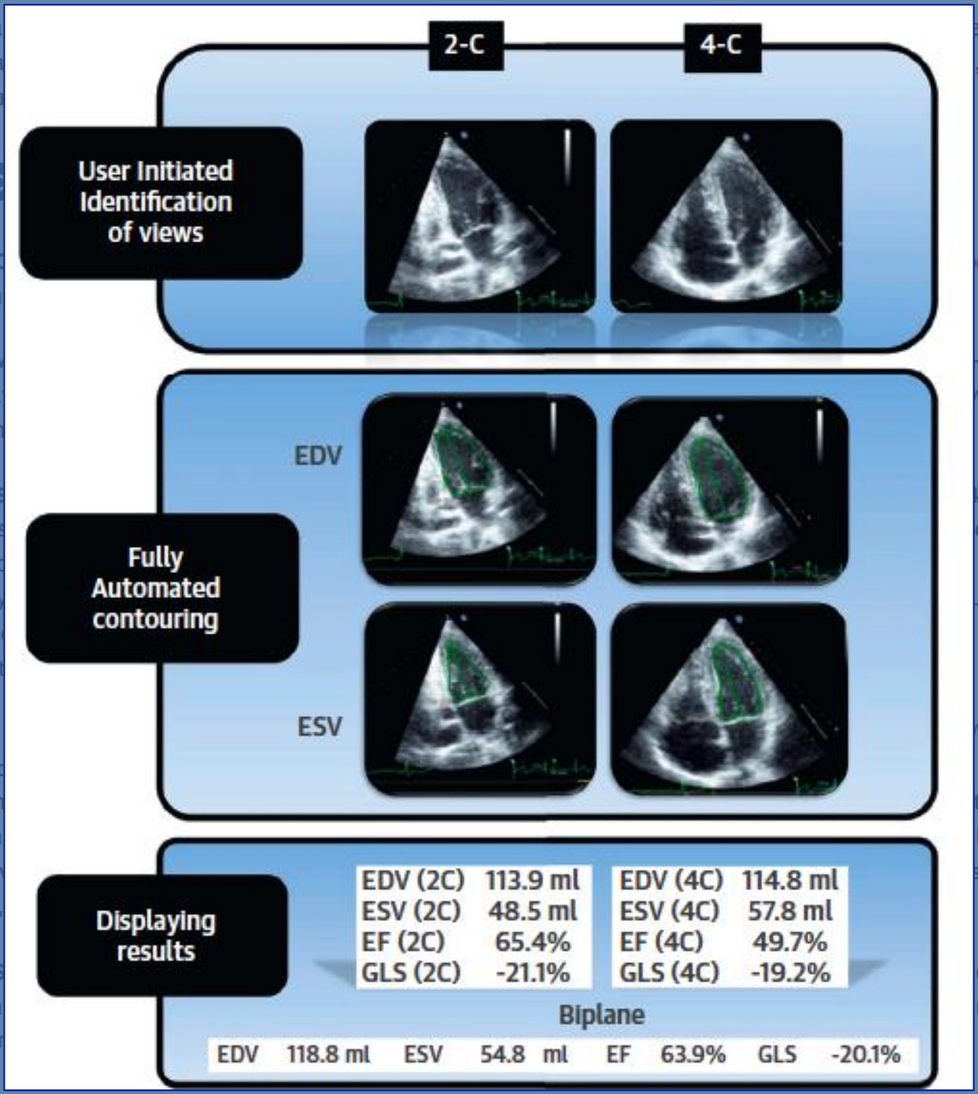
CONCLUSIONS Fully automated analysis of echocardiography images provides rapid and reproducible assessment of left ventricular EF and LS. (J Am Coll Cardiol 2015;66:1456-66) © 2015 by the American College of Cardiology Foundation.

J Am Coll Cardiol 2015;66:1456-66

Fully Automated Versus Standard Tracking of Left Ventricular Ejection Fraction and Longitudinal Strain

The FAST-EFs Multicenter Study

Christian Kn … enberg,†
Denisa Mura … ,||
Alaa Mabrou



ABSTRAC

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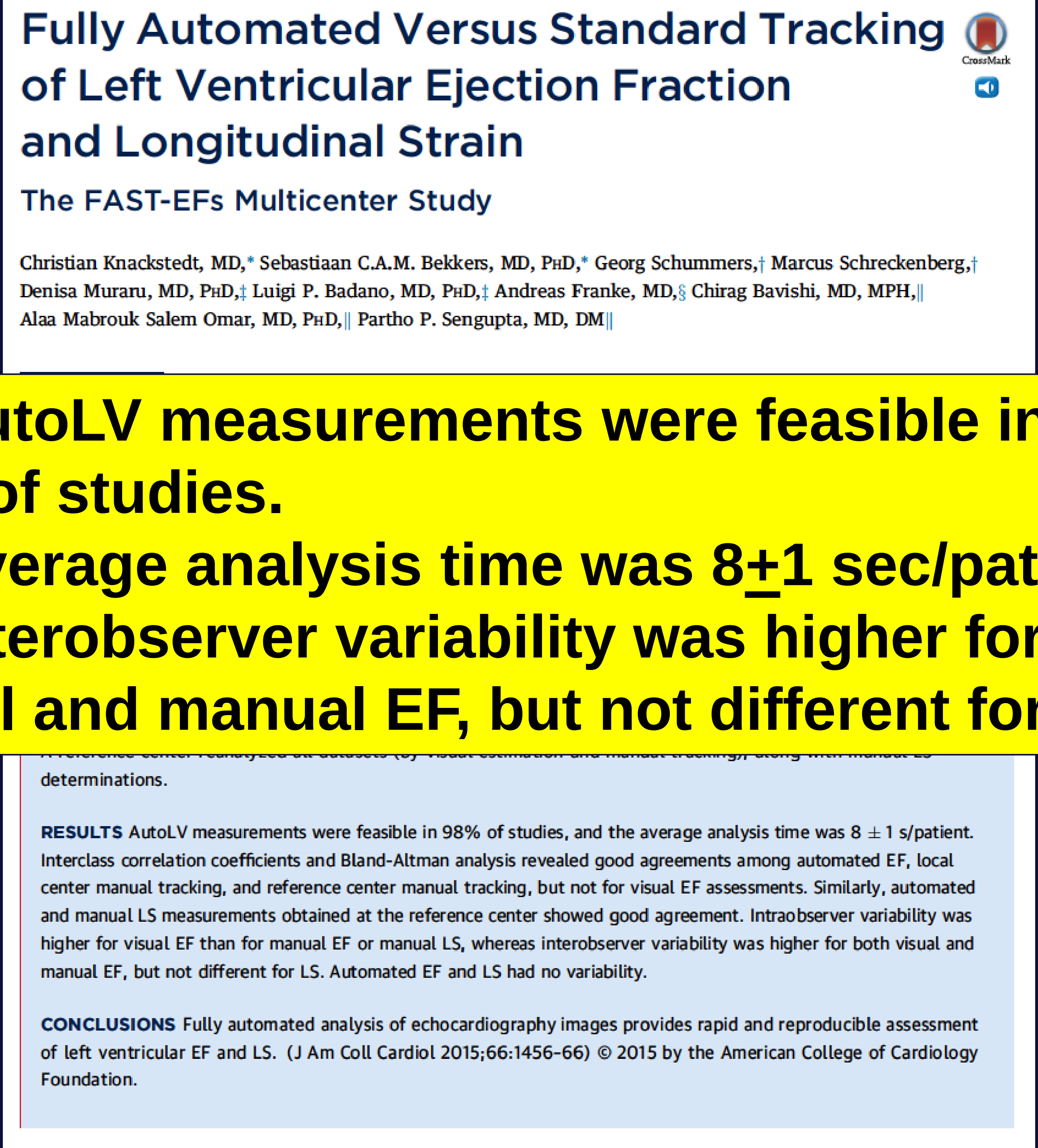

Fully Automated Versus Standard Tracking of Left Ventricular Ejection Fraction and Longitudinal Strain

The FAST-EFs Multicenter Study

Christian Knackstedt, MD,* Sebastiaan C.A.M. Bekkers, MD, PhD,* Georg Schummers,† Marcus Schreckenberg,†
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Alaa Mabrouk Salem Omar, MD, PhD,|| Partho P. Sengupta, MD, DM||

1. **AutoLV measurements were feasible in 98% of studies.**
2. **Average analysis time was 8$\underline{+}$1 sec/patient.**
3. **Interobserver variability was higher for both visual and manual EF, but not different for LS.**

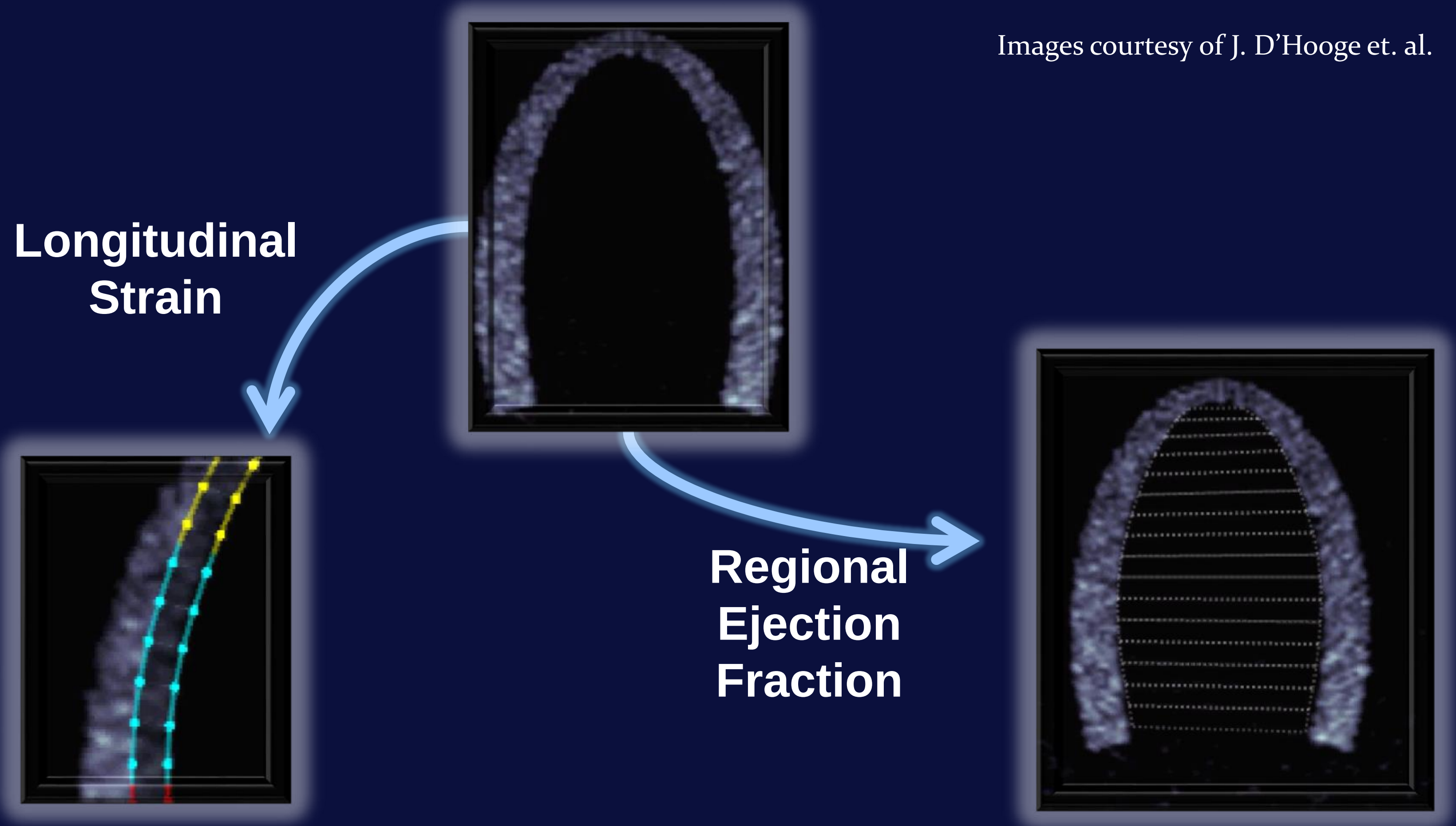
determinations.

RESULTS AutoLV measurements were feasible in 98% of studies, and the average analysis time was 8 ± 1 s/patient. Interclass correlation coefficients and Bland-Altman analysis revealed good agreements among automated EF, local center manual tracking, and reference center manual tracking, but not for visual EF assessments. Similarly, automated and manual LS measurements obtained at the reference center showed good agreement. Intraobserver variability was higher for visual EF than for manual EF or manual LS, whereas interobserver variability was higher for both visual and manual EF, but not different for LS. Automated EF and LS had no variability.

CONCLUSIONS Fully automated analysis of echocardiography images provides rapid and reproducible assessment of left ventricular EF and LS. (J Am Coll Cardiol 2015;66:1456-66) © 2015 by the American College of Cardiology Foundation.

Cardio-Oncology

Simultaneous measurement of Strain and Ejection Fraction



Images courtesy of J. D’Hooge et. al.

Longitudinal Strain

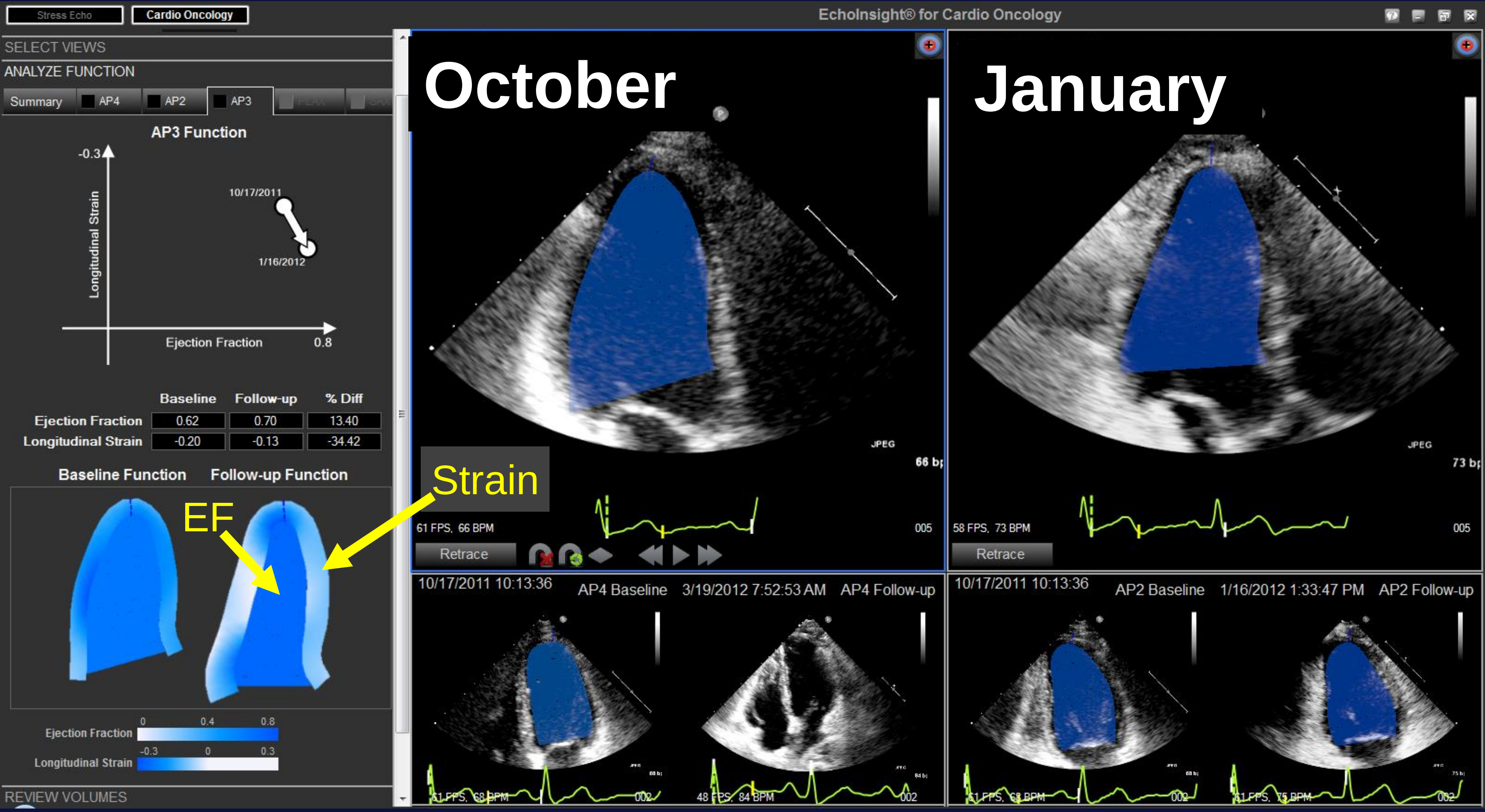
Regional Ejection Fraction

- Measures **systolic shortening**
- Sensitive measure of myocardium function

- Measures **fractional change in volume**
- Established, commonly used metric

Cardio-Oncology

Analysis

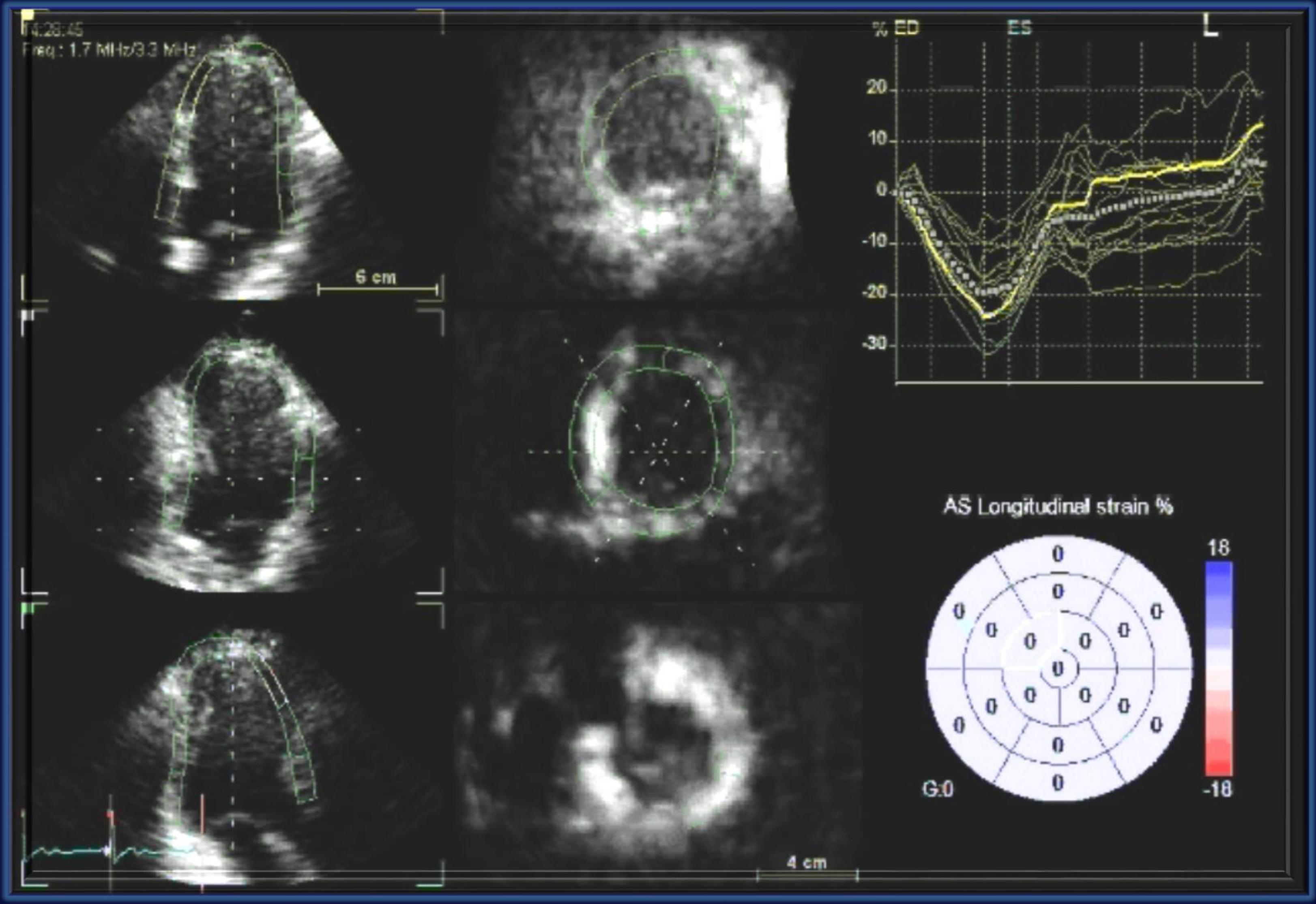


	Baseline	Follow-up	% Diff
Ejection Fraction	0.62	0.70	13.40
Longitudinal Strain	-0.20	-0.13	-34.42

Lower resolution

3D Strain Analysis

(spatial and temporal)



Evaluation of Global Left Ventricular Systolic Function Using Three-Dimensional Echocardiography Speckle-Tracking Strain Parameters

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Background: The aim of this study was to evaluate the capacity and reproducibility of three-dimensional echocardiographic (3DE) strain parameters in the assessment of global left ventricular (LV) systolic function.

Methods: A total of 128 subjects with differing LV ejection fractions were investigated using two-dimensional echocardiographic (2DE) and 3DE strains. Three-dimensional echocardiographic strain allows obtaining

"a promising approach"

Results: After excluding 21 patients for insufficient image quality, four for arrhythmia, two for severe valvular disease, and one for severe dyspnea, the final population consisted of 100 patients. Comparison between 2DE and 3DE GLS revealed high correspondence ($r = 0.91$, $y = 1.04x - 0.71$) and mean error measurement of −1.3% (95% confidence interval, −5.7 to 3.2). Among strain parameters, global area strain exhibited the highest correlation with LV ejection fraction ($y = -1.65 + 10.4$, $r = -0.92$, $P < .001$). Intraobserver measurement variability proved acceptable: 8% for GLS (vs 6% on 2DE analysis), 7% for circumferential strain (vs 15% on 2DE analysis), 7% for radial strain (vs 33% on 2DE analysis), and 5% for global area strain. The mean error between two measurements was low
but similar for GLS. The mean time of
than for 2DE analysis ($P < .001$).

J Am Soc Echocardiogr 2012;25:68-79

Conclusions: Of all strain parameters, new 3DE area strain correlated best with common LV systolic function parameters and is thus the most promising approach, while all 3DE strain markers exhibited good reproducibility (J Am Soc Echocardiogr 2012;25:68-79.)

Myocardial Imaging

“What’s Next Starts Soon”

Standardization

Workflow Efficiency

Confucius

“It doesn’t matter how slowly you go as long as you do not stop”

Take Home Points

1. DTI characterizes the low velocity, high intensity signals that come from the wall.
2. DTI is limited to movement relative to the sample volume fixed in space
3. Velocity: pitfalls of tethering and translational motion

Take Home Points

4. Local parameters of deformation (strain and strain rate) are not influenced by tethering or translational motion
5. Feature or Speckle tracking can evaluate velocity, strain and strain rate from standard gray scale images
6. Feature tracking permits assessment of strain in the axis of movement rather than the axis of the ultrasound beam.

When obtaining a pulsed wave tissue Doppler signal you should?

a. Turn the wall filters on and turn down the receiver gain.

b. Turn the wall filters off and turn up the receiver gain.

c. Turn the wall filters off and turn down the receiver gain.

d. Turn the wall filters on and turn up the receiver gain.

With "speckle tracking" myocardial imaging:

a. You measure strain along the axis of the ultrasound beam.
b. Velocity and strain measurements are measured from standard gray-scale images.
c. Myocardial velocity measurements are not influenced by translational or tethering motion as they are when obtained by pulsed wave tissue Doppler imaging.
d. You can measure longitudinal but not circumferential or radial strain.

Compared to pulsed wave tissue Doppler the myocardial velocities obtained by color tissue Doppler are?

a. Higher
b. Lower
c. The same

mayo