Established and Emerging Indications for Speckle Tracking Imaging

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Grant Support: Philips Ultrasound US

University of Massachusetts Medical School
UMASS

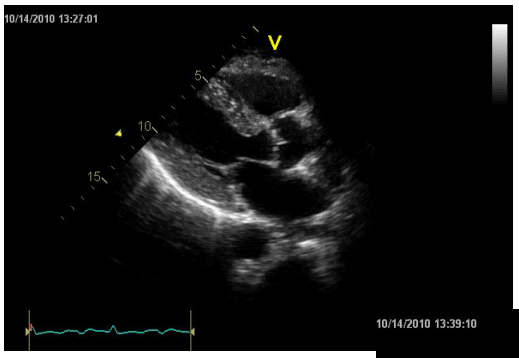
Strain Imaging Confirmed What We Suspected

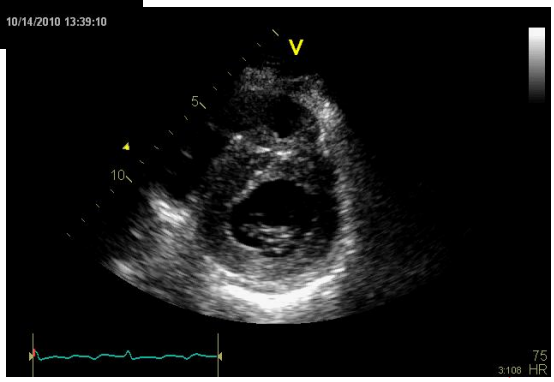
Case 1: Coach

78 year old man

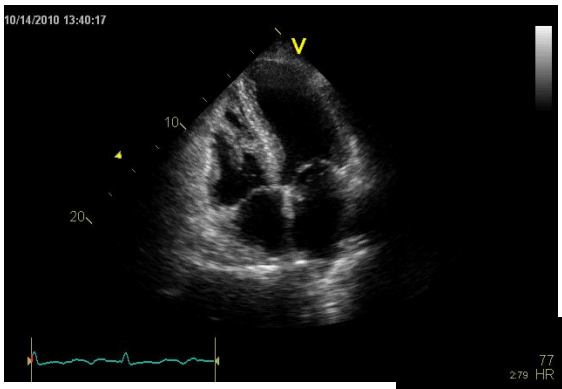
- Progressive exertional dyspnea
- Peripheral edema & S3
- Echo – LVH, normal ejection fraction

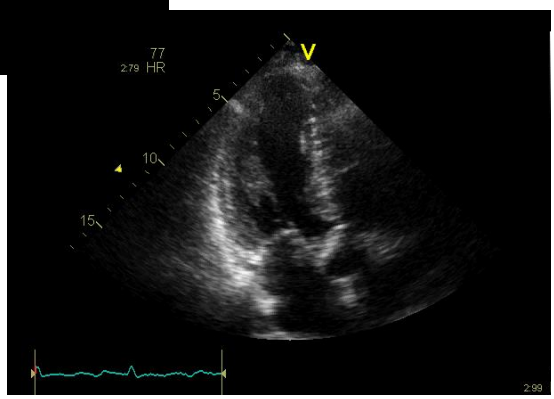
3



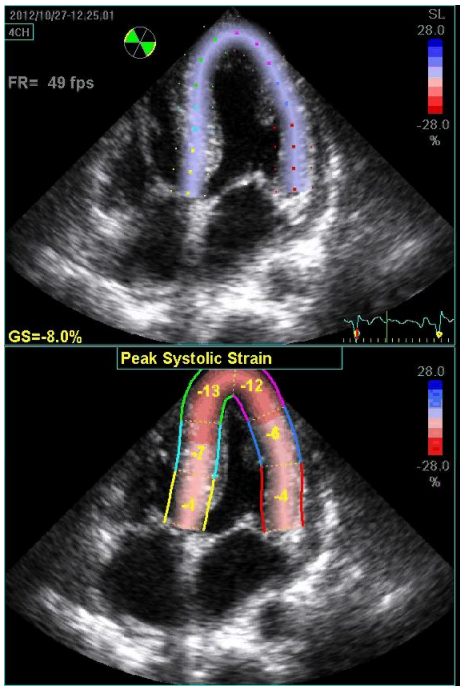


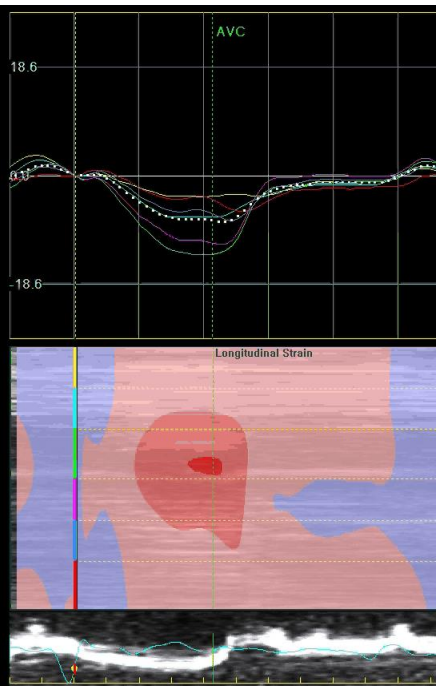
Small LV
High RWT
Low normal EF





Small LV
High RWT
Low normal
EF

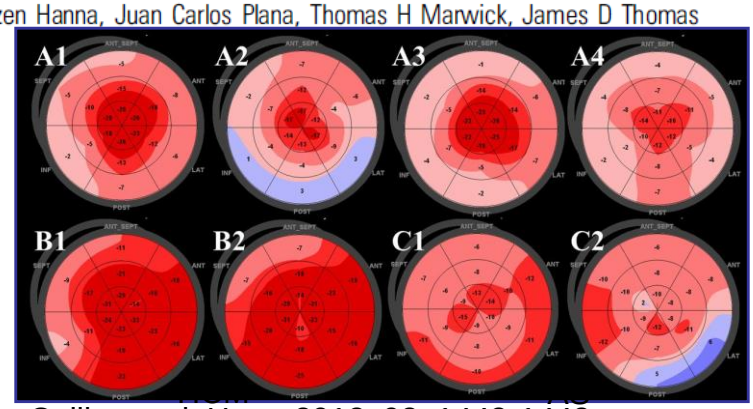




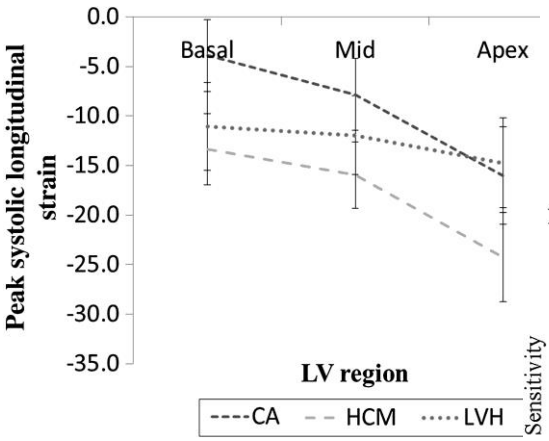
ORIGINAL ARTICLE

Relative 'apical sparing' of longitudinal strain using two-dimensional speckle-tracking echocardiography is both sensitive and specific for the diagnosis of cardiac amyloidosis

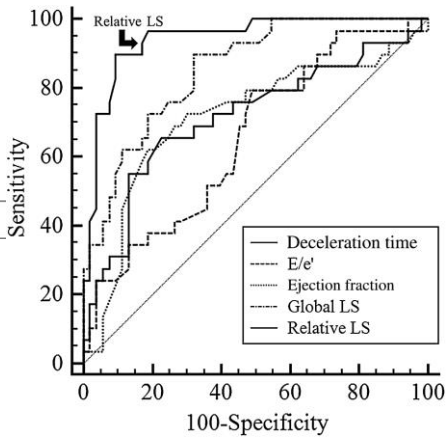
Dermot Phelan, Patrick Collier, Paaladinesh Thavendiranathan, Zoran B Popović, Mazen Hanna, Juan Carlos Plana, Thomas H Marwick, James D Thomas



Phelan, Collier et al. Heart 2012; 98: 1442-1448

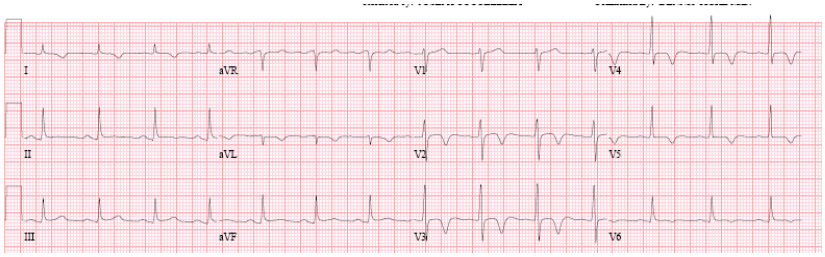


Amyloid: Apex > 2x Base & Mid

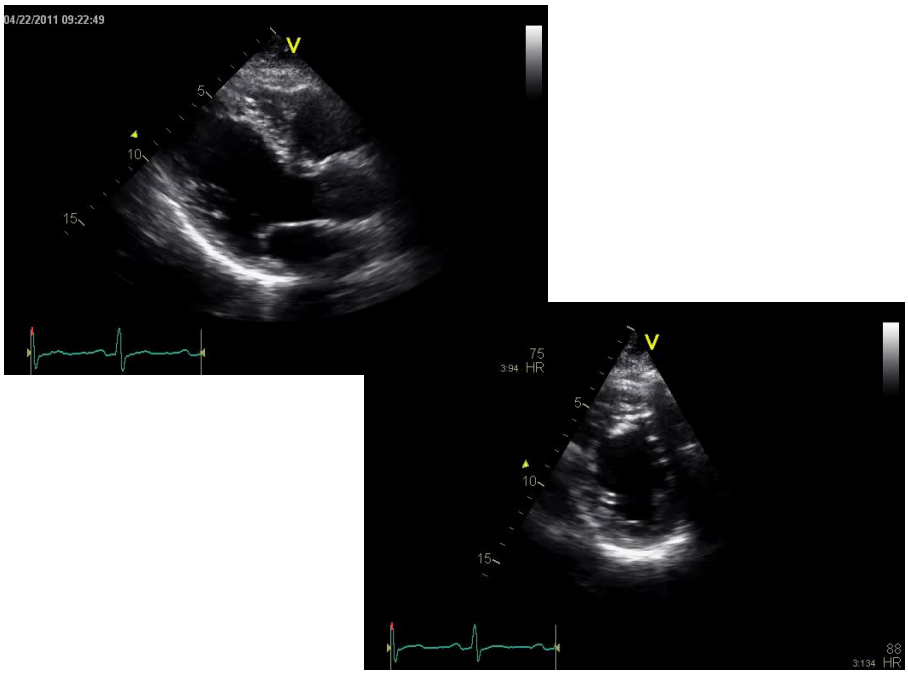


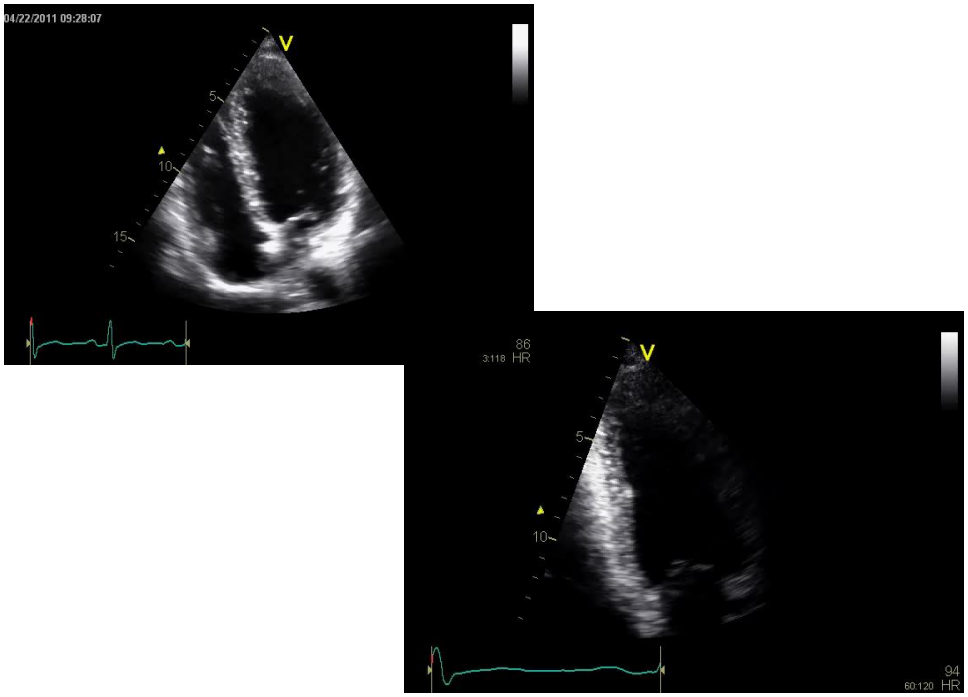
Phelan, Collier et al. Heart 2012; 98: 1442-1448

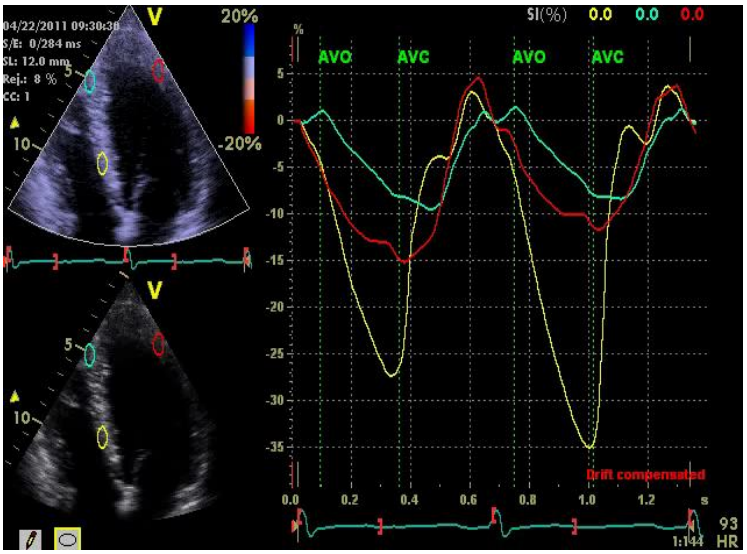
44 year old man with chest pain

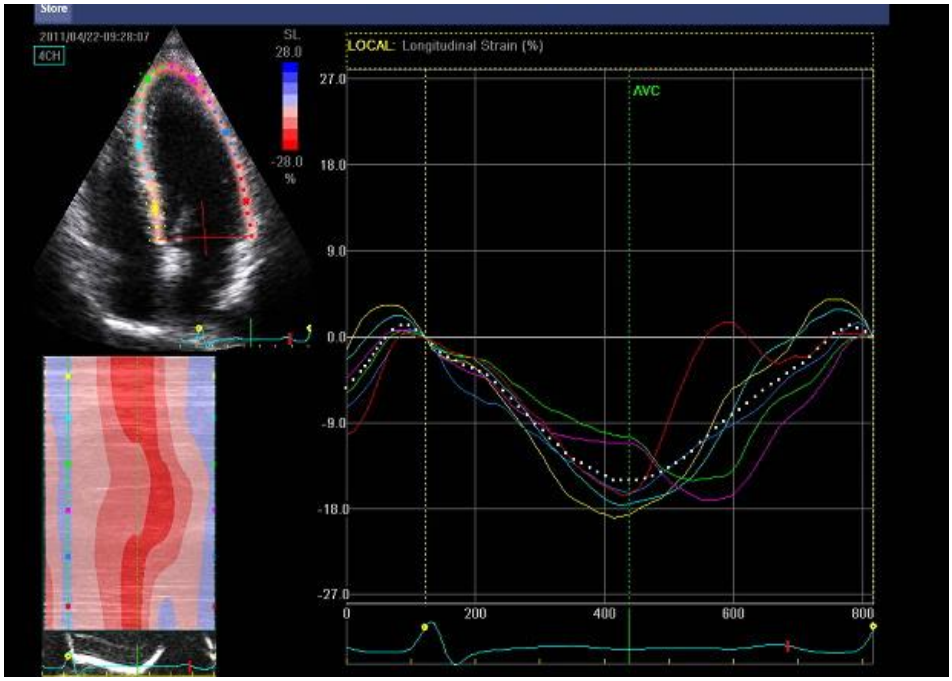


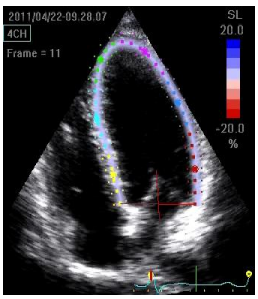
Troponin I 1.65

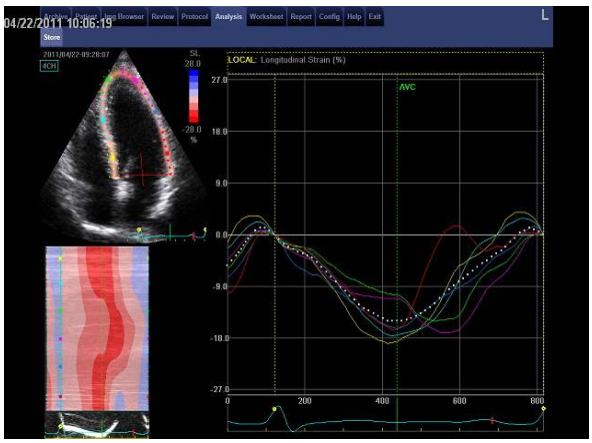


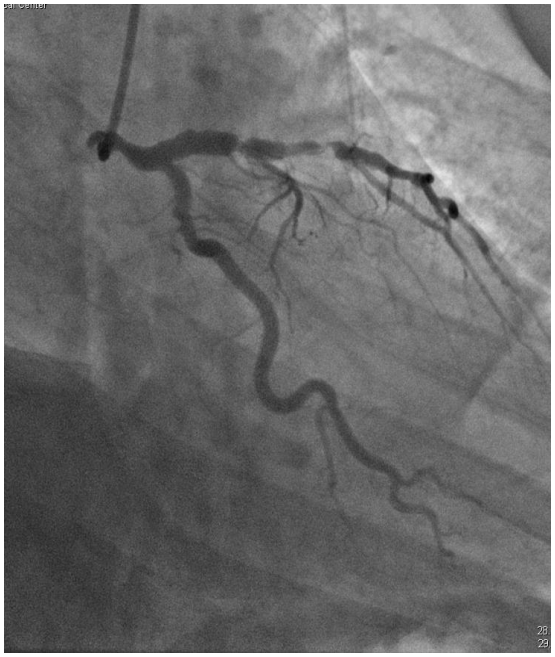

04/22/2011 09:28:07
V
5
10
15
86
3:118 HR
V
5
10
94
60:120 HR


04/22/2011 09:30:38
S/E: 0/284 ms
SL: 12.0 mm
Rej.: 8 %
CC: 1
V
20%
-20%
V
SI(%) 0.0 0.0 0.0
AVC
AVC
AVO
AVC
Drift compensated
0.0 0.2 0.4 0.6 0.8 1.0 1.2 s
93
1:144 HR

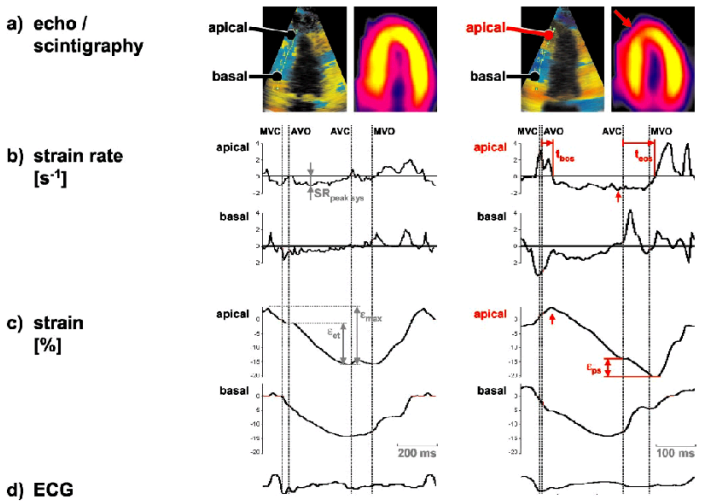

Store
2011/04/22-09:28:07
4CH
SL
28.0
-28.0
%
LOCAL: Longitudinal Strain (%)
AVC
27.0
18.0
9.0
0.0
-9.0
-18.0
-27.0
0
200
400
600
800


2011/04/22-09:28:07
4CH
Frame = 11
SL
20.0
-20.0
%

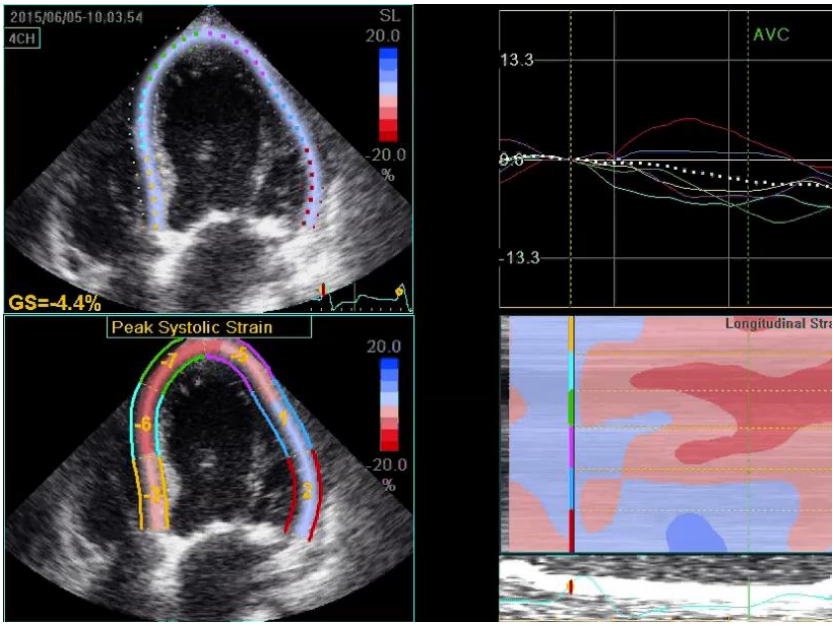

04/22/2011 10:06:19
Store
LOCAL: Longitudinal Strain (%)
AVC



Post Systolic Shortening

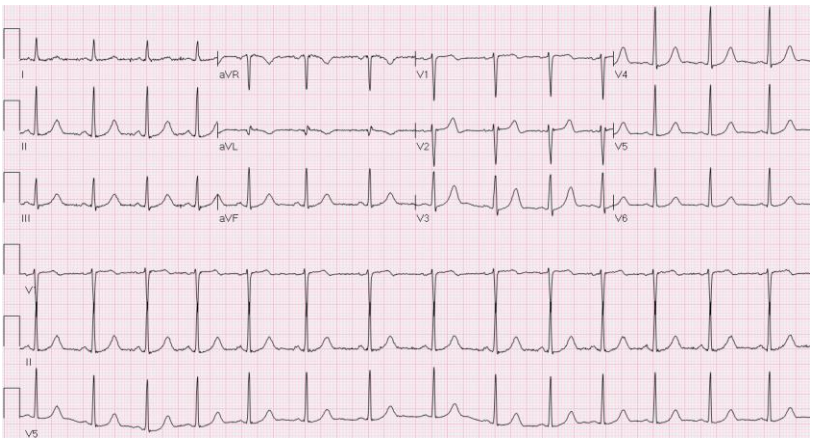


Voigt, Circulation. 2003;107:2120



17

32 year old woman with chest pain and + TnI 0.17



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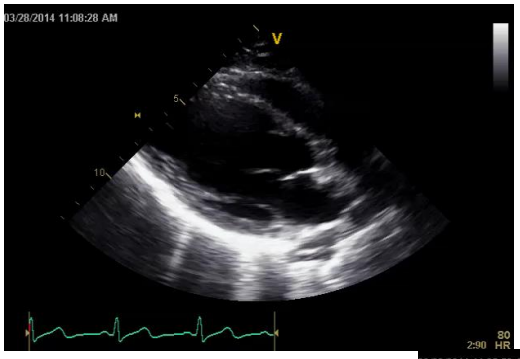
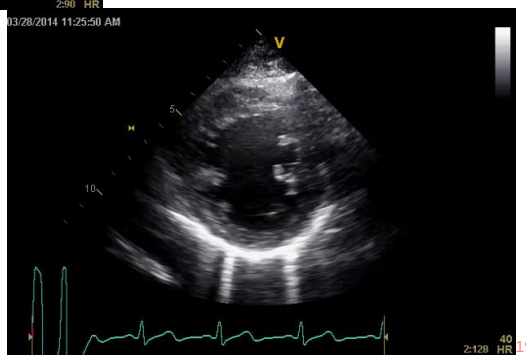


32 year old with chest pain and + TnI 0.17



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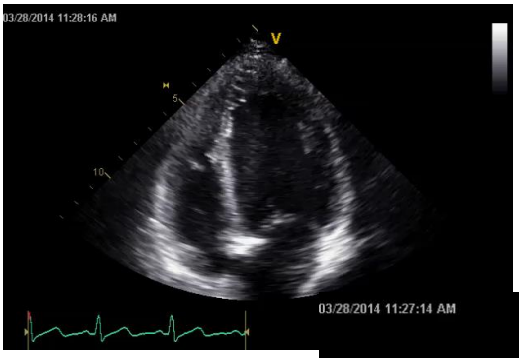
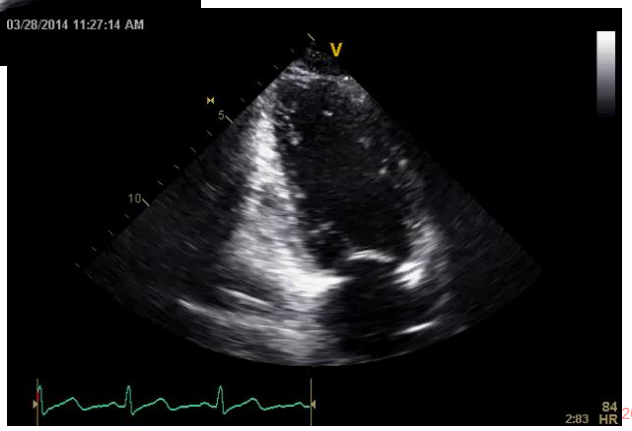
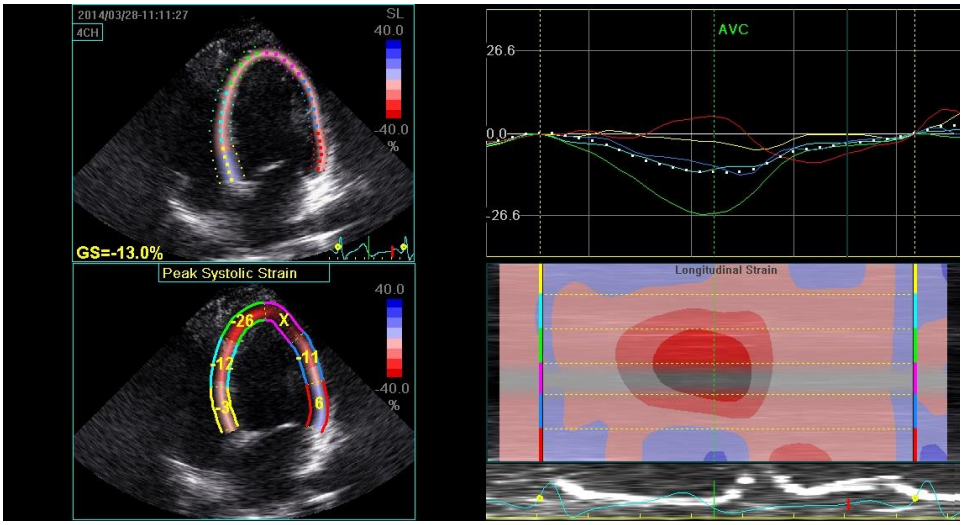


32 year old with chest pain and + TnI 0.17

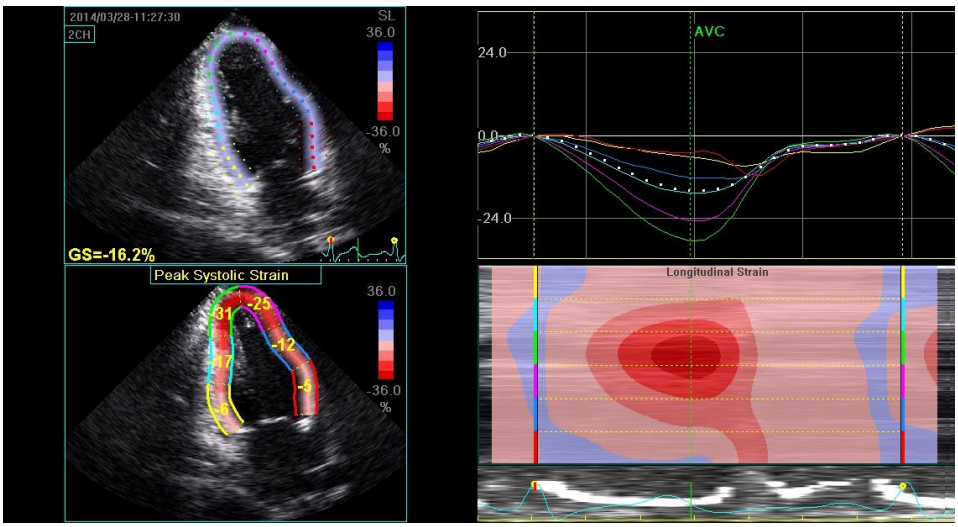


Coronary arteriogram is negative

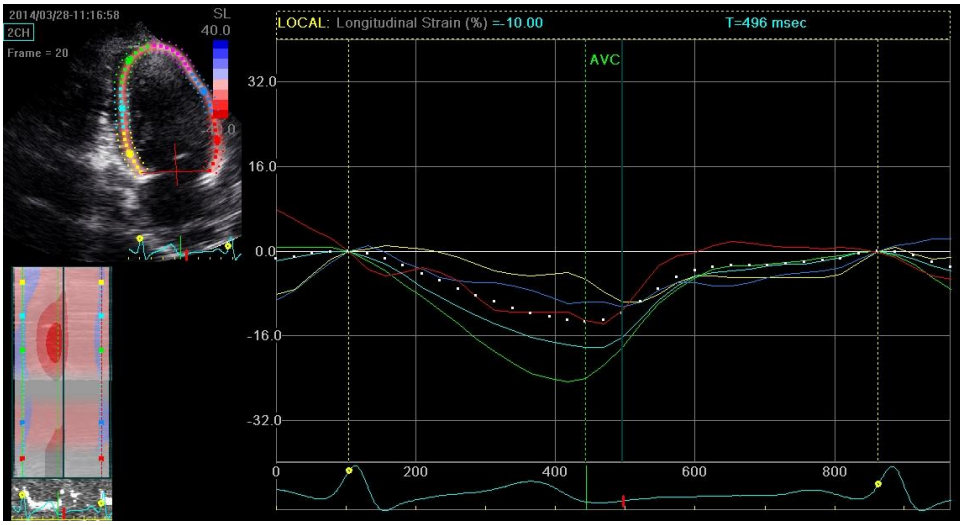
20


2014/03/28-11:11:27
4CH
SL
40.0
-40.0
%
GS=-13.0%
Peak Systolic Strain
40.0
-40.0
%
-26
X
-12
-11
-3
6
AVC
26.6
0.0
-26.6
Longitudinal Strain

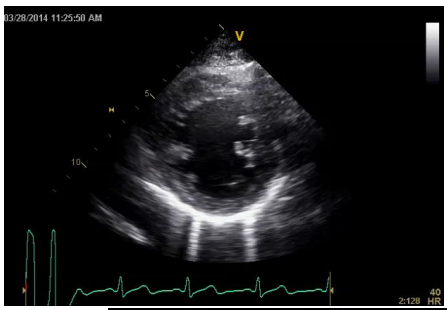
21


2014/03/28-11:27:30
2CH
SL
36.0
-36.0
%
GS=-16.2%
Peak Systolic Strain
36.0
-36.0
%
-31
-25
-12
-17
-3
-6
AVC
24.0
0.0
-24.0
Longitudinal Strain

22


2014/03/28-11:16:58
2CH
Frame = 20
SL
40.0
LOCAL: Longitudinal Strain (%) =-10.00
T=496 msec
AVC
32.0
16.0
0.0
-16.0
-32.0
0
200
400
600
800

23


03/28/2014 11:25:50 AM
V
40
2:128 HR


2014/03/28-11:09:11
SAX-PM
Frame = 22
SC
44.0
-44.0
%
LOCAL: Circumferential Strain (%) =-11.00
T=549 msec
AVC
35.2
17.6
0.0
-17.6
-35.2
0
200
400
600
800
1000

Recurrent Episodes of Takotsubo-Like Transient Left Ventricular Ballooning Occurring in Different Regions: A Case Report

Masatoshi SHIMIZU, MD
Yukio KATO, MD*
Hiroyuki MASAI, MD
Takashi SHIMA, MD
Yoichi MIWA, MD*

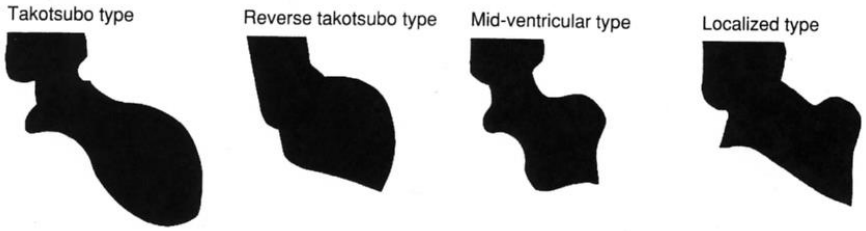


Fig. 5 Morphological classification of takotsubo-like left ventricular dysfunction
Takotsubo type represents apical akinesis and basal hyperkinesis. Reverse takotsubo type shows basal akinesis and apical hyperkinesis. Mid-ventricular type shows mid-ventricular ballooning accompanied by basal and apical hyperkinesis. Localized type includes any other segmental left ventricular ballooning with clinical characteristics suggestive of takotsubo-like left ventricular dysfunction.

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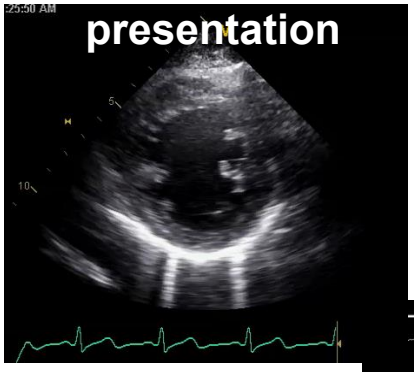
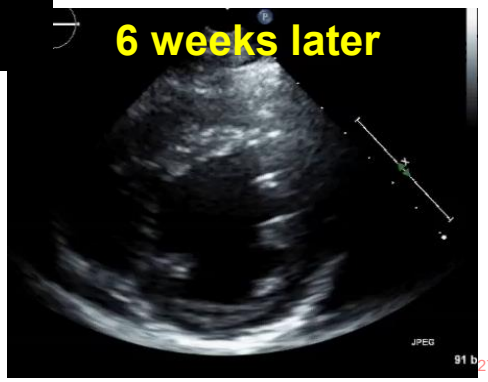
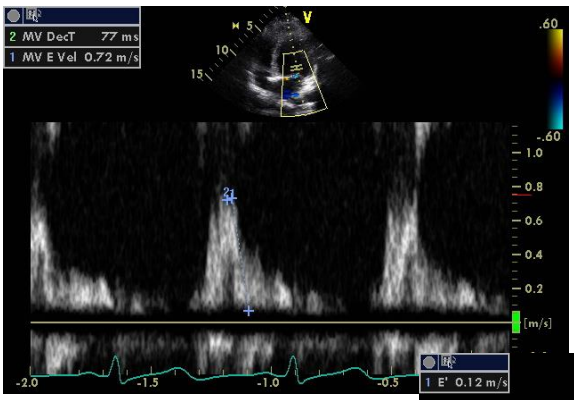
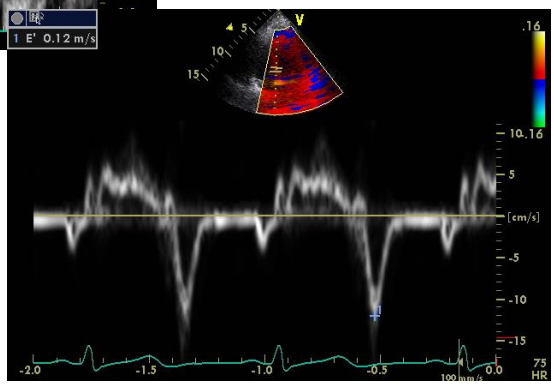


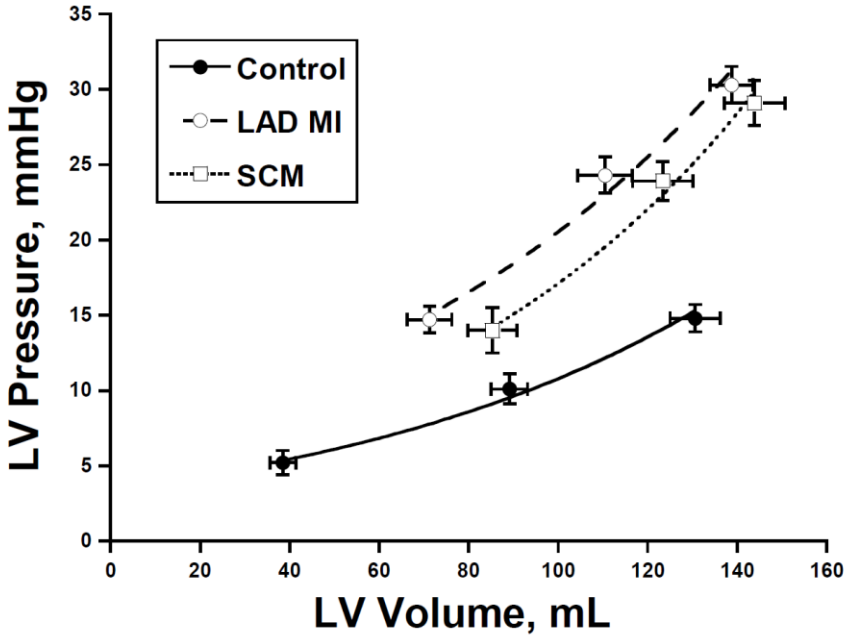




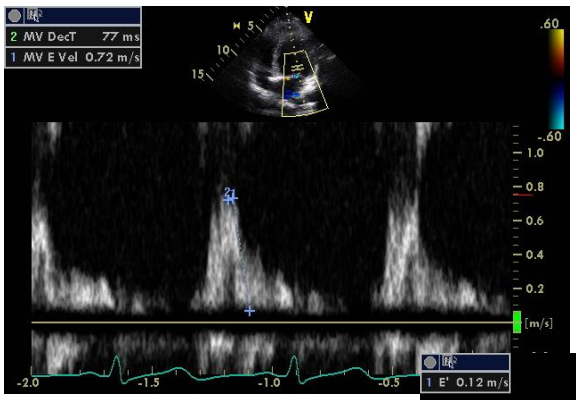


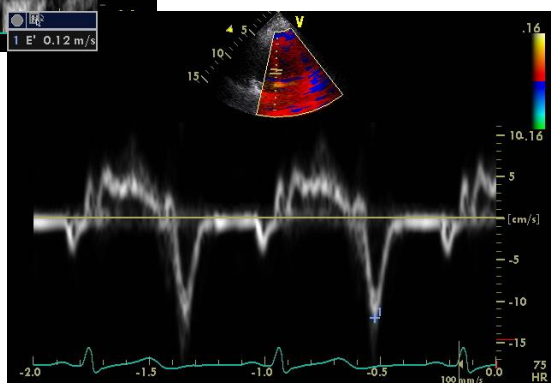
Bonus Question:

What is the filling pressure?



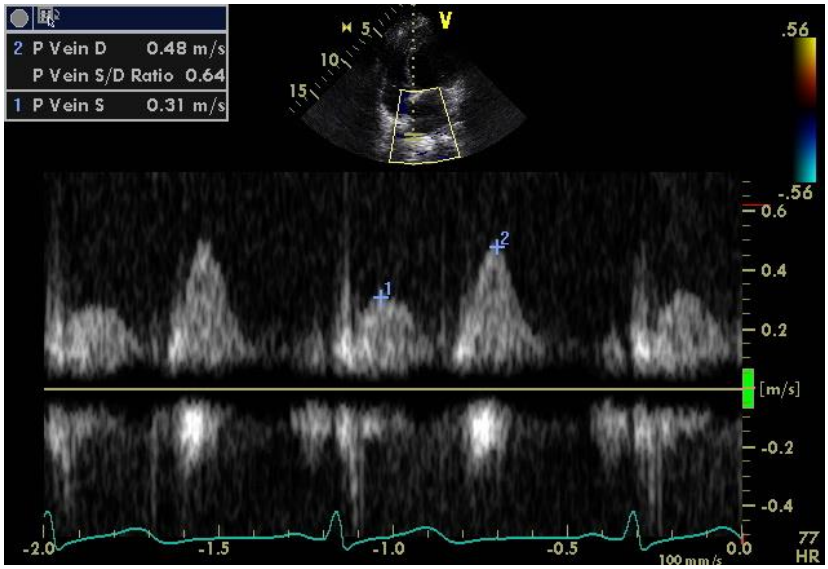
Medeiros Circ 2014



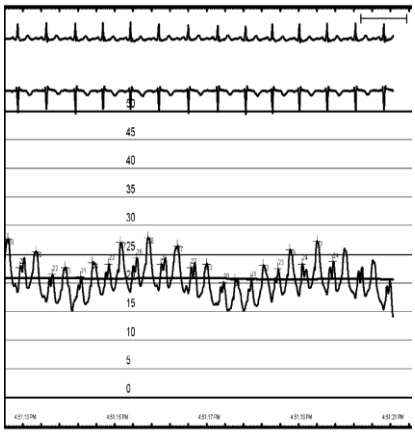


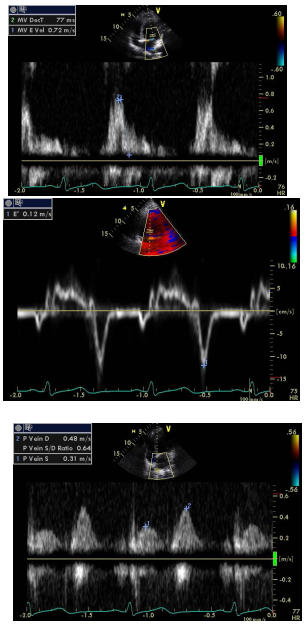
Bonus Question:

What is the filling pressure?


2 P Vein D 0.48 m/s
P Vein S/D Ratio 0.64
1 P Vein S 0.31 m/s
.56
-.56
0.6
0.4
0.2
[m/s]
-0.2
-0.4
-2.0
-1.5
-1.0
-0.5
0.0
100 mm/s
77
HR

31


45
40
35
30
25
15
10
5
0



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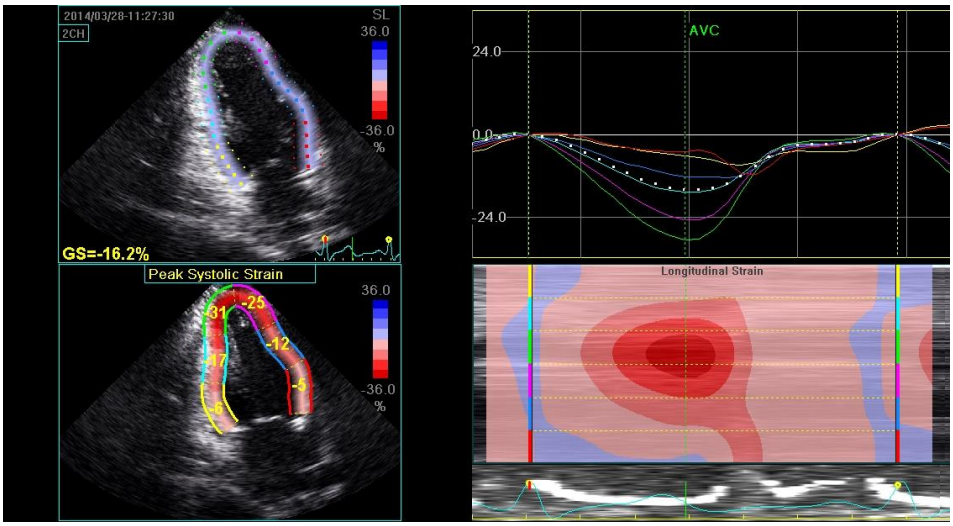

TnI peaks at 3.17 coronary arteriogram NL

33

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JACC Vol. 10, No. 3
September 1987:702–9

Right Ventricular Pacing Reduces the Rate of Left Ventricular Relaxation and Filling

MICHAEL R. ZILE, MD, FACC, ALVIN S. BLAUSTEIN, MD, GEN SHIMIZU, MD, WILLIAM H. GAASCH, MD, FACC

Boston, Massachusetts

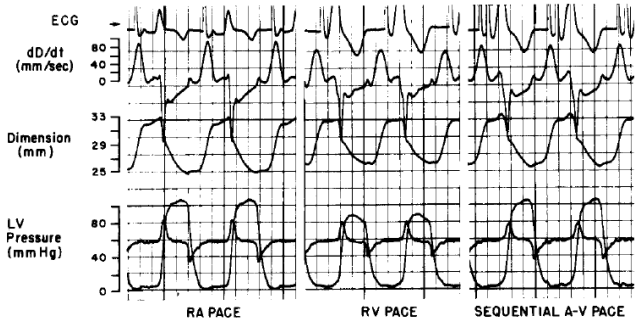

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Table 1.

	Case 1	Case 2	Case 3
LVEF at presentation	45%	50%	50%
E velocity (m/s)	0.73	0.60	0.63
Deceleration time (ms)	178	200	212
e' septum (m/s)	0.12	0.08	0.06
e' lateral (m/s)	0.11	0.08	0.07
E/e' septum	6	7.5	10.5
E/e' lateral	6.6	7.5	9
LVEDP (mmHg)	24	30	34
Average GLS (%)	-17.3	-19.4	-17.67

Iskandar Circ 2014 (abstract)

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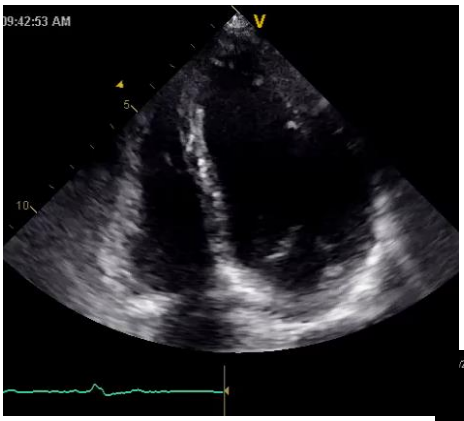
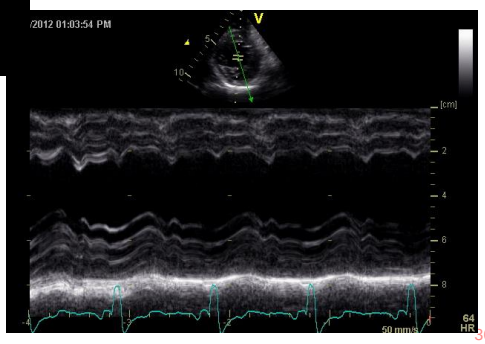
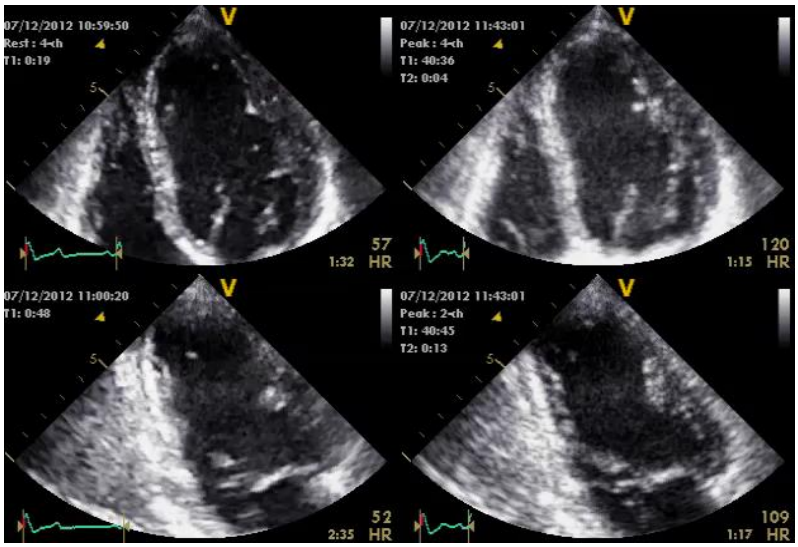


55 year old woman with chest pain and exertional dyspnea

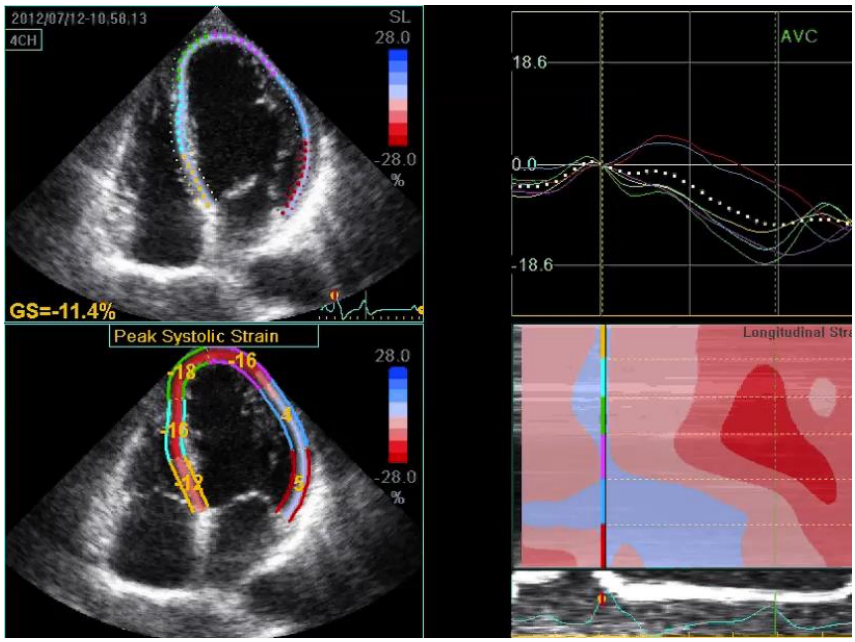


36



TSE: positive for LAD MI + ischemia
Cath: no obstructive CAD

37



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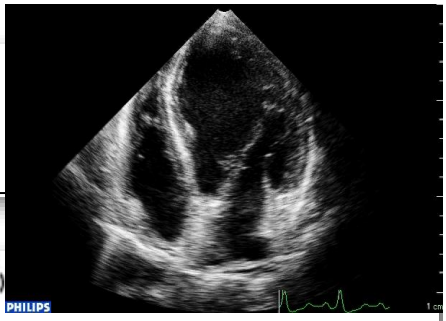
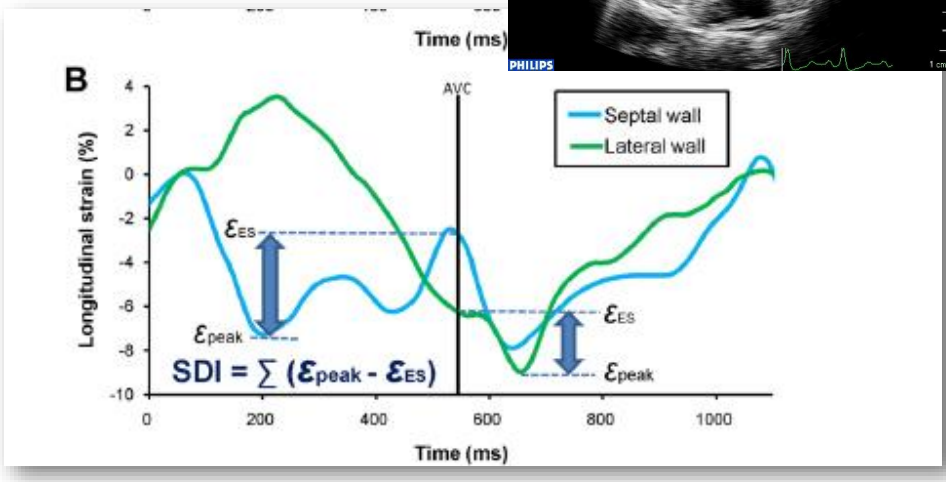
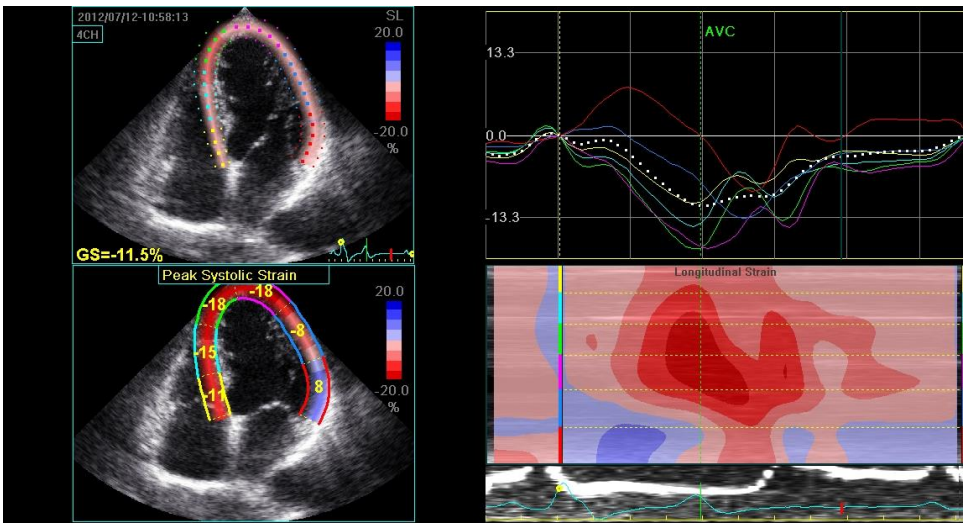
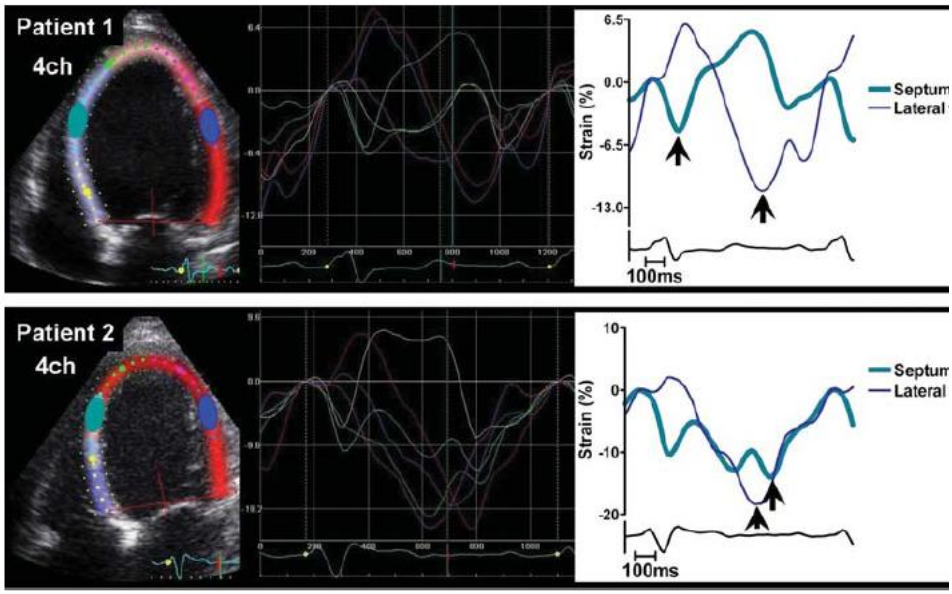
Incremental Value of Inefficient Deformation Indices for Predicting Response to Cardiac Resynchronization Therapy

Yi-Hsin Chan, MD, Lung-Sheng Wu, MD, Chi-Tai Kuo, MD, Chun-Li Wang, MD, Yung-Hsin Yeh, MD, Wan-Jing Ho, MD, and Lung-An Hsu, MD, PhD, *Taoyuan, Taiwan*









train traces by speckle-tracking echocardiography in four-chamber views showing peak septal strain and peak L
ing left bundle branch block for a patient with peak septal strain during isovolumic contraction (Patient 1) and
during late ejection (Patient 2). Note that for Patient 2, peak septal strain occurs after peak lateral wall strain.
>150 ms and no known or prior history of coronary artery disease

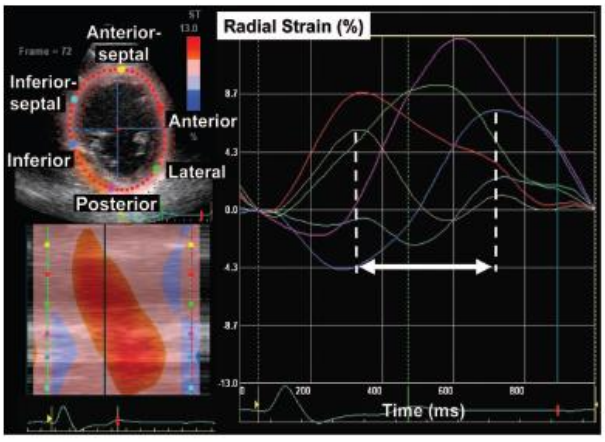
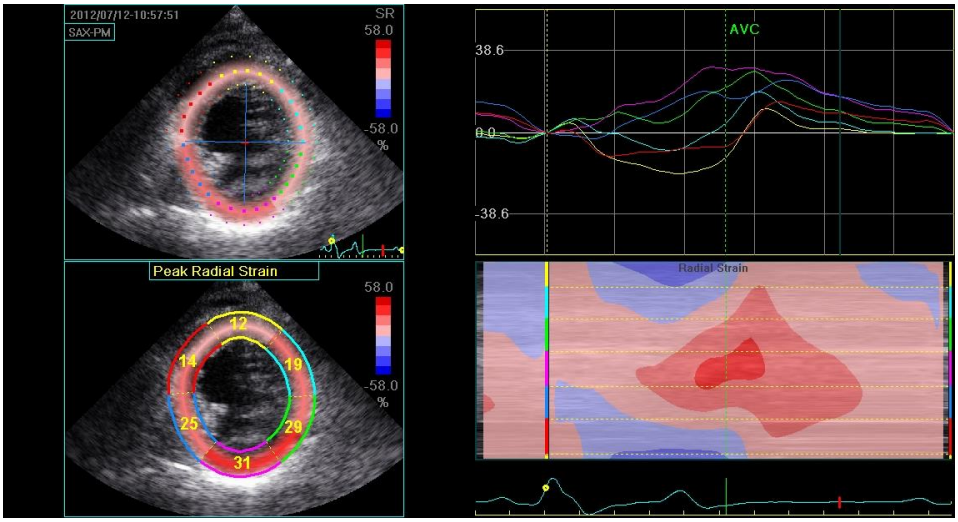
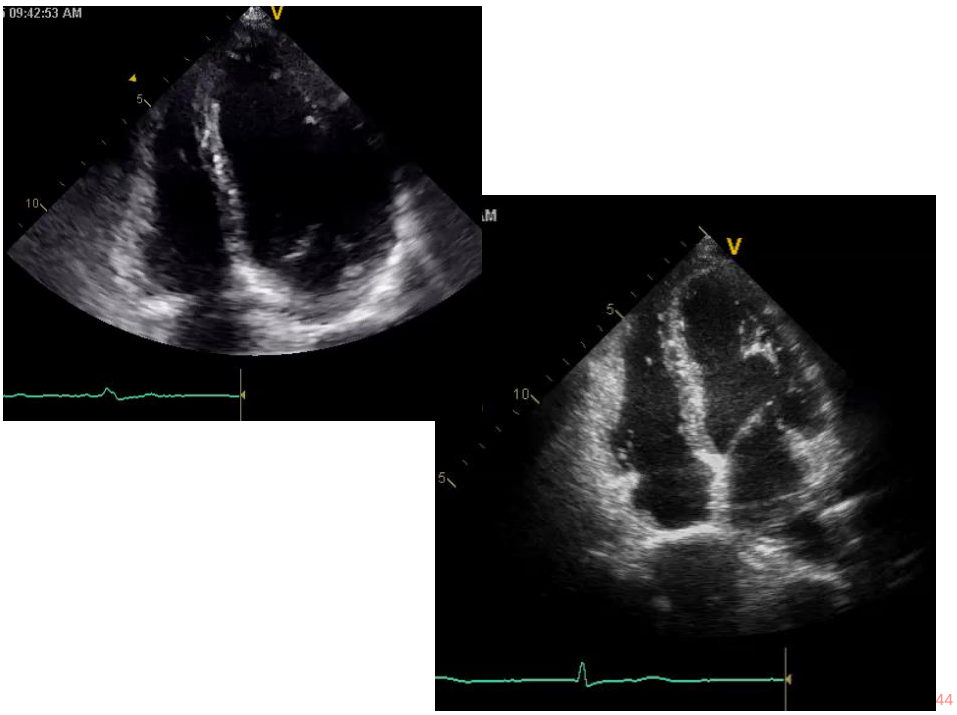


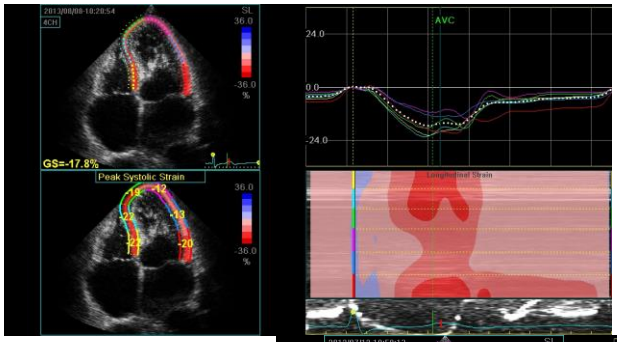
Figure 3. An example of radial time-strain curves in an HF study patient with left bundle-branch block. Radial strain was calculated by speckle tracking and averaged to 6 time-strain plots to represent standard segments. The curves are color-coded by the defined myocardial regions as depicted in the Figure (yellow=anterior septum; red=anterior segment; green=lateral; purple=posterior; dark blue=inferior; and light blue=septum). An example of dyssynchrony is shown as the difference in timing of peak strain from earliest to latest segment (white arrow). Dyssynchrony for the present study was defined as a time difference ≥130 ms between the anterior-septal and posterior wall peak strain.


2012/07/12-10:57:51
SAX-PM
SR
58.0
-58.0
%
Peak Radial Strain
58.0
-58.0
%
12
14
19
25
29
31
AVC
38.6
0.0
-38.6
Radial Strain

43

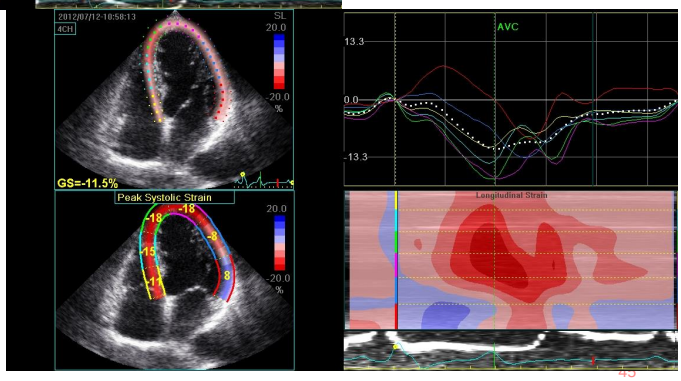

09:42:53 AM
V
5
10
V
5
10
5

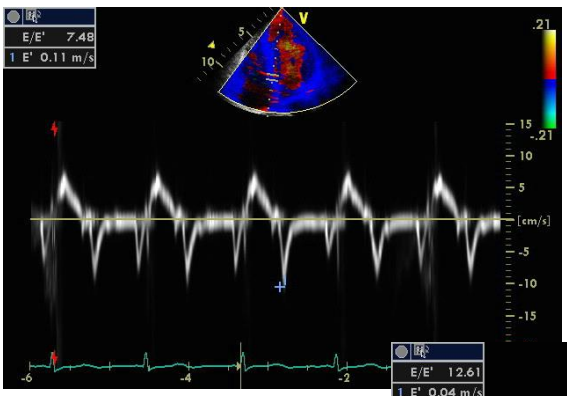
44



Without LBBB

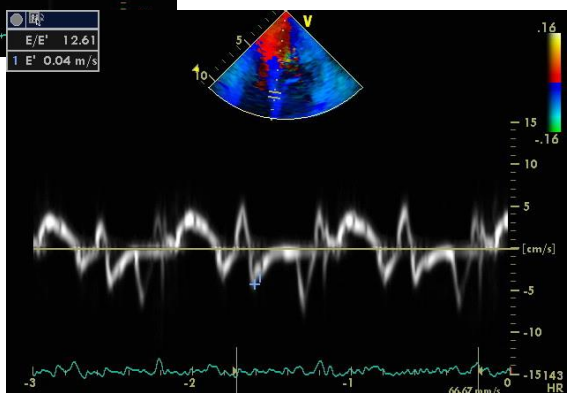
With LBBB

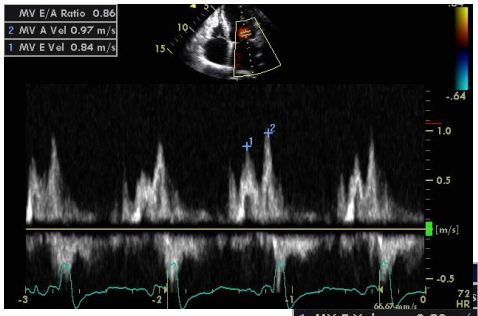




Without LBBB

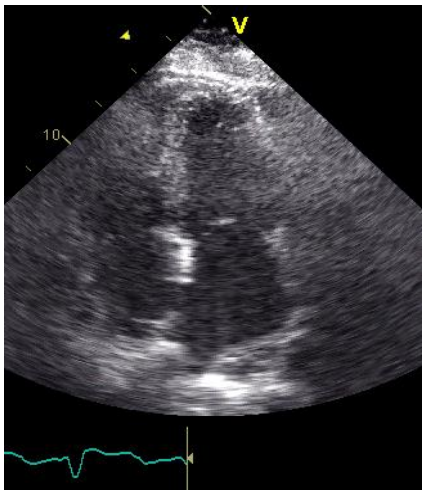
With LBBB



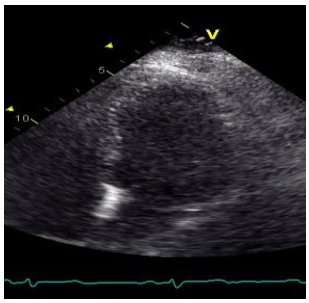


With LBBB

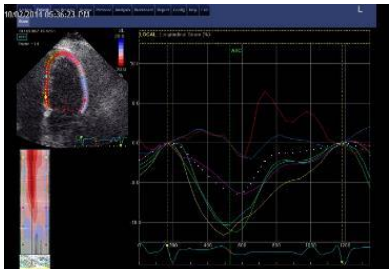
78 year old with hypotension following PPM --5 PM Friday echo

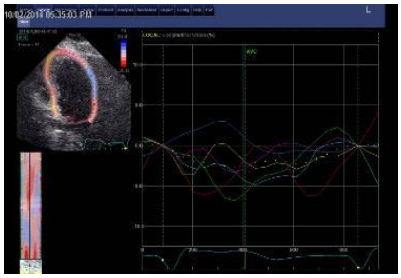


2 minutes later

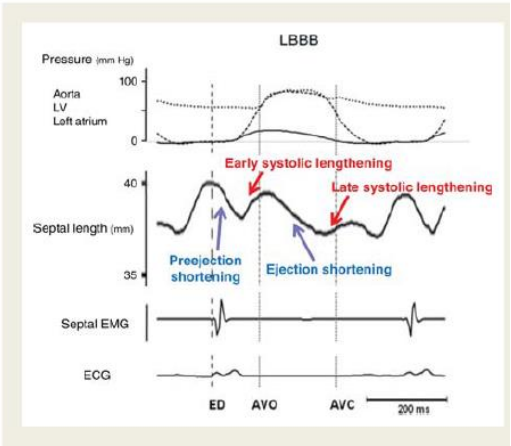


48





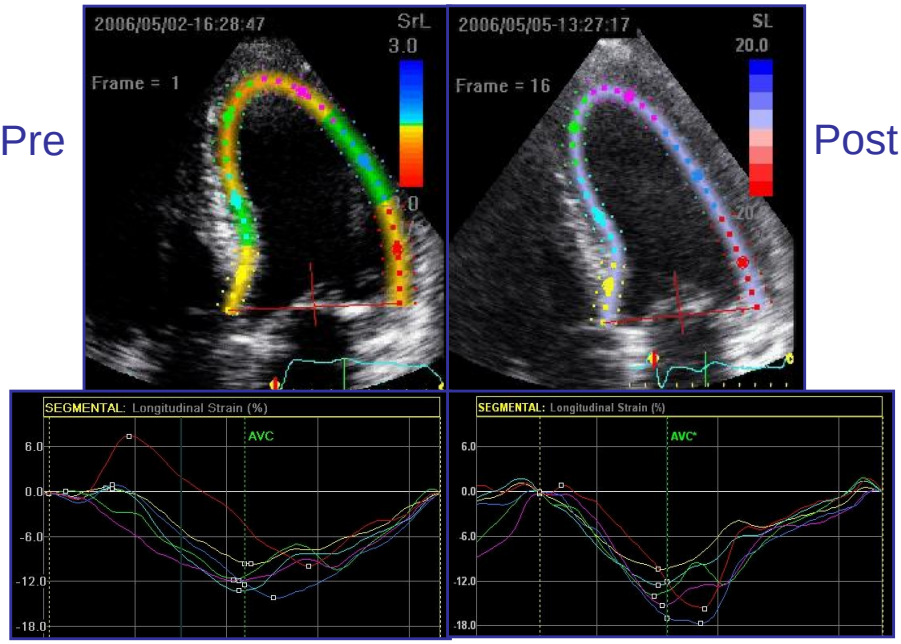
49


LBBB
Pressure (mm Hg)
100
Aorta
LV
Left atrium
0
Early systolic lengthening
Late systolic lengthening
40
Septal length (mm)
35
Preejection shortening
Ejection shortening
Septal EMG
ECG
ED
AVO
AVC
200 ms

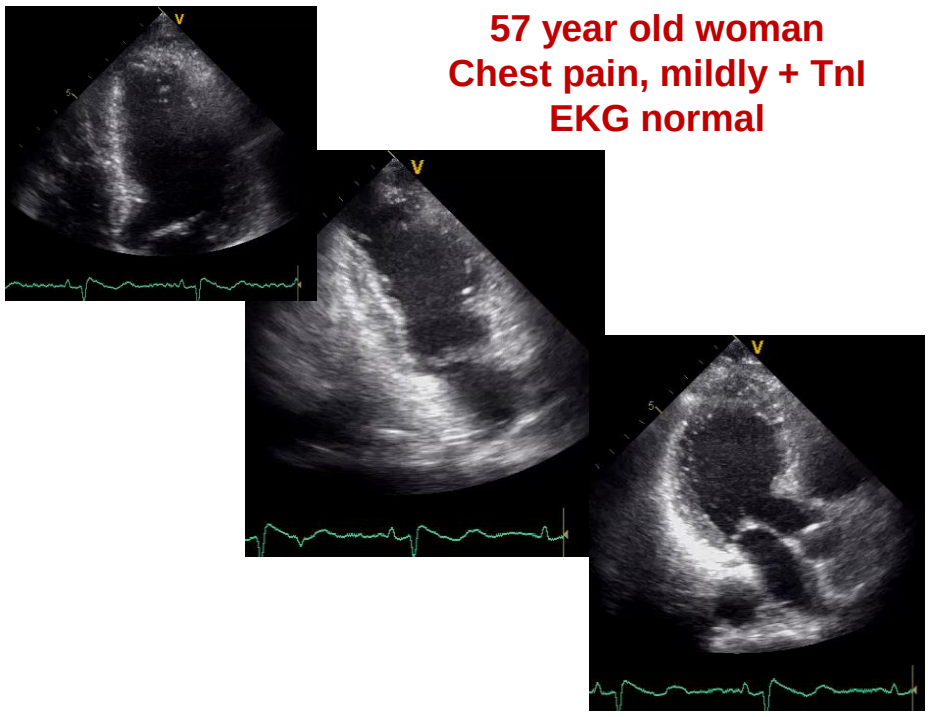
50

Increased Strain After TAVR

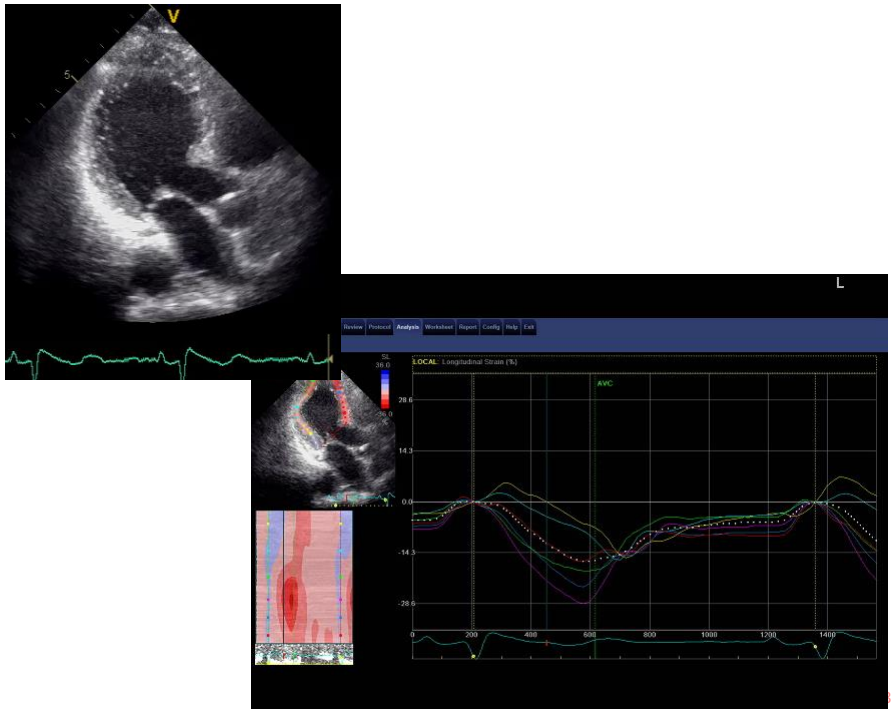
Pre

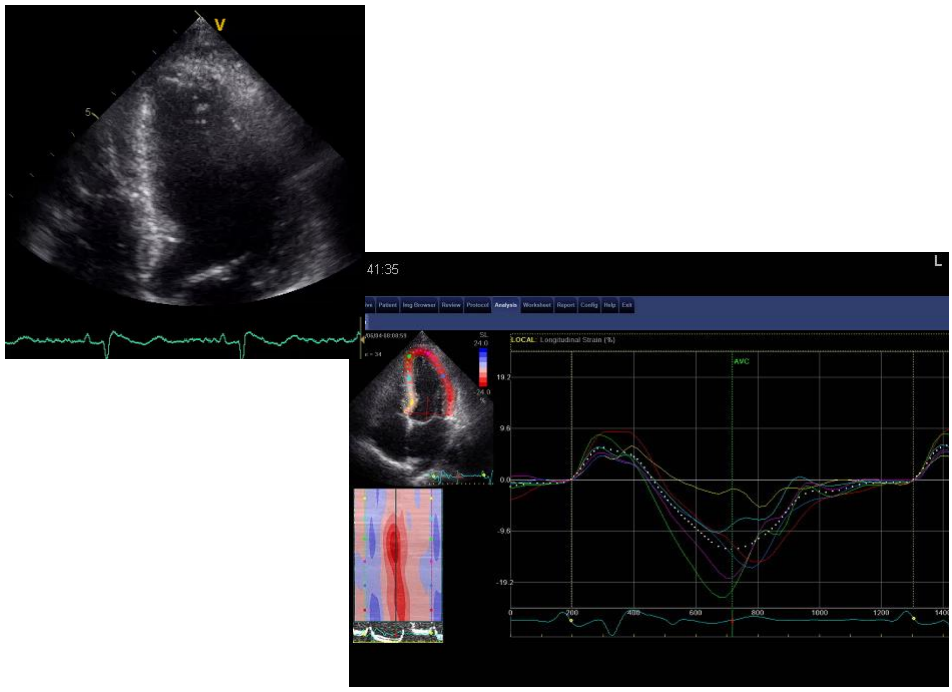


Post



57 year old woman
Chest pain, mildly + TnI
EKG normal


V
L
LOCAL: Longitudinal Strain (%)
AVC


V
41:35
L
LOCAL: Longitudinal Strain (%)
AVC

Strain Imaging Provided New Knowledge

Case 1: 46 year old woman

Day 1 (Saturday night)

- awoke from sleep,
- had epigastric pain and chest pressure,
- took omeprazole, with some relief

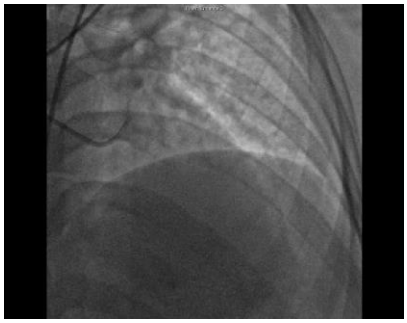
Day 2 (Sunday)

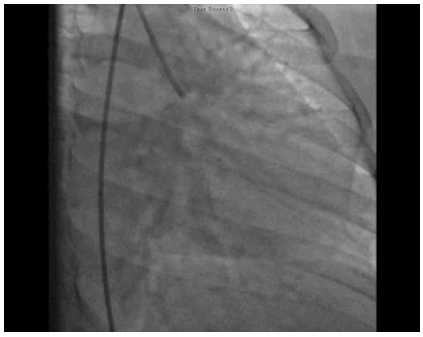
- epigastric pain, dull, crampy,
- worse with eating, better with burping
- nausea, decreased appetite, and weakness

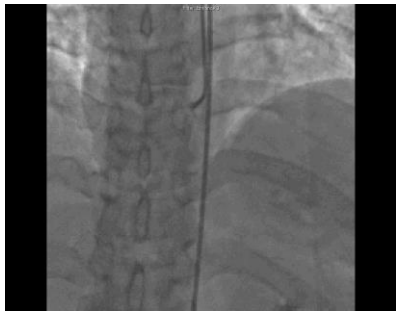
ECG

Cardiac Markers

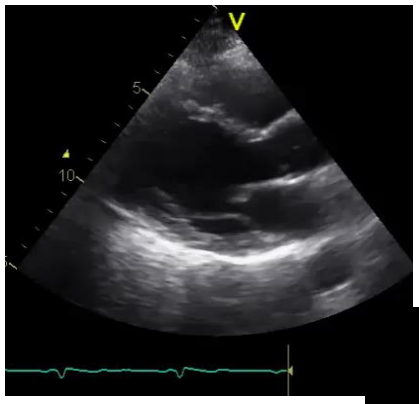
CPK	473
CK-MB	63.5
Index	13.4
Troponin	16.12

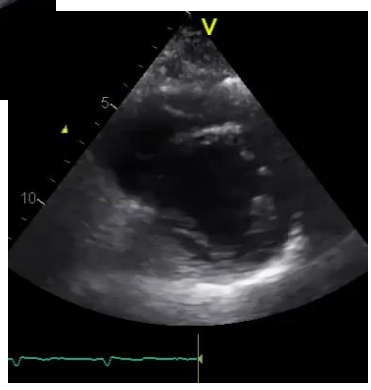


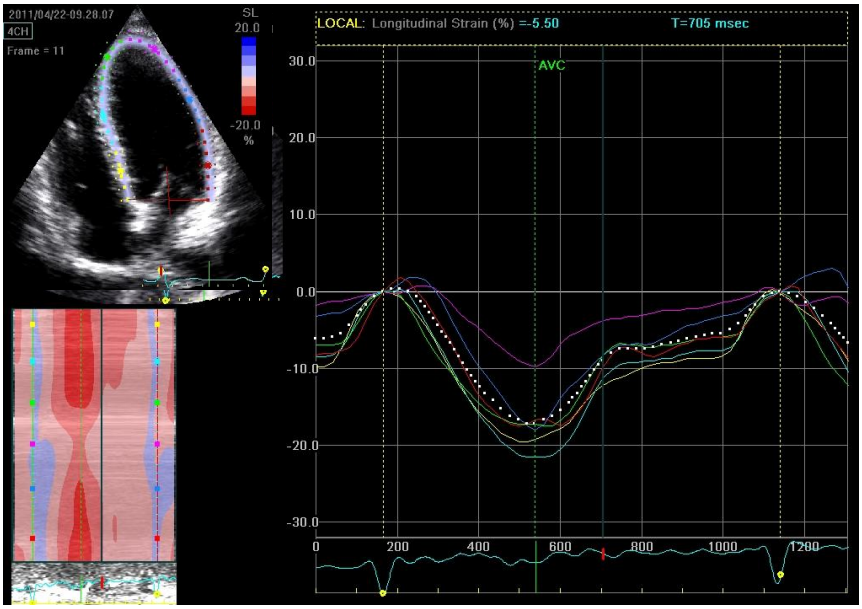




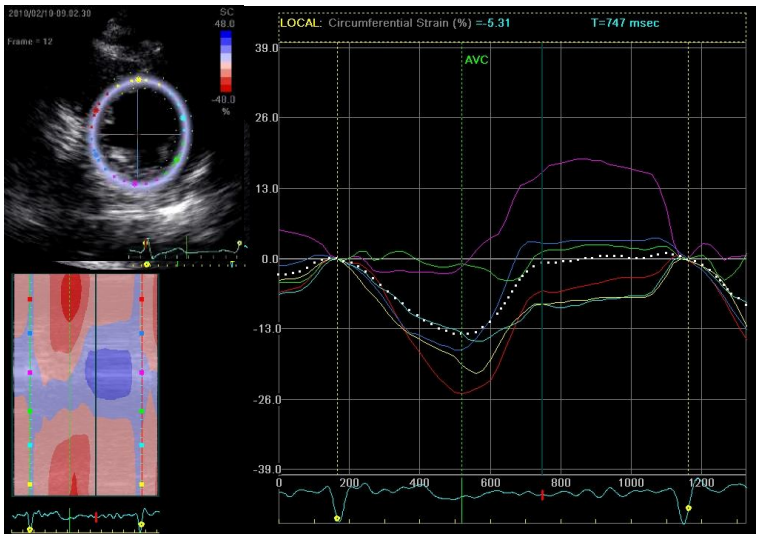
59

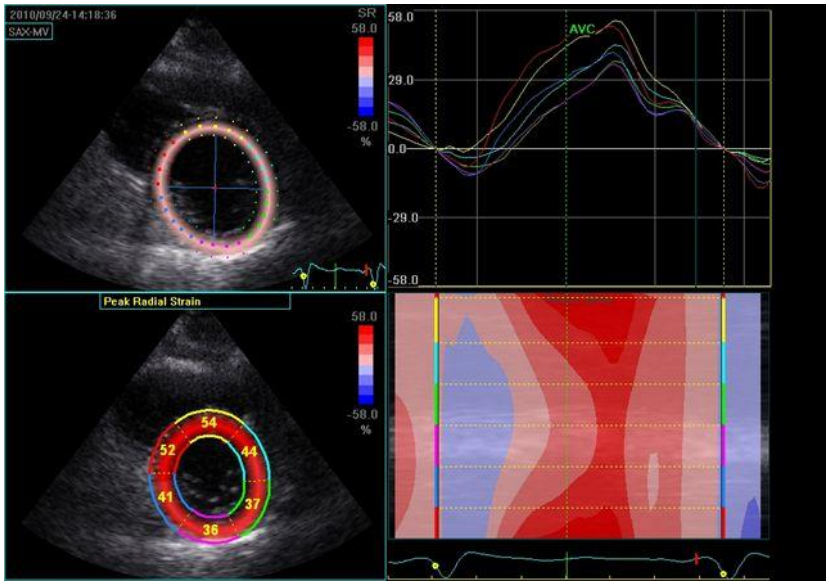


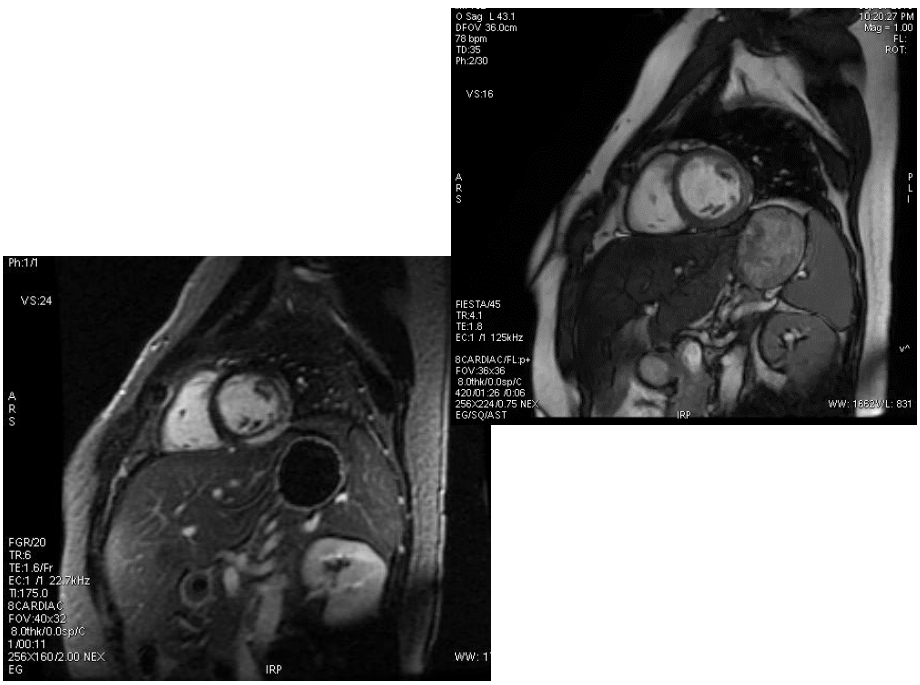



2011/04/22-09.28.07
4CH
Frame = 11
SL
20.0
-20.0
%
LOCAL: Longitudinal Strain (%) =-5.50
T=705 msec
AVC
30.0
20.0
10.0
0.0
-10.0
-20.0
-30.0
0
200
400
600
800
1000
1200

61


SC
48.0
-40.0
%
LOCAL: Circumferential Strain (%) =-5.31
T=747 msec
AVC
39.0
26.0
13.0
0.0
-13.0
-26.0
-39.0
0
200
400
600
800
1000
1200


2010/09/24-14:18:36
SAX-MV
SR
58.0
-58.0
%
58.0
29.0
0.0
-29.0
-58.0
AVC
Peak Radial Strain
58.0
-58.0
%
54
52
44
41
37
36


0 Sag L 43.1
DFOV 36.0cm
78 bpm
TD:35
Ph:2/30
VS:16
A
R
S
P
L
I
FIESTA/45
TR:4.1
TE:1.8
EC:1 /1 125kHz
8CARDIAC/FL:p•
FOV:36x36
8.0thk/0.0sp/C
420/01:26 /0:06
256X224/0.75 NEX
EG/SQ/AST
IRP
Ph:1/1
VS:24
A
R
S
FGR/20
TR:6
TE:1.6/Fr
EC:1 /1 22.7kHz
TI:175.0
8CARDIAC
FOV:40x32
8.0thk/0.0Sp/C
1/00:11
256X160/2.00 NEX
EG
IRP

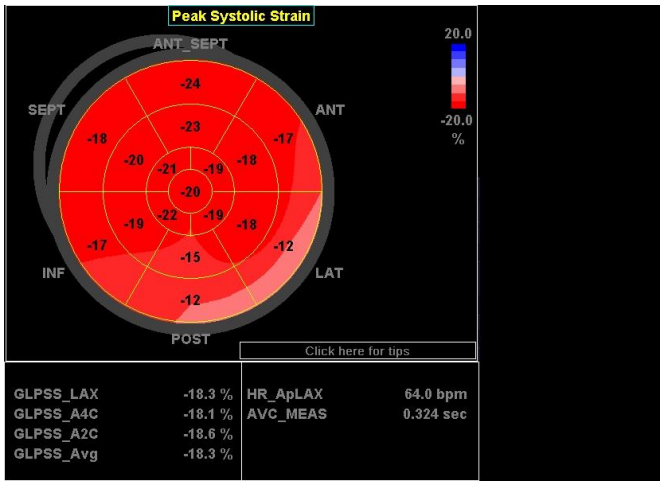
Enterovirus Serology

Coxsackievirus A9 Abs	< 1 : 8	1 : 16
Coxsackievirus B1 Abs	< 1 : 10	< 1 : 10
Coxsackievirus B2 Abs	< 1 : 10	< 1 : 10
Coxsackievirus B3 Abs	< 1 : 10	< 1 : 10
Coxsackievirus B4 Abs	< 1 : 10	≥ 1 : 640
Coxsackievirus B5 Abs	< 1 : 10	1 : 160
ECHO 6,7,9,11,30	< 1 : 10	< 1 : 10

Did strain *really* help?

Yes!

Peak Systolic Strain- AFI

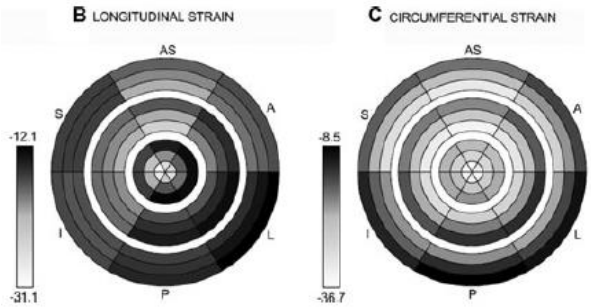


Speckle Tracking Imaging in Acute Inflammatory Pericardial Diseases

Marina Leitman, M.D.,* Noa Bachner-Hinenzon, Ph.D.,† Dan Adam, D.Sc.,† Therese Fuchs, M.D., F.A.C.C.,* Nickolas Theodorovich, M.D.,* Eli Peleg, M.D.,* Ricardo Krakover, M.D.,* Gil Moravsky, M.D.,* Nir Uriel, M.D.,‡ and Zvi Vered, M.D., F.A.C.C., F.E.S.C.*

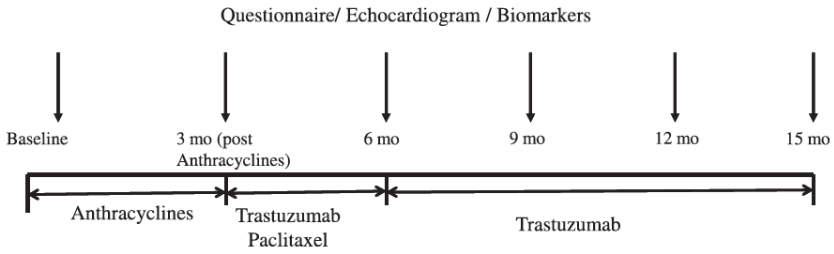
*Department of Cardiology, Assaf Harofeh Medical Center and Tel Aviv University, Tel Aviv, Israel; †Faculty of Biomedical Engineering, Technion-Israel Institute of Technology, Haifa, Israel; and ‡Division of Cardiology, Department of Medicine, College of Physicians and Surgeons, Columbia University, New York, New York

Background: Left ventricular (LV) function in acute perimyocarditis is variable. We evaluated LV function in patients with acute perimyocarditis with speckle tracking. Methods: Thirty-eight patients with acute perimyocarditis and 20 normal subjects underwent echocardiographic examination. Three-layers strain and twist angle were assessed with a speckle tracking. Follow-up echo was available in 21 patients. Results: Strain was higher in normal subjects than in patients with perimyocarditis. Twist angle was reduced in perimyocarditis—10.9° ± 5.4 versus 17.6° ± 5.8, P < 0.001. Longitudinal strain and twist angle were higher in normal subjects than in patients with perimyocarditis and apparently normal LV function. Follow-up echo in 21 patients revealed improvement in longitudinal strain. Conclusions: Patients with acute perimyocarditis have lower twist angle, longitudinal and circumferential strain. Patients with perimyocarditis and normal function have lower longitudinal strain and twist angle. Short-term follow-up demonstrated improvement in clinical parameters and longitudinal strain despite of residual regional LV dysfunction. (Echocardiography 2011;28:548-555)



Emerging Applications

Can Echo and Biomarkers Predict Chemo-Induced LV Dysfunction?



Assessment of Echocardiography and Biomarkers for the Extended Prediction of Cardiotoxicity in Patients Treated With Anthracyclines, Taxanes, and Trastuzumab

Heloisa Sawaya, MD, PhD; Igal A. Sebag, MD; Juan Carlos Plana, MD; James L. Januzzi, MD; Bonnie Ky, MD, MSCE; Timothy C. Tan, MBBS, PhD; Victor Cohen, MD; Jose Banchs, MD; Joseph R. Carver, MD; Susan E. Wiegers, MD; Randolph P. Martin, MD; Michael H. Picard, MD; Robert E. Gerszten, MD; Elkan F. Halpern, PhD; Jonathan Passeri, MD; Irene Kuter, MD; Marielle Scherrer-Crosbie, MD, PhD

Sawaya et al. AJC 2011; 107: 1375-80

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*

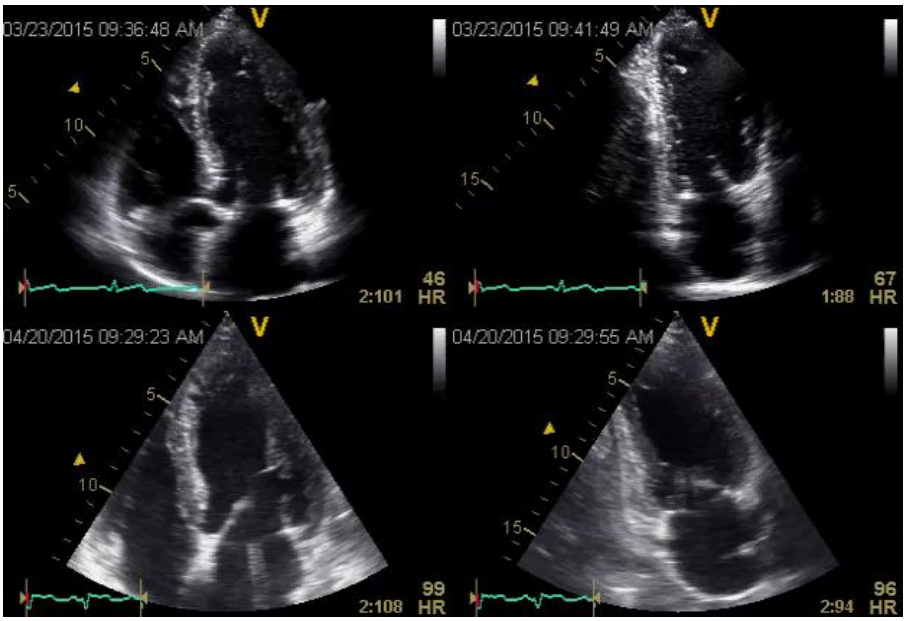
(J Am Soc Echocardiogr 2014;27:911-39.)

Key Points

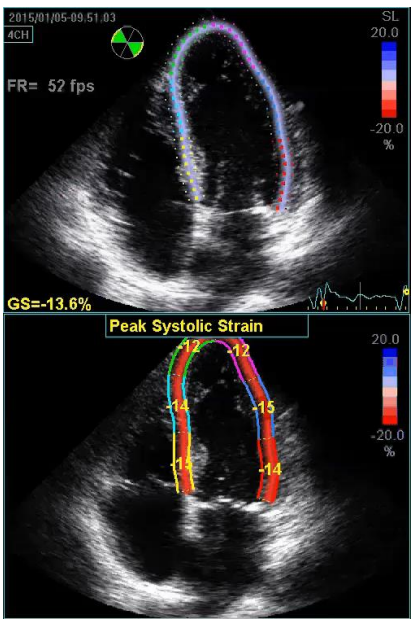
- Myocardial deformation (strain) can be measured using DTI or 2D STE. The latter is favored because of a lack of angle dependency.
- GLS is the optimal parameter of deformation for the early detection of subclinical LV dysfunction.
- Ideally, the measurements during chemotherapy should be compared with the baseline value. 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.
- When applying STE for the longitudinal follow-up of patients with cancer, the same vendor-specific ultrasound machine should be used.

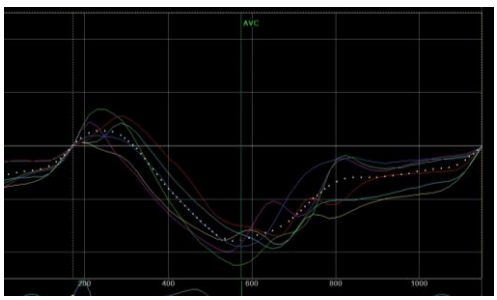
67 year old woman

- **Shortness of breath**
- **One month after beginning chemotherapy for non Hodgkin's lymphoma**

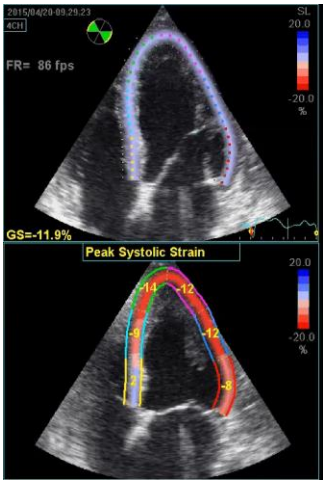

03/23/2015 09:36:48 AM
2:101
46 HR
03/23/2015 09:41:49 AM
1:88
67 HR
04/20/2015 09:29:23 AM
2:108
99 HR
04/20/2015 09:29:55 AM
2:94
96 HR

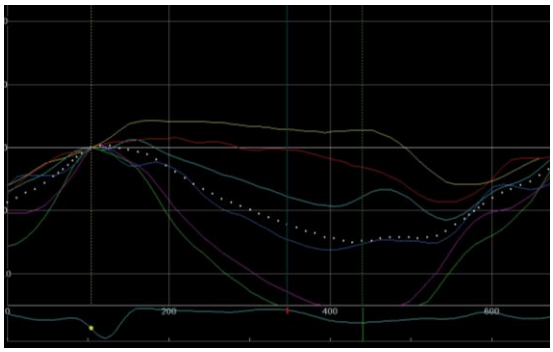
73


2015/01/05-09:51:03
4CH
FR= 52 fps
SL
20.0
-20.0
%
GS=-13.6%
Peak Systolic Strain
-12
-12
-14
-15
-15
-14


AVC

74

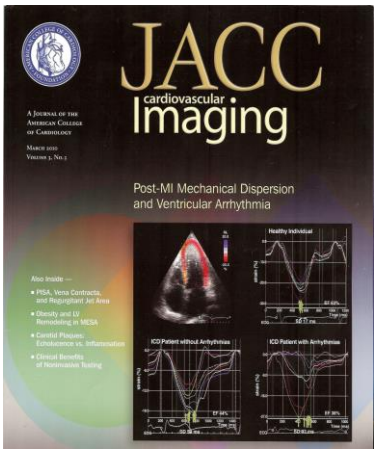




75

Myocardial Mechanical Dispersion

85 patients after myocardial infarction with ICD



Mechanical Dispersion Assessed by Myocardial Strain in Patients After Myocardial Infarction for Risk Prediction of Ventricular Arrhythmia

Kristina H. Haugaa, MD,*† Marit Kristine Smedsrud, MD,*† Torkel Steen, MD, PhD,‡ Erik Kongsgaard, MD, PhD,* Jan Pål Loennechen, MD, PhD,§‖ Terje Skjærpe, MD, PhD,‖ Jens-Uwe Voigt, MD, PhD,¶ Rik Willems, MD, PhD,¶ Gunnar Smith, MD,‡ Otto A. Smiseth, MD, PhD,* Jan P. Amlie, MD, PhD,* Thor Edvardsen, MD, PhD*

Oslo and Trondheim, Norway; and Leuven, Belgium

EDITOR'S PAGE

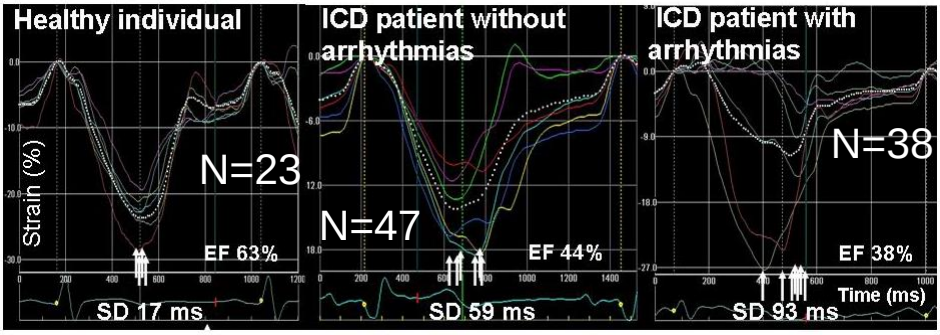
Is Mechanical Dispersion a Raven of Ventricular Arrhythmias?

William A. Zoghbi, MD,* Jagat Narula, MD, PhD†

2.3 (0.6-5.5) years follow up

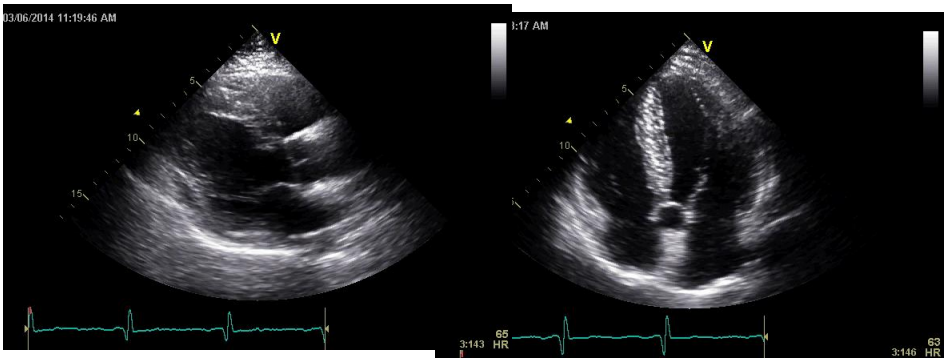
Myocardial Mechanical Dispersion

85 patients after myocardial infarction with ICD



2.3 (0.6-5.5) years follow up

Haugaa et al. JACC Img 2010; 3: 247-56

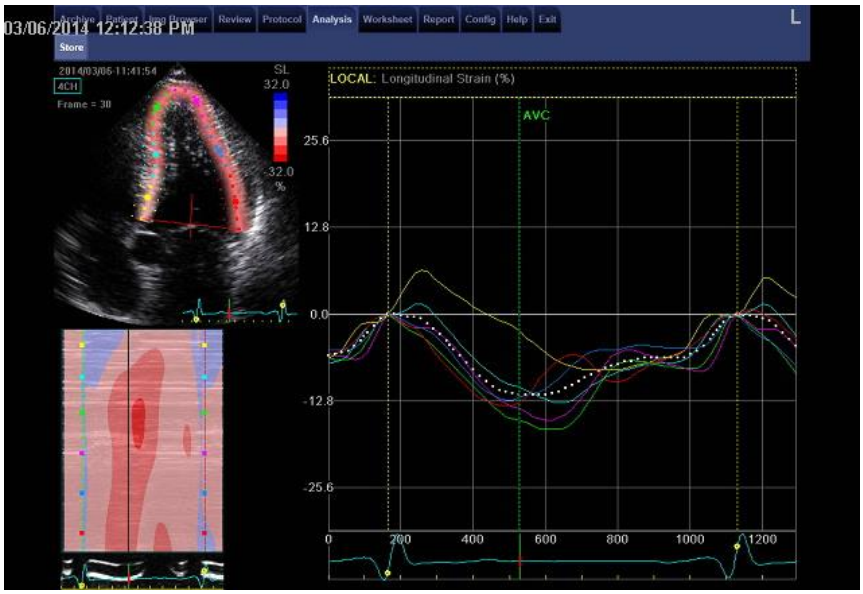


Case 3: 43 year old man with DOE

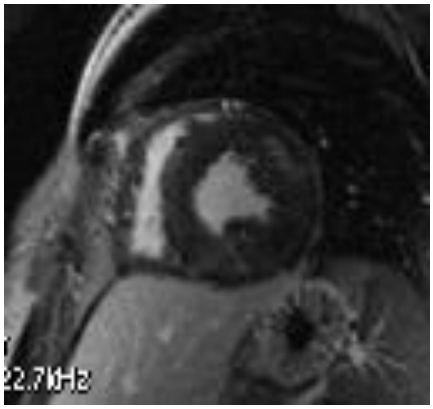
history of mild hypertension

no drug use

no family history

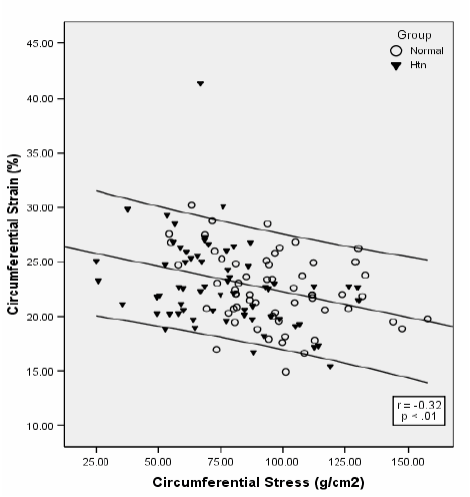

03/06/2014 12:12:38 PM
Archive
Review
Protocol
Analysis
Worksheet
Report
Config
Help
Exit
Store
2014/03/06-11:41:54
4CH
Frame = 30
SL
32.0
-32.0
%
LOCAL: Longitudinal Strain (%)
AVC
25.6
12.8
0.0
-12.8
-25.6
0
200
400
600
800
1000
1200

80


22.7kHz

Strain is NOT Load-Independent

Narayan Circ CI 2009



Did strain *really* help?

Quasi-quasi

ST Strain in HHD

- **Global strains are normal in HTN with mild to moderate HHD**
- **tagging studies--more LVH**
- **Longitudinal lengthening *rate* is directly related to shortening rate**
- **Abnormalities in velocity (*both lengthening and contraction rates*) likely occur before abnormalities in strain**

Narayanan Circ CI 2009

Cardiac Mechanics in Mild Hypertensive Heart Disease

A Speckle-Strain Imaging Study

Circ CV Imaging 2009

Arumugam Narayanan, MD; Gerard P. Aurigemma, MD; Marcello Chinali, MD, PhD; Jeffrey C. Hill, RDCS; Theo E. Meyer, MD, PhD; Dennis A. Tighe, MD

	Normal (n = 59)	HTN (n = 64)	p value
EF and shortening			
EF (%)	66 ± 9	69 ± 8	NS
FS endo (%)	37 ± 7	39 ± 7	NS
FS mw (%)	21 ± 3	19 ± 3	< .001
Stress			
σ_c (g/cm2)	96 ± 23	75 ± 24	< .001
σ_m (g/cm2)	50 ± 13	37 ± 13	< .001
Strain			
ε_c (%)	22 ± 3	23 ± 4	NS
ε_l (%)	21 ± 3	21 ± 3	NS
ε_r (%)	44 ± 11	42 ± 12	NS
Velocity			
V_l (cm/s)	4.5 ± 0.9	3.9 ± 0.7	< .001
S` (cm/s)	10 ± 2	9 ± 2	< .01
Strain rate			
Circumferential (s^{-1})	1.5 ± 0.2	1.5 ± 0.3	NS
Longitudinal (s^{-1})	1.3 ± 0.2	1.3 ± 0.2	NS
Radial (s^{-1})	1.6 ± 0.4	1.5 ± 0.3	NS
Displacement			
Longitudinal (mm)	10 ± 2	10 ± 2	NS
Radial (mm)	7 ± 1	8 ± 1	< .01

Circulation
JOURNAL OF THE AMERICAN HEART ASSOCIATION

American Heart Association.

Left Ventricular Structure and Function in Transthyretin-Related Versus Light-Chain Cardiac Amyloidosis

Candida Cristina Quarta, Scott D. Solomon, Imran Uraizee, Jenna Kruger, Simone Longhi, Marinella Ferlito, Christian Gagliardi, Agnese Milandri, Claudio Rapezzi and Rodney H. Falk

E wave, cm/s	81 [67–94]	84 [69–94]	78 [65–100]	77 [65–93]
A wave, cm/s	55 [34–74]	56 [33–80]†‡	66 [47–78]§	38 [29–55]
E wave deceleration time, ms	168 [130–216]	166 [130–201]	188 [142–231]	156 [127–201]
E/A	1.6 [1–2.5]	1.6 [1–2.5]	1.3 [0.9–1.8]	2 [1.2–2.8]
Lateral E′, cm/s	6 [5–7]	6 [5–8]	6 [5–8]	6 [5–7]
Lateral A′, cm/s	5 [4–7]	5 [4–8]†‡	6 [4–9]	4 [3–5]A')
Lateral S′, cm/s	5 [4–6]	6 [4–7]†‡	6 [5–8]	5 [4–5]
E/lateral E′	13 [10–17]	14 [11–18]	12 [10–17]	12 [10–16]

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