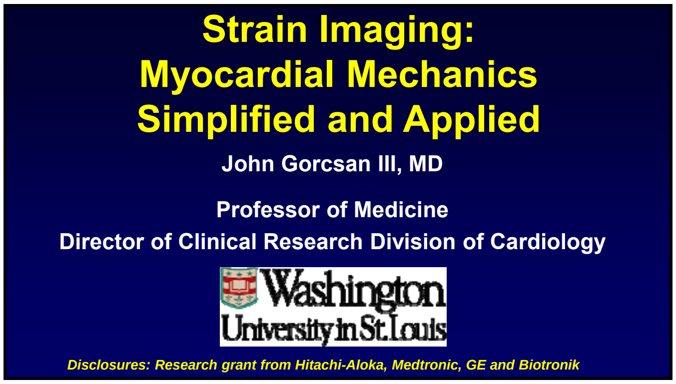
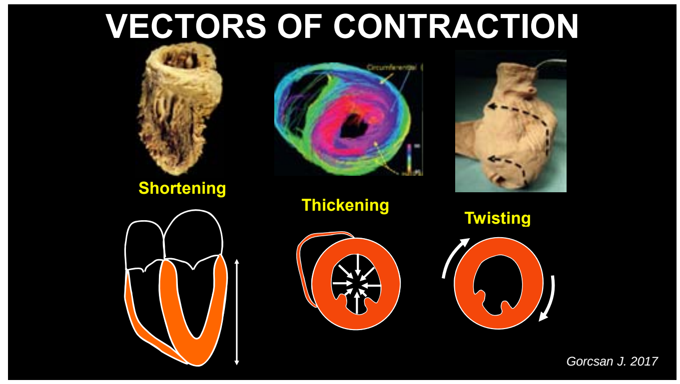
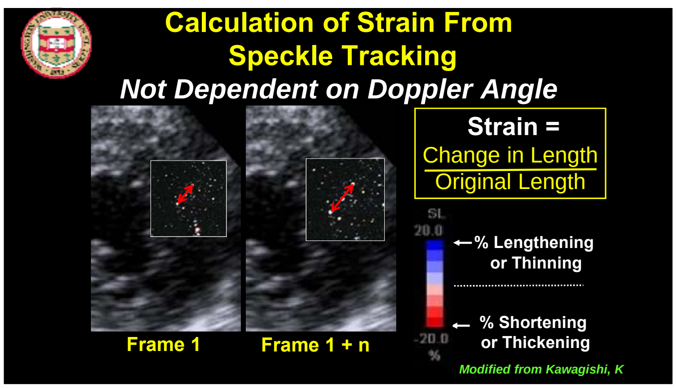
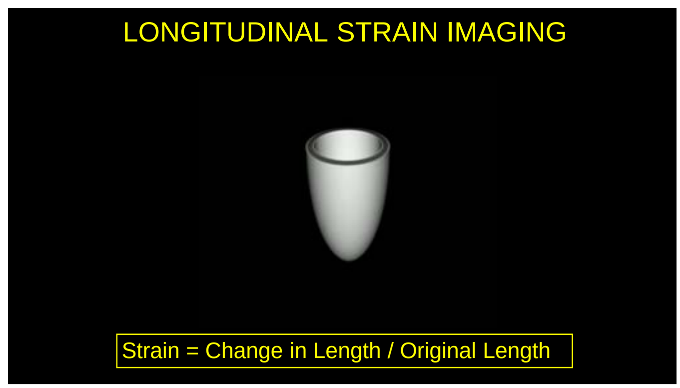
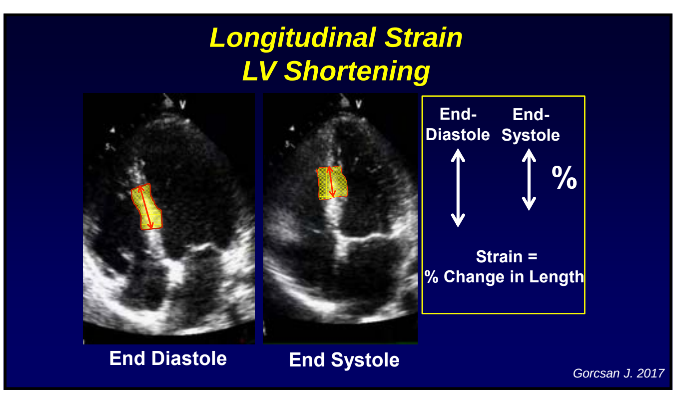
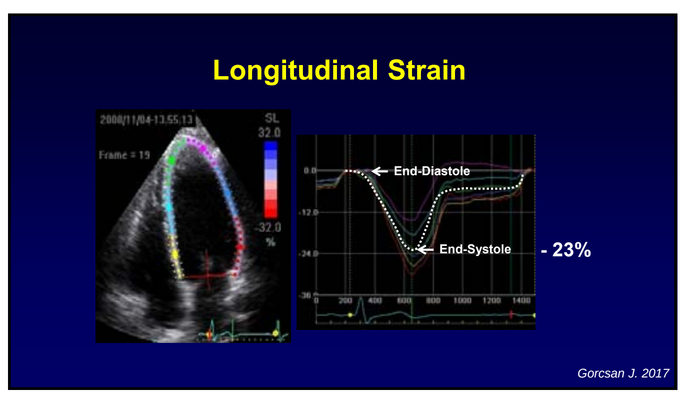

Strain Imaging:
Myocardial Mechanics
Simplified and Applied
John Gorcsan III, MD
Professor of Medicine
Director of Clinical Research Division of Cardiology
Washington University in St. Louis
Disclosures: Research grant from Hitachi-Aloka, Medtronic, GE and Biotronik


VECTORS OF CONTRACTION
Shortening
Thickening
Twisting
Gorcsan J. 2017

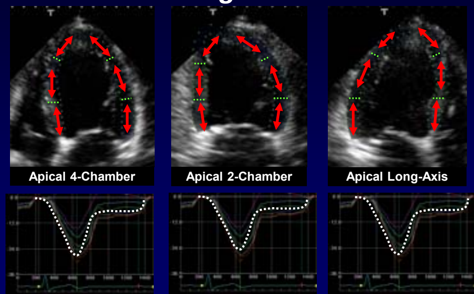

Calculation of Strain From
Speckle Tracking
Not Dependent on Doppler Angle
Strain =
Change in Length
Original Length
SL
20.0
% Lengthening
or Thinning
% Shortening
or Thickening
-20.0
%
Frame 1
Frame 1 + n
Modified from Kawagishi, K


LONGITUDINAL STRAIN IMAGING
Strain = Change in Length / Original Length


Longitudinal Strain
LV Shortening
End-
Diastole
End-
Systole
%
Strain =
% Change in Length
End Diastole
End Systole
Gorcsan J. 2017

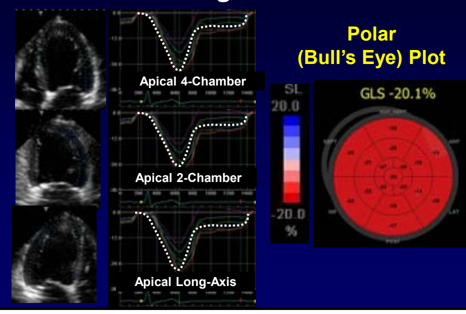

Longitudinal Strain
SL
32.0
-32.0
%
End-Diastole
End-Systole
- 23%
Gorcsan J. 2017

Global Longitudinal Strain (GLS)
Average Strain



Gorcsan J. 2017

Global Longitudinal Strain (GLS)
Average Strain



Polar (Bull's Eye) Plot

Gorcsan J. 2017

What is Normal? Global Longitudinal Strain

N = 2,597

Study name	Mean	Standard error	Variance	Lower limit	Upper limit	Z-Value	P-Value	Relative weight	Std Residual
Manovel (16)	21.950	0.313	0.098	21.336	22.564	70.052	.000	3.65	1.18
Delgado (18)	18.300	0.380	0.145	17.555	19.045	48.141	.000	3.61	-0.70
Kusunose (33)	19.500	0.762	0.580	18.007	20.993	25.605	.000	3.25	-0.08
Imbalzano (34)	20.400	0.350	0.123	19.714	21.086	58.274	.000	3.63	0.38
Syeda (31)	17.400	0.895	0.801	15.646	19.154	19.442	.000	3.09	-1.07
Marwick (9)	18.600	0.096	0.009	18.411	18.789	192.899	.000	3.74	-0.55
Kouzu (27)	18.900	0.445	0.198	18.028	19.772	42.475	.000	3.56	-0.39
Marcus (26)	18.900	0.277	0.077	18.356	19.444	68.145	.000	3.67	-0.39
Park (23)	19.500	0.470	0.221	18.578	20.422	41.450	.000	3.54	-0.08
Ho (24)	19.600	0.255	0.065	19.101	20.099	76.996	.000	3.68	-0.03
Marcus (26)	20.600	0.333	0.111	19.948	21.252	61.895	.000	3.64	0.48
Reckefuss (36)	20.600	0.217	0.047	20.175	21.025	95.077	.000	3.70	0.49
Mizariene (28)	20.300	0.335	0.113	19.642	20.958	60.509	.000	3.64	0.33
Lancellotti (17)	21.900	0.354	0.126	21.205	22.595	61.782	.000	3.63	1.15
Butz (30)	16.000	0.660	0.436	14.706	17.294	24.244	.000	3.36	-1.81
Takamura (29)	20.000	0.600	0.360	18.824	21.176	33.333	.000	3.42	0.17
Narayanan (19)	22.000	0.416	0.173	21.185	22.815	52.881	.000	3.58	1.19
Kang (14)	22.100	0.492	0.242	21.136	23.064	44.925	.000	3.52	1.23
Meluzin (20)	20.210	0.171	0.029	19.875	20.545	118.155	.000	3.72	0.29
Bussadori (21)	19.050	0.557	0.310	17.959	20.141	34.210	.000	3.46	-0.31
RodriguezBailon (25)	19.840	0.448	0.201	18.962	20.718	44.292	.000	3.56	0.09
Saleh (35)	17.280	0.254	0.065	16.782	17.778	68.034	.000	3.68	-1.23
Manovel (16)	22.280	0.366	0.134	21.564	22.996	60.947	.000	3.62	1.34
Saito (22)	19.900	0.781	0.611	18.368	21.432	25.466	.000	3.23	0.12
	19.662	0.377	0.142	18.923	20.402	52.121	.000		

Mean and 95% CI: 12.50 – 25.00

GLS: -15.7 to -21.1%, mean -19.7%

Yingchoncharoen…Marwick et al. JASE 2013;26:185

GLS Values Vary by Vendor, Gender and Age

able 5 Effect of vendor age and gender on GLS

Vendor	Age group (y) 0–19	20–29	30–39	40–49	50–59	≥60	P
GE							
Overall	−22.1 ± 2.4	−21.2 ± 1.9	−21.1 ± 2.1	−21.4 ± 2.0	−21.0 ± 2.2	−20.3 ± 1.9	.0218
Male	−21.7 ± 3.1	−20.9 ± 1.9	−20.6 ± 1.9	−20.9 ± 1.8	−21.0 ± 1.9	−19.7 ± 1.4	.1982
Female	−22.4 ± 1.6	−22.3 ± 1.6	−22.8 ± 1.8	−22.6 ± 2.1	−23.3 ± 1.9	−20.9 ± 2.1	.0348
P (male vs female)	.4292	.0316	<.0001	.0178	.0029	.1381	
Philips							
Overall	−19.9 ± 2.5	−19.0 ± 2.1	−19.5 ± 2.2	−18.2 ± 2.5	−17.6 ± 2.5	−16.7 ± 2.1	<.0001
Male	−19.4 ± 2.7	−18.8 ± 2.0	−19.1 ± 2.3	−17.9 ± 2.8	−16.9 ± 2.3	−15.8 ± 1.4	.0019
Female	−20.5 ± 2.2	−20.6 ± 2.3	−20.2 ± 2.0	−19.3 ± 0.9	−20.4 ± 1.5	−17.3 ± 2.3	.0002
P (male vs female)	.1349	.0248	.1083	.4316	.0294	.0928	
Toshiba							
Overall	−21.4 ± 1.7	−20.2 ± 2.1	−20.4 ± 2.3	−19.4 ± 2.2	−18.5 ± 2.6	−17.8 ± 2.8	<.0001
Male	−21.6 ± 2.0	−20.2 ± 2.0	−20.4 ± 2.2	−19.8 ± 2.3	−18.7 ± 2.6	−16.3 ± 3.1	<.0001
Female	−21.2 ± 1.5	−20.2 ± 2.4	−20.4 ± 2.8	−18.7 ± 1.8	−18.3 ± 2.8	−18.6 ± 2.3	.0141
P (male vs female)	.6076	.9787	.9201	.1415	.7374	.0668	

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

Normal Strain Values
Threshold for Abnormal
- **Global Longitudinal Strain**

Normal GLS:≥ -17%

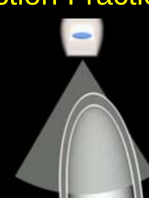
Borderline GLS: between -17% and -15%

Clearly Abnormal GLS: ≤ -15%

Think of GLS in absolute values
(I Prefer to Forget the – sign)

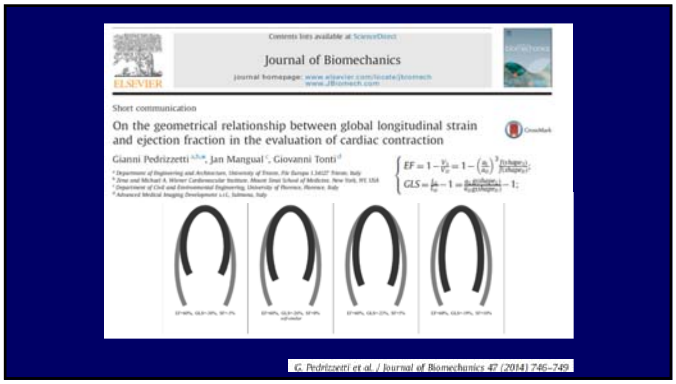
Gorcsan J. 2017

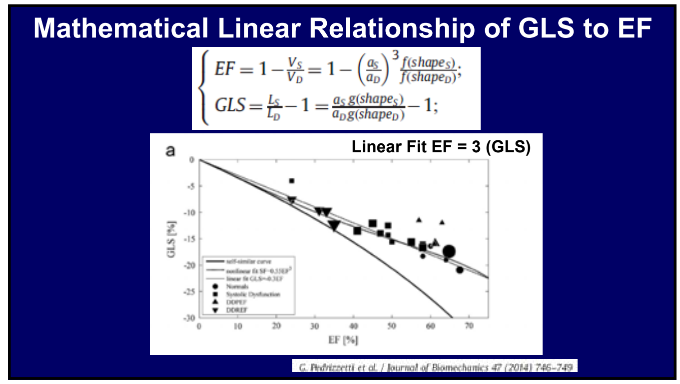
Global Strain Must Relate to Ejection Fraction

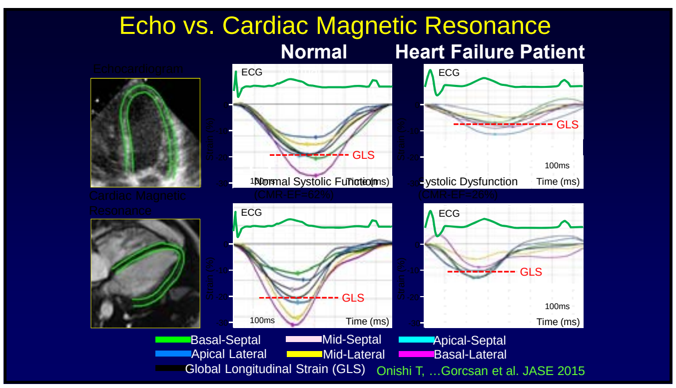


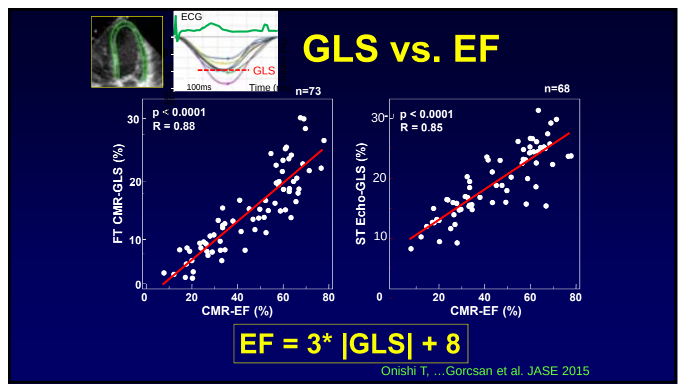
LV Deformation = LV Blood Ejection

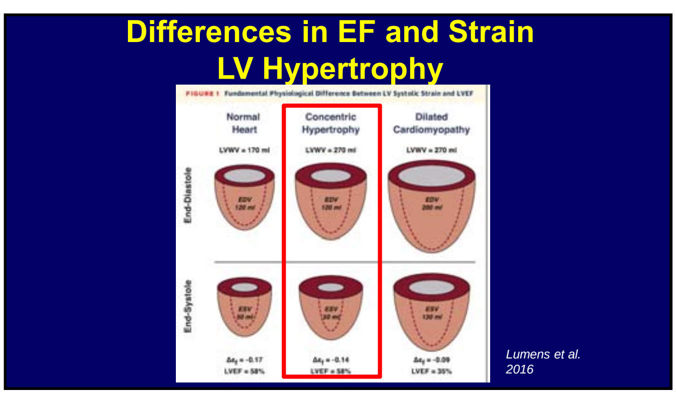
Gorcsan 2017

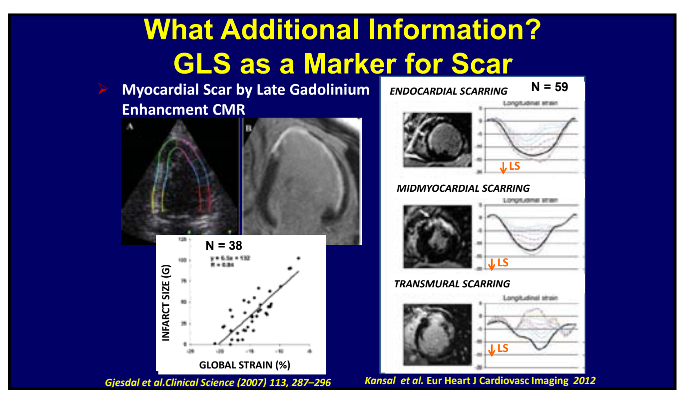

Journal of Biomechanics
ELSEVIER
Short communication
On the geometrical relationship between global longitudinal strain and ejection fraction in the evaluation of cardiac contraction
Gianni Pedrizzetti, Jan Mangual, Giovanni Tonti
G. Pedrizzetti et al. / Journal of Biomechanics 47 (2014) 746–749


Mathematical Linear Relationship of GLS to EF
$EF = 1 - \frac{V_S}{V_D} = 1 - \left(\frac{a_S}{a_D}\right)^3 \frac{f(shape_S)}{f(shape_D)}$;
$GLS = \frac{L_S}{L_D} - 1 = \frac{a_S\, g(shape_S)}{a_D\, g(shape_D)} - 1$;
a
Linear Fit EF = 3 (GLS)
GLS [%]
EF [%]
G. Pedrizzetti et al. / Journal of Biomechanics 47 (2014) 746–749


Echo vs. Cardiac Magnetic Resonance
Normal
Heart Failure Patient
ECG
GLS
Normal Systolic Function
Systolic Dysfunction
100ms
Time (ms)
Basal-Septal
Apical Lateral
Global Longitudinal Strain (GLS)
Mid-Septal
Mid-Lateral
Apical-Septal
Basal-Lateral
Onishi T, …Gorcsan et al. JASE 2015


GLS vs. EF
ECG
GLS
100ms
n=73
n=68
p < 0.0001
R = 0.88
R = 0.85
FT CMR-GLS (%)
ST Echo-GLS (%)
CMR-EF (%)
EF = 3* |GLS| + 8
Onishi T, …Gorcsan et al. JASE 2015


Differences in EF and Strain
LV Hypertrophy
Normal Heart
Concentric Hypertrophy
Dilated Cardiomyopathy
End-Diastole
End-Systole
LVEF = 58%
LVEF = 58%
LVEF = 35%
Lumens et al. 2016


What Additional Information?
GLS as a Marker for Scar
Myocardial Scar by Late Gadolinium Enhancment CMR
N = 38
INFARCT SIZE (G)
GLOBAL STRAIN (%)
N = 59
ENDOCARDIAL SCARRING
MIDMYOCARDIAL SCARRING
TRANSMURAL SCARRING
LS
Gjesdal et al.Clinical Science (2007) 113, 287–296
Kansal et al. Eur Heart J Cardiovasc Imaging 2012

Strain is Additive to EF

Ejection Fraction
- Blood Displacement

Strain
Wall Properties of Disease
- Hypertrophy
- Fibrosis

More Reproducible than EF

Washington University in St. Louis

Gorcsan J. 2017

Strain is Additive to EF
Far Ends of Spectrum

Very Low EF ⟷ High EF

JACC: CARDIOVASCULAR IMAGING
© 2015 BY THE AMERICAN COLLEGE OF CARDIOLOGY FOUNDATION
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ISSN 1936-878X/$36.00
http://dx.doi.org/10.1016/j.jcmg.2015.07.013

ORIGINAL RESEARCH

Global Longitudinal Strain Is a Superior Predictor of All-Cause Mortality in Heart Failure With Reduced Ejection Fraction

Morten Sengeløv, MB,* Peter Godsk Jørgensen, MD,*† Jan Skov Jensen, MD, PhD, DMSc,*† Niels Eske Bruun, MD, DMSc,*‡ Flemming Javier Olsen, MB,* Thomas Fritz-Hansen, MD,* Kotaro Nochioka, MD, PhD,§ Tor Biering-Sørensen, MD, PhD*‖§

Low EF Patients

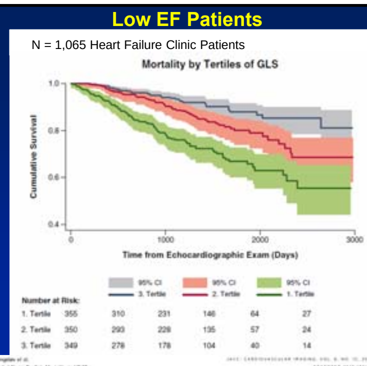
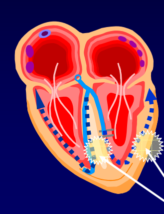


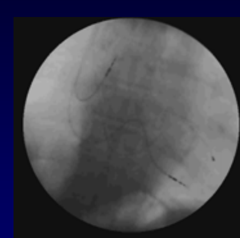
TABLE 3 Univariable and Multivariable Cox Proportional Hazard Models — N = 1,065 Heart Failure Clinic Patients

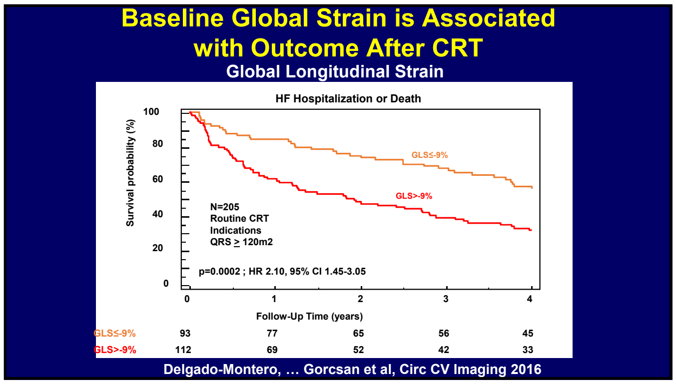
	Univariable Analysis				Multivariable Analysis*		
	HR	95% CI	p Value	C-Statistic	HR	95% CI	p Value
Age, per 1-yr increase	1.05	1.03-1.06	<0.001		1.05	1.02-1.07	<0.001
MAP, per 1-mm Hg increase	0.97	0.96-0.98	<0.001		0. 97	0.95-0.98	<0.001
Heart rate, per 1-beat/min decrease	1.01	1.00-1.02	0.015				
Ischemic cardiomyopathy	1.14	0.84-153	0.39		1.32	0.78-2.26	0.305
CABG	1.41	1.01-1.96	0.043				
PTCA	0.56	0.38-0.82	0.003				
Cholesterol, per 1-mmol/l increase	0.83	0.72-0.96	0.013				
NIDDM	1.88	1.25-2.81	0.002		2.66	1.55-4.30	<0.001
BMI, per 1-kg/m² increase	[illegible]	[illegible]	[illegible]				
Echo Parameters							
LVEF, per 1% increase	0.95	0.94-0.97	<0.001	0.6533			
LVMI, per 1-g/m² decrease	1.04	1.00-1.01	0.036	0.5641			
LAVI, per ml/m² decrease	1.02	1.01-1.03	<0.001	0.6048			
TAPSE, per 1-cm increase	0.44	0.34-0.58	<0.001	0.6319			
E, per 1-m/s increase	1.88	1.20-2.96	0.006	0.5694			
DT, per 1-ms decrease	0.99	0.99-1.00	0.031	0.5638			
E/A, per 1 increase	1.23	1.08-1.41	0.003	0.5709			
e', per 1-cm/s increase	0.004	0.00-1.96	0.08	0.5502			
E/e', per 1 decrease	1.06	1.02-1.06	0.001	05902			
GCS rate, per 1-s⁻¹ decrease	1.85	0.96-3.60	0.067	0.5833			
GCS, per 1% decrease	1.11	1.06-1.16	<0.001	0.6371			
GLS rate, per 1-s⁻¹ decrease	11.02	4.64-26.20	<0.001	0.6450			
GLS, per 1% decrease	**1.20**	**1.14-1.26**	**<0.001**	**0.6735**	**1.15**	**1.04-1.27**	**0.008**

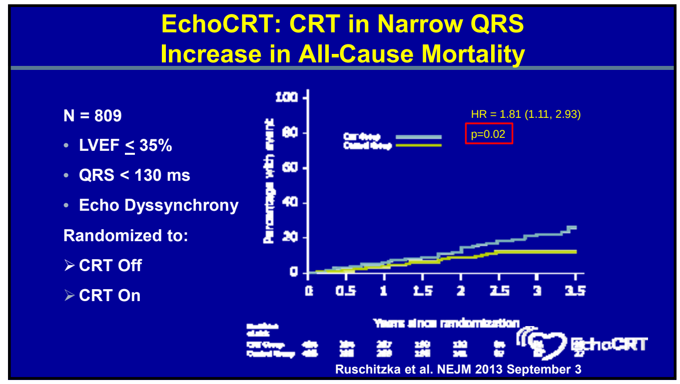
*Multivariable model includes age, sex, BMI, total cholesterol, MAP, heart rate, ischemic cardiomyopathy, PTCA, CABG, NIDDM, LVEF, LVMI, LAVI, TAPSE, DT, E velocity, E/e' ratio, E/A ratio, and GLS. Only HRs for variables that are significant in the multivariable analysis are shown.
CI = confidence interval; HR = hazard ratio; other abbreviations as in Tables 1 and 2.

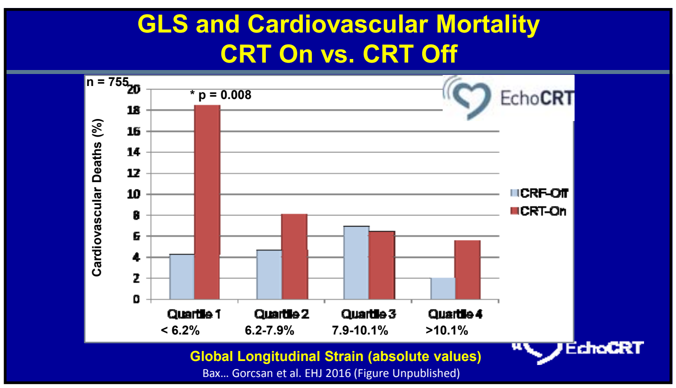
Cardiac Resynchronization Therapy
Treatment for Low EF Wide QRS Heart Failure

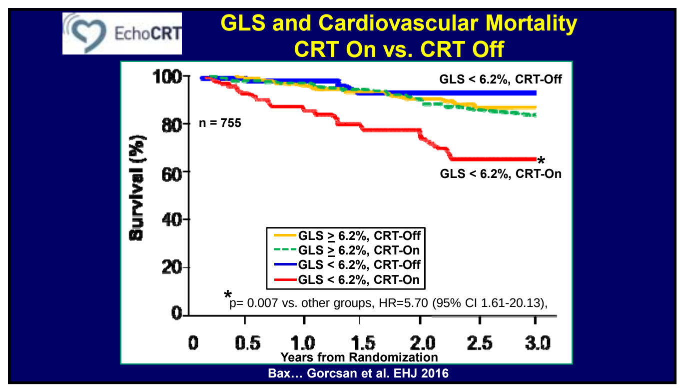


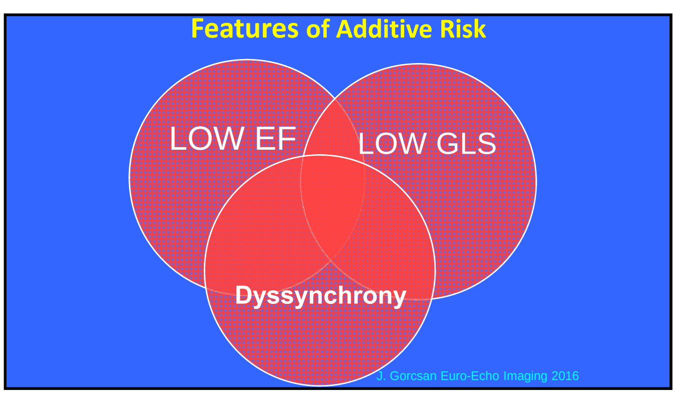


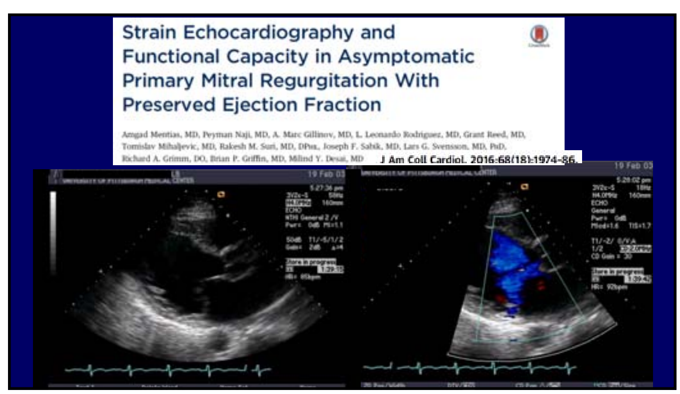

Baseline Global Strain is Associated with Outcome After CRT
Global Longitudinal Strain
HF Hospitalization or Death
Survival probability (%)
GLS≤-9%
GLS>-9%
N=205
Routine CRT
Indications
QRS ≥ 120m2
p=0.0002 ; HR 2.10, 95% CI 1.45-3.05
Follow-Up Time (years)
GLS≤-9% 93 77 65 56 45
GLS>-9% 112 69 52 42 33
Delgado-Montero, … Gorcsan et al, Circ CV Imaging 2016


EchoCRT: CRT in Narrow QRS
Increase in All-Cause Mortality
N = 809
• LVEF ≤ 35%
• QRS < 130 ms
• Echo Dyssynchrony
Randomized to:
➢ CRT Off
➢ CRT On
HR = 1.81 (1.11, 2.93)
p=0.02
Percentage with event
Years since randomization
EchoCRT
Ruschitzka et al. NEJM 2013 September 3


GLS and Cardiovascular Mortality
CRT On vs. CRT Off
n = 755
* p = 0.008
EchoCRT
Cardiovascular Deaths (%)
CRF-Off
CRT-On
Quartile 1 < 6.2%
Quartile 2 6.2-7.9%
Quartile 3 7.9-10.1%
Quartile 4 >10.1%
Global Longitudinal Strain (absolute values)
Bax… Gorcsan et al. EHJ 2016 (Figure Unpublished)

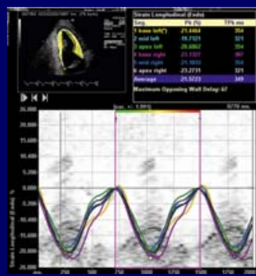

EchoCRT
GLS and Cardiovascular Mortality
CRT On vs. CRT Off
GLS < 6.2%, CRT-Off
n = 755
GLS < 6.2%, CRT-On
Survival (%)
GLS ≥ 6.2%, CRT-Off
GLS ≥ 6.2%, CRT-On
GLS < 6.2%, CRT-Off
GLS < 6.2%, CRT-On
*p= 0.007 vs. other groups, HR=5.70 (95% CI 1.61-20.13),
Years from Randomization
Bax… Gorcsan et al. EHJ 2016


Features of Additive Risk
LOW EF
LOW GLS
Dyssynchrony
J. Gorcsan Euro-Echo Imaging 2016


Strain Echocardiography and Functional Capacity in Asymptomatic Primary Mitral Regurgitation With Preserved Ejection Fraction
J Am Coll Cardiol. 2016;68(18):1974-86.

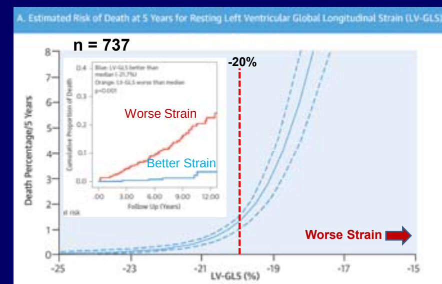
GLS and Asymptomatic Severe MR with Preserved EF

- 737 patients
- Severe MR
- LVEF $\geq$ 60%
- Non-dilated LV
  - ESD < 4.0cm
  - ESDi < 3.3cm/m²



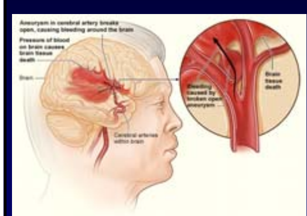
Mentias, A. et al. J Am Coll Cardiol. 2016;68(18):1974-86.

GLS and Asymptomatic Severe MR with Preserved EF: Risk of Death



Mentias, A. et al. J Am Coll Cardiol. 2016;68(18):1974-86.

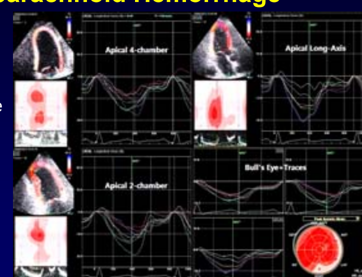
Neurocardiac Injury in Subarachnoid Hemorrhage



"Cerebral T Waves"

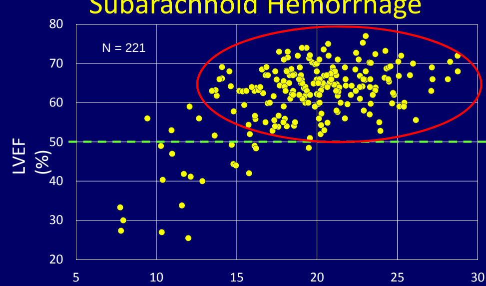
GLS to Assess Neurocardiac Injury in Subarachnoid Hemorrhage

- 255 patients
  - 52±10 yrs
  - 72% female
- GLS in ICU (mean 2 days from bleed)
  - Strain feasible on 221



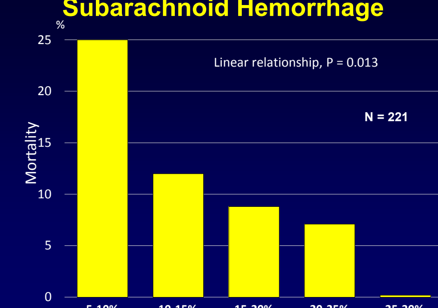
Kagiyama…Gorcsan et al. ASE 2017

Relationship of GLS to EF in Subarachnoid Hemorrhage

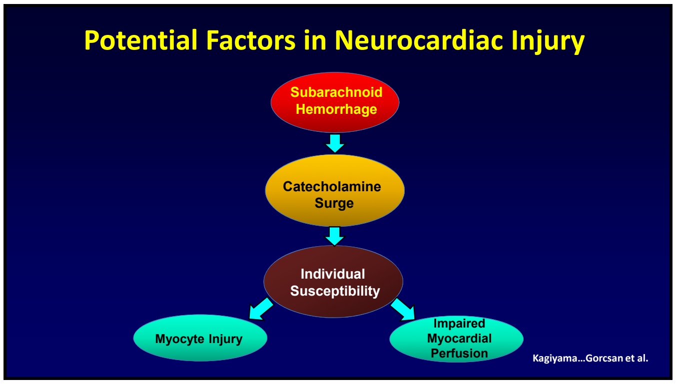


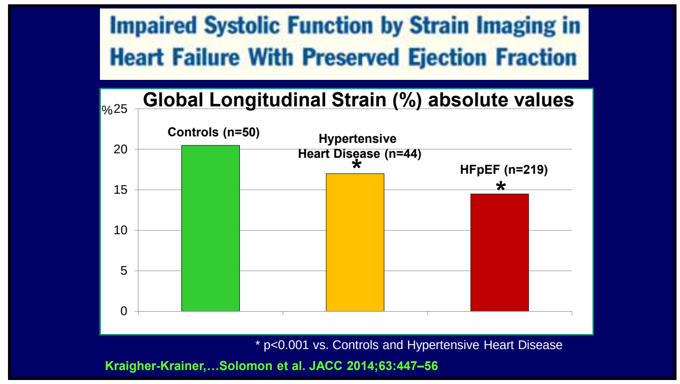
Kagiyama…Gorcsan et al. ASE 2017

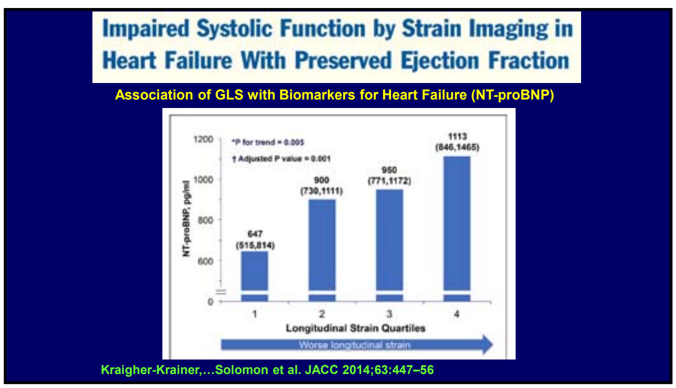
GLS and In-Hospital Mortality with Subarachnoid Hemorrhage

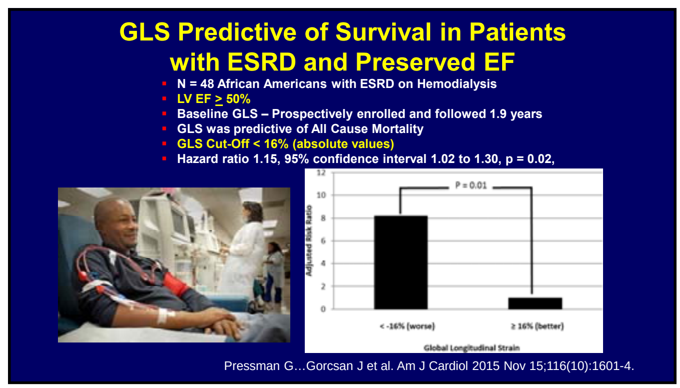


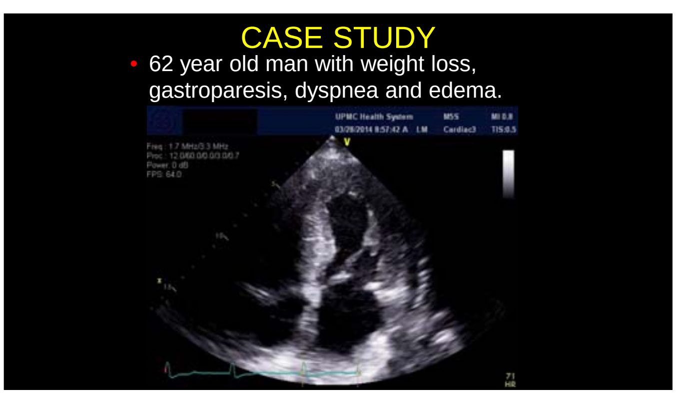
Kagiyama…Gorcsan et al. ASE 2017

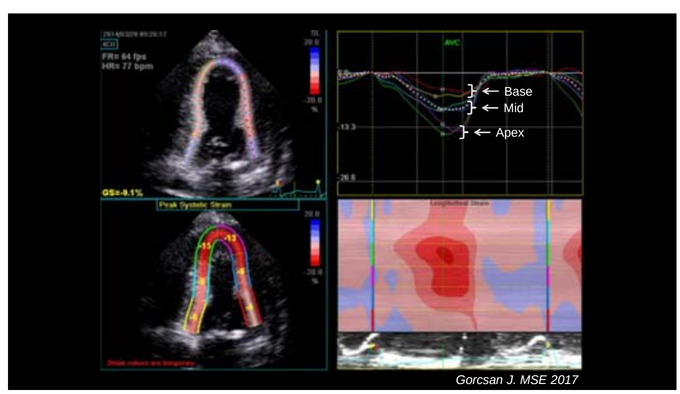

Potential Factors in Neurocardiac Injury
Subarachnoid Hemorrhage
Catecholamine Surge
Individual Susceptibility
Myocyte Injury
Impaired Myocardial Perfusion
Kagiyama...Gorcsan et al.


Impaired Systolic Function by Strain Imaging in Heart Failure With Preserved Ejection Fraction
Global Longitudinal Strain (%) absolute values
%25
20
15
10
5
0
Controls (n=50)
Hypertensive Heart Disease (n=44)
HFpEF (n=219)
*
* p<0.001 vs. Controls and Hypertensive Heart Disease
Kraigher-Krainer,…Solomon et al. JACC 2014;63:447–56


Impaired Systolic Function by Strain Imaging in Heart Failure With Preserved Ejection Fraction
Association of GLS with Biomarkers for Heart Failure (NT-proBNP)
*P for trend = 0.005
† Adjusted P value = 0.001
NT-proBNP, pg/ml
1200
1000
800
600
0
647 (515,814)
900 (730,1111)
950 (771,1172)
1113 (846,1465)
1
2
3
4
Longitudinal Strain Quartiles
Worse longitudinal strain
Kraigher-Krainer,…Solomon et al. JACC 2014;63:447–56


GLS Predictive of Survival in Patients with ESRD and Preserved EF
N = 48 African Americans with ESRD on Hemodialysis
LV EF ≥ 50%
Baseline GLS – Prospectively enrolled and followed 1.9 years
GLS was predictive of All Cause Mortality
GLS Cut-Off < 16% (absolute values)
Hazard ratio 1.15, 95% confidence interval 1.02 to 1.30, p = 0.02,
P = 0.01
Adjusted Risk Ratio
12
10
8
6
4
2
0
< -16% (worse)
≥ 16% (better)
Global Longitudinal Strain
Pressman G…Gorcsan J et al. Am J Cardiol 2015 Nov 15;116(10):1601-4.


CASE STUDY
62 year old man with weight loss, gastroparesis, dyspnea and edema.
UPMC Health System


FR= 64 fps
HR= 77 bpm
AVC
Base
Mid
Apex
Peak Systolic Strain
Gorcsan J. MSE 2017

Segmental Longitudinal Strain

Normal Subject

Basal Strain = - 21.1%
Mid Strain = - 22.3%
Apical Strain = -25.3%

Our Patient
Apical Sparing

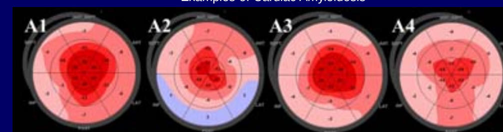
Basal Strain = - 5.0%
Mid Strain = - 5.8%
Apical Strain = -17.2%

Amyloid Heart Disease

Apical Longitudinal Strain Sparing in Amyloidosis

Examples of Increase Wall Thickness No Amyloidosis

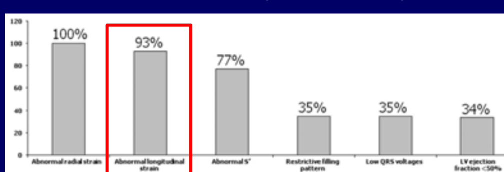
Examples of Cardiac Amyloidosis



Phelan…Thomas JD. Heart 2012

Prevalence of Abnormal Echo Indices in Cardiac Amyloidosis

n = 172 patients with Cardiac Amyloidosis
- n=80 with Light Chain Immunoglogulins
- n=36 transthyretin-related mutant form
- n=56 Nonmutant transthyretin-related amyloidosis



Quarta, Solomon et al. Circulation. 2014;129:18 1840-1849

GLS Predicts Survival in Cardiac Amyloidosis

Table 6. Multivariable Analysis of Risk of Death Resulting from Any Cause and Incident Heart Failure

	HR	95% CI	*P*
Death resulting from any cause			
Pathogenesis of ATTRm versus AL	0.39	1.66–0.92	0.032
Pathogenesis of ATTRwt versus AL	0.36	0.18–0.71	0.003
NYHA class III–IV	1.92	1.00–3.65	0.047
eGFR, each incremental 1 mL/min	0.98	0.97–0.99	0.001
Global LV longitudinal strain, each incremental 1%	1.1	1.01–1.19	0.026

Quarta, Solomon et al. Circulation. 2014;129:18 1840-1849

An 85 year woman with progressive shortness of breath and syncope

Severe Aortic Stenosis Peak Velocity 5 m/sec
Peak Gradient 100 mmHg, Mean Gradient 69 mmHg
AVA = 0.6 cm^2

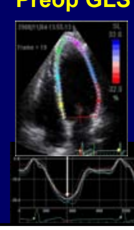
Circulation
Cardiovascular Imaging
American Heart Association

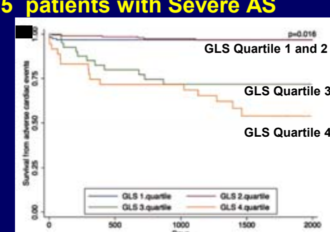
Global Strain in Severe Aortic Valve Stenosis: Relation to Clinical Outcome After Aortic Valve Replacement
Jordi S. Dahl, Lars Videbæk, Mikael K. Poulsen, Torsten R. Rudbæk, Patricia A. Pellikka and Jacob E. Møller

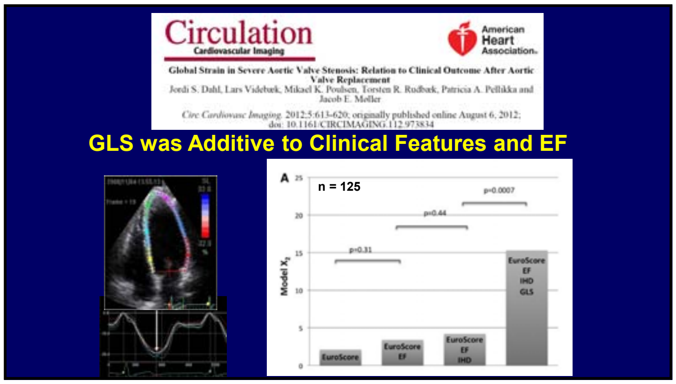
Circ Cardiovasc Imaging. 2012;5:613-620; originally published online August 6, 2012;
doi: 10.1161/CIRCIMAGING.112.973834

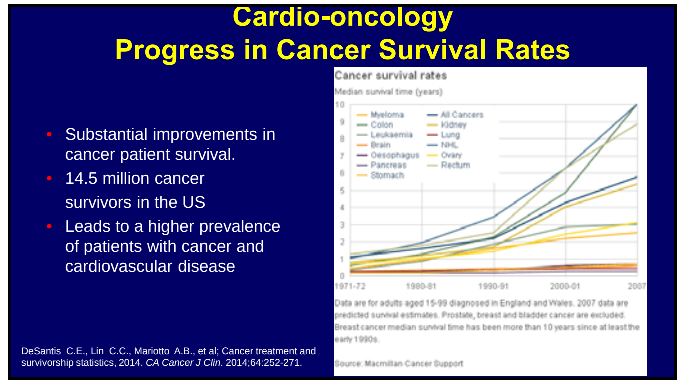
n = 125 patients with Severe AS

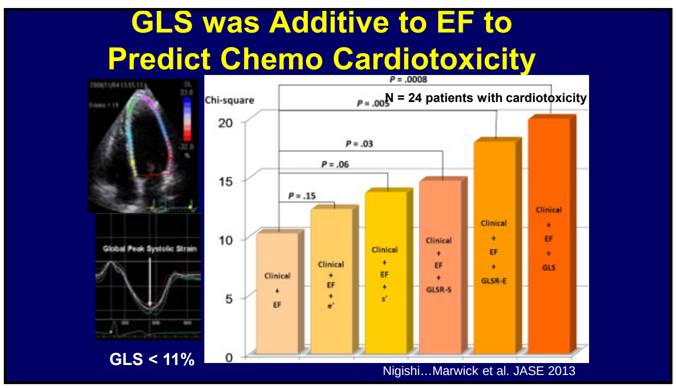
Preop GLS

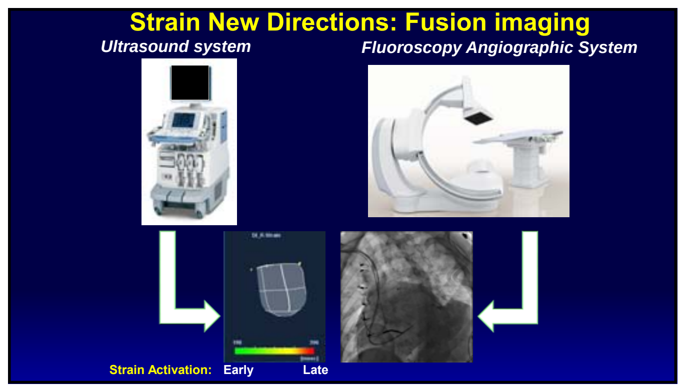


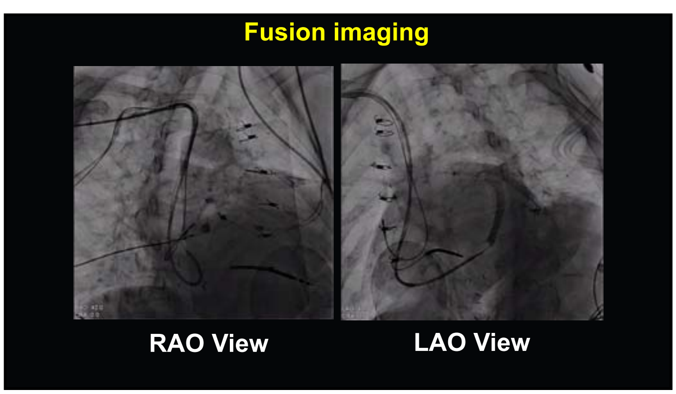


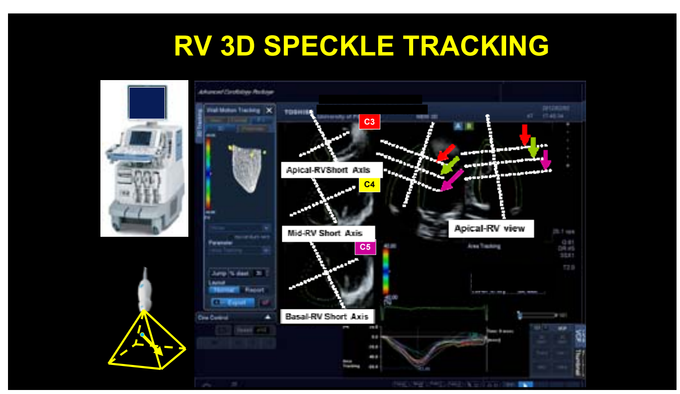

Circulation
Cardiovascular Imaging
American Heart Association.
Global Strain in Severe Aortic Valve Stenosis: Relation to Clinical Outcome After Aortic Valve Replacement
Jordi S. Dahl, Lars Videbæk, Mikael K. Poulsen, Torsten R. Rudbæk, Patricia A. Pellikka and Jacob E. Møller
Circ Cardiovasc Imaging. 2012;5:613-620; originally published online August 6, 2012;
doi: 10.1161/CIRCIMAGING.112.973834
GLS was Additive to Clinical Features and EF
n = 125
p=0.31
p=0.44
p=0.0007
EuroScore
EuroScore EF
EuroScore EF IHD
EuroScore EF IHD GLS

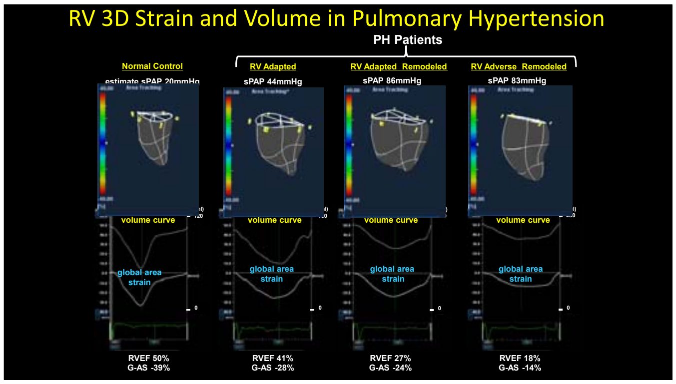

Cardio-oncology
Progress in Cancer Survival Rates
Substantial improvements in cancer patient survival.
14.5 million cancer survivors in the US
Leads to a higher prevalence of patients with cancer and cardiovascular disease
DeSantis C.E., Lin C.C., Mariotto A.B., et al; Cancer treatment and survivorship statistics, 2014. CA Cancer J Clin. 2014;64:252-271.
Cancer survival rates
Median survival time (years)
Myeloma
Colon
Leukaemia
Brain
Oesophagus
Pancreas
Stomach
All Cancers
Kidney
Lung
NHL
Ovary
Rectum
1971-72
1980-81
1990-91
2000-01
2007
Data are for adults aged 15-99 diagnosed in England and Wales. 2007 data are predicted survival estimates. Prostate, breast and bladder cancer are excluded. Breast cancer median survival time has been more than 10 years since at least the early 1990s.
Source: Macmillan Cancer Support

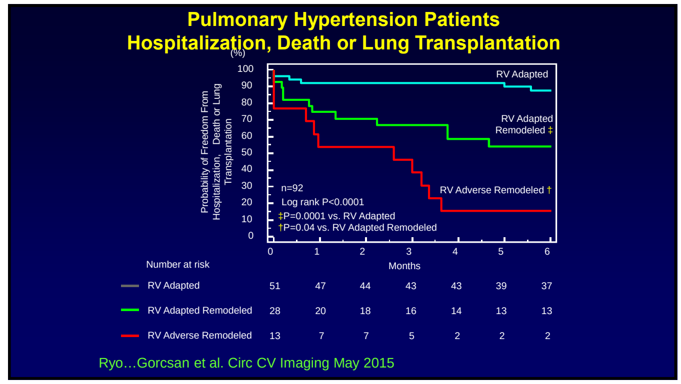

GLS was Additive to EF to Predict Chemo Cardiotoxicity
N = 24 patients with cardiotoxicity
Chi-square
P = .0008
P = .005
P = .03
P = .06
P = .15
Clinical + EF
Clinical + EF + e'
Clinical + EF + s'
Clinical + EF + GLSR-S
Clinical + EF + GLSR-E
Clinical + EF + GLS
Global Peak Systolic Strain
GLS < 11%
Nigishi…Marwick et al. JASE 2013


Strain New Directions: Fusion imaging
Ultrasound system
Fluoroscopy Angiographic System
Strain Activation: Early Late

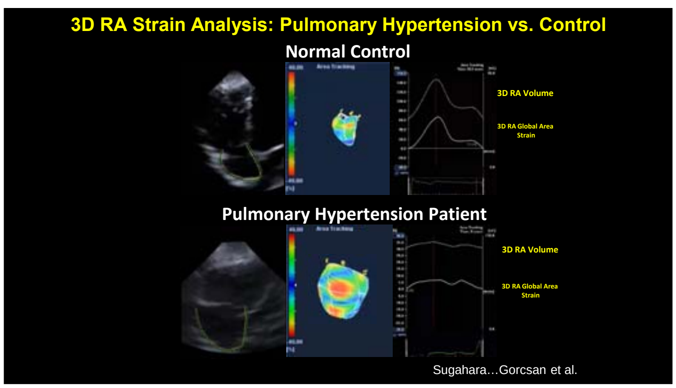

Fusion imaging
RAO View
LAO View

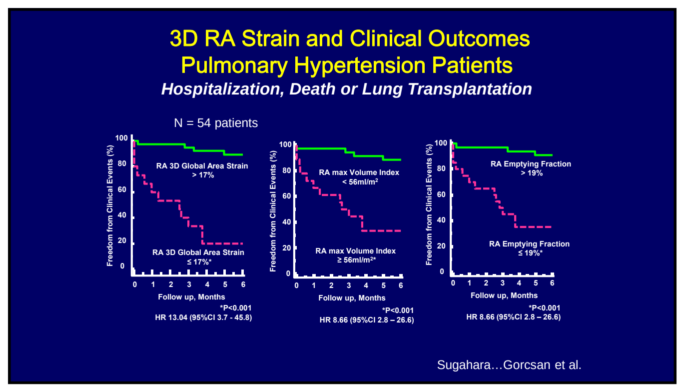

RV 3D SPECKLE TRACKING
Apical-RVShort Axis
Mid-RV Short Axis
Basal-RV Short Axis
Apical-RV view
C3
C4
C5





Number at risk	0	1	2	3	4	5	6
RV Adapted	51	47	44	43	43	39	37
RV Adapted Remodeled	28	20	18	16	14	13	13
RV Adverse Remodeled	13	7	7	5	2	2	2





Strain Imaging into the Future

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

J Am Soc Echocardiogr 2015;28:183-93

ASE Announcement:
Myocardial Strain Imaging
- *Acceptance of New CPT Category III code, 039X9T*
- *Introduced January, 2016.*
- *Category III codes are not yet reimbursed: Often lead to the adoption of payable codes by CMS and other payers.*

Take Home Messages

- **Speckle Tracking Strain has emerged as the most useful new echocardiographic tool to assess myocardial function.**
- **Global Longitudinal Strain is best represented in the literature as being a sensitive measure additive to EF.**
- **Most Promising New Clinical Applications:**
  - **Adding to EF in Heart Failure to Enhance Prognosis**
  - **Cardiac Amydoidosis**
  - **Valvular Heart Disease**
  - **Neurocardiac Injury**
  - **Cardio-oncology**
  - **3D Strain has promise for the future!**

Gorcsan J. 2017