



LEIDEN UNIVERSITY MEDICAL CENTER

Νεότερα στην Υπερηχοκαρδιογραφία

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HEARTLUNG
CENTER LEIDEN



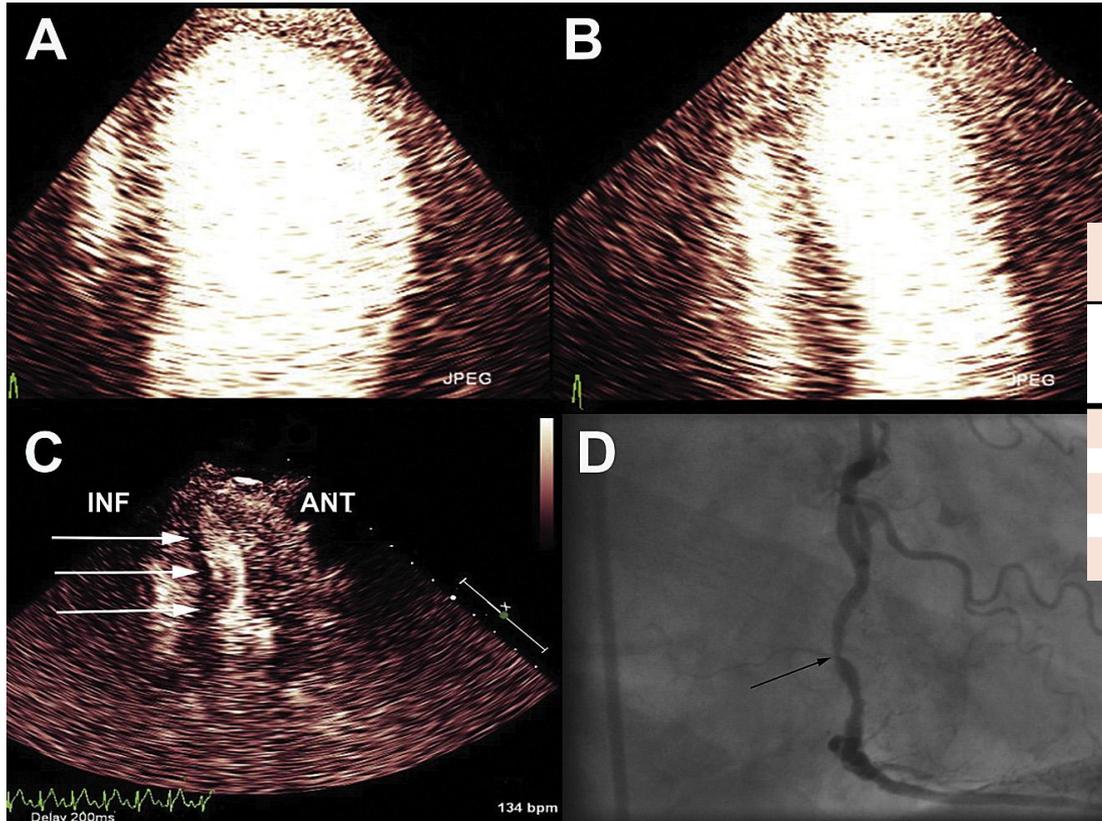
Disclosures

- ESC training grant
- EACVI research grant
- HCS training grant
- ELIKAR research grant

Evolution of Echocardiography

- Diagnostic accuracy
 - Elucidate Pathophysiology
 - Predict the Outcome
 - Risk stratification
 - Guide Intervention
-
- **Stress Echocardiography**
 - **Speckle tracking Echocardiography - Strain**
 - **3D Echocardiography**

Stress Echocardiography – Myocardial Contrast Echocardiography



Normal Wall Motion

Table 6 Ischemic burden detected by WM and MP in all patients with confirmed CAD and those with MVD

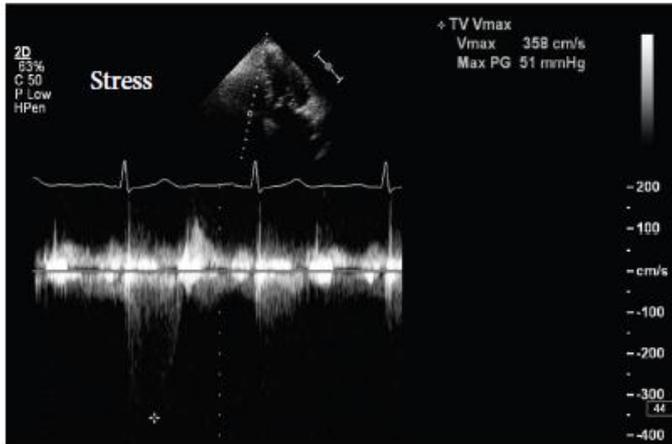
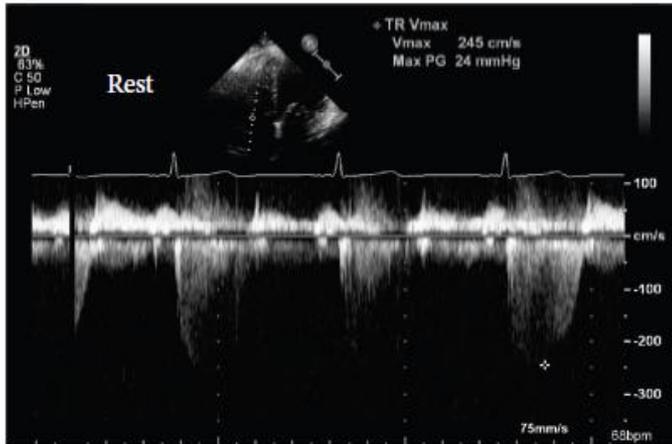
Patients	Segments, Median (IQR)		P
	WM	MP	
All (n = 60)	4 (2-7)	5 (3-8)	<.001
LAD	1 (0-4)	3 (0-5)	<.001
LCx	0 (0-2)	1 (0-3)	.005
RCA	1 (0-2)	2 (0-3)	.003
MVD (n = 34)	5 (1-8)	7 (4-9)	<.001

Perfusion Defect

A 70-year-old man with chest pain had normal WM after exercise SE (diastolic and systolic still frames in A and B), but MCE demonstrated an inferior (INF) wall perfusion defect (C). Subsequent angiography confirmed a severe eccentric middle right coronary artery stenosis (D).

Stress Echocardiography –

for risk stratification in valvular heart disease



In asymptomatic severe aortic stenosis

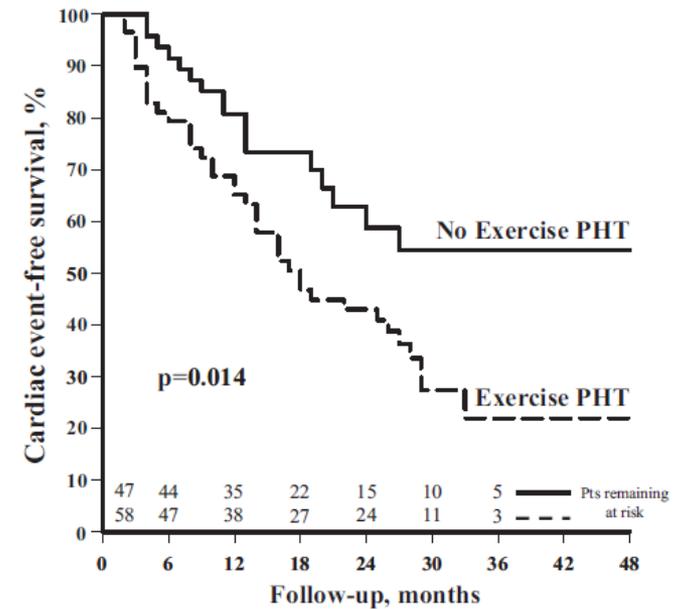


Figure 2. Cardiac event-free survival according to the presence or absence of exercise pulmonary hypertension (PHT).

Stress Echocardiography –

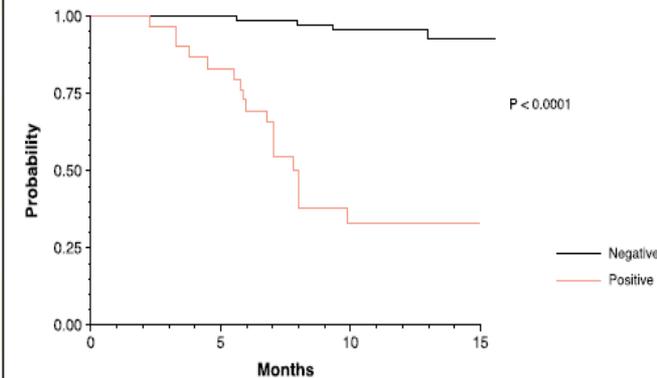
Predicts outcome in valvular heart disease

Table 1. Criteria for a Positive Stress Echocardiogram

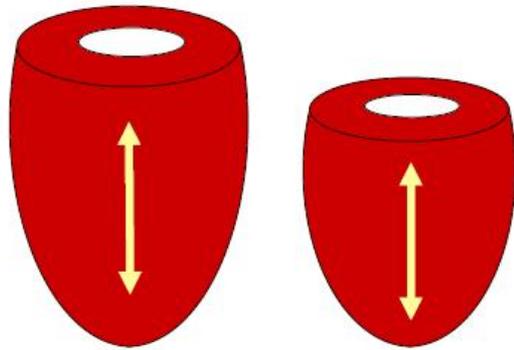
Valve Assessment	Criteria for Positive Test Results
Assessment of mitral regurgitation in patients with symptoms but mild or moderate mitral regurgitation at rest	Increase in severity of mild or moderate mitral regurgitation to severe. Effective orifice area ≥ 0.4 cm ² (organic) or ≥ 0.2 cm ² (functional)
Assessment of asymptomatic severe mitral regurgitation	Increase in pulmonary artery systolic pressure >60 mm Hg
Assessment of mitral stenosis in patients with symptoms but mild or moderate mitral stenosis at rest	Increase in the mean transmitral gradient ≥ 15 mm Hg or estimated pulmonary artery systolic pressure ≥ 60 mm Hg
Assessment of asymptomatic severe mitral stenosis	As above and symptoms
Assessment of asymptomatic severe aortic stenosis (AVA <1 cm ²)	Increase in mean transaortic gradient ≥ 20 mm Hg
Assessment of asymptomatic severe aortic regurgitation	Lack of increase in LVEF $\geq 5\%$ or exercise-induced reduction in LVEF

AVA = aortic valve area; LVEF = left ventricular ejection fraction.

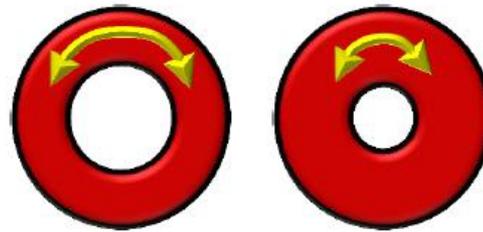
Event-free survival in valvular heart disease



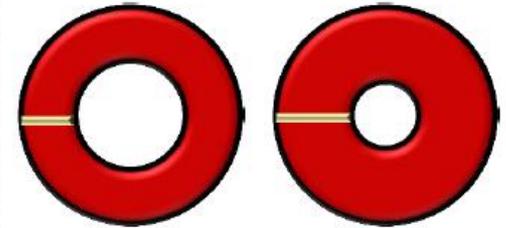
Strain



Longitudinal
Strain

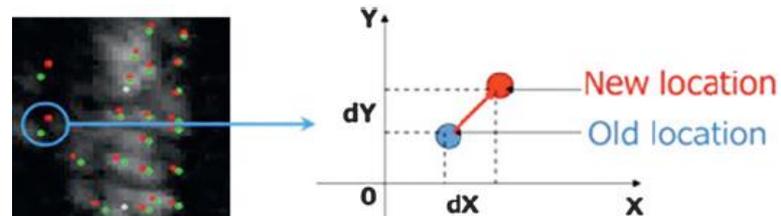
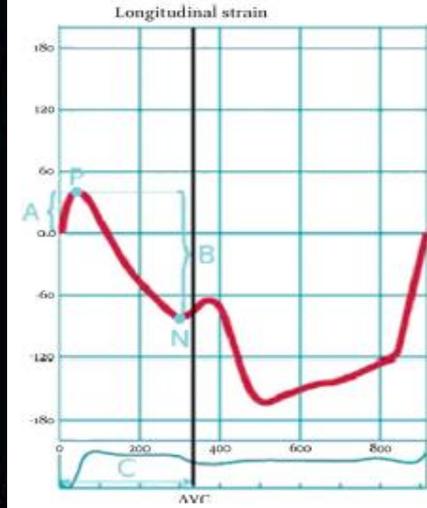
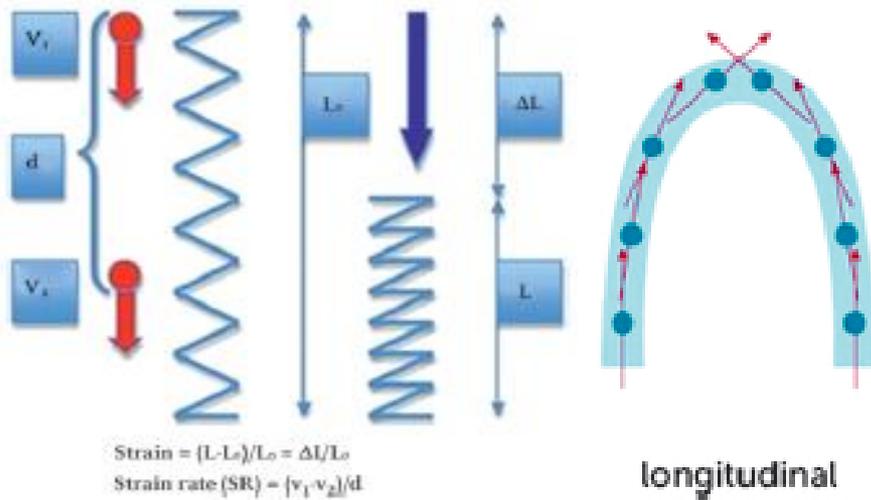


Circumferential
Strain



Radial Strain

GLOBAL LONGITUDINAL SYSTOLIC STRAIN



Normal Range of Left Ventricular Strain

A Meta-Analysis

Normal **GLS**: 19.7% (95% CI, 20.4% to 18.9%)

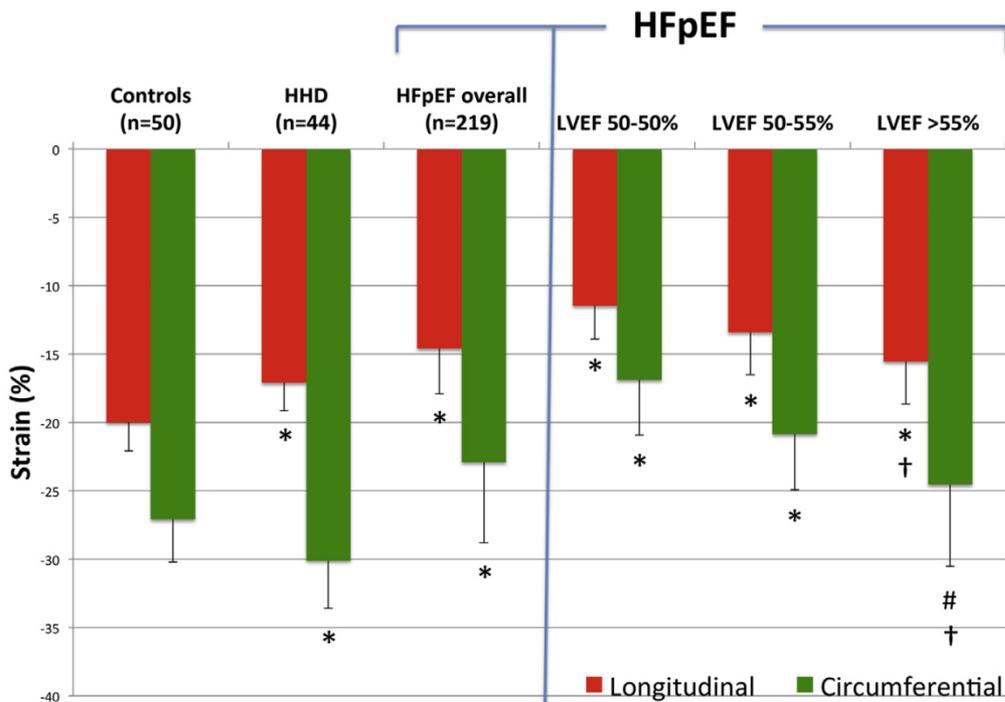
Normal **GCS**: 23.3% (95% CI, 24.6% to 22.1%)

Normal **GRS**: 47.3% (95% CI, 43.6% to 51.0%)

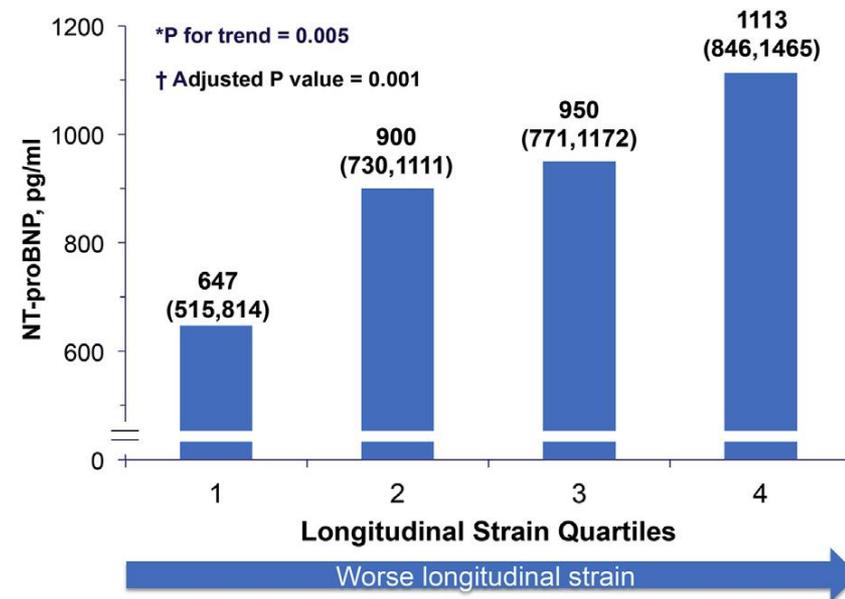
Strain in prEF Heart Failure

pathophysiology insight

Average Longitudinal and Circumferential Systolic Strain



Association of Longitudinal Systolic Strain And NT-proBNP



Pathophysiology of prEF HF

pathophysiology insight

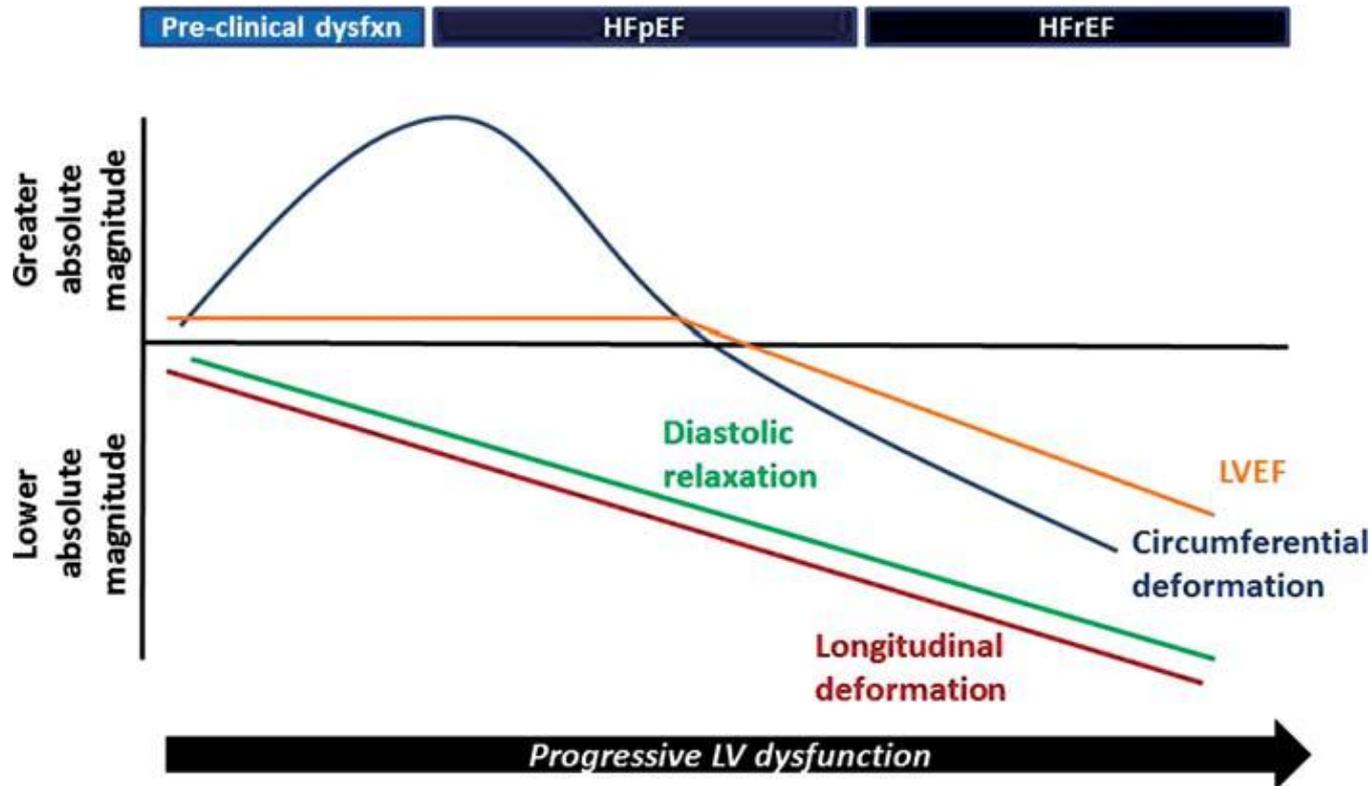
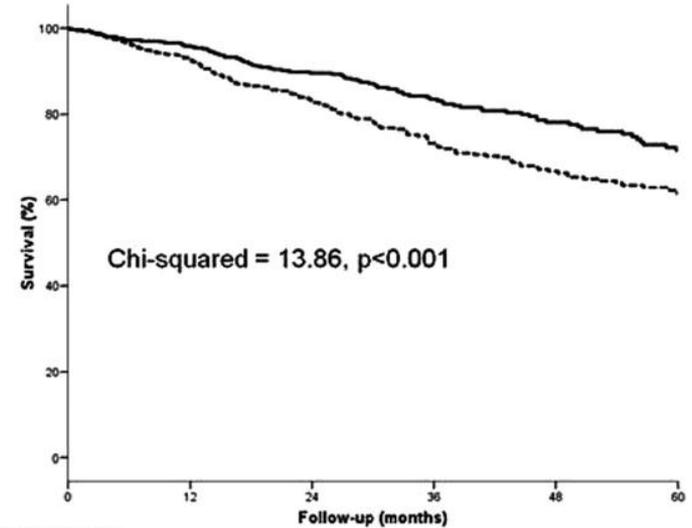
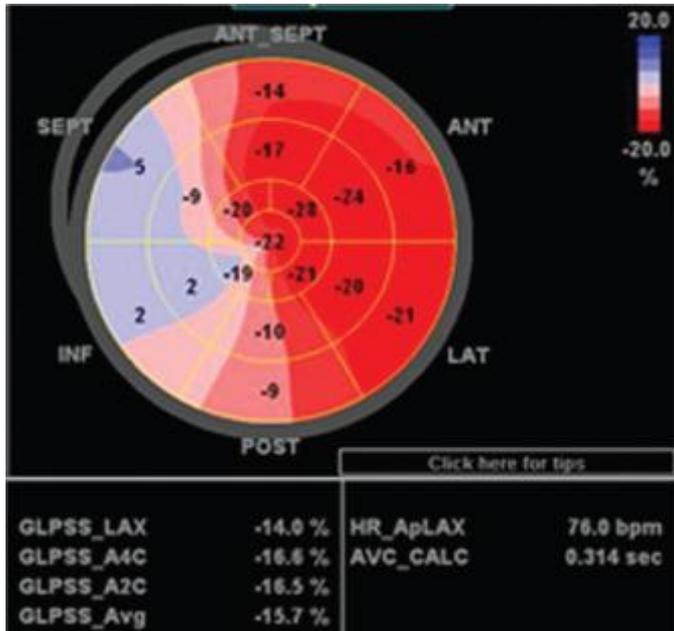


Figure 1 Model of progressive abnormalities in left ventricular (LV) diastolic and systolic function underlying heart failure across the LV ejection fraction (EF) spectrum. Early myocardial dysfunction, triggered by conditions such as hypertension and diabetes, may be associated with coupled impairments in both diastolic function and LV longitudinal deformation. Concomitant augmentation of circumferential deformation can lead to preservation of gross LVEF. Progression is characterized by worsening impairment in diastolic function and longitudinal deformation. Decline in circumferential deformation ultimately results in falling LVEF. The clinical syndrome of heart failure can occur at any point along this continuum, with varying contributions of diastolic and systolic dysfunction. HFpEF, heart failure with preserved ejection fraction; HFrEF, heart failure with reduced ejection fraction

GLS in ischemic cardiomyopathy

for prediction of survival



	Number of patients at risk					
	0	12	24	36	48	60
— GLS ≤ -11.5%	531	413	321	238	166	116
- - - GLS > -11.5%	529	464	335	229	165	95

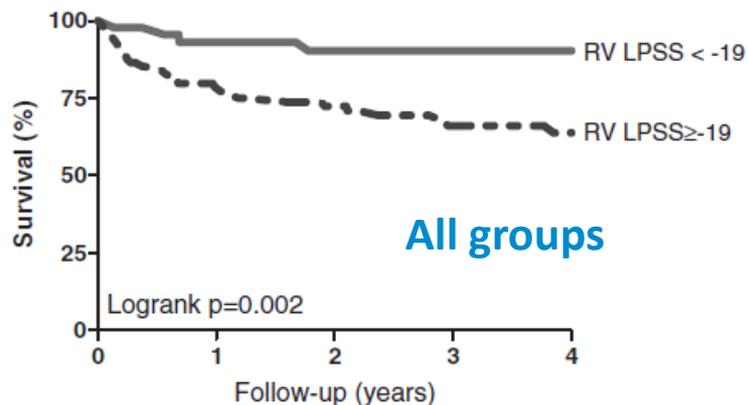
Independent variables:
clinical + GLS

Age, y	1.03 (1.02–1.04)	<0.001
Diabetes	1.37 (1.08–1.74)	0.010
GFR, per 10 mL/min per 1.73 m ² decrease	1.14 (1.08–1.21)	<0.001
GLS, per 5% increment	1.64 (1.32–2.04)	<0.001

Model	All-Cause Mortality	Harrell C Concordance Statistic Index
1	Clinical parameters+WMSI	0.689
2	Clinical parameters+LVEF	0.686
3	Clinical parameters+GLS	0.700

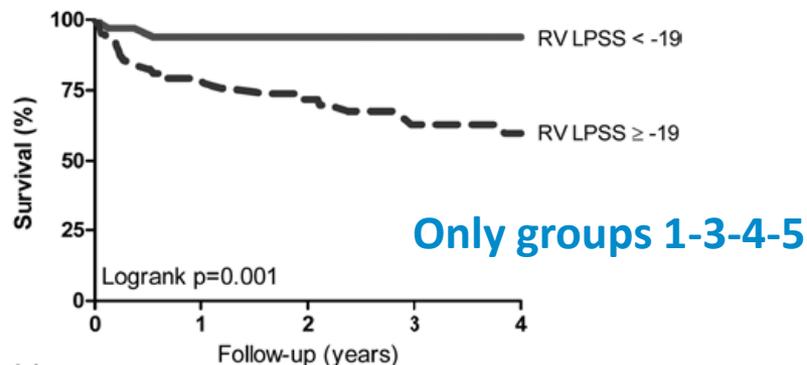
RV GLS in Pulmonary Hypertension

for prediction of survival



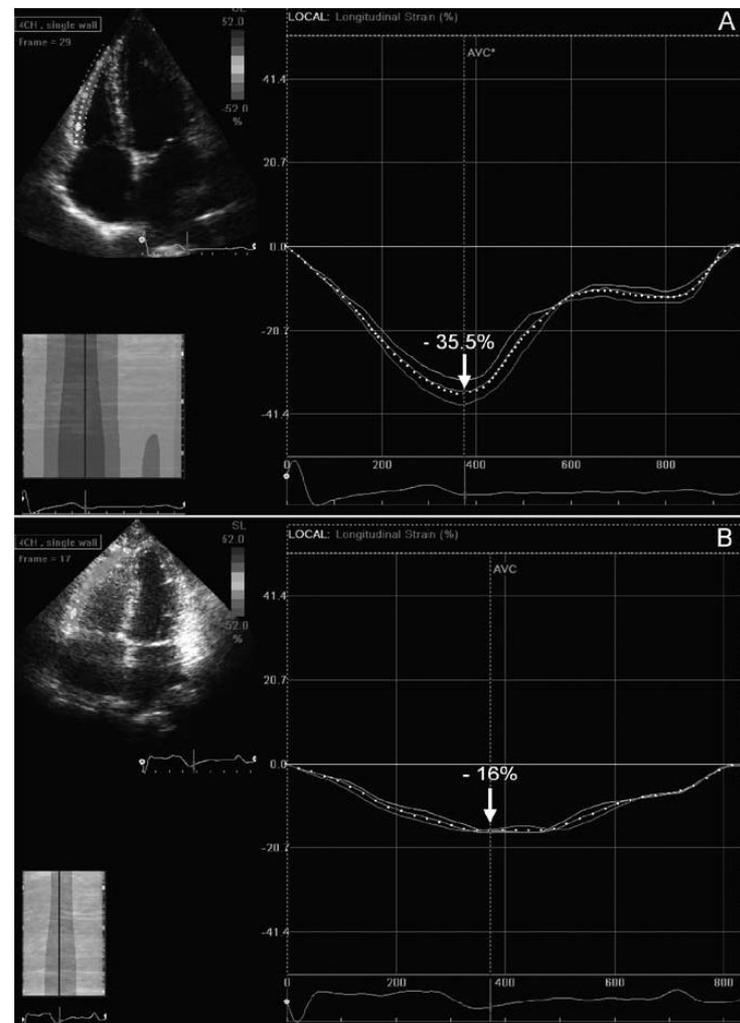
No. at risk

< -19%	46	39	33	24	18
\geq -19%	96	67	54	40	27



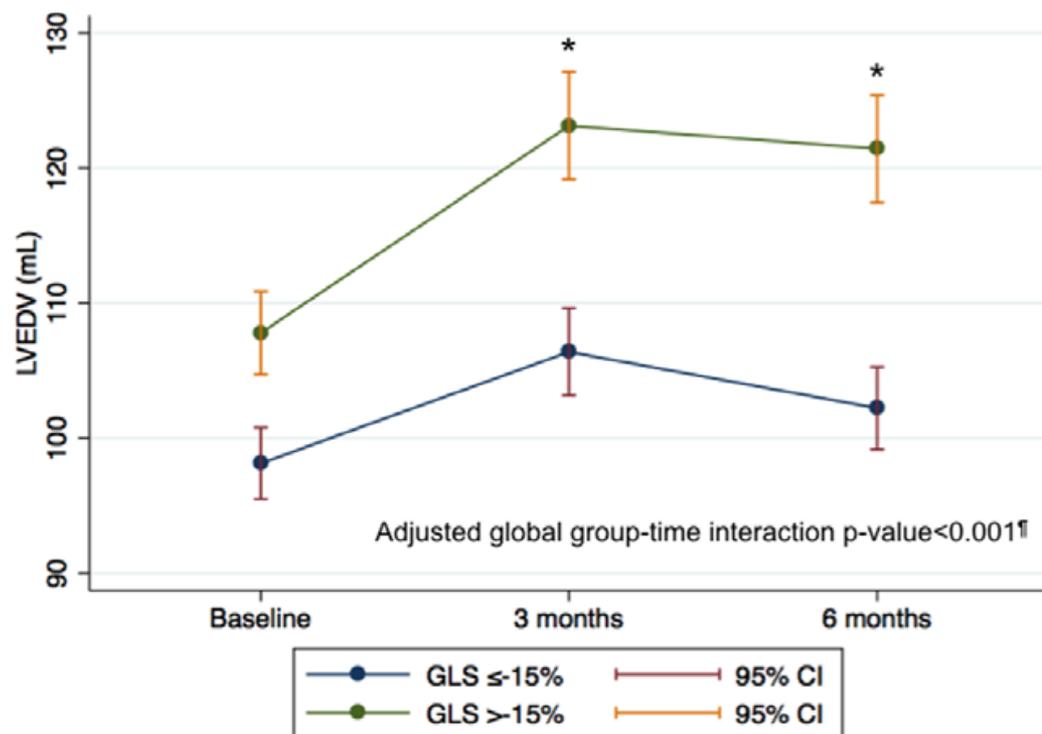
No. at risk

< -19%	33	28	24	18	12
\geq -19%	63	45	35	27	17



GLS after STEMI

for risk stratification



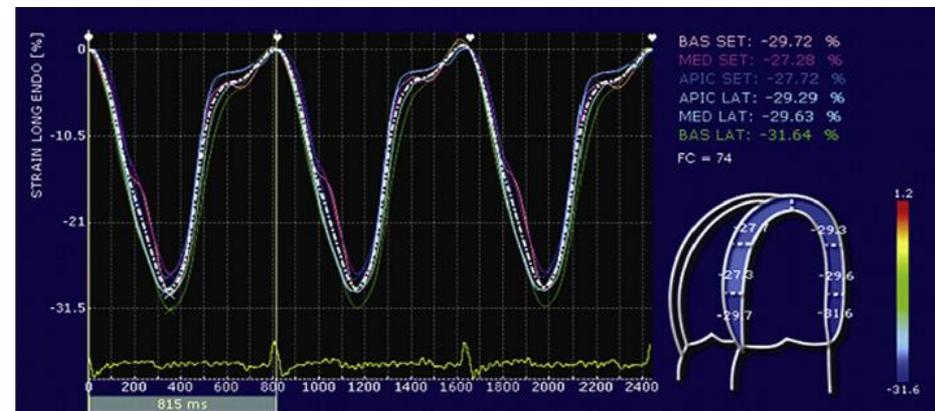
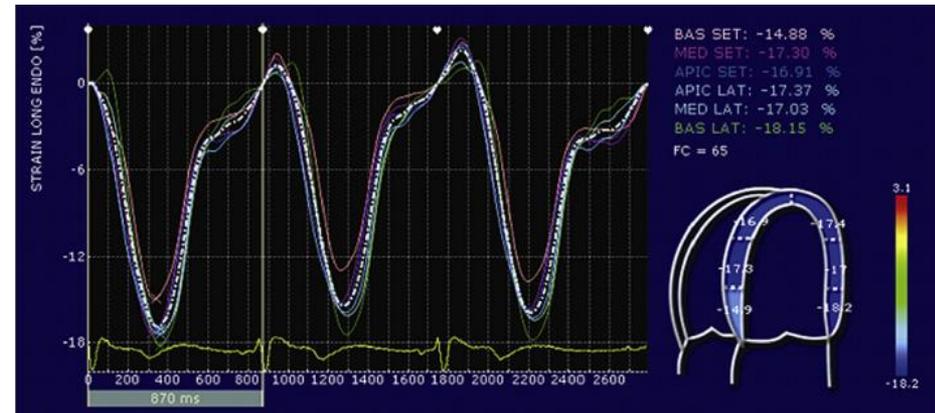
LVGLS also provided incremental value to traditional parameters for assessment of infarct size, including wall motion score index and peak troponin level, for prediction of LV enlargement after STEMI.

GLS in Thalassemia major

for early myocardial dysfunction

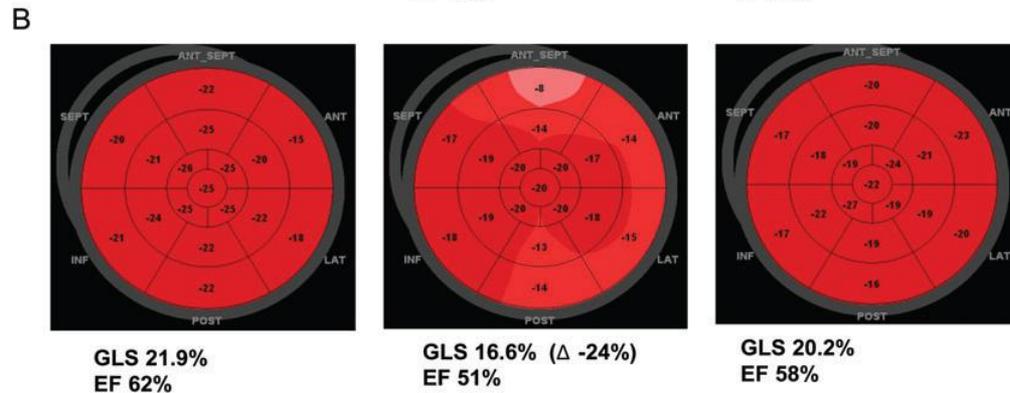
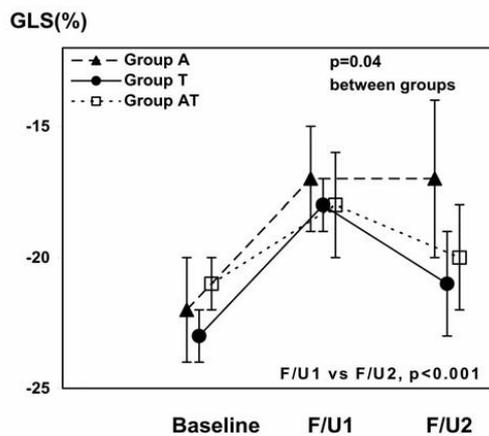
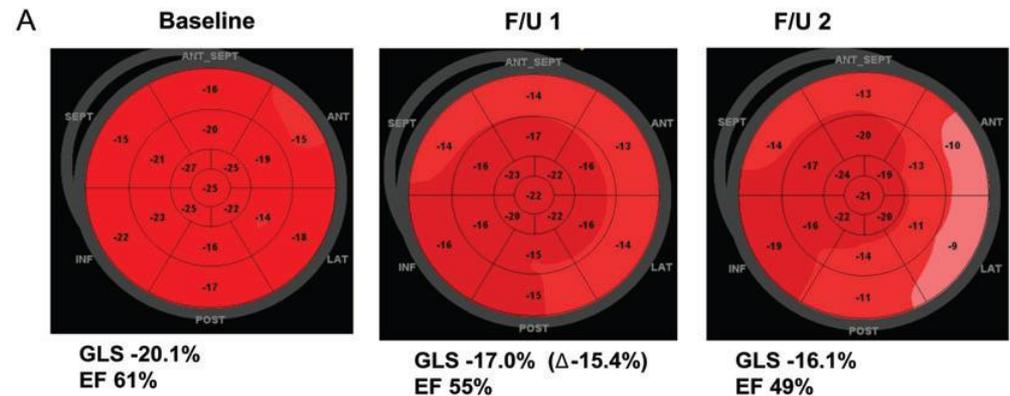
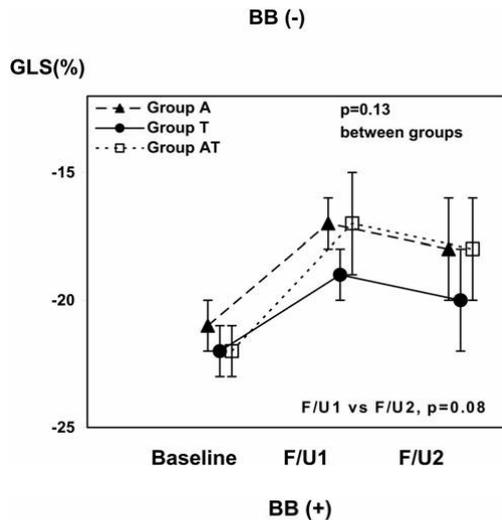
Clinical and echocardiographic features of patients and controls

Characteristic	Controls (n = 33)	β -TM (n = 32)
Age (yrs)	34.9 \pm 6.1	35.3 \pm 7.7
Women	20 (61)	23 (71)
Systolic blood pressure (mm Hg)	116.9 \pm 9.8	114.2 \pm 10.6
Diastolic blood pressure (mm Hg)	71.5 \pm 7.7	70.2 \pm 9.3
End-diastolic volume (ml)	76.4 \pm 16.4	73.5 \pm 19.8
End-systolic volume (ml)	27.2 \pm 6.3	26.9 \pm 8.4
Ejection fraction (%)	64.1 \pm 3.8	63.6 \pm 3.9
LV myocardial mass (g/m ²)	67.7 \pm 8.1	68.3 \pm 7.9
E/A ratio	1.26 \pm 0.5	1.30 \pm 0.47
DTE (ms)	176 \pm 15	175 \pm 13
Septal S' (cm/s)	9.2 \pm 0.7	8.5 \pm 0.6
E/E' ratio	6.6 \pm 0.8	6.9 \pm 1.2
Radial strain (%)	38.3 \pm 5.8	36.7 \pm 8.2
Circumferential strain (%)	-22.4 \pm 4.1	-20.5 \pm 5.1
Longitudinal strain (%)	-24.3 \pm 3.4*	-17.9 \pm 3.5*

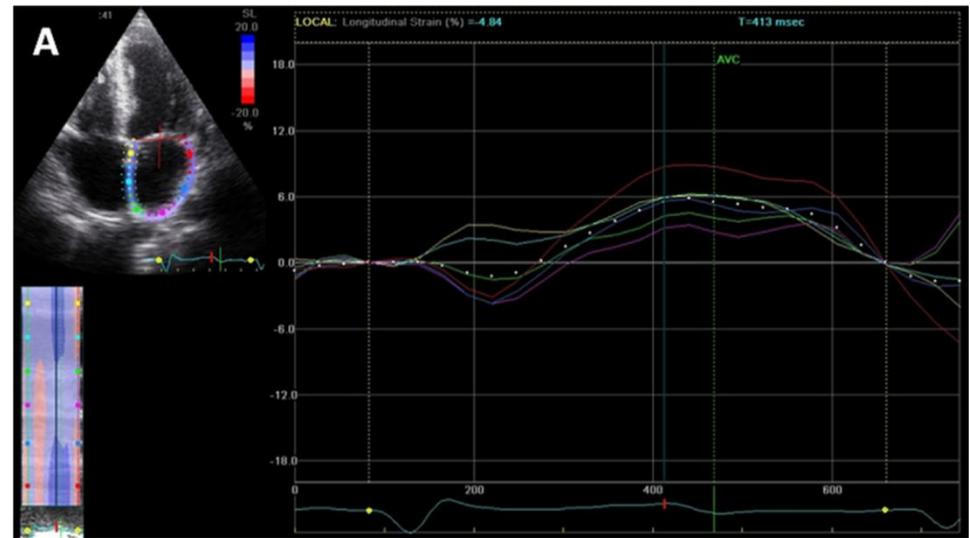
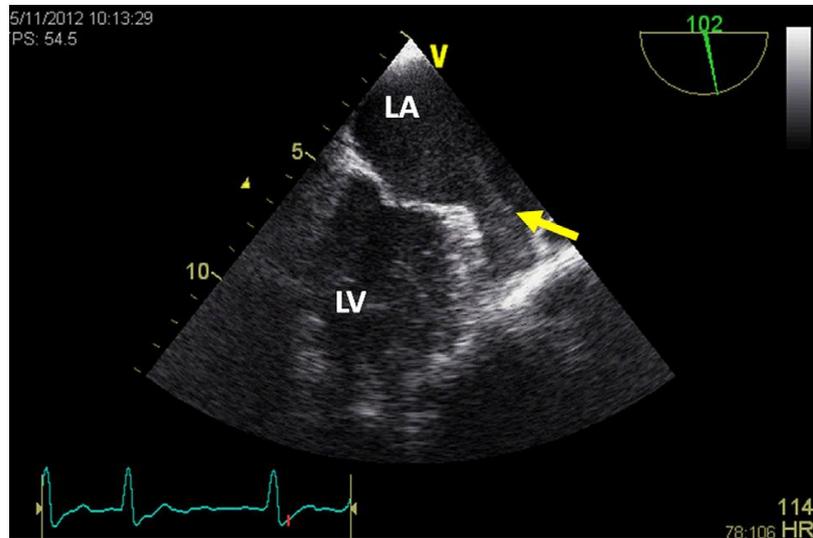
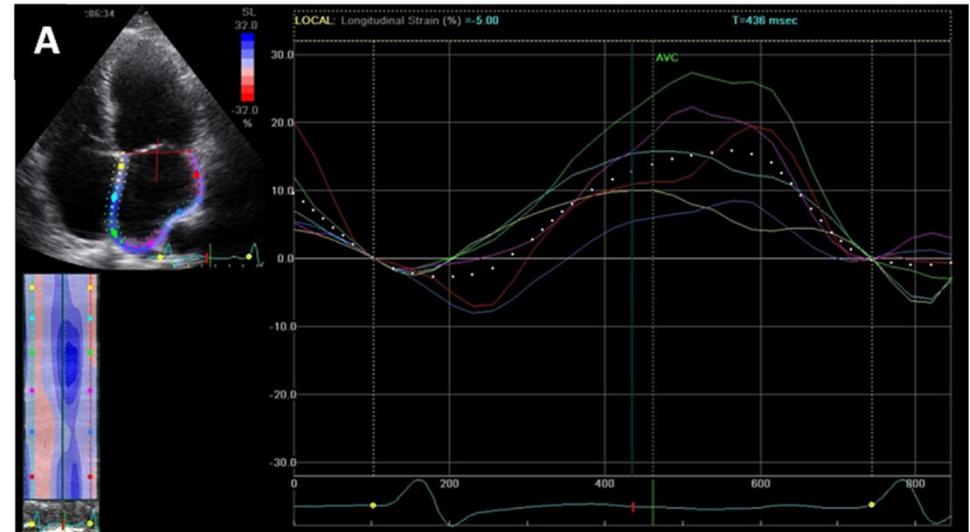


GLS in cancer / chemotherapy

for cardioprotection



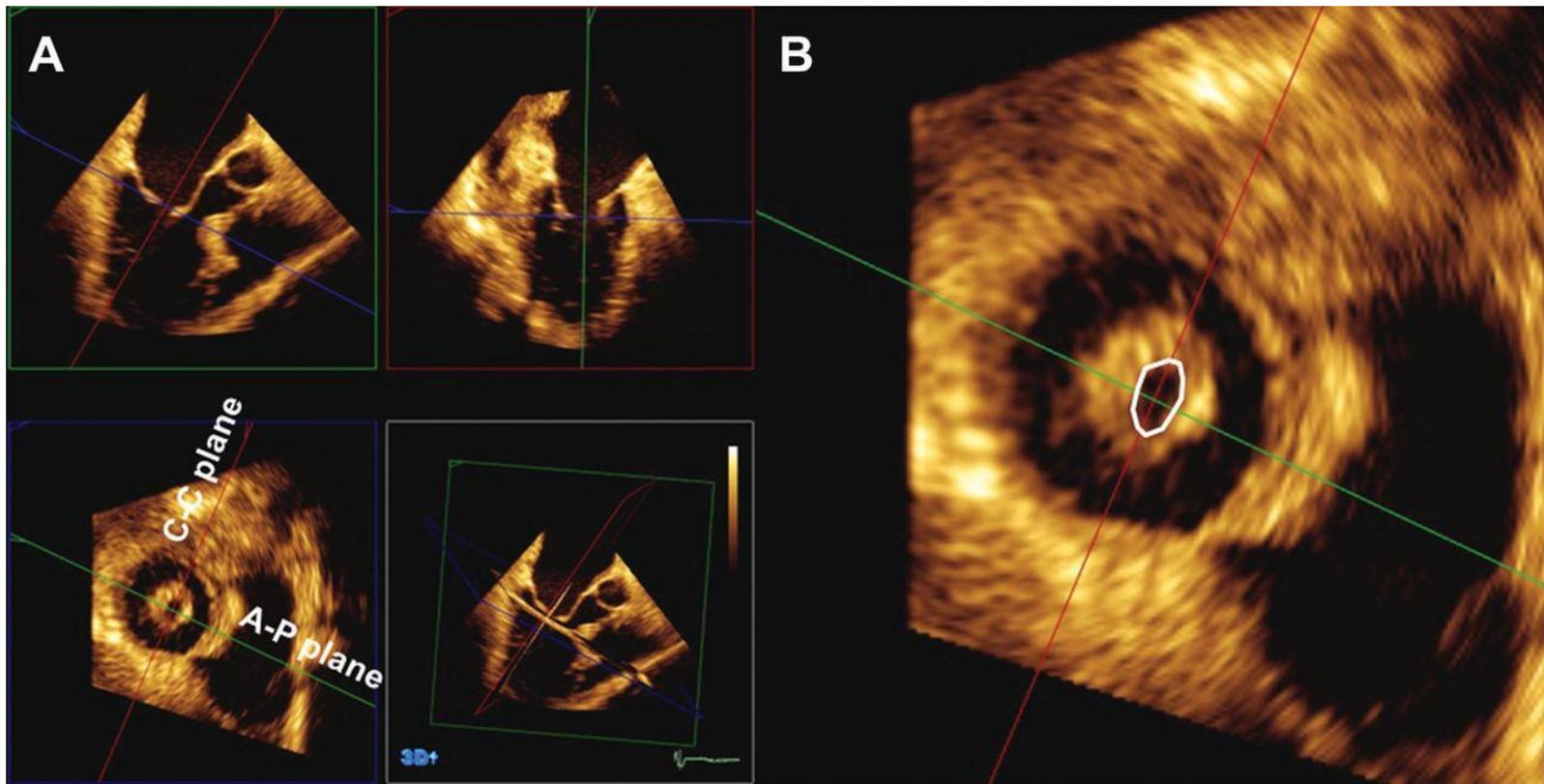
LA strain in AF for thromboembolic risk



3D Echo in mitral stenosis

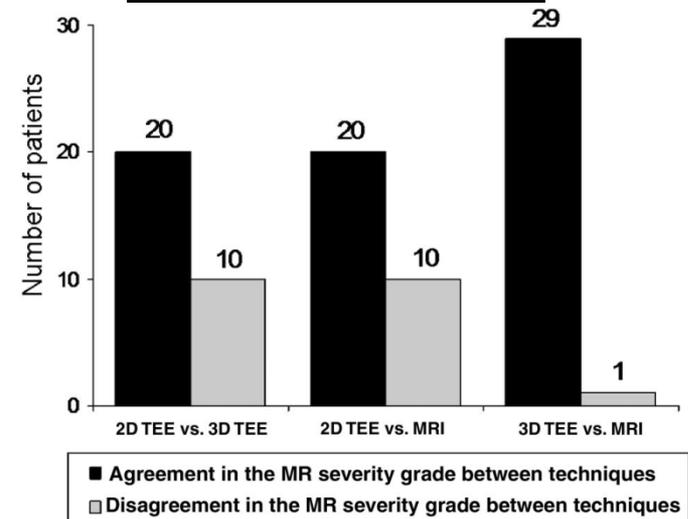
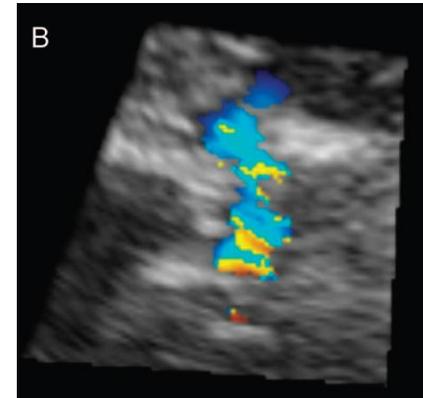
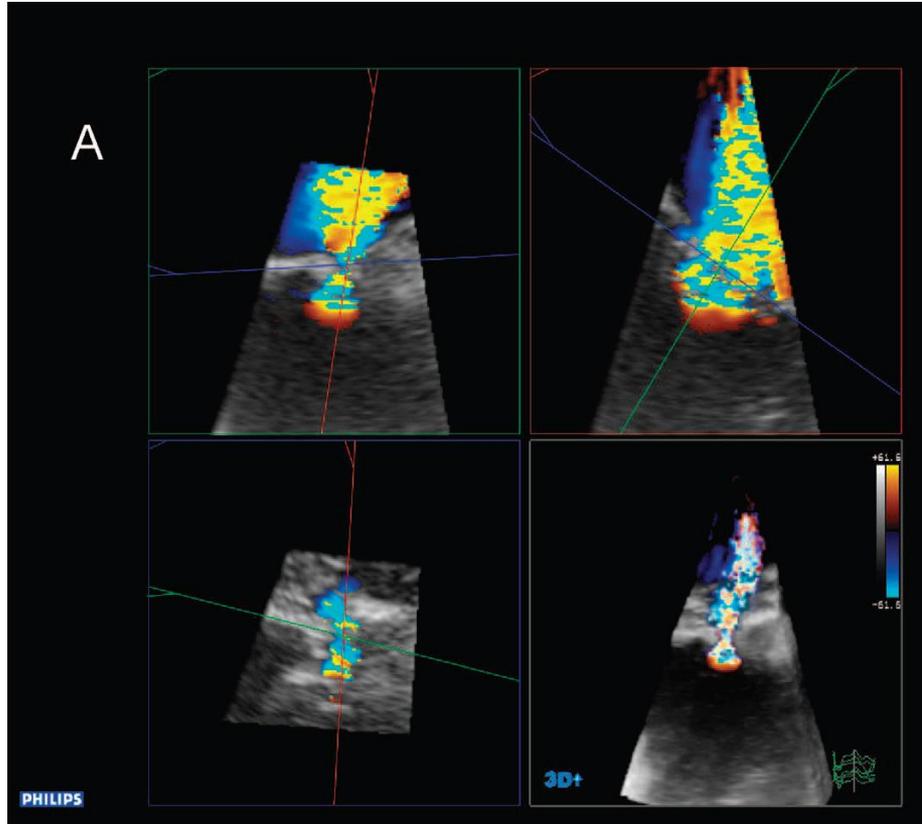
for Diagnostic accuracy

Discrepancy between mitral valve areas measured by 2D planimetry and 3D TEE echocardiography in patients with mitral stenosis.



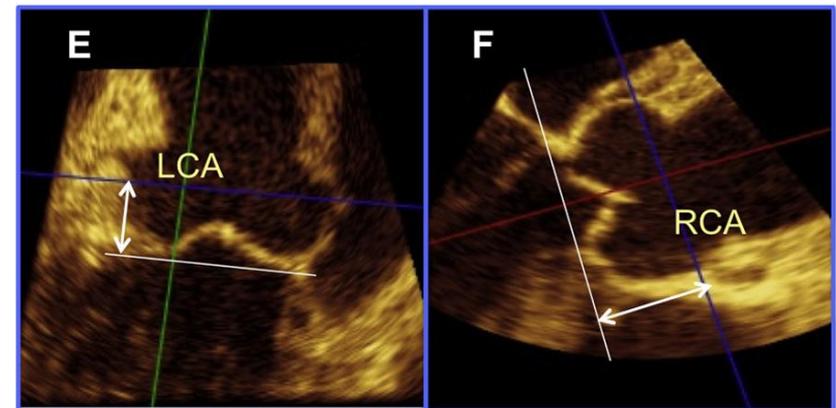
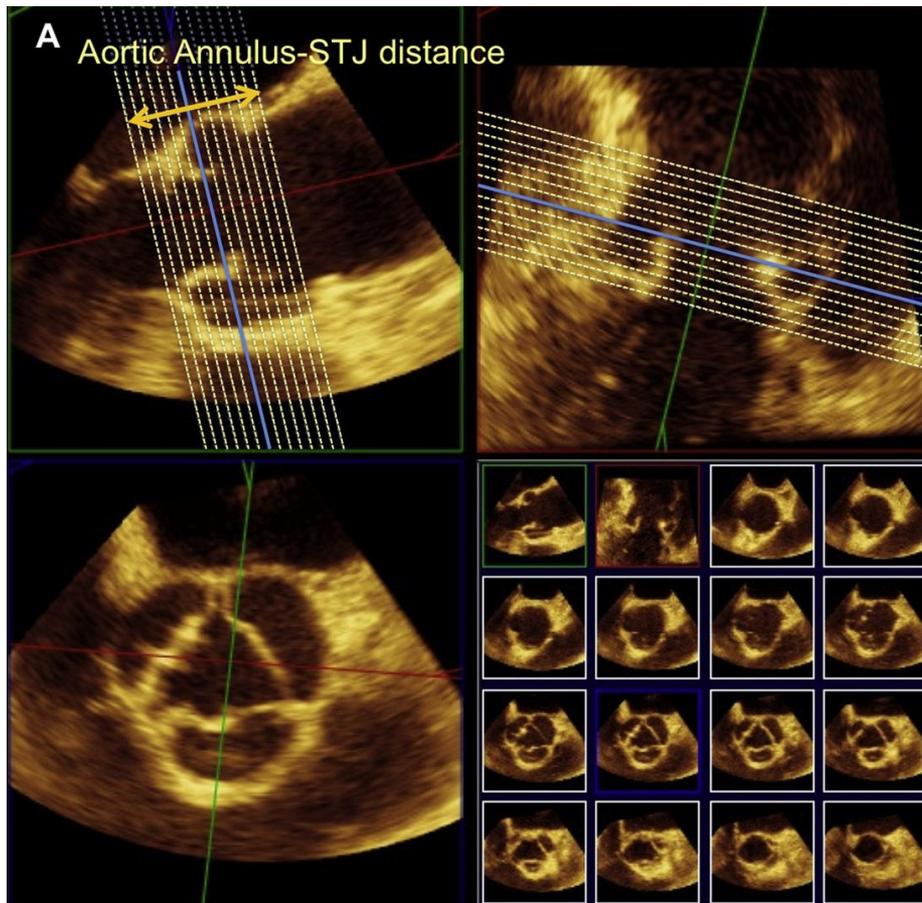
3D Echo in mitral regurgitation for Diagnostic accuracy

Three-dimensional echocardiography for assessment of EROA
Compared to CMR



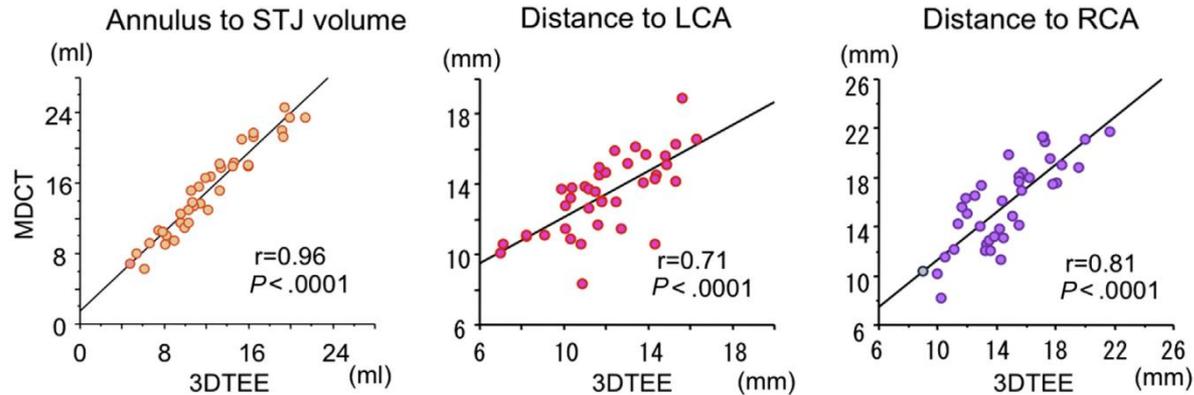
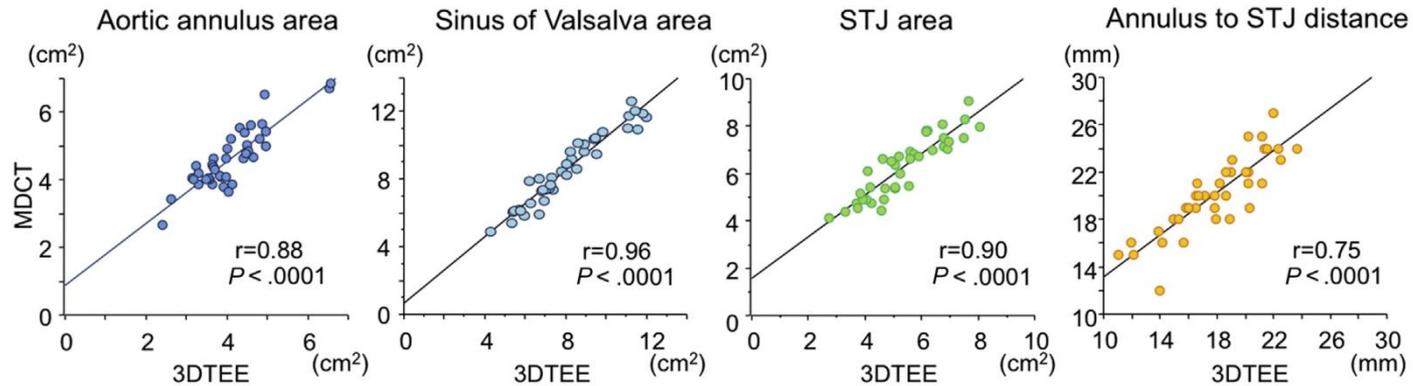
3D Echo of the aortic root

for Diagnostic accuracy



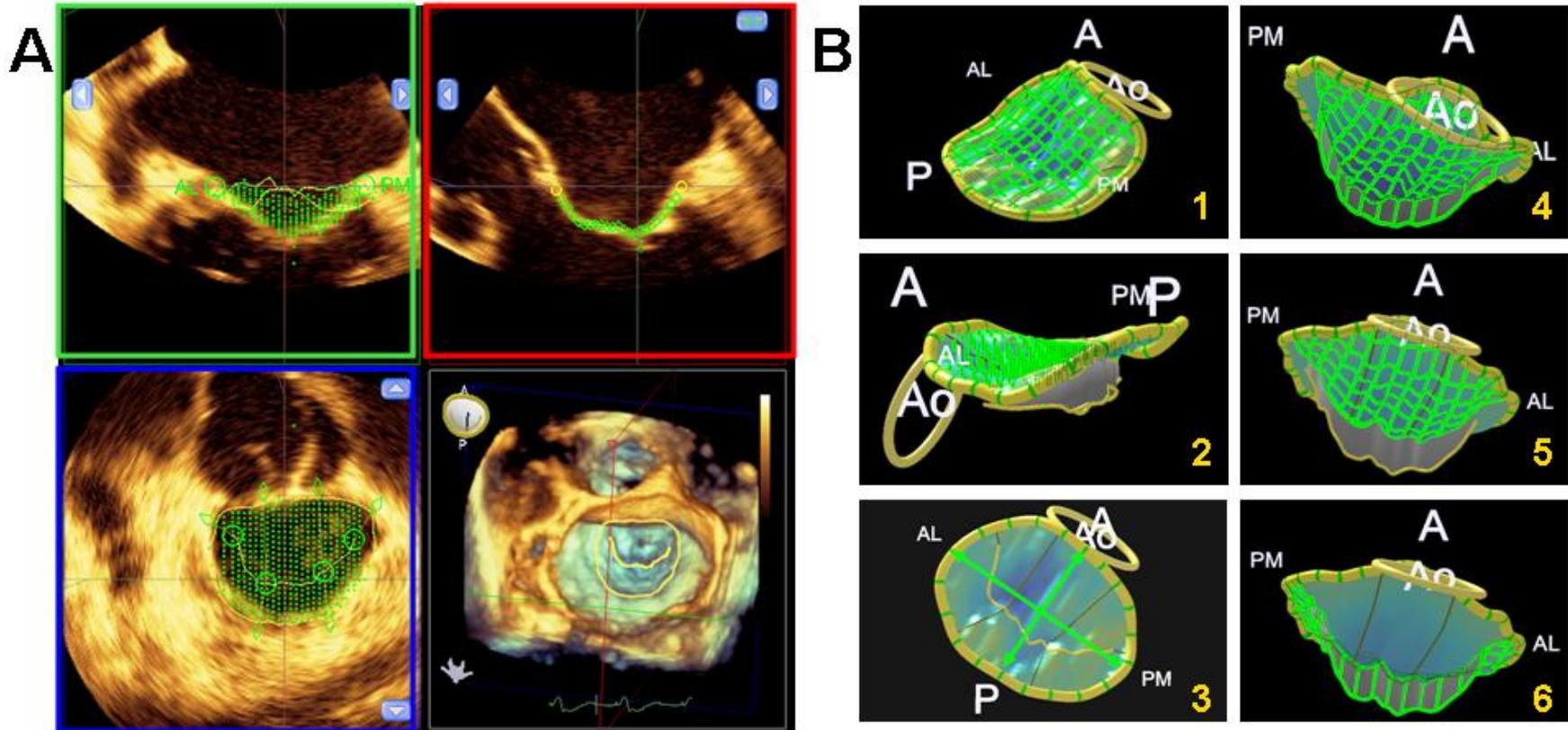
3D Echo of the aortic root

for Diagnostic accuracy



3D Echo of mitral valve

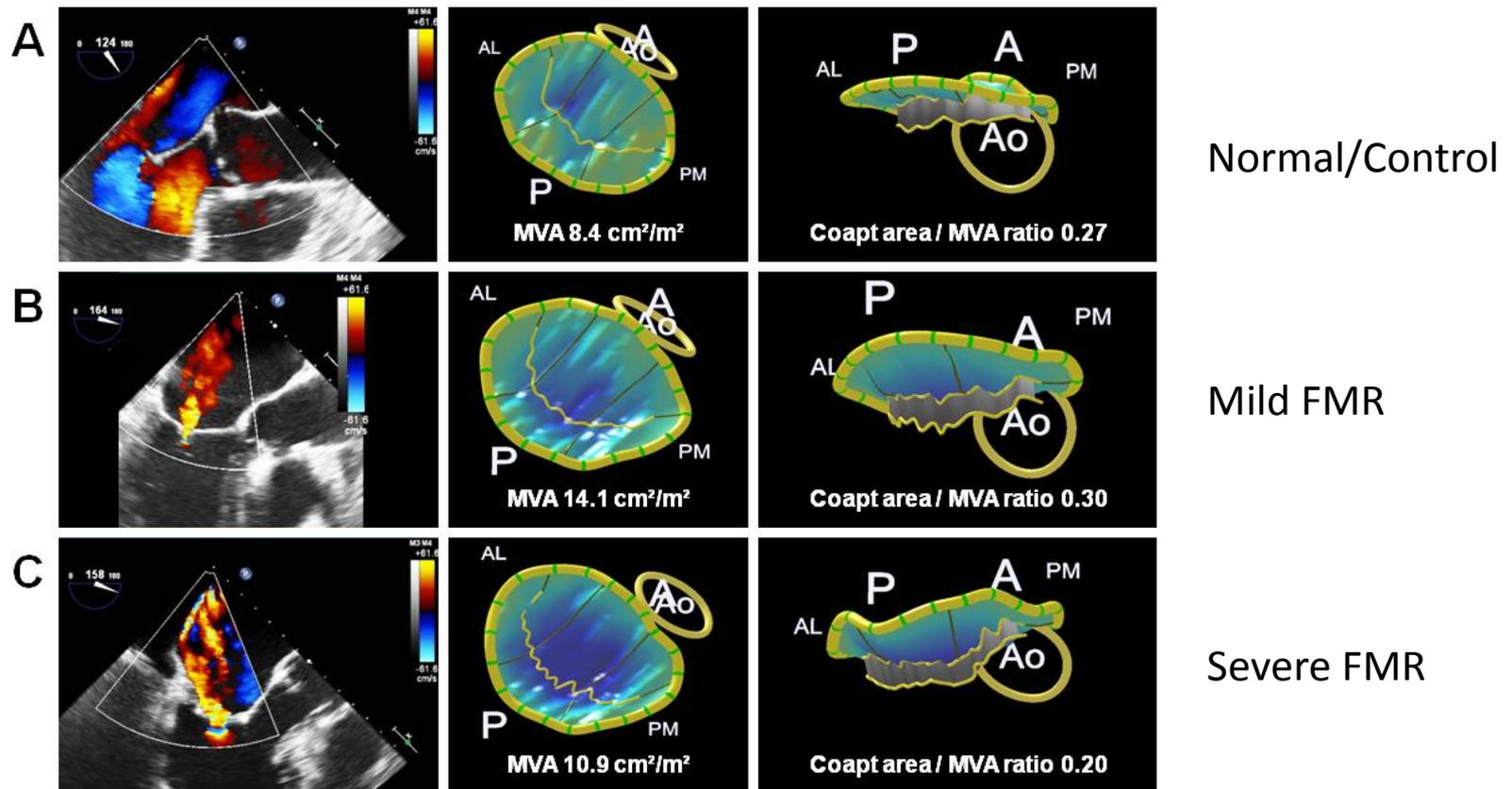
Pathophysiology of FMR



3D Echo of mitral valve

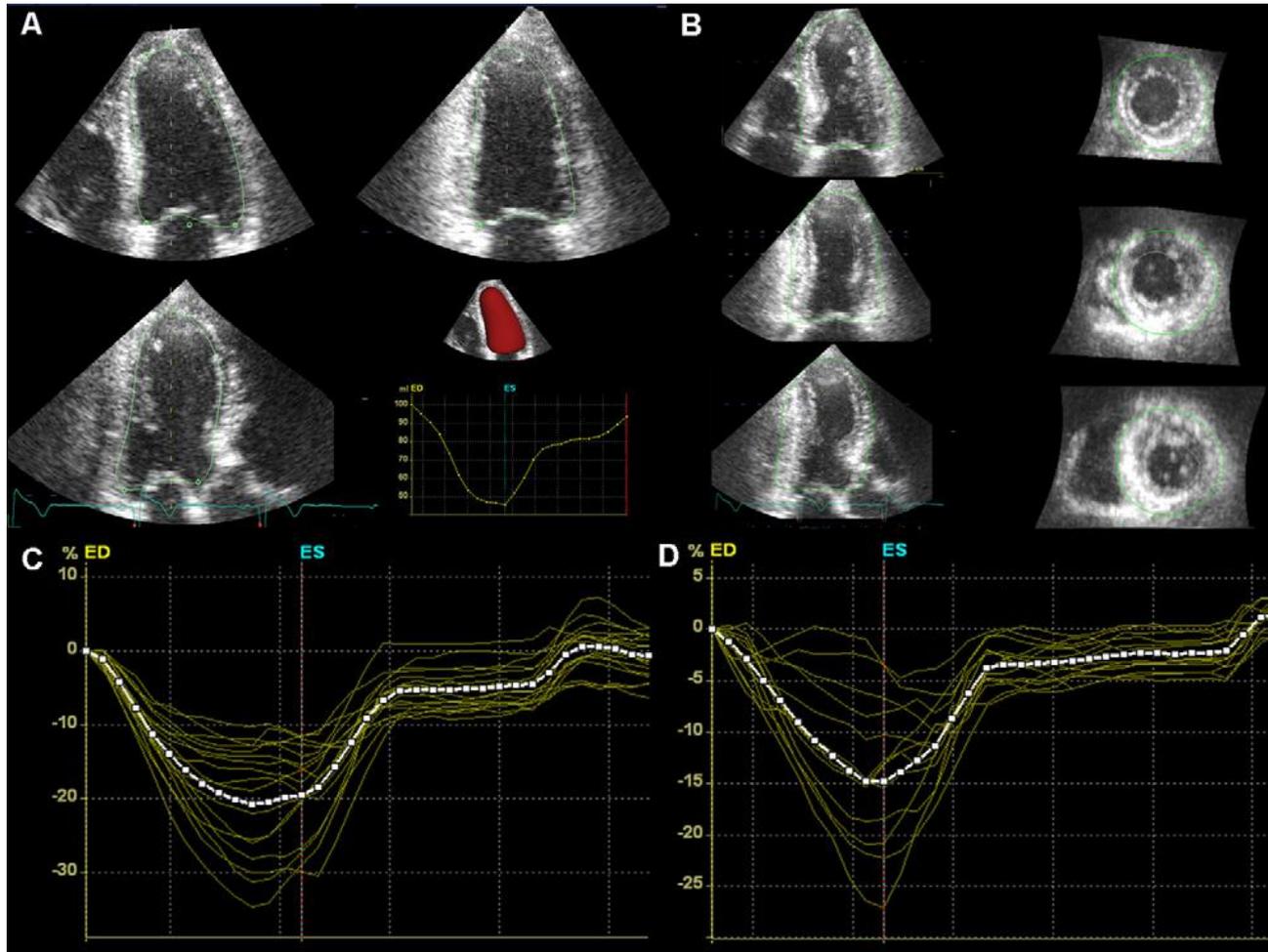
Pathophysiology of FMR

Functional Mitral Regurgitation post inferior STEMI



3D GLS

for risk stratification post STEMI



3D GLS

for risk stratification post STEMI



Clinical and echocardiographic characteristics of patients with versus without left ventricular ejection fraction improvement

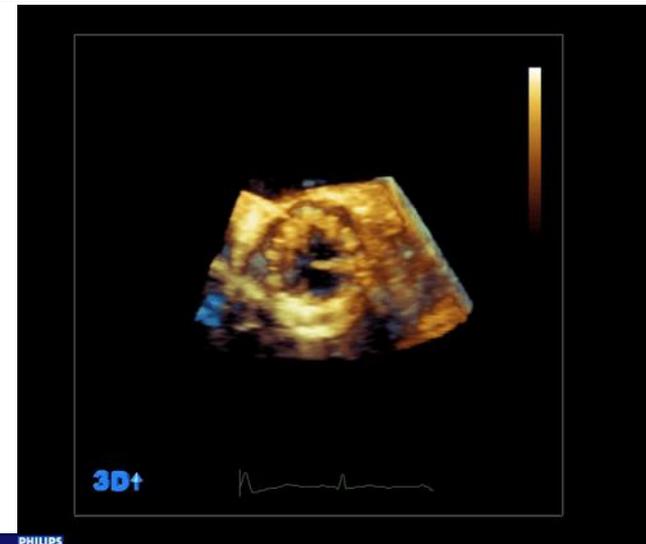
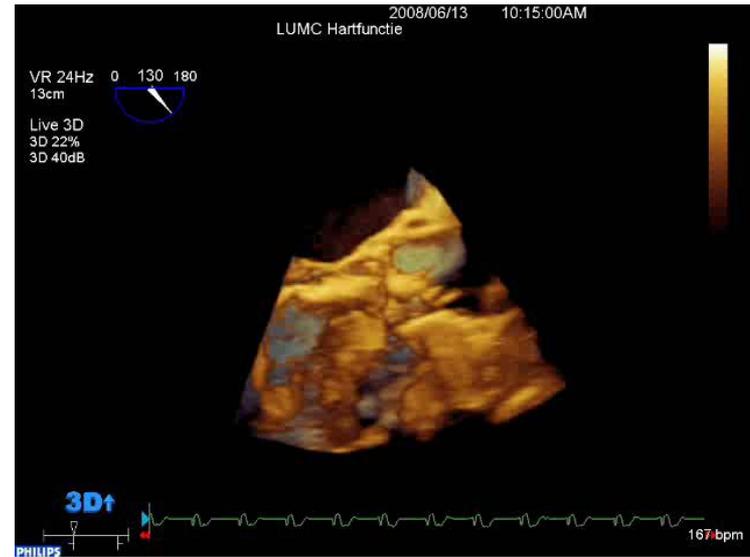
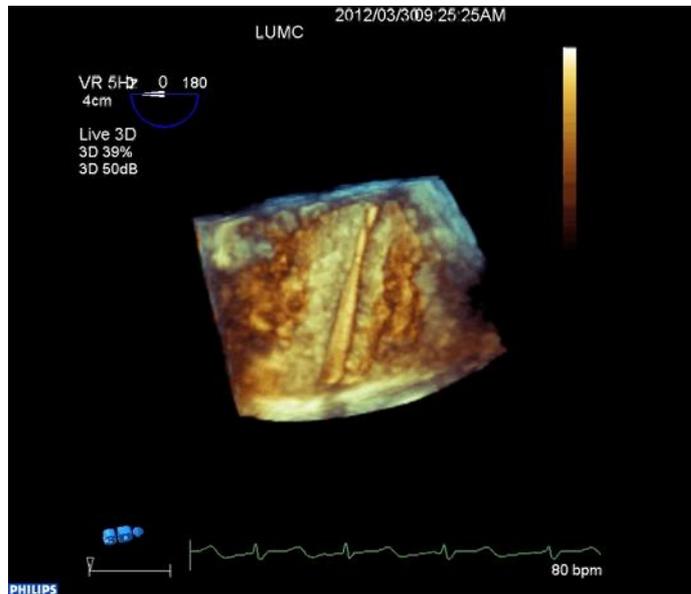
Variable	Improvement in LVEF		p Value
	Yes (n = 67)	No (n = 86)	
Global 3-dimensional longitudinal strain (%)	-16.7 ± 2.1	-13.3 ± 2.6	<0.001

Univariate and multivariate linear regression analyses for change in left ventricular ejection fraction at six-month follow-up

Dependent variable	Univariate		Multivariate	
	Beta	p Value	Beta	p Value
Change in left ventricular ejection fraction at 6-month follow-up				
Independent variables				
Age (years)	-0.082	0.317		
Gender	0.139	0.086	-0.016	0.823
Diabetes mellitus	0.017	0.830		
Left anterior descending coronary artery as infarct-related artery	-0.144	0.077	0.017	0.798
Multivessel coronary disease	-0.072	0.374		
Thrombolysis In Myocardial Infarction flow grade 3	0.129	0.113		
Peak troponin T ($\mu\text{g/L}$)	-0.444	<0.001	-0.216	0.003
Left ventricular end-diastolic volume (ml)	-0.138	0.088	-0.117	0.083
Left ventricular ejection fraction (%)	0.057	0.487		
Wall motion score index	-0.432	<0.001	0.084	0.365
Global 3-dimensional longitudinal strain (%)	-0.640	<0.001	-0.611	<0.001

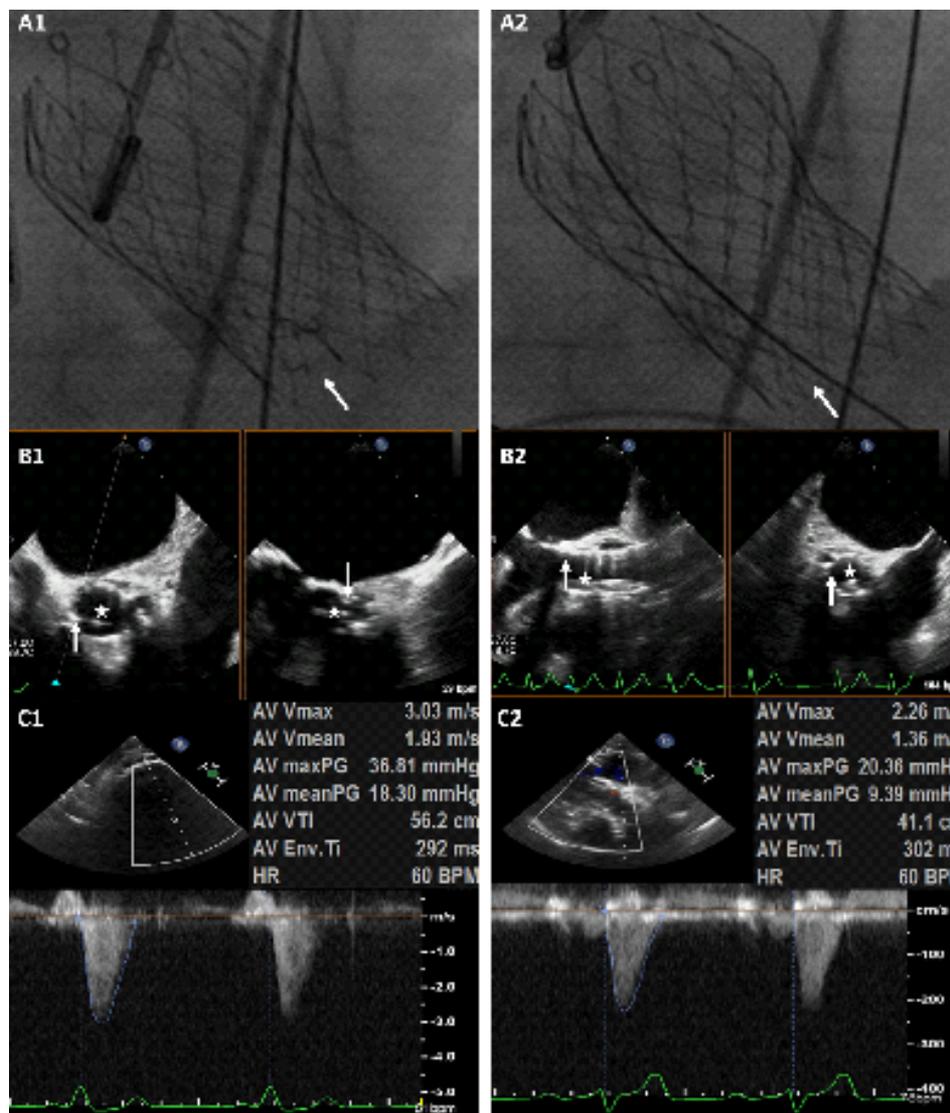
Interventional Echocardiography

in TAVR



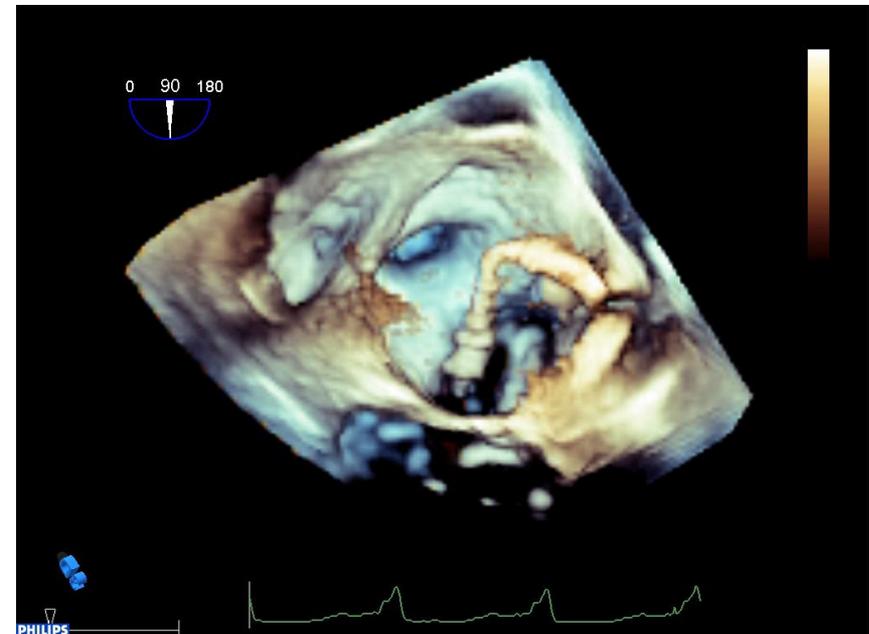
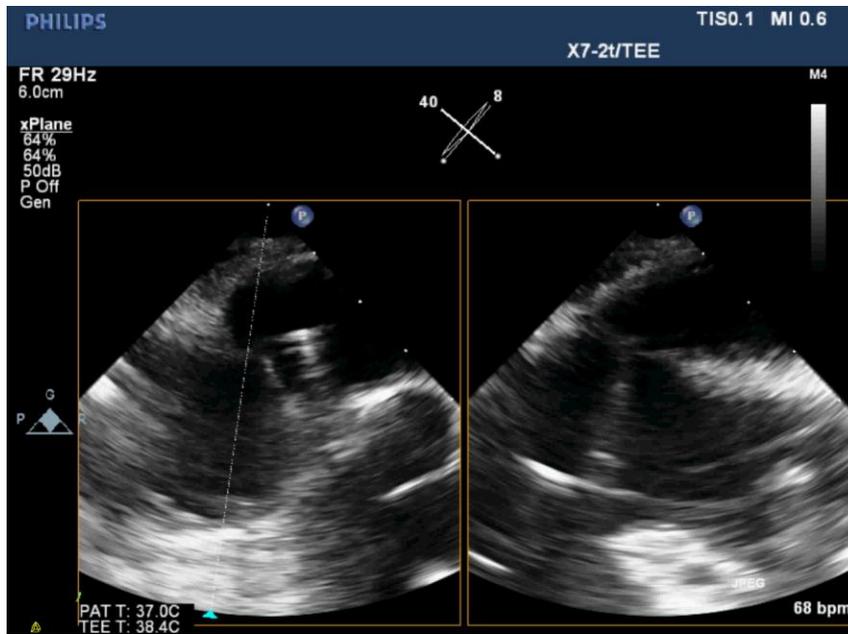
Interventional Echocardiography

in TAVR



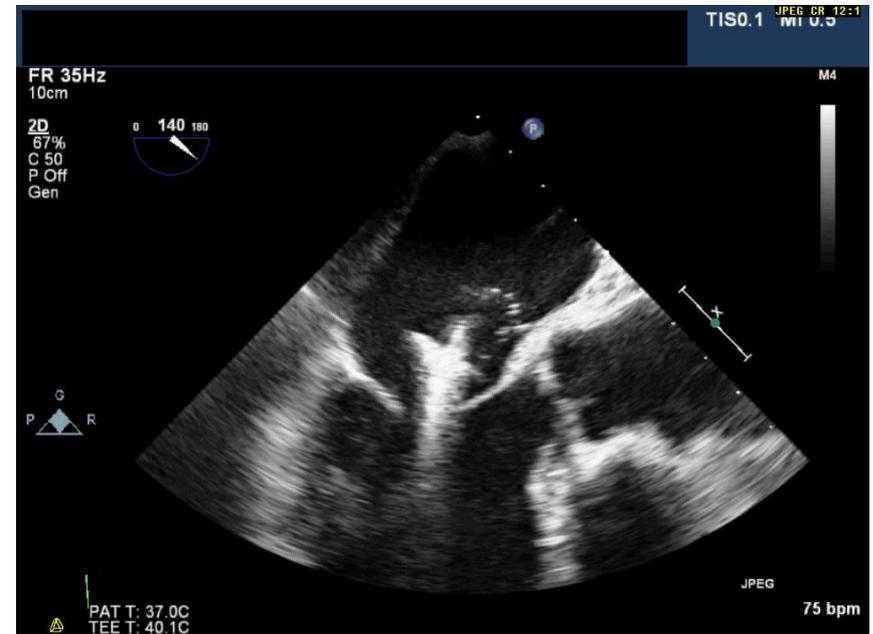
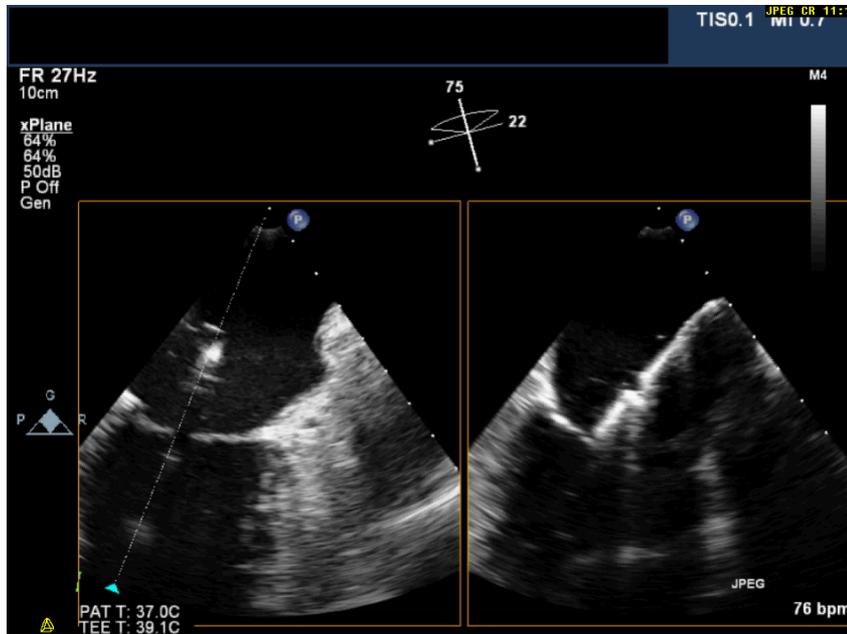
Interventional Echocardiography

in MitraClip



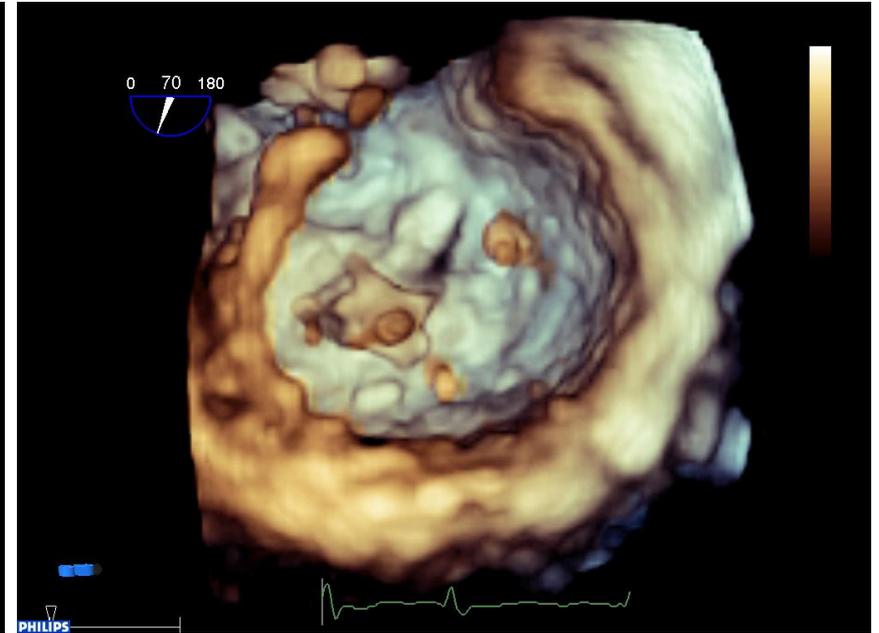
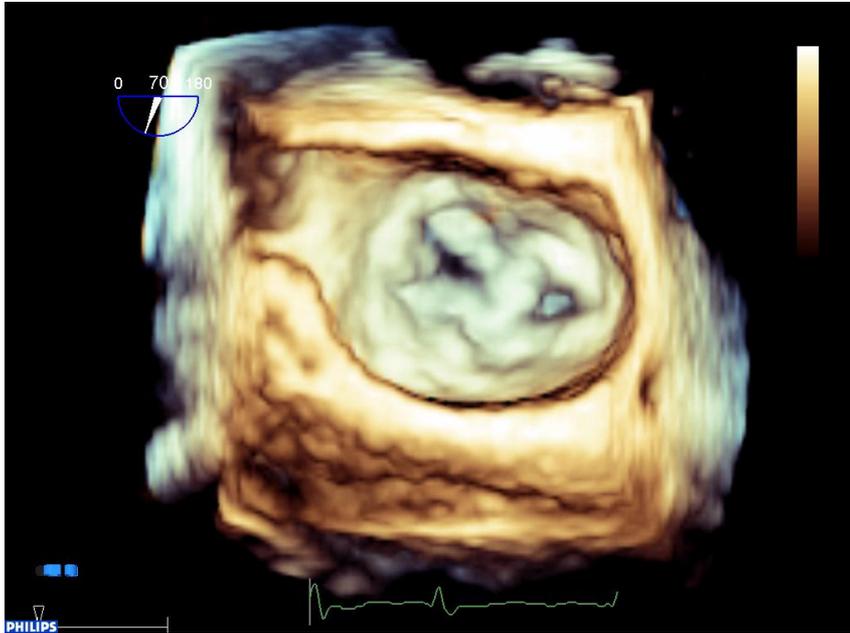
Interventional Echocardiography

in MitraClip



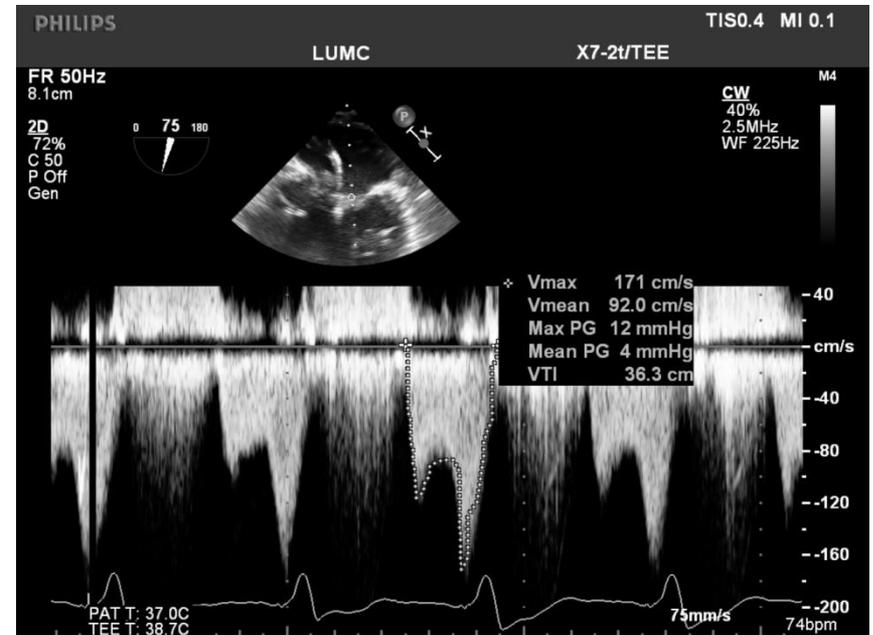
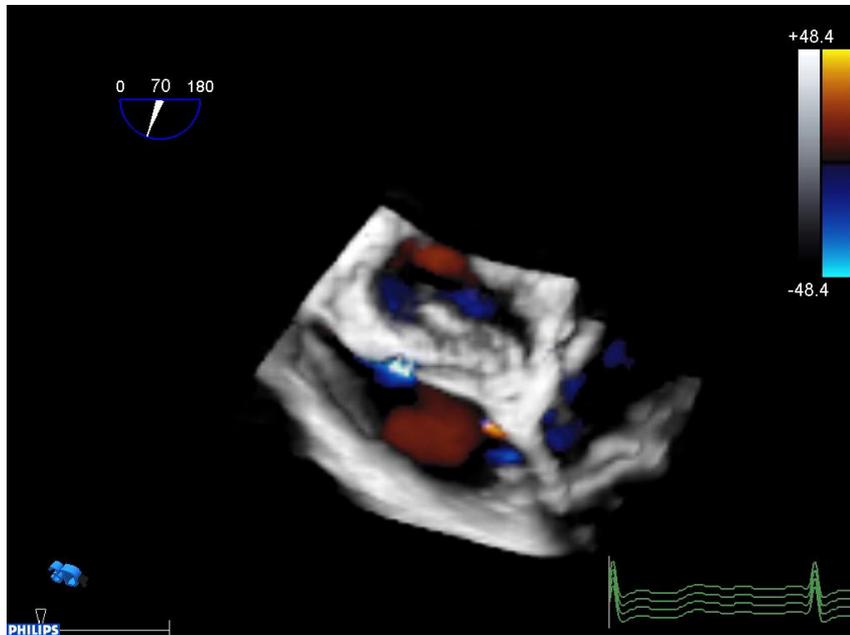
Interventional Echocardiography

in MitraClip



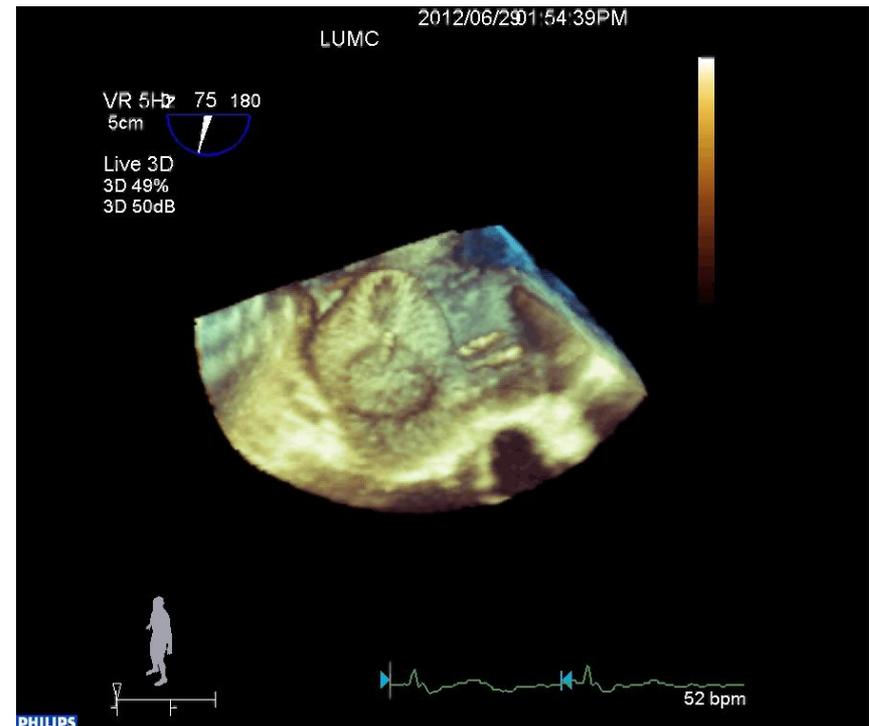
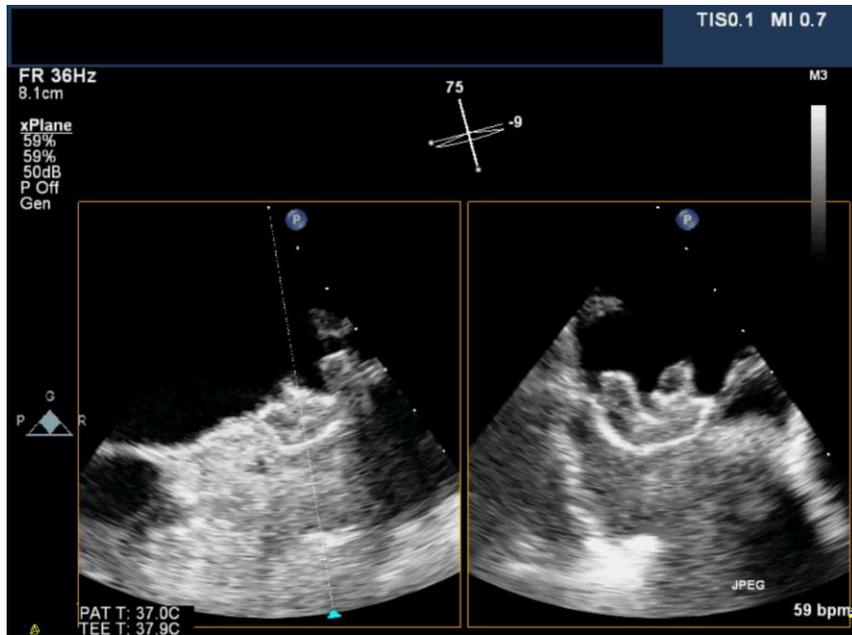
Interventional Echocardiography

in MitraClip



Interventional Echocardiography

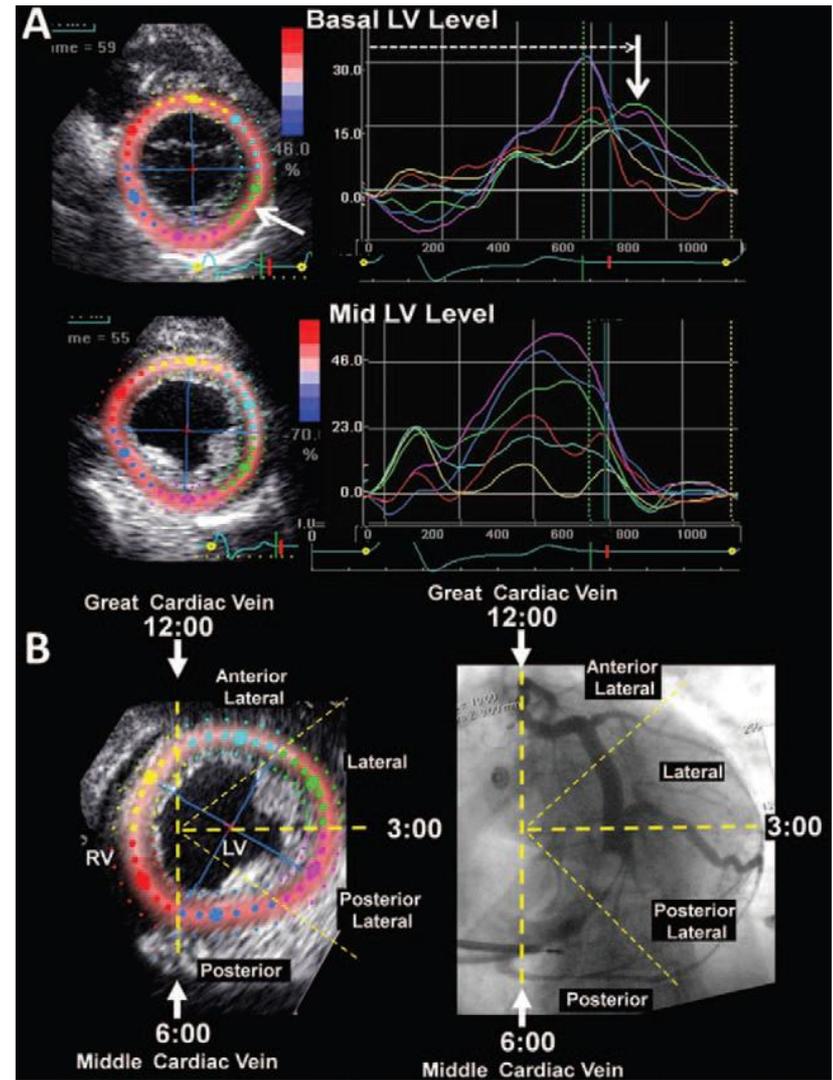
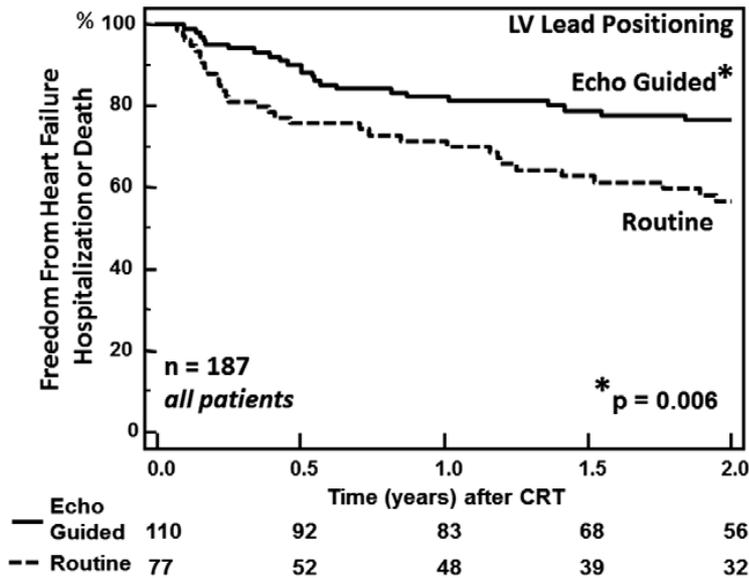
in LAA Closure



Echocardiography-Guided CRT

Echocardiography-Guided Left Ventricular Lead Placement

Results of the Speckle Tracking Assisted Resynchronization Therapy for Electrode Region Trial (STARTER)

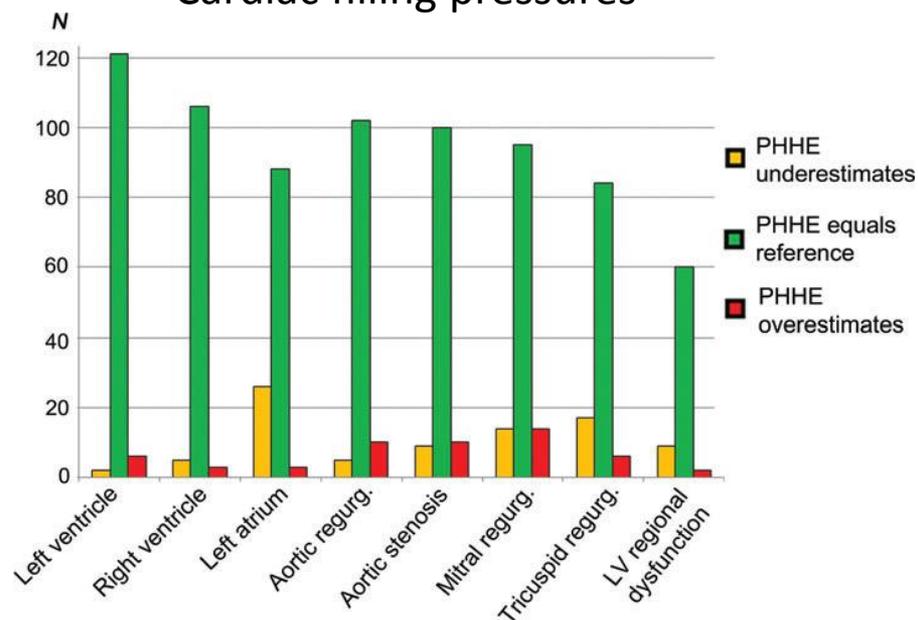


Hand Held Echo

examination to recognize a narrow list of potential diagnoses in specific clinical settings



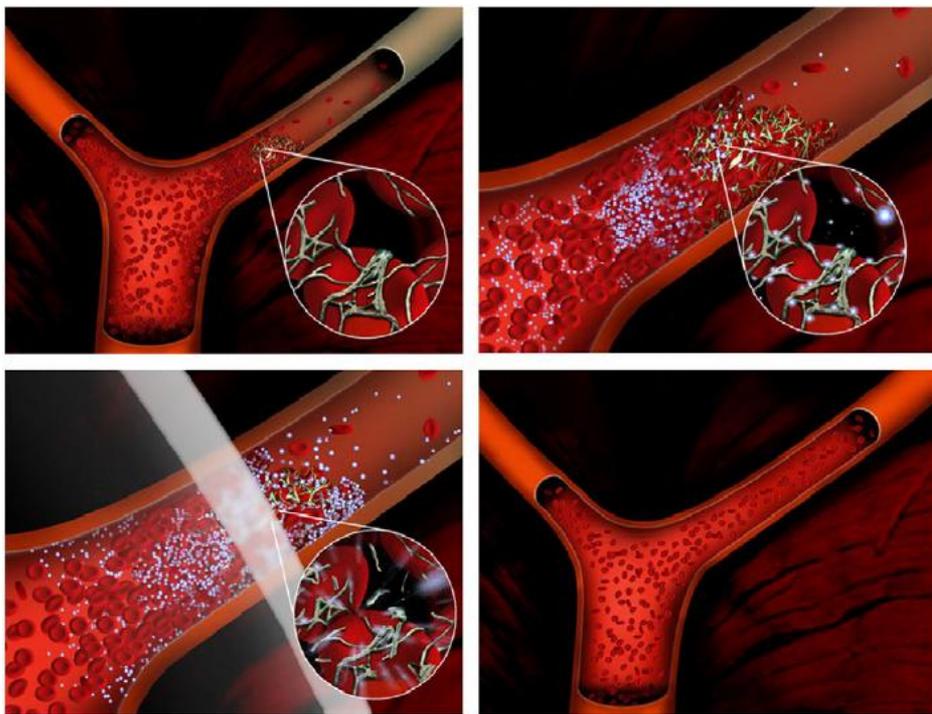
- LV size / LV systolic function
- LA size / LV hypertrophy
- Valvular lesions
- Pericardial disease
- RV size and function
- Cardiac filling pressures



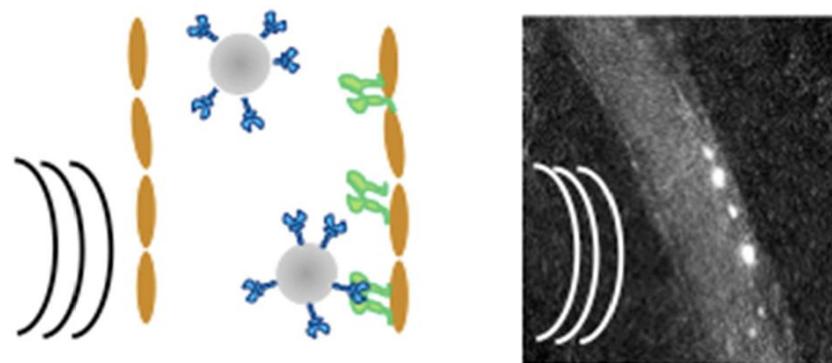
Future - Therapeutics

Targeted microbubbles have applications as molecular imaging contrast agents and also for drug and gene delivery

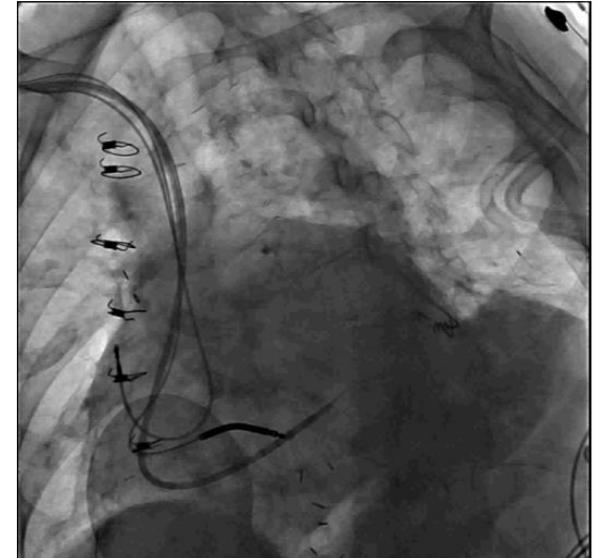
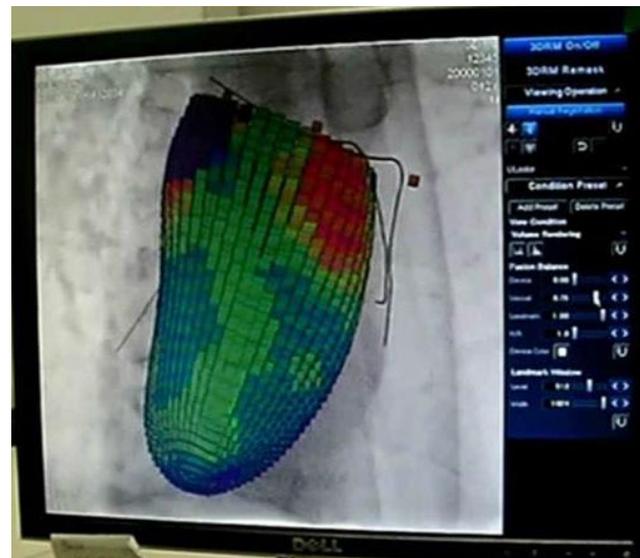
Cavitation for sonothrombolysis of occlusive clot



Radiation force for drug or gene delivery

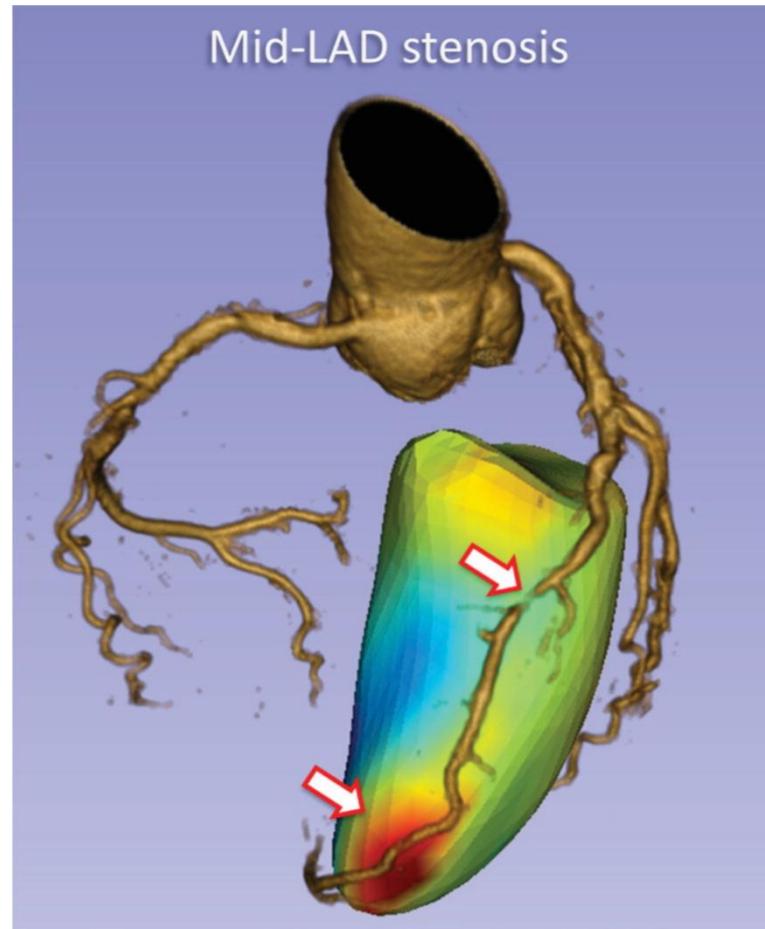


Future - Fusion



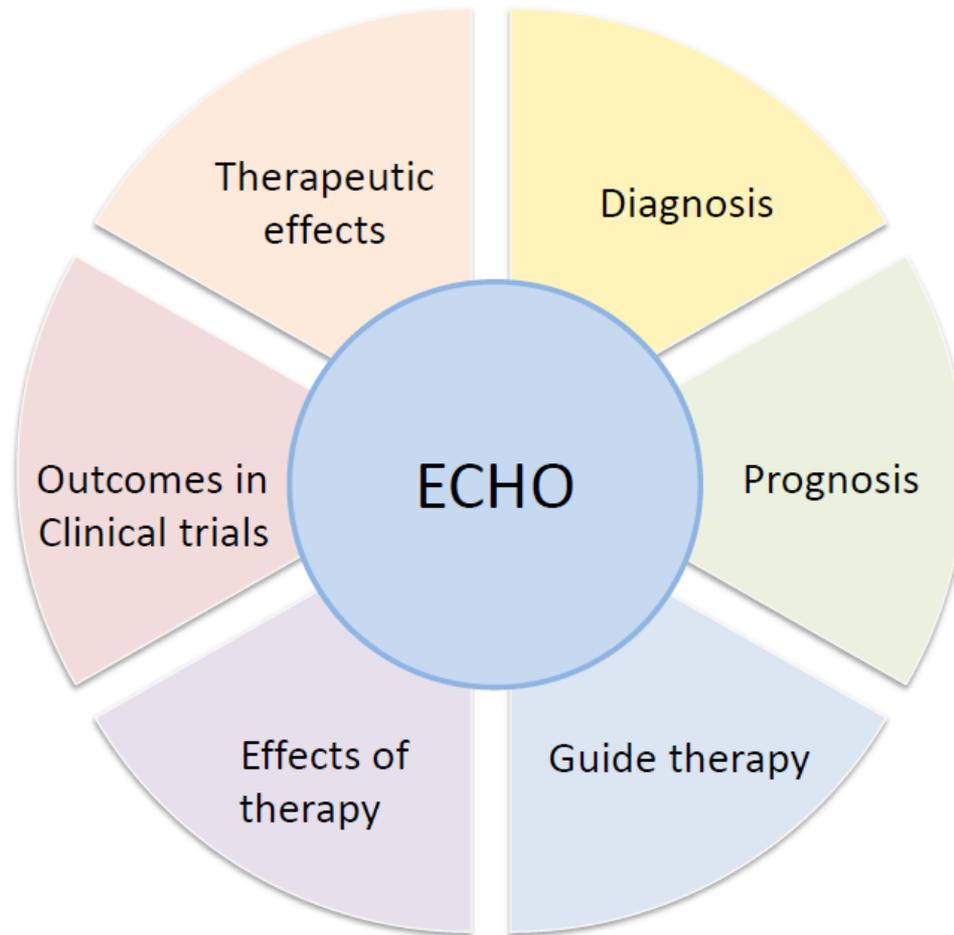
Future - Fusion

FUSION IMAGING OF COMPUTED TOMOGRAPHY AND 3D ECHOCARDIOGRAPHY



Conclusion

“Echocardiography at the Heart of Cardiology “ *Catherine Otto*



Ευχαριστώ