

3D-stress echocardiography



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No Disclosure



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Overview

- **2D stress echocardiography: main limitations**
- **3D echocardiography: potential incremental value**
- **Accuracy of 3D stress echocardiography**
- **Which modalities of 3D – echo during stress**
- **Which modalities of stress during 3D – echo**
- **Do we have to throw the baby out with the bath water ?**

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Main limitations of 2D-stress echo

- **Image quality during transthoracic scanning with insufficient visualization of left ventricle (LV) walls**
- **Probe positioning difficulties resulting in inadequate image planes**
- **Time-consuming serial acquisition of different image planes which has to be performed in a narrow time window during peak stress while wall motion abnormalities exist**
- **Data analysis: subjectivity of image interpretation still is the major problem, which leads to poor inter-observer agreement and causes a relevant examiner-dependency**

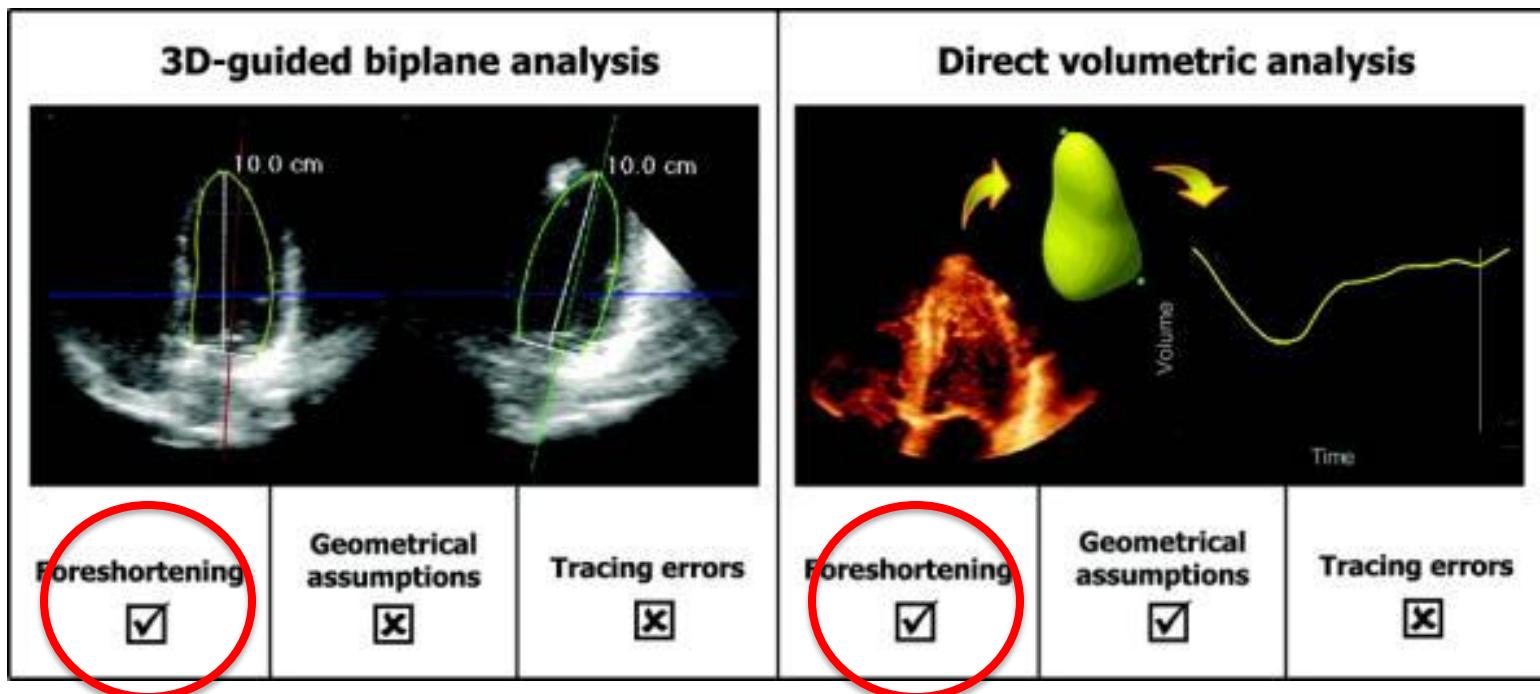
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3D echocardiography: incremental value

- **Avoid foreshortening**
- More accurate evaluation of LV volumes and LVEF
- Time saving for acquisition
- LV dyssynchrony 3D stress map contraction

3DE to avoid foreshortening: Reproducibility of the scan planes between stages

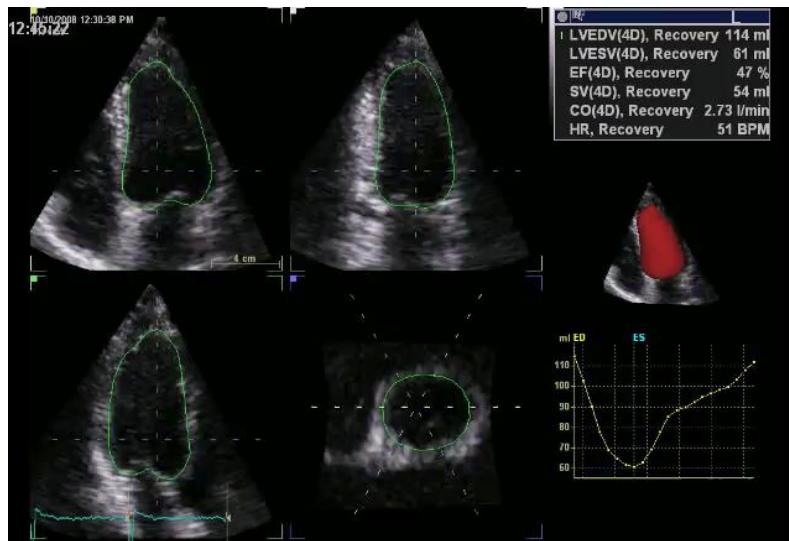


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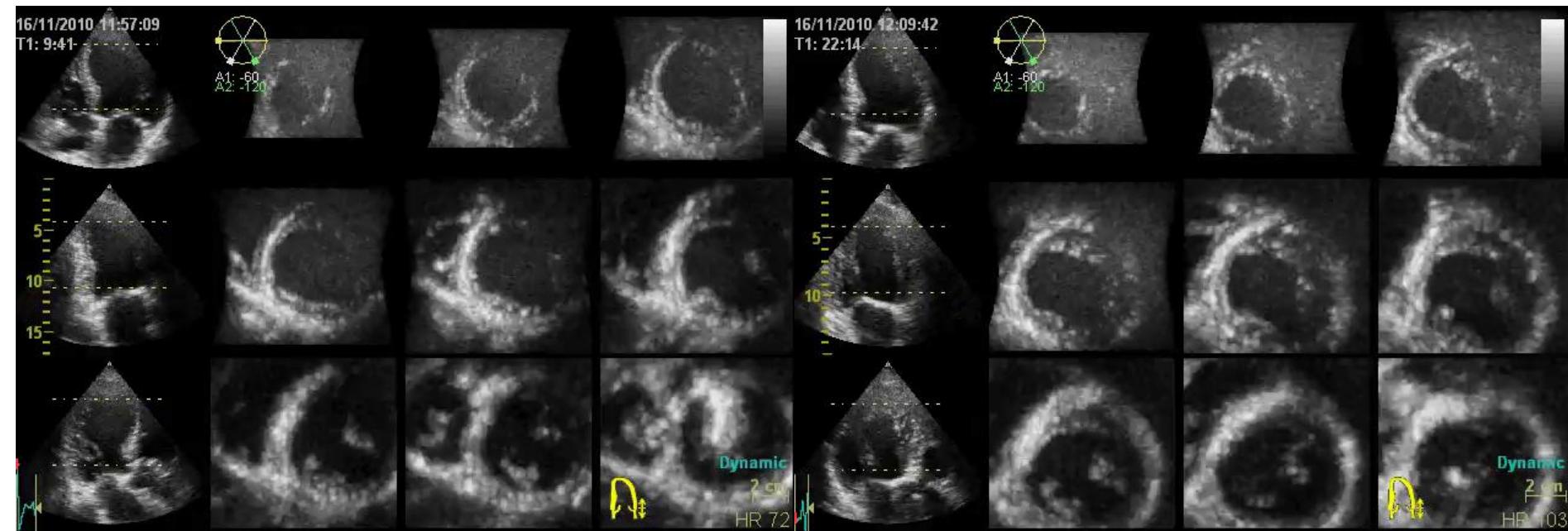
Evaluation of LV volumes and LVEF

**Changes in ejection fraction and ventricular volume
= stress-induced regional wall motion abnormalities for
diagnosis of the extent of coronary disease and predictive of
outcome**



Contractile reserve with 3DE

Wall motion and thickening

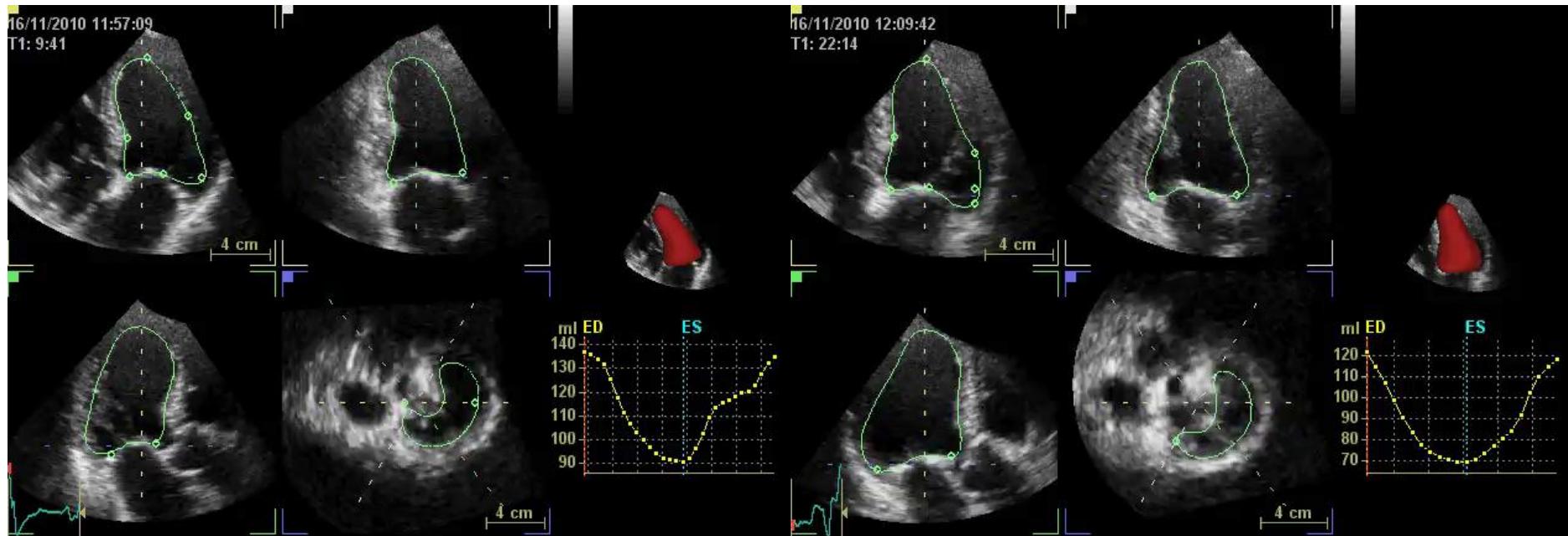


Rest

Low-dose dobutamine

Contractile reserve with 3DE

LV ejection fraction

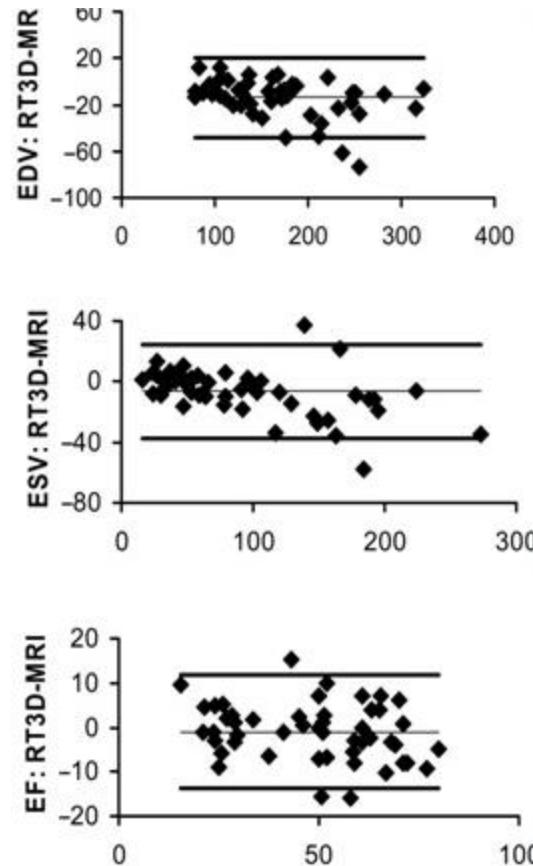
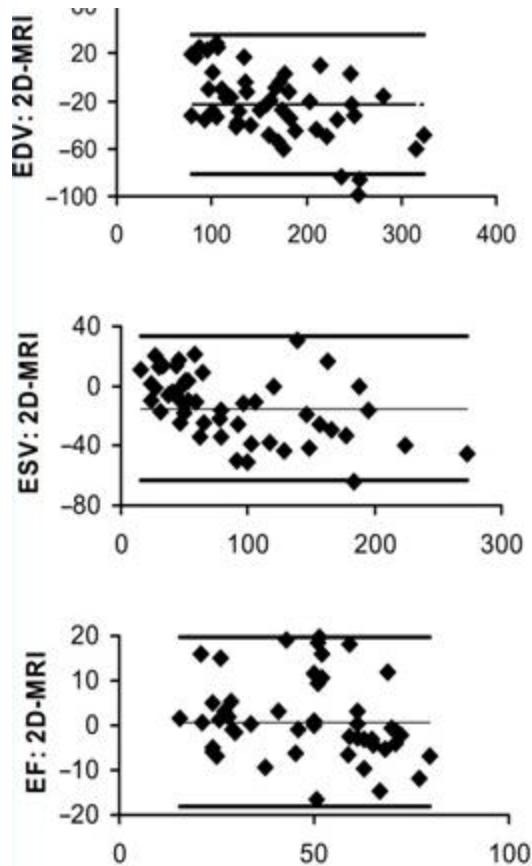


Rest

LV EF = 36%

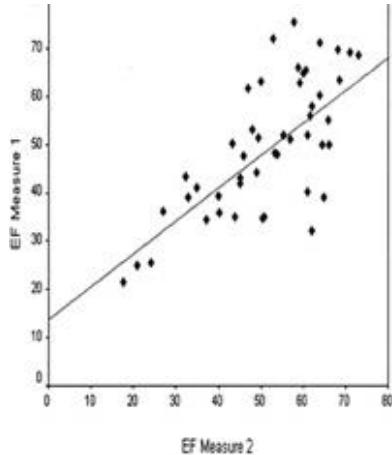
Need for accuracy and reproducibility

Agreement of 2D vs RT3D compared to MRI

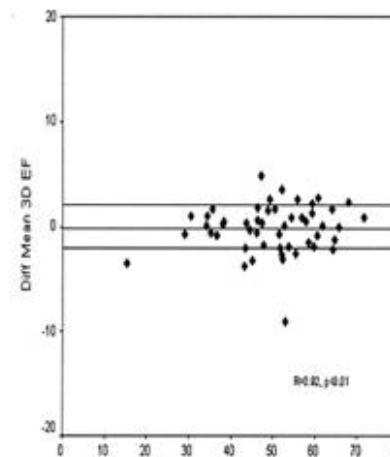
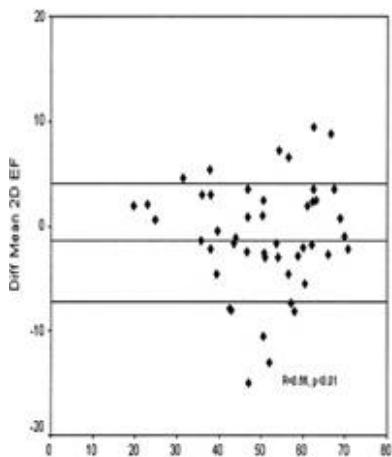
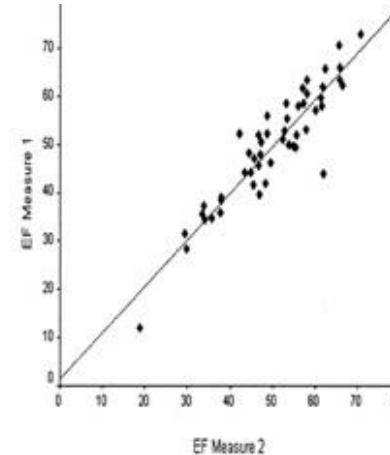


RT3D improves reproducibility

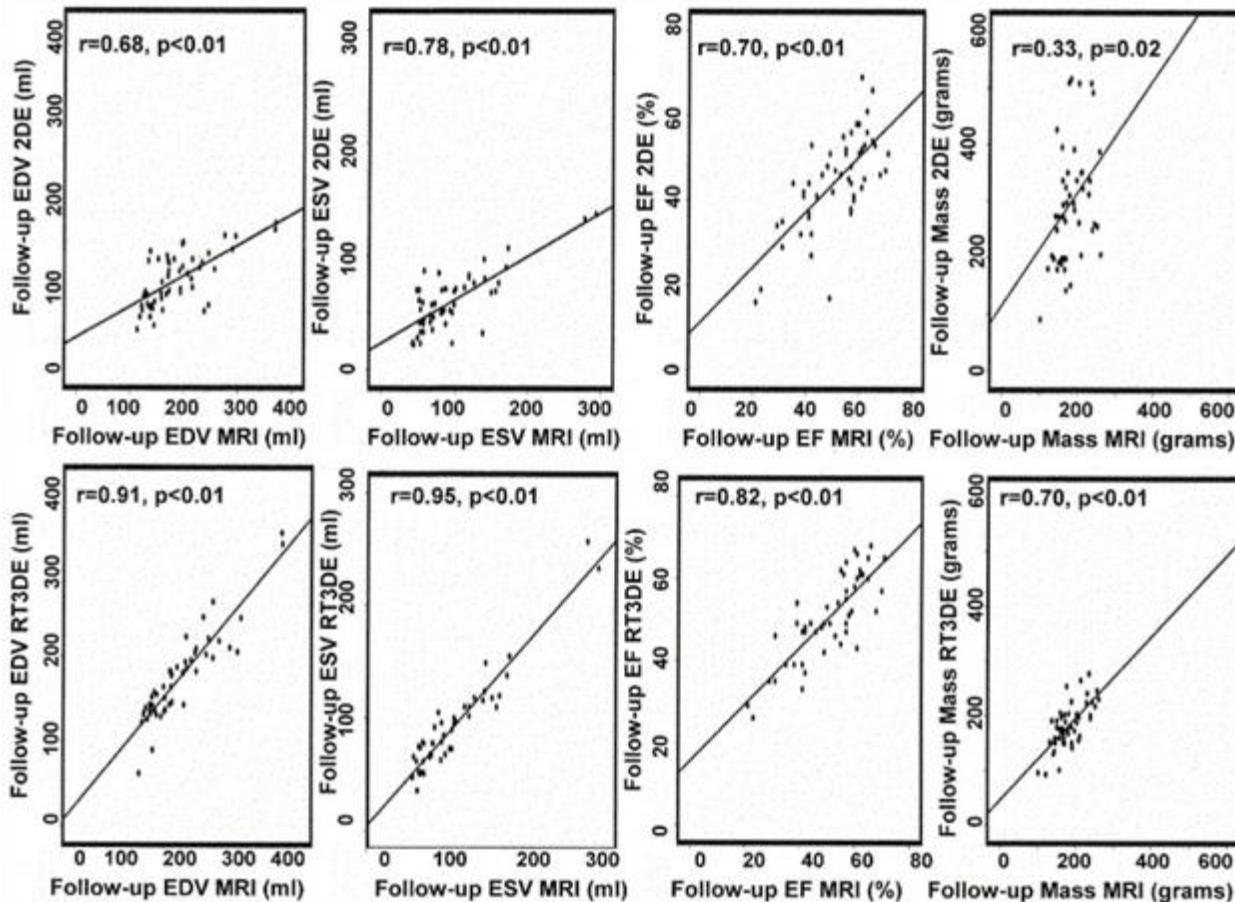
2D



3D



Reproducibility in serial fup (1y)



3D echocardiography: incremental value

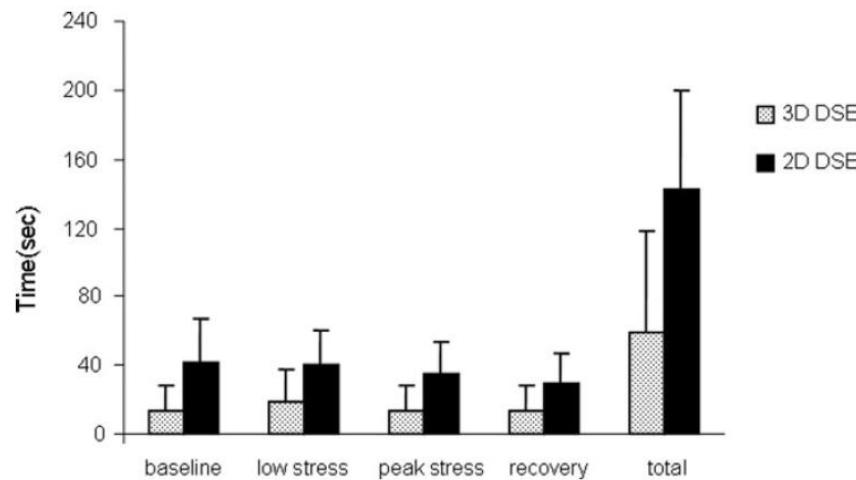
- Avoid foreshortening
- More accurate evaluation of LV volumes and LVEF
- Time saving for acquisition
- LV dyssynchrony 3D stress map contraction

Stress 3DE : Time saving

- No need to change the transducer position during apical scanning once the echo window is found
- Acquisition easier and faster for both the beginner and the expert echocardiographer
- The narrow time window at peak stress (especially in exercise stress echo) can be used much more effectively when acquiring two or even three image planes simultaneously

Stress 3DE : Acquisition Time Saving

- A shorter time needed for scanning at peak stress
- More complete monitoring (more segments can be observed on-line during stress testing)
- Also reduces the potential risk of prolonged myocardial ischaemia for the individual patient.

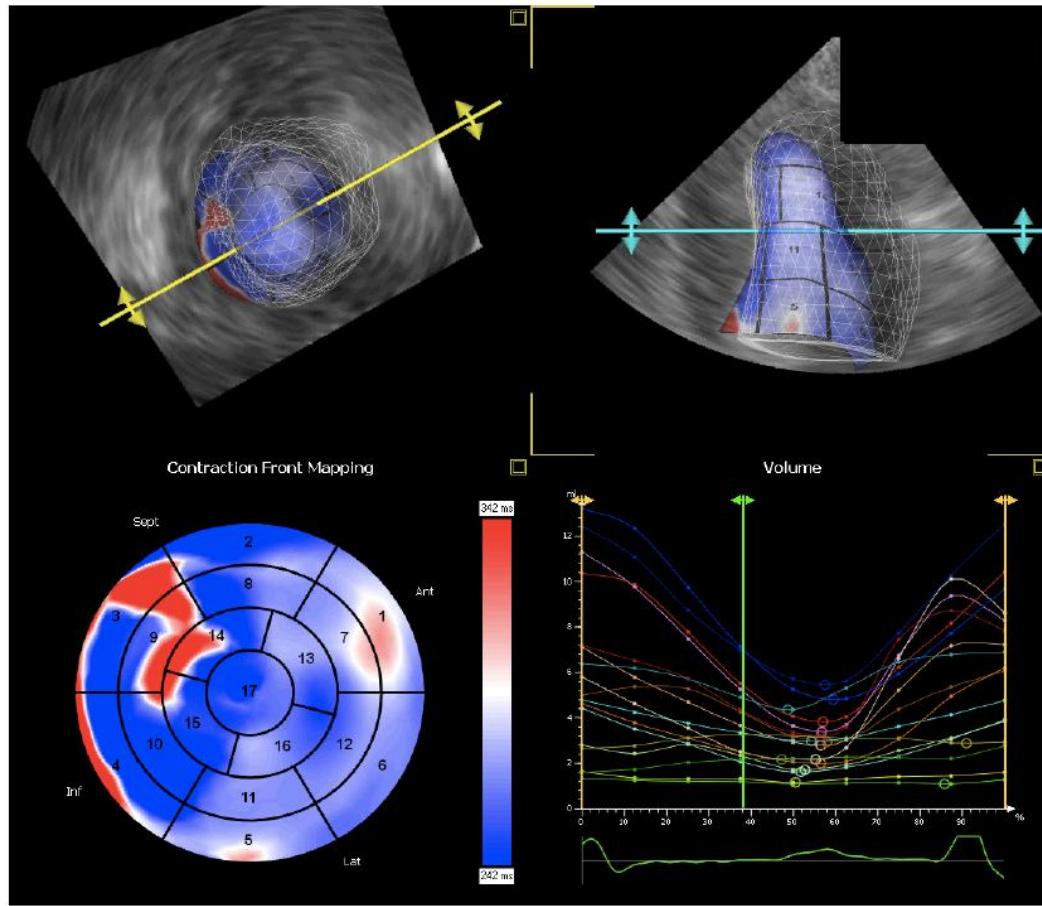


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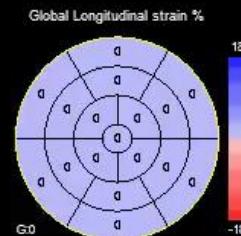
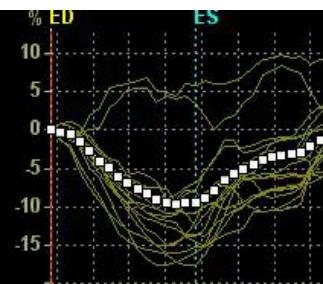
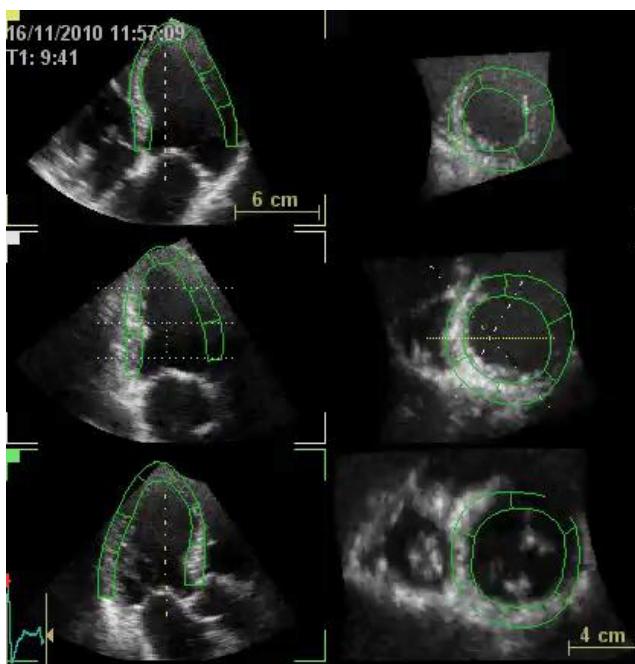
LV 3D – stress dynamic contraction map

Accurately localize and estimate the severity of stress-induced ischemia by identifying areas of delayed contraction

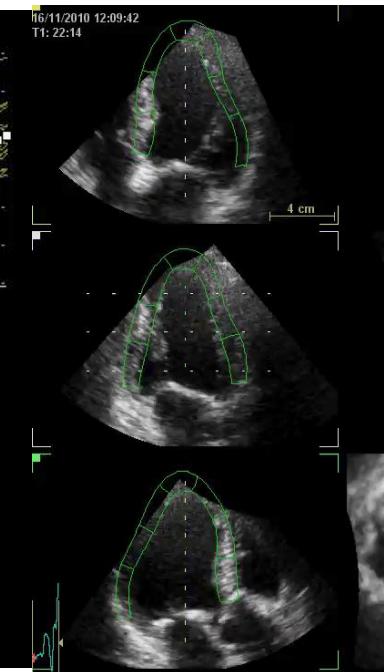


Contractile reserve with 3DE

Global longitudinal strain assessment



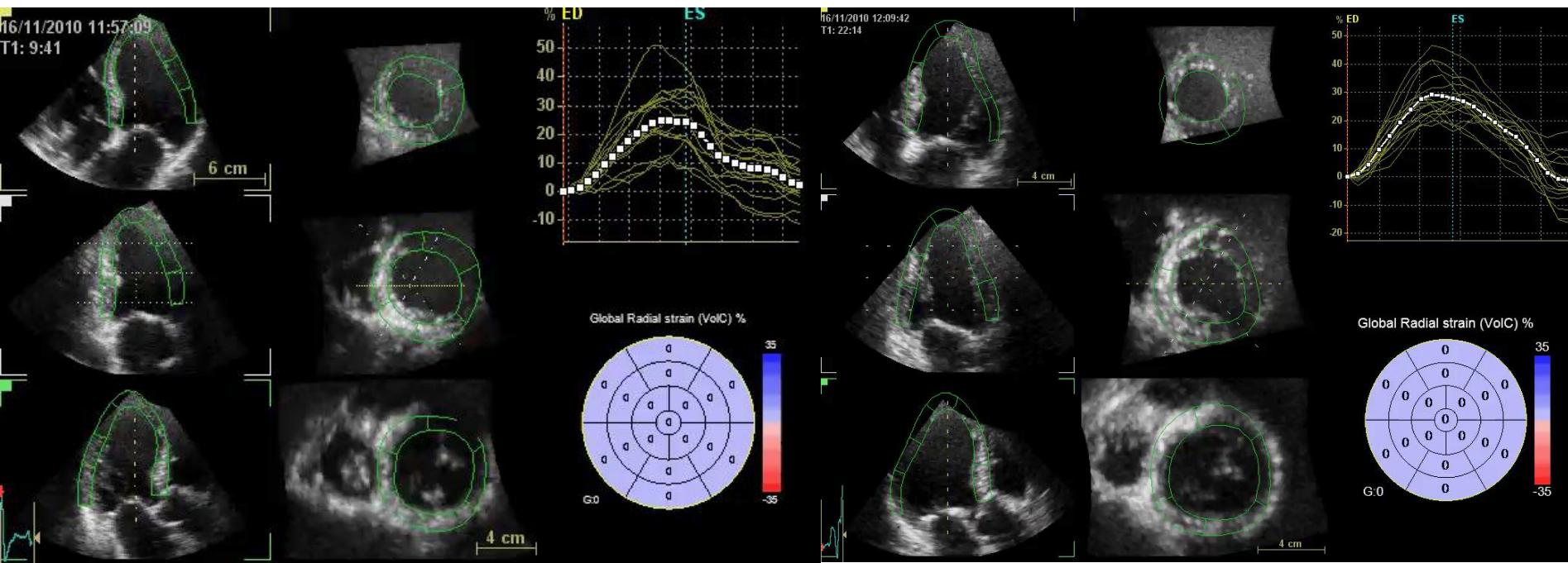
Rest GLS = - 10%



LDD GLS = - 12%

Contractile reserve with 3DE

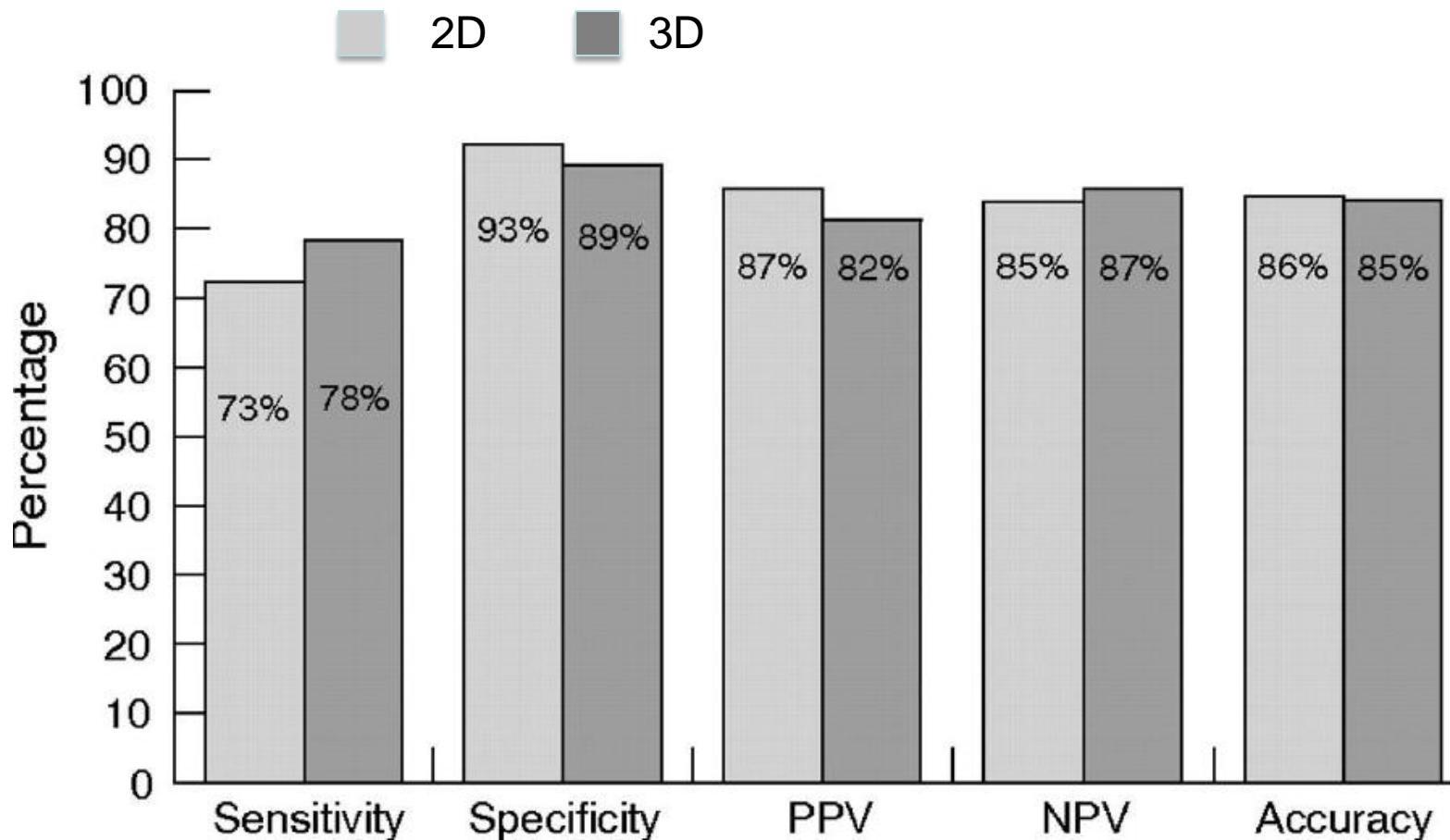
Global radial strain assessment



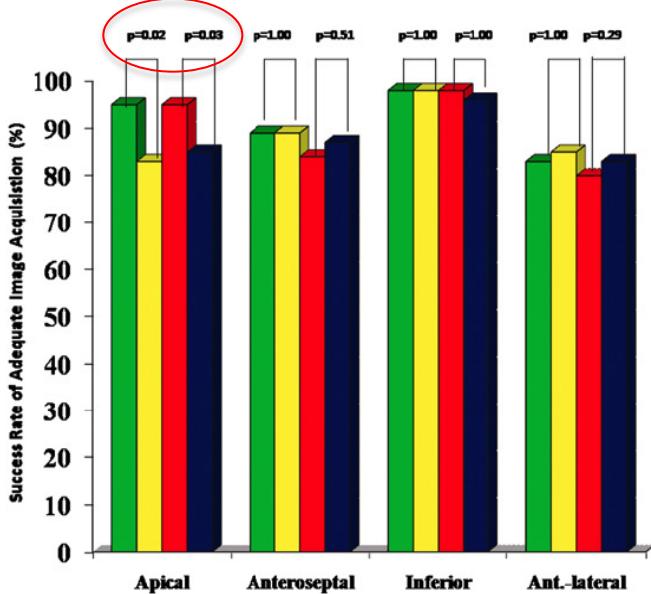
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Accuracy of 3D stress echocardiography

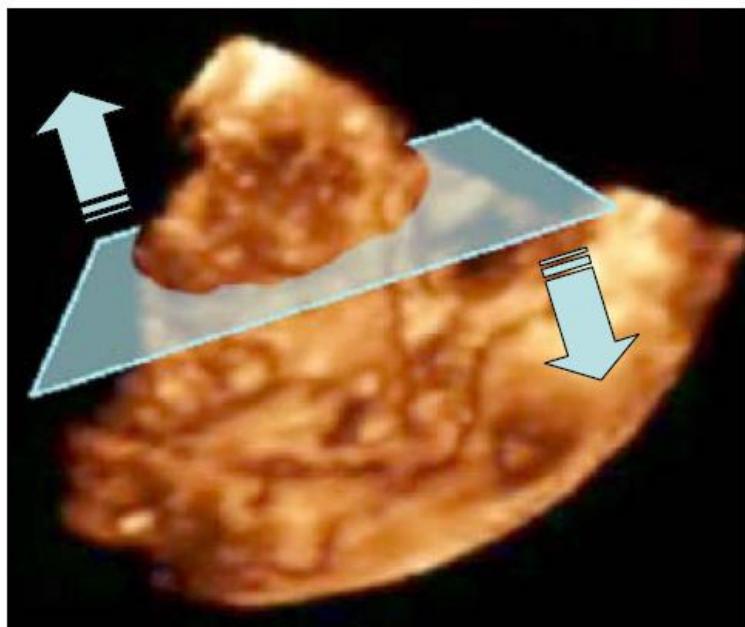


Accuracy of Dipyridamole-3DE

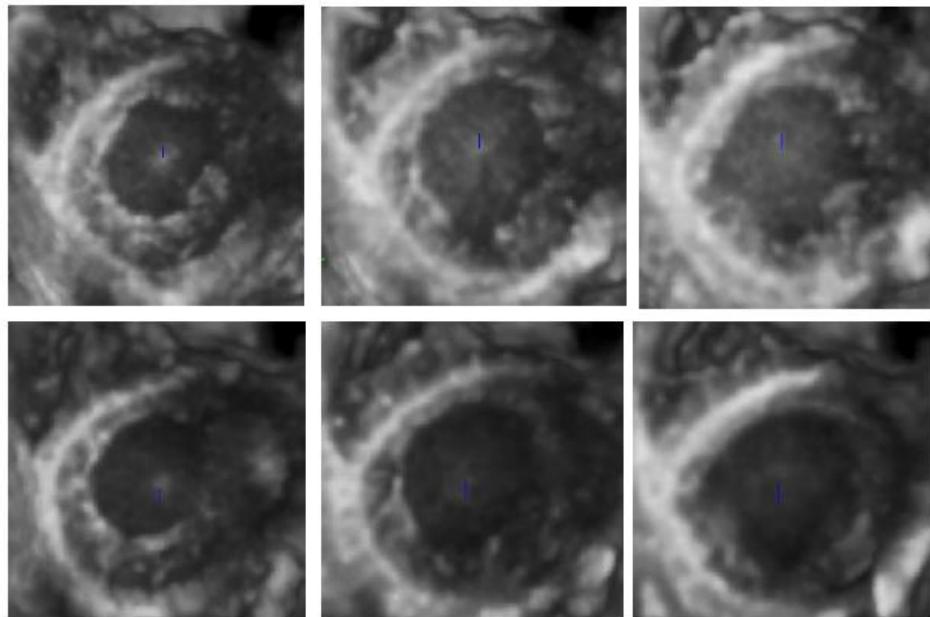


Coronary artery territory	Sensitivity (%)			Specificity (%)		
	3DE	2DE	P	3DE	2DE	P
All	80	78	NS	87	91	NS
Left anterior descending	87	78	.011	90	93	NS
Right	82	77	NS	85	88	NS
Left circumflex	65	63	NS	94	92	NS

Improved apical visualization

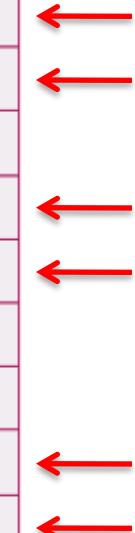


Peak stress Rest

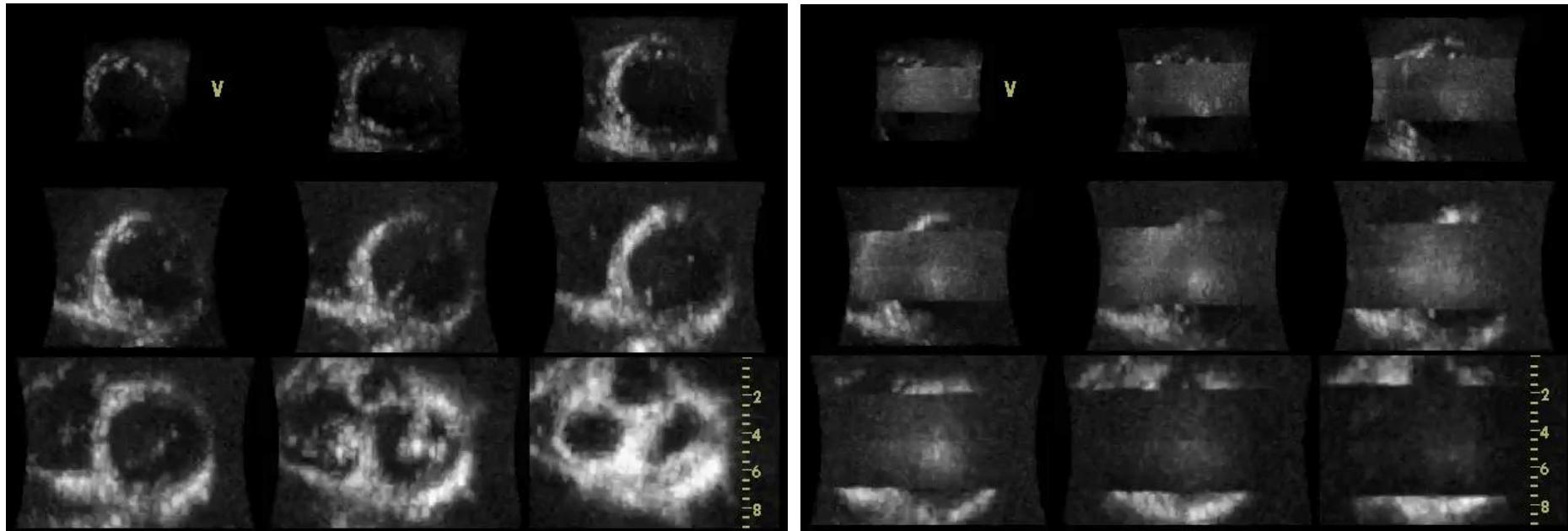


Accuracy of 3D Stress Echo

Study	No.	Stress	Validation	Sen.	Sp.	Sen.	Sp.
Ahmad, 2001	58	DSE	Coronary angiography	79	-	88	-
Matsumura, 2005	56	DSE	Thalium201-SPECT	86	83	86	80
Takeuchi, 2006	78	DSE	None	58	75		
Aggeli, 2007	56	DSE	Coronary angiography	73	78	93	89
Yoshitani, 2009	71	DSE-3D Multiplane	Coronary angiography	-	-	72	72
		DSE-3D Multislice	Coronary angiography	-	-	77	95
Jenkins, 2009	90	Treadmill exercise-2D	Coronary angiography	83	65		
		Treadmill exercise-3D	Coronary angiography	-	-	40	84
		Treadmill exercise-3D +CFM	Coronary angiography	-	-	55	78
Badano, 2010	107	Dipyridamole	None	78	91	80	87
Abdelmoneim, 2010	30	Adenosine 2D	Tc 99m Sestamibi SPECT	92	75	-	-
		Adenosine Live 3D	Tc 99m Sestamibi SPECT	-	-	91	69
		Adenosine Full volume 3D	Tc 99m Sestamibi SPECT	-	-	90	79



Real life - exercise 3DE

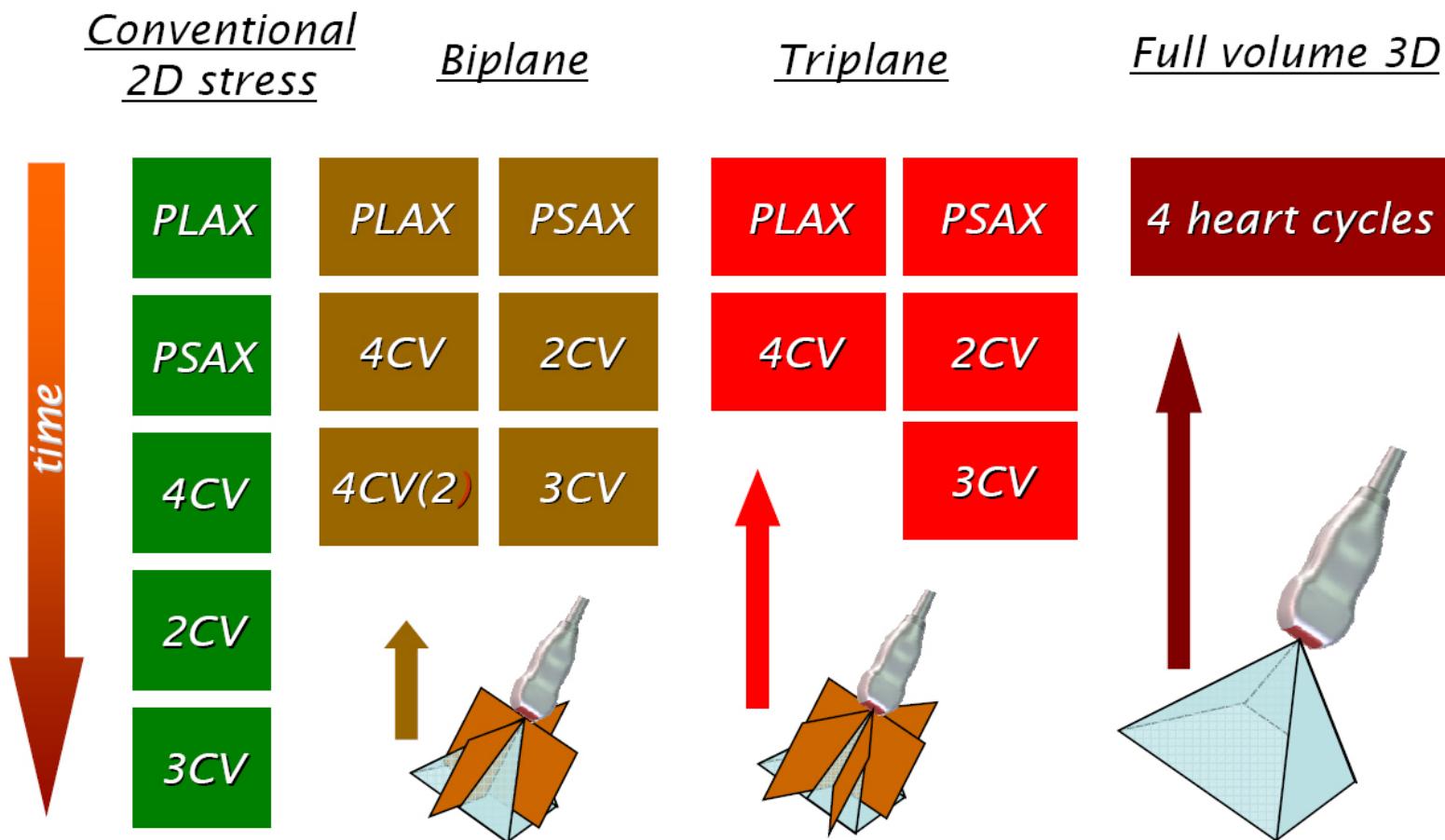


Breath holding during stress

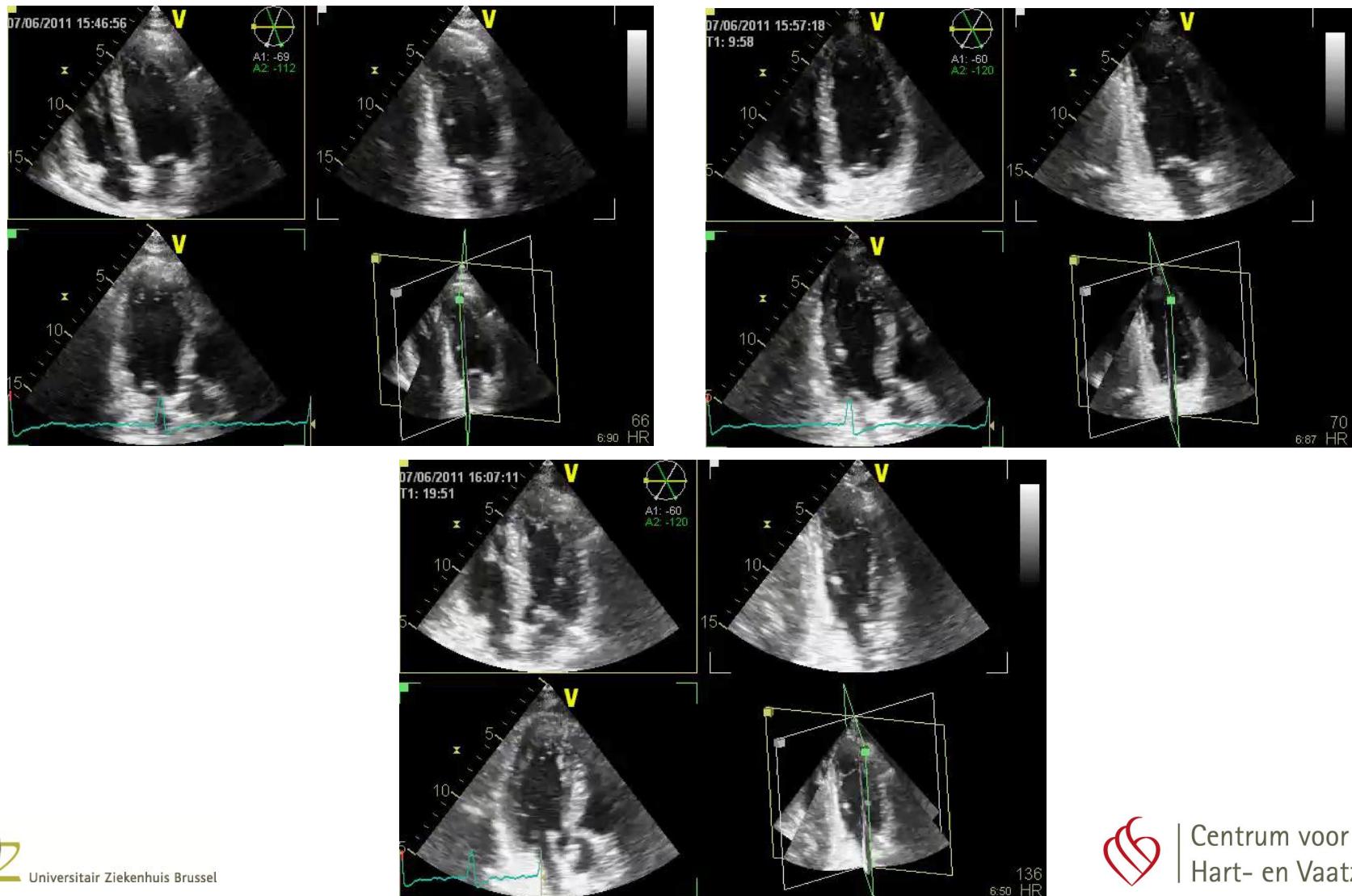
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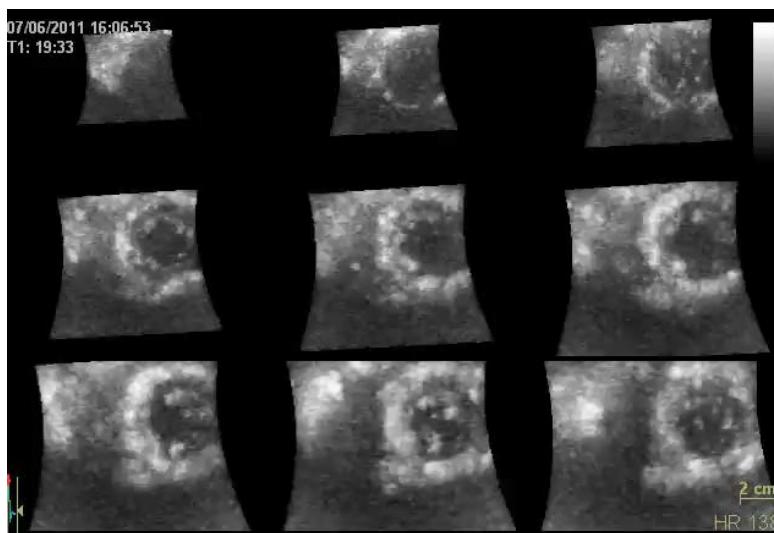
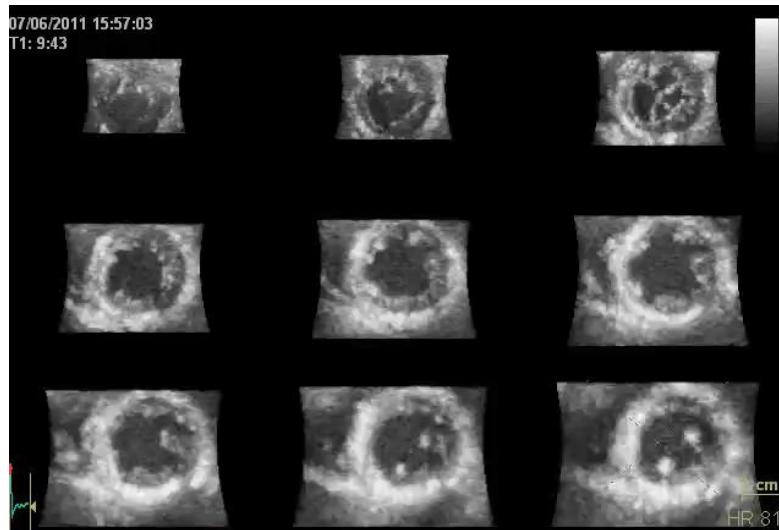
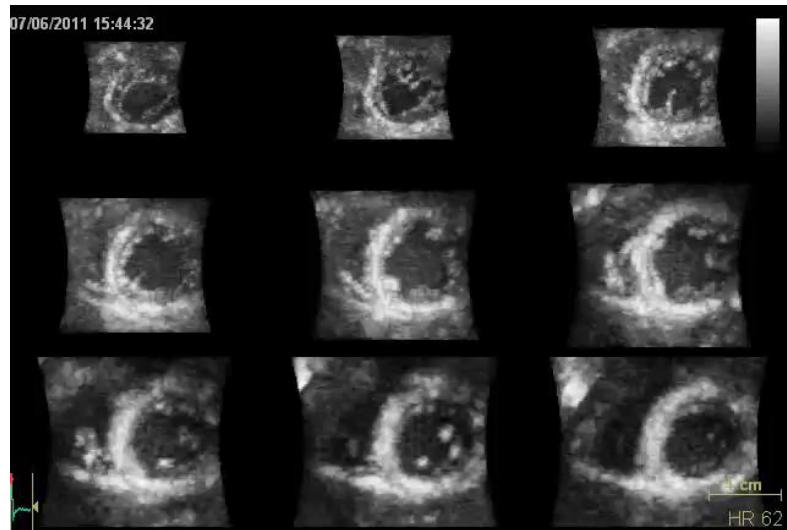
Modalities of 3D echo during stress



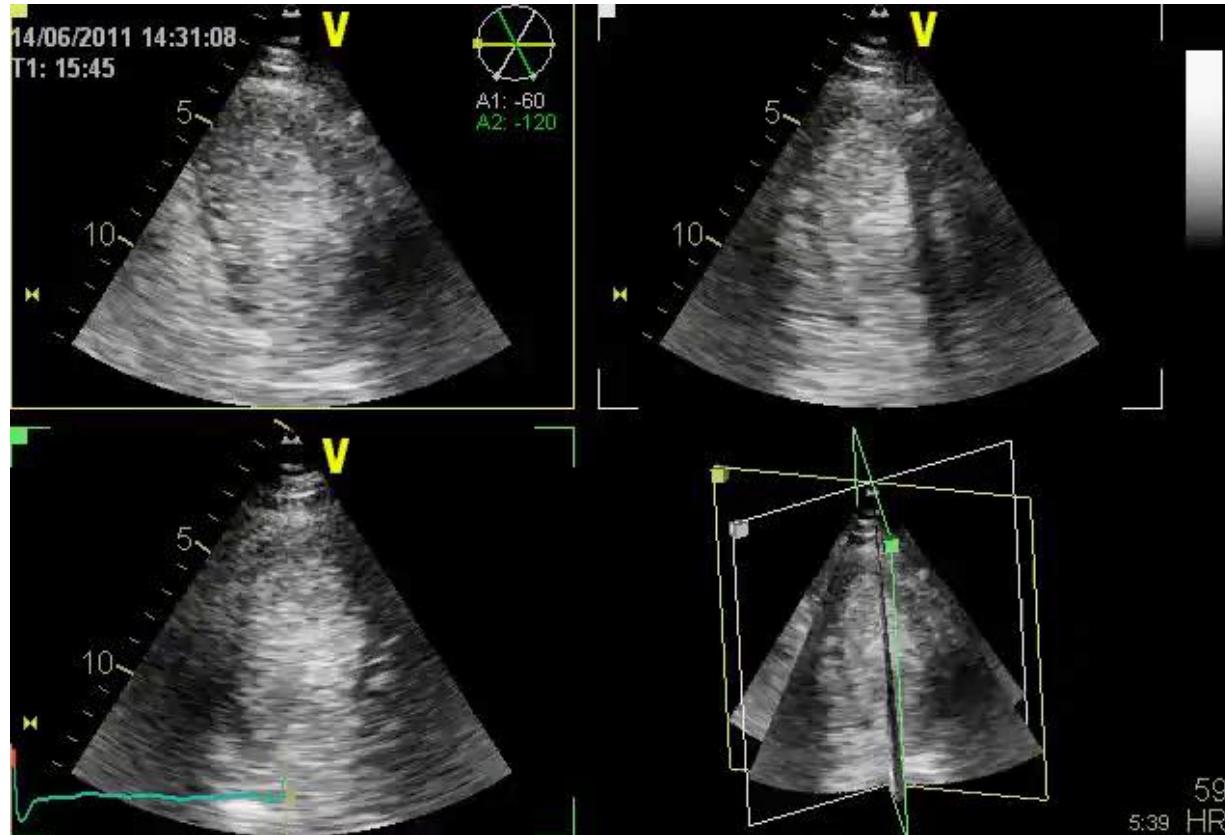
Tri-plane 3D stress echo



Full 3D - stress echo

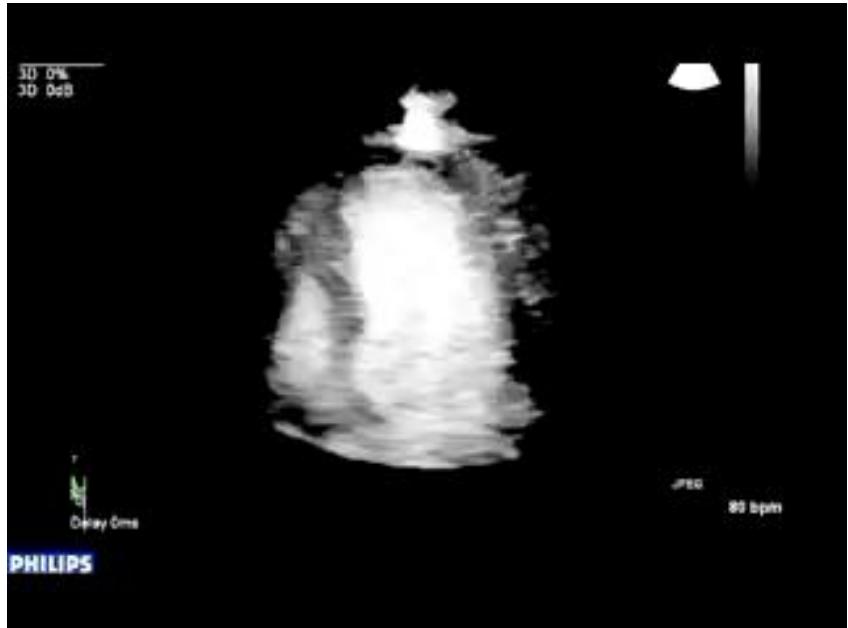


Contrast 3D stress echo



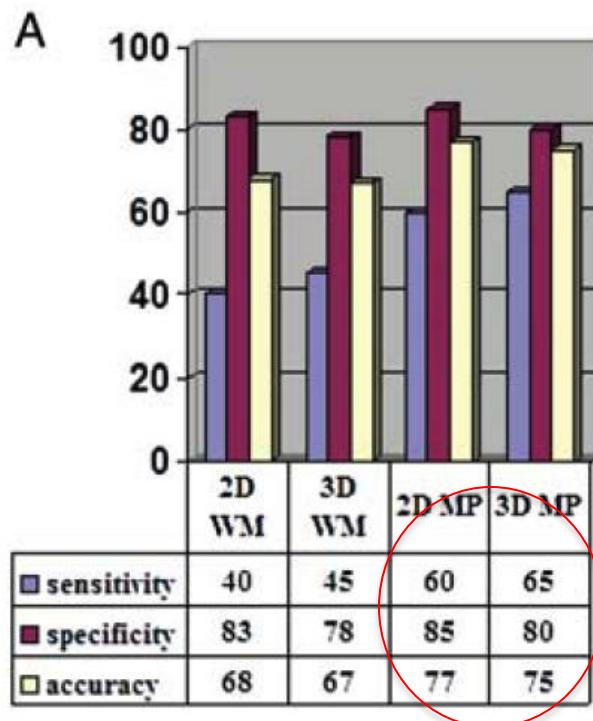
Contrast perfusion 3D stress echo

- Is feasible
- Low spatial resolution
- Lower frame rate (volume rate)
- No “flash destruction of bubbles”
- Only adenosine (lower heart rates)

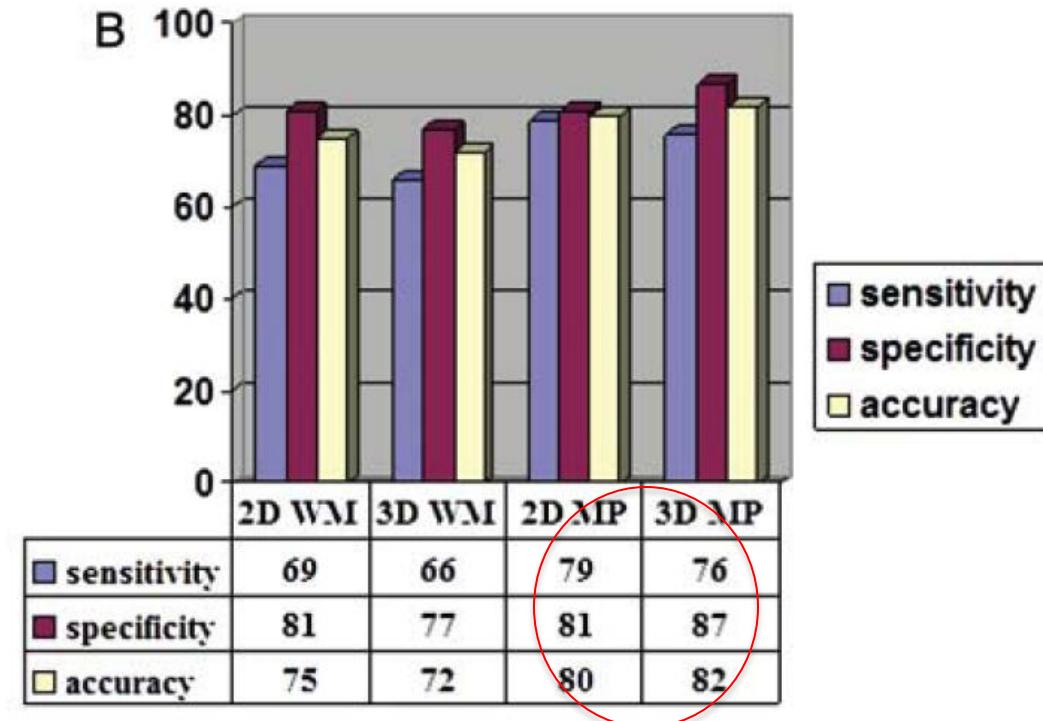


Courtesy of I. Felekos

Perfusion Contrast 3D stress echo

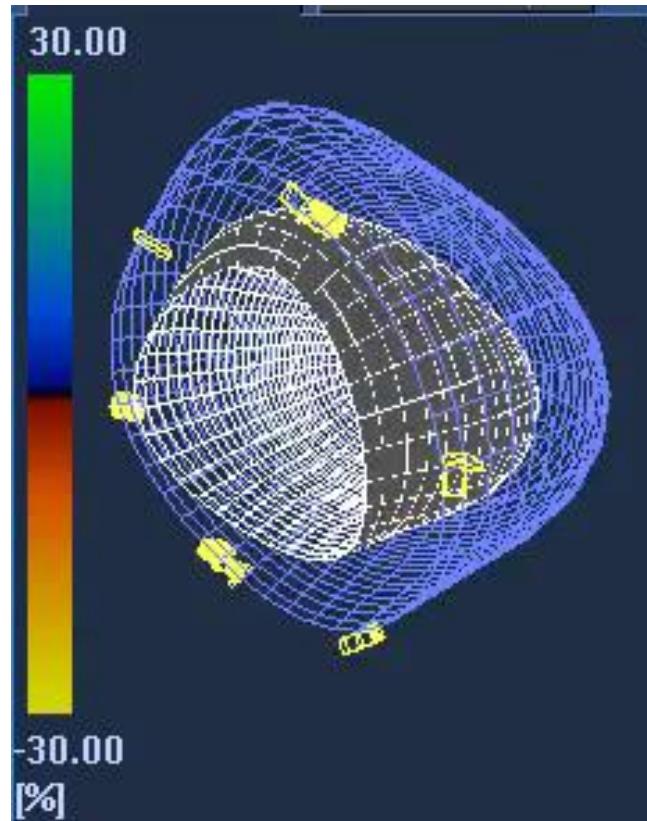
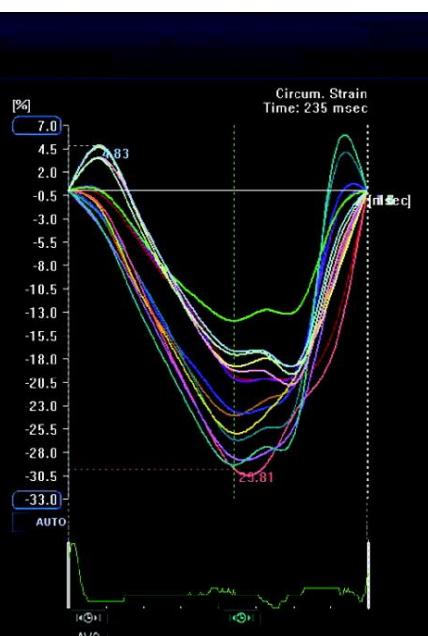
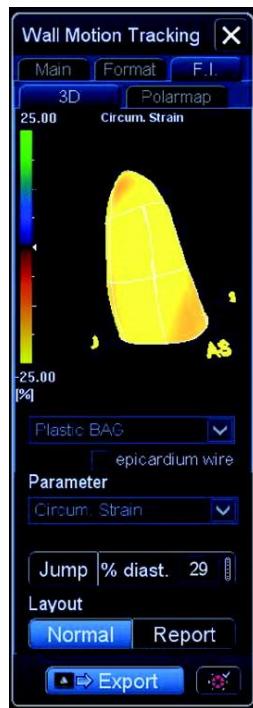


SVD

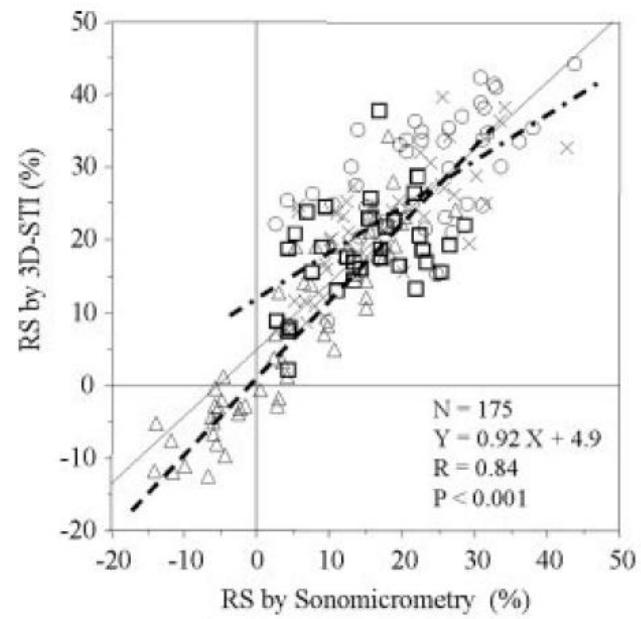
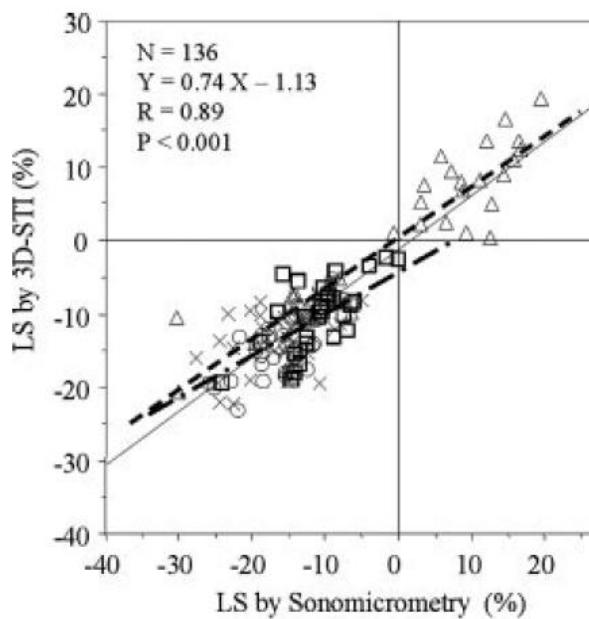
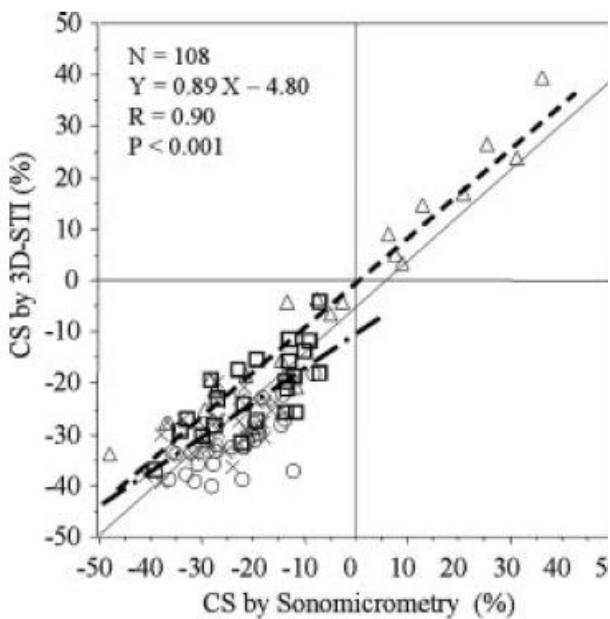


MVD

3D stress STI



3D stress STI vs Sonomicrometry

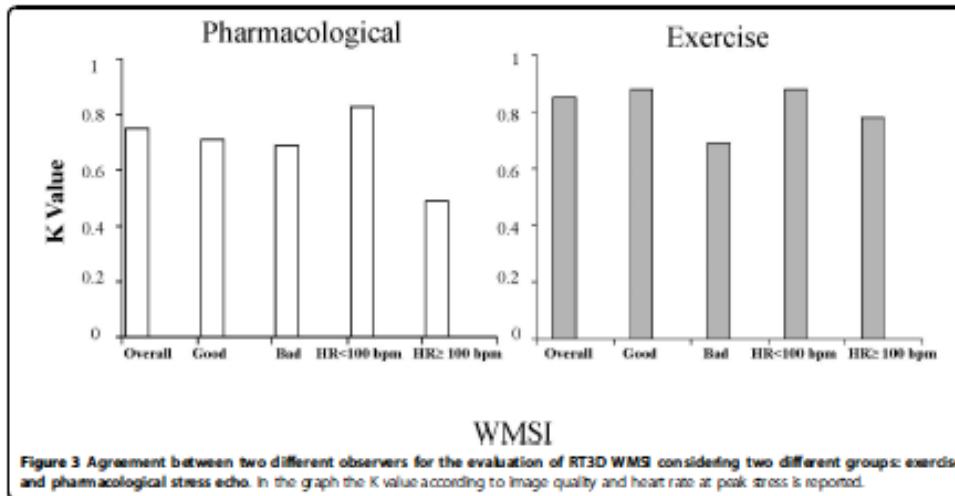
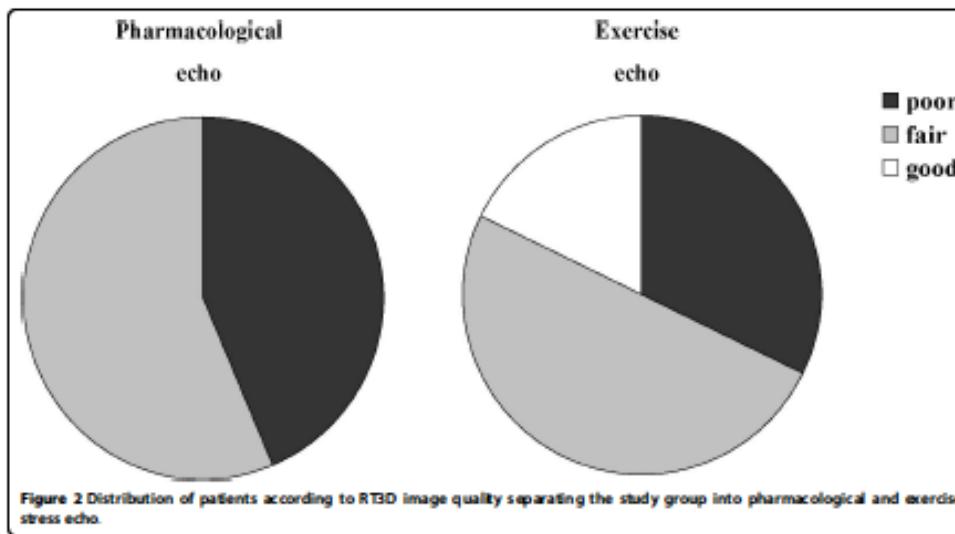


X = dobutamine infusion

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Which Stress ?



Stress 3D- Echocardiography

- **Advantages**

- 1) better visualization of the LV apex, which is frequently foreshortened on standard 2DE apical images
- 2) rapid acquisition of peak stress images before the heart rate declines in recovery
- 3) evaluation of multiple segments from different planes from a single dataset.

- **Disadvantages**

- 1) lower spatial resolution
- 2) lower frame rates (tardokinesia can be missed)
- 3) Learning curve required
- 4) Automated algorythms not yet validated during stress

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Do we have to throw the baby out with the bath water ?



European Journal of Echocardiography (2008) 9, 415–437
doi:10.1093/ejechocard/jen175

EAE GUIDELINES

Stress echocardiography expert consensus statement

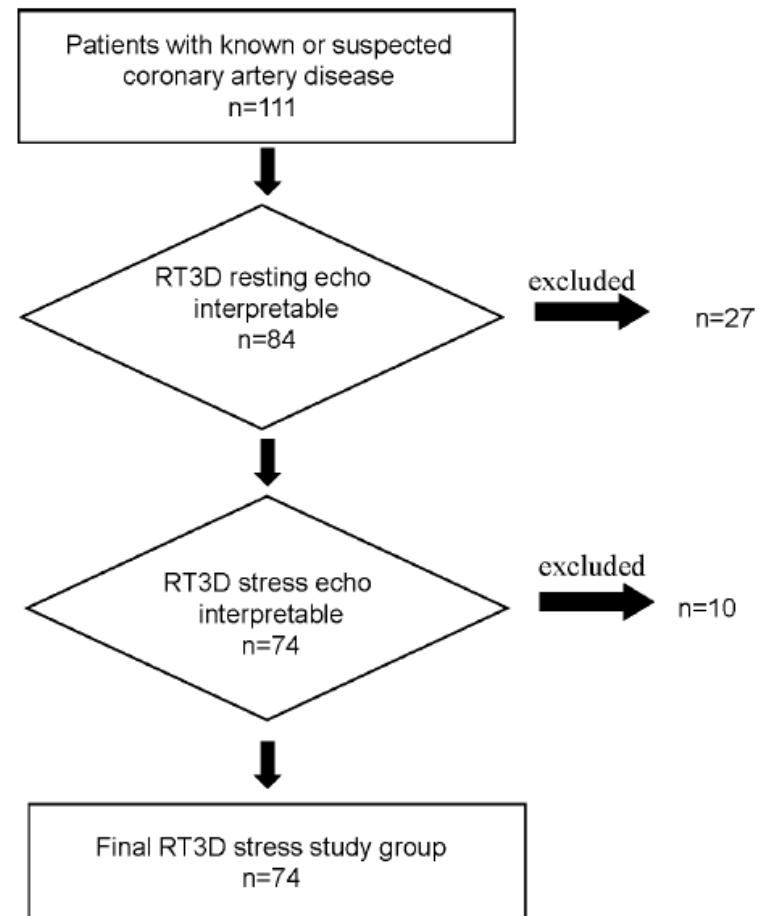
Real-time three-dimensional imaging

Technological advances in transducer and computer technology have led to the recent introduction of real-time 3D echocardiography. Similar to 2D echocardiography, contrast echocardiography can be used for enhancement of endocardial border definition and possibly for myocardial perfusion. Initial studies with 3D echocardiography during stress echocardiography have been encouraging;^{345,346} however, no data are available on the additional value of this technique over conventional wall motion interpretation. Matrix probes used for real-time 3D echocardiography offer the unique feature of recording all LV segments simultaneously, which may be advantageous for stress studies.

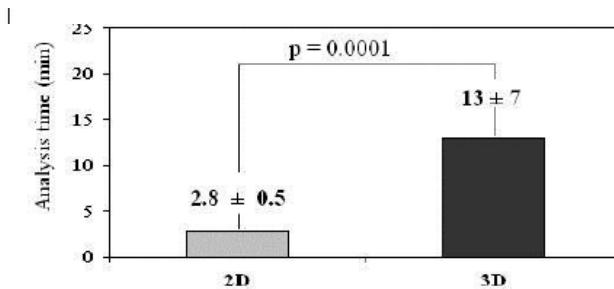
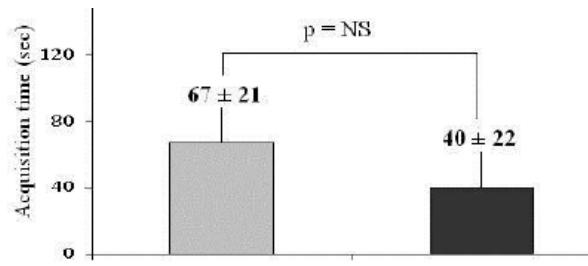
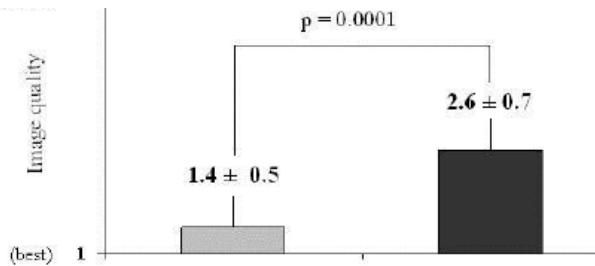
Feasibility of 3D stress echo

Variable	Value
Adequate 3D echocardiographic imaging	84 (79%)
Heart rate (beats/min)	
Baseline	79 ± 13
Peak stress	115 ± 15
Blood pressure (mm Hg)	
Baseline	131 ± 16
Peak stress	125 ± 34
Reason for test termination	
End of the protocol	46 (55%)
New or worsening wall motion	38 (45%)
LV segments available for analysis	1428 × 2
Uninterpretable segments on 2DE	311
Baseline	197 (14%)
Peak stress	114 (8%)
Uninterpretable segments on 3DE	213 ($P < .001$ vs 2DE)
Baseline	127 (9%) ($P < .03$ vs 2DE)
Peak stress	81 (6%)

We excluded patients requiring contrast during 2D acquisitions. The impact of adding contrast to improve the feasibility of 3DE with DipSE and its effect on diagnostic accuracy remain to be determined.^{8,19,20}



Prolonged Analysis Time ?



	2D ECHO	3D ECHO	P
Acquisition time	$65 +/ - 30$	$16 +/ - 3$	$P < 0.0001$
Analysis time	$176 +/ - 63$	$91 +/ - 5$	$P < 0.0001$

Additional value of 3D > 2D-stress echo



Image quality during transthoracic scanning with insufficient visualization of left ventricle (LV) walls



Probe positioning difficulties resulting in inadequate image planes

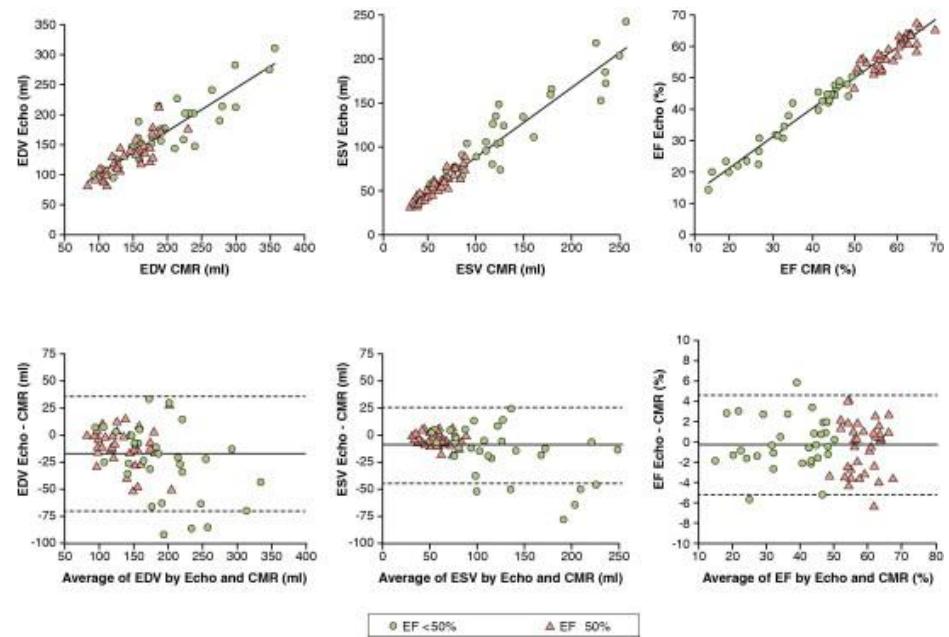
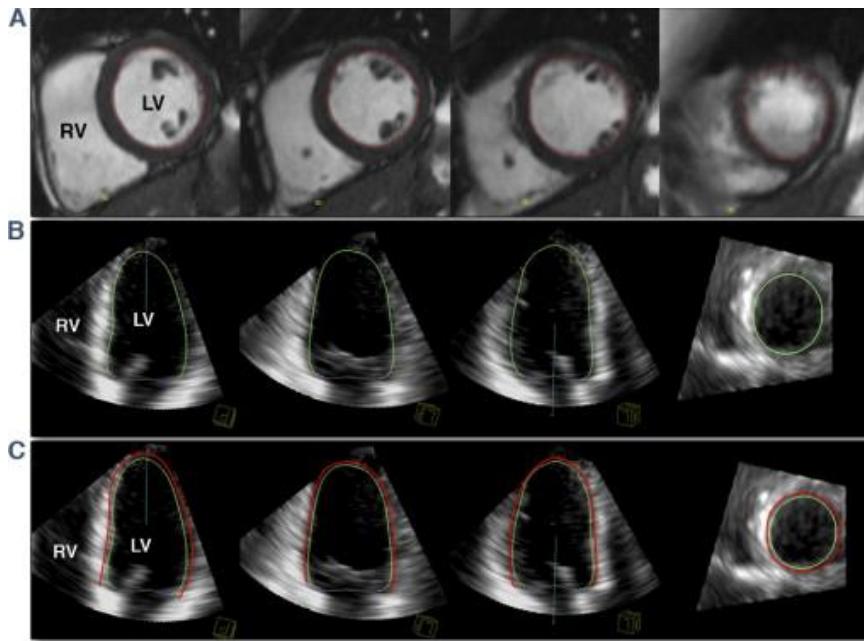


Time-consuming serial acquisition of different image planes which has to be performed in a narrow time window during peak stress while wall motion abnormalities exist

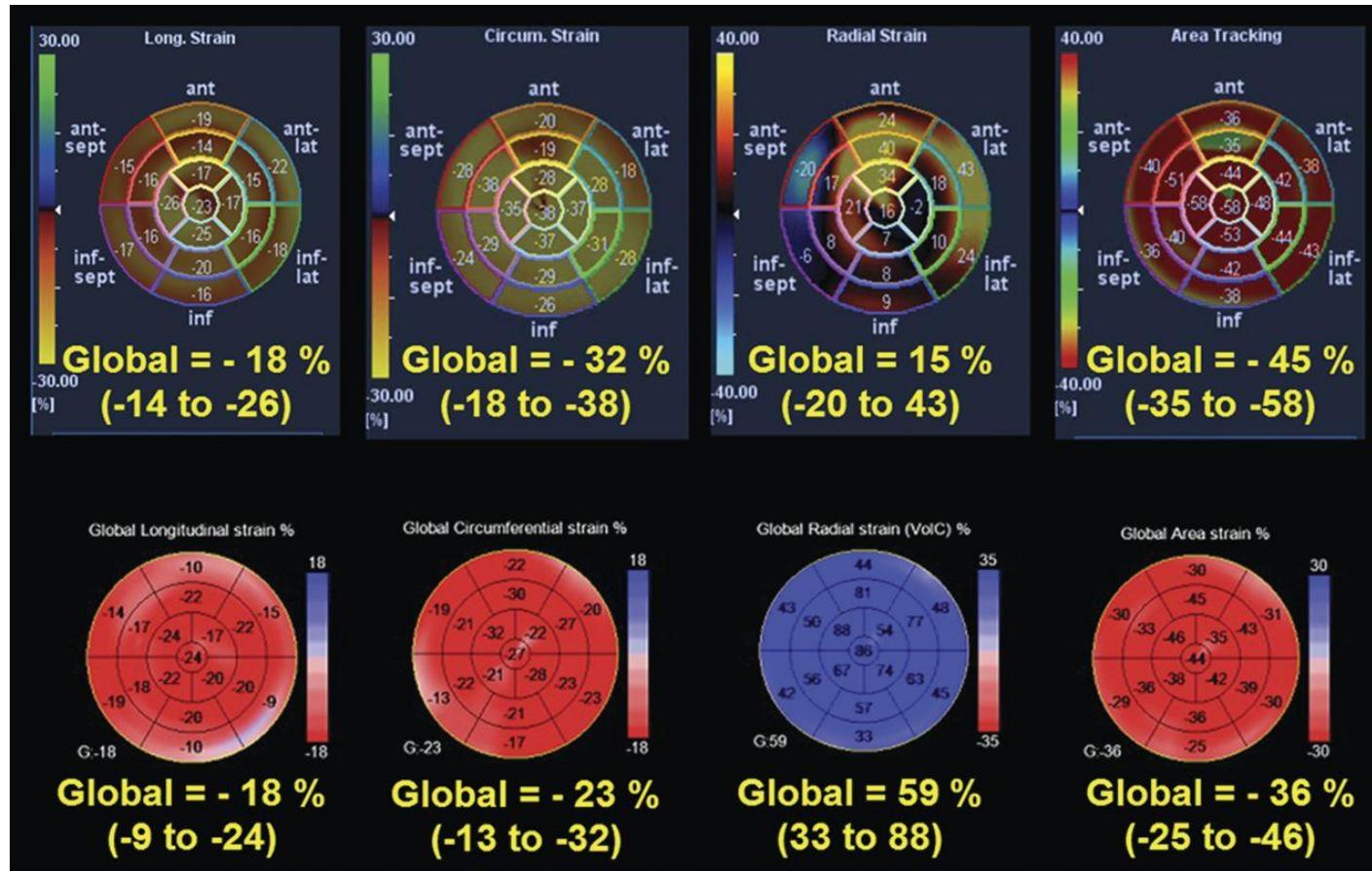


Data analysis: subjectivity of image interpretation still is the major problem, which leads to poor inter-observer agreement and causes a relevant examiner-dependency

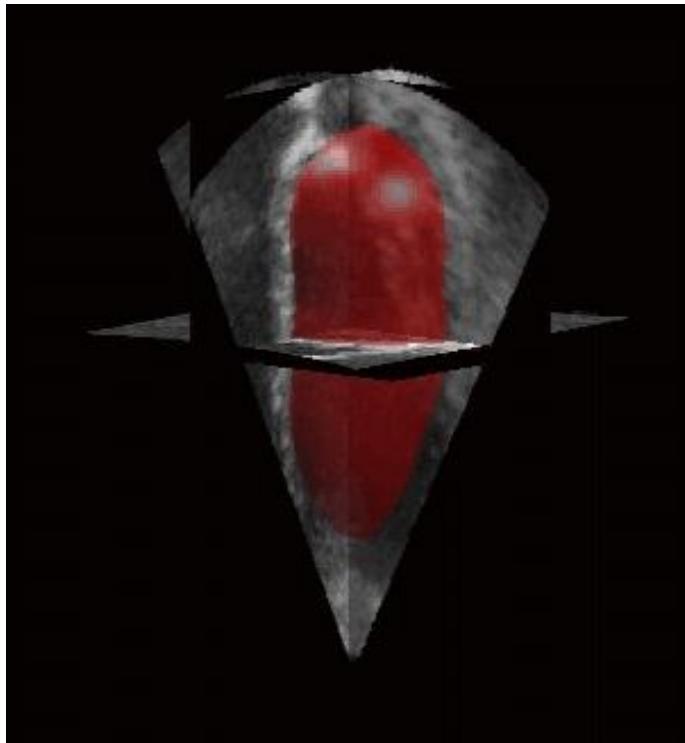
Automatic Boundary Detection



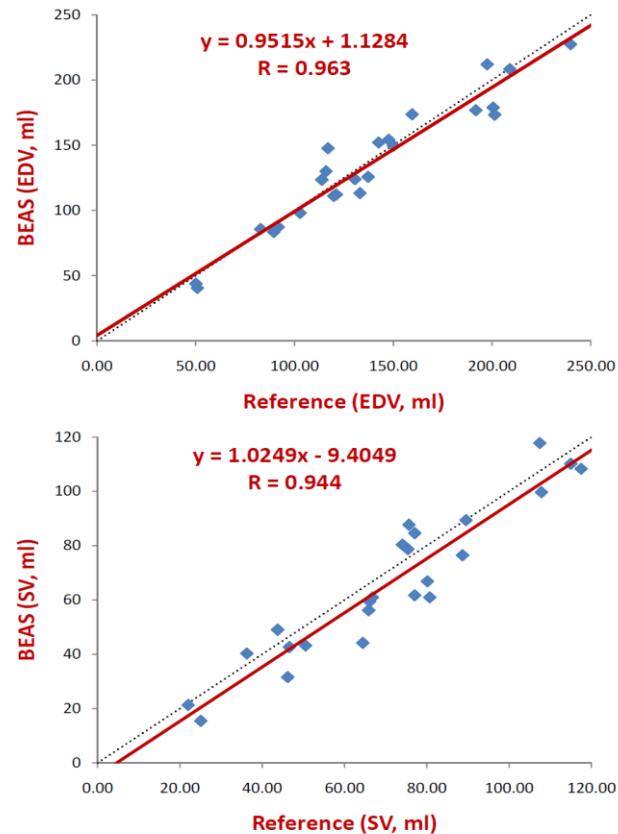
Inconsistencies between softwares



Fully automated segmentation



Real-time segmentation →
Real-time volume measurements!



Limitations still to overcome ...

- **3D stress echo is still work in progress**
- **Further quality image improvement**
- **Higher Frame Rates, less stitching (tachycardia, arrhythmias)**
- **More well validated automated algorithms**
- **Side by side analysis and synchronization (different stages)**
- **Implementation and validation of other echo- modalities (STI)**
- **Validation in various indications and non selected patients**

The Pro-Technology bias



A coffee is a coffee, is a coffee, is a coffee...

Cardiologists have to be aware that due to the pro-technology bias of modern medicine, we, as physicians, are encouraged to trust, to use (and to buy) technologies far before their clinical incremental value has been shown

Challenges for 3D speckle tracking

- Increased FOV at the cost of both spatial and temporal resolution
- Speckle pattern has less details and de-correlation between subsequent volumes is high
- 3D strain normal values depending on the method used (block matching vs elastic registration)
- Same information 2D in less time

