UPMC SORBONNE UNIVERSITÉS
FACULTÉ DE MÉDECINE PIERRE & MARIE CURIE

STRESS ECHOCARDIOGRAPHY

Hôpitaux Universitaires Paris Est
SAINT-ANTOINE
ASSISTANCE PUBLIQUE HÔPITAUX DE PARIS

Impossible d'afficher l'image. Votre ordinateur manque peut-être de mémoire pour ouvrir l'image ou l'image est endommagée. Redémarrez l'ordinateur, puis ouvrez à nouveau le fichier. Si le x rouge est toujours affiché, vous devrez peut-être supprimer l'image avant de la réinsérer.

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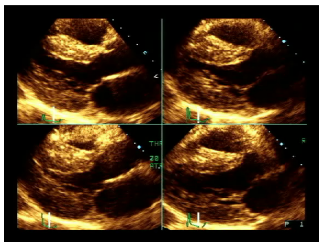

Echocardiography and myocardial ischemia

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Disclosures

DISCLOSURE STATEMENT
Ariel COHEN, MD, PhD, FESC, FACC

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1- General Considerations

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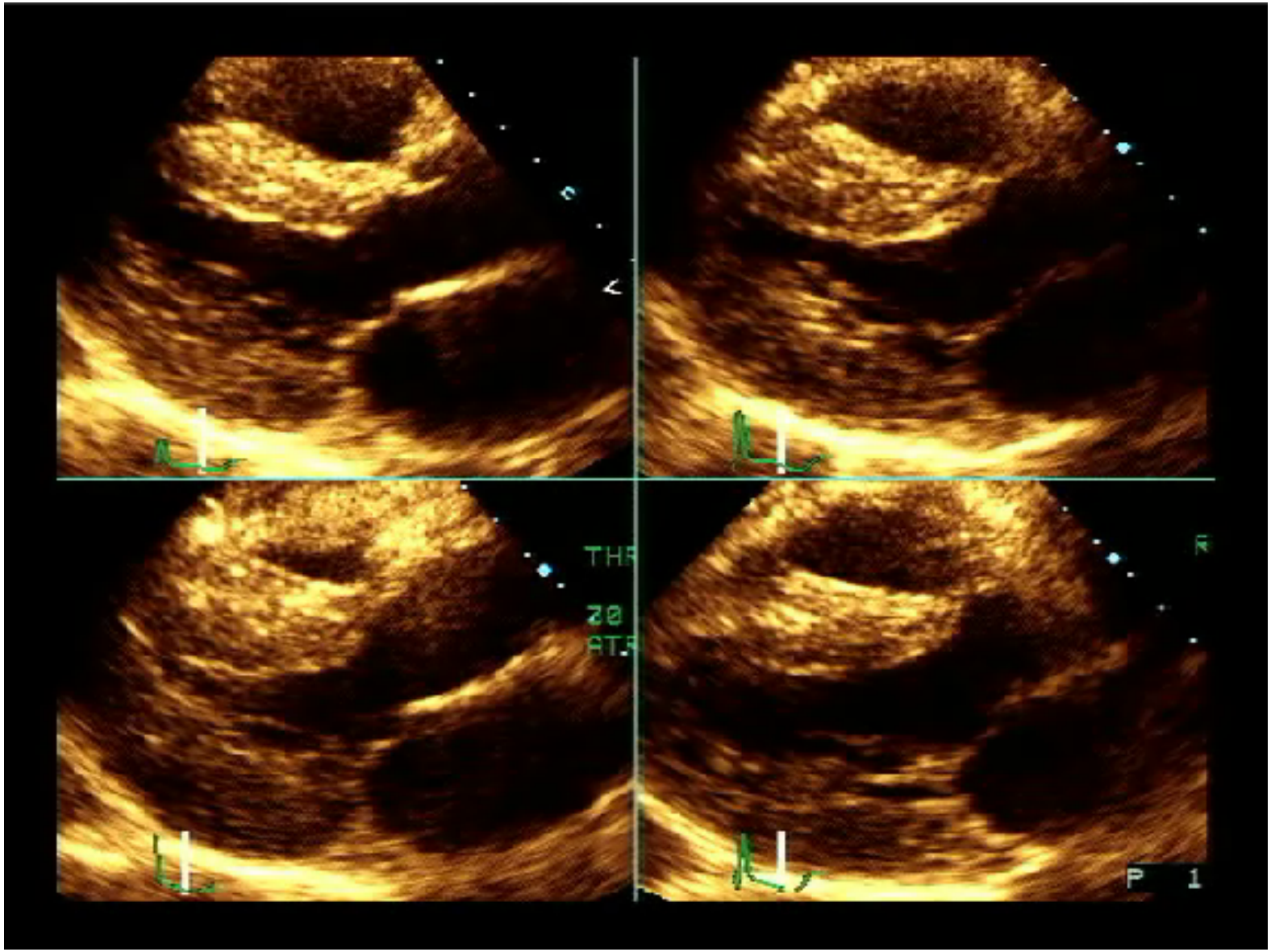
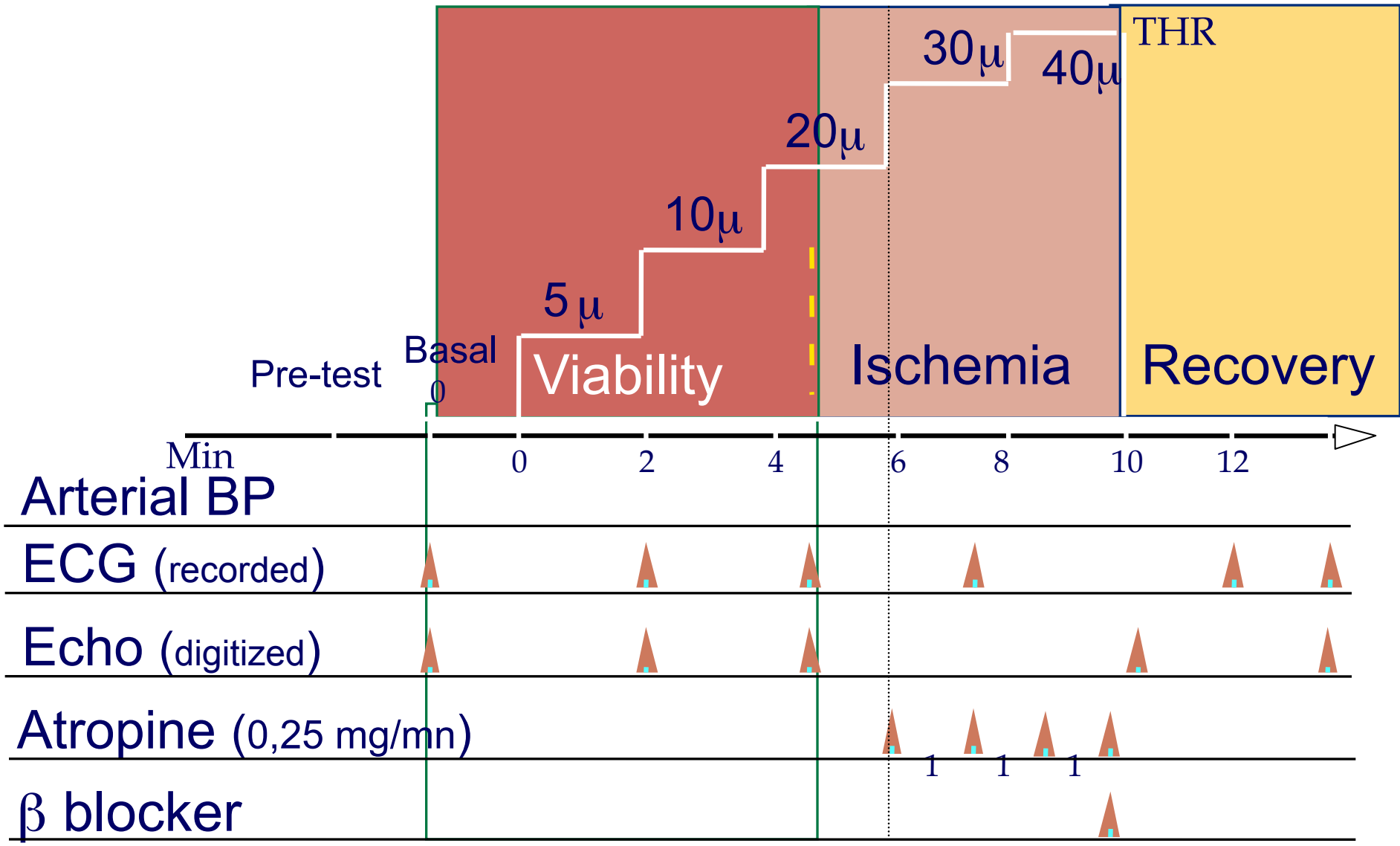


Dobutamine stress echocardiography protocol



Types of response during DSE

	Basal	Low dose	Peak
Normal			
Ischemia			
Viability + Ischemia ("Biphasic")			
Viability			

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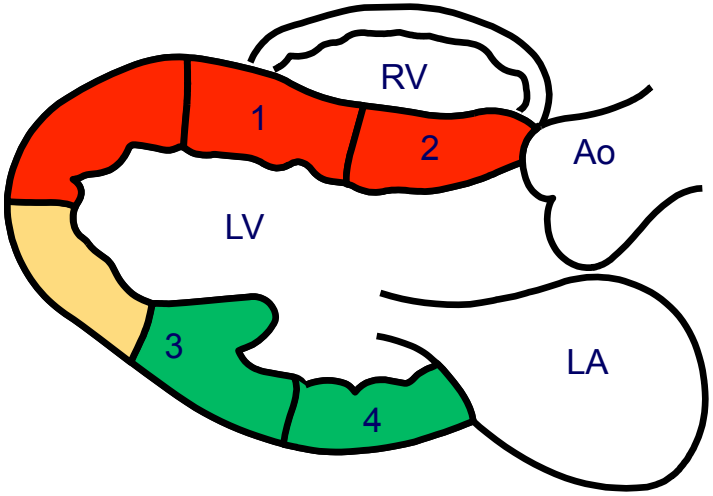
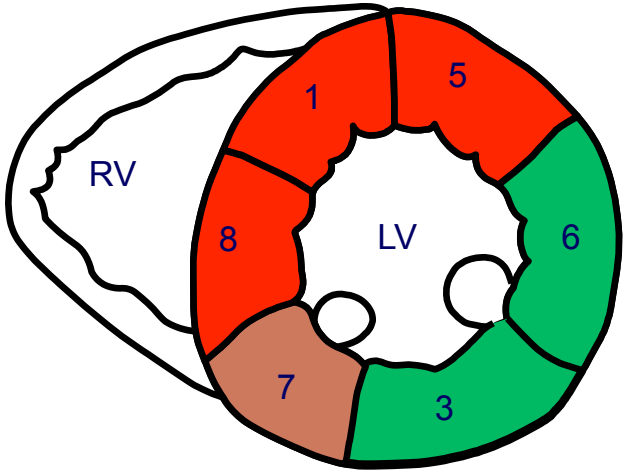
ASE Segmentation

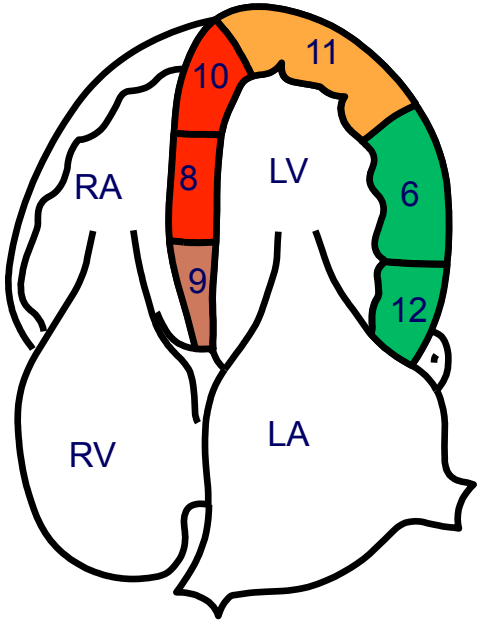
Parasternal Long axis



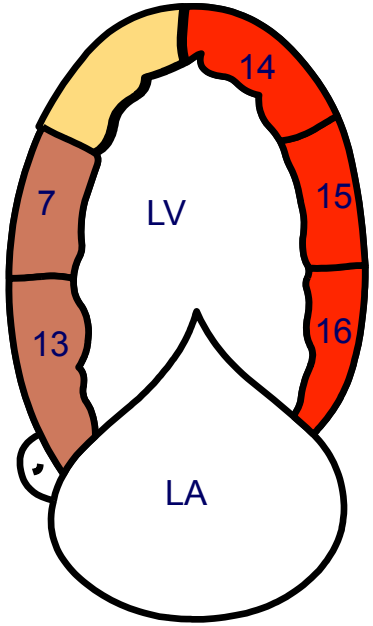
Parasternal short axis



1 Normal
2 HypoK
3 AK
4 DysK



Apical 4 Chamber



Apical 2 Chamber

LAD
Cx
RCA
LAD/CD
LAD/Cx

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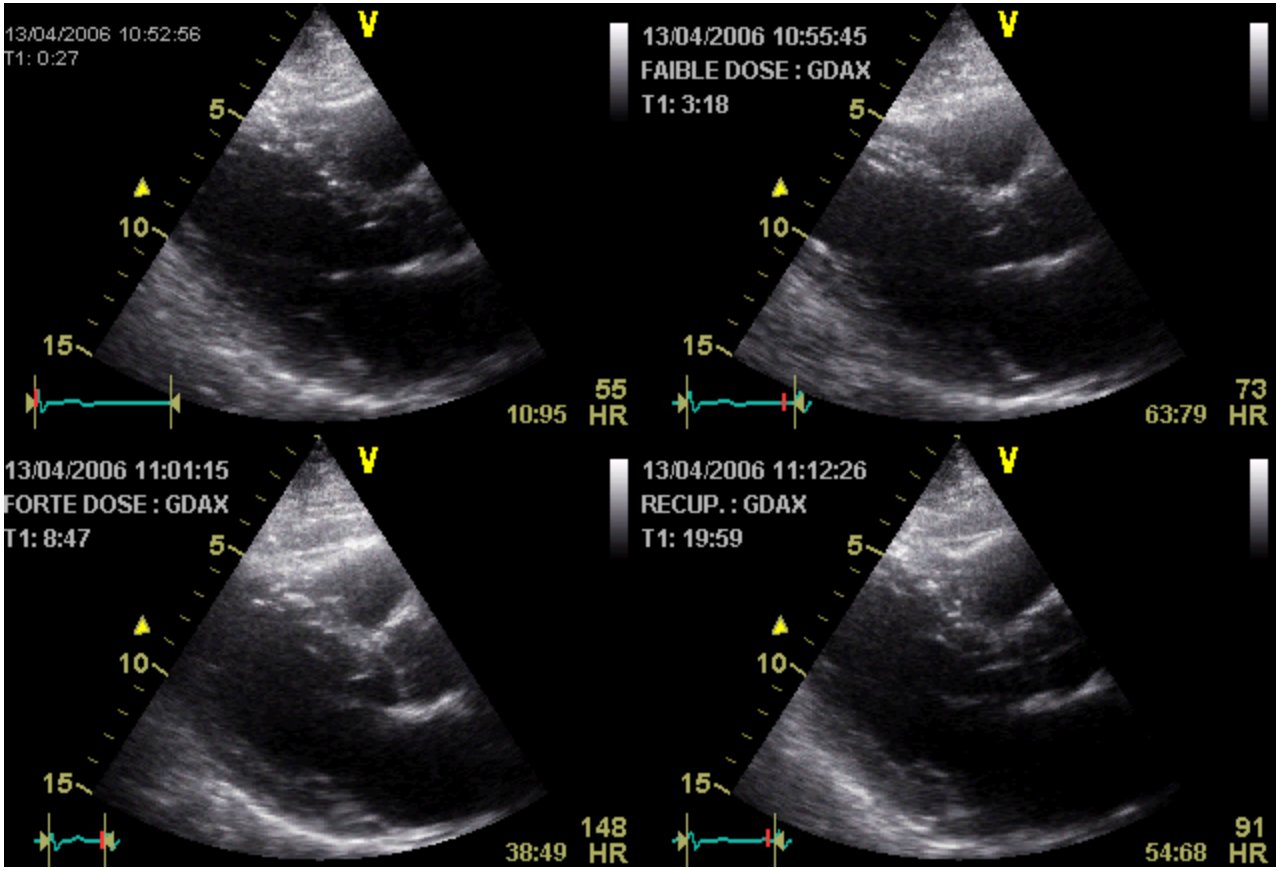

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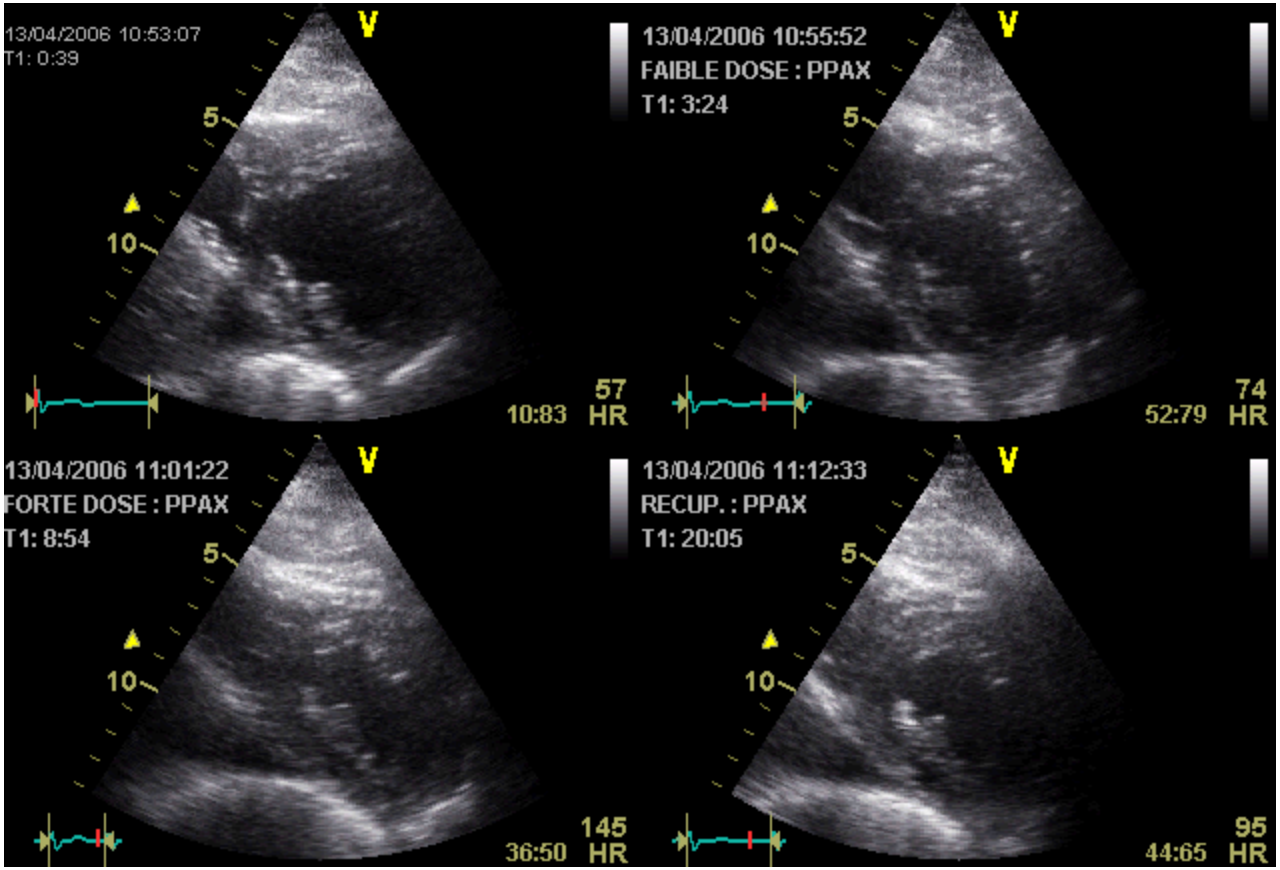

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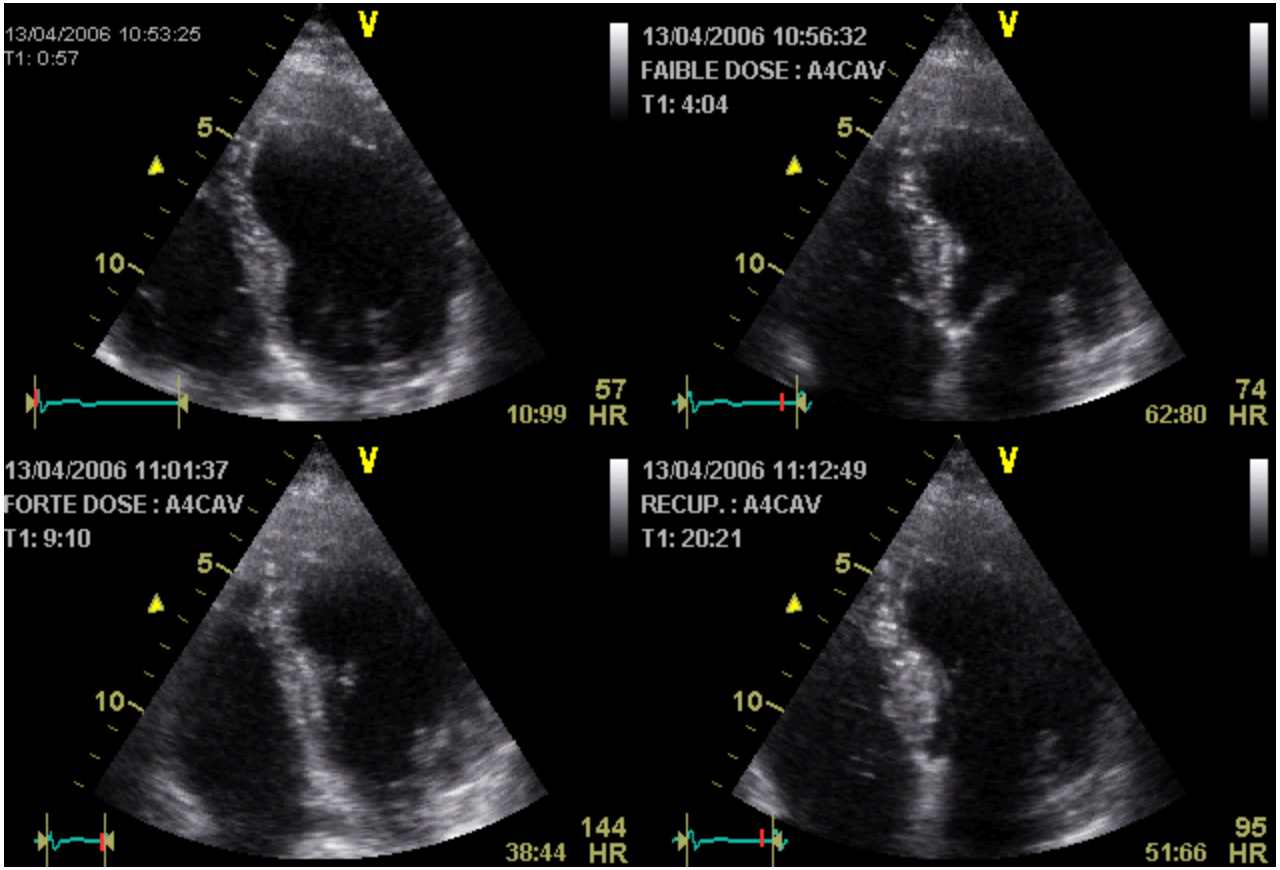

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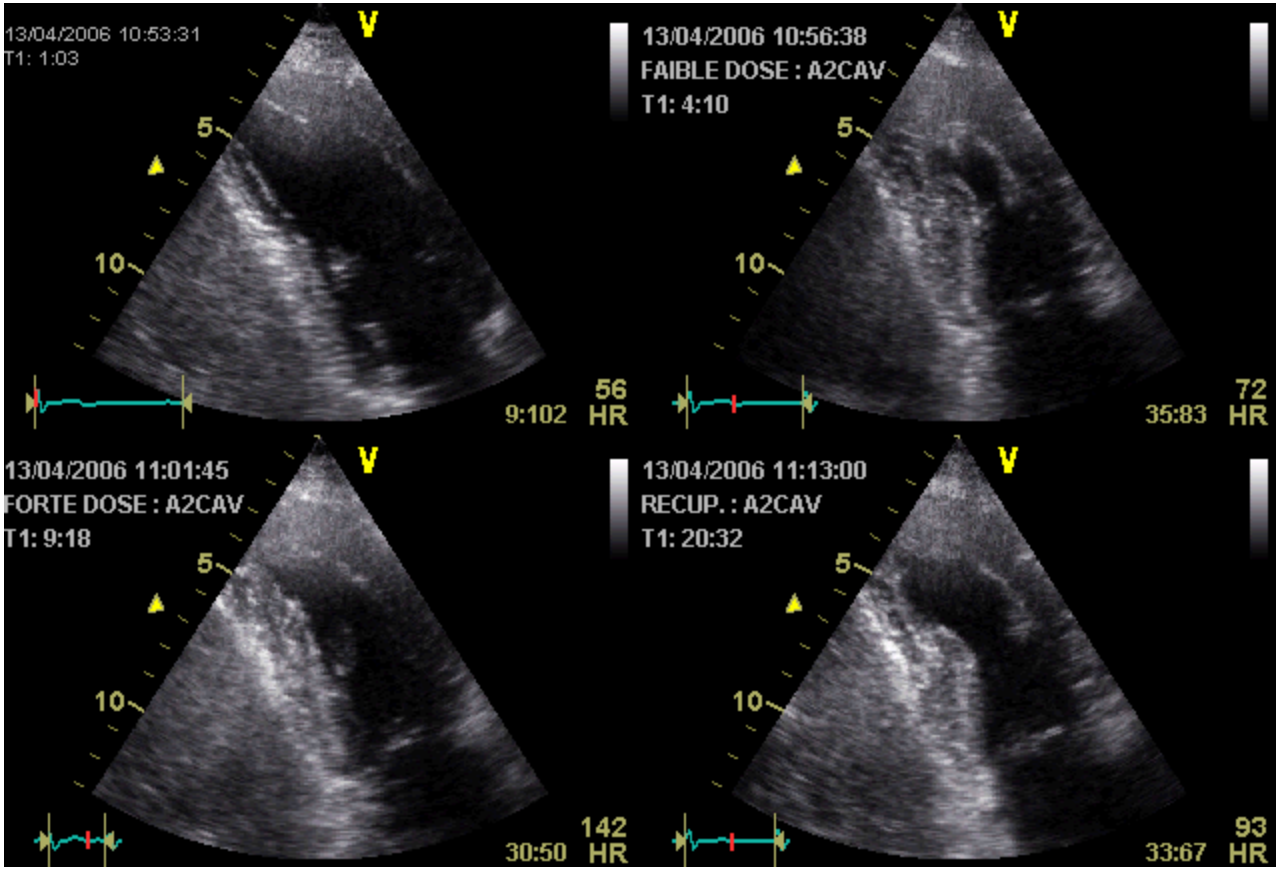

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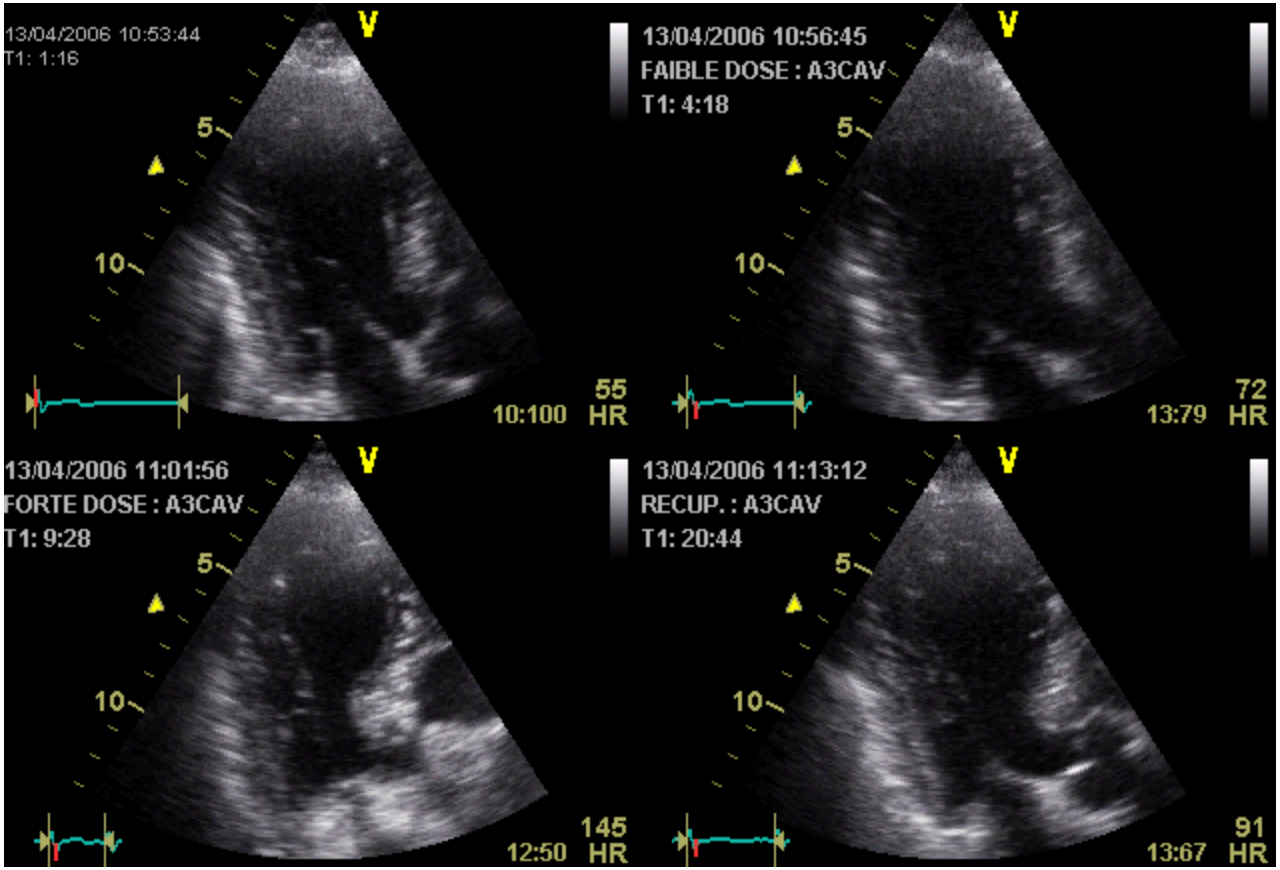


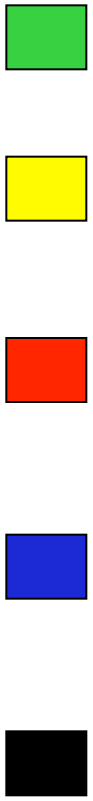
Normokinétique

Hypokinétique

Akinétique

Dyskinétique

Non Visualisé



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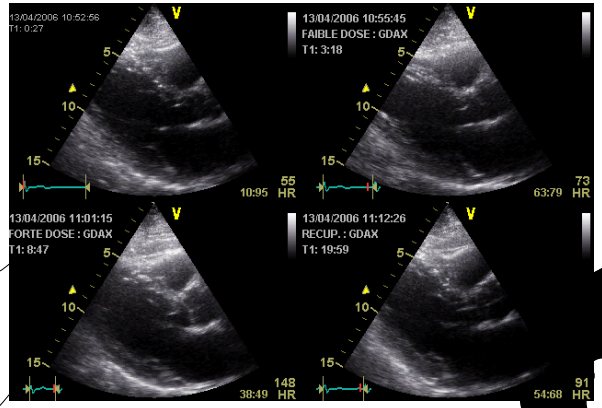

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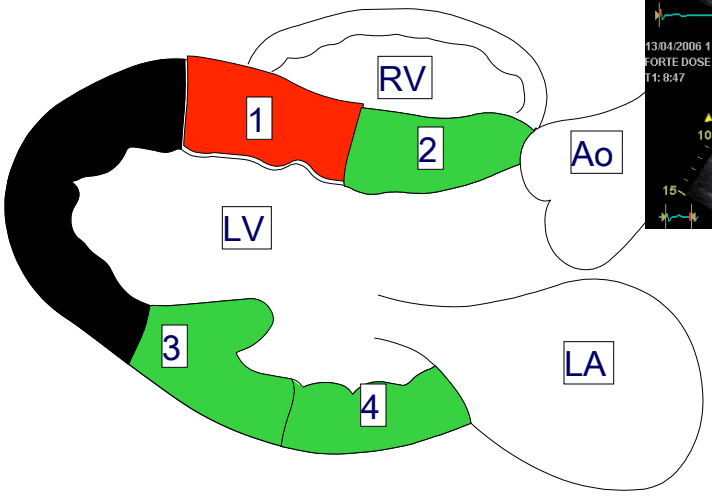

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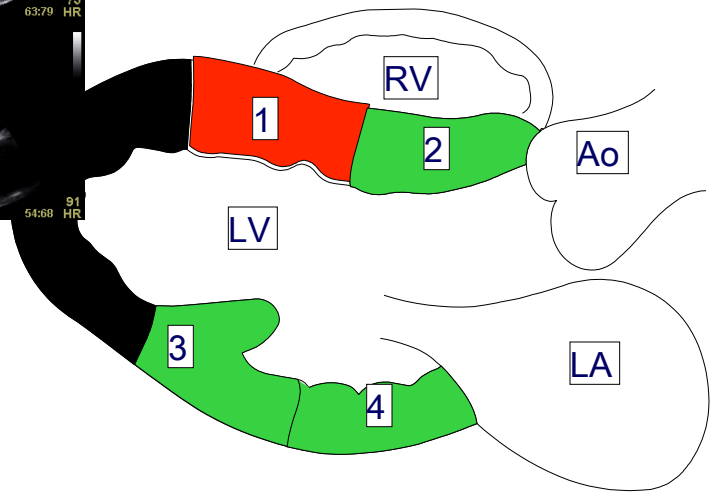

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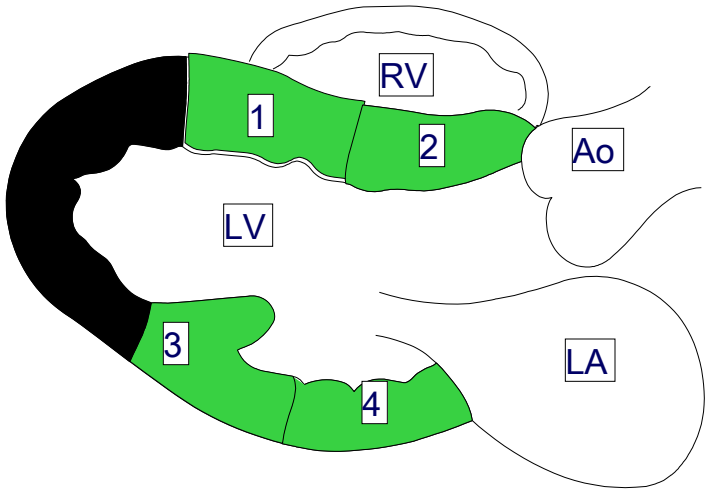

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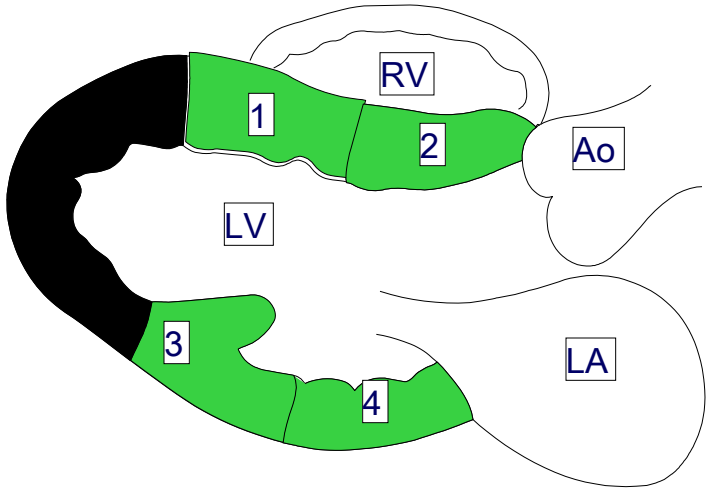

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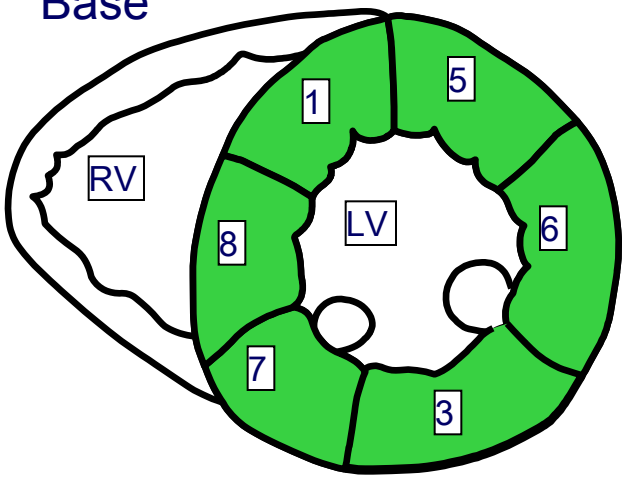

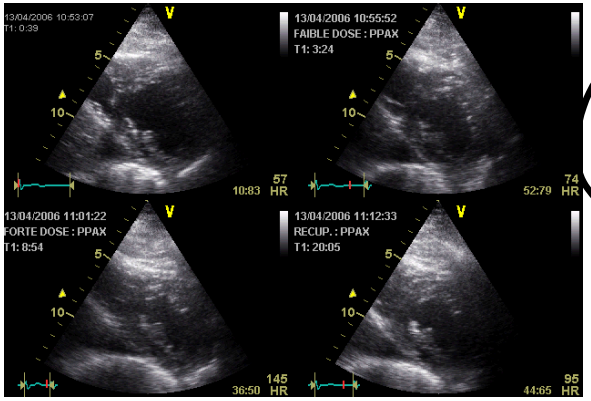

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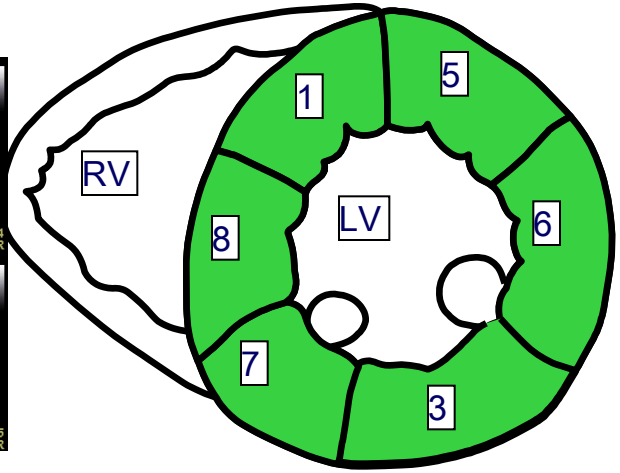

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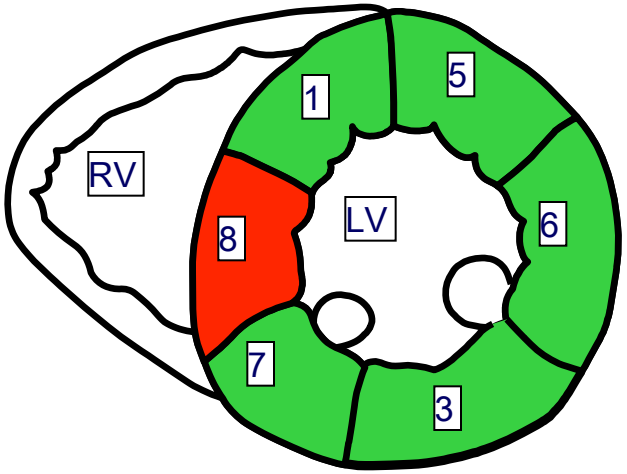

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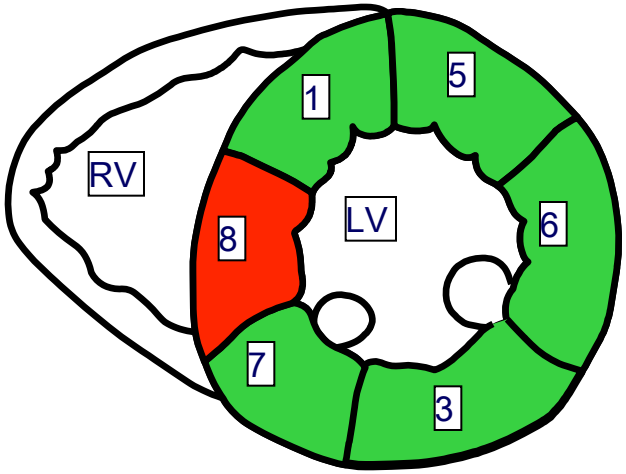

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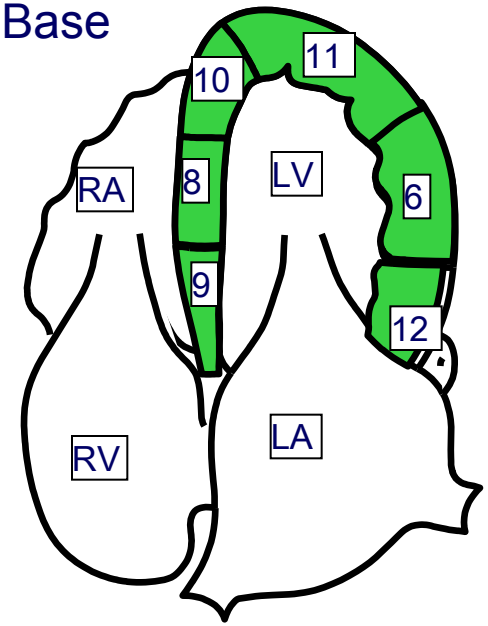

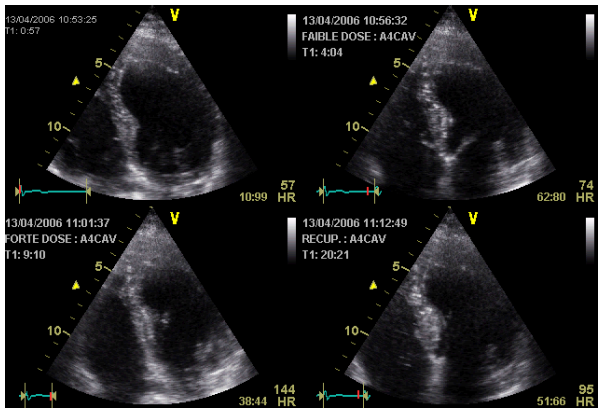

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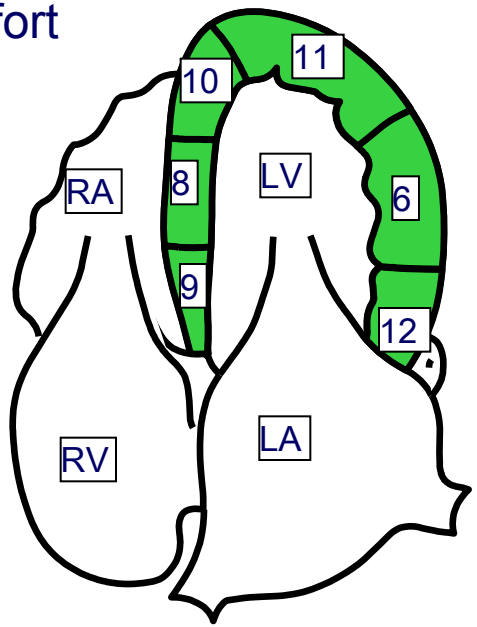

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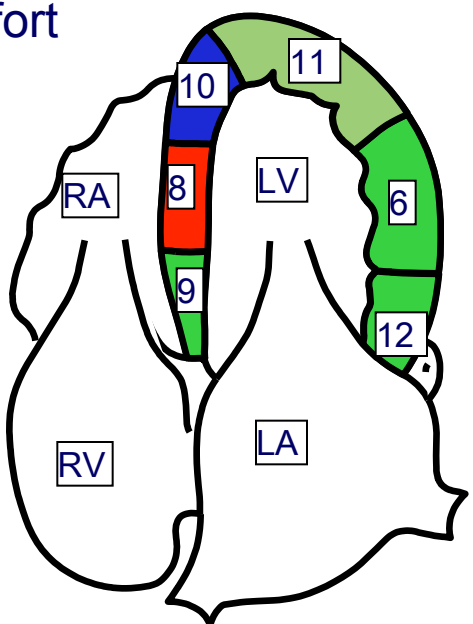

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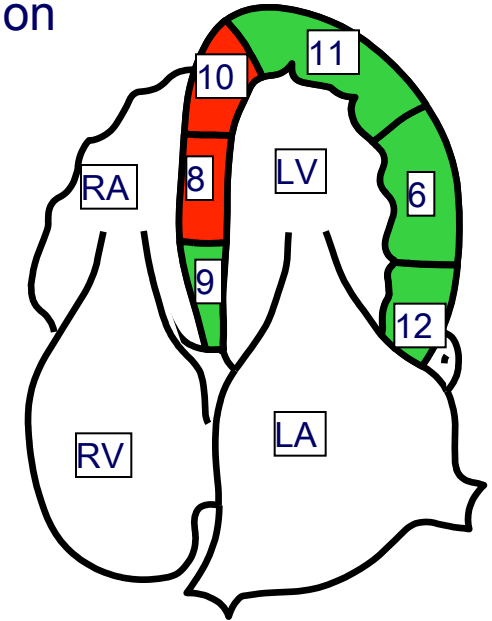

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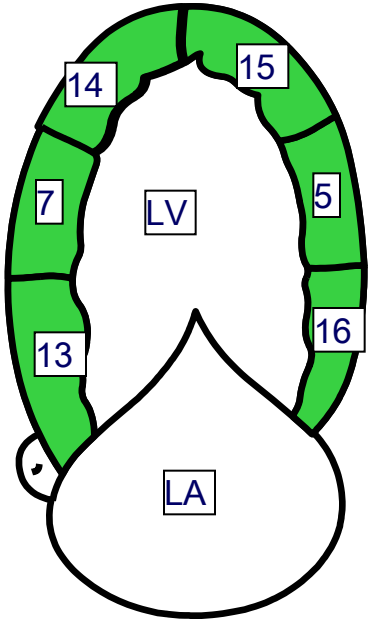

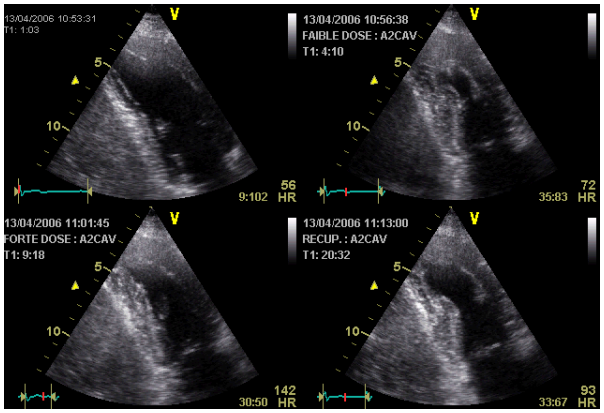

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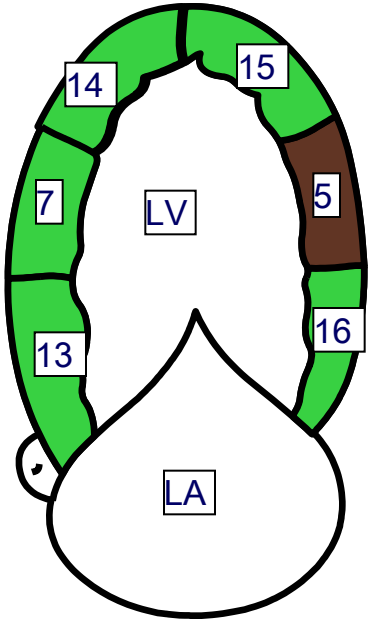

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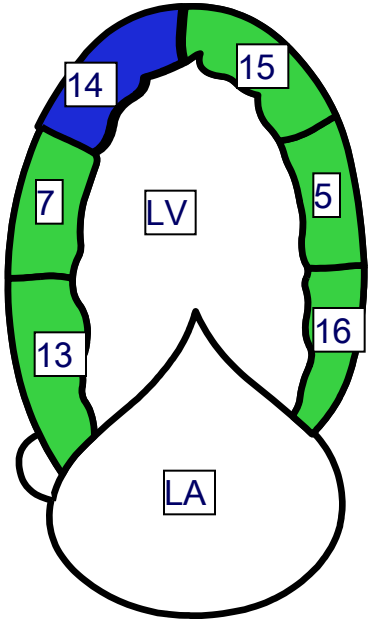

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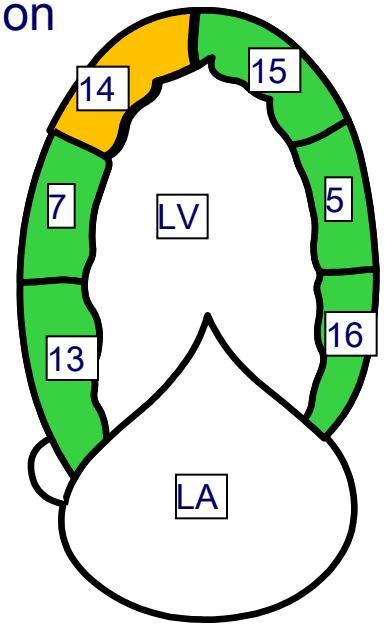

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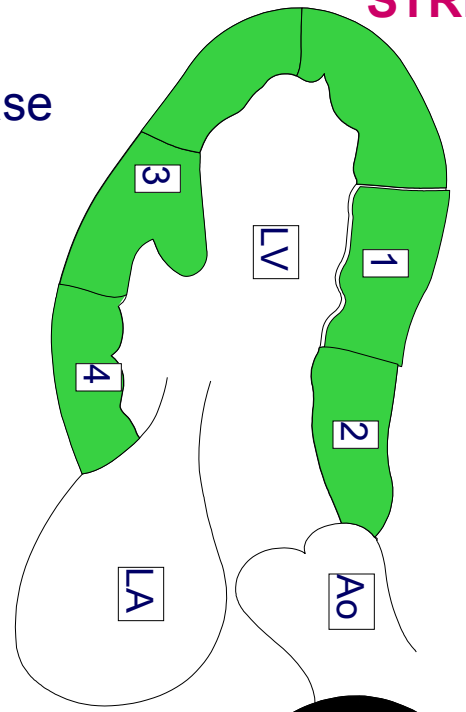

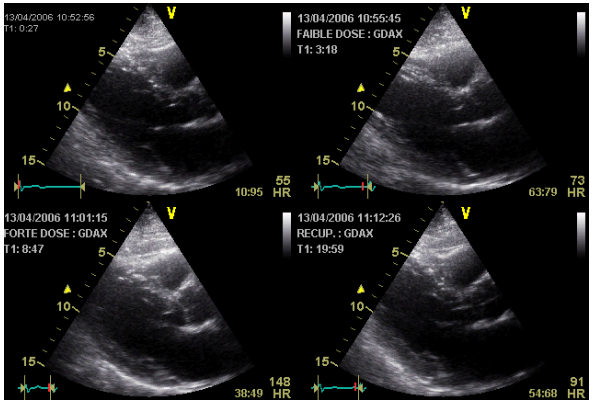

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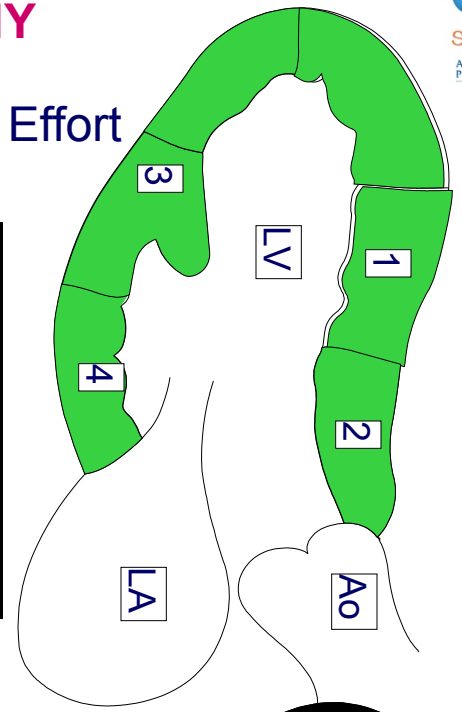

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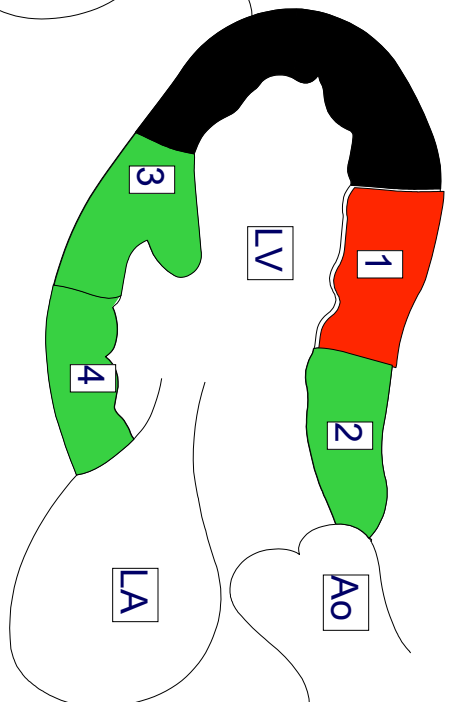

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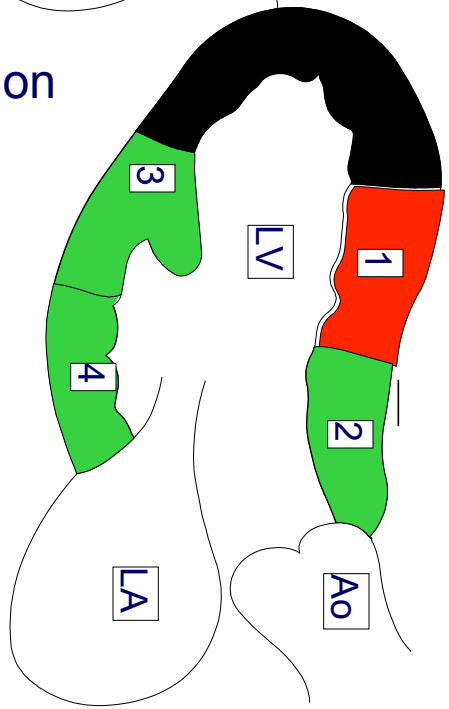

Safety of DSE

International Stress-Echo Complication registry

Data from 85 997 examinations at 71 Centers from Europe, Israel, Russia and South America

	Dobutamine n= 35 103	Dipyridamole n= 24 599	Exercise n= 26 295
Acute myocardial MI	11	5	1
Ventricular fibrillation	11	2	0
Cardiac rupture	5	0	1
TIA / Stroke	3	3	0
Hypotension/ Shock	2	4	0

Varga A. Am J. Cardiol 2006 ; 98 : 541-3

Safety of DSE

International Stress-Echo Complication registry

Data from 85 997 examinations at 71 Centers from Europe, Israel, Russia and South America

Life-threatening events in 86 patients : 1/ 1000

- **Exercise Echo**: 1 Event in 6 574 examinations
- **Dobutamine**: 1 Event in 557 examinations (p<0.01 vs. Exercise)
- **Dipyridamole**: 1 Event in 1 294 examinations (p<0.01 vs. Exercise and dobutamine)

Fatal events : 1/ 14 332 Examinations (All types of stress)

Varga A. Am J. Cardiol 2006 ; 98 : 541-3

STRESS ECHOCARDIOGRAPHY

General considerations in exercise testing

Contraindications

- **Acute MI in the previous 4 to 6 days**
- **Unstable angina with rest pain in the previous 48 hours**
- **Uncontrolled heart failure**
- Acute myocarditis or pericarditis
- Acute systemic infection
- Deep vein thrombosis is likely to shift and cause pulmonary embolism
- Uncontrolled hypertension with systolic BP > 220 mmHg or diastolic BP > 120 mmHg
- **Severe smptomatic aortic stenosis**
- **Severe hypertrophic obstructive cardiomyopathy**
- **Untreated life threatening arrhythmia**
- Dissecting aneurysm
- Recent aortic surgery

STRESS ECHOCARDIOGRAPHY

General considerations in exercise testing

Abnormalities during testing

- **Abnormal ST segment response** (horizontal, planar or down-sloping depression of >1 mm (0.5 mm or 2 mm are sometimes used as cut-off points)
- **T wave elevation of > 1mm** in leads without Q waves
- **T wave changes** such as inversion and pseudo-normalisation when an inverted T wave becomes upright are non-specific changes

STRESS ECHOCARDIOGRAPHY

General considerations in exercise testing

Stopping the test

ECG criteria

- **Severe ST depression of > 3mm**
- **ST elevation > 1 mm in non-Q wave lead**
- **Frequent ventricular extrasystoles**
- **Onset of ventricular tachycardia**
- New atrial fibrillation or supraventricular tachycardia
- Development of new bundle branch block
- Progression of heart block to second or third degree
- Cardiac arrest

STRESS ECHOCARDIOGRAPHY

General considerations in exercise testing

Stopping the test

Clinical criteria

- Excessive fatigue
- Severe chest pain, dyspnoea, or dizziness
- **> 20 mmHg reduction in systolic blood pressure**
- Rise in blood pressure above systolic BP of 300 mmHg or diastolic BP of 130 mmHg
- Unsteadiness

1- General Considerations

2- Diagnosis of myocardial ischemia

Diagnostic accuracy of stress test

351 studies in 11 meta-analyses included 35 268 pts with stress test between 1991 and 2005

	Nb of series	Sensitivity (%)	Specificity (%)
Exercise Echo	**55**	**82.7**	**84.0%**
Adenosine Echo	**11**	**79.2%**	**91.5%**
Dipyridamole Echo	**58**	**71.9%**	**94.6%**
Dobutamine Echo	**101**	**81.0%**	**84.1%**
Combined Echo	**226**	**79.1%**	**87.1%**
Exercise SPECT	48	88.1%	68.8%
Adenosine SPECT	14	90.5%	81.0%
Dipyridamole SPECT	23	90.4%	75.4%
Dobutamine SPECT	16	83.6%	75.1%
Combined SPECT	103	88.1%	73.0%

Heijenbrok-kal MH. Am Heart J 2007 ; 154 : 415-23

Diagnostic accuracy of stress test

62 studies included 6881 pts with DSE and coronary angiography between 1991 and 2006
4718 patients (68.5%) with angiographically proven CAD

SENSITIVITY 81.2%, SPECIFICITY 82.2%

SENSITIVITY single vessel CAD 72.8%, multi vessel CAD 87.7%

	Sensitivity (%)			Specificity (%)		
	Yes	No	p	Yes	No	p
History of MI	**0.834**	0.740	**<0.01**	0.811	0.852	0.17
Rest wall motion abnormality included	0.821	0.756	0.14	0.812	0.877	<0.10
Referral bias present	0.831	0.804	0.40	**0.771**	**0.842**	**<0.01**
Ischemia for test result positivity needed	**0.786**	0.864	**<0.01**	0.838	**0.789**	**<0.10**

Geleinjse ML. J Am Soc Echocardiogr 2009 ; 22 : 1199-208

STRESS ECHOCARDIOGRAPHY

SYSTEMATIC REVIEW

Diagnostic accuracy of exercise stress testing for coronary artery disease: a systematic review and meta-analysis of prospective studies

A. Banerjee[1], D.R. Newman[2], A. Van den Bruel[2], C. Heneghan[2]

THE INTERNATIONAL JOURNAL OF CLINICAL PRACTICE
Editor's Choice

6 055 potentially relevant records identified and screened

1 675 duplicate records excluded

4 380 potentially relevant records screened by 1 reviewer

4 254 records excluded because clearly not relevant

126 potentially relevant records

106 records relating to diagnostis of CAD screened by 2 reviewers

20 records relating to stress test methods screened by 2 reviewers

34 records included in review

Banerjee A. Int J Clin Pract. 2012 ;66:477-92.

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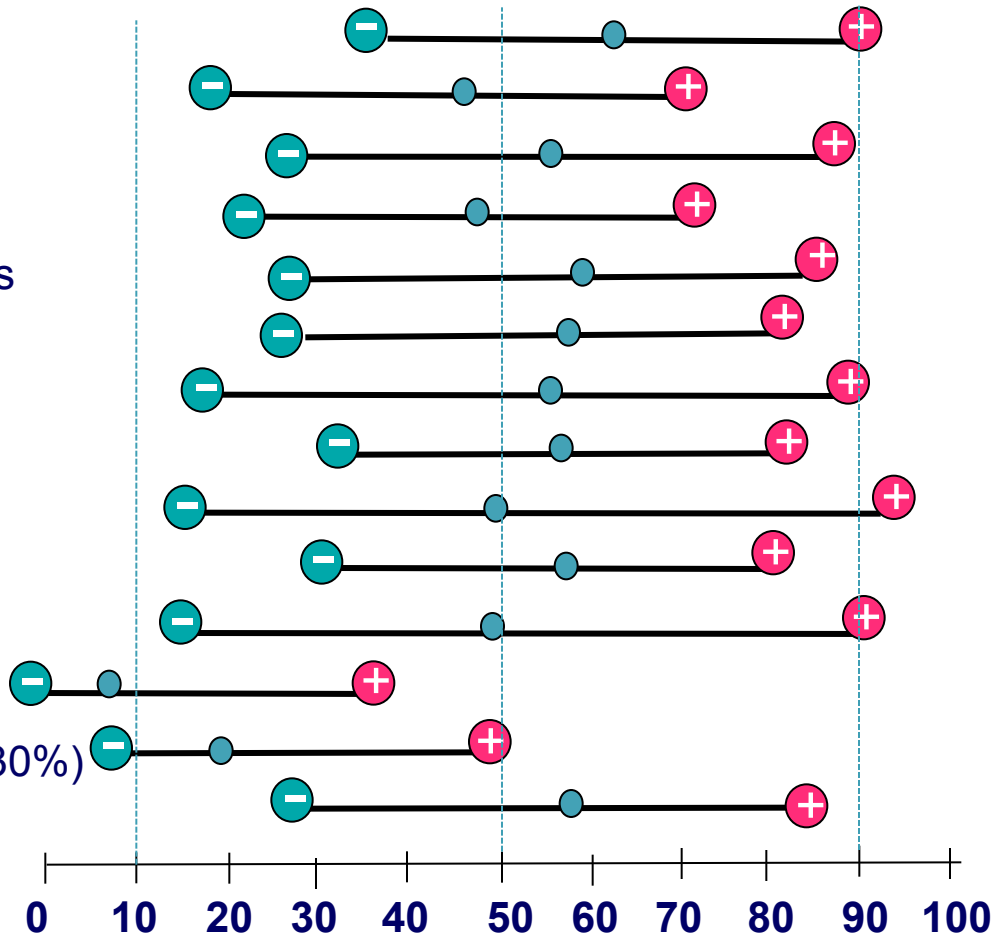
Editor's Choice

Subgroup analysis of probability of coronary artery disease pre- and post-exercise testing

Subgroup	Prior	Test+	Test-
Men	62	89	37
Women	46	69	18
Age<60	55	84	25
Age>60	47	70	23
Double-blinded studies	59	83	27
Treadmill ECG	57	80	28
Treadmil echo	55	89	19
Bicycle ECG	56	80	35
Bicycle echo	49	92	16
ECG	57	79	31
Echo	49	90	16
Low risk (<10%)	7	36	2
Intermediate risk (10-30%)	19	49	9
High risk (>30%)	57	84	29



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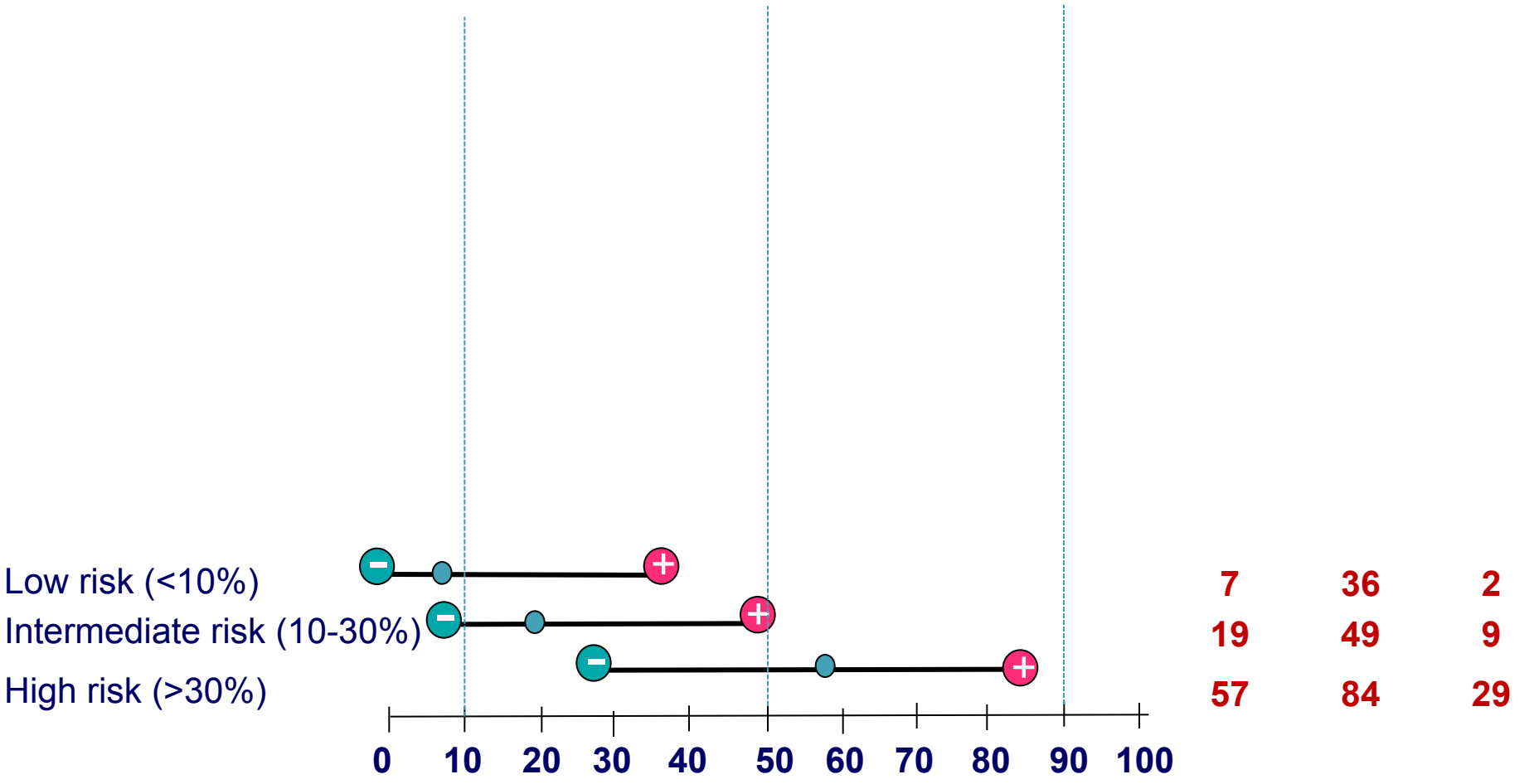

Banerjee A. Int J Clin Pract. 2012 ;66:477-92.

STRESS ECHOCARDIOGRAPHY

SYSTEMATIC REVIEW

Diagnostic accuracy of exercise stress testing for coronary artery disease: a systematic review and meta-analysis of prospective studies

A. Banerjee[1], D.R. Newman[2], A. Van den Bruel[2], C. Heneghan[2]

THE INTERNATIONAL JOURNAL OF CLINICAL PRACTICE
Editor's Choice

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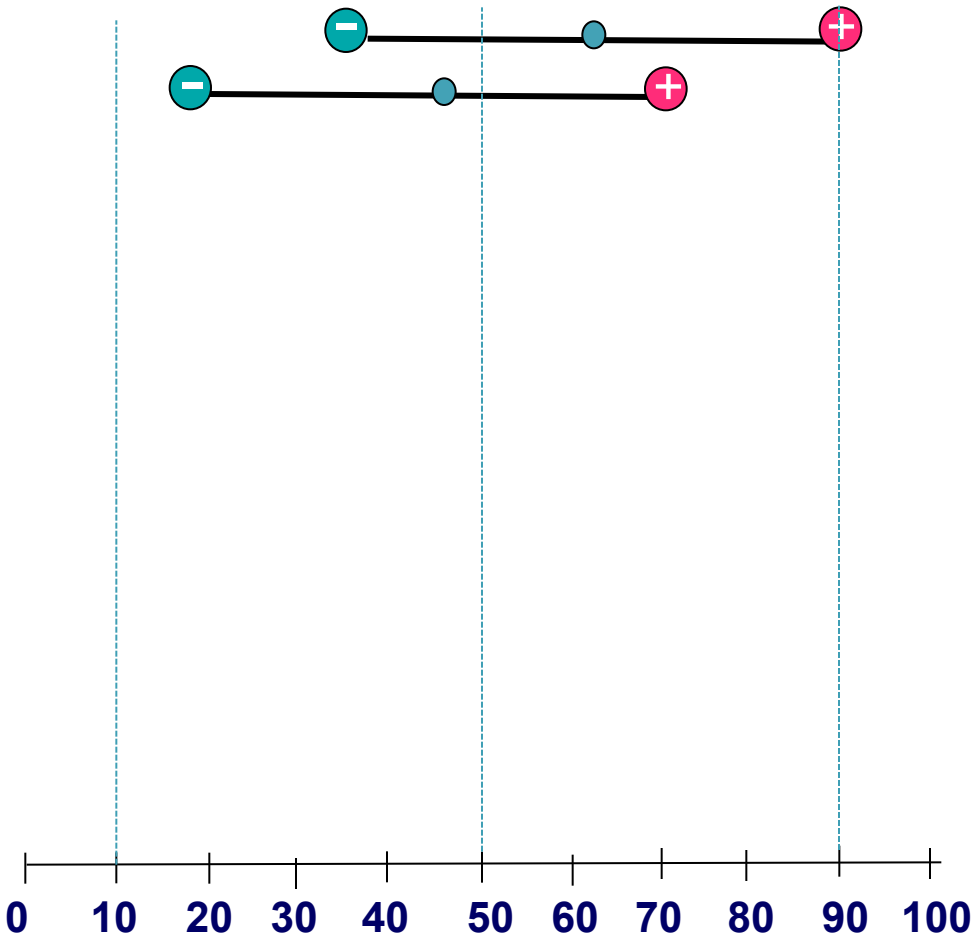
Subgroup	Prior	Test+	Test-
Men	62	89	37
Women	46	69	18



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STRESS ECHOCARDIOGRAPHY

Meta-analysis on the accuracy of diagnostic stress tests in women

	Exercise electrocardiography		Stress echocardiography		Stress SPECT	
Author	**Ss, %**	**Sp, %**	**Ss, %**	**Sp, %**	**Ss, %**	**Sp, %**
Fleischmann 1998	-	-	85	77	87	64
Kwok, 1999	61	70	86	79	78	64
Beattie 2003	-	-	81	73	77	69
Average	**61**	**70**	**84**	**76**	**81**	**66**

STRESS ECHOCARDIOGRAPHY

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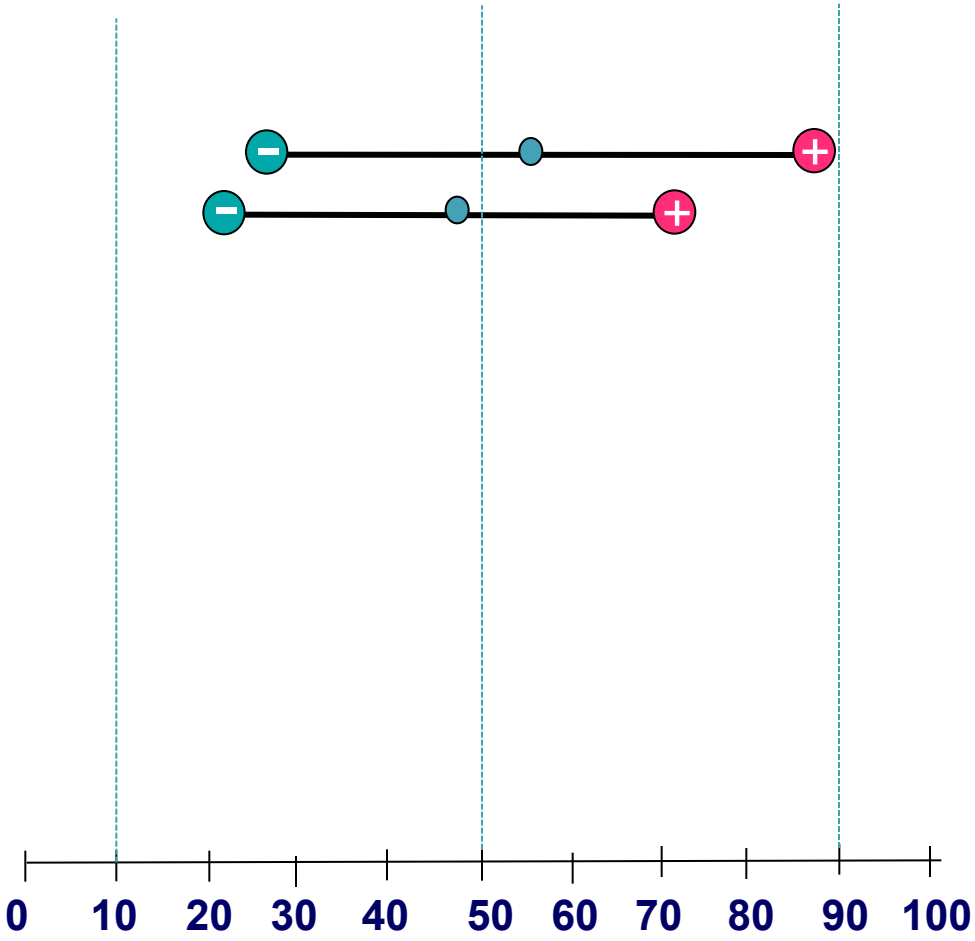
Subgroup	Prior	Test+	Test-
Age<60	55	84	25
Age>60	47	70	23



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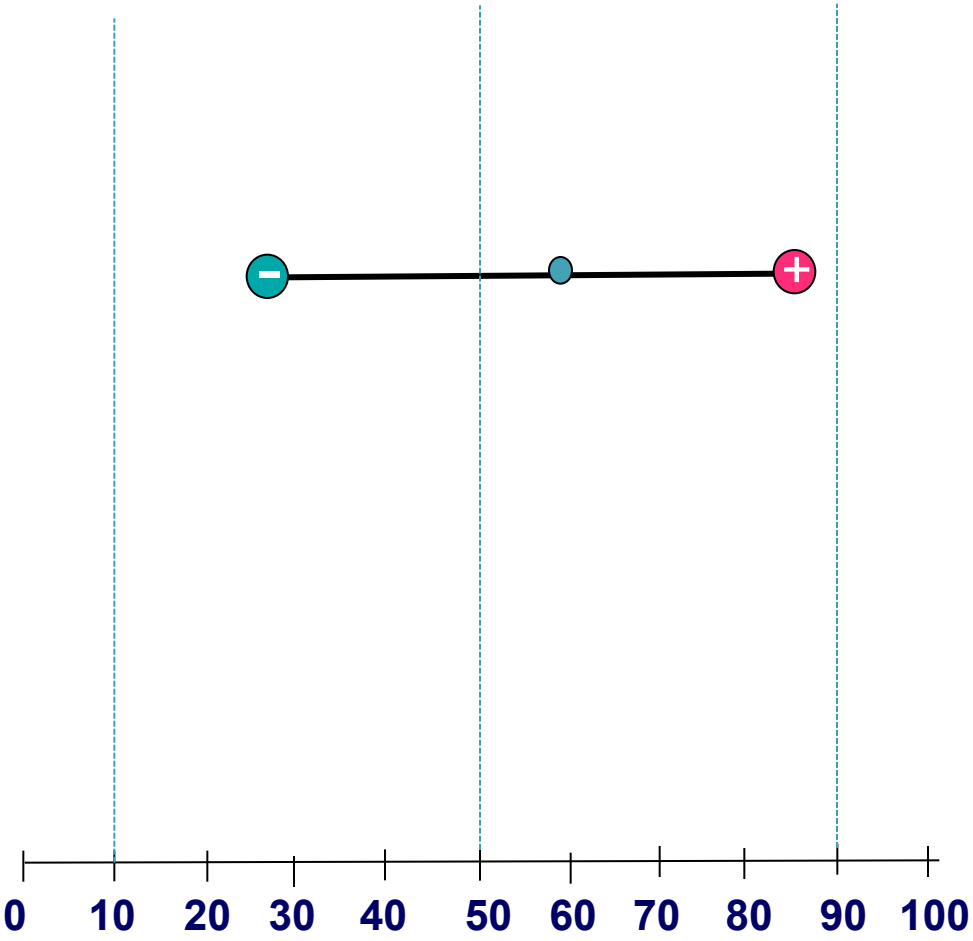
Subgroup	Prior	Test+	Test-
Double-blinded studies	59	83	27



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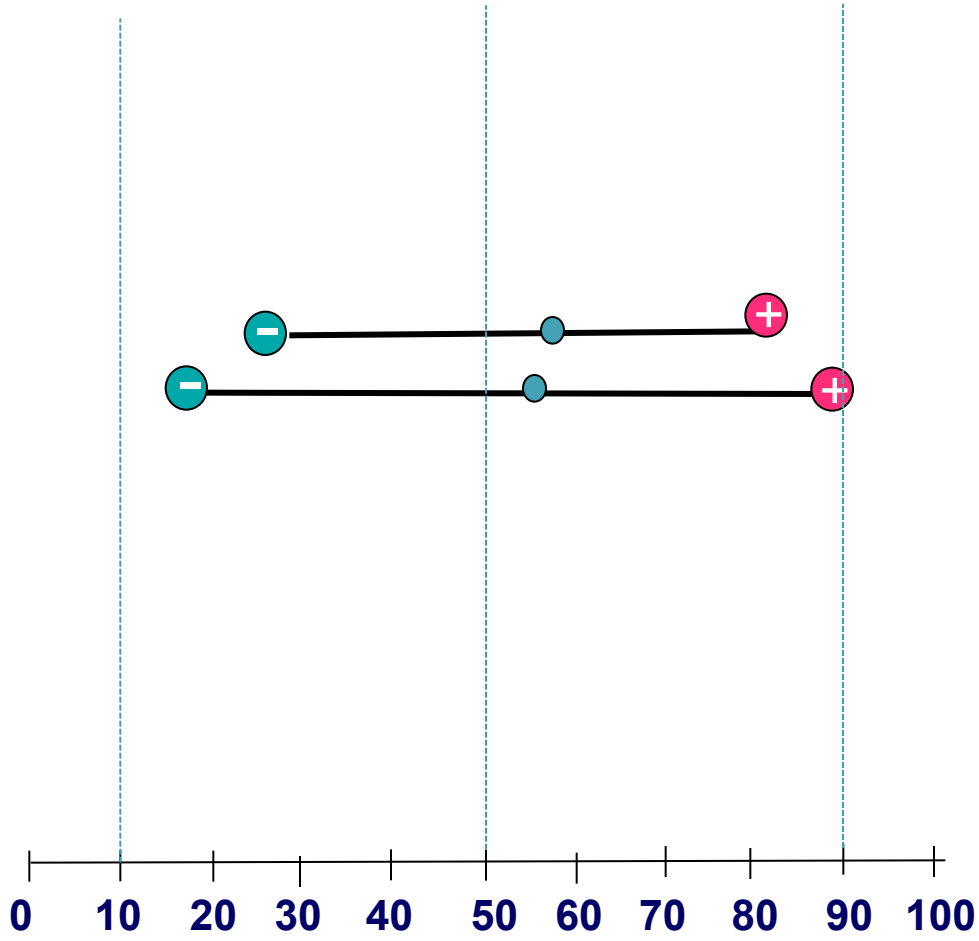
Subgroup	Prior	Test+	Test-
Treadmill ECG	57	80	28
Treadmil echo	55	89	19



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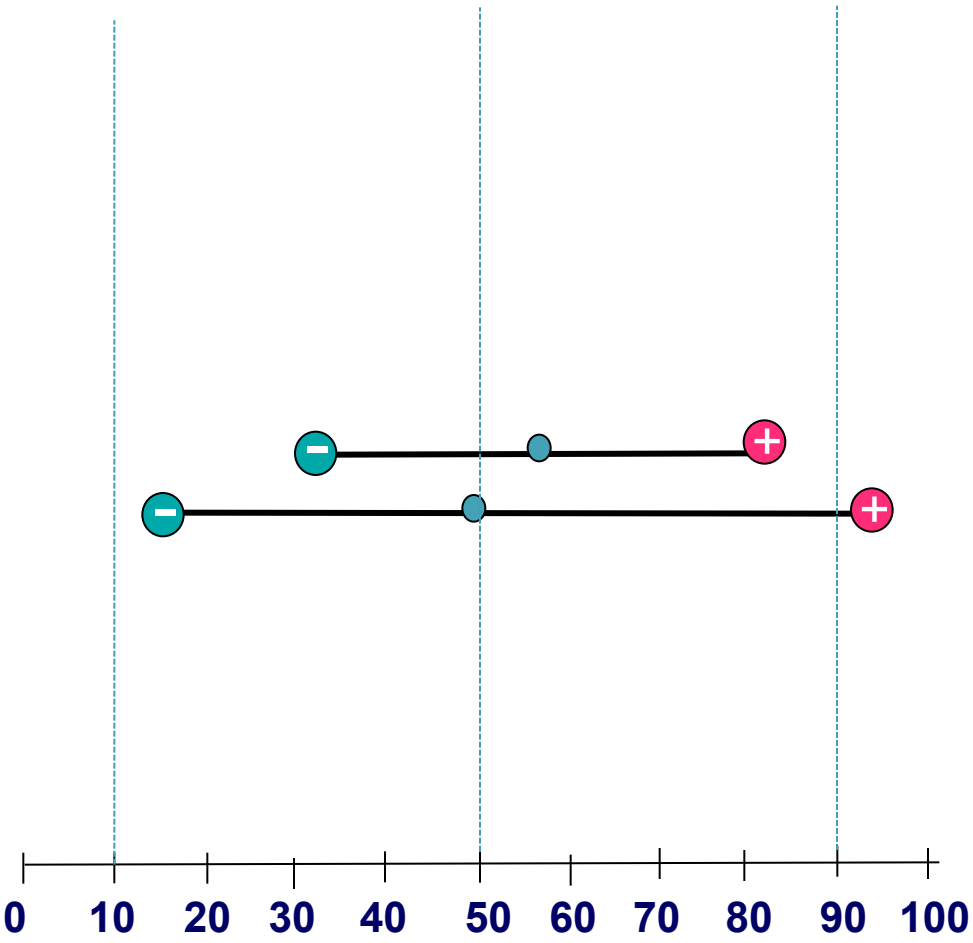

Subgroup	Prior	Test+	Test-
Bicycle ECG	56	80	35
Bicycle echo	49	92	16

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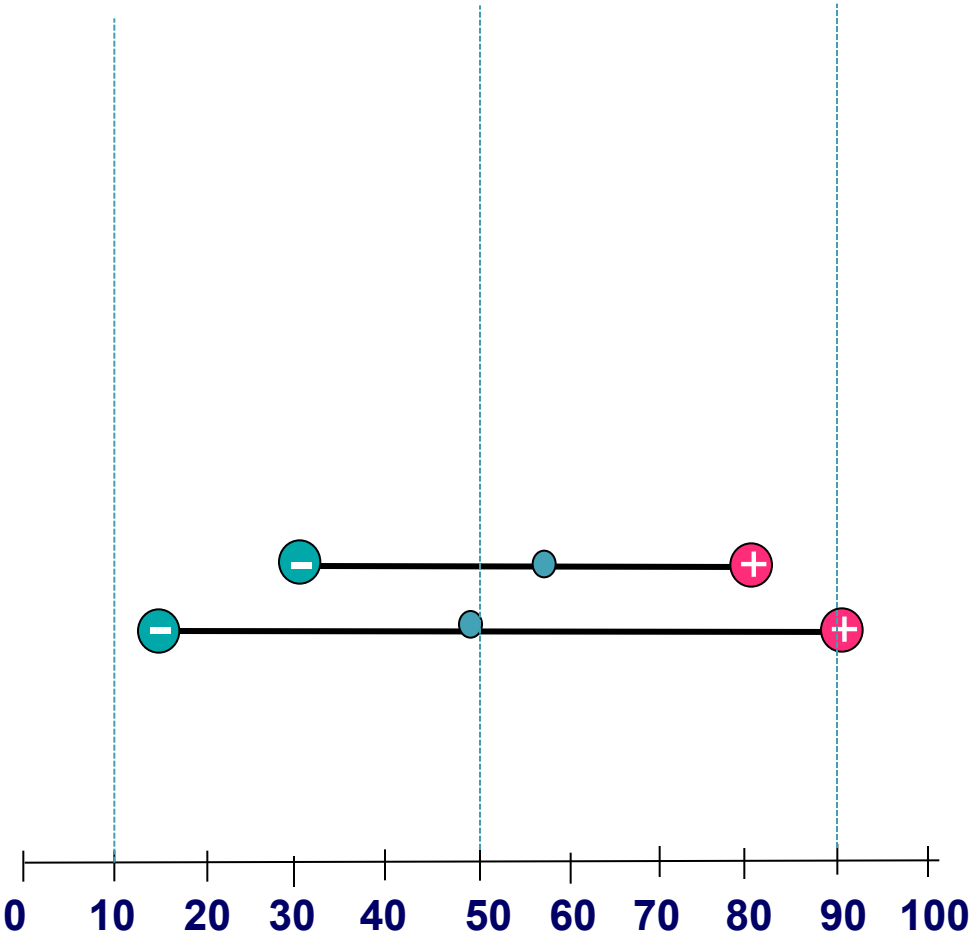

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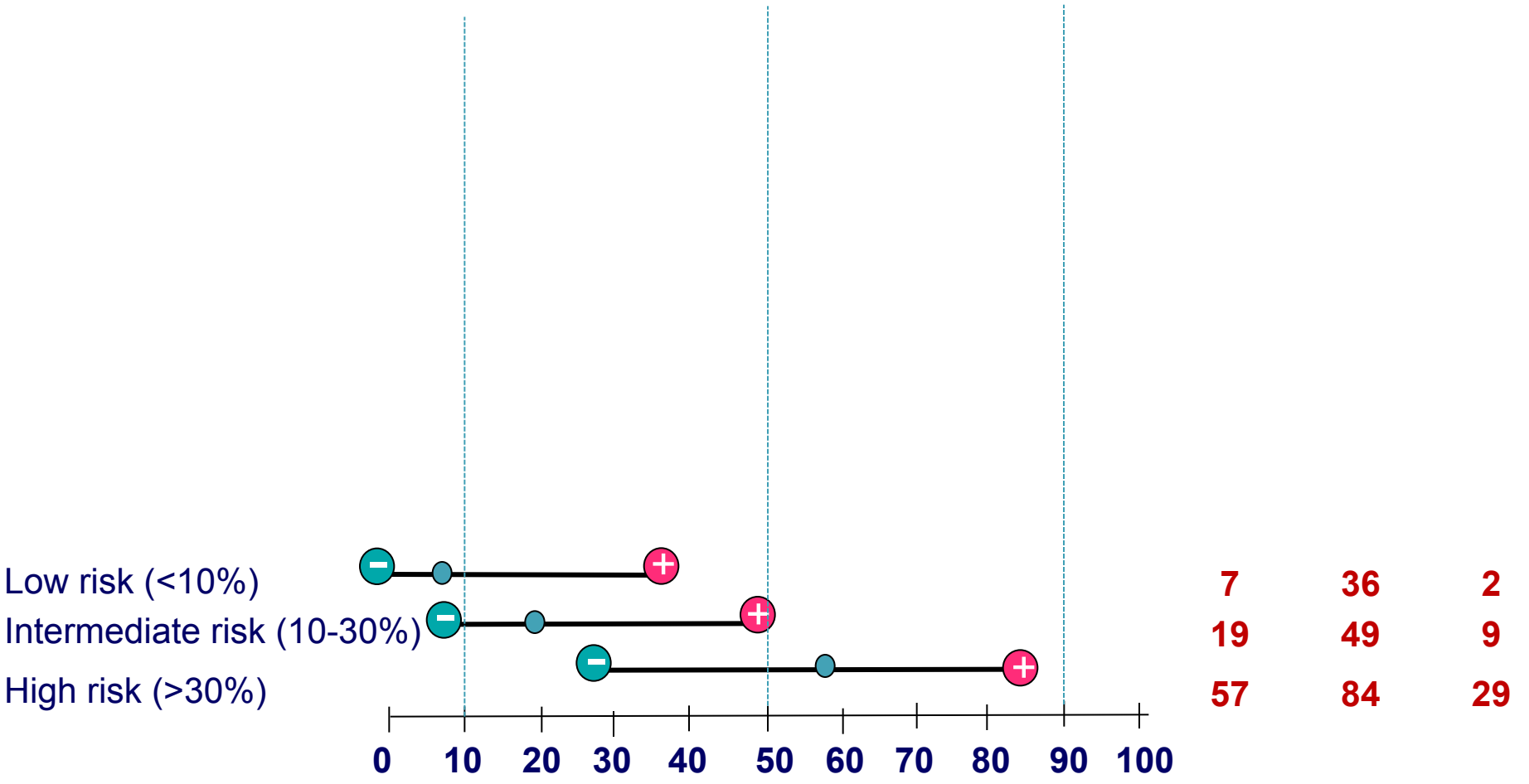

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Women	46	69	18
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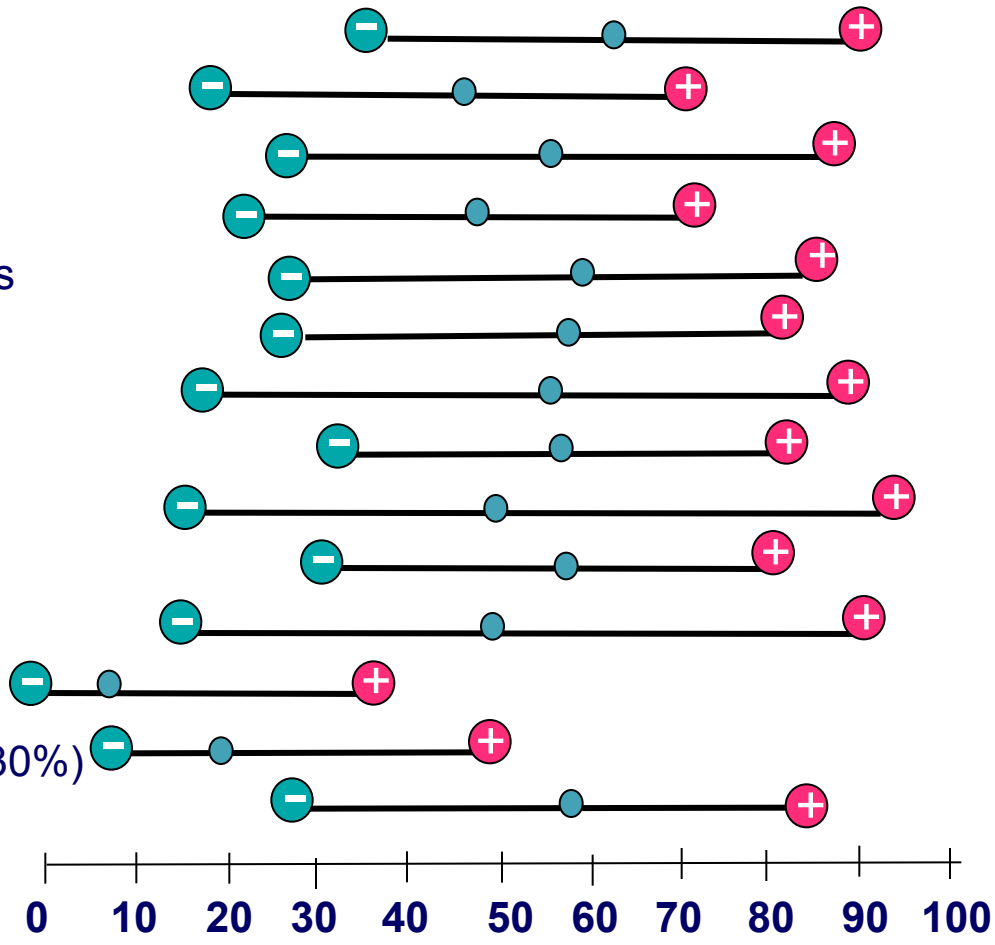
Age>60	47	70	23
Double-blinded studies	59	83	27
Treadmill ECG	57	80	28
Treadmil echo	55	89	19
Bicycle ECG	56	80	35
Bicycle echo	49	92	16
ECG	57	79	31
Echo	49	90	16
Low risk (<10%)	7	36	2
Intermediate risk (10-30%)	19	49	9
High risk (>30%)	57	84	29

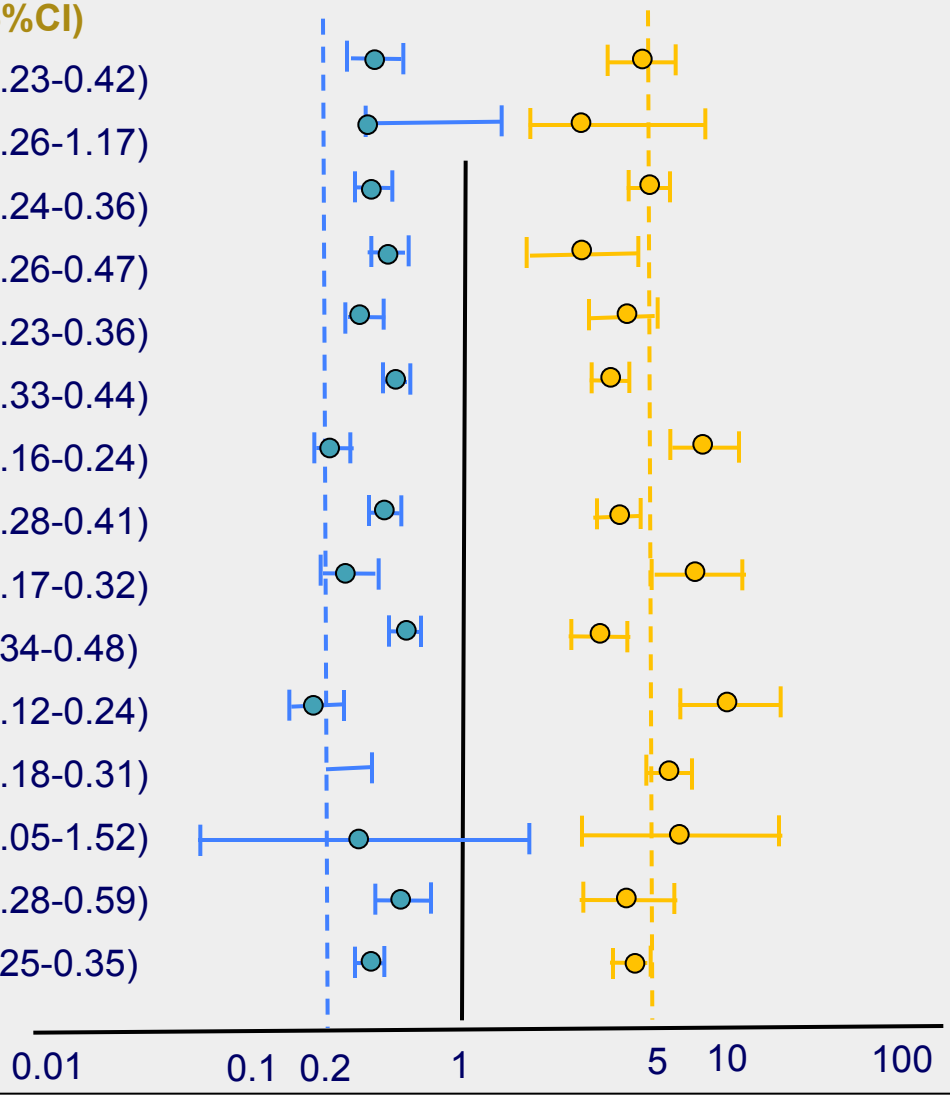


Banerjee A. Int J Clin Pract. 2012 ;66:477-92.

STRESS ECHOCARDIOGRAPHY

Subgroup analysis of positive and negative likelihood ratios for exercise testing

Study	LR+ (95% CI)	LR- (95%CI)
Men	4.36 (2.89-6.56)	0.31 (0.23-0.42)
Women	2.75 (1.42-8.92)	0.27 (0.26-1.17)
Age<60	4.74 (3.79-5.93)	0.29 (0.24-0.36)
Age>60	2.8 (1.77-4.43)	0.35 (0.26-0.47)
Double blinded studies	3.7 (2.59-5.28)	0.28 (0.23-0.36)
ECG	3.22 (2.59-4.00)	0.38 (0.33-0.44)
Echo	8.57 (5.94-12.40)	0.19 (0.16-0.24)
Treadmill ECG	3.57 (2.71-4.71)	0.34 (0.28-0.41)
Treadmill echo	7.94 (4.67-13.48)	0.24 (0.17-0.32)
Bicycle ECG	2.94 (2.18-3.96)	0.4 (0.34-0.48)
Bicycle echo	11.34 (6.31-20.38)	0.17 (0.12-0.24)
Pharm. stress imaging	6.14 (4.27-8.82)	0.24 (0.18-0.31)
Low risk <10%	7.5 (2.74-20.51)	0.28 (0.05-1.52)
Intermediate risk 10-30	4.14 (2.38-7.23)	0.41 (0.28-0.59)
High risk >30%	3.92 (3.12-4.93)	0.3 (0.25-0.35)

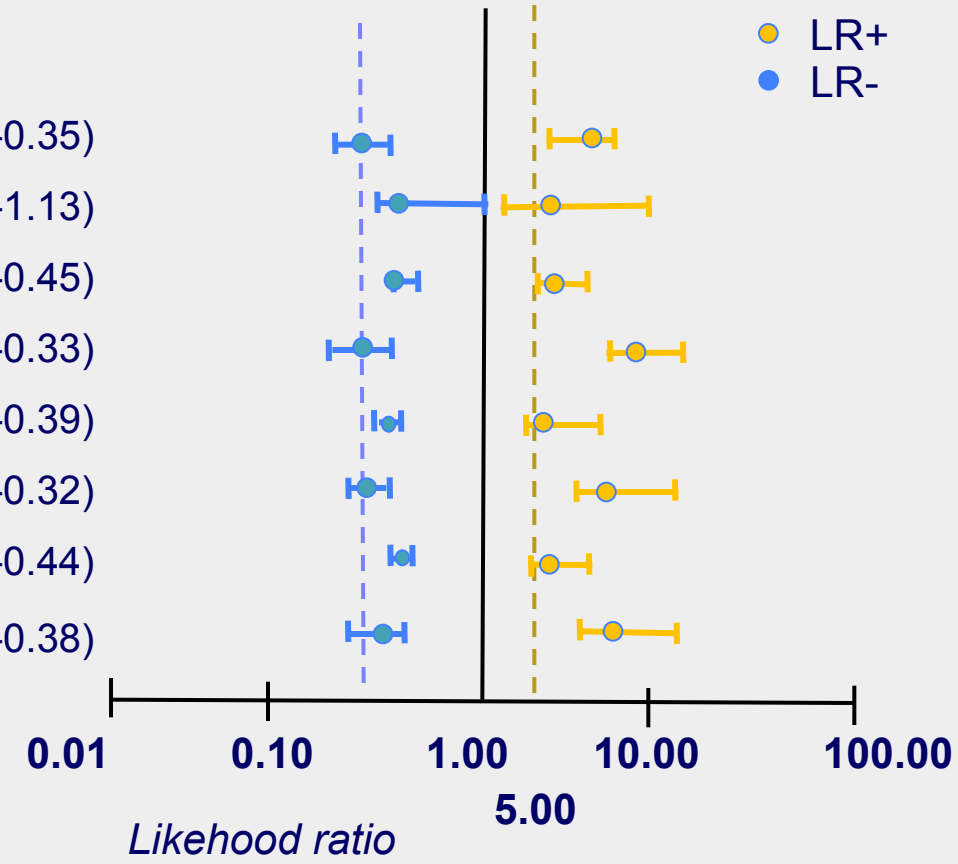


Banerjee A. Int J Clin Pract. 2012 ;66:477-92.

STRESS ECHOCARDIOGRAPHY

Sensitivity analysis of subgroup analysis of positive and negative likelihood ratios for exercise testing (including only studies of quality rating A and B)

Study	LR+	LR-
Men	3.64 (2.17-4.98)	0.23 (0.16-0.35)
Women	2.20 (1.31-6.53)	0.32 (0.27-1.13)
ECG	2.26 (1.97-3.46)	0.34 (0.31-0.45)
Echo	6.48 (4.39-11.13)	0.22 (0.16-0.33)
Treadmill ECG	2.18 (1.67-4.38)	0.32 (0.26-0.39)
Treadmill echo	5.12 (3.25-10.91)	0.23 (0.18-0.32)
Bicycle ECG	2.47 (2.03-3.91)	0.37 (0.32-0.44)
Bicycle echo	4.97 (3.19-11.78)	0.29 (0.19-0.38)



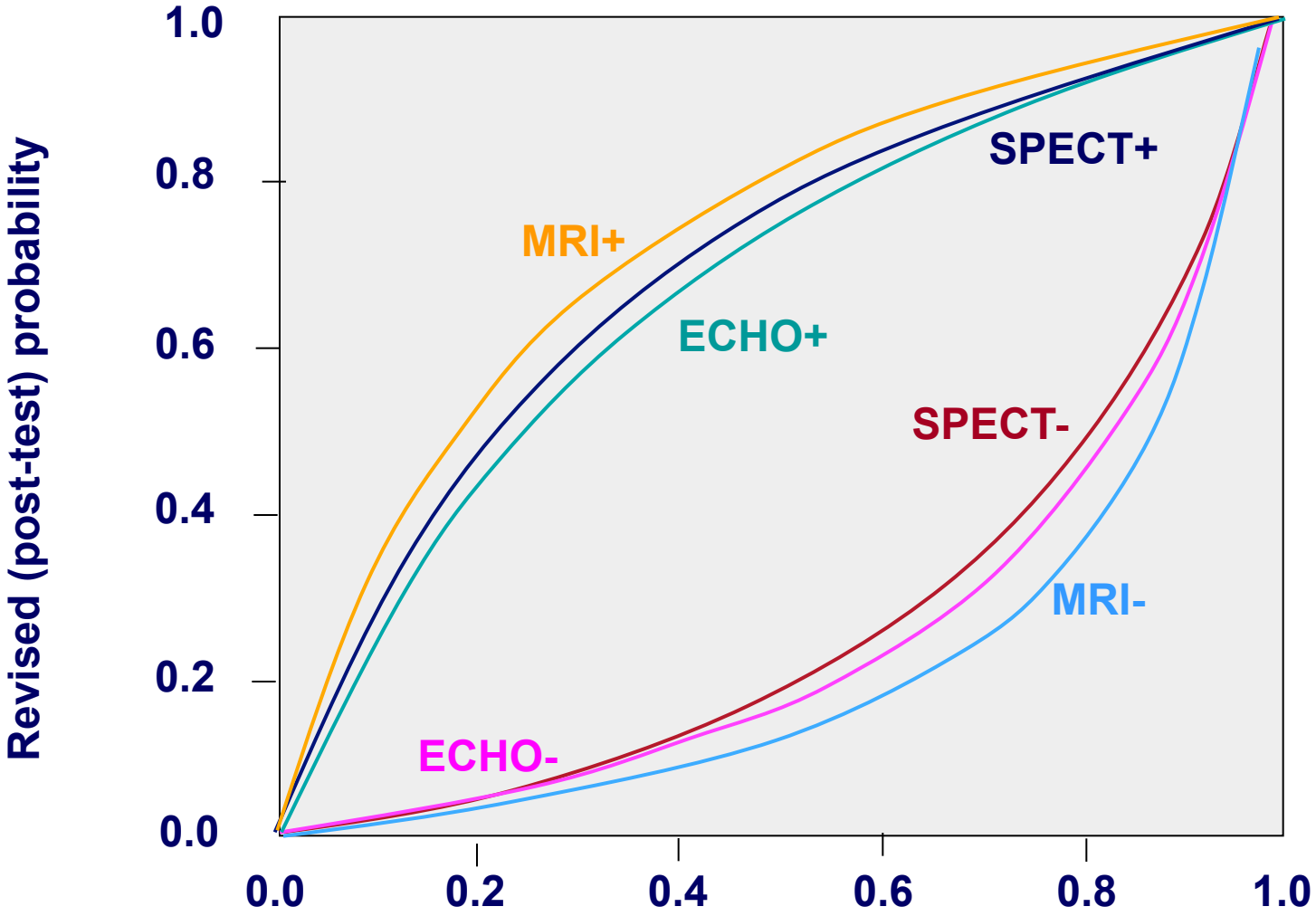
Banerjee A. Int J Clin Pract. 2012 ;66:477-92.

Diagnostic performance of noninvasive myocardial perfusion imaging using SPECT, CMR, and PET imaging for the detection of obstructive CAD

Characteristics	Studies n	Ss (95%CI)	Sp (95% CI)	DOR (95% CI)	RDOR (95% CI)	p
Patients basis						
SPECT	105	88 (88-89)	61 (59-62)	15.31 (12.66-18.52)		-
CMR	27	89 (88-91)	76 (73-78)	26.42 (17.69-39.47)	1.67 (1.07-2.61)	<0.05
PET	11	84 (81-87)	81 (74-87)	36.47 (21.48-61.92)	2.25 (1.05-4.84)	<0.05
Coronary territory basis						
SPECT	45	69 (68-70)	79 (78-80)	11.75 (9.26-14.91)		-
CMR	17	84 (81-86)	83 (81-86)	24.11 (15.68-37.07)	2.58 (1.53-4.35)	<0.001
PET	7	77 (73-81)	88 (84-90)	24.74 (15.57-39.30)	2.30 (1.10-4.77)	<0.05

Jaarsma C. J Am Coll Cardiol 2012;59:1719–28

STRESS ECHOCARDIOGRAPHY



De Jong MC. Eur Radiol 2012;22:1881-95

1- General Considerations

2- Diagnosis of myocardial ischemia

3- Potential impact of 3D / strain

Real Time Three-Dimensional Stress Echocardiography Advantages and Limitations

Advantages and Limitations of RT-3D-SE

Advantages

1. Shorter acquisition time.
2. User friendly and less operator-dependent.
3. Good interobserver agreement. Reproducible.
4. Precise alignment/anatomically correct tomographic section. More accurate comparison of matched rest and stress images.
5. Full volume acquisition of entire true LV. Multiple sections of the LV and apical region essentially eliminate problems related to off-axis image acquisition or LV foreshortening.
6. Quantitative assessment of LV volume and EF **comparable to CMR**.

Abusaid GH. Echocardiography 2012;29:200-206

STRESS ECHOCARDIOGRAPHY

Real Time Three-Dimensional Stress Echocardiography Advantages and Limitations

Advantages and Limitations of RT-3D-SE

Limitations

1. **Lower spatial and temporal** (frame/volume rate) resolution especially at peak stress.
2. **Influenced by respiration, patient motion, and significant variation in heart rate causing image artifacts**.
3. **Suboptimal anterior and lateral wall visualization** related to larger transducer footprint.
4. Longer offline data analysis time

Abusaid GH. Echocardiography 2012;29:200-206

STRESS ECHOCARDIOGRAPHY

Advantages and Limitations of RT-3D-SE

Study	No	Stress	Validation	Ss 2D	Sp 2D	Ss 3D	Sp 3D
Ahmad 2001	58	DSE	Coronary angiography	79	-	88	-
Matsumura 2005	56	DSE	Thallium201-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
		DES-3D multislice	Coronary angiography	-	-	77	95

Abusaid GH. Echocardiography 2012;29:200-206

STRESS ECHOCARDIOGRAPHY

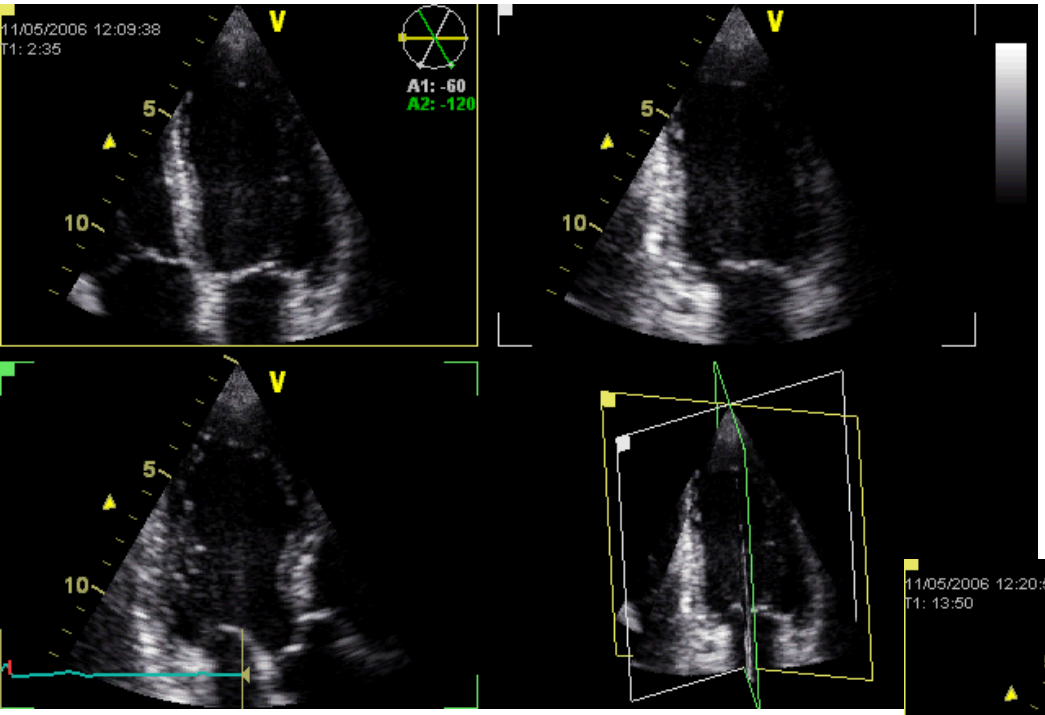
Advantages and Limitations of RT-3D-SE

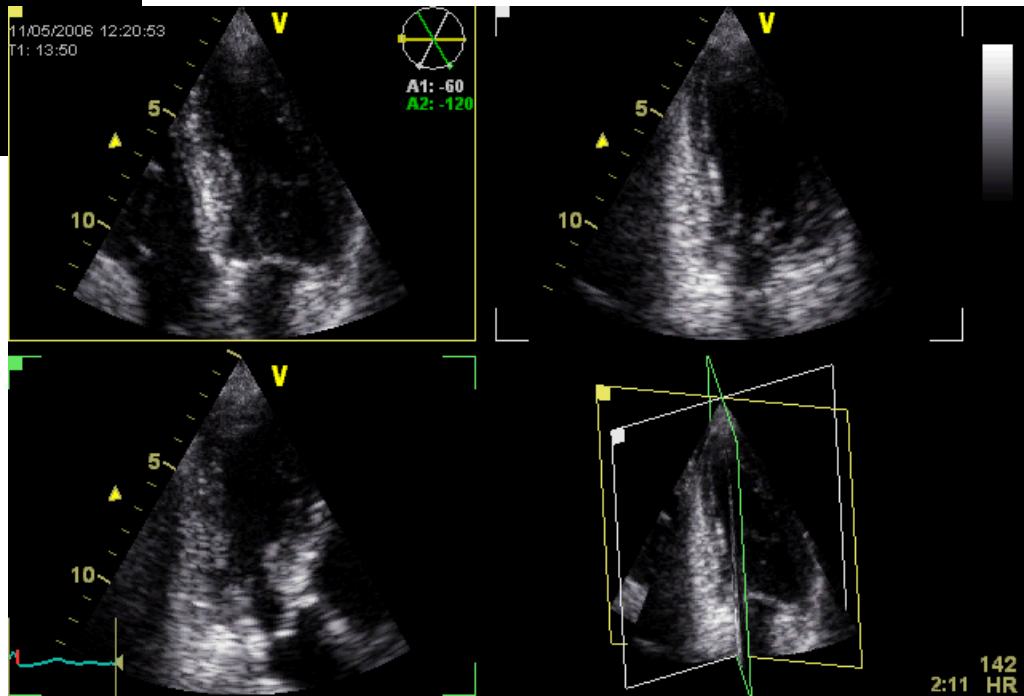
Study	No	Stress	Validation	Ss 2D	Sp 2D	Ss 3D	Sp 3D
Jenkins 2009	90	Treadmill exercise-2D	Coronary angiography	83	65		
		Treadmill exercise-3D	Coronary angiography	-	-	40	84
		Treadmill exercise-3D + CFM	Coronary angiography		-	55	78
Badano 2010	107	Dipyridamole	None	78	91	80	87
Abdelmoneim 2010	30	Adenosine 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

Abusaid GH. Echocardiography 2012;29:200-206

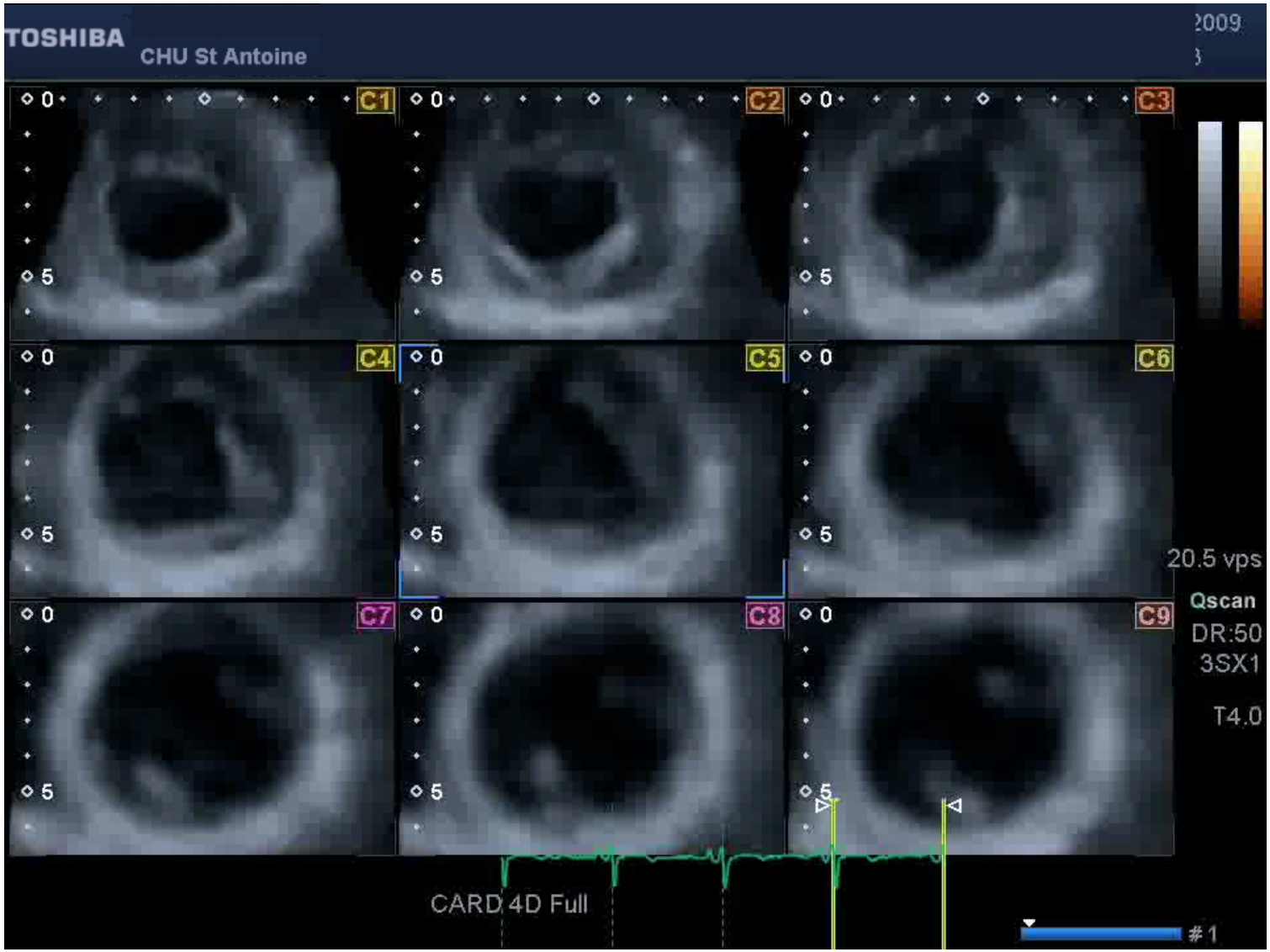
STRESS ECHOCARDIOGRAPHY

3D stress echocardiography





3D stress echocardiography



1- General Considerations

2- Diagnosis of myocardial ischemia

3- Potential impact of 3D / strain

STRESS ECHOCARDIOGRAPHY

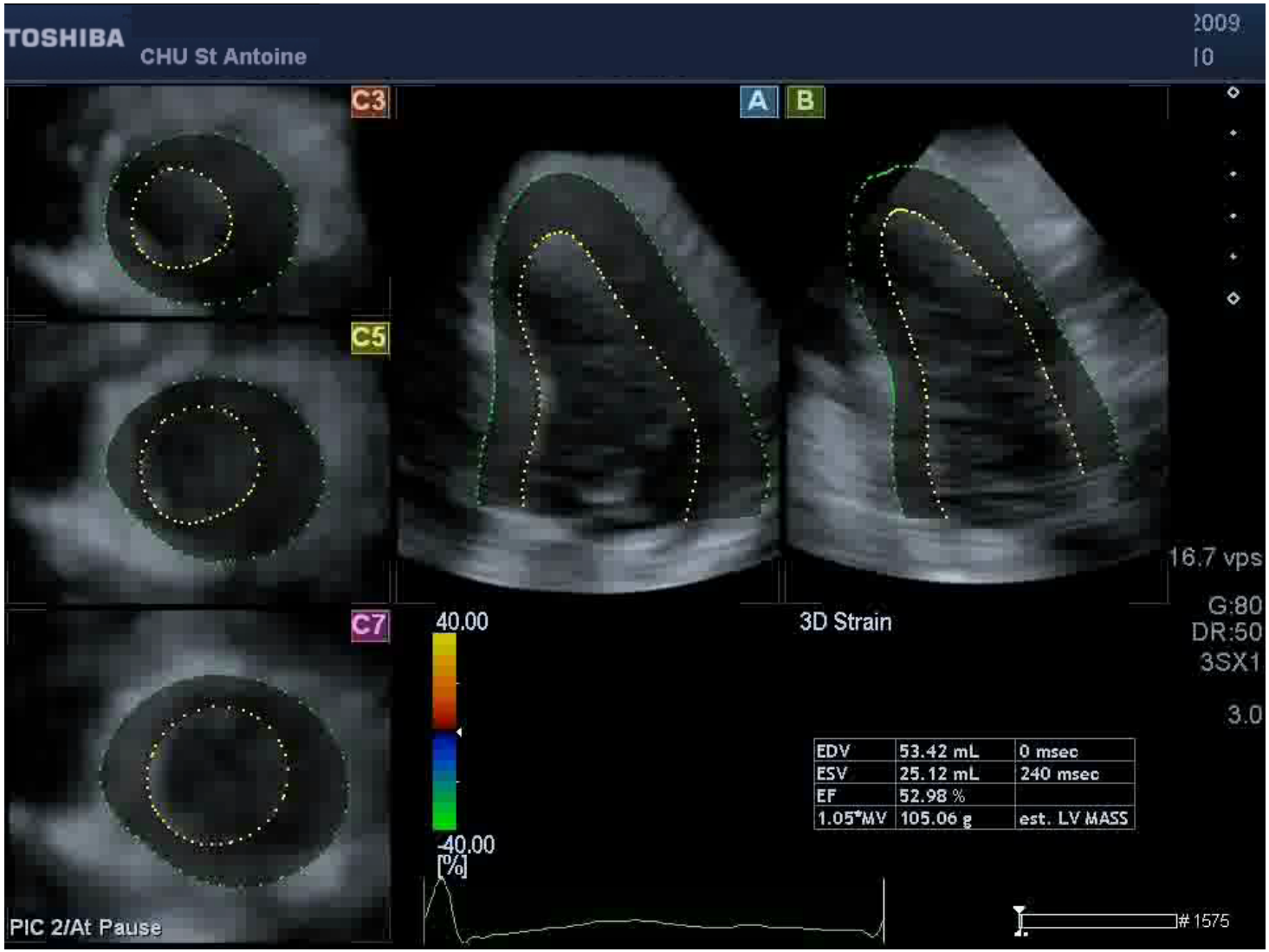
2D Strain and stress echocardiography

Multicenter study, 102 pts with concomitant DSE and coronary angiography
Longitudinal (LS), circumferential (CS), radial (RS) strain at rest and peak stress compared with WMS and significant CAD (> 50% diameter stenosis)

	Sensitivity (%)	Specificity (%)	Accuracy (%)
Mean radial strain (RS)	78.3	57.1	70.3
Global circumferential strain (CS)	73.9	78.6	75.7
Mean global longitudinal strain (LS)	**84.2**	**87.5**	**85.2**
Expert wall motion analysis (WMA)	76.0	92.9	82.1
Combination mean RS and expert WMA	95.7	57.1	81.1
Combination global CS and expert WMA	82.6	78.6	81.1
Combination mean global LS and expert WMA	**100**	**87.5**	**96.3**

Ng A. Am Heart J 2009 ; 158 : 836-44

STRESS ECHOCARDIOGRAPHY



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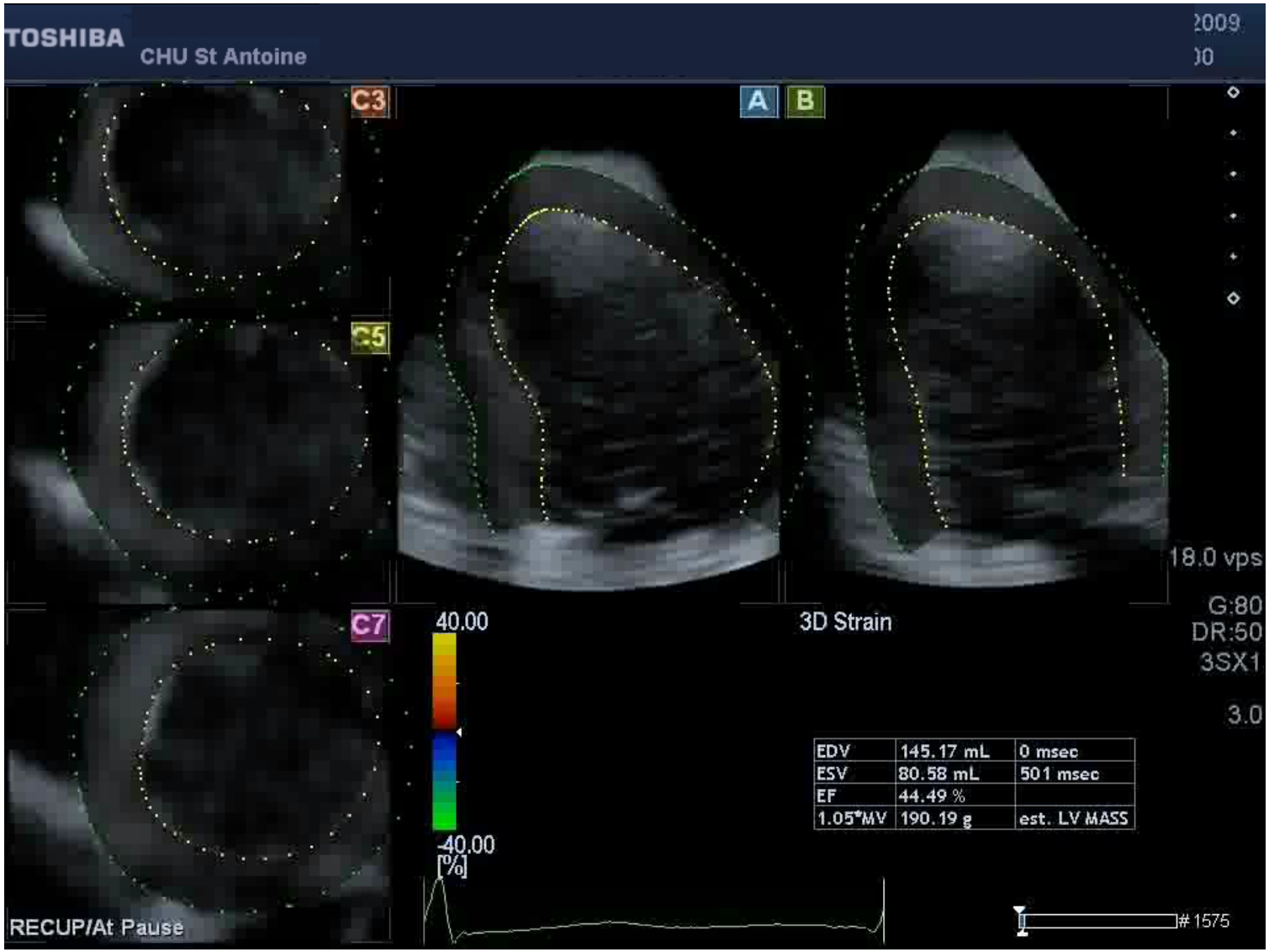


1- General Considerations

2- Diagnosis of myocardial ischemia

3- Potential impact of 3D

4- What to do in case of inconclusive test?

STRESS ECHOCARDIOGRAPHY

CLINICAL CASE 2

60 years old man

Dyslipidemia, hypertension

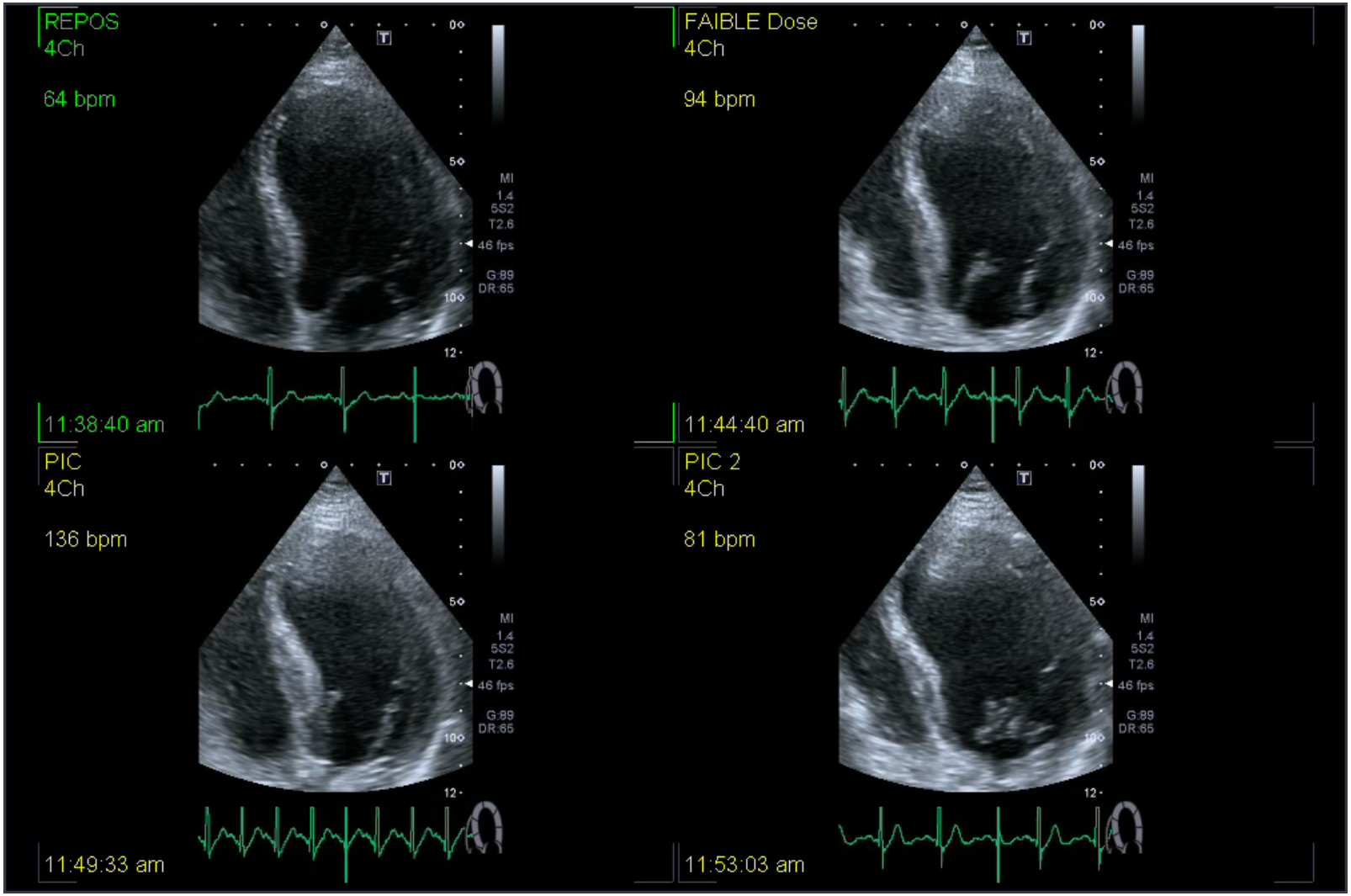
Prior MI in october 2009 with PTCA + stenting of 1^{rst} diagonal branch

Atypical chest pain, normal ECG

Dobutamine stress echocardiography (DSE)

STRESS ECHOCARDIOGRAPHY

CLINICAL CASE 2



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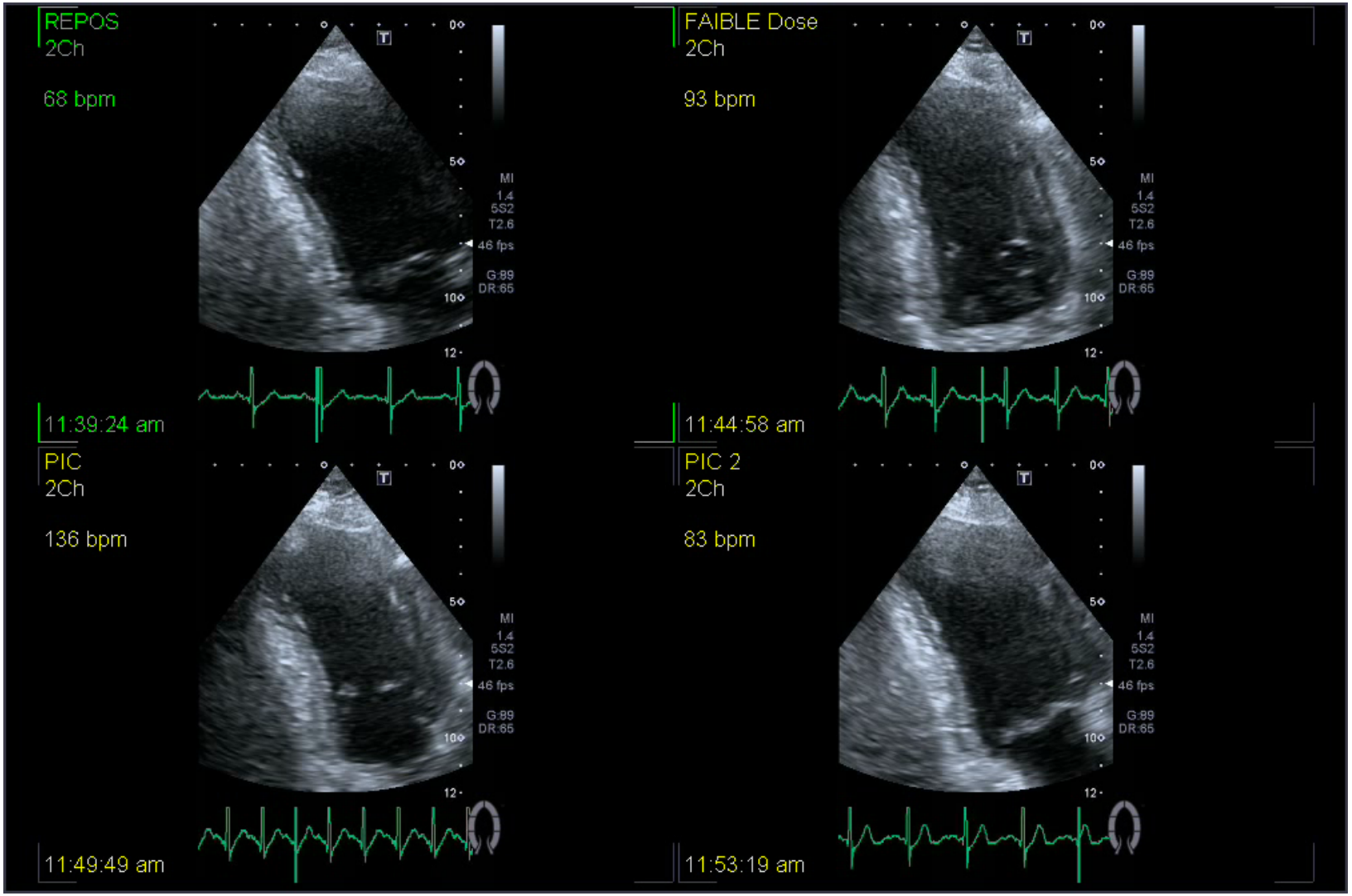

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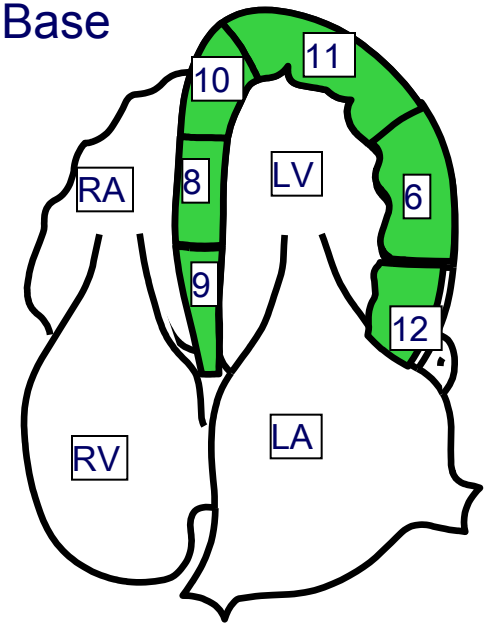

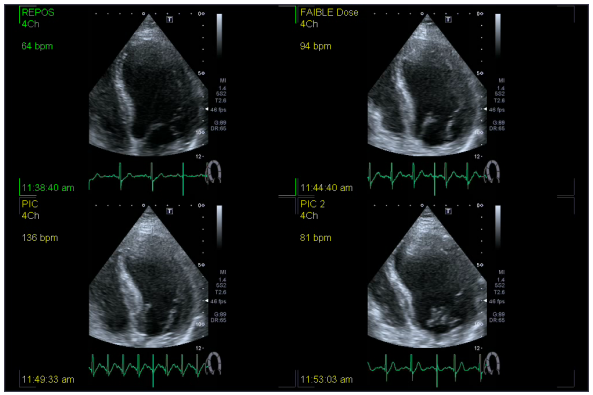

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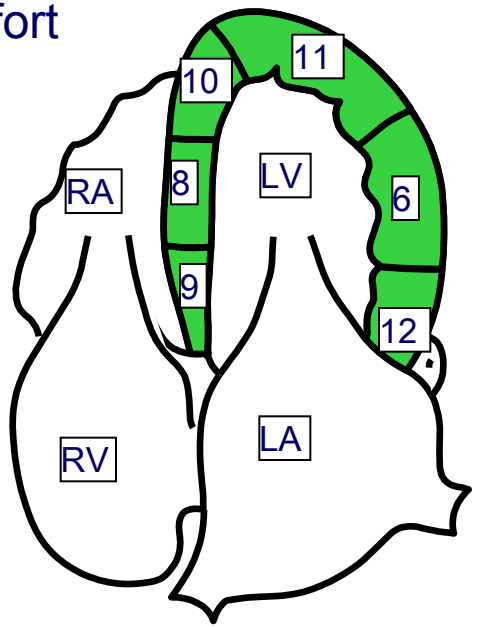
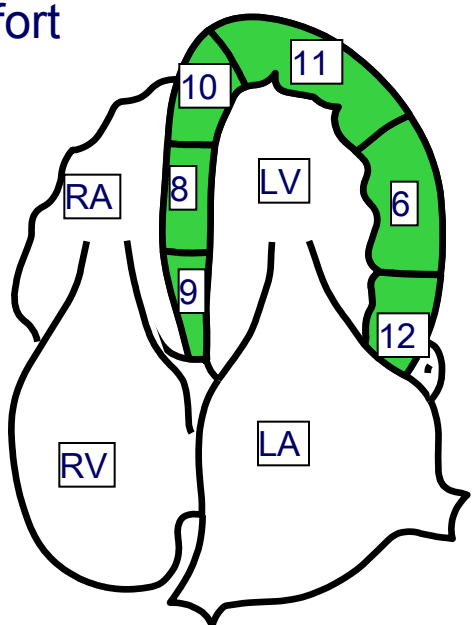
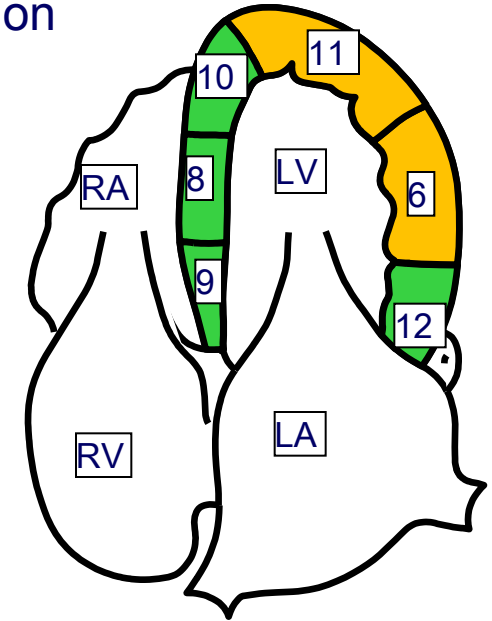


Pic Effort



Récupération



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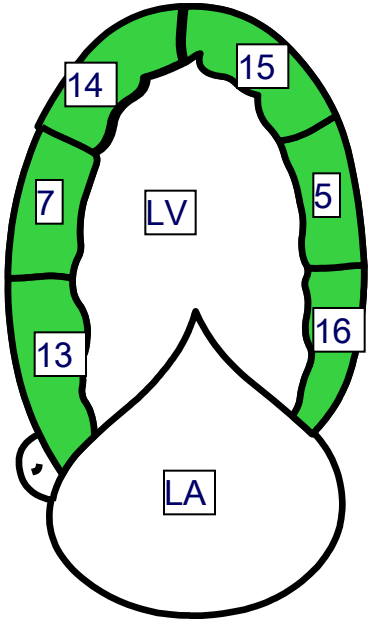

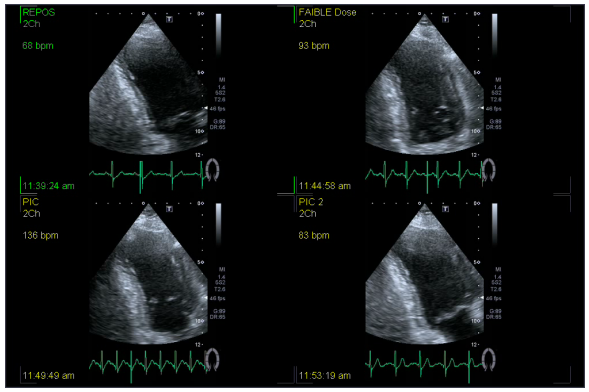

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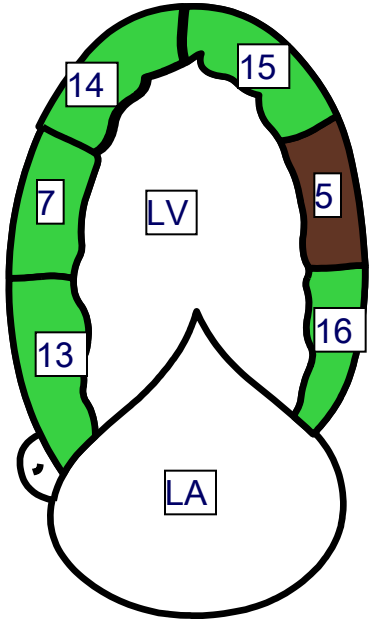

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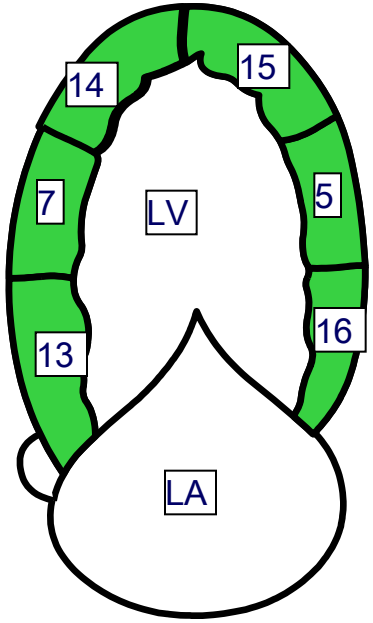

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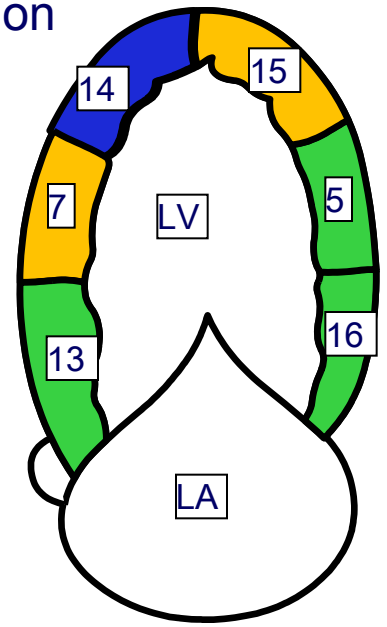
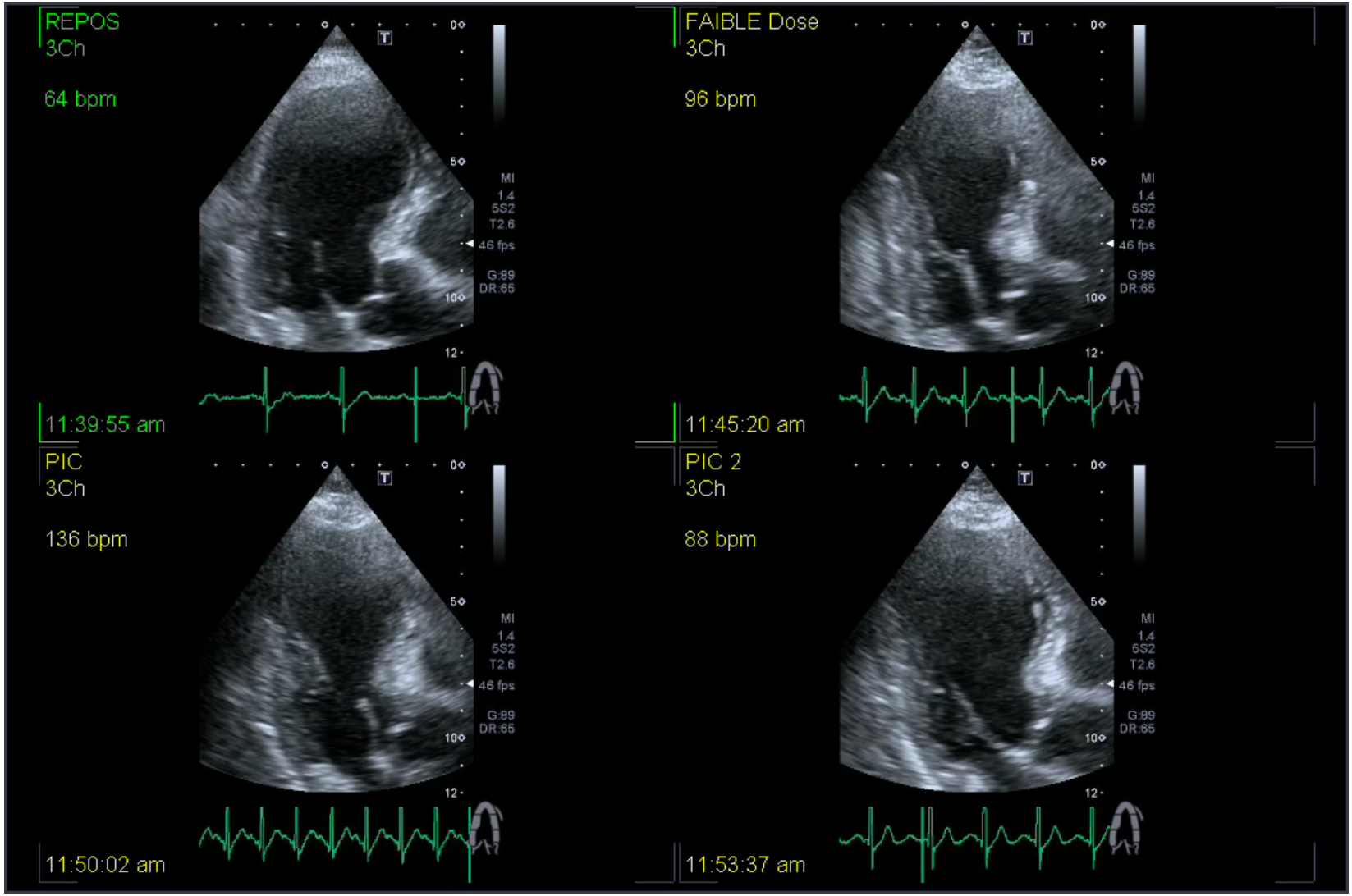


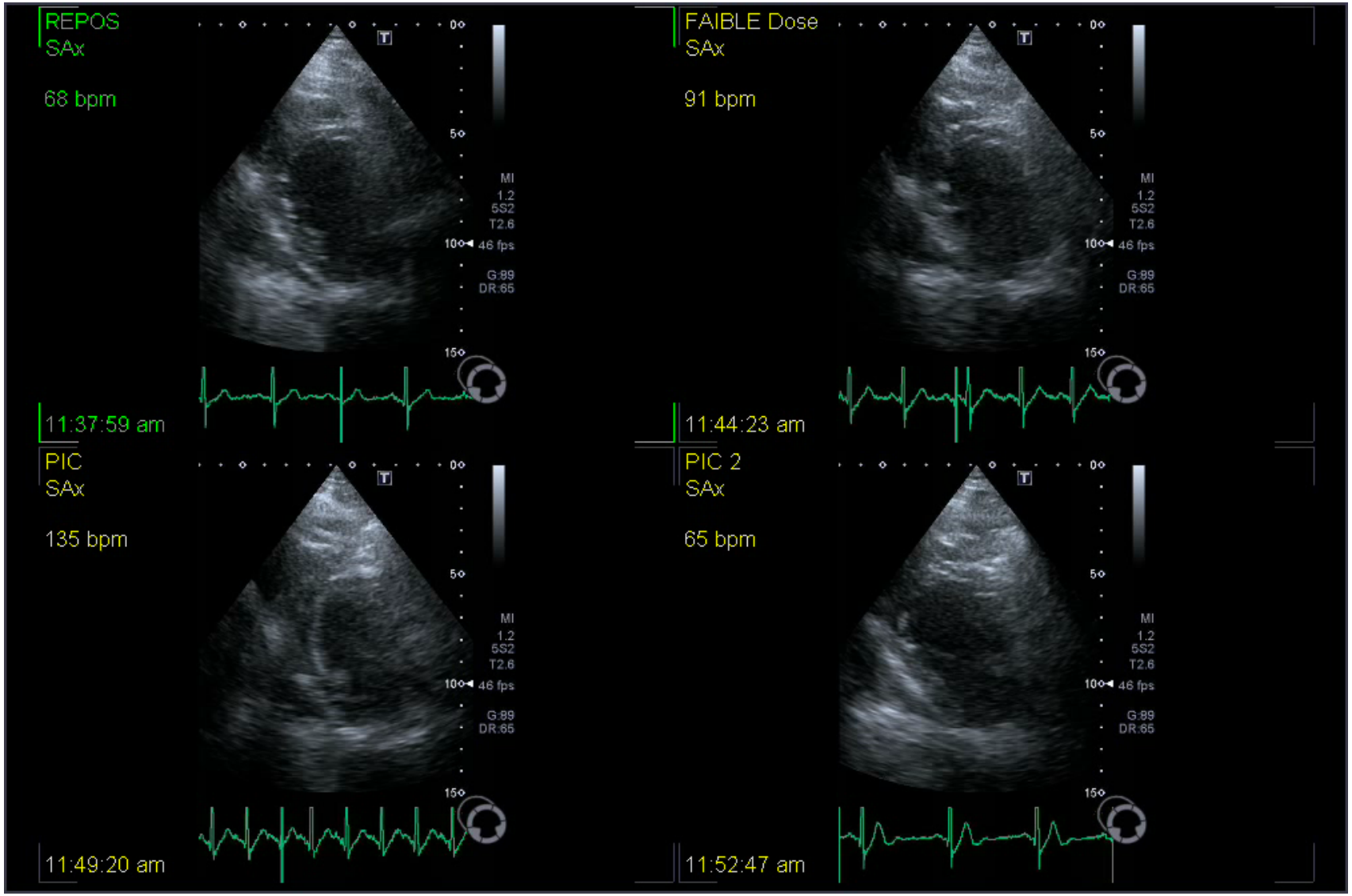
STRESS ECHOCARDIOGRAPHY

CLINICAL CASE 2



STRESS ECHOCARDIOGRAPHY

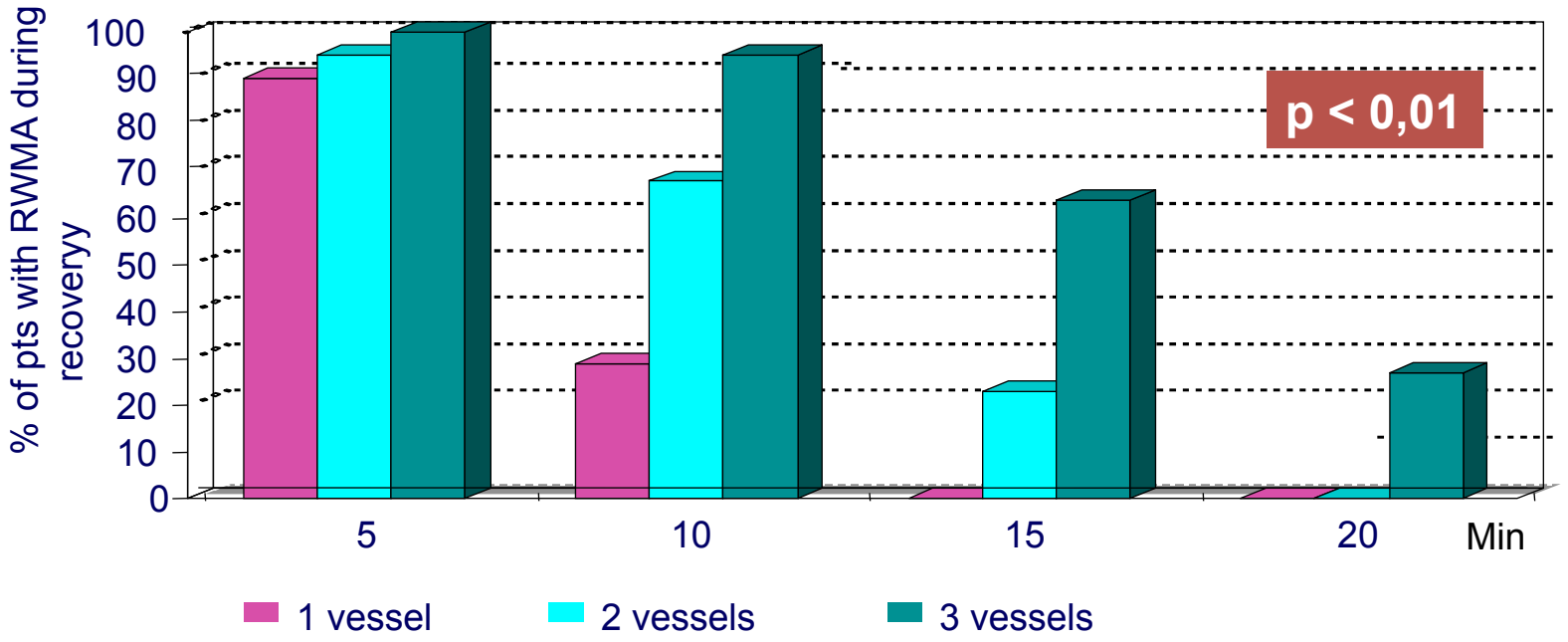
CLINICAL CASE 2



STRESS ECHOCARDIOGRAPHY

Persistant LV dysfunction during recovery

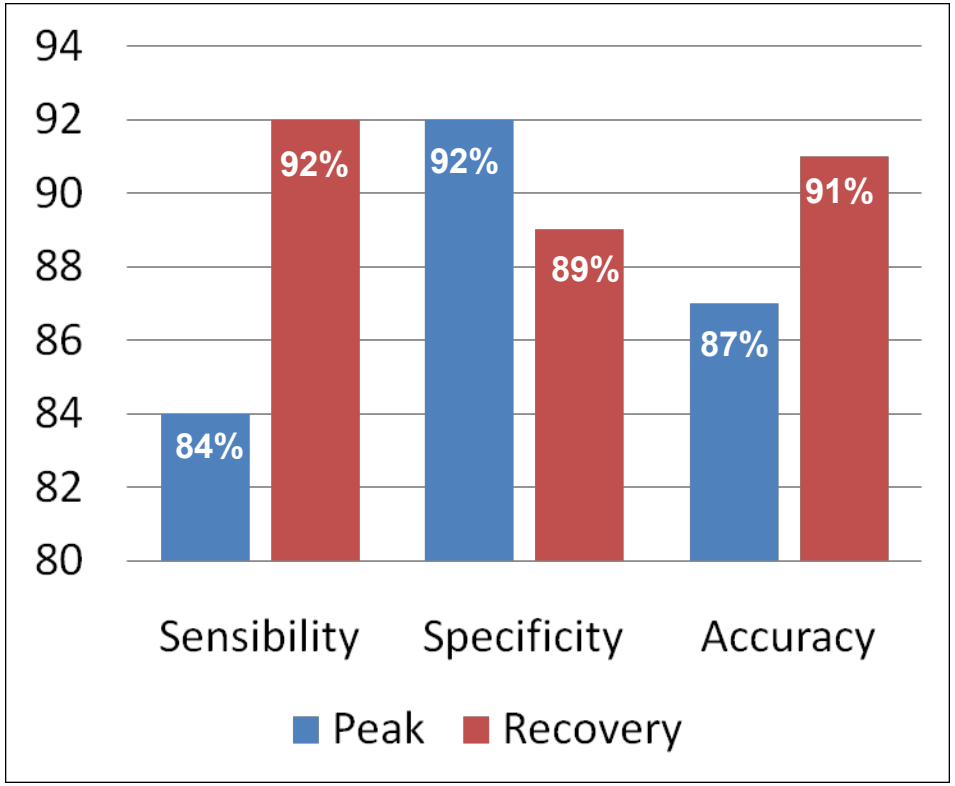
- **65 Pts with DES and coronary angiography**
- **Dobutamine ± atropine**
- **No ßblocker**

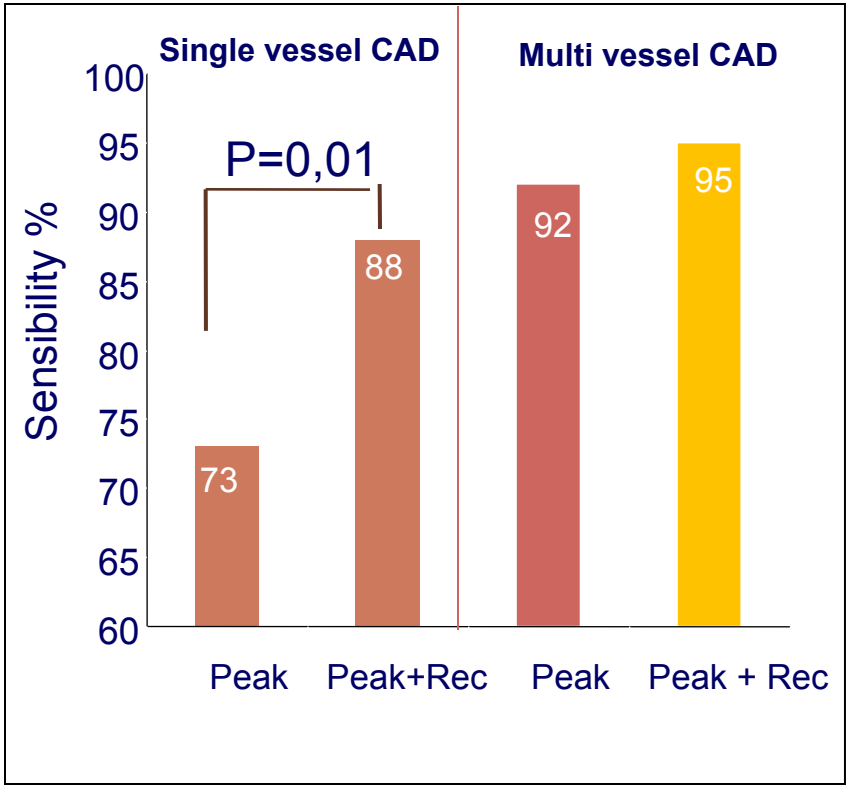


Tsoukas A. J Am Coll Cardiol 1997 ; 30 : 621-6

Diagnostic value of recovery during DSE

- 101 pts (58 yrs; 61 men) with DSE and coronary angiography
- 63% with CAD (60% with multi vessel CAD)
- 47 pts with + during peak and recovery (extension of + in 14 patients, + only in recovery in 5 pts with CAD)

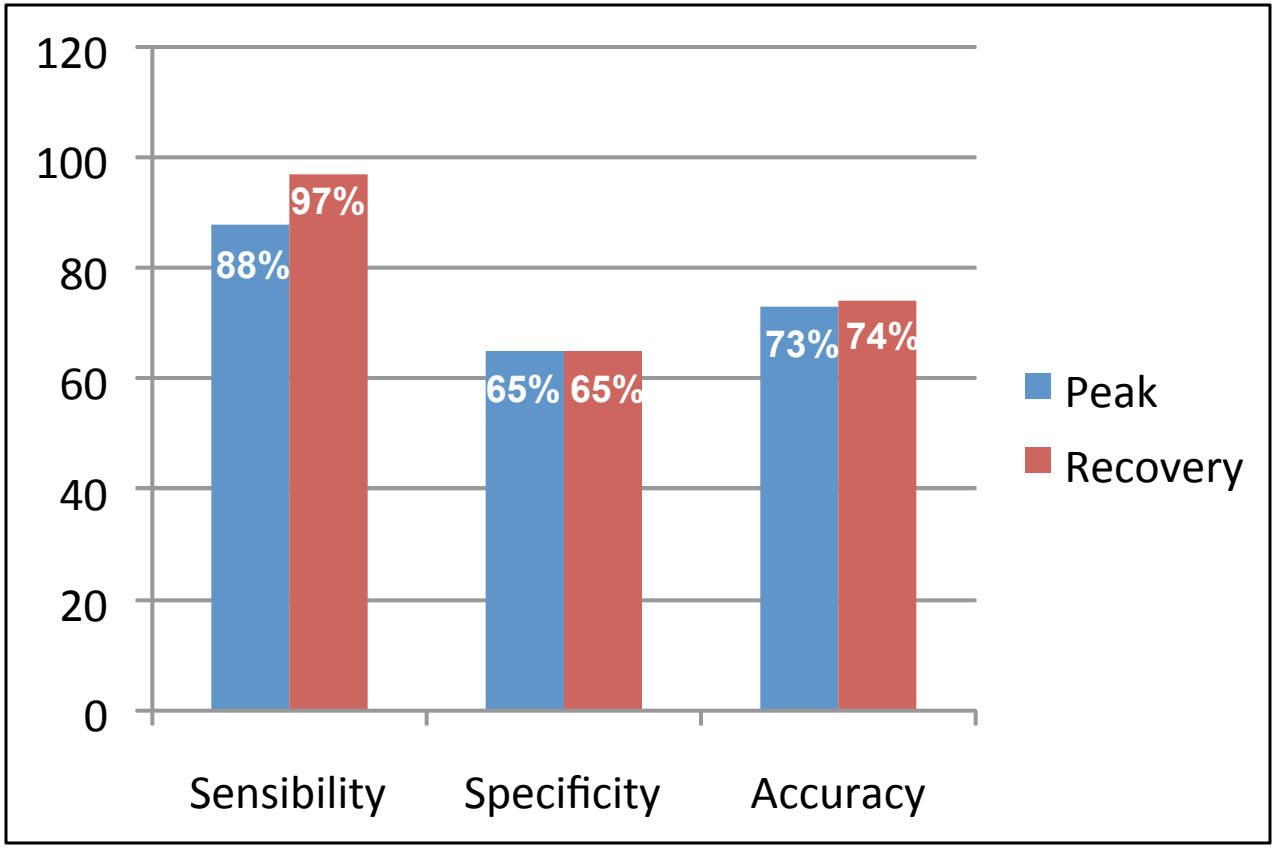




Mathias W. J Am Coll Cardiol 2003 ; 41 : 1583-9

Diagnostic value of recovery during DSE

- 200 pts with DSE and coronary angiography
- WMA for 168 pts at peak + 14 pts at recovery only
- 182 pts with CAD (86 pts with single vessel CAD)



Karagiannis SE. Am J Cardiol 2006 ; 97 : 462-5

The Value of b-Blockers Administration during Recovery Phase of Dobutamine Stress Echocardiography: A review

							Outcome				
Study	Study type	Center	Analysis	n	Mean age		SN %	SP %	AC %	PPV %	NPV %
Mathias 2003	Prospective	Single Brazil	Direct	101	58	Peak DSE	84	92	87	95	77
			Comparison			With BB	92	89	91	94	87
Karagiannis 2006	Prospective	Single Europe	Direct	200	59	Peak DSE	88	65	73		
			Comparison			With BB	97	65	74		

Nguyen J. Echocardiography 2013;0:1-7

STRESS ECHOCARDIOGRAPHY

Selecting a Noninvasive Imaging Study After an Inconclusive Exercise Test

Reason	Example	Impact on diagnostic accuracy
Insufficient workload	Inability to achieve on appropriate peak heart rate response during exercise	Reduced sensitivity
Baseline ECG changes	Resting ST segment depressions < 1 mm, LVH with repolarization abnormalities	Reduced specificity
Rapid resolution of ECG changes	Resolution of exercise-induced ST segment depressions in early recovery (eg. <1min)	Reduced specificity
Discordance between symptoms and test results	Typical angina during exercise in a high-risk patient but no diagnostic ECG changes. Inadequate blood pressure response (eg. Increase in SBP<25mmHg) in the absence of valvular disease or HF	Increased risk Reduced NPV

Blankstein R. Circulation. 2010;122:1514-1518

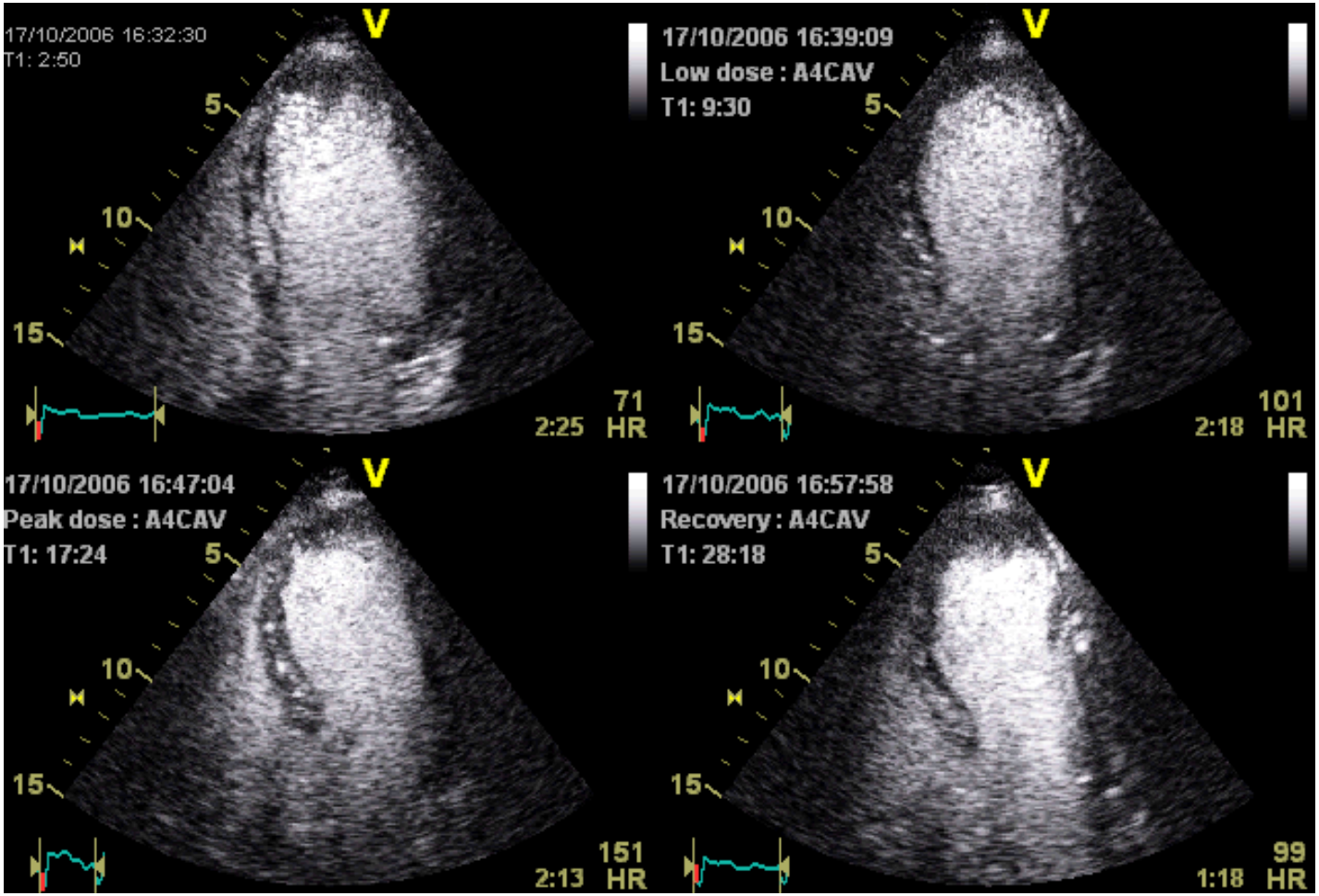
STRESS ECHOCARDIOGRAPHY

Selecting a Noninvasive Imaging Study After an Inconclusive Exercise Test

	Contraindication	Caution/warming
Dobutamine	Hypertrophic cardiomyopathy with dynamic LVOT gradient. Unstable ventricular arrhythmias	AF may cause rapid ventricular response. Hypovolemia may potentiate lowering or blood pressure. Use with caution after MI.
Adenosine	High-grade AV block (2 & 3 degree) or sinus node dysfunction unless functional pacemaker present. Known or suspected bronchoconstrictive or bronchospastic lung disease.	May cause profound vasodilation with subsequent hypotension ; use with caution in patients with autonomic dysfunction, hypovolemia, cerebrovascular insufficiency, or severe stenotic valvular disease. Use with caution in patients with unstable angina.
Regadenoson	Similar to adenosine, although current ongoing trials are investigating safety in patients with bronchoconstrictive or bronchospastic ilung disease ; when regadenoson is administered to such patients, resuscitative measures should be available.	
Dypiridamole	Similar to other vasodilators but may be safer for patients with AV block, use with caution in patients with hepatic impairment.	

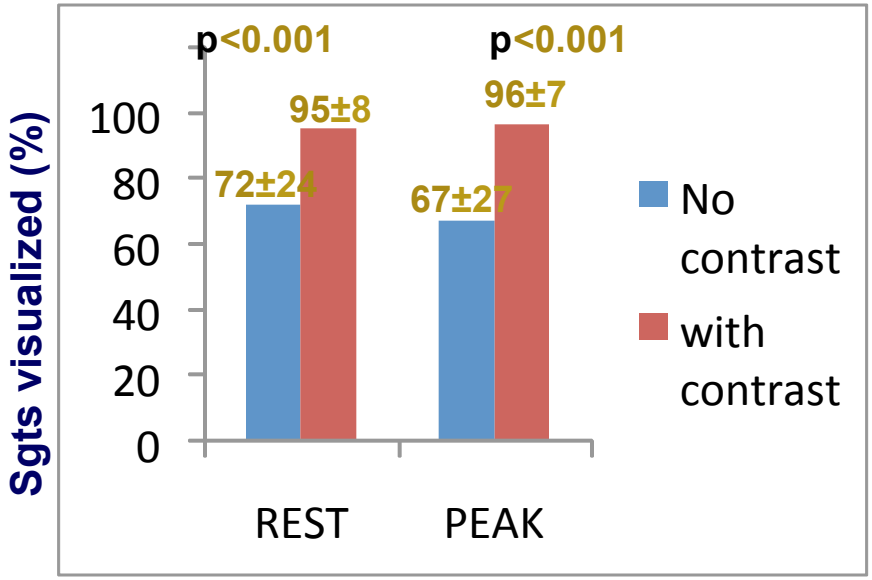
Blankstein R. Circulation. 2010;122:1514-1518

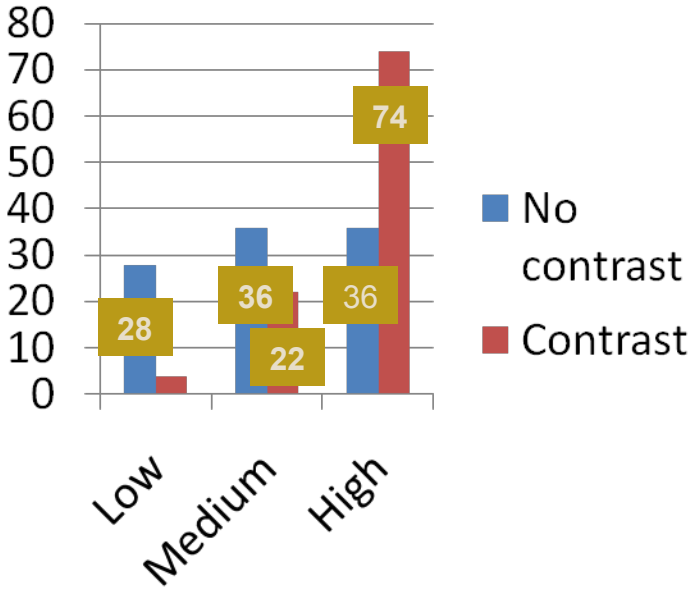
STRESS ECHOCARDIOGRAPHY



Clinical efficacy of stress contrast echocardiography

Prospective, randomized study of 101 patients (91% coronary angiography)
2 DSE with and without contrast agent (4 h - 24-h)





Contrast agent administration improves endocardial visualization at rest and peak

with a higher confidence of interpretation and greater accuracy in evaluating CAD

Accurate detection of ischemia higher with contrast-enhanced studies versus nonenhanced studies (p<0.02)

Plana JC. JACC Cardiovascular Imaging 2008 ; 1 : 145-52

Clinical efficacy of stress contrast echocardiography

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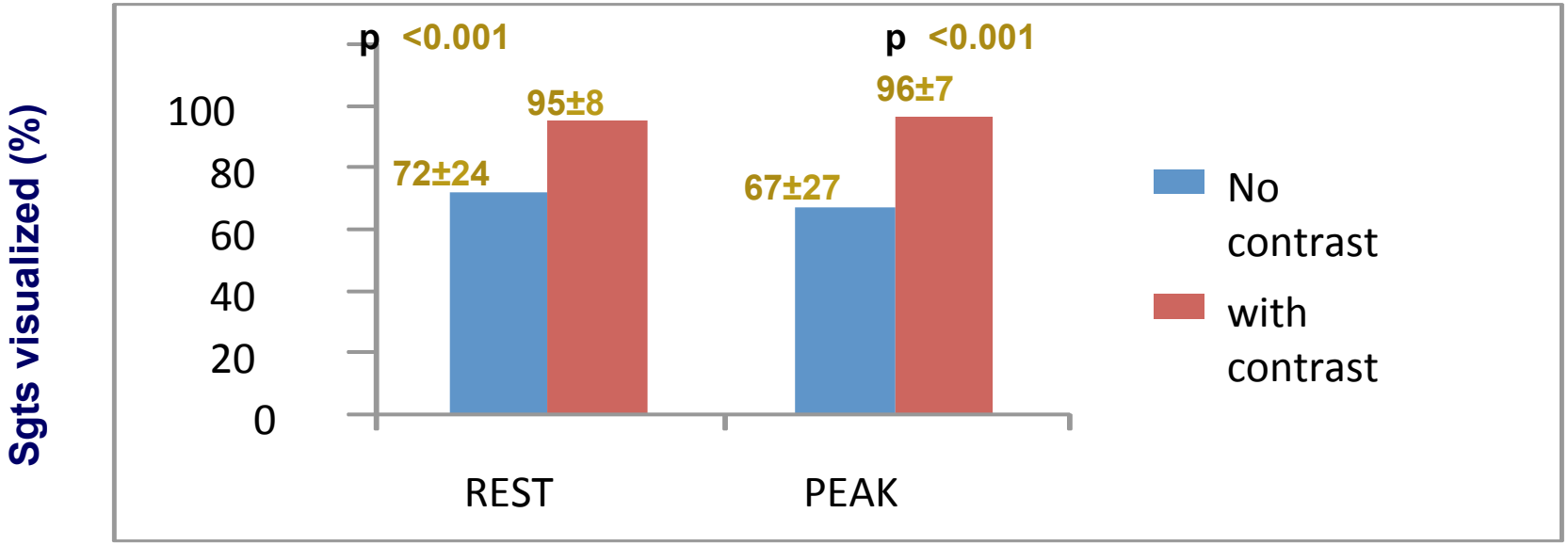

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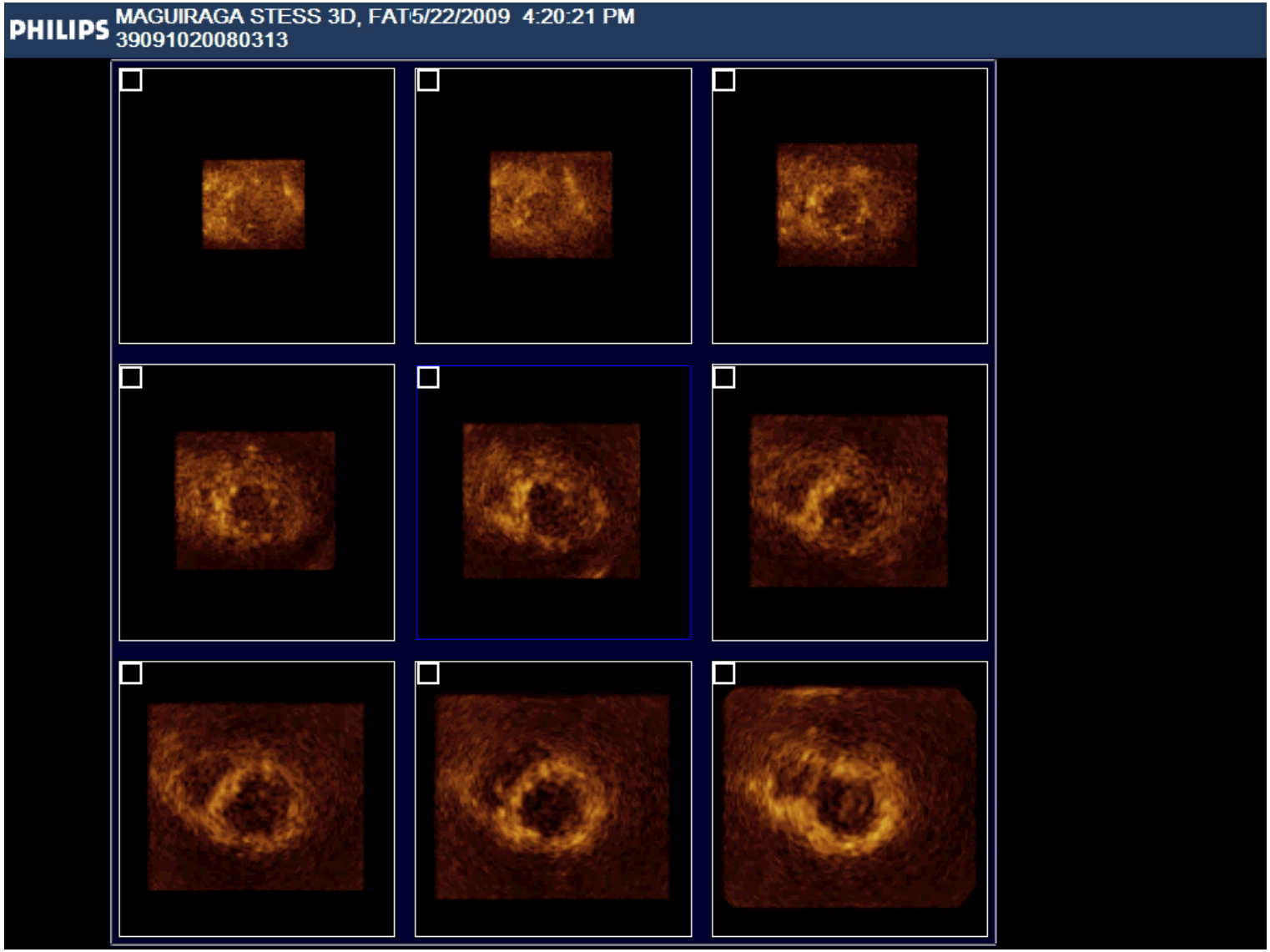
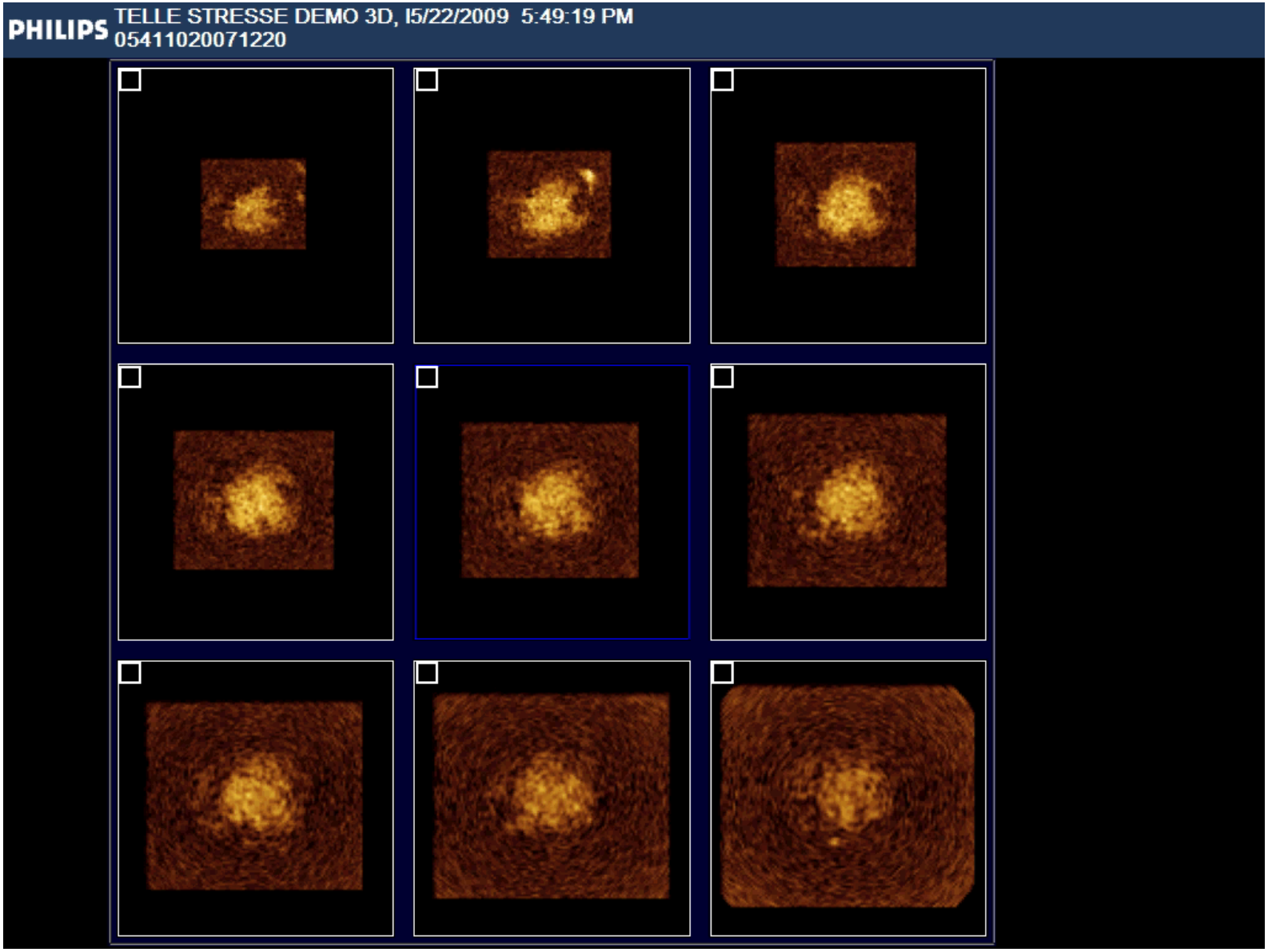
STRESS ECHOCARDIOGRAPHY

3D stress echocardiography



STRESS ECHOCARDIOGRAPHY

3D stress echocardiography



STRESS ECHOCARDIOGRAPHY

Selecting a Noninvasive Imaging Study After an Inconclusive Exercise Test

Goals of Testing After Inconclusive ETT

Identification of a need for immediate treatment for symptomatic patients

Secondary prevention of known CAD

Primary prevention of future disease

Blankstein R. Circulation. 2010;122:1514-1518

1- General Considerations

2- Diagnosis of myocardial ischemia

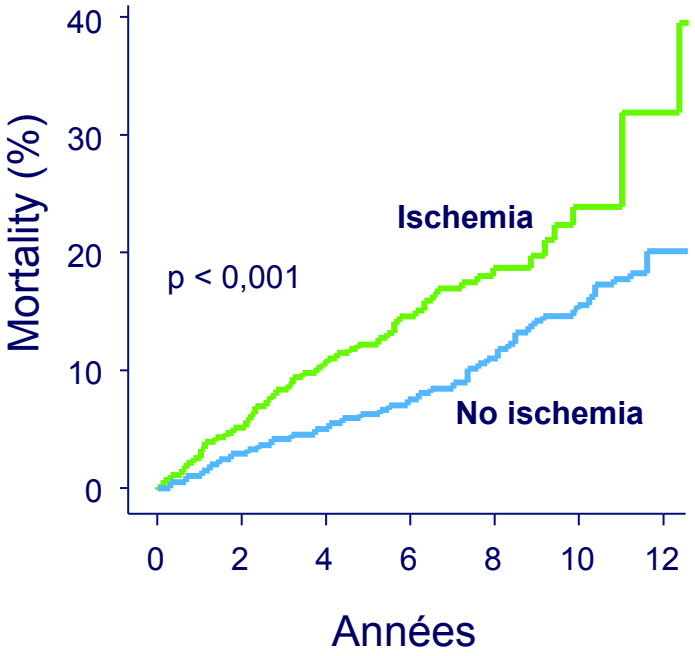
3- Potential impact of 3D

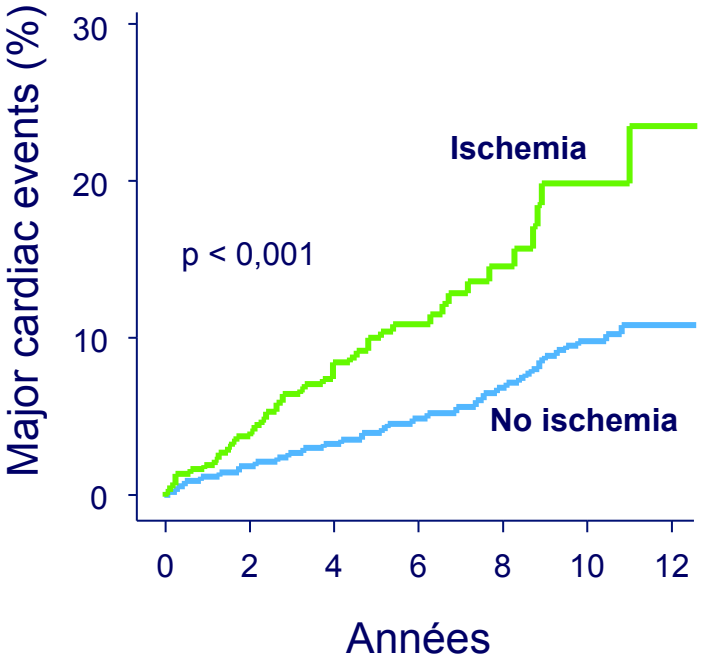
4- What to do in case of inconclusive test?

4- Prognostic impact of a stress test

STRESS ECHOCARDIOGRAPHY

Prediction of Mortality and Major Cardiac Events by Exercise Echocardiography in Patients With **Normal Exercise Electrocardiographic Testing**



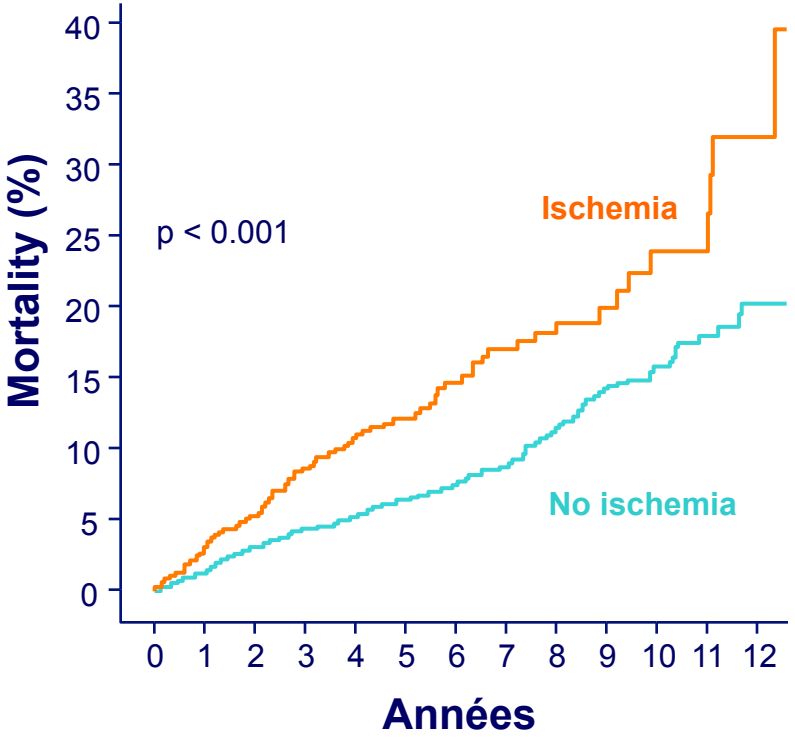


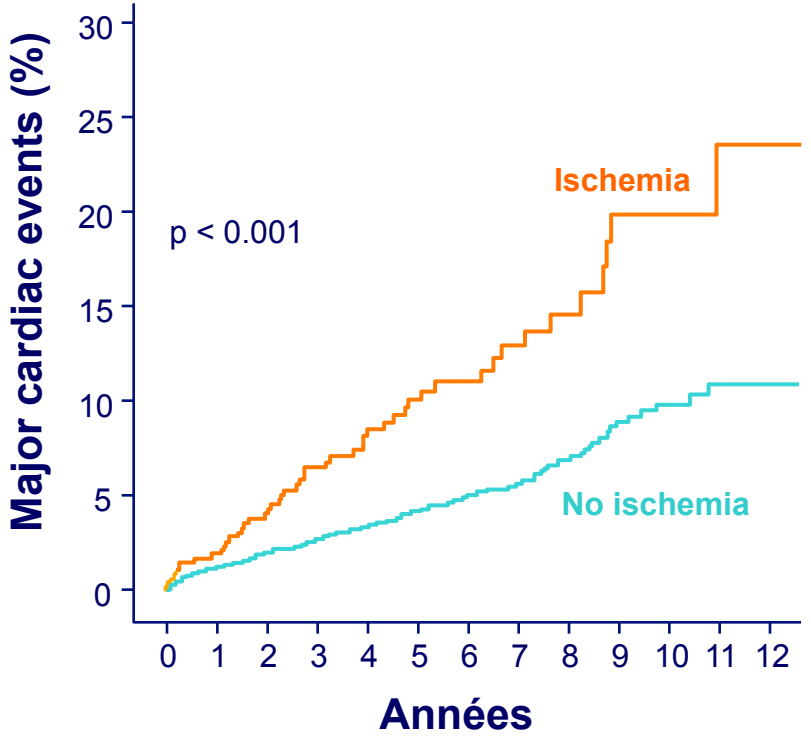
- The use of EE provides significant prognostic information for predicting mortality and MACE in patients with interpretable ECG and normal exercise ECG testing

Bouzas-Mosquera . J Am Coll Cardiol 2009;53:1981–90

STRESS ECHOCARDIOGRAPHY

Prediction of Mortality and Major Cardiac Events by Exercise Echocardiography in Patients With Normal Exercise Electrocardiographic Testing





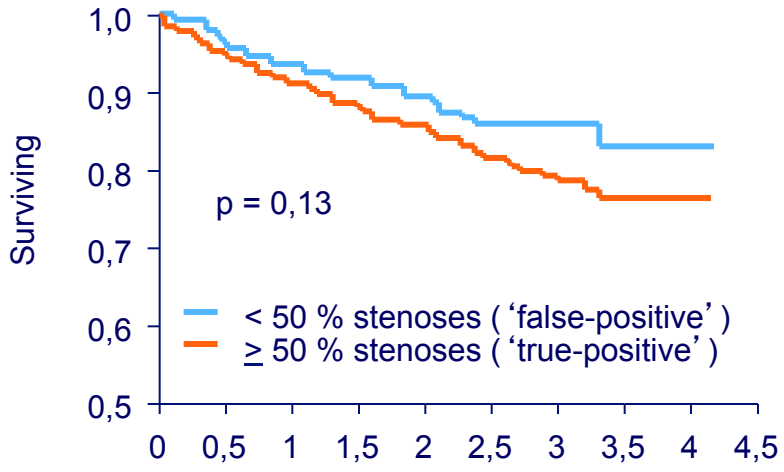
- The use of EE provides significant prognostic information for predicting mortality and MACE in patients with interpretable ECG and normal exercise ECG testing.

Bouzas-Mosquera. J Am Coll Cardiol 2009;53:1981–90

STRESS ECHOCARDIOGRAPHY

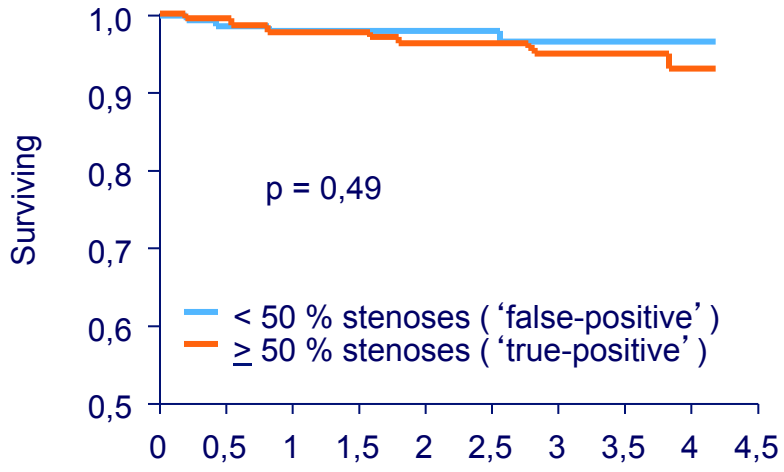
Characteristics and Outcomes of Patients With Abnormal Stress Echocardiograms and Angiographically Mild Coronary Artery Disease (<50% Stenoses) or Normal Coronary Arteries

Abnormal dobutamine stress echo



Nombre à risque					
'False-positive'	188	177	111	46	6
'True-positive'	534	490	329	161	14

Abnormal exercise echo

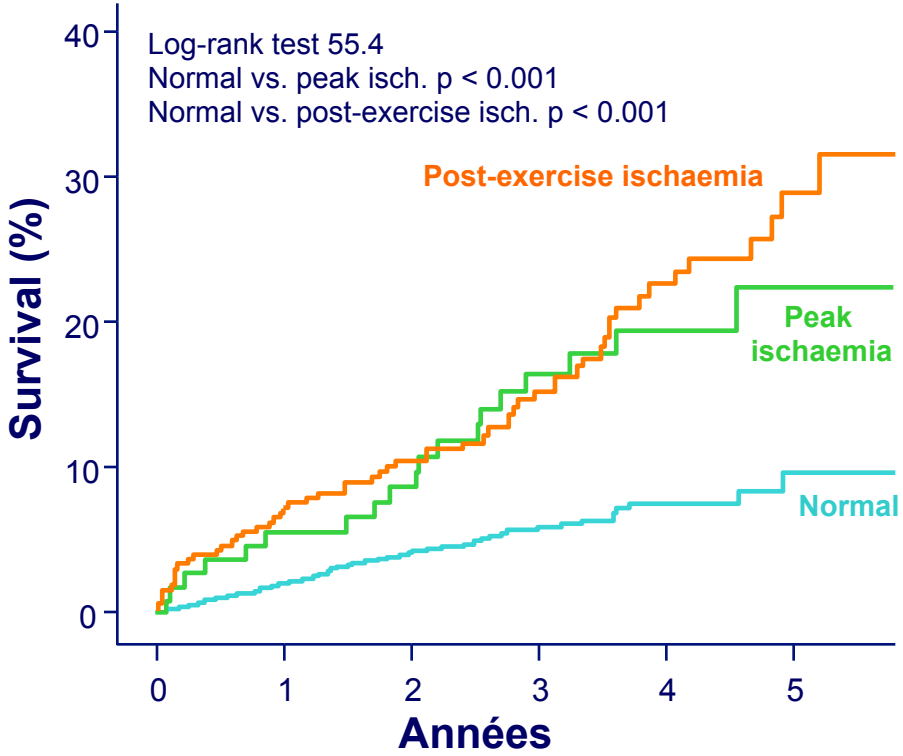


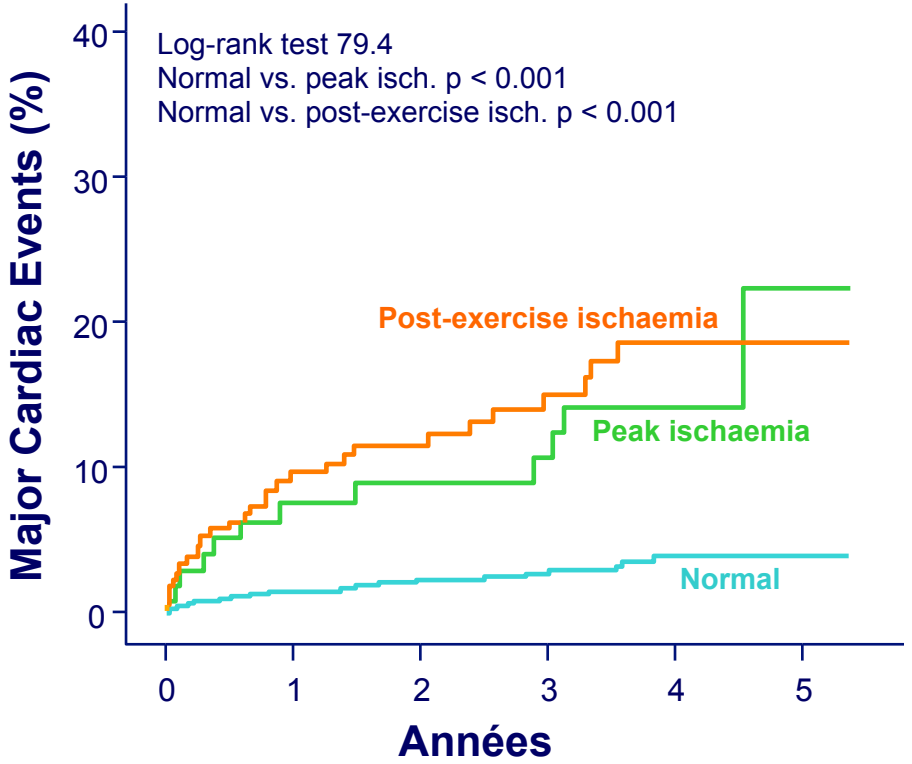
Nombre à risque					
'False-positive'	287	284	198	83	16
'True-positive'	445	439	310	176	30

From. J Am Soc Echocardiogr 2010;23:207-14

STRESS ECHOCARDIOGRAPHY

Prognostic value of **peak and post-exercise treadmill exercise echocardiography** in patients with known or suspected coronary artery disease



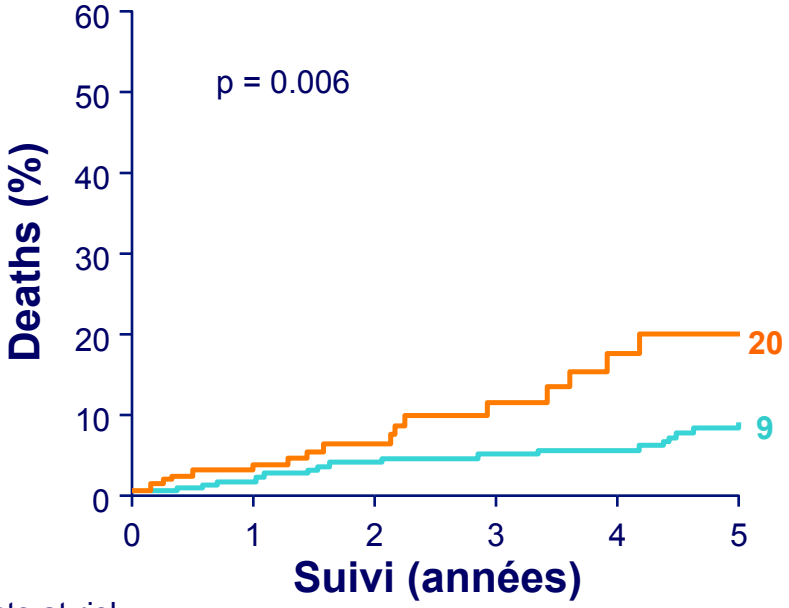


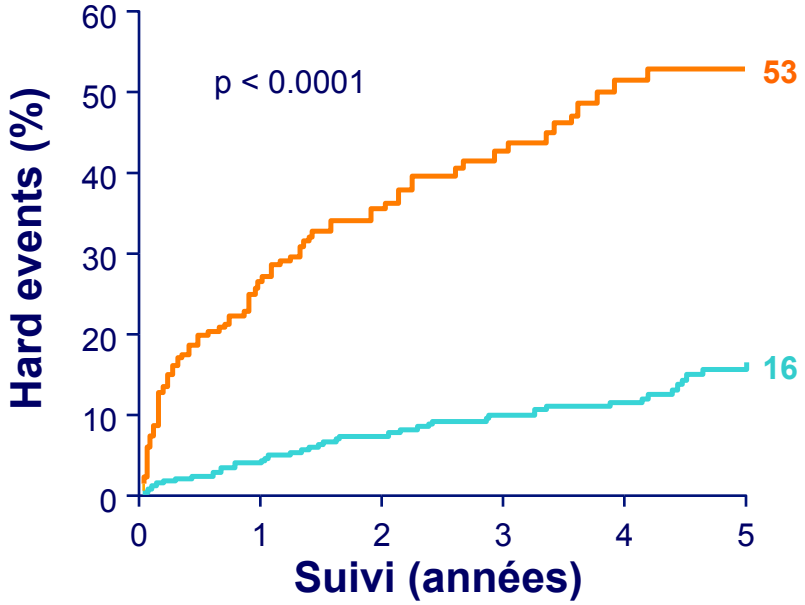
- Peak treadmill EE provides significant incremental information over post-EE for predicting outcome in patients with known or suspected CAD

Peteiro. Eur Heart J 2010. 31, 187–195

STRESS ECHOCARDIOGRAPHY

Usefulness of Stress Echocardiography for Risk Stratification of Patients After **Percutaneous Coronary Intervention**





Subjects at risk

SE (+)	333	135	91	53	37	28
SE (-)	748	556	377	259	186	129

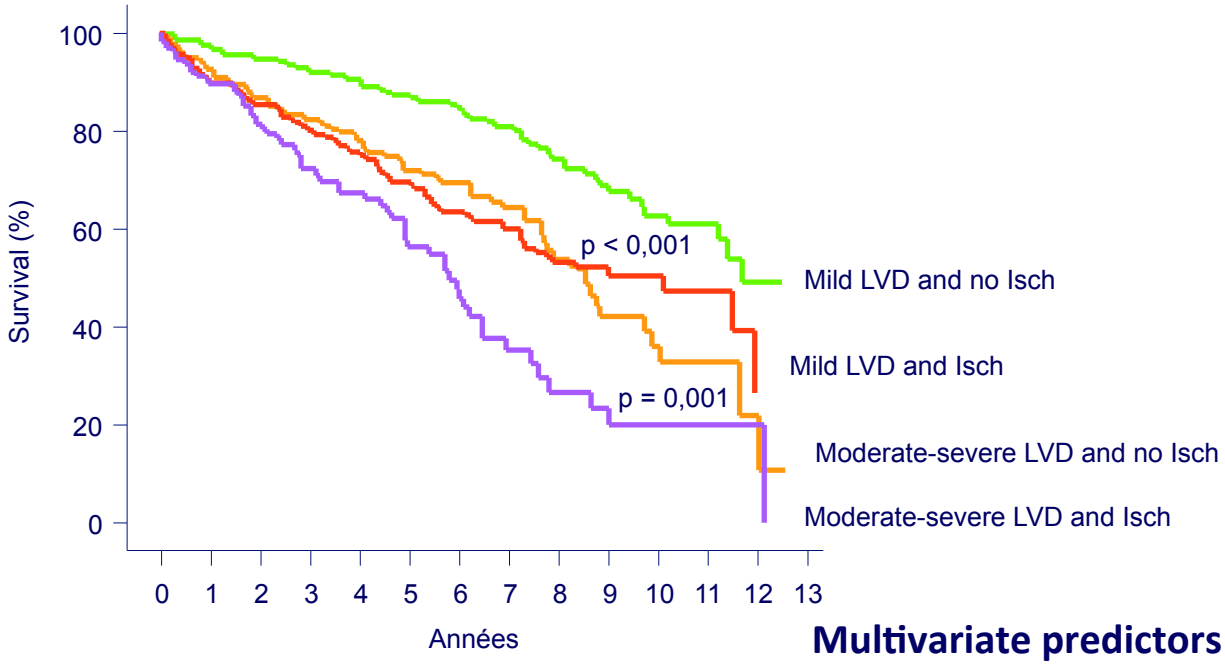
333	134	89	52	35	26	
748	552	372	251	177	120	

- Stress echocardiography is effective in risk-stratifying patients with previous PCI. In particular, inducible ischemia is a strong and independent predictor of mortality and hard events

Cortigiani. Am J Cardiol 2008;102:1170 –1174

STRESS ECHOCARDIOGRAPHY

Prognostic value of exercise echocardiography in patients with **left ventricular systolic dysfunction** and known or suspected coronary artery disease



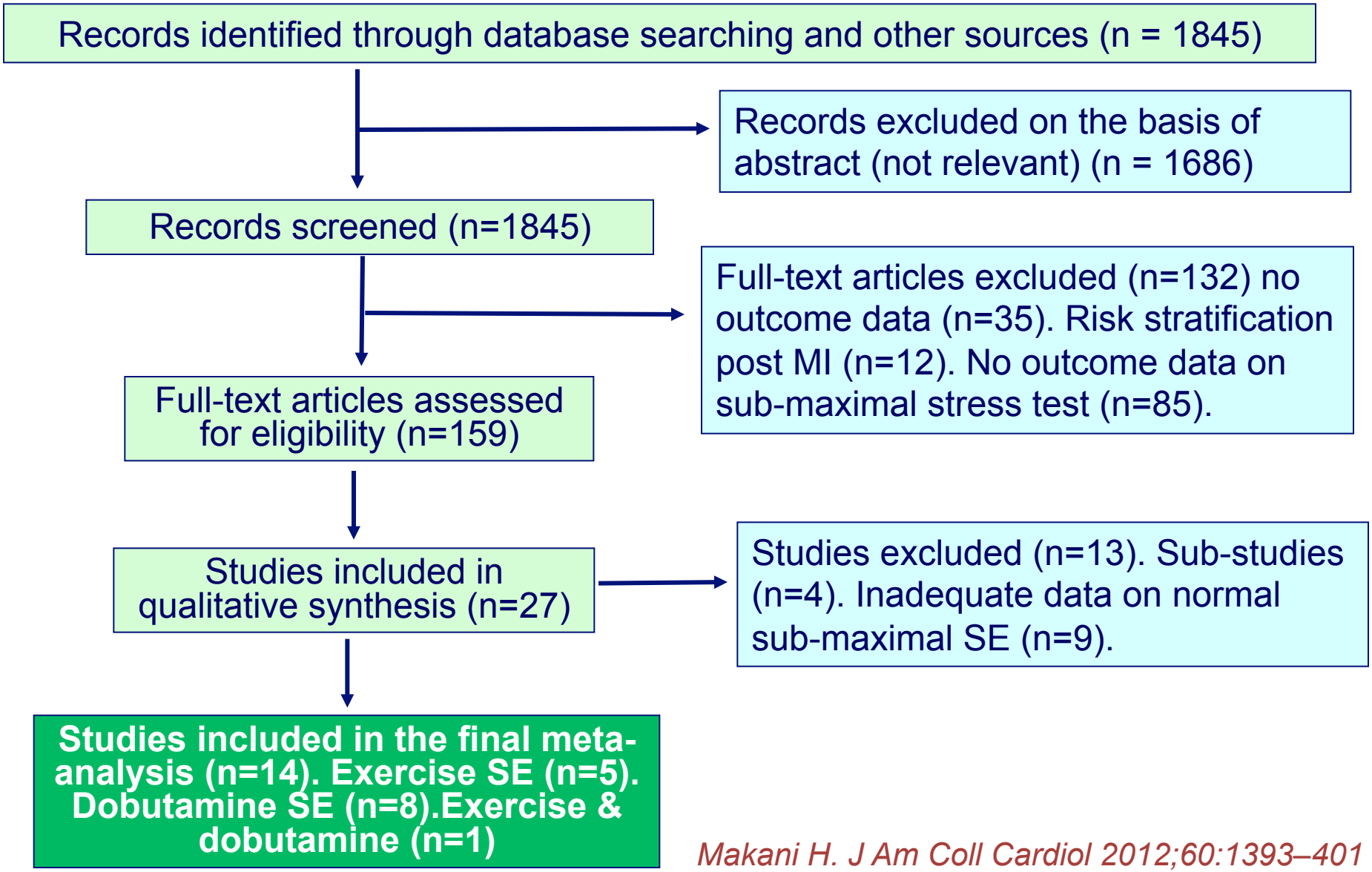
Multivariate predictors of major cardiac events

	HR	95 % CI	p
Male sex	1,78	1,18-2,67	0,006
Age (per year)	1,02	1,00-1,04	0,02
Diabetes	1,78	1,24-2,57	0,002
Resting WMSI	3,01	1,86-4,87	< 0,001
METs	0,89	0,84-0,95	< 0,001
ΔWMSI	2,60	1,34-5,04	0,005

Peteiro J . Am Heart J 2010;160:301-7

STRESS ECHOCARDIOGRAPHY

Cardiac Outcomes With Submaximal Normal Stress Echocardiography
A Meta-Analysis

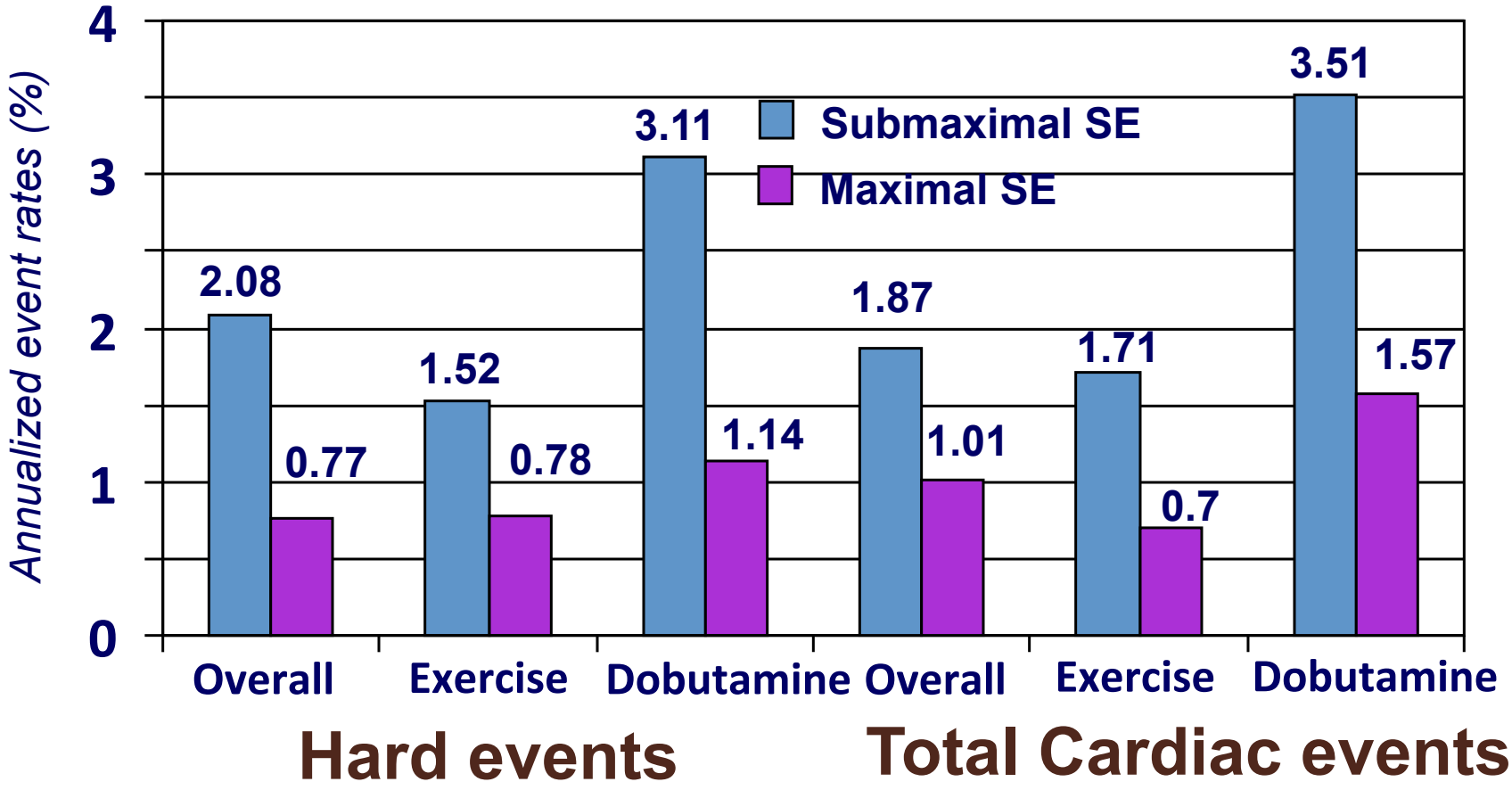


Makani H. J Am Coll Cardiol 2012;60:1393–401

STRESS ECHOCARDIOGRAPHY

Cardiac Outcomes With Submaximal Normal Stress Echocardiography A Meta-Analysis

Annualized Event Rates With Submaximal and Maximal Normal SE



Makani H. J Am Coll Cardiol 2012;60:1393–401

STRESS ECHOCARDIOGRAPHY

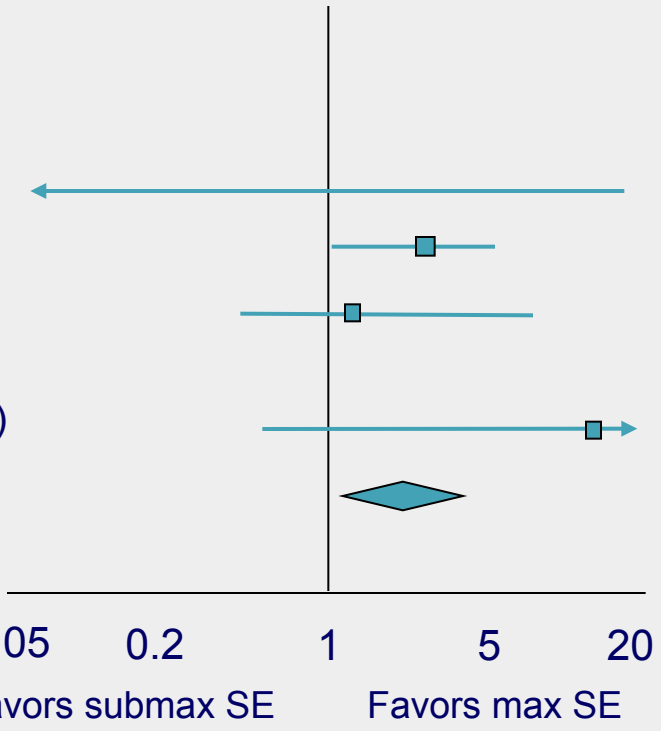
Hard events with normal SE comparing submaximal with maximal age-predicted heart rate

Exercise SE

Study	Hard events submax SE Events/t	Hard events max SE Events/t	Weight	RR M-H, random, 95% CI
Chung 2004	0/17	5/168	1.2	0.85 (0.05-14.81)
Peteiro 2010	13/425	30/1978	23.0	2.02 (1.06-3.83)
Rakhit 2006	3/26	12/156	6.6	1.50 (0.45-4.96)
Sawada 1990	2/50	0/120	1.0	11.86 (0.58-242.76)
Subtotal	518	2422	31.8	1.95 (1.13-3.36)
Total events	18	47		

Heterogeneity : Tau²=0.00, Chi²=1.91, df=3 (P=0.59), I²=0%

Test for overall effect : Z=2.93 (p=0.02)



Head-to-head comparison of hard events between submaximal and maximal normal stress echocardiography (SE). APHR age-predicted heart rate; CI confidence interval; df degrees of freedom; M-H Mantel-Haenszel.

Makani H. J Am Coll Cardiol 2012;60:1393–401

STRESS ECHOCARDIOGRAPHY

Hard events with normal SE comparing submaximal with maximal age-predicted heart rate

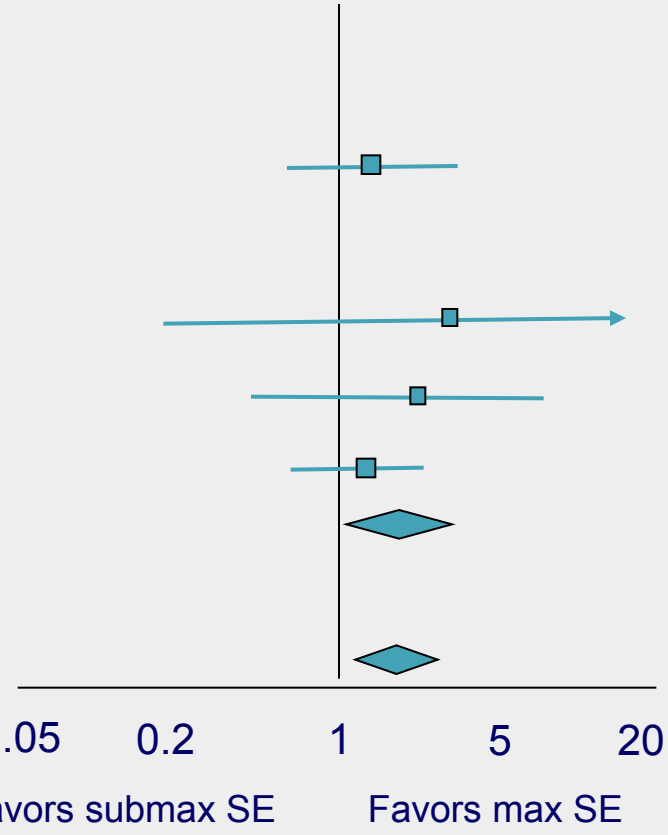
Dobutamine SE

Study	Hard events submax SE Events/t	Hard events max SE Events/t	Weight	RR M-H, random, 95% CI
Chuah 1998	27/280	15/259	25.6	1.67 (0.91-3.06)
Chung 2004	0/4	0/44		NE
Lerakis 2010	1/28	2/178	1.7	3.42 (0.32-36.43)
Marwick 1998	11/68	3/51	6.3	2.75 (0.81-9.35)
Srivastava 2008	27/324	25/403	34.5	1.34 (0.80-2.27)
Subtotal	792	935	68.2	1.59 (1.10-2.31)
Total events	66	45		
Total (95% CI)	t1220	3357	100	1.70 (1.25-2.31)

Heterogeneity : Tau²=0.00, Chi²=3.84, df=3 (P=0.80), I²=0%

Test for overall effect : Z=3.37 (p=0.0008)

Test for subgroup diffrences : Chi²=0.35, df=1 (p=0.55), I²=0%



Head-to-head comparison of hard events between submaximal & maximal normal stress echocardiography (SE).
APHR age-predicted heart rate; CI confidence interval;
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Makani H. J Am Coll Cardiol 2012;60:1393–401

STRESS ECHOCARDIOGRAPHY

Hard events with normal SE comparing submaximal with maximal age-predicted heart rate

Dobutamine SE

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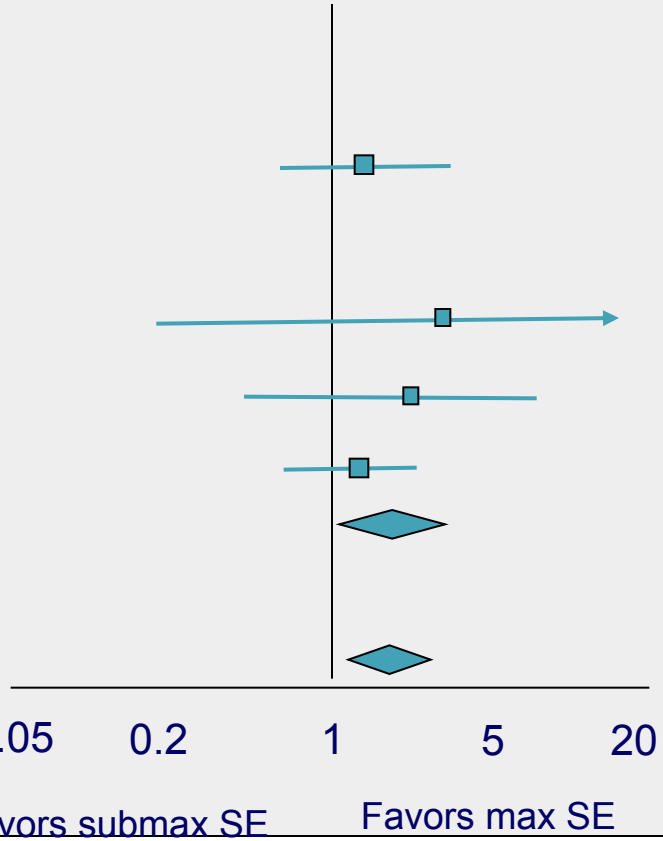


Head-to-head comparison of hard events between submaximal & maximal normal stress echocardiography (SE).
APHR age-predicted heart rate; CI confidence interval;
df degrees of freedom; M-H Mantel-Haenszel.

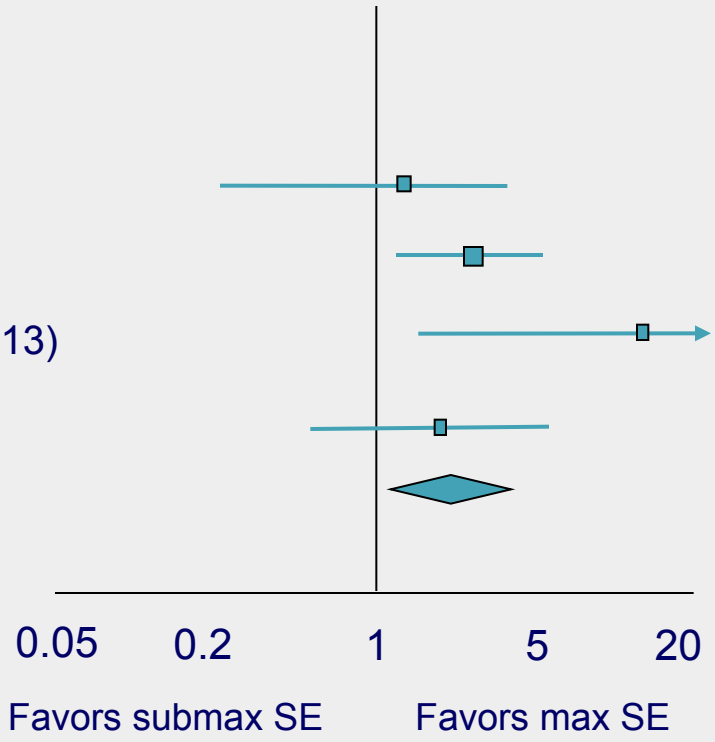
Makani H. J Am Coll Cardiol 2012;60:1393–401

STRESS ECHOCARDIOGRAPHY

Total Cardiac Events With Normal SE Comparing Submaximal With Maximal age-predicted heart rate

Exercise SE

Study	Hard events submax SE Events/t	Hard events max SE Events/t	Weight	RR M-H, random, 95% CI
Lauer 1998	3/25	14/147	9.2	1.26 (0.39-4.07)
Mc Cully 1998	9/236	17/1089	16.8	2.44 (1.10-5.41)
Sawada 1990	5/50	1/120	3.1	12.00 (1.44-100.13)
Syed 1998	16/482	4/315	10.4	2.61 (0.88-7.75)
Subtotal	793	1671	39.5	2.41 (1.32-4.40)
Total events	33			



Heterogeneity : Tau²=0.05, Chi²=3.45, df=3 (P=0.33), I²=13%

Test for overall effect : Z=2.88 (p=0.0004)

Head-to-head comparison of hard events between submaximal and maximal normal stress echocardiography (SE).
APHR age-predicted heart rate; CI confidence interval;
df degrees of freedom; M-H Mantel-Haenszel.

Makani H. J Am Coll Cardiol 2012;60:1393–401

STRESS ECHOCARDIOGRAPHY

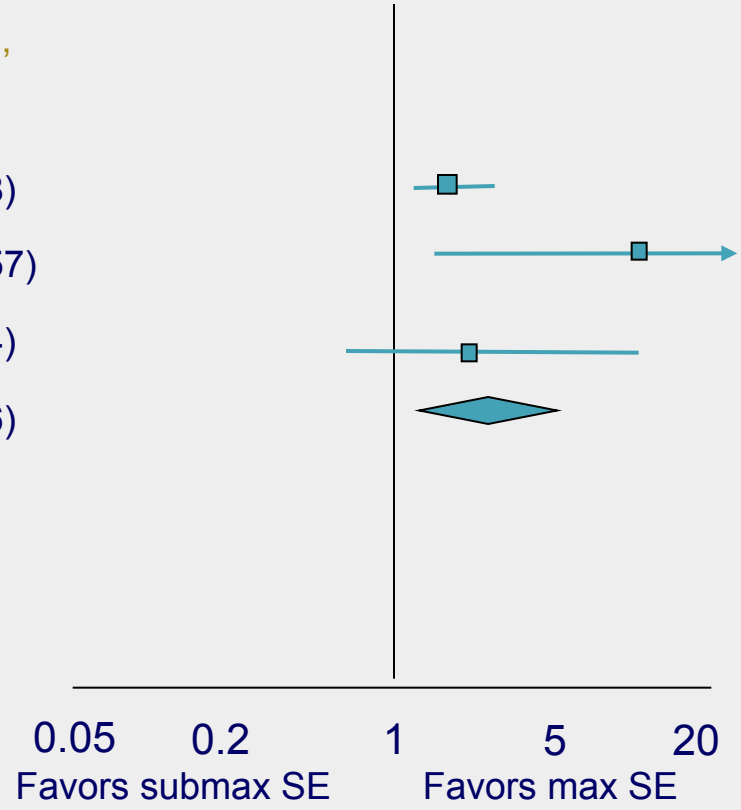
Total Cardiac Events With Normal SE Comparing Submaximal With Maximal age-predicted heart rate

Dobutamine SE

Study	Hard events submax SE Events/t	Hard events max SE Events/t	Weight	RR M-H, random, 95% CI
Chaowalit 2006	53/427	1180/2587	44.0	1.78 (1.34-2.38)
Geleijnse 1998	3/21	3/179	5.7	8.52 (1.84-39.57)
Marwick 1998	13/69	4/51	10.8	2.40 (0.83-6.94)
Subtotal	517	2817	60.5	2.50 (1.21-5.16)
Total events	69	187		
Total (95% CI)	1310	3357	100	

Heterogeneity : Tau²=0.22, Chi²=4.04, df=2 (P=0.13), I²=51%

Test for overall effect : Z=2.47 (p=0.01)



Head-to-head comparison of hard events between submaximal and maximal normal stress echocardiography
APHR age-predicted heart rate; CI confidence interval; df degrees of freedom; M-H Mantel-Haenszel.

Makani H. J Am Coll Cardiol 2012;60:1393–401

STRESS ECHOCARDIOGRAPHY

Cardiac Outcomes With Submaximal Normal Stress Echocardiography
A Meta-Analysis : Subgroup analysis

Subgroups	N of studies	N of events	N of pts	N of events	N of pts	RR	Ratio of RR (95% CI)	Inter-action p
Hard events	Sub-max			Max				
Resting WMA								0.75
Yes	1	21	130	9	107	1.9 (0.9-4.0)	1.1 (0.5-2.3)	
No	5	22	315	26	691	1.8 (1.0-3.3)		
Unclear	3	41	775	57	2.559	1.6 (1.1-2.4)		
Duration, yrs								0.37
≤ 3	5	19	531	44	2.476	2.1 (1.2-3.5)	1.3 (0.7-2.6)	
>3	3	59	539	42	729	1.6 (1.1-2.3)		
Pts on betablockers, %								0.54
≤ 20	3	25	519	35	2.207	2.2 (1.3-3.9)	1.3 (0.6-2.7)	
> 20	3	32	360	27	579	1.7 (1.0-2.9)		
Mean age, yrs								0.64
≤ 60	3	6	102	14	454	2.2 (0.8-6.0)	1.3 (0.5-3.7)	
> 60	5	78	1.118	78	2.903	1.7 (1.2-2.3)		

Makani H. J Am Coll Cardiol 2012;60:1393–401

STRESS ECHOCARDIOGRAPHY

Cardiac Outcomes With Submaximal Normal Stress Echocardiography
A Meta-Analysis : subgroup analysis

Subgroups	N of studies	N of events	N of pts	N of events	N of pts	RR	Ratio of RR (95% CI)	Inter-action p
Total cardiac events	Sub-max			Max				
Resting WMA								0.06
Yes	0							
No	4	30	376	25	1.439	3.2 (1.9-5.6)	1.78 (0.9-3.3)	
Unclear	3	72	934	198	3.049	1.8 (1.4-2.4)		
Duration, yrs								0.06
≤ 3	4	33	789	25	1.703	3.5 (1.8-6.8)	1.97 (0.9-3.9)	
>3	3	69	521	198	2.785	1.8 (1.4-2.3)		
Pts on betablockers, %								0.40
≤ 20	3	25	330	35	1.287	2.1 (1.2-3.7)	0.65 (0.2-1.8)	
> 20	4	77	980	188	3.201	3.3 (1.4-7.5)		
Mean age, yrs								0.24
≤ 60	4	20	332	35	1.535	3.3 (1.3-7.9)	1.75 (0.7-4.5)	
> 60	3	82	978	188	2.953	1.9 (1.4-2.4)		

Makani H. J Am Coll Cardiol 2012;60:1393–401

STRESS ECHOCARDIOGRAPHY

Cardiac Outcomes With Submaximal Normal Stress Echocardiography
A Meta-Analysis

Recommandations for Normal SE With Submaximal age-predicted heart rate

Further workup indicated

1. High-risk population (prior MI, PCI, CABG, DM, PAD, HF with EF 40%)
2. Limited exercise capacity (7 METs for men, 5 METs for women)
3. Evidence of arrhythmias, hypotension, severe hypertension during the stress
4. Significant electrocardiographic abnormalities during or after stress
5. Patients with moderate or severe renal dysfunction* (CrCl 60)
6. Intermediate- or high-risk Duke treadmill score (4)
7. Resting wall-motion abnormalities
8. Chest pain during stress testing
9. Echocardiographic evidence of left ventricular hypertrophy
10. Advanced age, male sex

No further workup indicated

1. Asymptomatic patient/atypical symptoms with minimal or no risk factors
2. Good exercise capacity (7 METs for men, 5 METs for women)

Makani H. J Am Coll Cardiol 2012;60:1393–401

STRESS ECHOCARDIOGRAPHY

1- General Considerations

2- Diagnosis of myocardial ischemia

3- Potential impact of 3D

4- What to do in case of inconclusive test?

4- Prognostic impact of a stress test

5- Additional role of perfusion evaluation?

Contrast agents

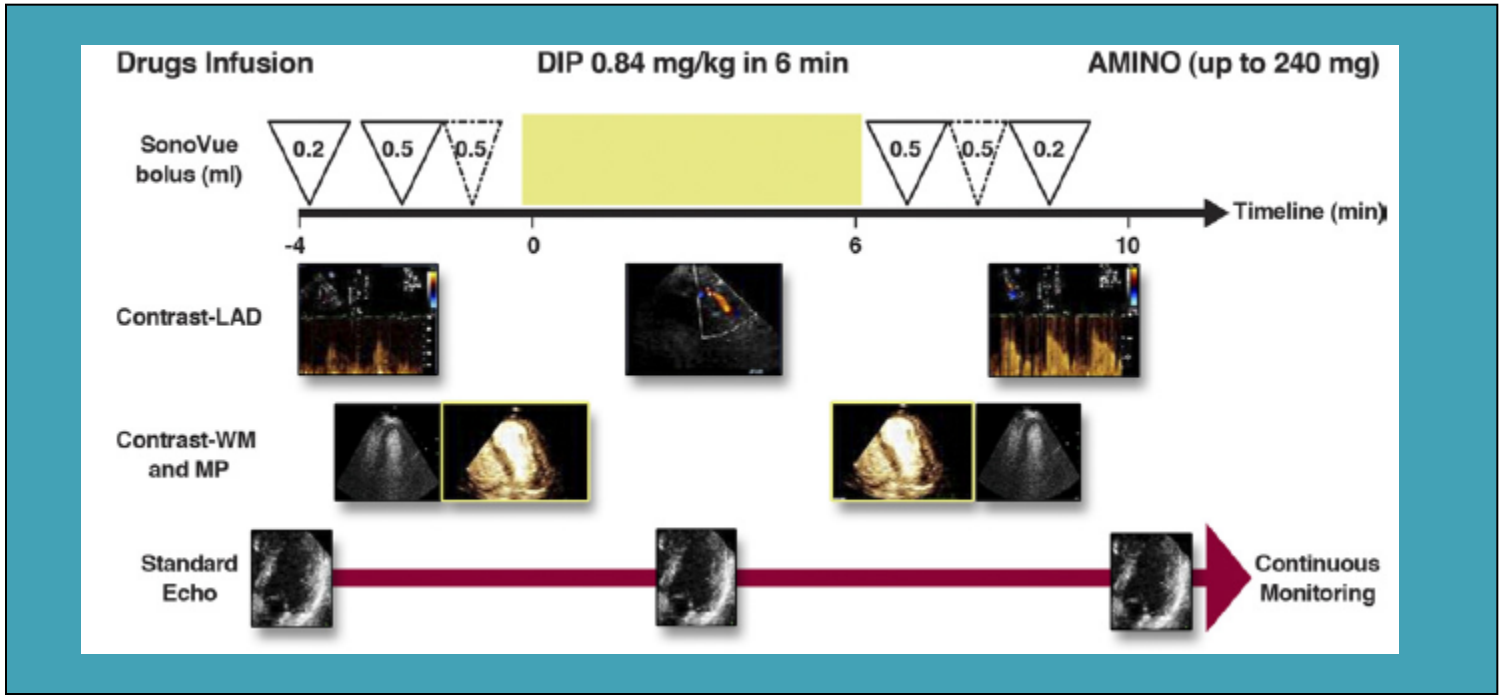
	SonoVue	Optison	Luminity
Gas	Sulphur hexafluoride	Perfluoropropane	Perfluoropropane
Surface coating	Surfactant/powder	Human albumin	Naturally occcuring lipids
Mean bubble size	2-8 µm	3.0-4.5 µm	1.1-2.5 µm
Patients experiencing side effects in clinical trials	11.4%	16.8%	7.6%
Most frequent side effects in clinical trials	Headache (2.1%), nausea (1.3%), chest pain (1.3%), taste perversion (0.9%), hyperglycemia (0.6%), injection site reaction (0.6%), paresthesia (0.6%), vasodilation (0.6%), injection site pain (0.5%)	Headache (5.4%), nausea and/or vomiting (4.3%), warm sensation or flushing (3.6%), dizziness (2.5%)	Headache (2.0%), flushing (1.0%), back pain (0.9%)
Manufacturer	Bracco Diagnostics	GE Healthcare	Lantheus Medical Imaging

Mulvagh SL. J Am Soc Echocardiogr 2008 ; 21 : 1179-201
Senior R. Eur J Echocardiogr 2009 ; 10 : 194–212

STRESS ECHOCARDIOGRAPHY

Comparative Prediction of Cardiac Events by Wall Motion, Wall Motion Plus Coronary Flow Reserve, or Myocardial Perfusion Analysis
A Multicenter Study of Contrast Stress Echocardiography

Schematic of the Contrast SE Protocol



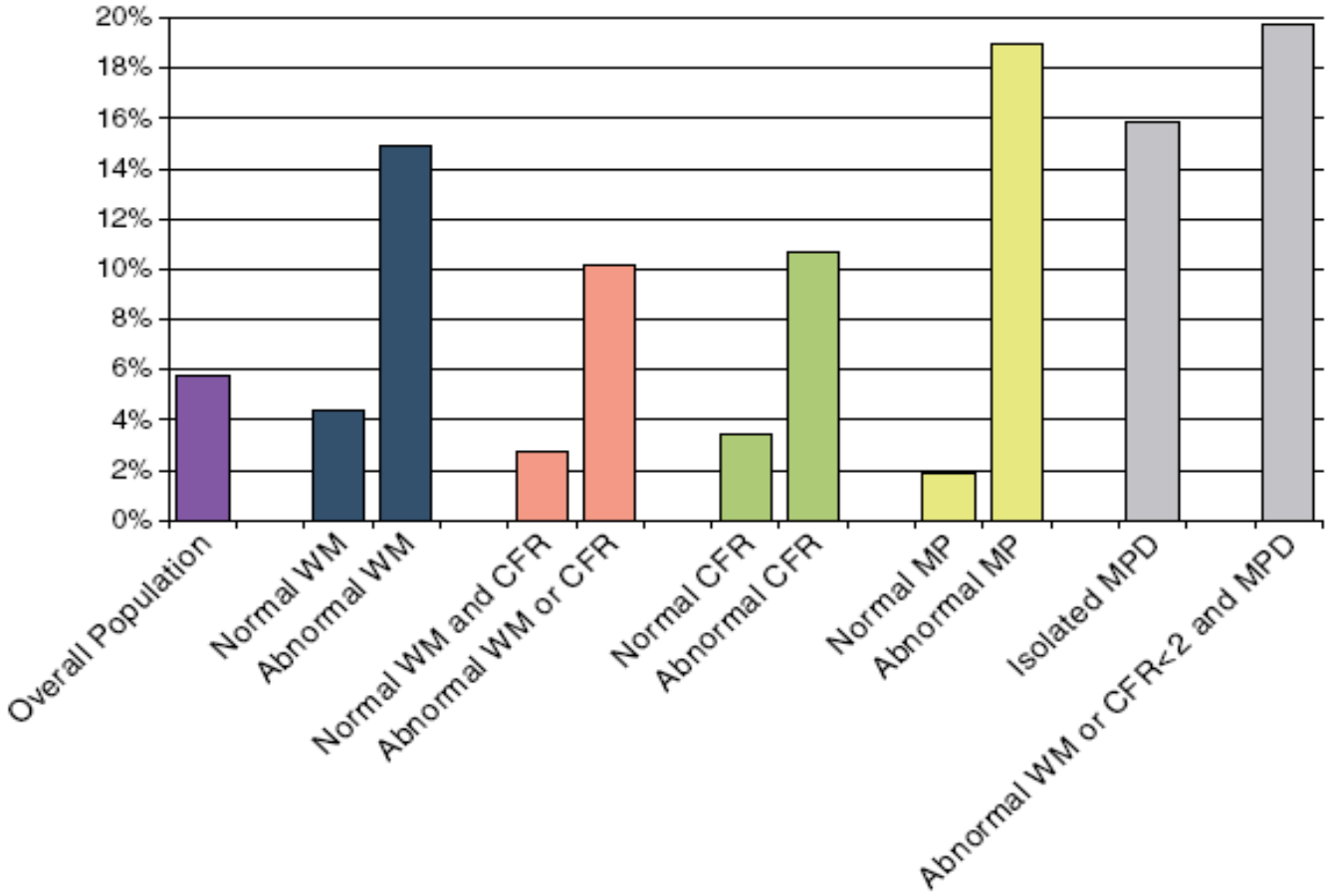
AMINO aminophylline; contrast-LAD Doppler sampling of the mid-distal left anterior descending artery; contrast-WM contrast wall motion; DIP dipyridamole; MP myocardial perfusion; SE stress echocardiography

Gaibazy N. J Am Coll Cardiol Img 2013;xx:xxx

STRESS ECHOCARDIOGRAPHY

Comparative Prediction of Cardiac Events by Wall Motion, Wall Motion Plus Coronary Flow Reserve, or Myocardial Perfusion Analysis
A Multicenter Study of Contrast Stress Echocardiography

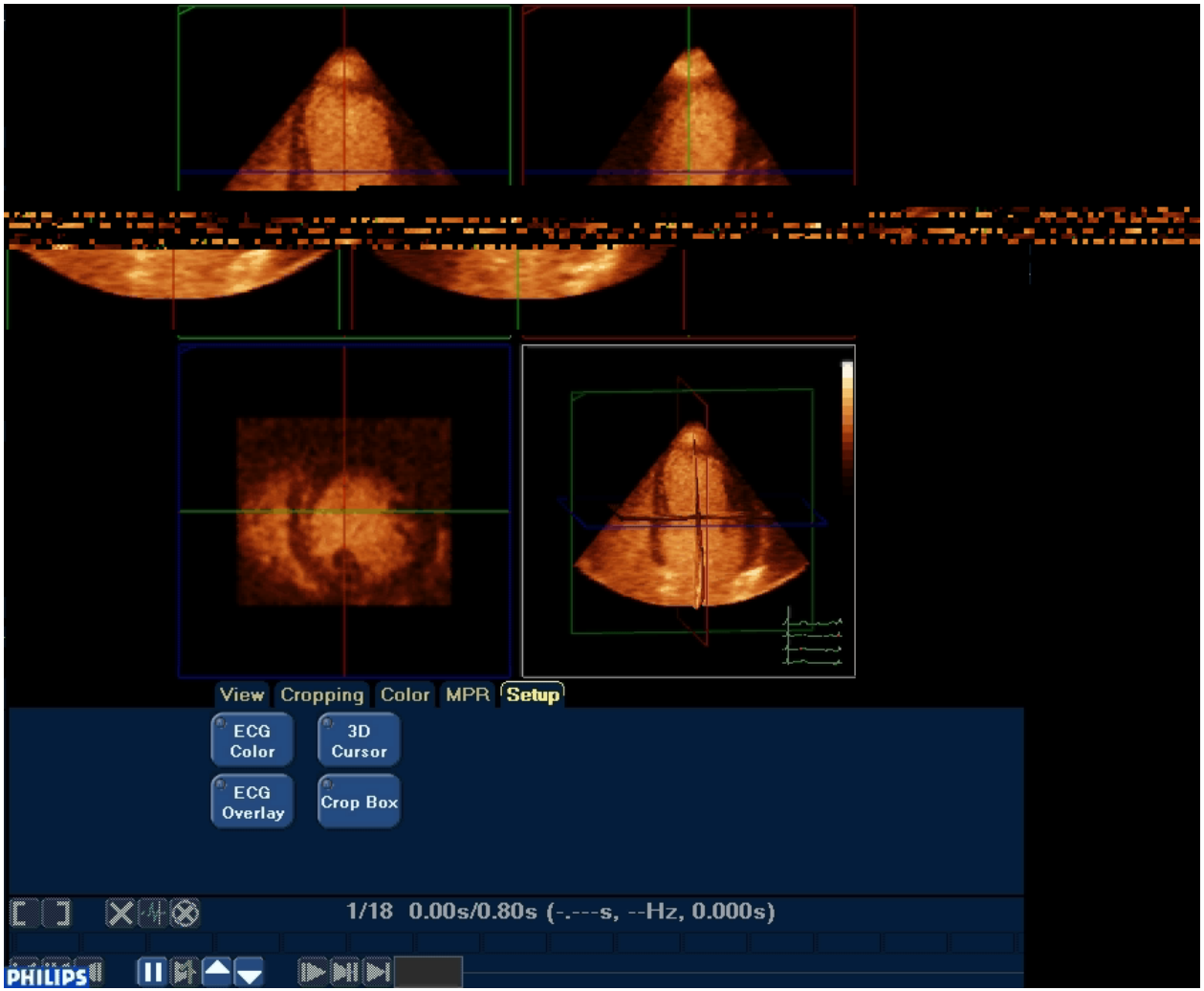
Total cardiac 1-year event rate in the overall population and classified based on stress-echocardiography



Gaibazy N. J Am Coll Cardiol Img 2013;xx:xxx

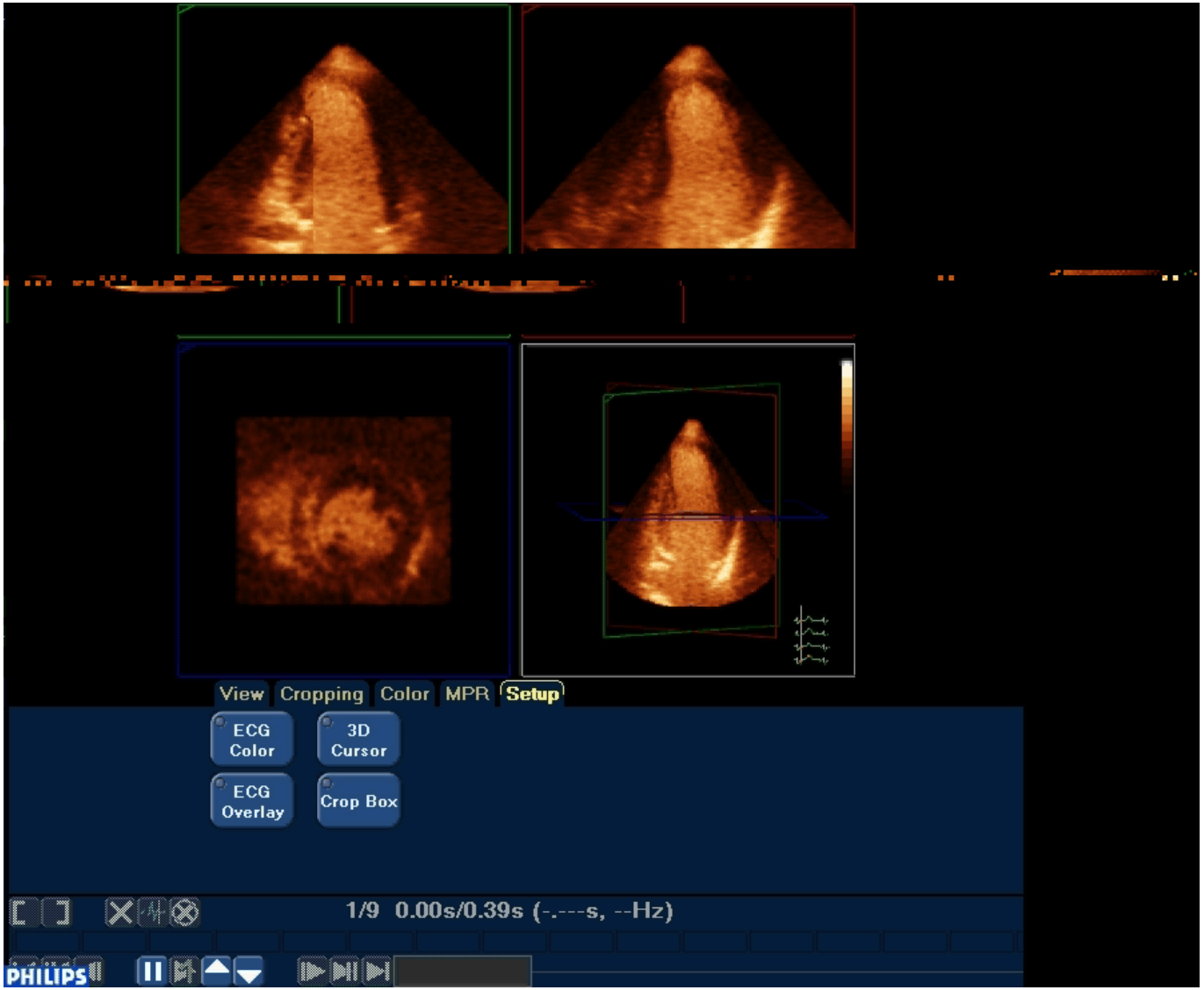
STRESS ECHOCARDIOGRAPHY

Contrast-enhanced 3D-SE showing multiplane (orthogonal and short axis) views of a patient who underwent dobutamine stress echocardiography study at baseline (rest images).



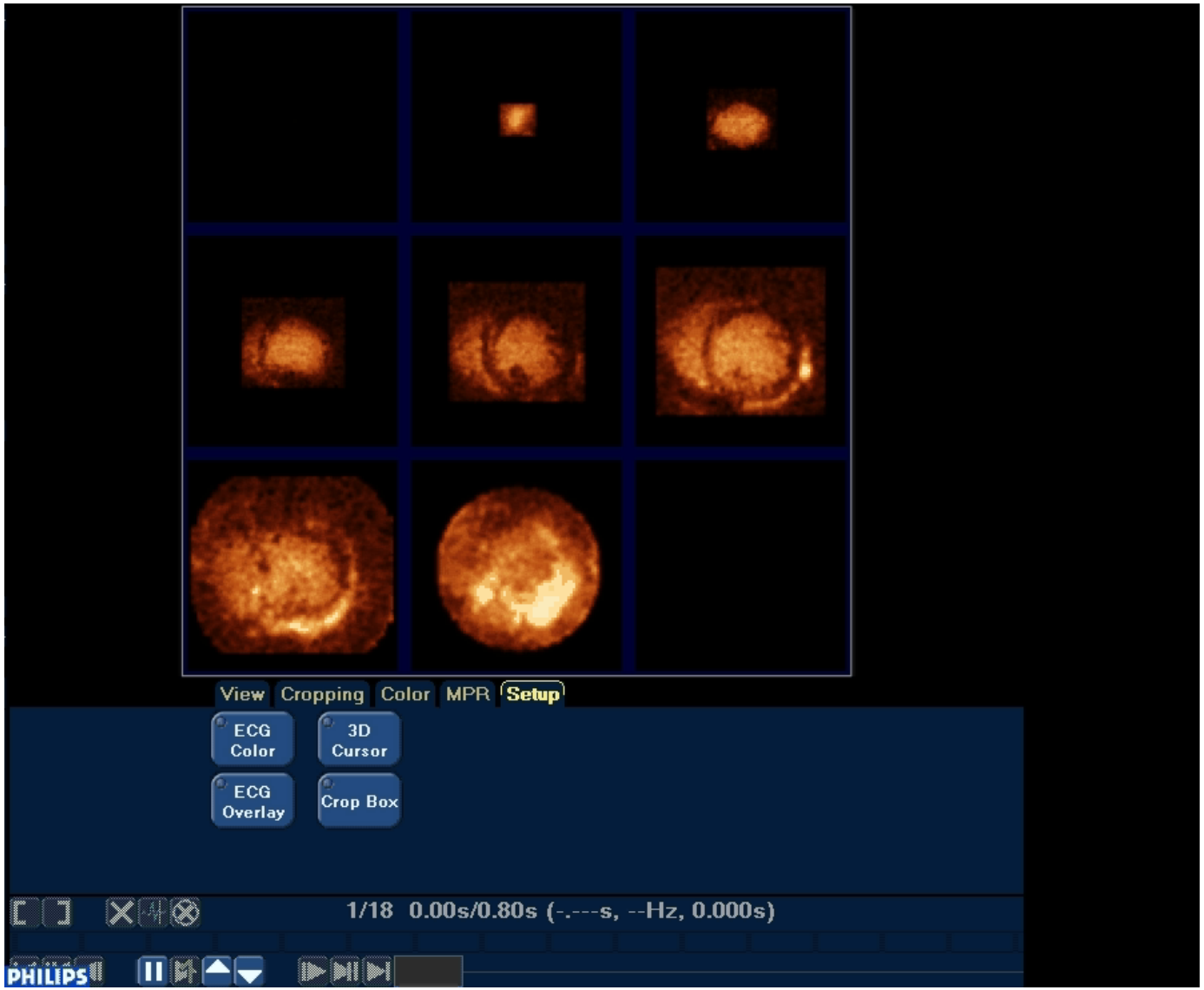
STRESS ECHOCARDIOGRAPHY

Contrast-enhanced 3D-SE showing multiplane (orthogonal and short-axis) views of the same patient at peak stress



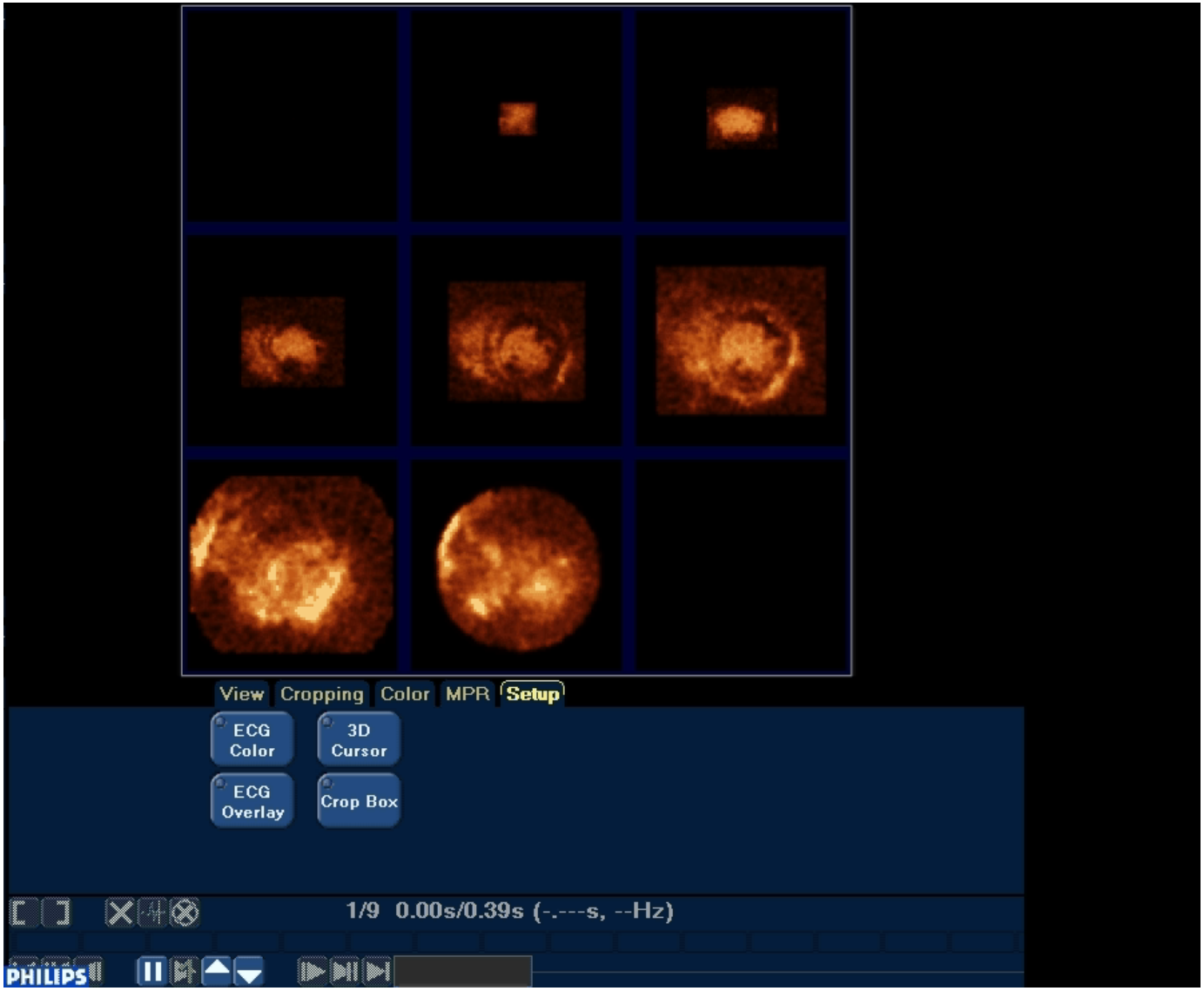
STRESS ECHOCARDIOGRAPHY

Contrast-enhanced 3D-SE showing multislice view at baseline.



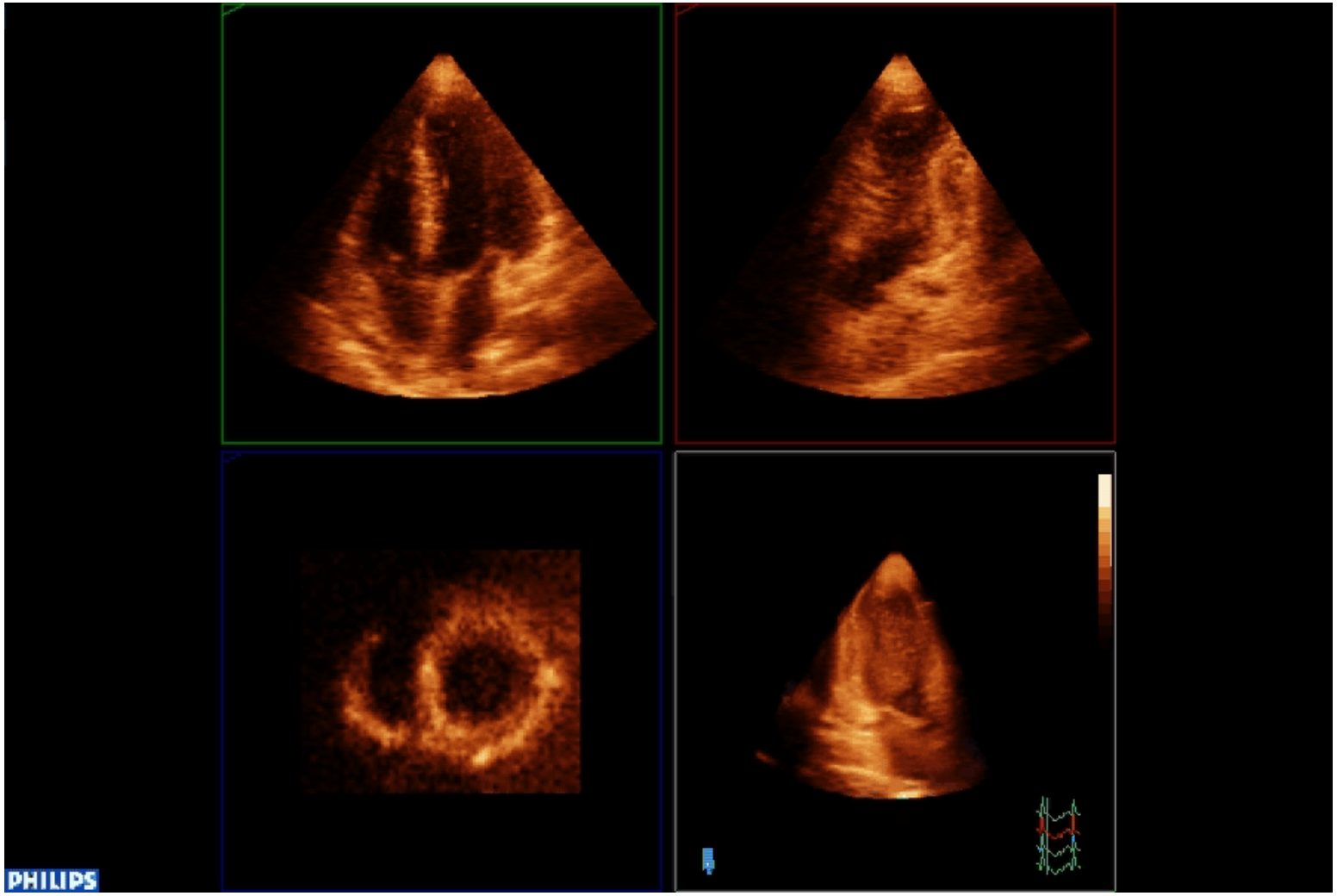
STRESS ECHOCARDIOGRAPHY

Contrast-enhanced 3D-SE showing multislice view of the same patient at peak stress.



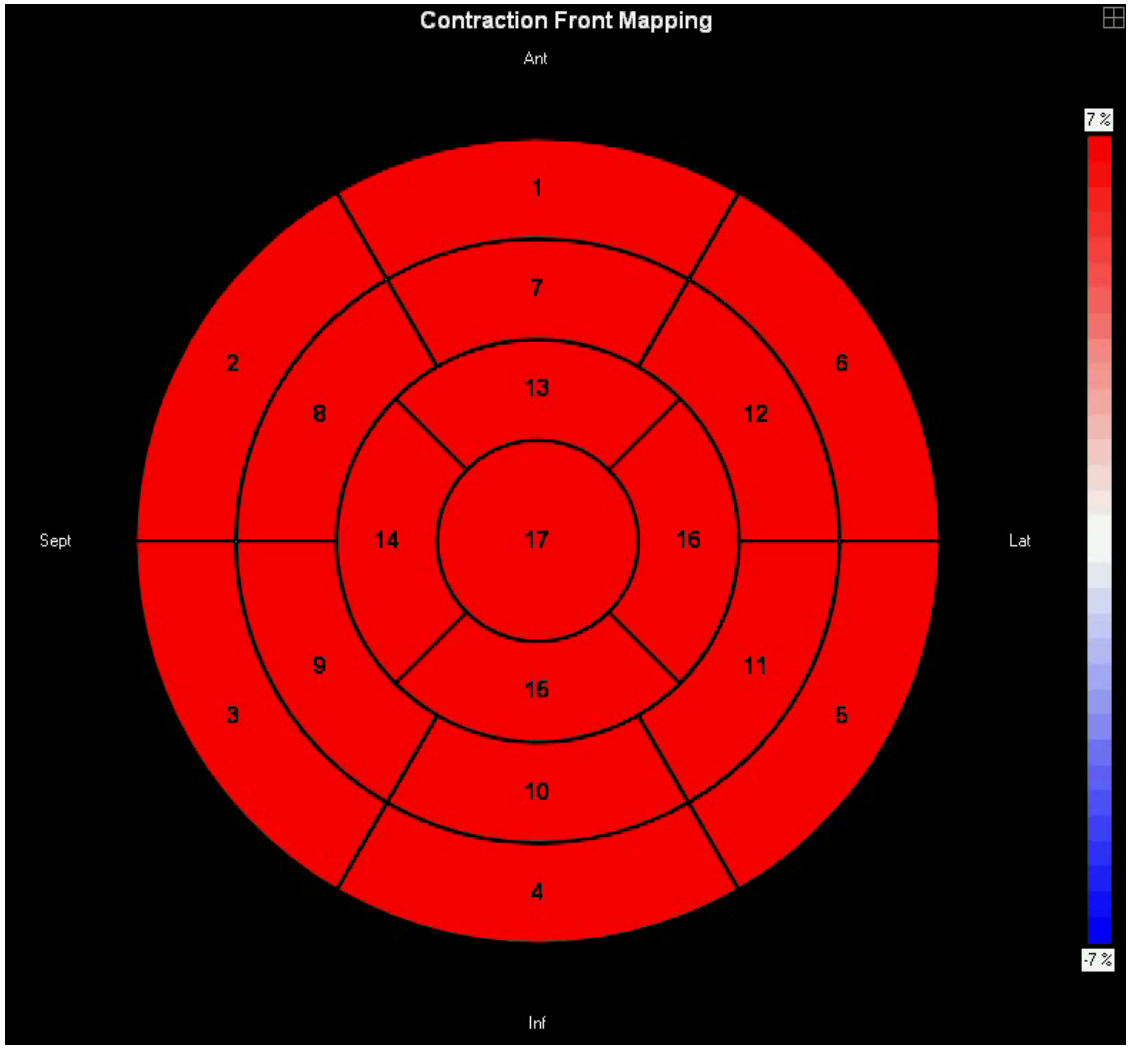
STRESS ECHOCARDIOGRAPHY

Quad screen display of simultaneously acquired 3D multiplane views of the same patient during peak stress. Note that the entire true left ventricle is obtained with better visualization of the LV apex showing akinesis.



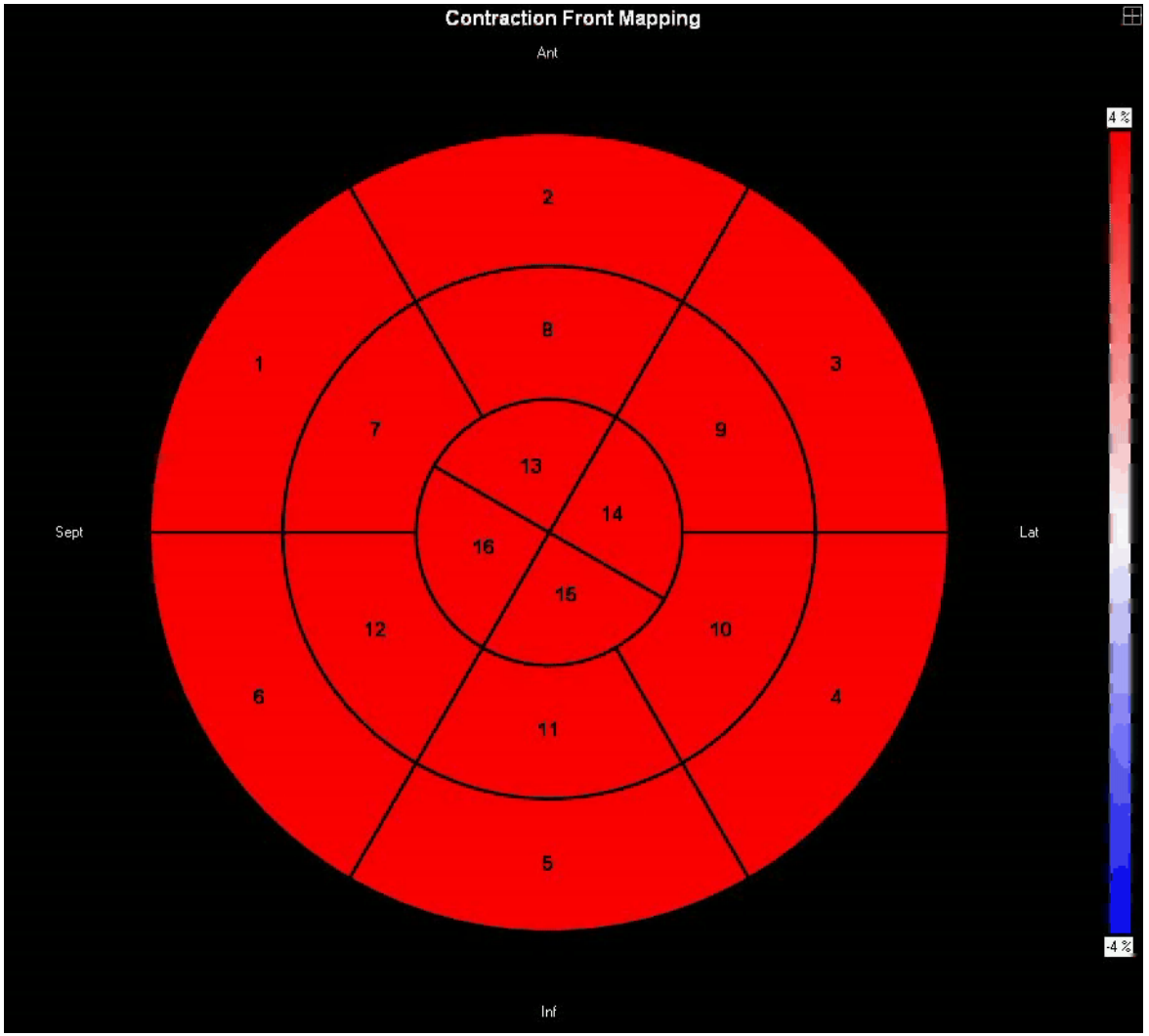
STRESS ECHOCARDIOGRAPHY

3D-derived contraction front map (CFM), in a patient who underwent DSE. At baseline, the dynamic map shows synchronous and uniform activation of all LV segments.



STRESS ECHOCARDIOGRAPHY

CFM of the same patient during peak stress shows delayed activation of segments 1, 2, 7, and 8 consistent with reversible ischemia in the basal and midanteroseptal wall (LAD territory).



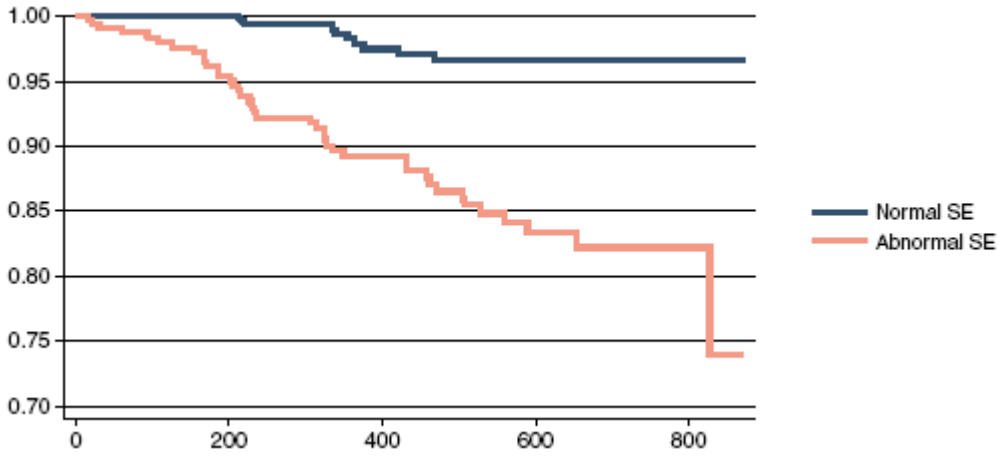
STRESS ECHOCARDIOGRAPHY

Comparative Prediction of Cardiac Events by Wall Motion, Wall Motion Plus Coronary Flow Reserve, or Myocardial Perfusion Analysis
A Multicenter Study of Contrast Stress Echocardiography

Total cardiac 1-year event rate in the overall population and classified based on stress-echocardiography

Total Cardiac and Hard Event-Free Survival Rates

Total cardiac event-free survival rates classified by positivity of at least 1 contrast SE variable (either WMA, CFR-LAD 2, or MPD)



Gaibazy N. J Am Coll Cardiol Img 2013;xx:xxx

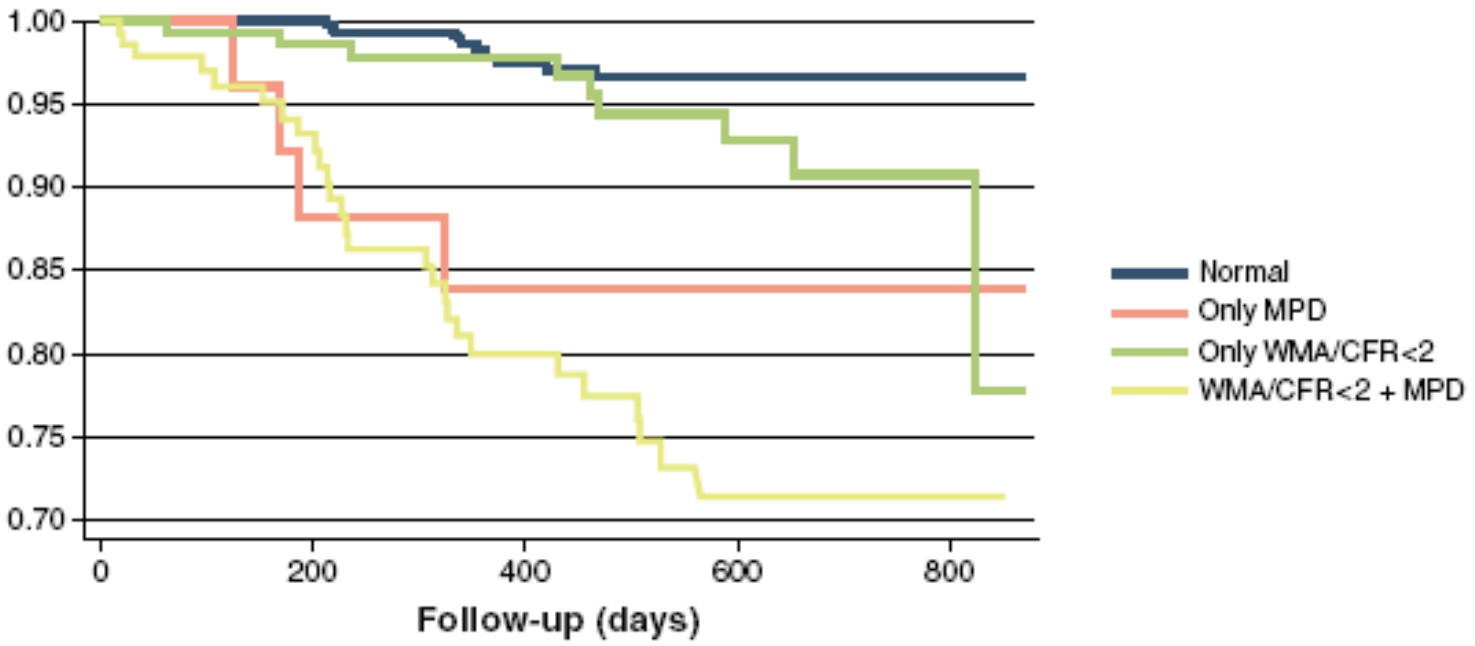
STRESS ECHOCARDIOGRAPHY

Comparative Prediction of Cardiac Events by Wall Motion, Wall Motion Plus Coronary Flow Reserve, or Myocardial Perfusion Analysis
A Multicenter Study of Contrast Stress Echocardiography

Total cardiac 1-year event rate in the overall population and classified based on stress-echocardiography

Total Cardiac and Hard Event-Free Survival Rates

Total cardiac event-free survival rates classified by possible combinations of contrast SE variables



Gaibazy N. J Am Coll Cardiol Img 2013;xx:xxx

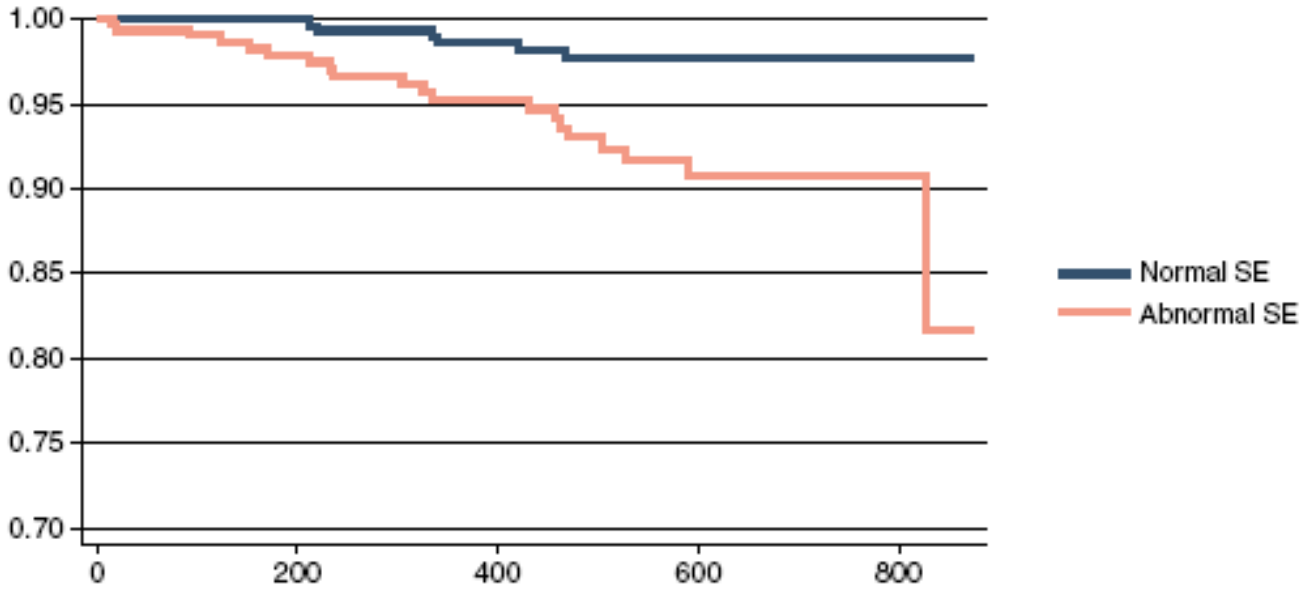
STRESS ECHOCARDIOGRAPHY

Comparative Prediction of Cardiac Events by Wall Motion, Wall Motion Plus Coronary Flow Reserve, or Myocardial Perfusion Analysis
A Multicenter Study of Contrast Stress Echocardiography

Total cardiac 1-year event rate in the overall population and classified based on stress-echocardiography

Total Cardiac and Hard Event-Free Survival Rates

Cardiac hard event-free survival rates classified by positivity of at least 1 contrast SE variable (either wall motion abnormality [WMA], CFR-LAD 2, or MPD)



Gaibazy N. J Am Coll Cardiol Img 2013;xx:xxx

STRESS ECHOCARDIOGRAPHY

Comparative Prediction of Cardiac Events by Wall Motion, Wall Motion Plus Coronary Flow Reserve, or Myocardial Perfusion Analysis
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Total cardiac 1-year event rate in the overall population and classified based on stress-echocardiography

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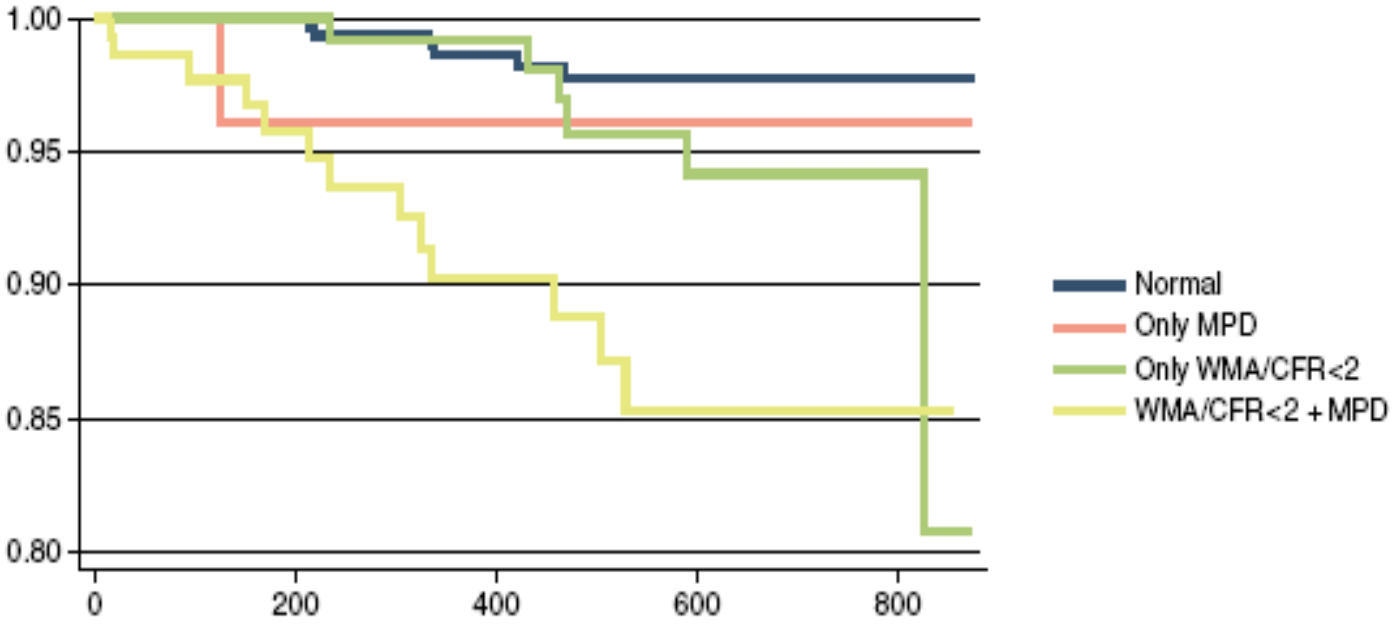
Cardiac hard event-free survival rates classified by possible combinations of contrast SE variables



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STRESS ECHOCARDIOGRAPHY

Univariable and Selected Multivariable Cox Regression Analysis of the 3 SE Variables for the Prediction of Total Cardiac Events

	Univariate			Multivariate	
	Harrell C-index (95% CI)	**HR (95% CI)**	**P**	**HR (95% CI)**	**p**
Stress echo					
Reduced LVEF, <50 %	0.583 (0.51-0.65)	2.25 (1.28-3.95)	0.005		
CFR-LAD <2	0.654 (0.59-0.72)	3.58 (1.99-6.45)	0.000	2.25 (1.21-4.17)	0.01
WMA	0.589 (0.52-0.66)	3.01 (1.62-5.61)	0.001	0.72 (0.36-1.46)	0.37
MPD	0.735 (0.67-0.8)	6.57 (3.67-11.75)	0.000	5.97 (3.02-11.78)	<0.001
WMA or CFR-LAD < 2	0.667 (0.6-0.73)	4.27 (2.27-8.06)	0.000		

Gaibazy N. J Am Coll Cardiol Img 2013;xx:xxx

STRESS ECHOCARDIOGRAPHY

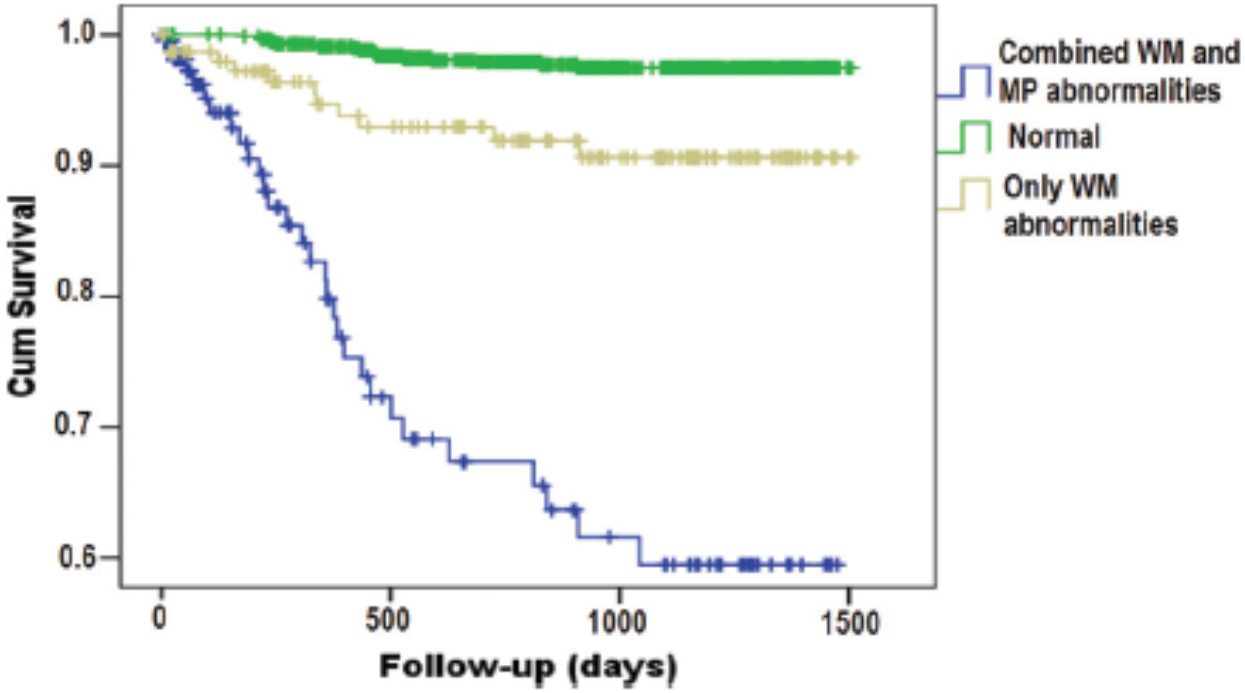
Summary of Model Comparisons for Total Cardiac Events Prediction, Based on Harrell C-Index and Likelihood Ratio Test

Summary table for model comparison	P for Harrell C-index difference	P for likelihood ratio test	NRI
Clinical parameters only model (model 1) vs			
Clinical data + WMA	0.148	0.012	0.810
Clinical data + WMA/CFR-LAD <2	0.037		0.001
Clinical data + MPD	<0.001		<0.001
Clinical parameters + WMA (model 2) vs			
Clinical data + WMA/CFR-LAD <2	0.242	Not feasible	0.001
Clinical data + WMA + MPD	0.004	<0.001	<0.001
Clinical data + MPD	0.003	Not feasible	<0.001
Clinical parameters + WMA/CFR-LAD (model 3) vs			
Clinical data + WMA/CFR-LAD >2 + MPD	0.012	<0.001	0.025
Clinical parameters + MPD (model 4) vs			
Clinical data + MPD + WMA/CFR-LAD <2	0.766	0.059	0.542

Gaibazy N. J Am Coll Cardiol Img 2013;xx:xxx

STRESS ECHOCARDIOGRAPHY

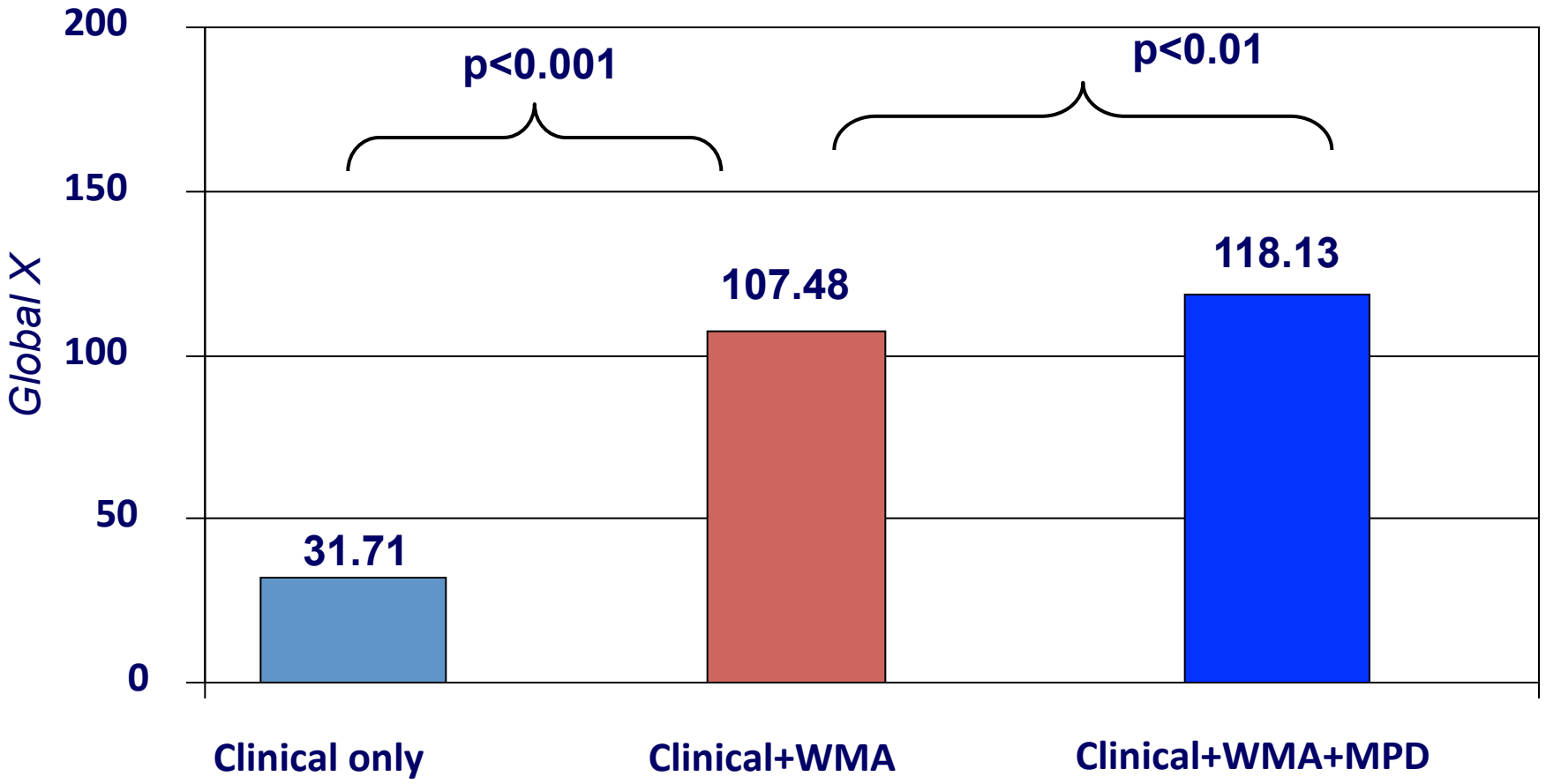
Prognostic Value of High-Dose Dipyridamole Stress Myocardial Contrast Perfusion Echocardiography



Gaibazy N. Circulation. 2012;126:1217-1224

STRESS ECHOCARDIOGRAPHY

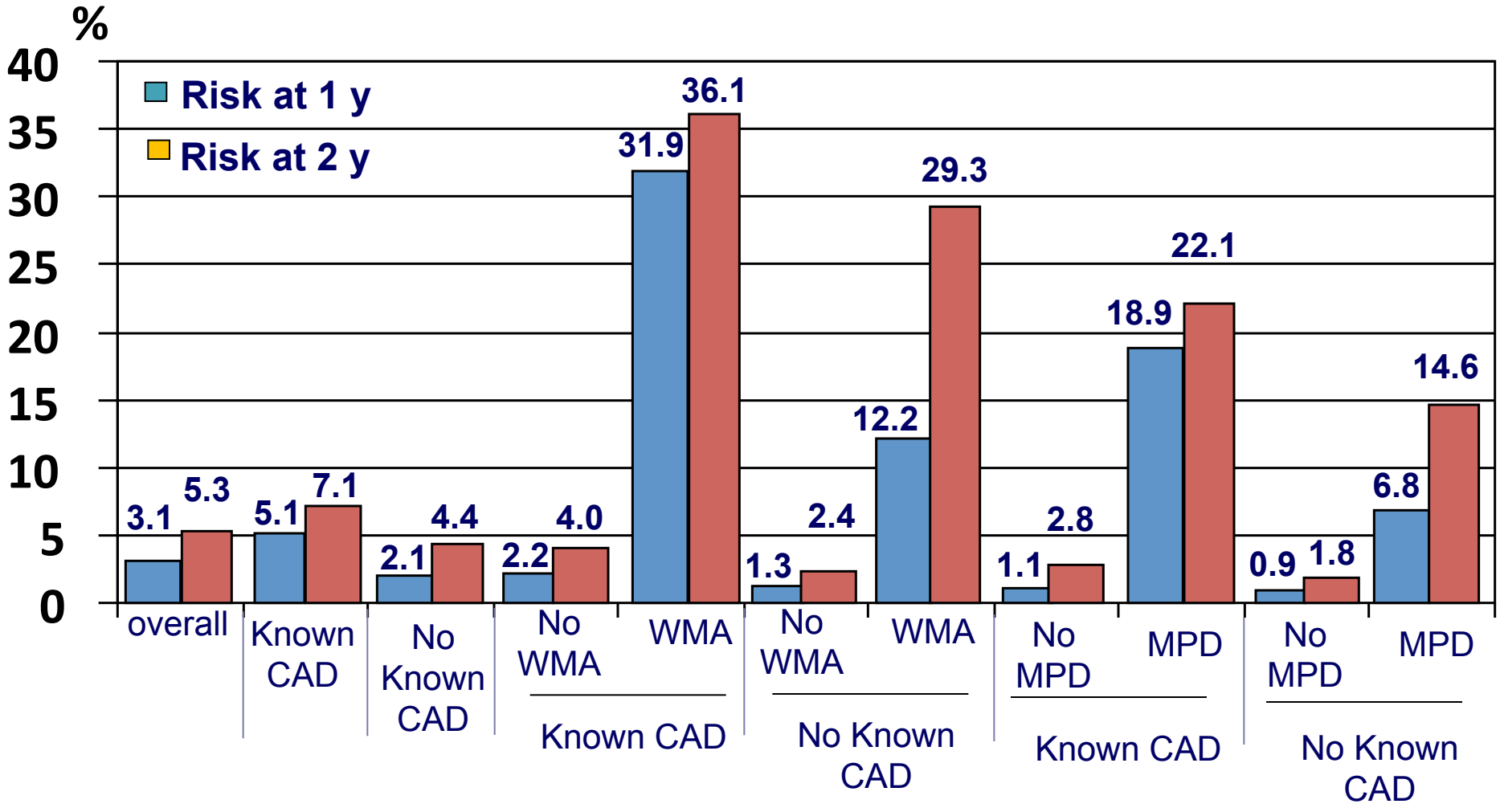
Prognostic Value of High-Dose Dipyridamole Stress Myocardial Contrast Perfusion Echocardiography



Gaibazy N. Circulation. 2012;126:1217-1224

STRESS ECHOCARDIOGRAPHY

Cumulative 1- and 2-year hard event rate in the overall population, subsets with or without previously known CAD and for each pattern of abnormality either in patients with or without previously known CAD



Gaibazy N. Circulation. 2012;126:1217-1224

1- General Considerations

2- Diagnosis of myocardial ischemia

3- Potential impact of 3D

4- What to do in case of inconclusive test?

4- Prognostic impact of a stress test

5- Additional role of perfusion evaluation?

5- Appropriateness in the real world?

STRESS ECHOCARDIOGRAPHY

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APPROPRIATE USE CRITERIA

ACCF/ASE/AHA/ASNC/HFSA/HRS/SCAI/SCCM/SCCT/SCMR 2011 Appropriate Use Criteria for Echocardiography

A Report of the American College of Cardiology Foundation Appropriate Use Criteria Task Force, American Society of Echocardiography, American Heart Association, American Society of Nuclear Cardiology, Heart Failure Society of America, Heart Rhythm Society, Society for Cardiovascular Angiography and Interventions, Society of Critical Care Medicine, Society of Cardiovascular Computed Tomography, and Society for Cardiovascular Magnetic Resonance

Endorsed by the American College of Chest Physicians

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Douglas P. J Am Coll Cardiol 2011;. 57:1126–66

STRESS ECHOCARDIOGRAPHY

Technical panel scored each indication as follows:

Median Score 7 to 9

Appropriate test for specific indication (test **is** generally acceptable and **is** a reasonable approach for the indication).

Median Score 4 to 6

Uncertain for specific indication (test **may** be generally acceptable and **may** be a reasonable approach for the indication). Uncertainty also implies that more research and/or patient information is needed to classify the indication definitively.

Median Score 1 to 3

Inappropriate test for that indication (test **is not** generally acceptable and **is not** a reasonable approach for the indication).

Douglas P. J Am Coll Cardiol 2011;. 57:1126–66

STRESS ECHOCARDIOGRAPHY

Indication	Appropriate indications (median score 7-9)	Appropriate use score (1-9)
Stress Echocardiography for Detection of CAD/Risk Assessment: Symptomatic or Ischemic Equivalent Evaluation of Ischemic Equivalent (Nonacute)		
115	Low pretest probability of CAD ECG uninterpretable or unable to exercise	A (7)
116	Intermediate pretest probability of CAD ECG interpretable and able to exercise	A (7)
117	**Intermediate pretest probability of CAD** **ECG uninterpretable or unable to exercise**	**A (9)**
118	High pretest probability of CAD Regardless of ECG interpretability and ability to exercise	A (7)

Douglas P. J Am Coll Cardiol 2011;. 57:1126–66

STRESS ECHOCARDIOGRAPHY

Indication	Appropriate indications (median score 7-9)	Appropriate use score (1-9)
Stress Echocardiography for Detection of CAD/Risk Assessment: Symptomatic or Ischemic Equivalent Acute Chest Pain		
119	**Possible ACS** ECG: no ischemic changes or with LBBB or electronically paced ventricular rhythm Low-risk TIMI score Negative troponin levels	A (7)
120	**Possible ACS** ECG: no ischemic changes or with LBBB or electronically paced ventricular rhythm Low-risk TIMI score Peak troponin: borderline, equivocal, minimally elevated	A (7)
121	**Possible ACS** ECG: no ischemic changes or with LBBB or electronically paced ventricular rhythm High-risk TIMI score Negative troponin levels	A (7)
122	**Possible ACS** ECG: no ischemic changes or with LBBB or electronically paced ventricular rhythm High-risk TIMI score Peak troponin: borderline, equivocal, minimally elevated	A (7)

STRESS ECHOCARDIOGRAPHY

Indication	Appropriate indications (median score 7-9)	Appropriate use score (1-9)
Stress Echocardiography for Detection of CAD/Risk Assessment: Asymptomatic (Without Ischemic Equivalent) in Patient Populations With Defined Comorbidities New-Onset or Newly Diagnosed HF or LV Systolic Dysfunction		
128	No prior CAD evaluation and no planned coronary angiography	A (7)
Stress Echocardiography for Detection of CAD/Risk Assessment: Asymptomatic (Without Ischemic Equivalent) in Patient Populations With Defined Comorbidities Arrhythmias		
129	Sustained VT	A (7)
130	Frequent PVCs, exercise-induced VT, or nonsustained VT	A (7)

Douglas P. J Am Coll Cardiol 2011;. 57:1126–66

STRESS ECHOCARDIOGRAPHY

Indication	Appropriate indications (median score 7-9)	Appropriate use score (1-9)
Stress Echocardiography for Detection of CAD/Risk Assessment: Asymptomatic (Without Ischemic Equivalent) in Patient Populations With Defined Comorbidities Syncope		
134	Intermediate or high global CAD risk	A (7)
Stress Echocardiography for Detection of CAD/Risk Assessment: Asymptomatic (Without Ischemic Equivalent) in Patient Populations With Defined Comorbidities Elevated Troponin		
135	Troponin elevation without symptoms or additional evidence of ACS	A (7)
Stress Echocardiography Following Prior Test Results Asymptomatic: Prior Evidence of Subclinical Disease		
139	Coronary calcium Agatston score >400	A (7)
Stress Echocardiography Following Prior Test Results Coronary Angiography (Invasive or Noninvasive)		
141	Coronary artery stenosis of unclear significance	A (7)

STRESS ECHOCARDIOGRAPHY

Indication	Appropriate indications (median score 7-9)	Appropriate use score (1-9)
Stress Echocardiography Following Prior Test Results ECG Stress Test		
149	Intermediate-risk treadmill score (e.g., Duke)	A (7)
150	High-risk treadmill score (e.g., Duke)	A (7)
Stress Echocardiography Following Prior Test Results New or Worsening Symptoms		
151	Abnormal coronary angiography or abnormal prior stress imaging study	A (7)
Stress **Echocardiography Following Prior Test Results Prior Noninvasive Evaluation**		
153	**Equivocal, borderline, or discordant stress testing where obstructive CAD remains a concern**	**A (8)**
Stress Echocardiography for Risk Assessment: Perioperative Evaluation for Noncardiac Surgery Without Active Cardiac Conditions Vascular Surgery		
161	>1 clinical RF poor or unknown functional capacity (<4 METs)	A (7)

STRESS ECHOCARDIOGRAPHY

Indication	Appropriate indications (median score 7-9)	Appropriate use score (1-9)
Stress Echocardiography for Risk Assessment: Within 3 Months of an ACS STEMI		
164	Hemodynamically stable, no recurrent chest pain symptoms, or no signs of HF To evaluate for inducible ischemia No prior coronary angiography since the index event	A (7)
Stress Echocardiography for Risk Assessment: Within 3 Mo of an ACS UA/ NSTEMI		
166	Hemodynamically stable, no recurrent chest pain symptoms, or no signs of HF To evaluate for inducible ischemia No prior coronary angiography since the index event	A (8)
Stress Echocardiography for Risk Assessment: Postrevascularization (PCI or CABG) Symptomatic		
169	Ischemic equivalent	A (8)

STRESS ECHOCARDIOGRAPHY

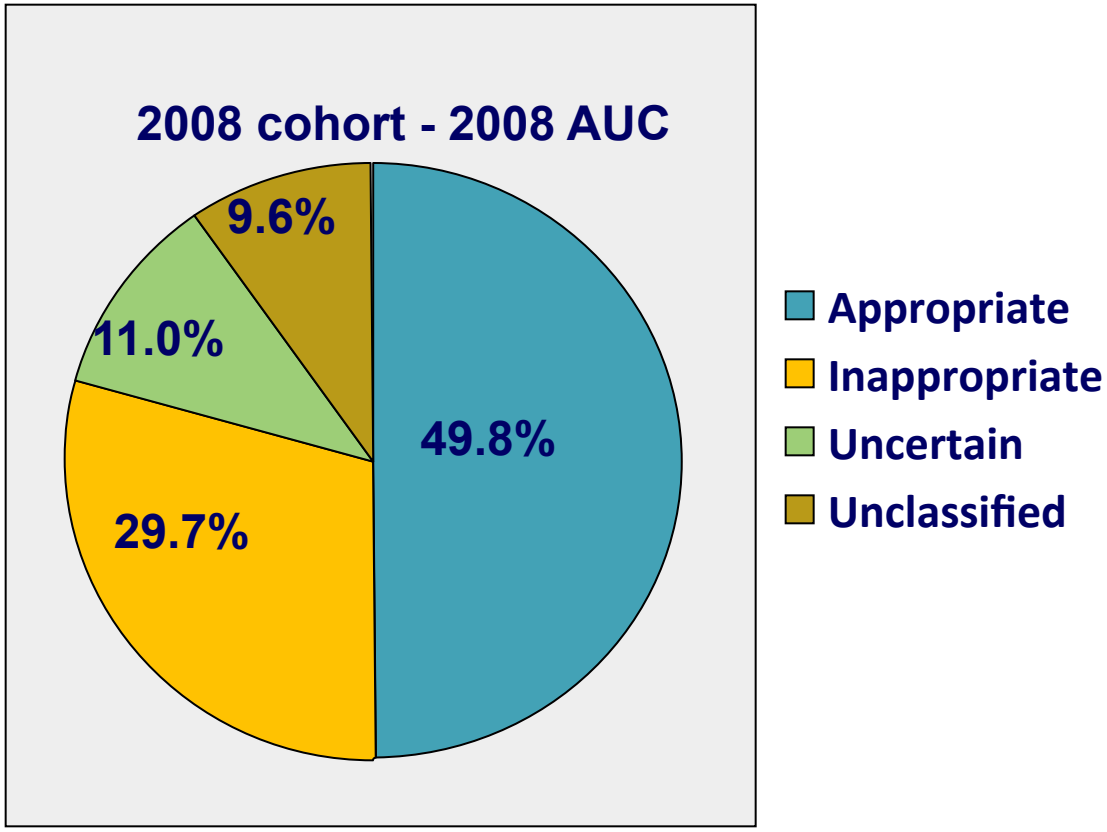
Indication	Appropriate indications (median score 7-9)	Appropriate use score (1-9)
Stress Echocardiography for Risk Assessment: Postrevascularization (PCI or CABG) Asymptomatic		
170	Incomplete revascularization Additional revascularization feasible	A (7)
Stress Echocardiography for Assessment of Viability/Ischemia Ischemic Cardiomyopathy/Assessment of Viability		
176	Known moderate or severe LV dysfunction Patient eligible for revascularization Use of dobutamine stress only	A (8)

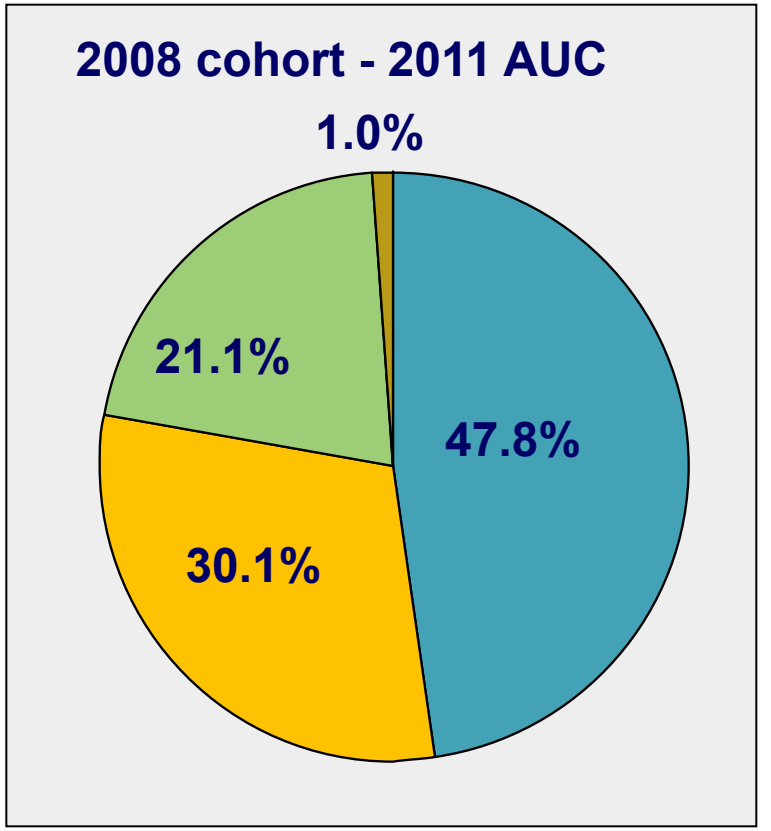
Douglas P. J Am Coll Cardiol 2011;. 57:1126–66

STRESS ECHOCARDIOGRAPHY

Appropriate Use Criteria for Stress Echocardiography

Comparison of Appropriateness Ratings of 2008 Cohort by the 2008 and 2011 AUC





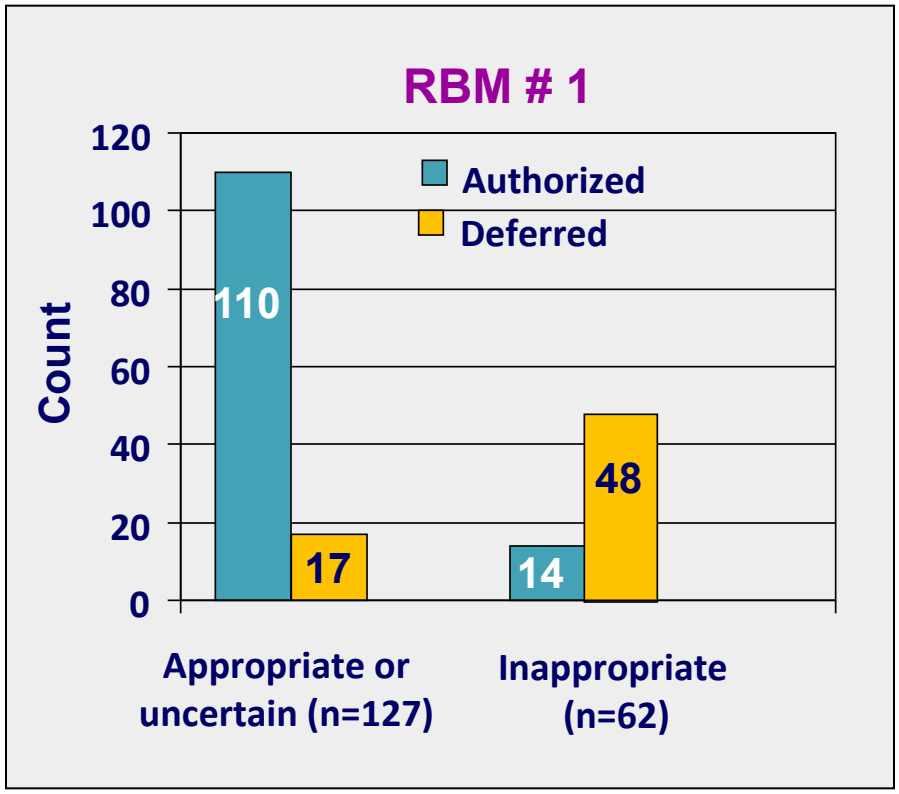
Appropriateness ratings of stress echocardiograms (SE) from the 2008 cohort according to the (A) 2008 appropriate use criteria (AUC) and the (B) 2011 AUC, shown as percent of total studies. Using the new criteria, the percent of unclassified studies decreased from 9.6% to 1%.

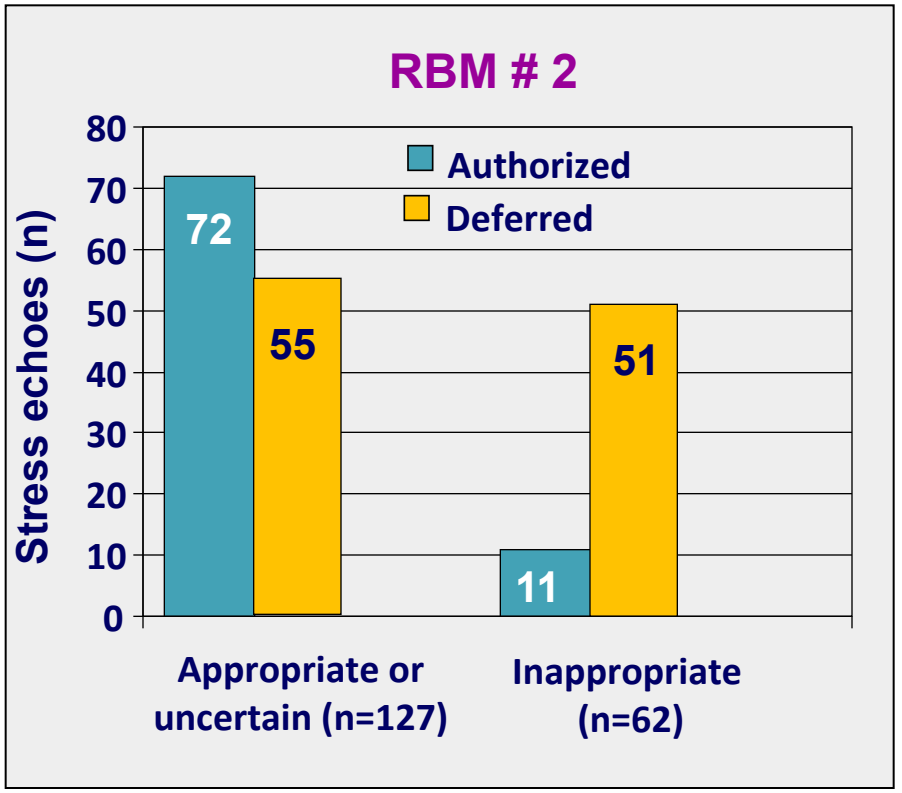
Willen HJ. J Am Coll Cardiol Img 2013;6:297–309

STRESS ECHOCARDIOGRAPHY

Appropriate Use Criteria for Stress Echocardiography

Distribution of pre-authorization determinations according to appropriateness classification





Number of stress echocardiograms (SE) that would have been authorized (green bars) or deferred (pink bars) according to the guidelines of (A) radiology benefits managers (RBM) #1 and (B) RBM #2, stratified according to their appropriateness rating (combined appropriate and uncertain vs. inappropriate) by the 2008 AUC. According to guidelines of RBM #2, 52 (41.9%) of 124 Ses with an appropriate and uncertain rating would not have been pre-approved

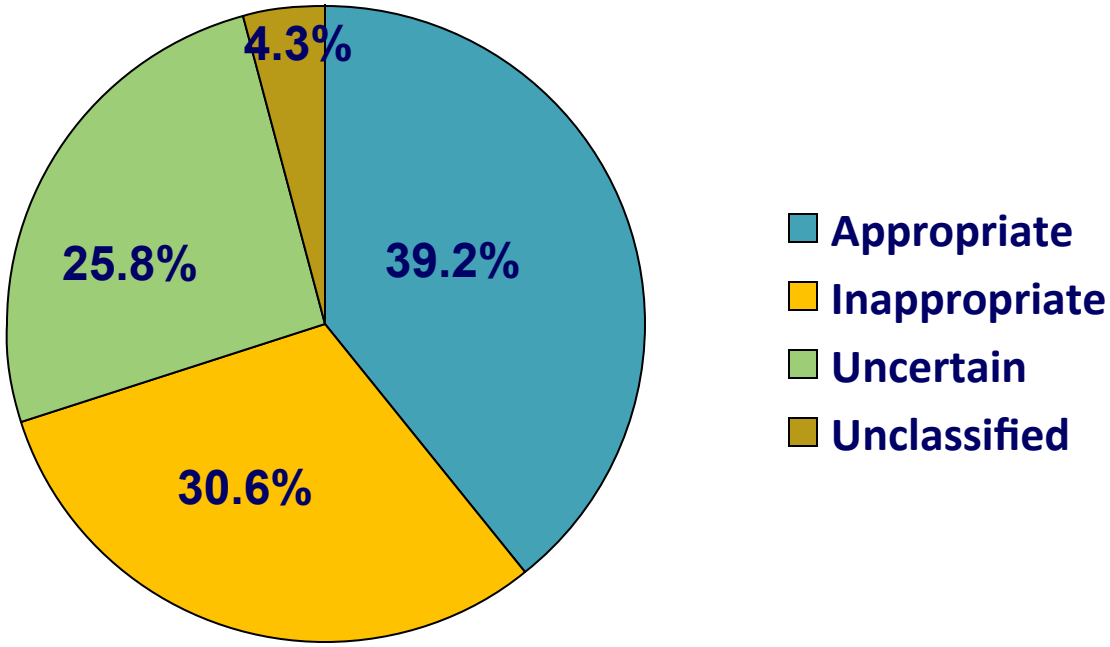
Willen HJ. J Am Coll Cardiol Img 2013;6:297–309

Appropriate Use Criteria for Stress Echocardiography

Appropriateness Ratings of 2011 Cohort

2011 cohort

2011 AUC

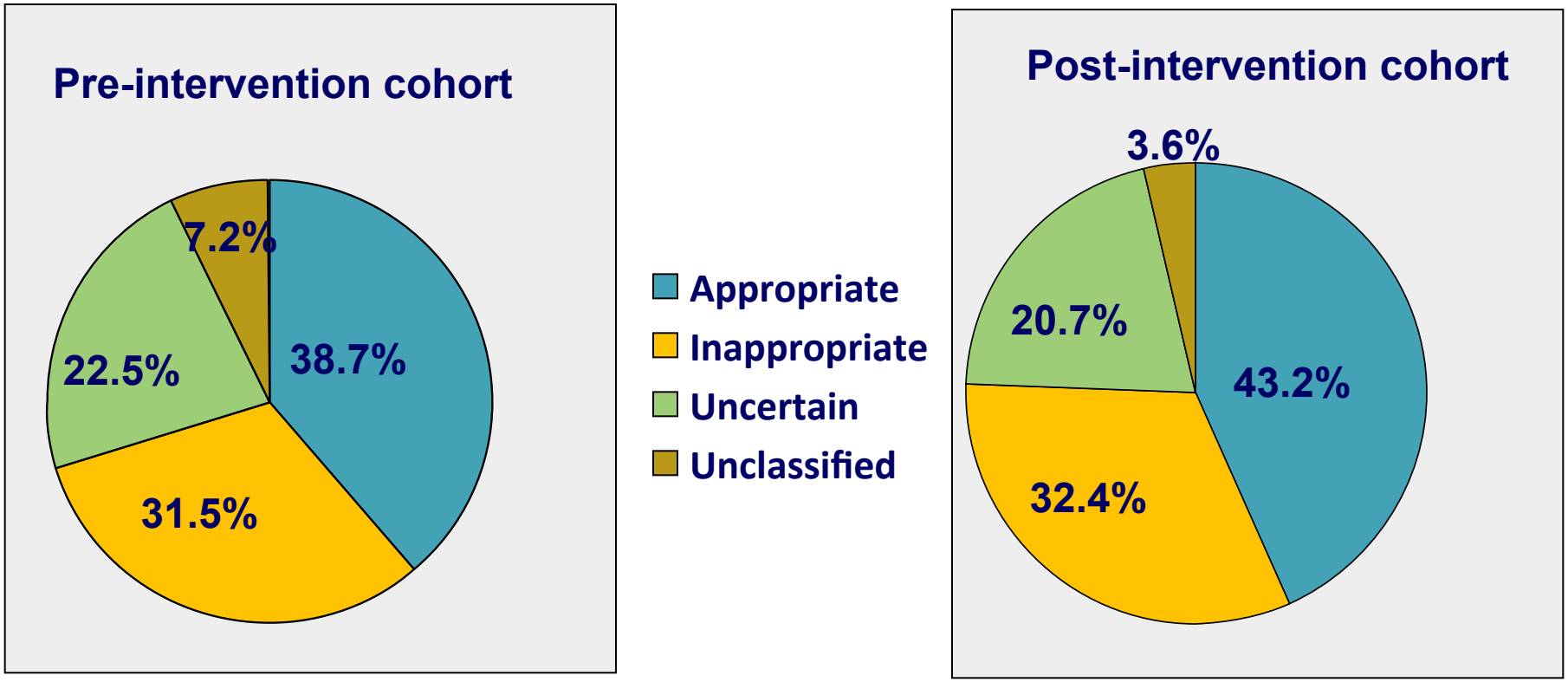


Appropriateness ratings of stress echocardiograms (SE) from the 2011 cohort according to the 2011 appropriate use criteria (AUC) shown as percent of total studies. Appropriateness did not significantly change compared to the 2008 cohort.

Willen HJ. J Am Coll Cardiol Img 2013;6:297–309

Appropriate Use Criteria for Stress Echocardiography

Impact of Education on Appropriateness Ratings



Appropriateness ratings according to the updated appropriate use criteria (AUC) of stress echocardiograms (SE) referred by cardiologists from the 20011 cohort (A) before education and (B) after education, shown as percent of total examinations. There was no statistically significant difference in the ratings after the educational intervention.

Willen HJ. J Am Coll Cardiol Img 2013;6:297–309

STRESS ECHOCARDIOGRAPHY

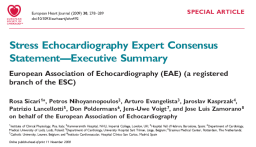
Indication	Appropriate indications (median score 7-9)	Appropriate use score (1-9)
Stress Echocardiography for Risk Assessment: Postrevascularization (PCI or CABG) Asymptomatic		
170	Incomplete revascularization Additional revascularization feasible	A (7)
Stress Echocardiography for Assessment of Viability/Ischemia Ischemic Cardiomyopathy/Assessment of Viability		
176	Known moderate or severe LV dysfunction Patient eligible for revascularization Use of dobutamine stress only	A (8)
Stress Echocardiography for Hemodynamics (Includes Doppler During Stress) Chronic Valvular Disease—Asymptomatic		
179	Severe mitral stenosis	A (7)
185	Severe mitral regurgitation LV size and function not meeting surgical criteria	A (7)
188	Severe aortic regurgitation LV size and function not meeting surgical criteria	A (7)

STRESS ECHOCARDIOGRAPHY

Indication	Appropriate indications (median score 7-9)	Appropriate use score (1-9)
Stress Echocardiography for Hemodynamics (Includes Doppler During Stress) Chronic Valvular Disease—Symptomatic		
190	Moderate mitral stenosis	A (7)
193	Evaluation of equivocal aortic stenosis Evidence of low cardiac output or LV systolic dysfunction (‘ ‘low gradient aortic stenosis’ ’) Use of dobutamine only	A (8)
195	Moderate mitral regurgitation	A (7)
Contrast Use in TTE/TEE or Stress Echocardiography		
202	Selective use of contrast $2 contiguous LV segments are not seen on noncontrast images	A (8)

Douglas P. J Am Coll Cardiol 2011;. 57:1126–66

ESC Guidelines


SPECIAL ARTICLE

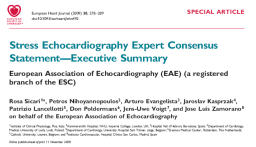
Stress Echocardiography Expert Consensus Statement—Executive Summary

European Association of Echocardiography (EAE) (a registered branch of the ESC)

- - L'échocardiographie d'effort, sous dobutamine et sous vasodilatateurs aux doses appropriées, sont des **modalités équivalentes d'induction d'une ischémie myocardique** pour induire une asynergie segmentaire, et ainsi détecter la présence d'une sténose coronaire épicardique significative.
- - Ces agents pharmacologiques permettent de distinguer **4 états myocardiques** : repos, cinétique normale, ischémie, cinétique anormale, nécrose, absence de modification de la cinétique pariétale et du déplacement endocardique et viabilité, amélioration aux faibles doses d'agents inotropes positifs.
- - La **précision diagnostique des différents agents pharmacologiques** est superposable à celle obtenue avec l'exercice physique, le choix de chacune de ces méthodes reposant sur le respect des contre indications à l'une de ces méthodes ou des limites d'une modalité d'ischémie en fonction de l'état physique et physiopathologique du patient.

Sicari R. Eur Heart J 2009;30:278-89
Sicari R. Eur J Echocardiogr 2008;9:415-437

ESC Guidelines

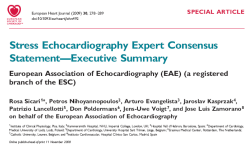

SPECIAL ARTICLE

Stress Echocardiography Expert Consensus Statement—Executive Summary

European Association of Echocardiography (EAE) (a registered branch of the ESC)

- - **La valeur pronostique de ces différents agents de stress, exercice physique ou pharmacologique est superposable**, avec une préférence cependant pour l'utilisation de la dobutamine et à un degré du dipyridamole moindre car les données de la littérature sont plus importantes avec la dobutamine.
- - **L'échographie sous dobutamine est la modalité préférentielle utilisée pour la détection d'une viabilité myocardique** (dobutamine à une dose < 15 mcg/kg/mn), en particulier en cas de dysfonction ventriculaire gauche avant revascularisation.
- - **En cas de contre indication à la dobutamine**, la réalisation d'un exercice physique à faibles paliers, l'adénosine, le dipyridamole ou l'enoximone pourraient être proposés.
- - **La procédure la mieux tolérée, associée au moindre risque de complications cardiovasculaires est l'exercice physique**, comparativement à un stress pharmacologique. Parmi ces agents, le dipyridamole parait mieux toléré que la dobutamine.

Sicari R. Eur Heart J 2009;30:278-89
Sicari R. Eur J Echocardiogr 2008;9:415-437


SPECIAL ARTICLE

Stress Echocardiography Expert Consensus Statement—Executive Summary

European Association of Echocardiography (EAE) (a registered branch of the ESC)

ESC Guidelines

- - **Le médecin et le patient doivent être prévenus du risque de complications**, de leur taux, dans la perspective de délivrer une information complète au patient.
- - L'échographie de stress doit être proposée en seconde intention après qu'un test d'effort n'ait pas permis de poser un diagnostic ou n'ait pas répondu à la question clinique posée (valeur pronostique) ; cela concernant en particulier les tests sous maximaux, ou les situations dans lesquelles l'électrocardiogramme ne peut être interprété, tant au repos qu'à l'effort.
- - L'échographie de stress doit être préférée aux autres modalités de documentation d'une ischémie myocardique couplée à une imagerie en particulier scintigraphie, car l'échographie est une méthode à faible coût et sans irradiation.

Sicari R. Eur Heart J 2009;30:278-89
Sicari R. Eur J Echocardiogr 2008;9:415-437

STRESS ECHOCARDIOGRAPHY

Agent de contraste

Recommandations

Amélioration du contour endocardique chez des patients avec une imagerie difficile ou suboptimale au repos ou au pic[1]

Recommandée quand au moins deux segments contigus sont non ou mal visualisés pour améliorer la visualisation de l'épaississement segmentaire au repos et au pic et ainsi améliorer la performance diagnostique de l'échographie de stress et augmenter la confiance de l'interprétation[2,3]

Contre-indications

Shunt intra cardiaque significatif

Hypersensibilité connue à l'agent de contraste[2,3]

Sonovue® ne doit pas être utilisé dans les 7 jours suivant un SCA

[1] *Sicari R. Eur J Echocardiogr 2008 ; 9 : 415-437*

[2] *Senior R. Eur J Echocardiogr 2009 ; 10 : 194–212*

[3] *Mulvagh SL. J Am Soc Echocardiogr 2008 ; 21 : 1179-201*

Stratification du risque cardiovasculaire en péri-opératoire d'une chirurgie non cardiaque

- Importance du problème :
  - 7.10^6 procédures chirurgicales / an en Europe sont réalisées chez des patients « à risque cardiaque »
  - MACEs péri-opératoire : 1.7 à 6%
  - 150 à 200.000 complications cardiaques majeures / an

- Vieillissement de la population
  - Chirurgie après 75 ans : + 24% en 10 ans
  - Après 75 ans : 12 à 19% de maladies cardiovasculaires

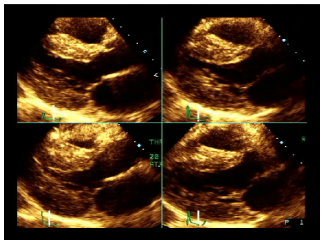
Poldermans D. Eur Heart J; 2009;30:2769-812

ECHOCARDIOGRAPHIE

MUST EN

Summary of preoperative cardiac risk evaluation & peroperative management

Step	Urgency	Cardiac condition	Type of surgery	Functiona capacity	Number of clinical risk factors	LV Echo	ECG	Stress testing	B-blockers	ACE-inhibitors	Aspirin	Statins	Coronary revaculari sation
1	Urgent surgery					III C	IIa C	III C	I C	I C	I C	I C	III C
2	Elective surgery	Unstable				I C	I C	III C					I C
3	Elective surgery	stable	Low risk (< 1 %)		None	III B	III B	III C	III B	IIa C	IIb C	IIa B	III C
					≥ 1	III B	IIa B	III C	IIb B (titration) III A (no titration)	IIa C	IIb C	IIa B	III C
4				Excellent or good		III B	IIa B	III C	IIb B (titration) III A (no titration)	IIa C	IIb C	IIa B	III C
5	Elective surgery		Intermediate risk (1-5 %)	Moderate or poor	None	III B	IIb B	IIb C	IIb B (titration) III A (no titration)	I C	IIb C	IIa B	III B
					1	III B	I B	IIb C	IIb B (titration) III A (no titration)	I C	IIb C	IIa B	III B
6	Elective surgery		High risk (> 5 %)	Moderate or poor	≤ 2	IIa C	I B	IIb B	I B (titration) III A (no titration)	I C	IIb C	I B	IIb B
					≥ 3	IIa C	I B	I C	I B (titration) III A (no titration)	I C	IIb C	I B	IIb B



MERCI!!

- **Ariel**

CASE STUDY. Mrs BBB…

- Woman, 55 yrs old
- Risk Factots; hypertension, NIDM, smoging
- HbA1C 8,5%.
- LAD PTCA 2 years
- PAD.
- Asymptomatic

CASE STUDY. Mrs BBB…

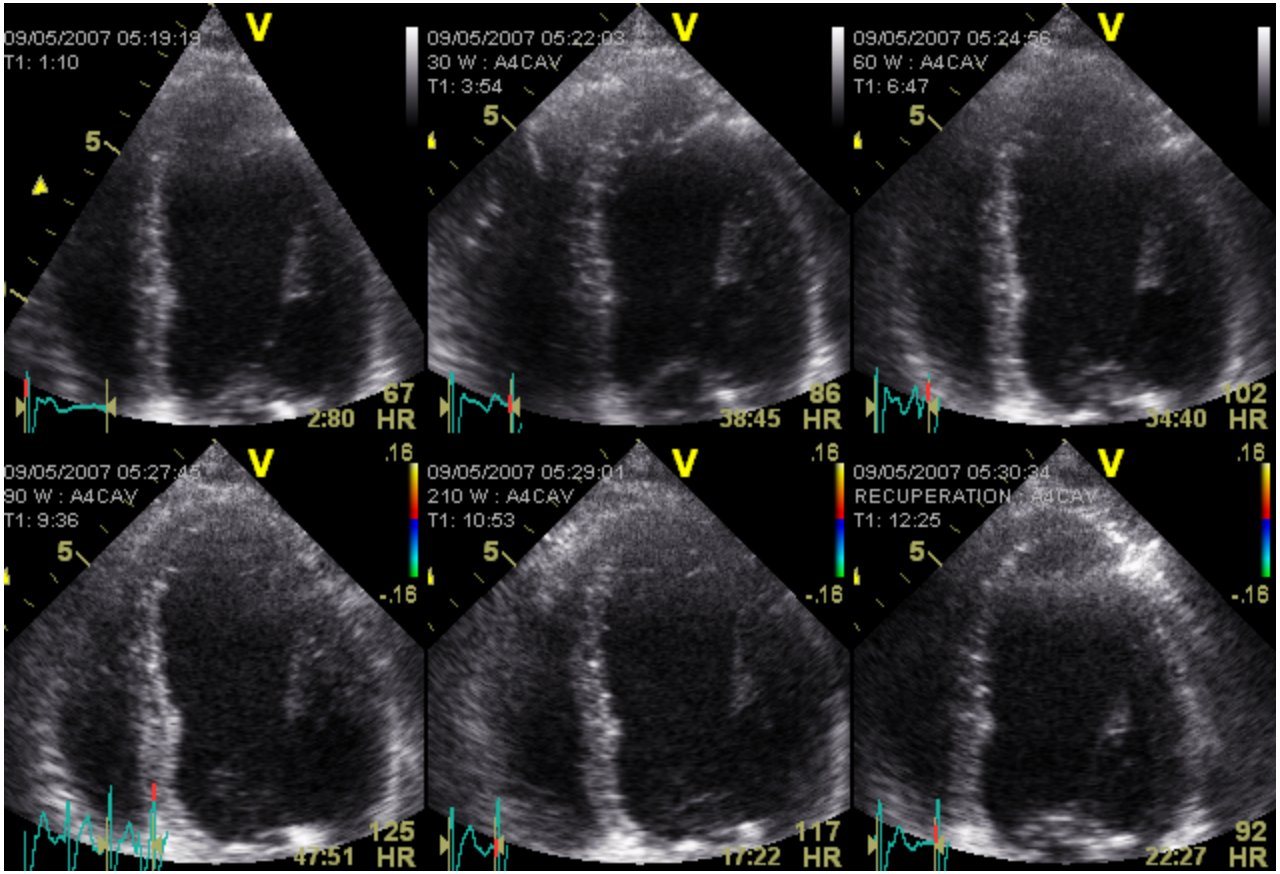
90 W, 85 % MPHR, Stopped because of fatigue

Clinical : Asymptomatic

ECG : No ST segment deviation

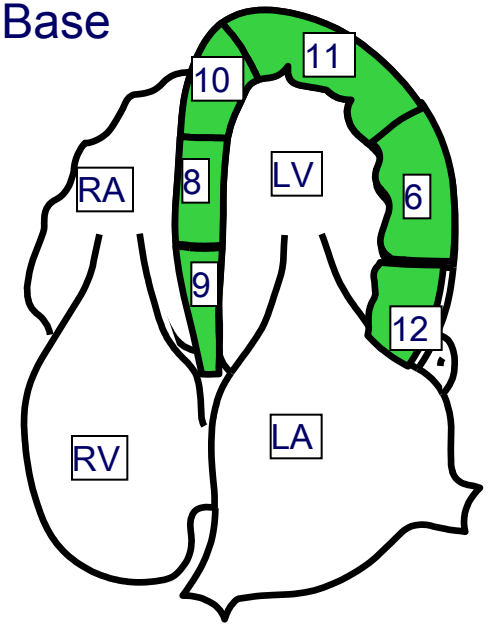
Echocardiography

CASE STUDY. Mrs BBB…

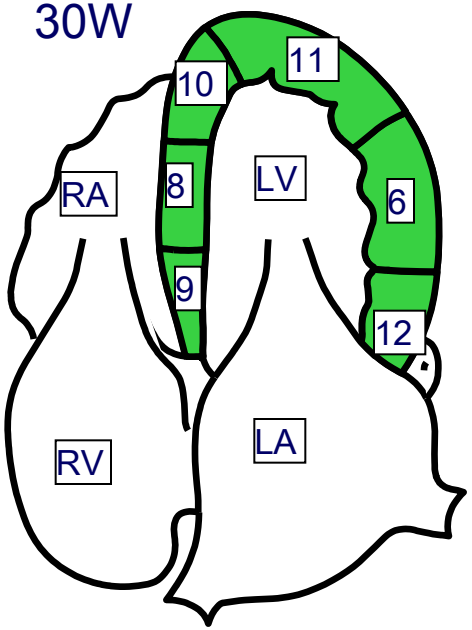


STRESS ECHOCARDIOGRAPHY

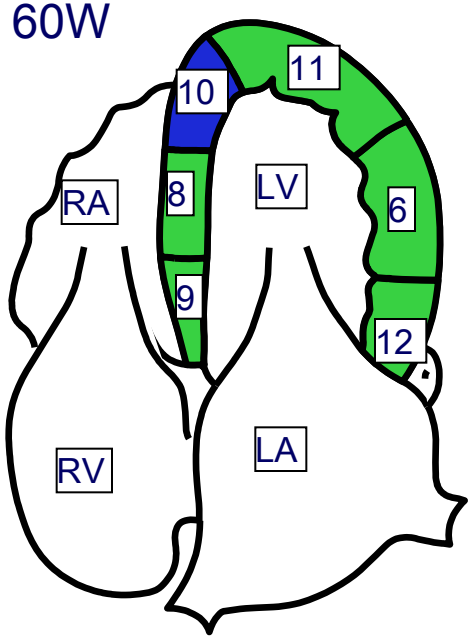
Base



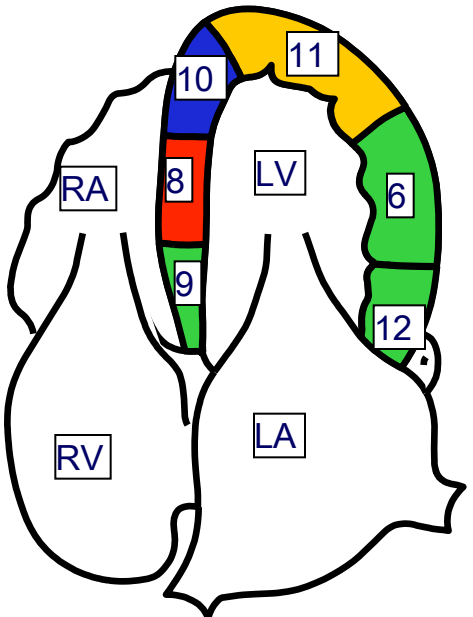
30W



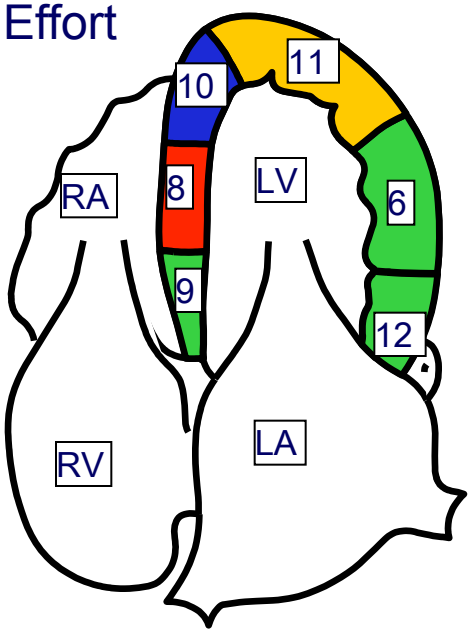
60W



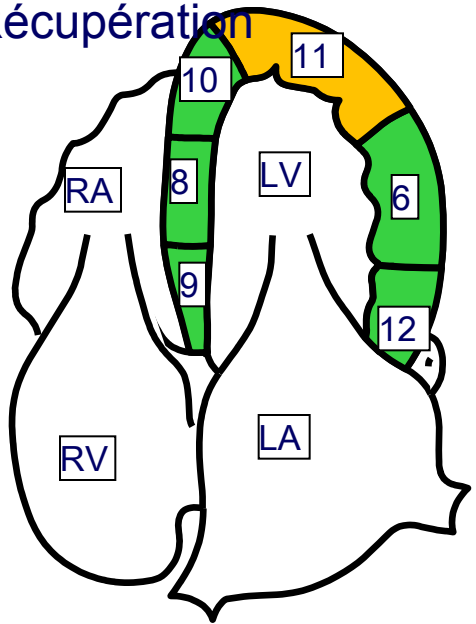
90W



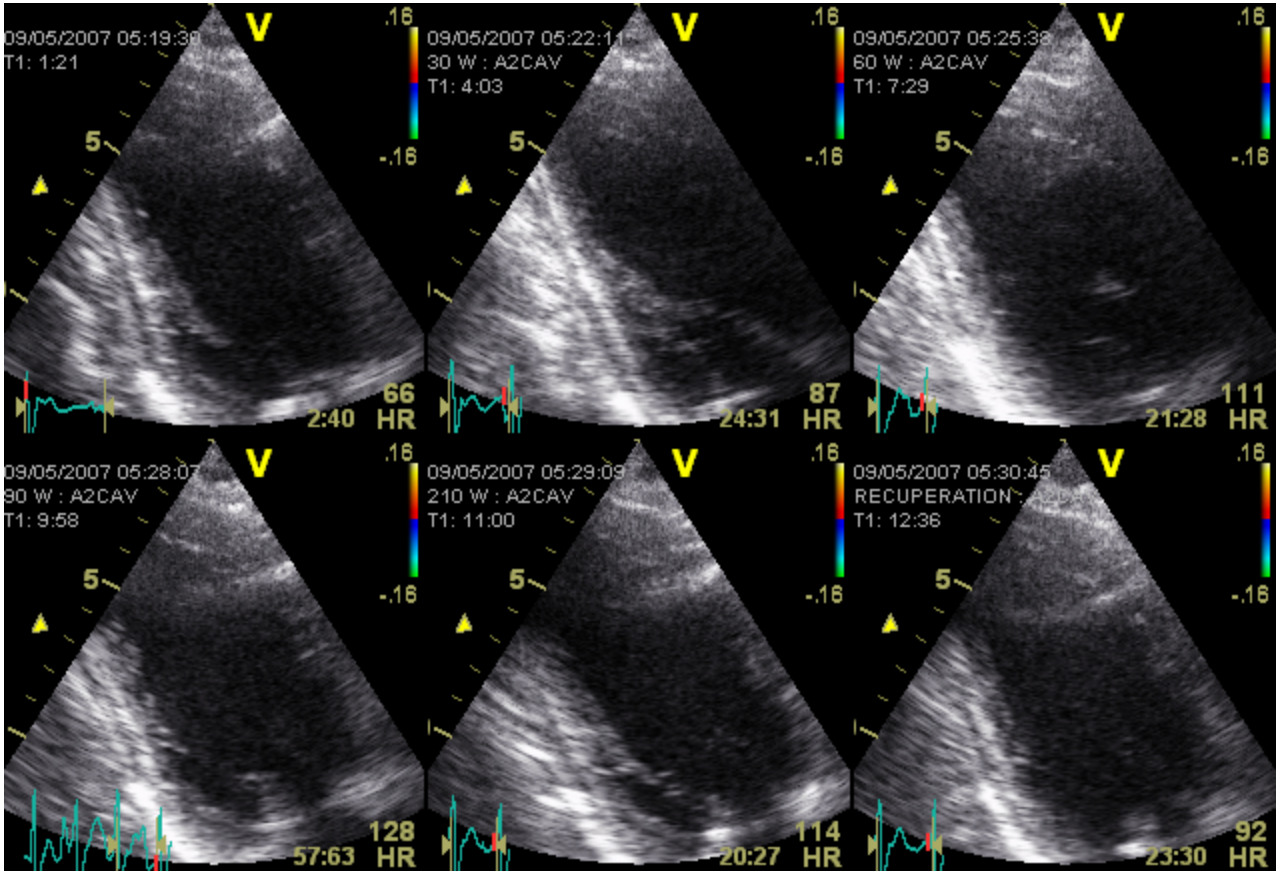
Pic Effort



Récupération

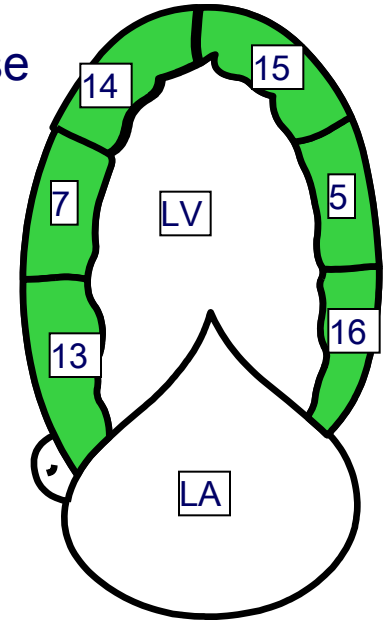


CASE STUDY. Mrs BBB…



STRESS ECHOCARDIOGRAPHY

Base



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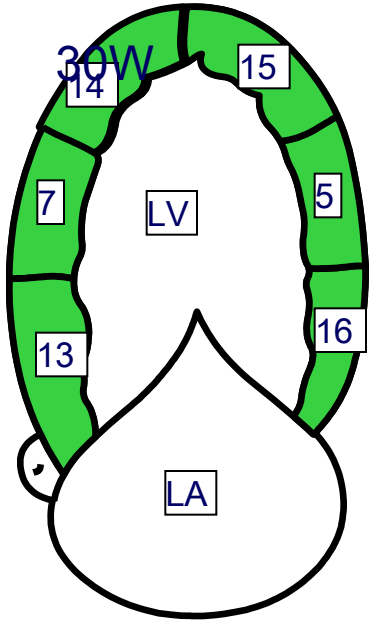

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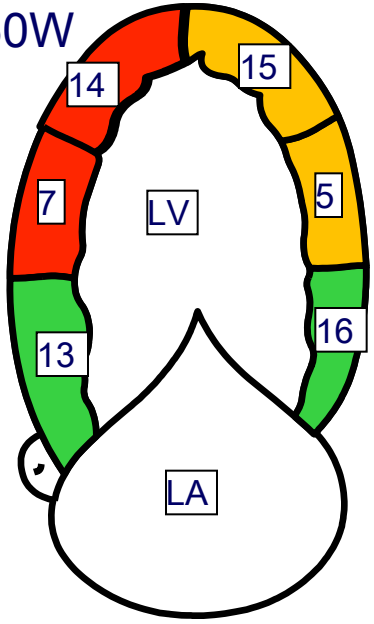

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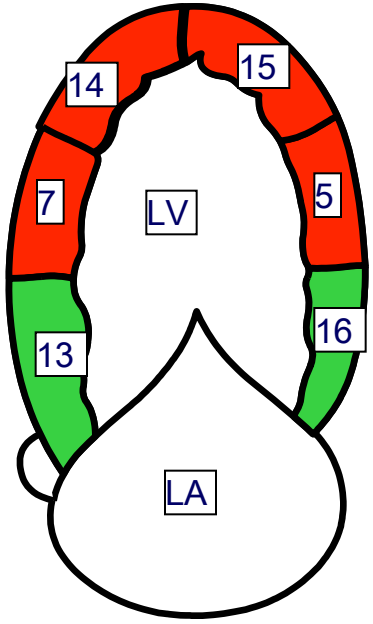
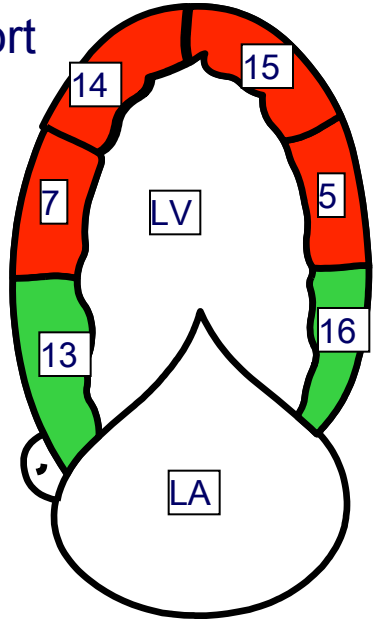


Pic Effort



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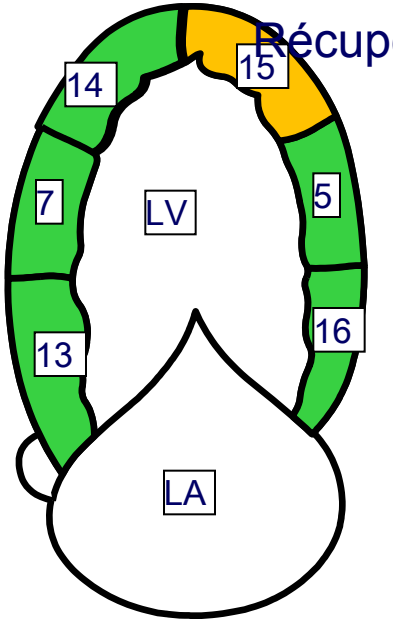
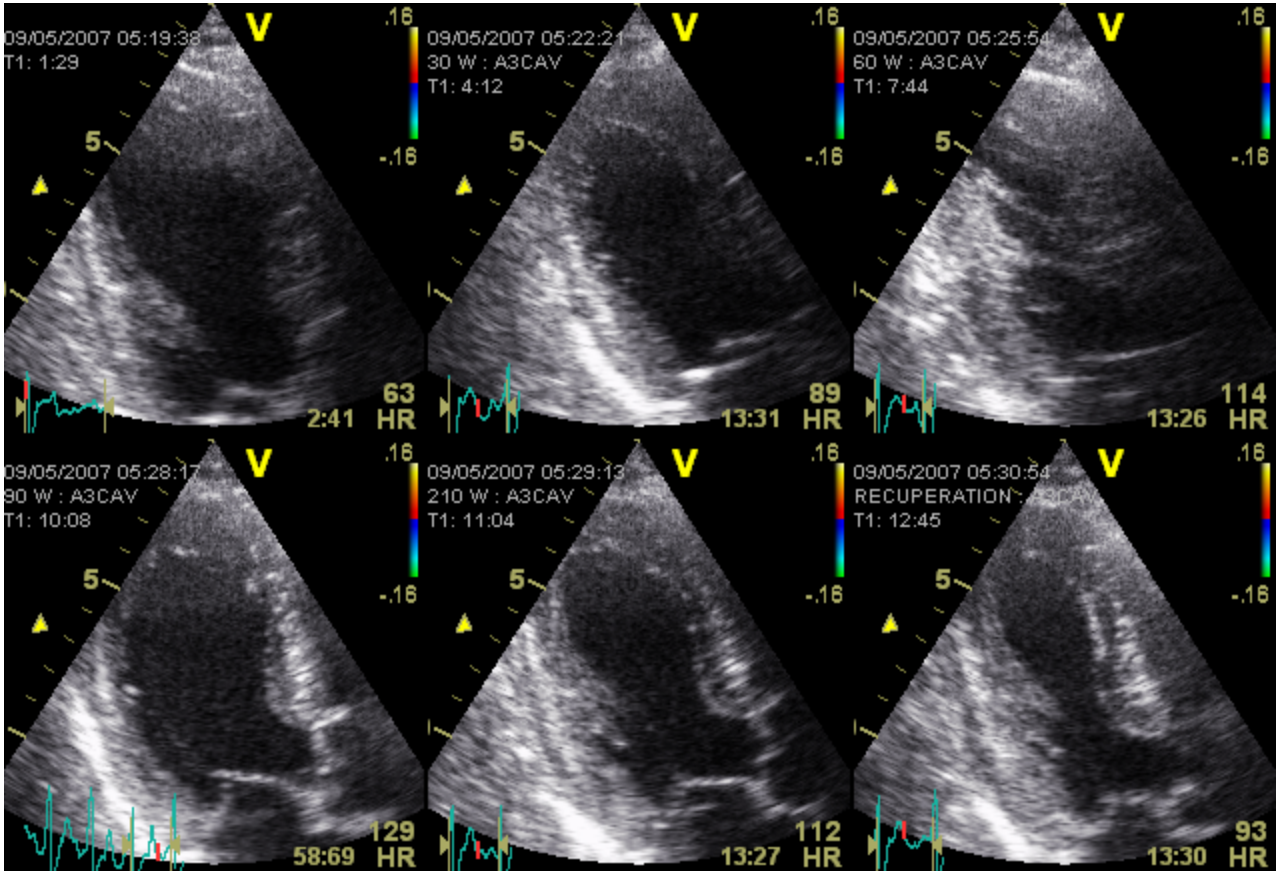
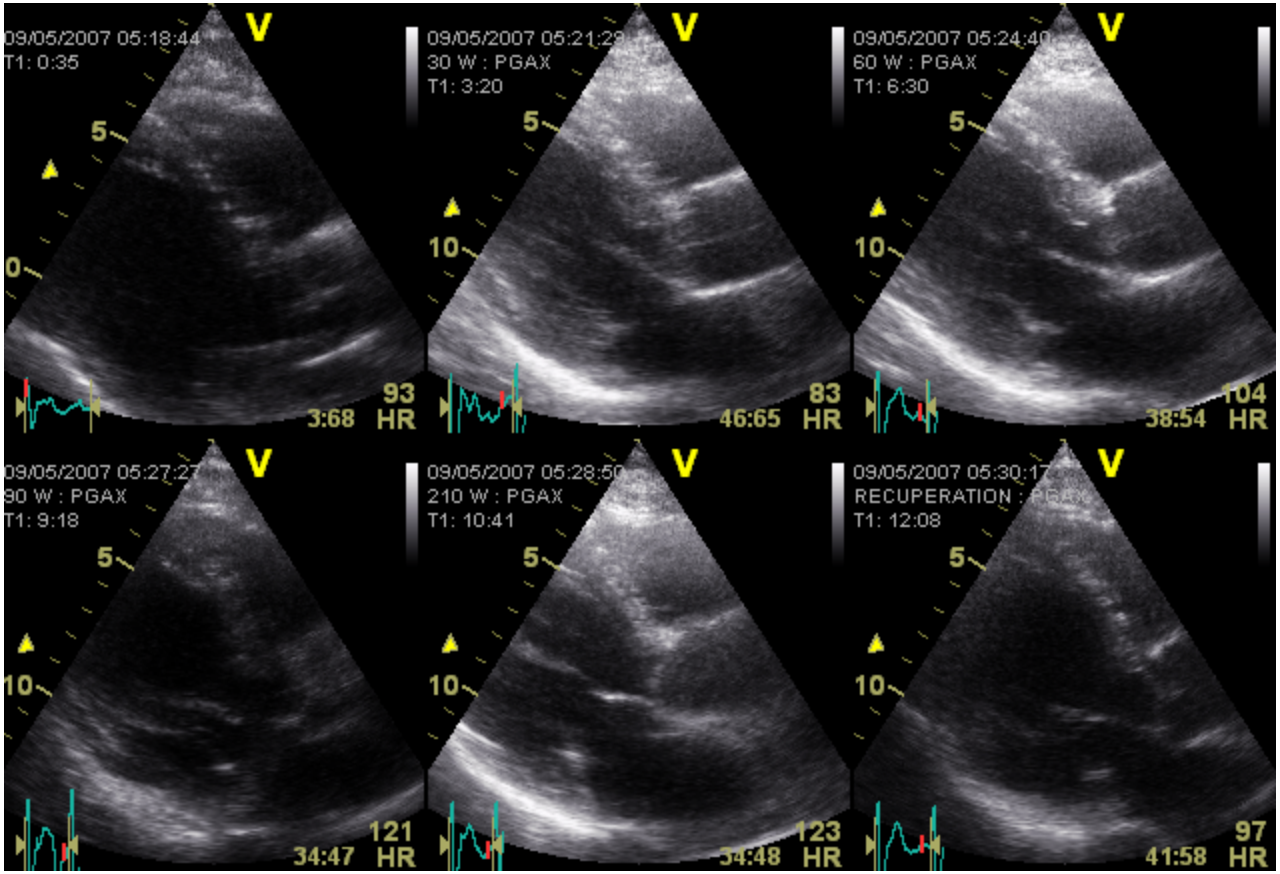


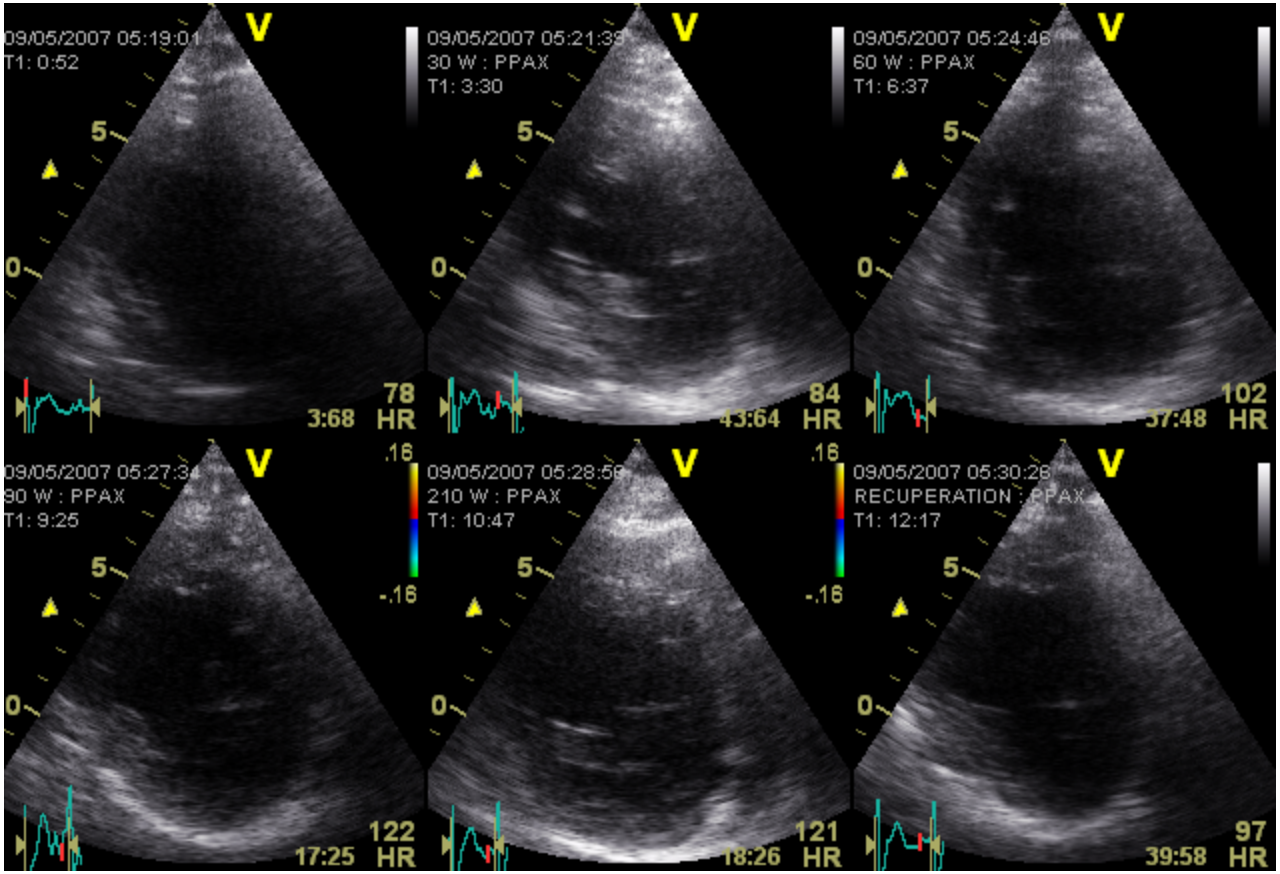
CASE STUDY. Mrs BBB…



CASE STUDY. Mrs BBB…



CASE STUDY. Mrs BBB…



CASE STUDY. Mrs CCC…

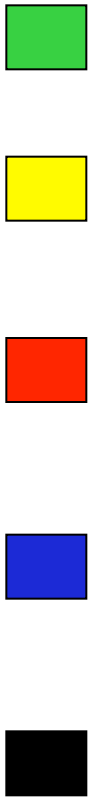
Normokinétique

Hypokinétique

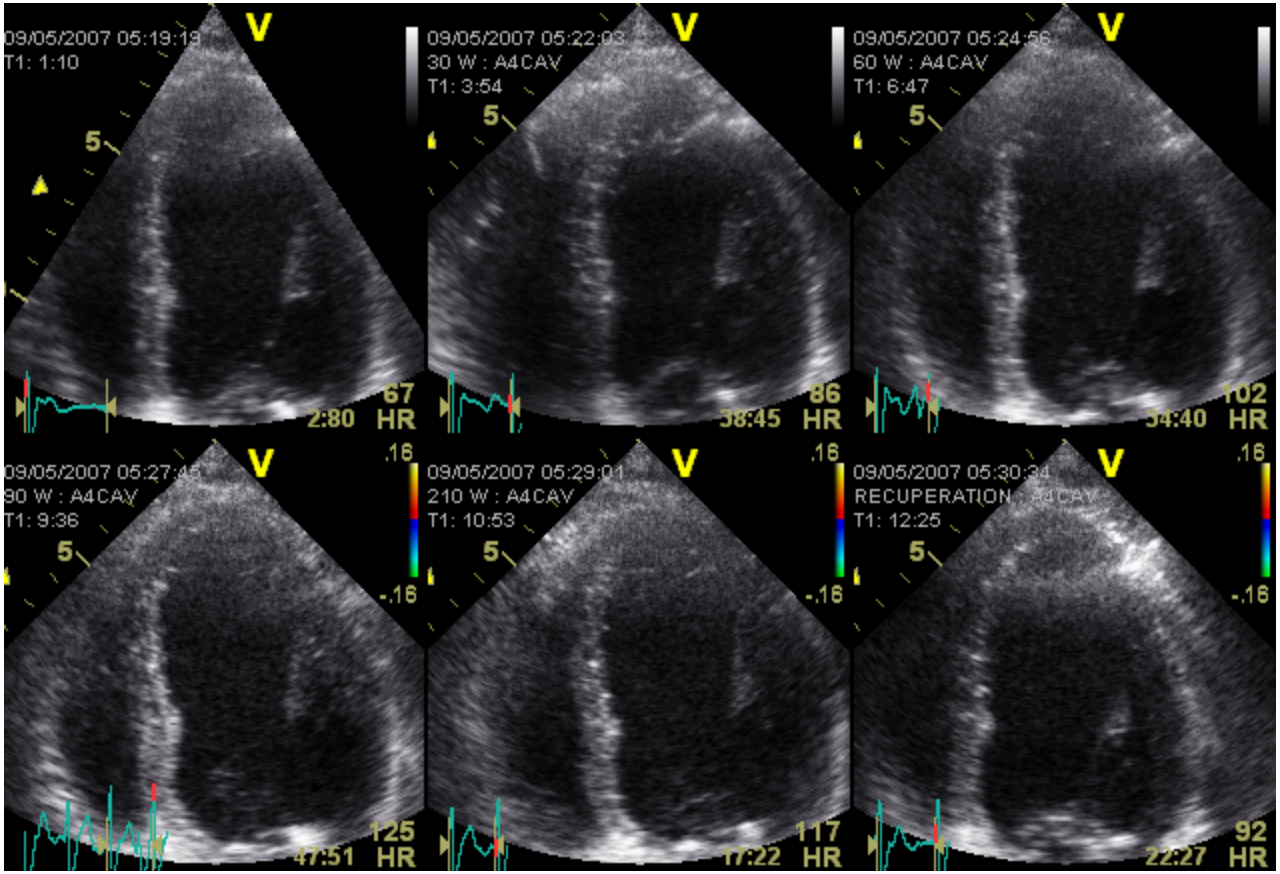
Akinétique

Dyskinétique

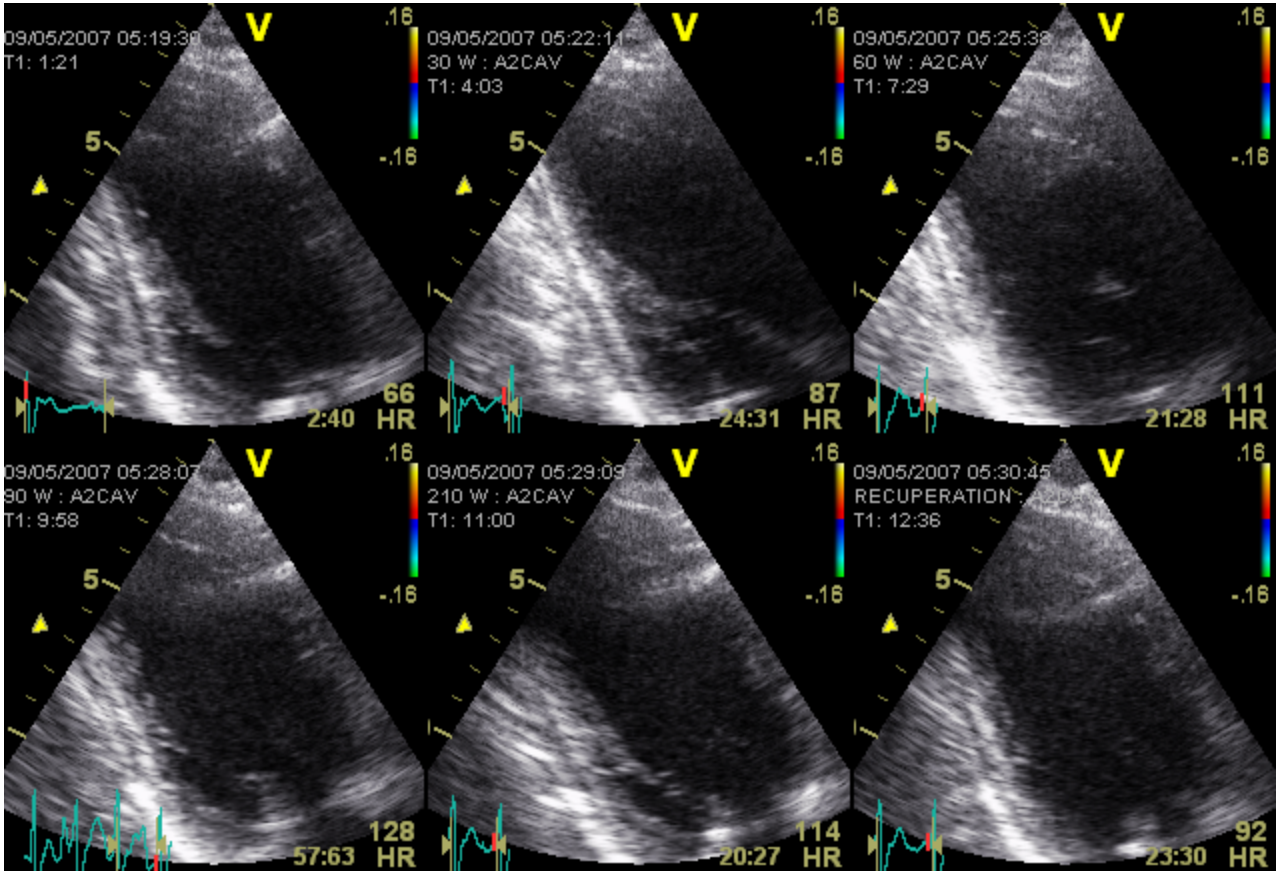
Non Visualisé



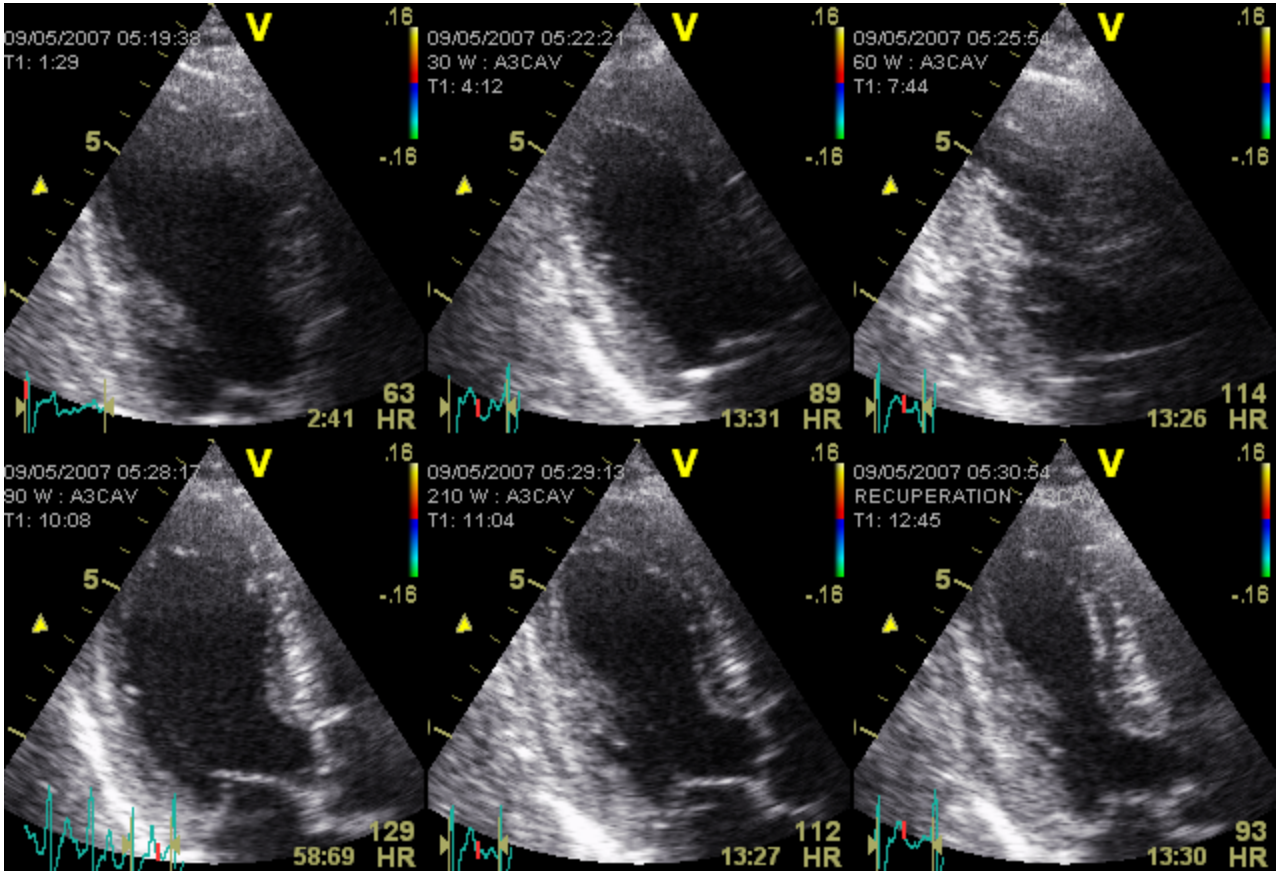
CASE STUDY. Mrs CCC…



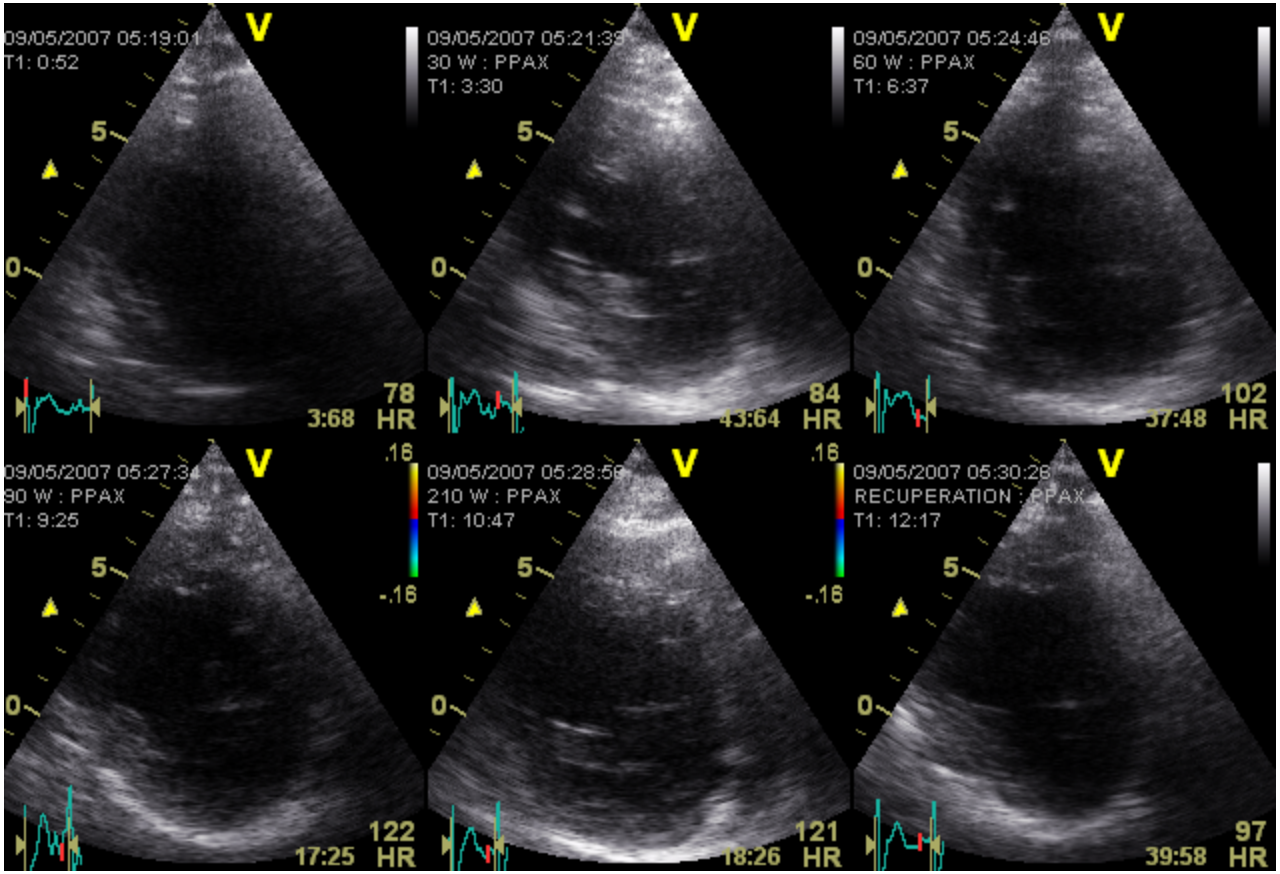
CASE STUDY. Mrs CCC…



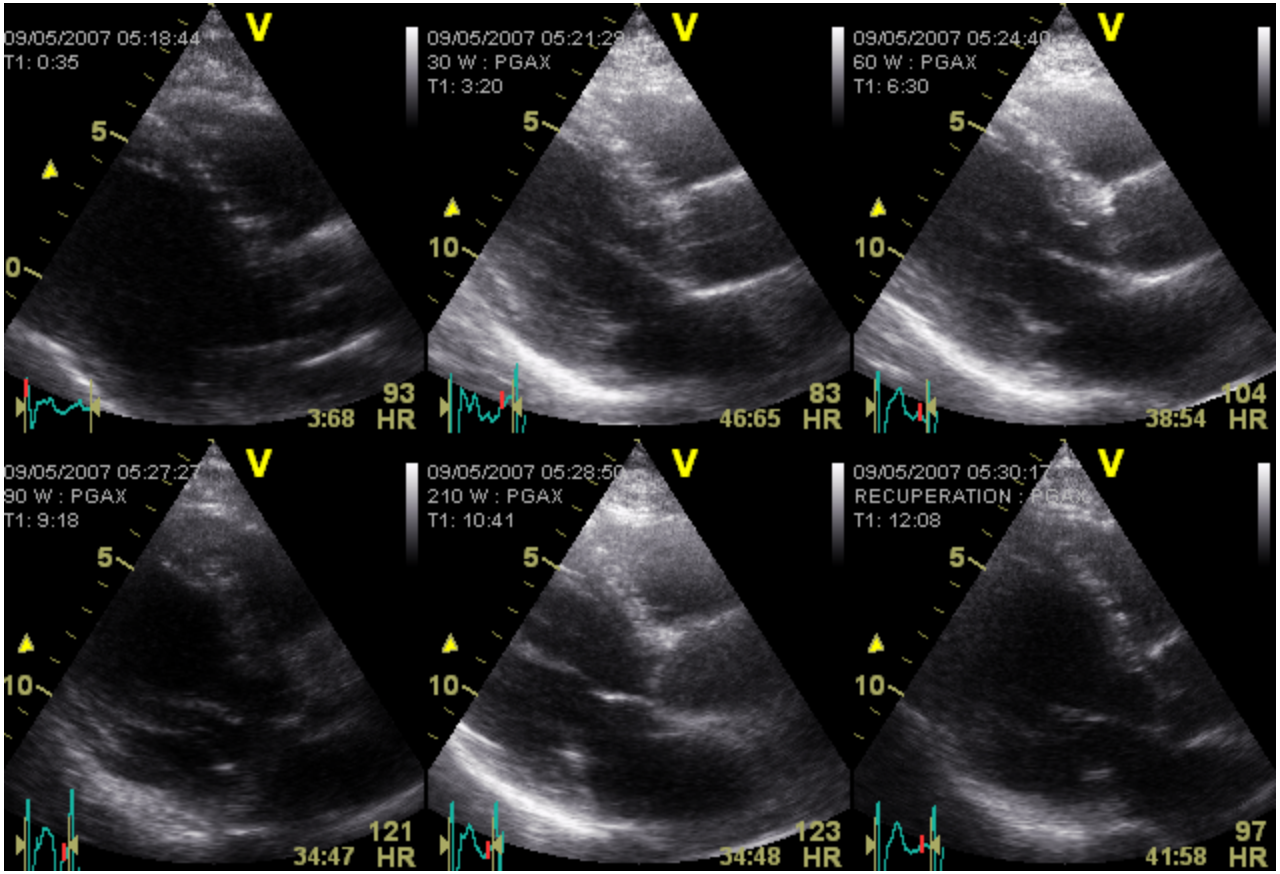
CASE STUDY. Mrs CCC…



CASE STUDY. Mrs CCC…



CASE STUDY. Mrs CCC…



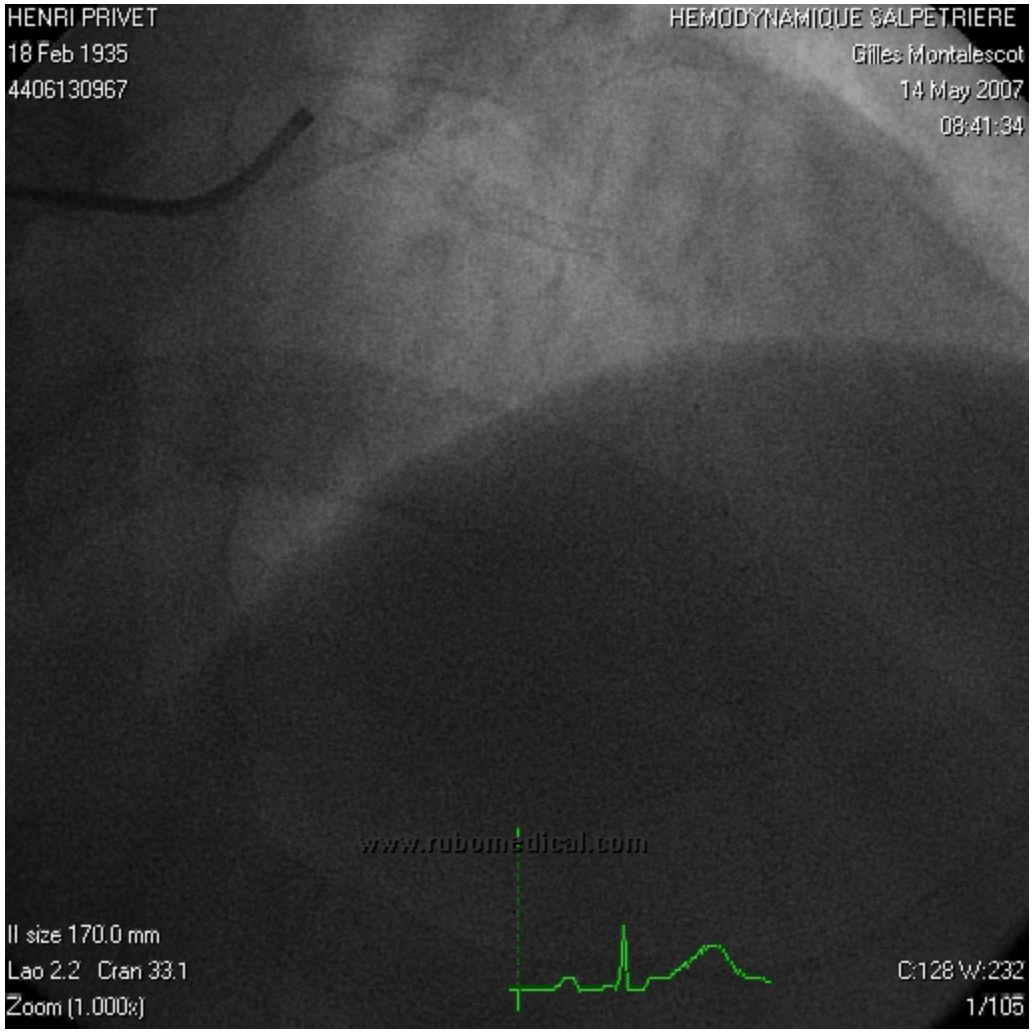
CASE STUDY. Mrs CCC… Coronary Angiography

	I	II	III
LAD	**> 70 %**	**> 70 %**	**> 70 %**
CX			
RCA			**50 %**

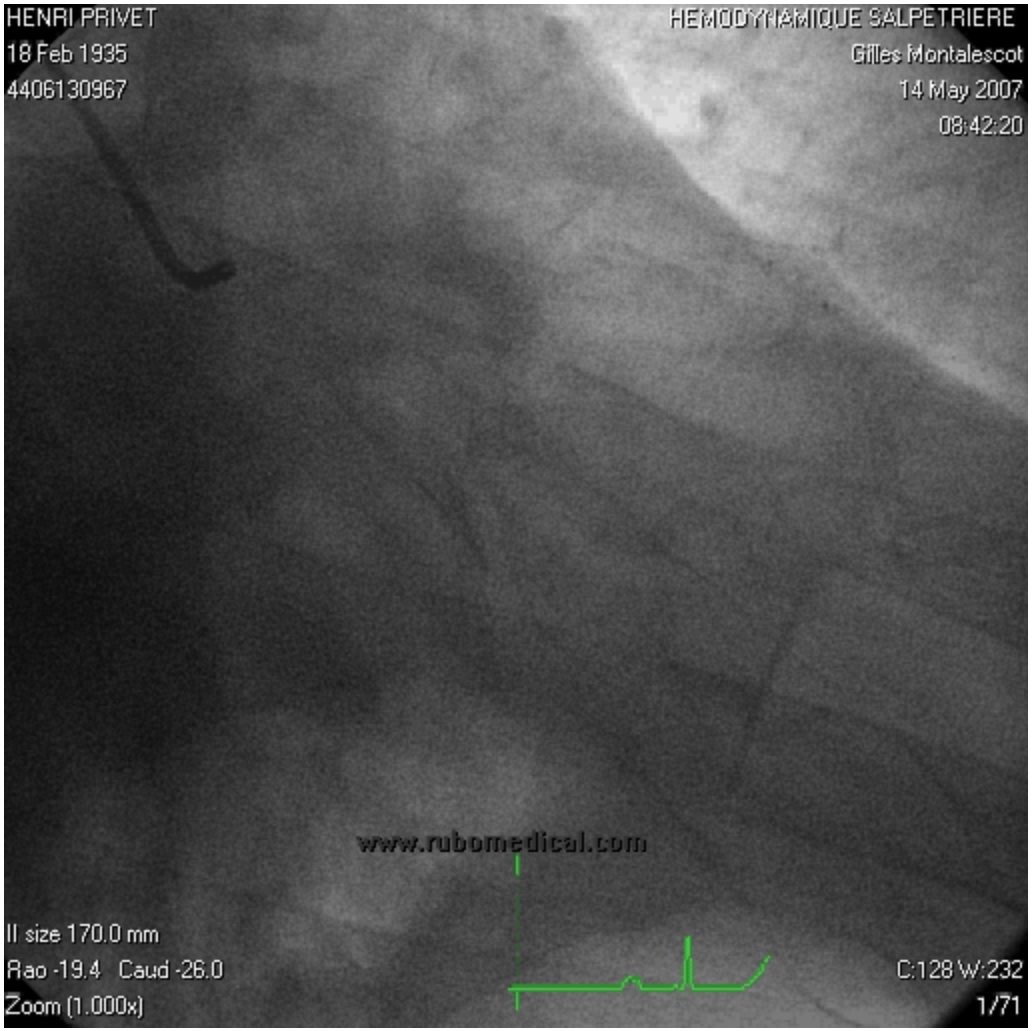
CASE STUDY. Mrs CCC…

Coronary Angiography

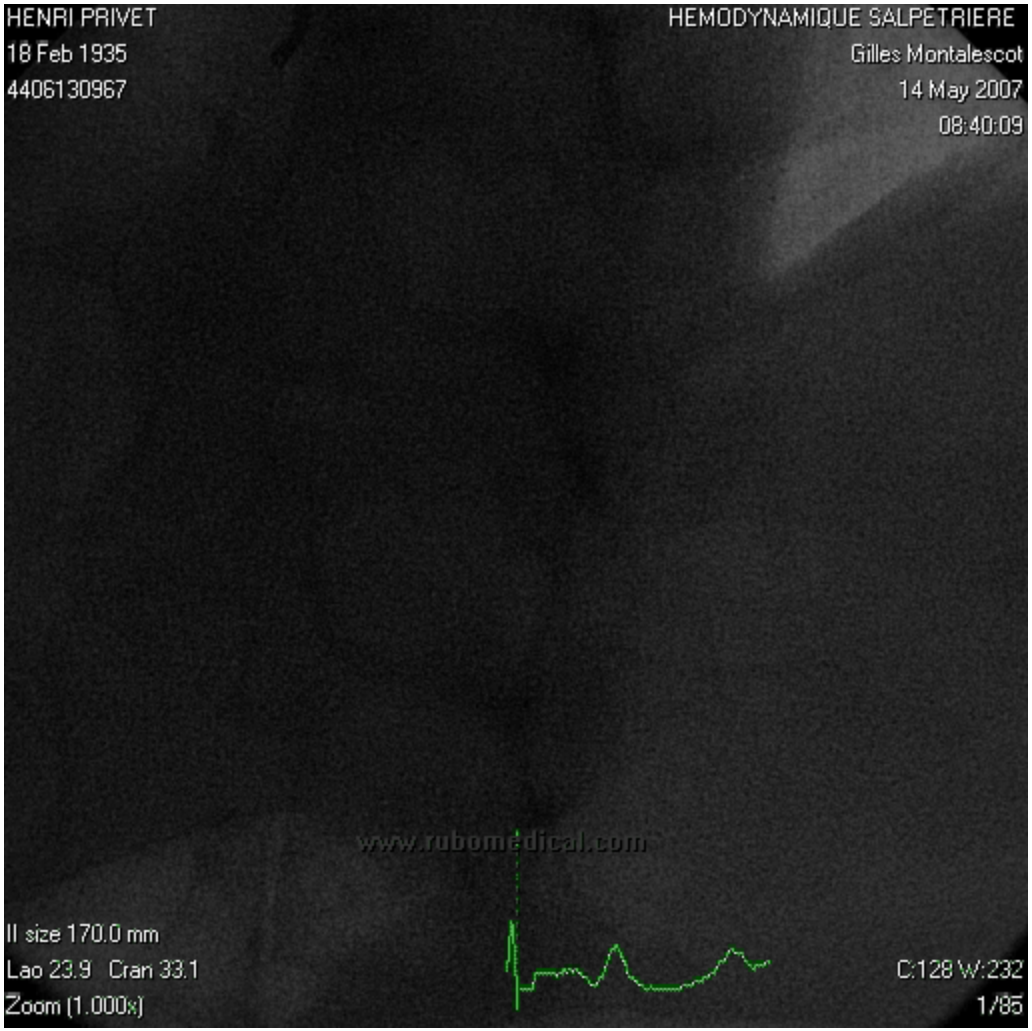
CASE STUDY. Mrs CCC…



CASE STUDY. Mrs CCC…



CASE STUDY. Mrs CCC…



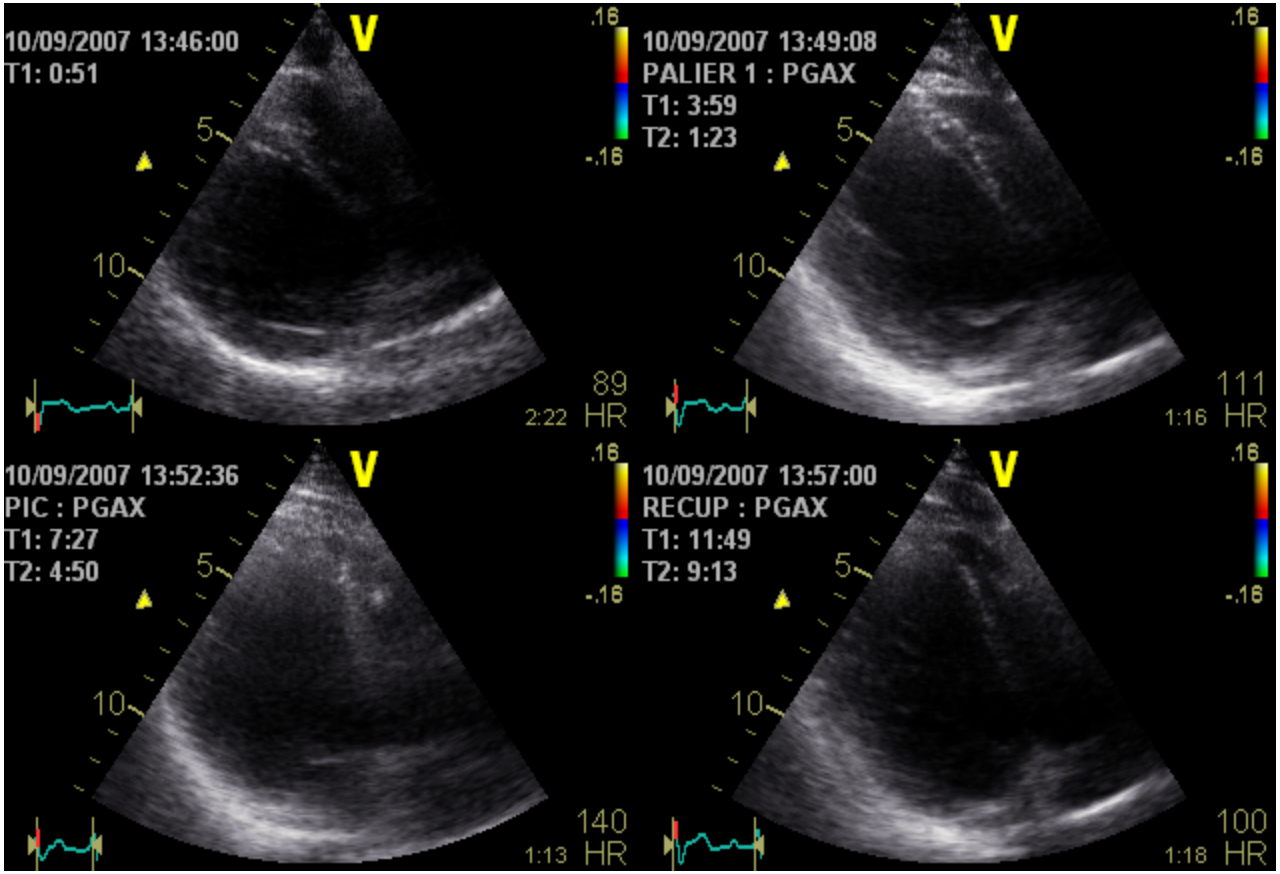
CASE STUDY. Mrs TU…

- Asymptomatic
- Chest pain
- HT

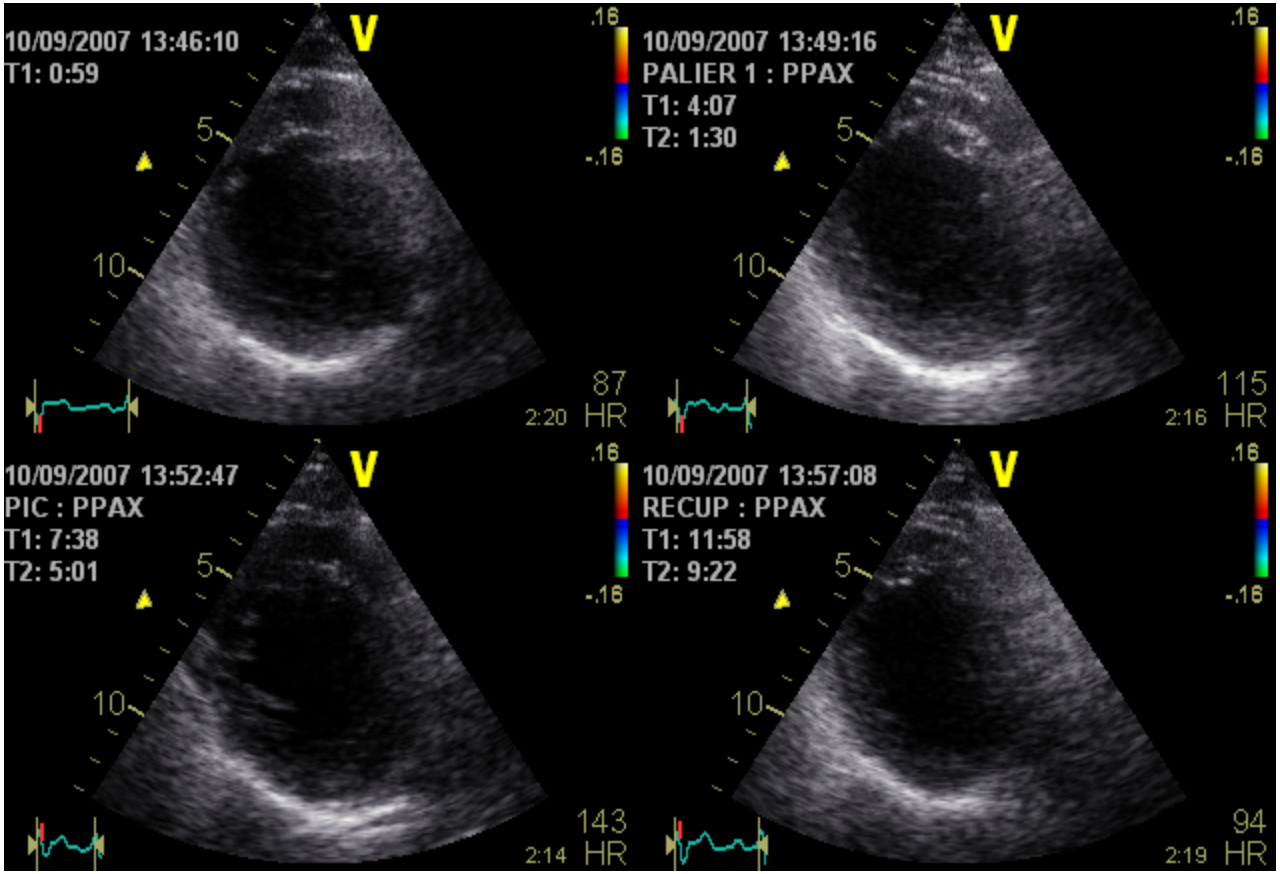
Mr TU-Echo Effort

- Echo Effort :
- Maximale, 125 w, 88 % FMT
- ECG litigieux : sous decalage de 1 mm ascendant
- Clinique : Negatif

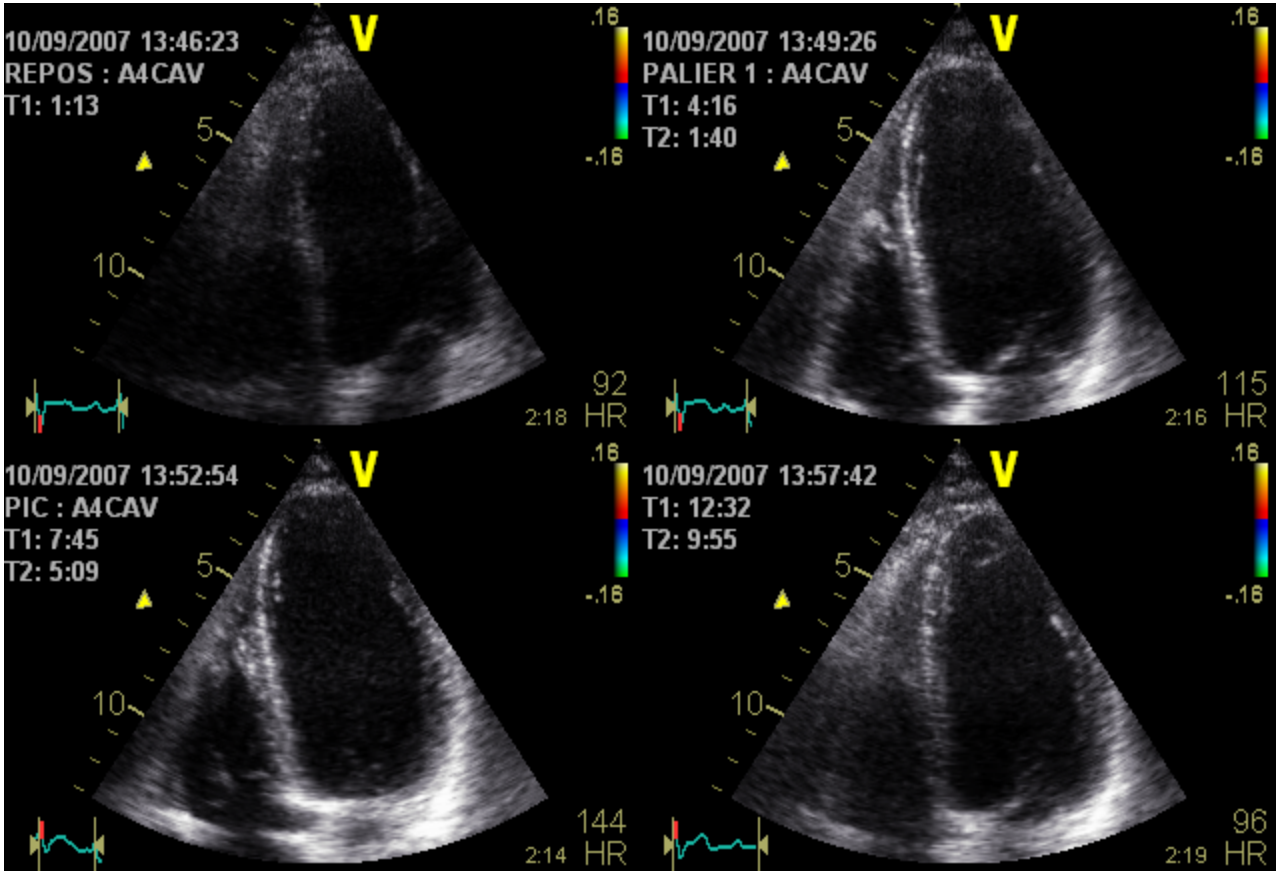
CASE STUDY. Mrs TU…



CASE STUDY. Mrs TU…

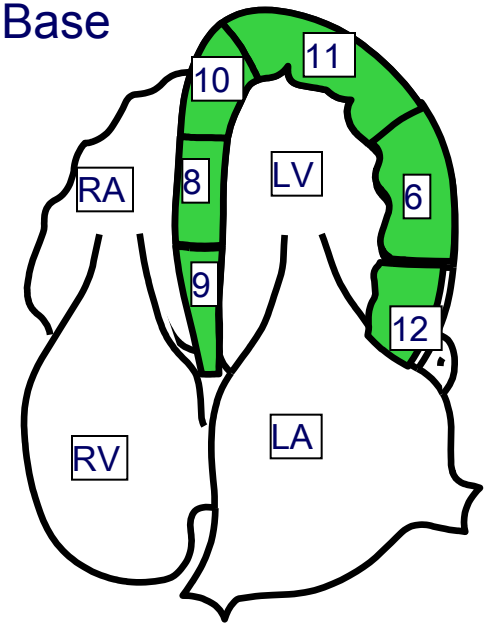


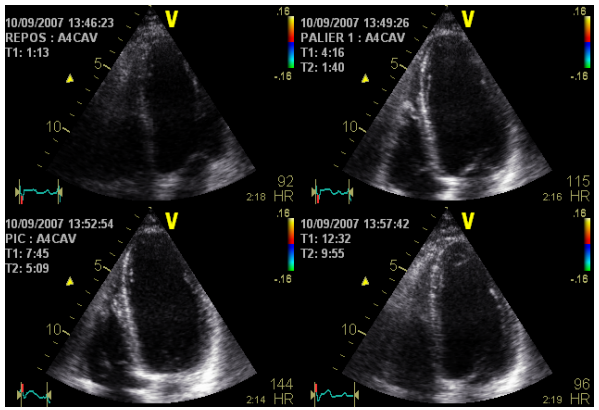
CASE STUDY. Mrs TU…



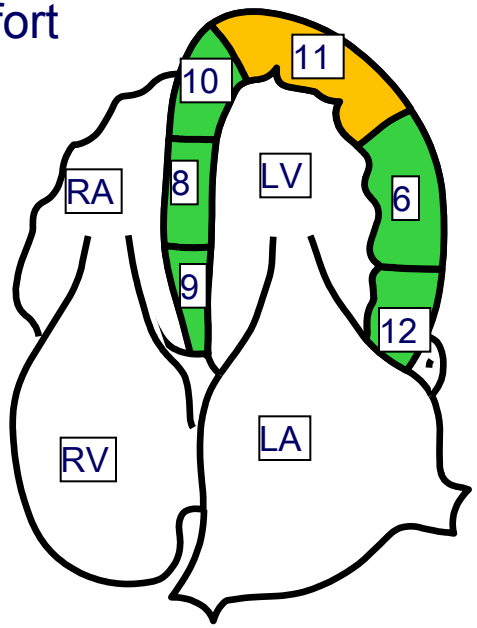
STRESS ECHOCARDIOGRAPHY

Base

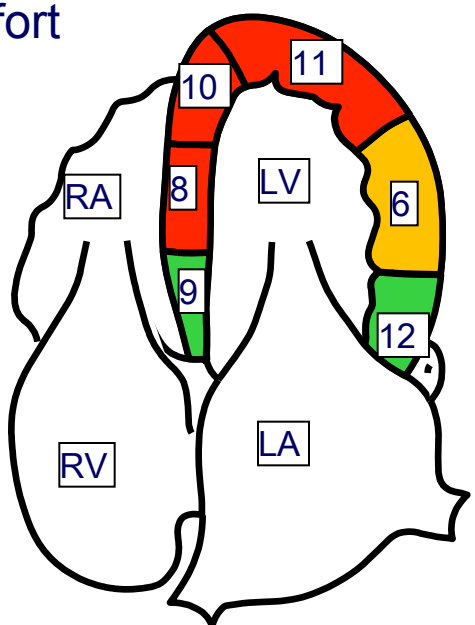




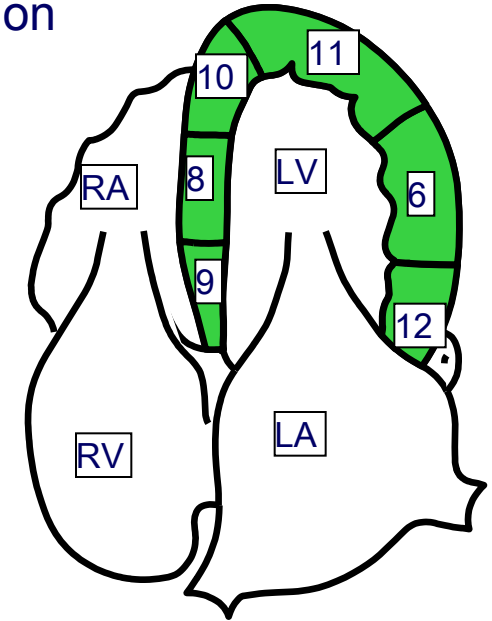
Faible Effort



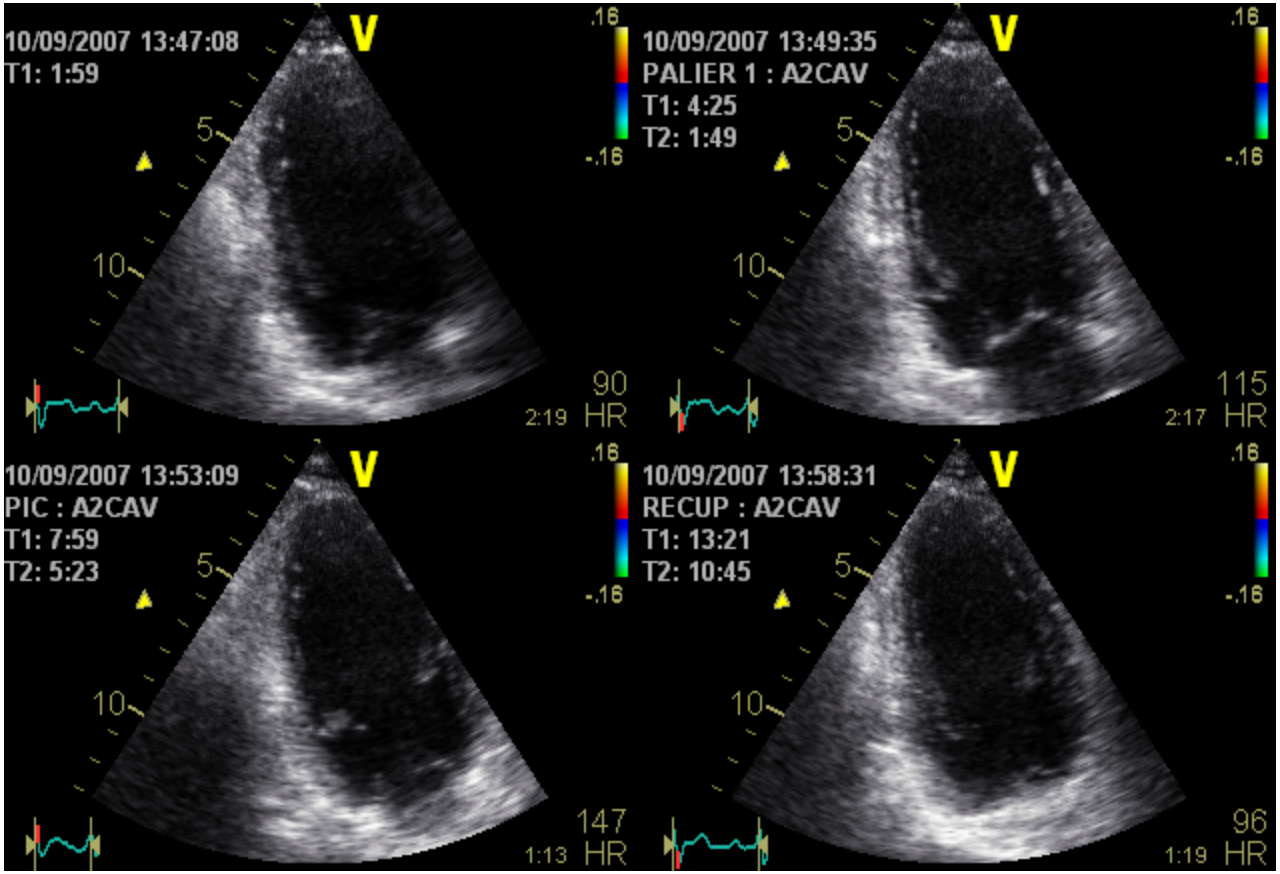
Pic Effort



Récupération

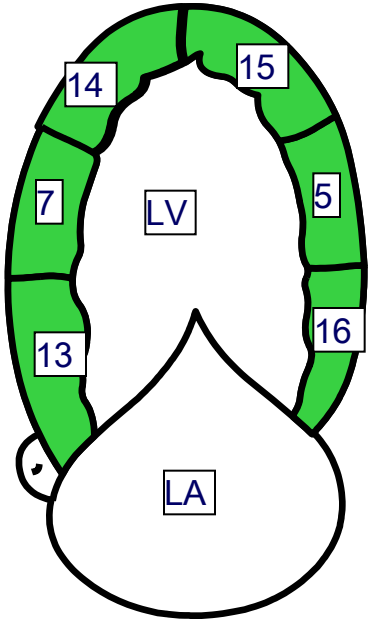


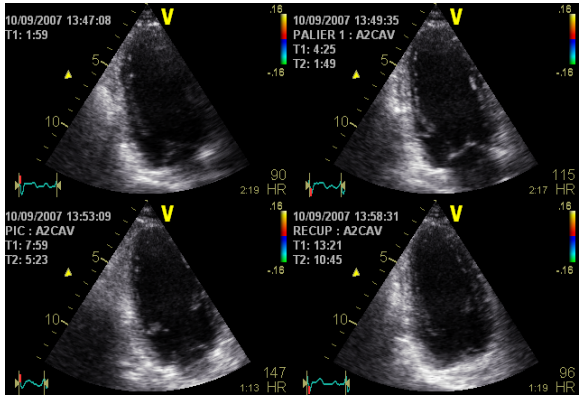
CASE STUDY. Mrs TU…



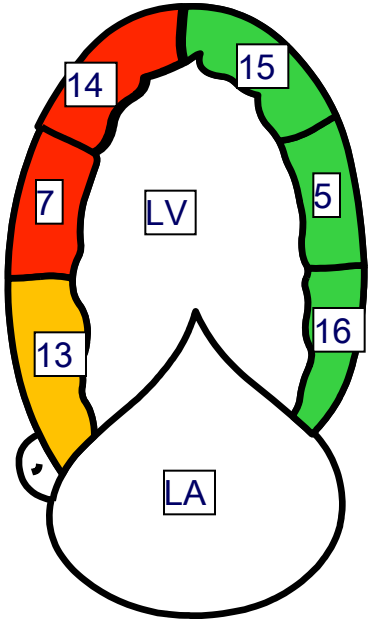
STRESS ECHOCARDIOGRAPHY

Base





Faible Effort



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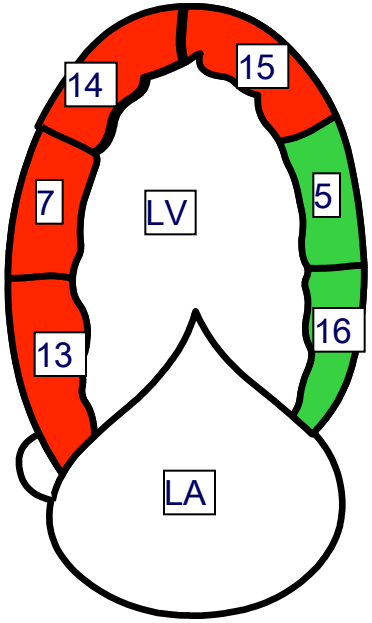

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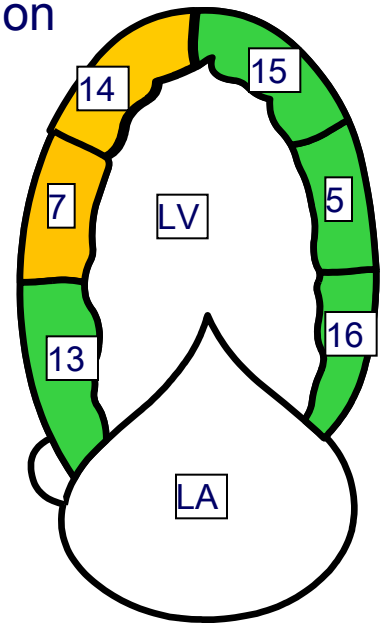
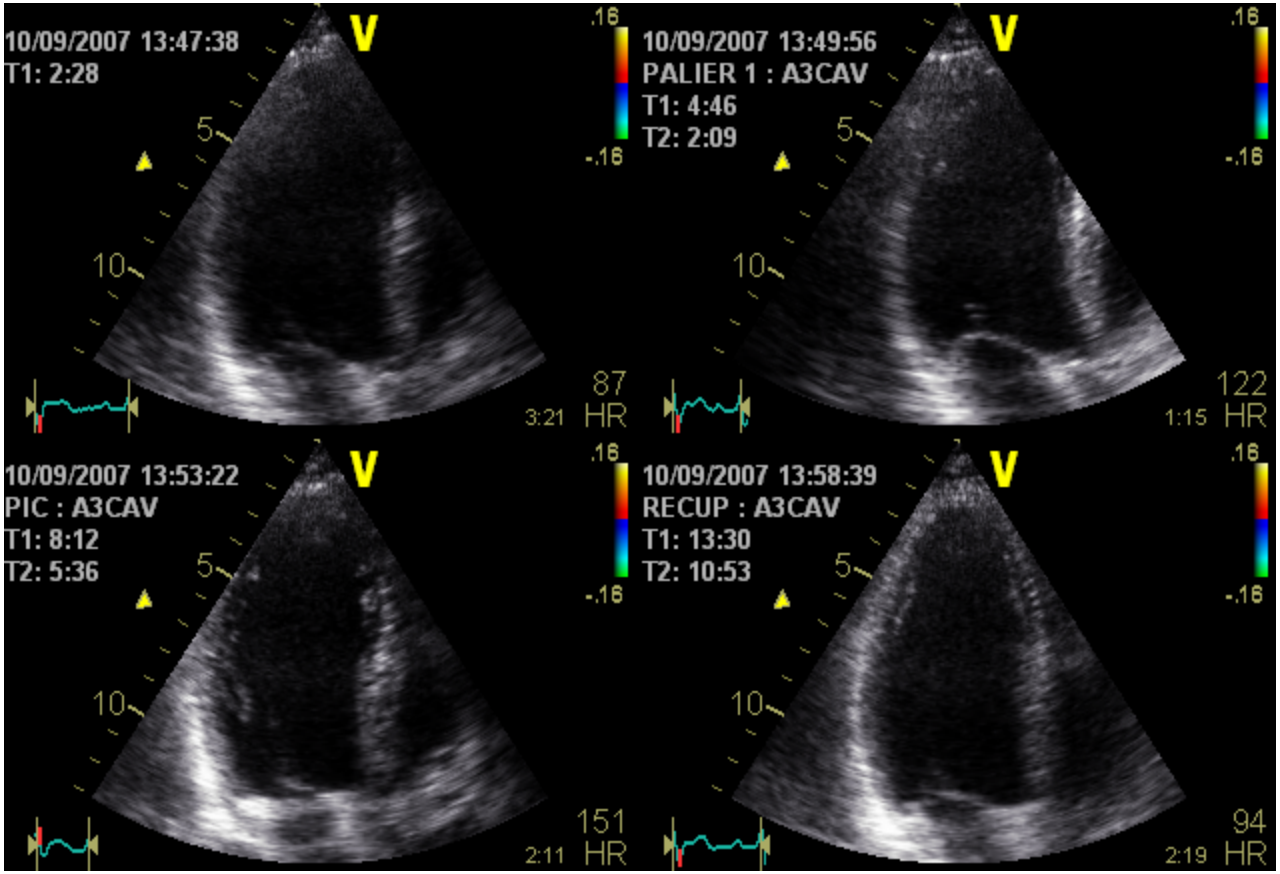


CASE STUDY. Mrs TU…



CASE STUDY. Mrs TU…

- CORONARO ANGIOGRAPHY :

LAD (segm3): 90%

Cx (small artery): severe (mid-segment

RCA (segmII): 90%

+ distal, retroventricular (90%)