III CONGRESSO NAZIONALE DI ECOCARDIOCHIRURGIA
Milano 17-19 giugno 2009

LE METODICHE DI IMAGING NON INVASIVO DI II LIVELLO

Valutazione della funzione ventricolare: ECO o RM indifferentemente ?

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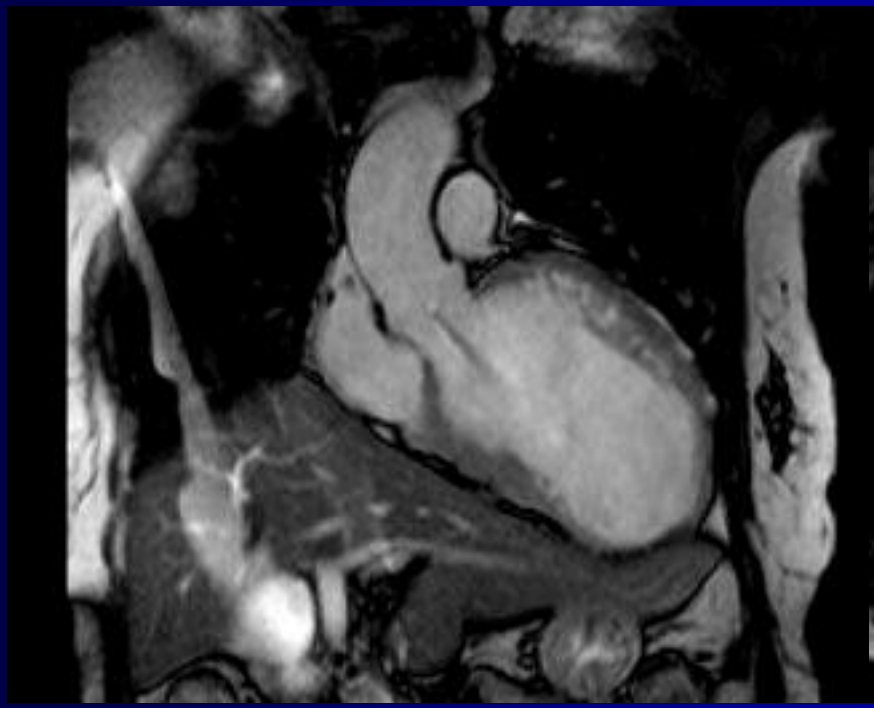
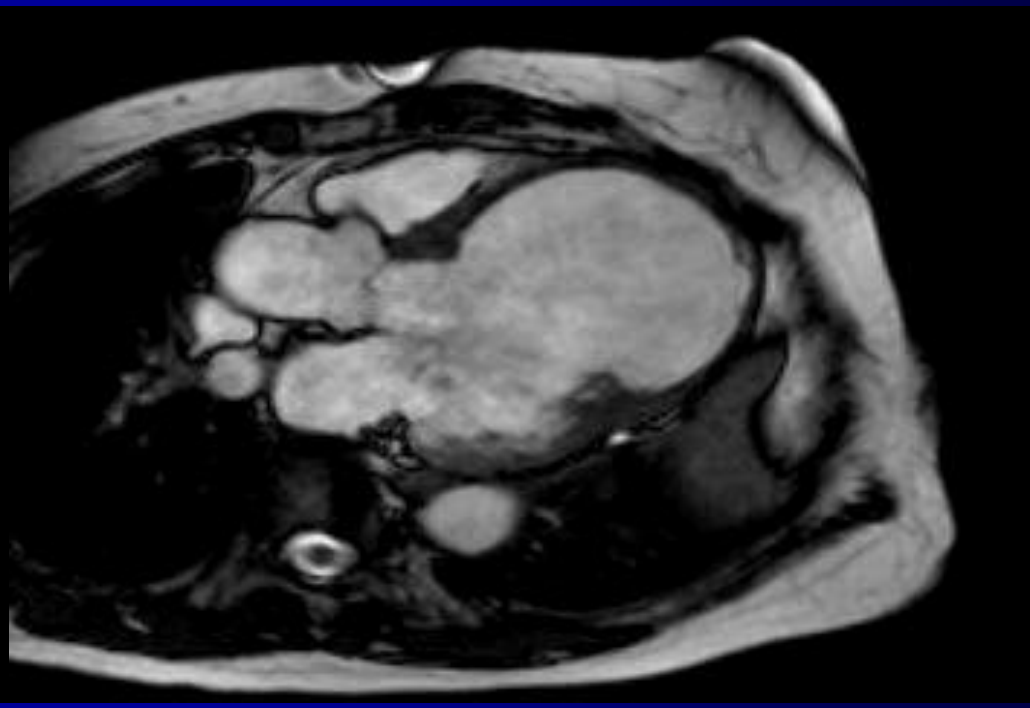
Caratteristiche

	Ecocardiografia	CMR
Invasività	no	no
Uso di Rx	no	no
Contrasto	no	no
Oggettività	no	no
Diffusione	si	no
Costo	basso	alto

Perché
Come
Dove
Quando

Perché?





Importance of Imaging Method Over Imaging Modality in Noninvasive Determination of Left Ventricular Volumes and Ejection Fraction

Assessment by Two- and Three-Dimensional Echocardiography and Magnetic Resonance Imaging

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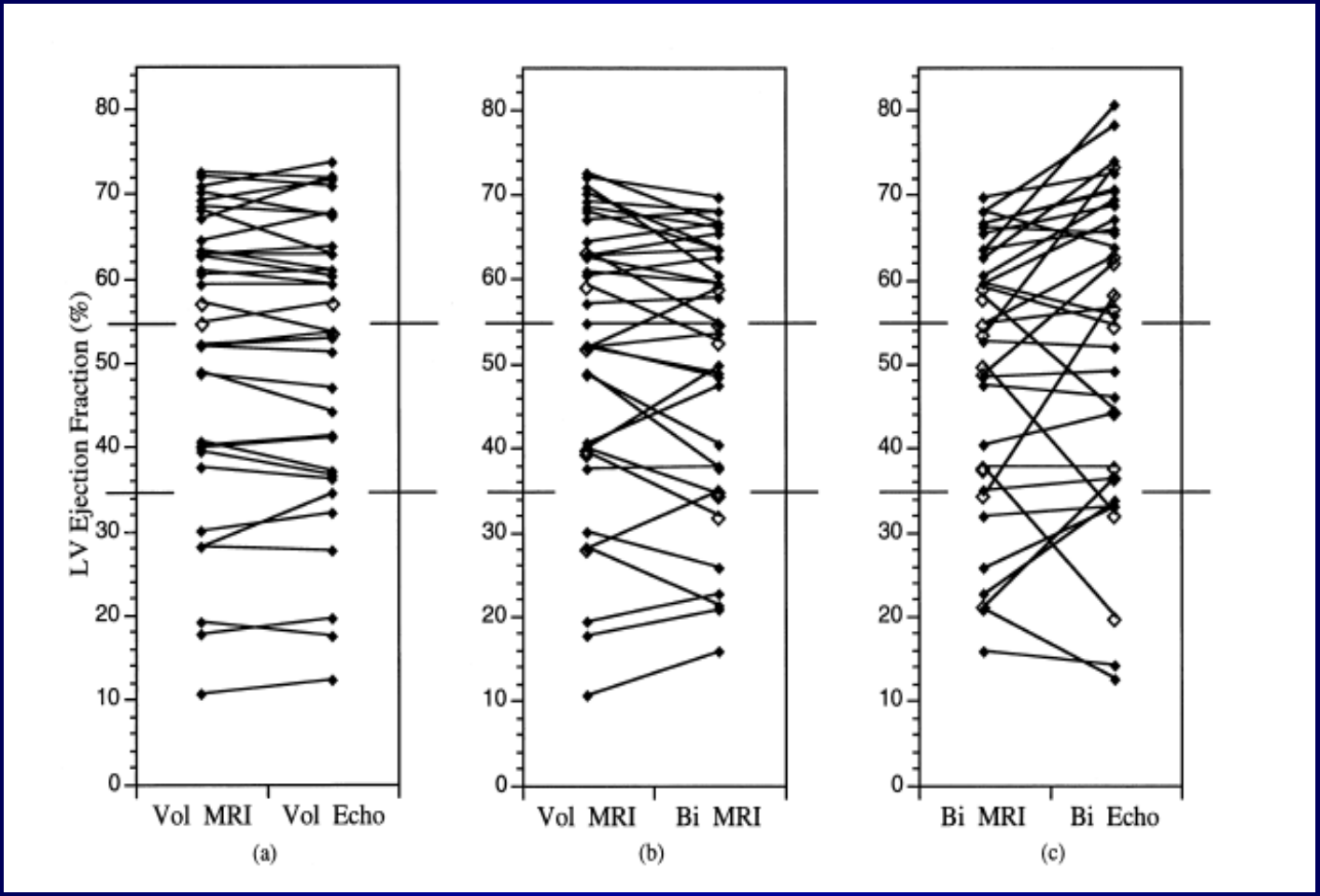
Marilyn F. Riley, BS,* Robert A. Parker, SCD,‡ Pamela S. Douglas, MD, FACC,*
Warren J. Manning, MD, FACC*§

Boston and Andover, Massachusetts

J Am Coll Cardiol 2000;35:477– 84)

Variazioni tra diversi metodi nella valutazione della FE



35 Pts; 10 Volontari e 25 CMP, di cui 10 con alterazioni segmentarie

J Am Coll Cardiol 2000;35:477– 84)

Table 1. Mean (±SD) Values for Left Ventricular End-Diastolic Volume, End-Systolic Volume and Ejection Fraction for the Four Imaging Strategies

	EDV (ml)	ESV (ml)	EF (%)
Volumetric MRI	196 ± 91	105 ± 91	52 ± 17
Volumetric echocardiography	195 ± 91	104 ± 90	52 ± 17
Biplane MRI	200 ± 94	110 ± 89	50 ± 16
Biplane echocardiography	180 ± 88*	94 ± 83*	53 ± 19

*$p \leq 0.01$ vs. volumetric MRI, volumetric echocardiography and biplane MRI.
EDV = end-diastolic volume; EF = ejection fraction; ESV = end-systolic volume; MRI = magnetic resonance imaging.

J Am Coll Cardiol 2000;35:477– 84

Riclassificazione

Table 2. Patient Classification by Systolic Function as Normal (A, LVEF ≥55%), Depressed (B, LVEF >35% to <55%) or Severely Depressed (C, LVEF ≤35%)*

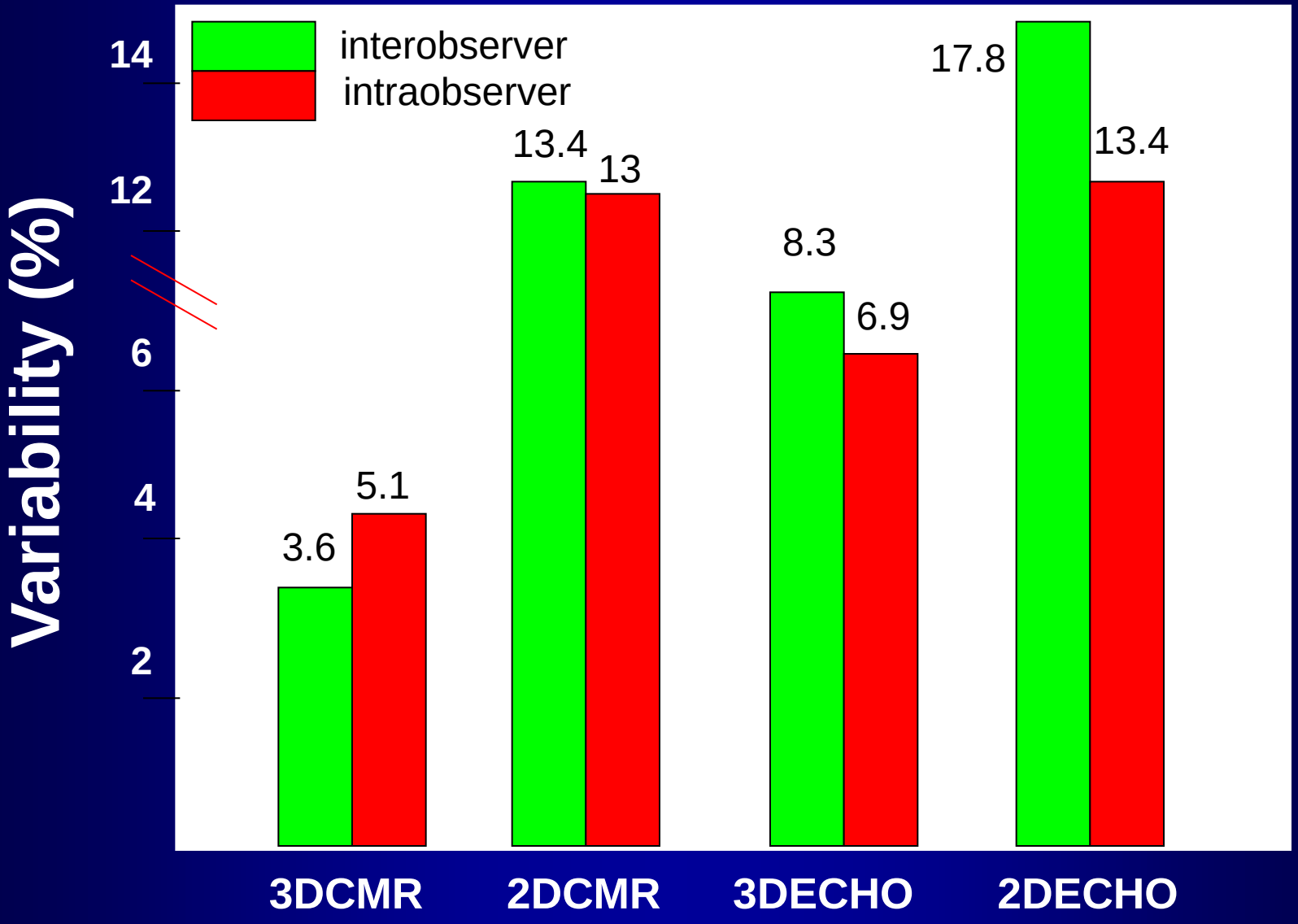
Comparisons	A<−>B*	B<−>C†	A<−>C‡	Total Changes§
Volumetric MRI vs. volumetric echocardiography	2	0	0	2
Volumetric MRI vs. biplane MRI	3	3	0	6
Volumetric MRI vs. biplane echocardiography	6	5	0	11
Volumetric echocardiography vs. biplane echocardiography	4	5	0	9
Volumetric echocardiography vs. biplane MRI	5	3	0	8
Biplane MRI vs. biplane echocardiography	6	3	1	10

*The first data column shows number of patients whose classification differed between categories A and B. †The second column gives changes between categories B and C. ‡The third column shows changes between category C (LVEF ≤35%) and category A (LVEF ≥55%). §The last column shows the total number of category changes among the 25 patients.
LVEF = left ventricular ejection fraction; MRI = magnetic resonance imaging.

The choice of imaging method (volumetric or biplane) has a greater impact on the results than does the choice of imaging modality (echocardiography or MRI) when measuring LV volume and systolic function

J Am Coll Cardiol 2000;35:477– 84

Left ventricular ejection fraction



Chuang et Al. JACC 2000: 35,477

Comparison of left ventricular ejection fraction and volumes in heart failure by echocardiography, radionuclide ventriculography and cardiovascular magnetic resonance

Are they interchangeable?

N. G. Bellenger[1], M. I. Burgess[2], S. G. Ray[2], A. Lahiri[3], A. J. S. Coats[1], J. G. F. Cleland[4] and D. J. Pennell[1]

CHRISTMAS Study Steering Committee and Investigators

European Heart Journal (2000) **21,** 1387–1396

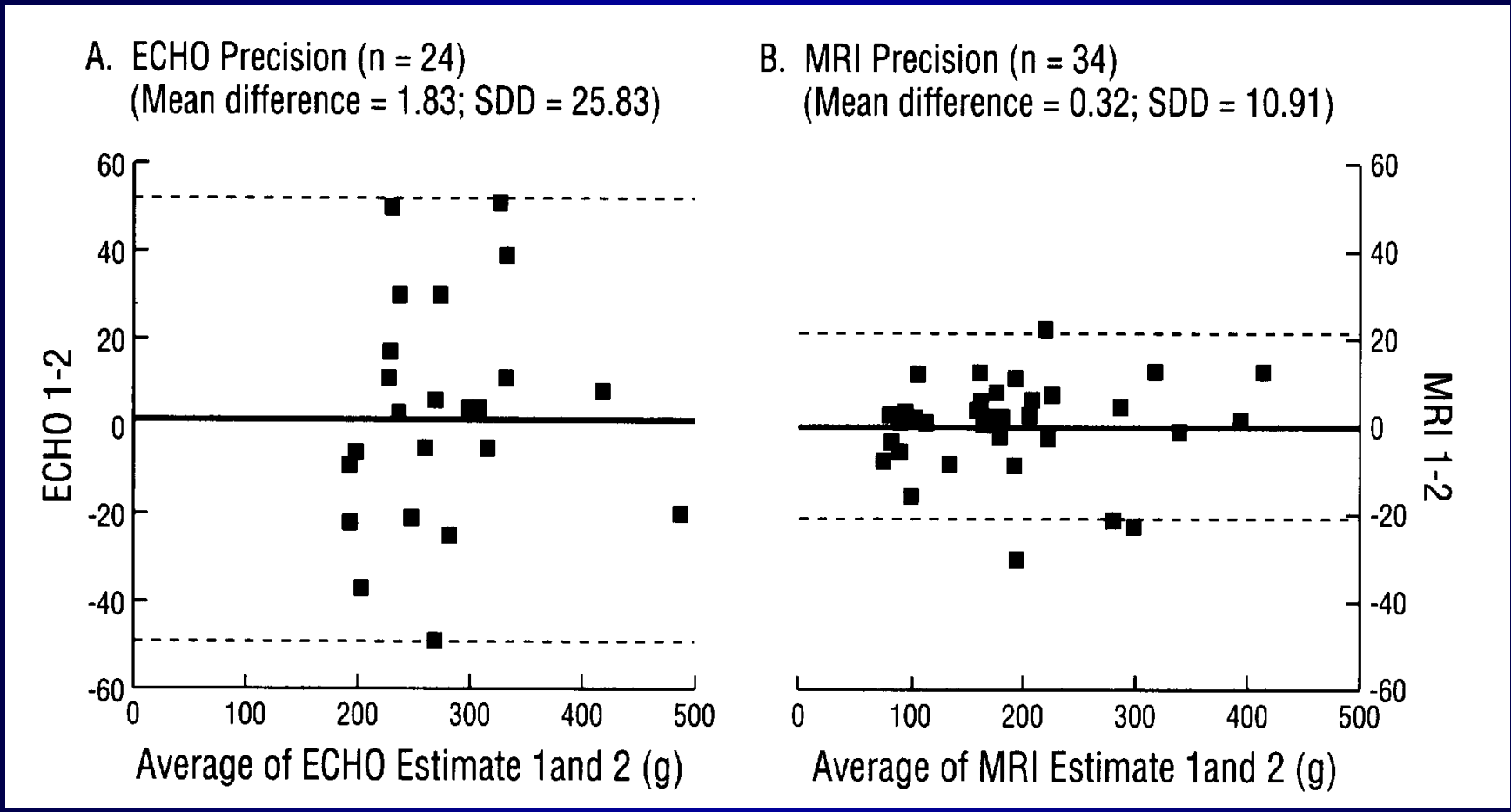
Studio Christmas

Parameter	Number	Mean ± SD
M-mode echo		
LV end-diastolic diameter	45	59 ± 11 mm
LV end-systolic diameter	45	50 ± 16 mm
Fractional shortening	45	16 ± 13%
Ejection fraction by cube	45	39 ± 22%
Ejection fraction by Teichholz	45	29 ± 15%
2D echo		
LV end-diastolic volume	36	136 ± 51 ml
LV end-systolic volume	36	98 ± 37 ml
EF by Simpson's biplane	36	31 ± 5%
RNV		
Ejection fraction	51	24 ± 21%
CMR		
LV end-diastolic volume	52	267 ± 106 ml
LV end-systolic volume	52	192 ± 98 ml
LV ejection fraction	52	30 ± 9%

	EDV CMR–2D echo	ESV CMR–2D echo
Mean diff ± SD (ml)	133 ± 42	99 ± 45
Corr coef, r	0·83	0·8
P	<0·0001	<0·0001
BA limits (ml)	52 to 216	11 to 188
BA range (ml)	268	199

European Heart Journal (2000) **21,** 1387–1396

Precisione delle tecniche nella misurazione della massa ventricolare sinistra



Bottini P. et Al. Am Heart J 1995

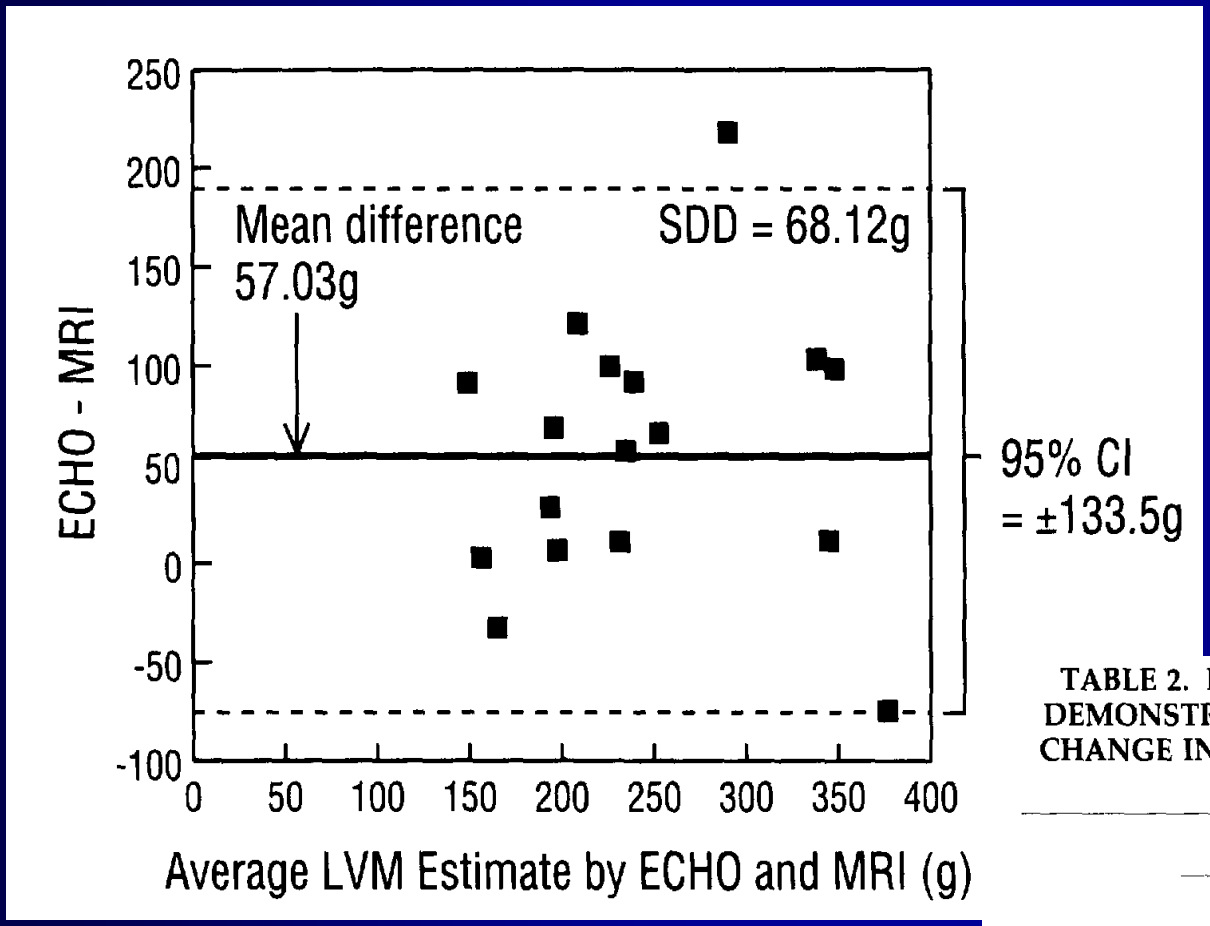


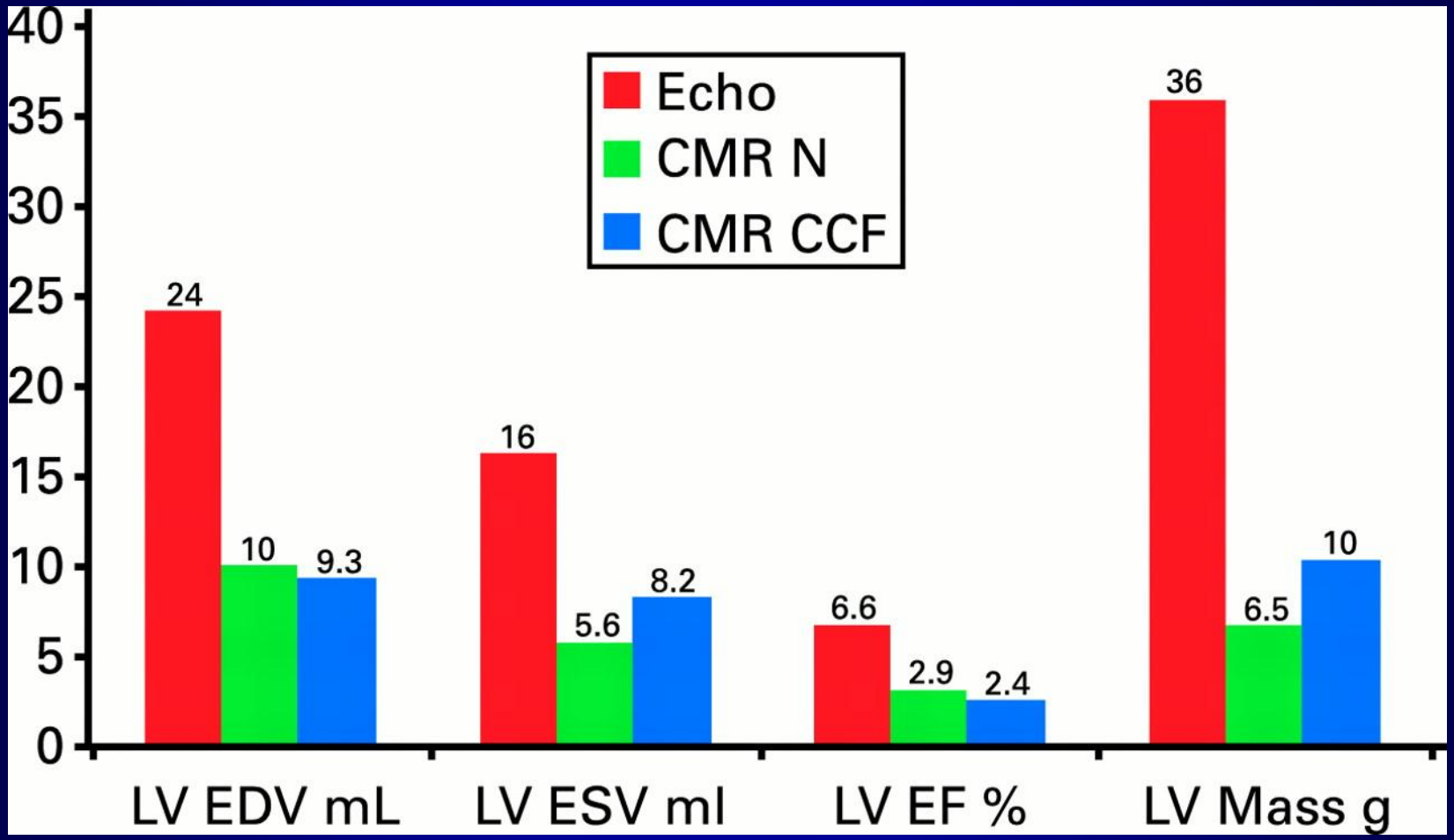
TABLE 2. NUMBERS OF PATIENTS NEEDED TO DEMONSTRATE A STATISTICALLY SIGNIFICANT CHANGE IN LVM AS A FUNCTION OF THE LEVEL OF A TYPE 2 (β) ERROR

	ΔLVM = 10 g		ΔLVM = 20 g	
	N		N	
β Error	ECHO	MRI	ECHO	MRI
1%	880	24	220	6
5%	626	17	157	5
10%	505	14	126	5
20%	377	10	95	3

Bottini P. et Al. Am Heart J 1995

Interstudy reproducibility of standard deviation between CMR and Echocardiography

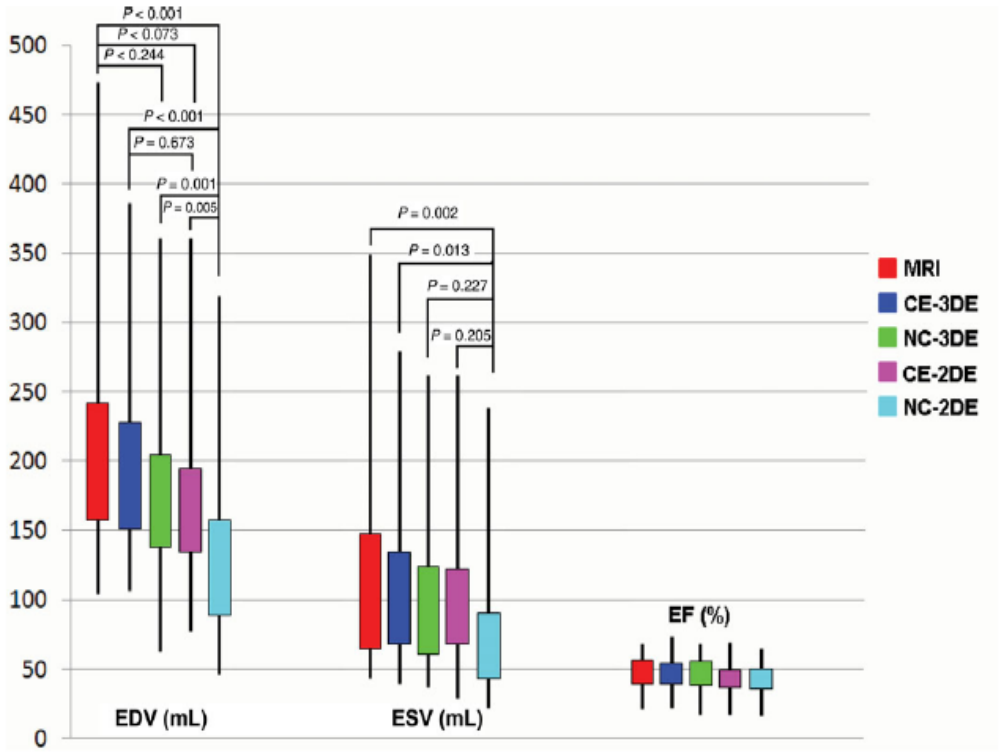
No Caption Found



Pennell, D. Heart 2001;85:581-589

Sono cambiate le cose?

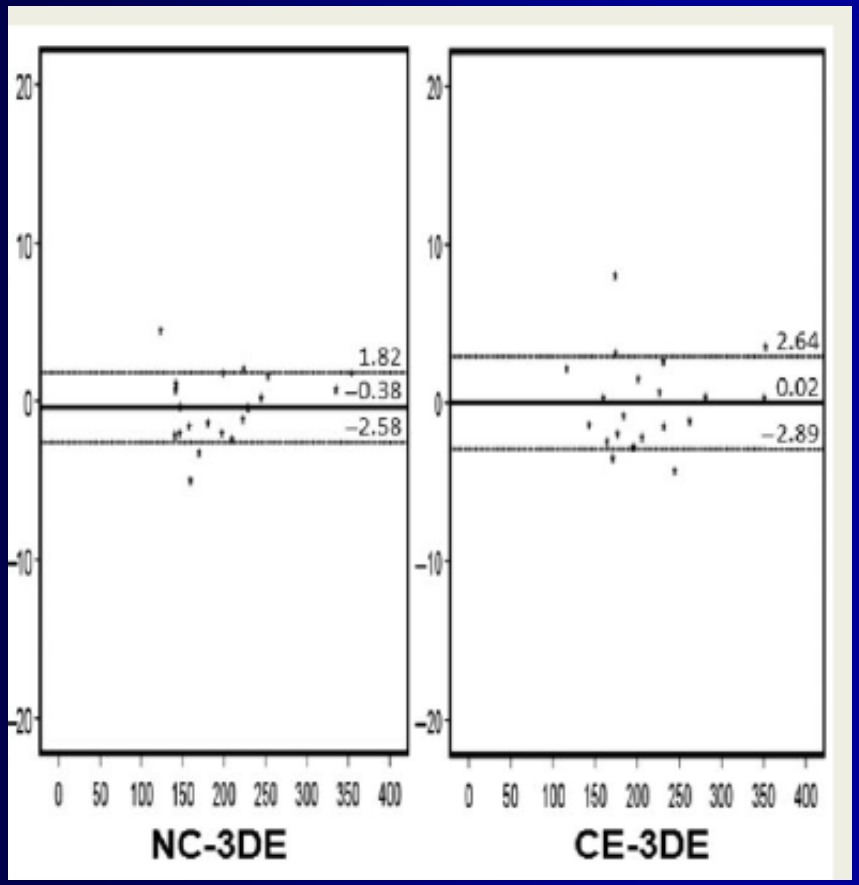
50 Pts with prior MI
Ecocontrasto

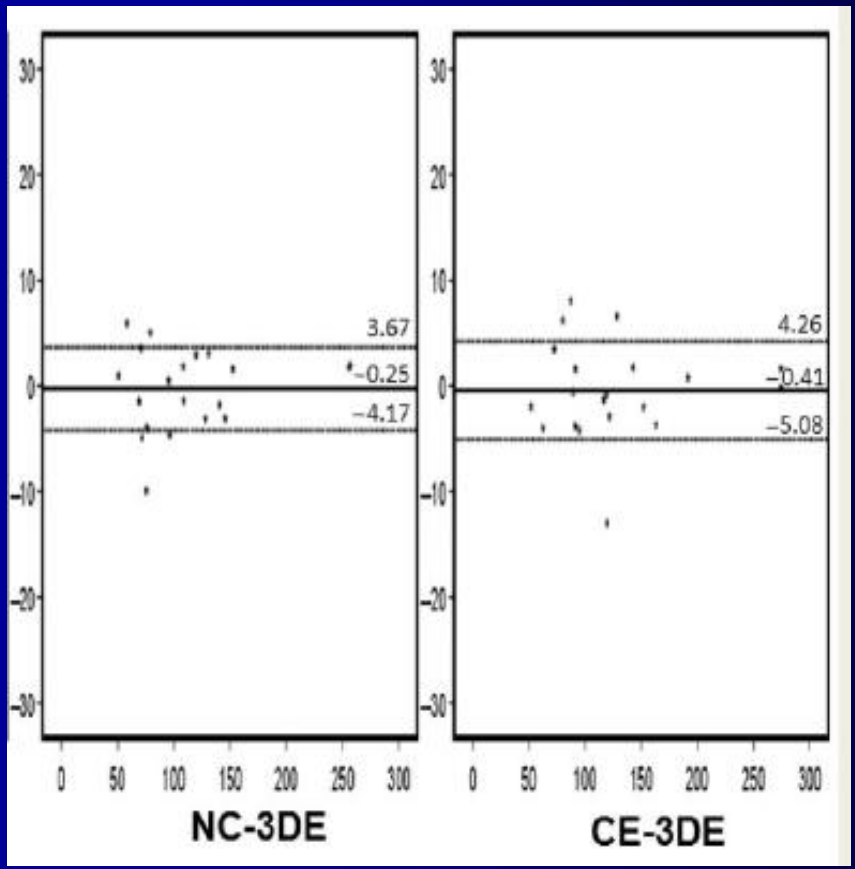


EDV (207 ± 79 mL)	ESV (117 ± 71 mL)	EF (47 ± 13 %)	MRI
–41 ± 21	–22 ± 18	–2 ± 4	NC–2DE
–18 ± 19	–8 ± 16	–2 ± 4	CE–2DE
–15 ± 18	–9 ± 12	0 ± 3	NC–3DE
–6 ± 14	–3 ± 10	0 ± 3	CE–3DE

Jenkins C, et Al. Eur Heart J 2009

Ridotta variabilità nelle misure con opacificazione di contrasto

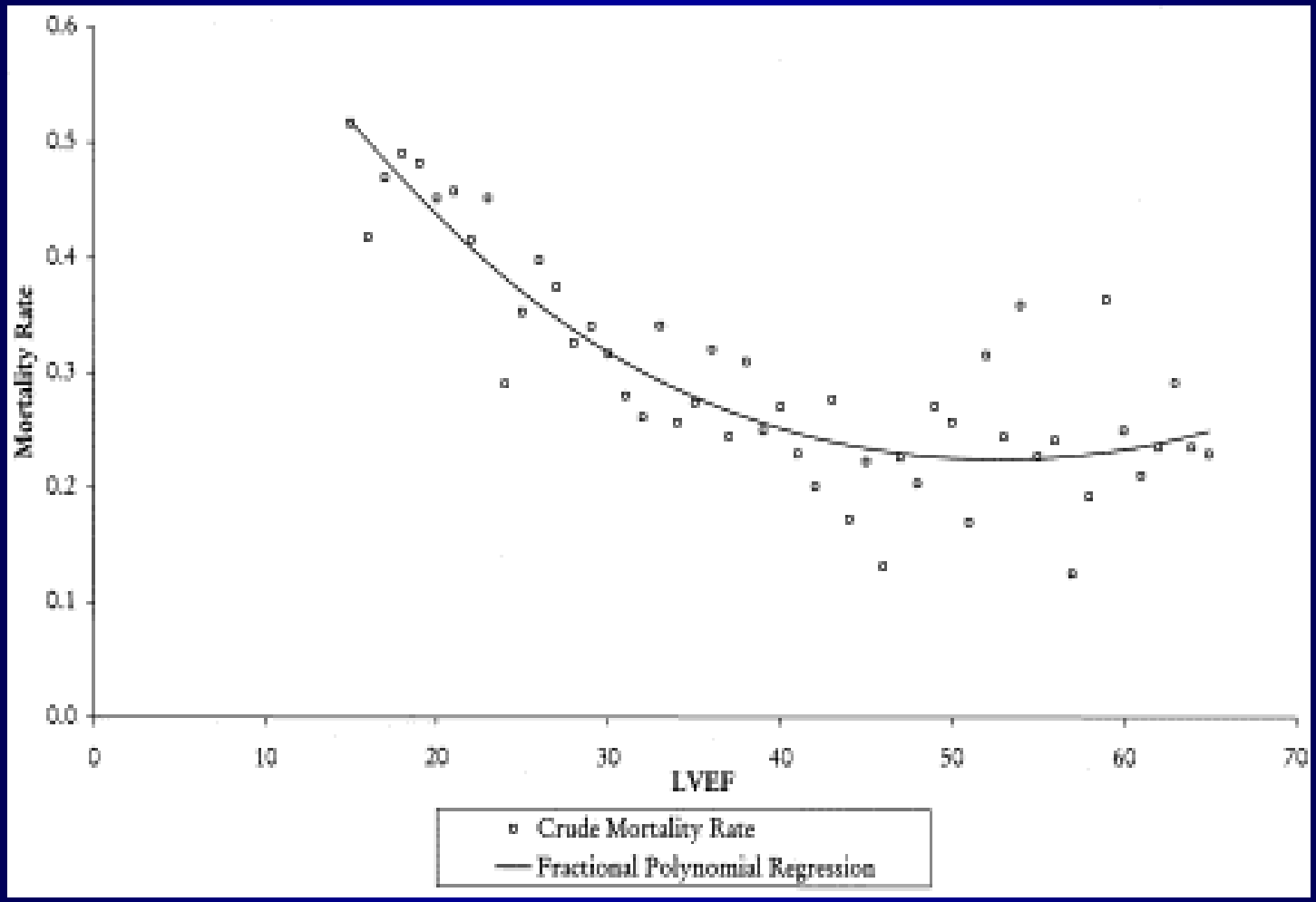




Jenkins C, et Al. Eur Heart J 2009

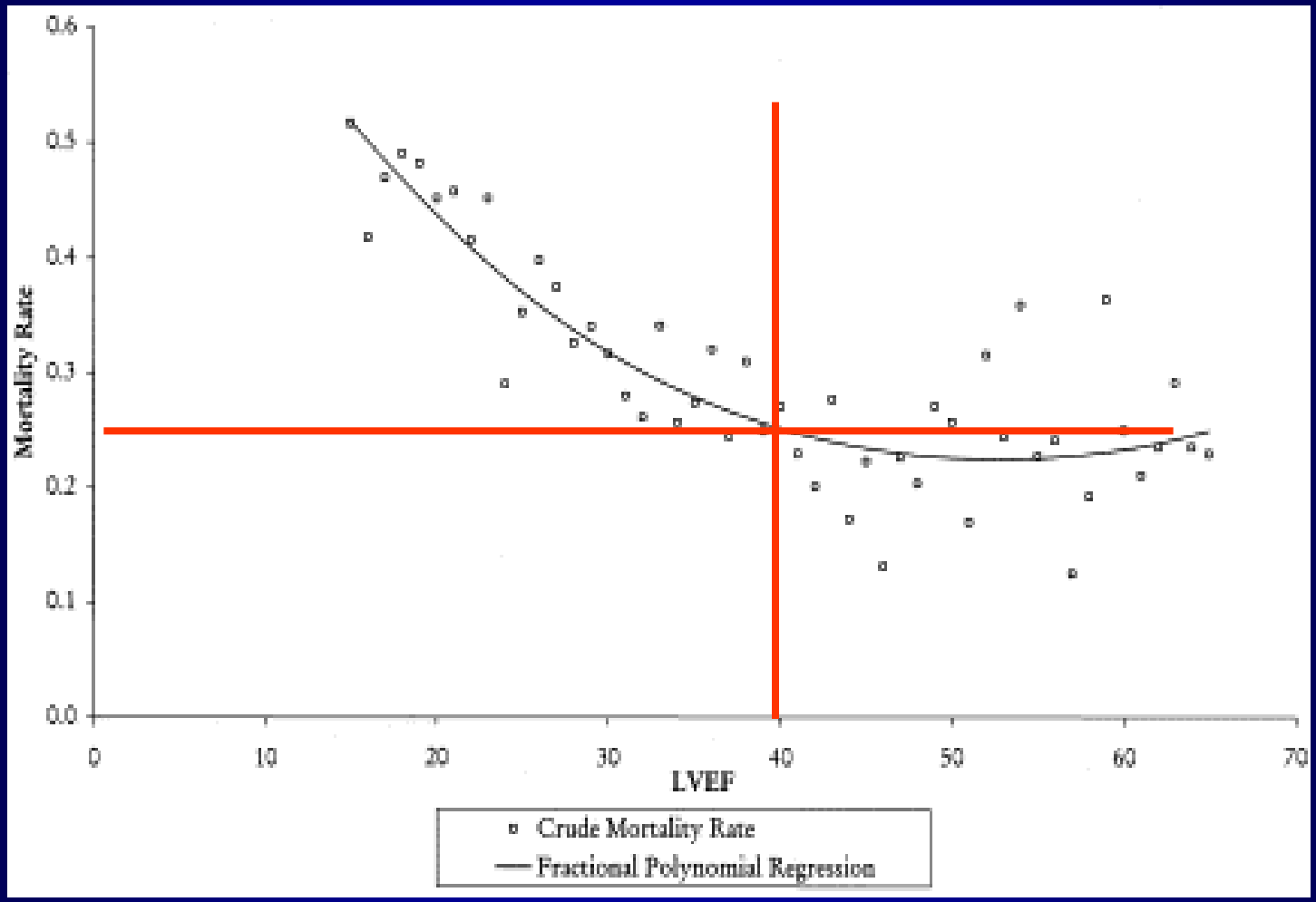
Ma è così importante alla fine dei conti essere così precisi nella valutazione funzionale?

Relationship between LVEF and mortality in stable HF

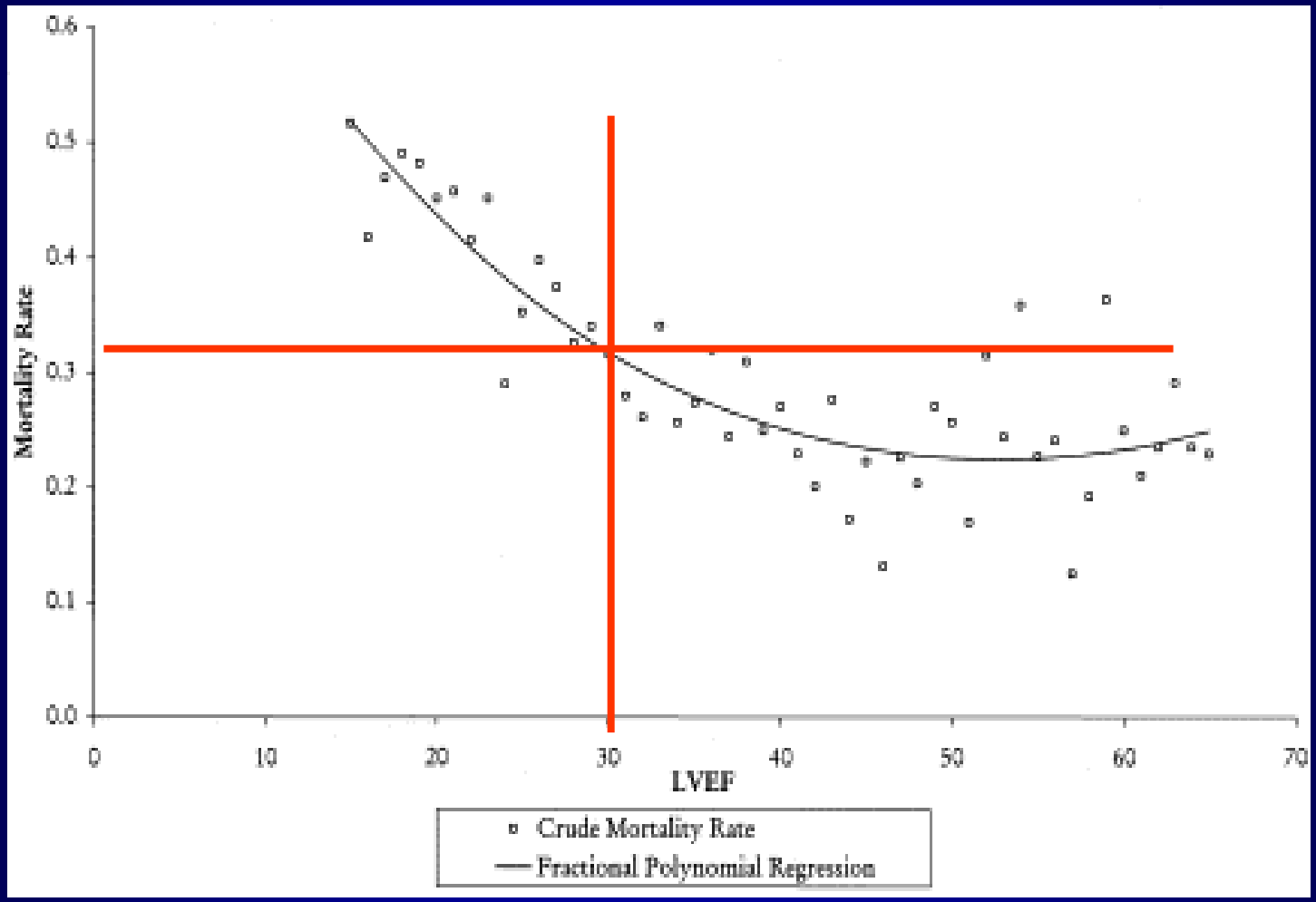


Curtis et Al. JACC 2003;42:736

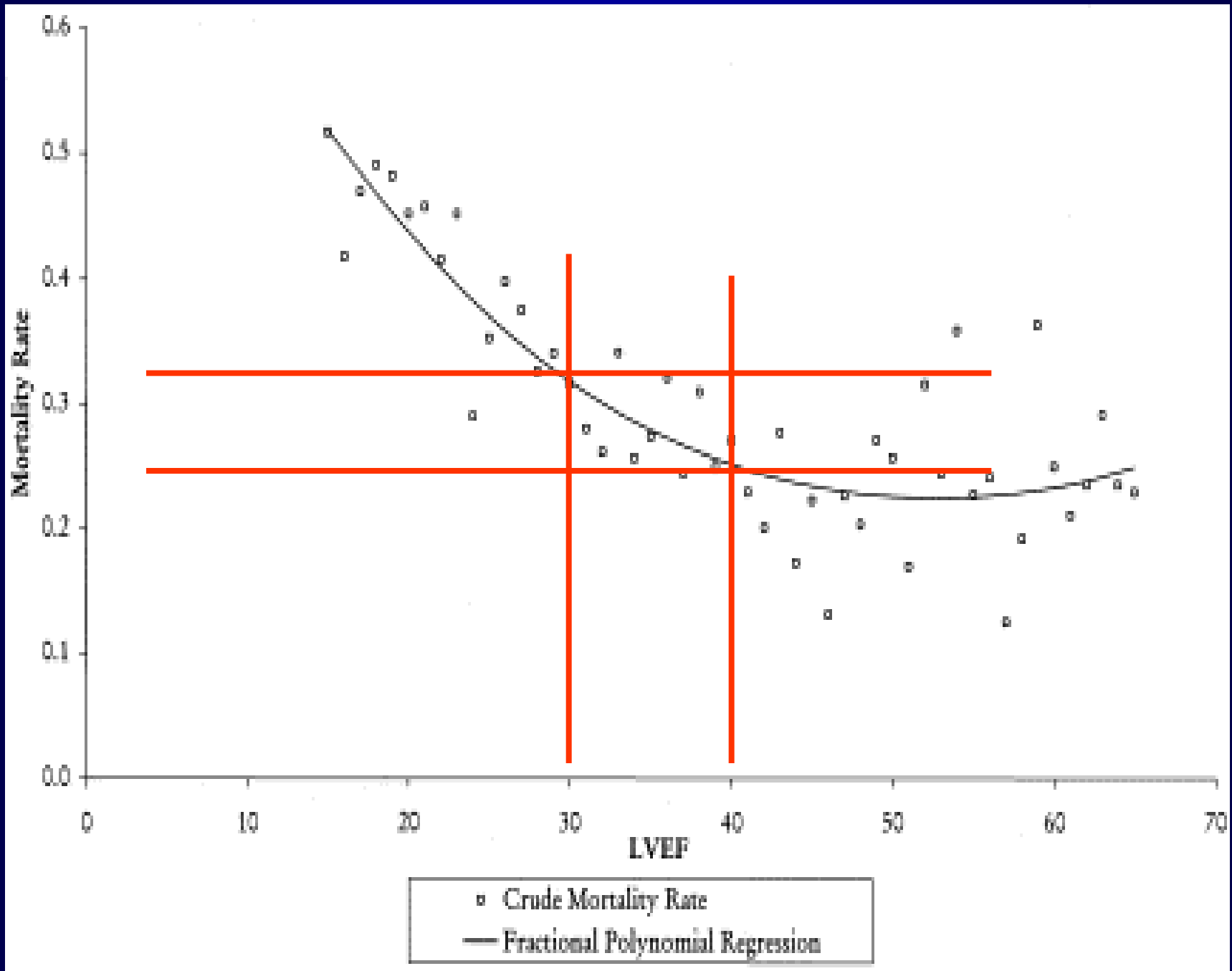
Relationship between LVEF and mortality in stable HF



Relationship between LVEF and mortality in stable HF



Curtis et Al. JACC 2003;42:736


0.6
0.5
0.4
0.3
0.2
0.1
0.0
Mortality Rate
0
10
20
30
40
50
60
70
LVEF
Crude Mortality Rate
Fractional Polynomial Regression

Effetto degli ACEi dopo IM sui parametri di funzione del ventricolo sinistro

Table 1. Most Representative Echocardiographic Studies in Patients With AMI and Left Ventricular Remodeling

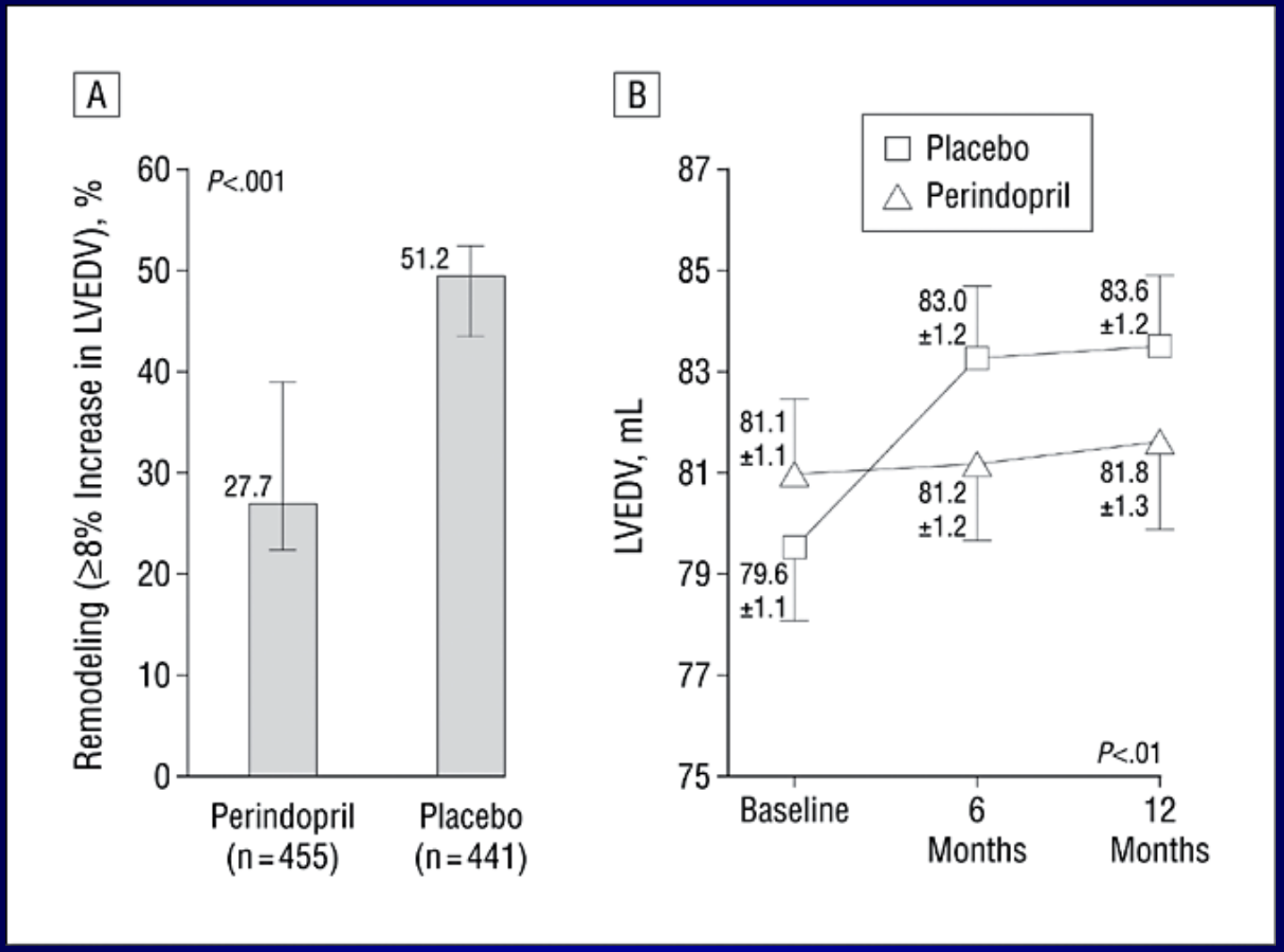
Study	Mean Age, y	Treatment	No. of Patients	Interval Between AMI and Start of Treatment	Follow-up	Mean EF at Baseline, %	Mean % Increase of LVEDV During Follow-up	Difference in LVEDV Increase Between Drug and Placebo
CONSENSUS II[6]	66	Enalapril maleate, 20 mg	428	5 d	6 mo	45	7.7	2 mL/m^2
SAVE[2]	59	Captopril, 150 mg	512	11 d	2 y	31	2.0	3 cm^2*
SOLVD[3]	59	Enalapril maleate, 10 mg	301	1 mo	1 y	29	2.8	9 mL
GISSI-3[1]	59	Lisinopril, 10 mg, ± nitrate	6405	24 h	6 mo	47	1.4	0.7 mL
FAMIS[4]	60	Fosinopril sodium, 20 mg	285	<9 h	2 y	50	10.8	2.2 mL/m^2
VALIANT[5]†	63	Captopril, 50 mg	204	5 d	20 mo	39	2.1	NA

Abbreviations: AMI, acute myocardial infarction; CONSENSUS, Cooperative New Scandinavian Enalapril Survival Study; EF, ejection fraction; FAMIS, Fosinopril in Acute Myocardial Infarction Study; GISSI-3, Gruppo Italiano per lo Studio della Sopravvivenza nell'Infarto Miocardico; LVEDV, left ventricular end-diastolic volume; NA, not applicable; SAVE, Survival and Ventricular Enlargement; SOLVD, Studies of Left Ventricular Dysfunction; VALIANT, Valsartan in Acute Myocardial Infarction.

*Left ventricular end-diastolic cavity area.

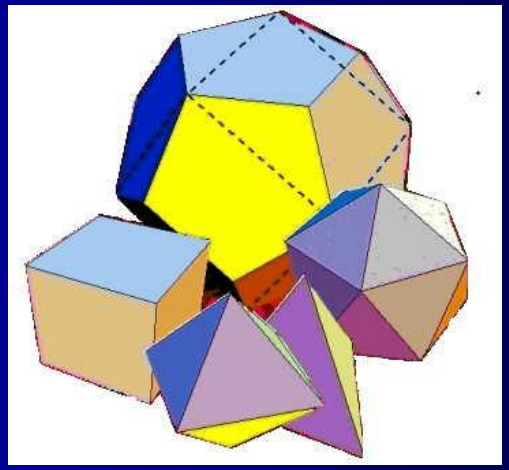
†Only patients treated with captopril.

Preami Invest. Arch Int Med 2006

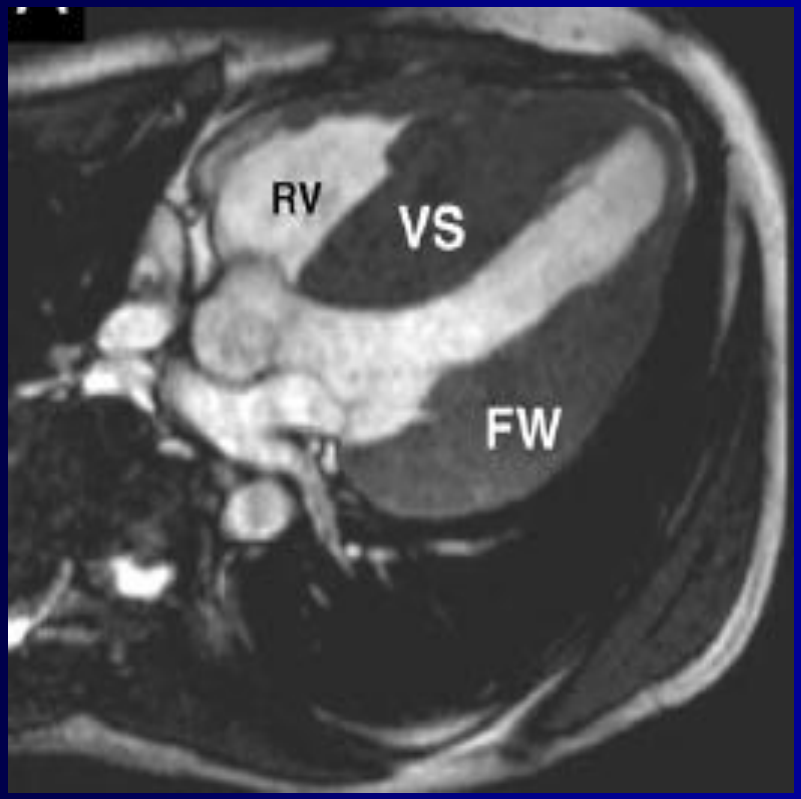


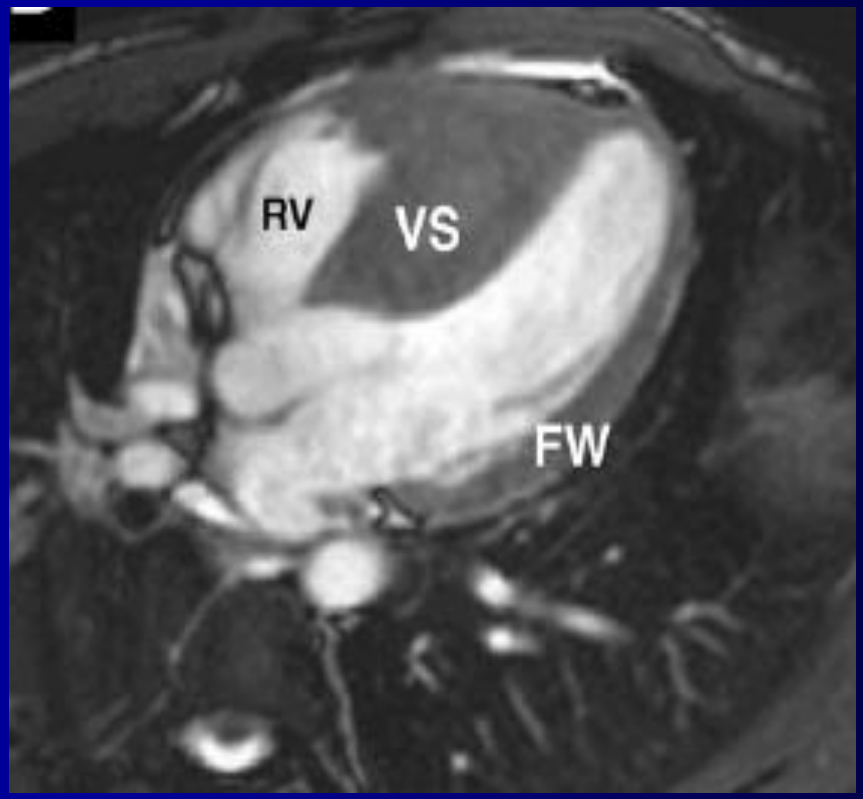
Preami Invest. Arch Int Med 2006

Fattori fondamentali influenzati la correlazione tra Eco e CMR



CMP Ipertrofica



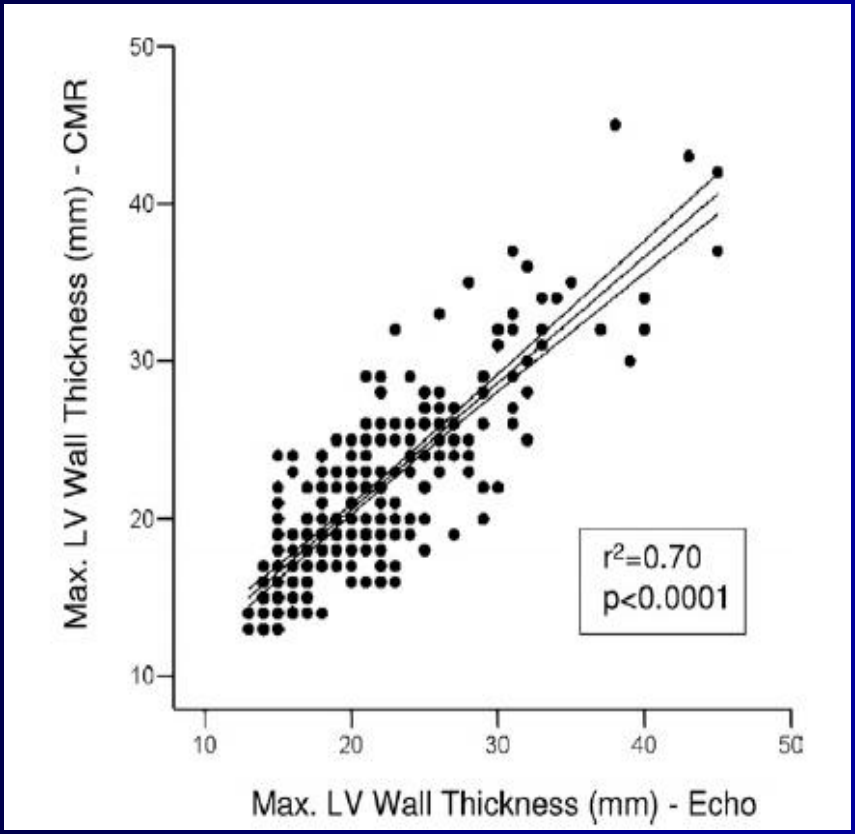


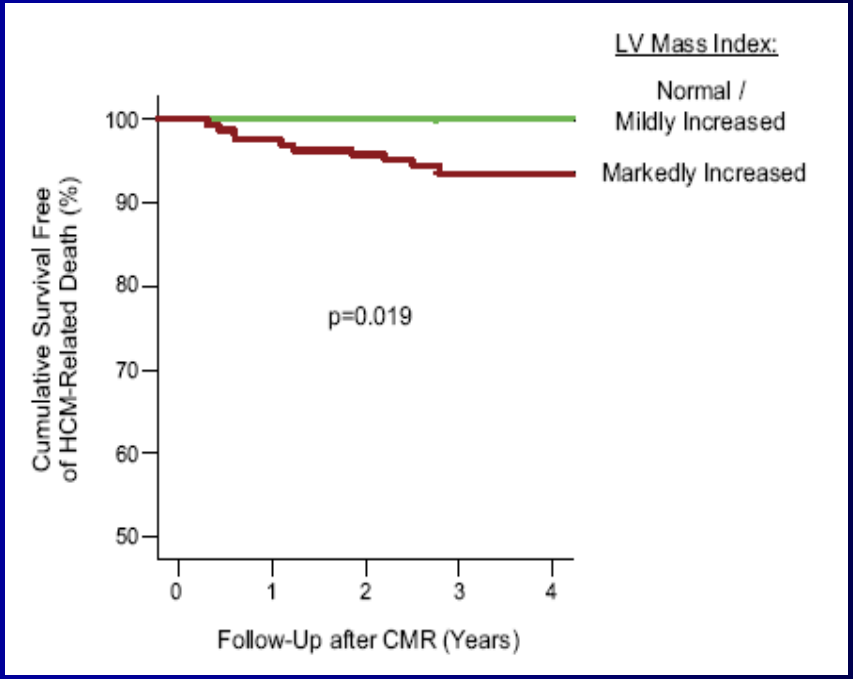
Assessment and Significance of Left Ventricular Mass by Cardiovascular Magnetic Resonance in Hypertrophic Cardiomyopathy

Iacopo Olivotto, MD,* Martin S. Maron, MD,§ Camillo Autore, MD,† John R. Lesser, MD,‡ Luigi Rega, MD,* Giancarlo Casolo, MD,* Marcello De Santis, MD,† Giovanni Quarta, MD,† Stefano Nistri, MD,* Franco Cecchi, MD,* Carol J. Salton, BA,‖ James E. Udelson, MD,§ Warren J. Manning, MD,‖ Barry J. Maron, MD‡

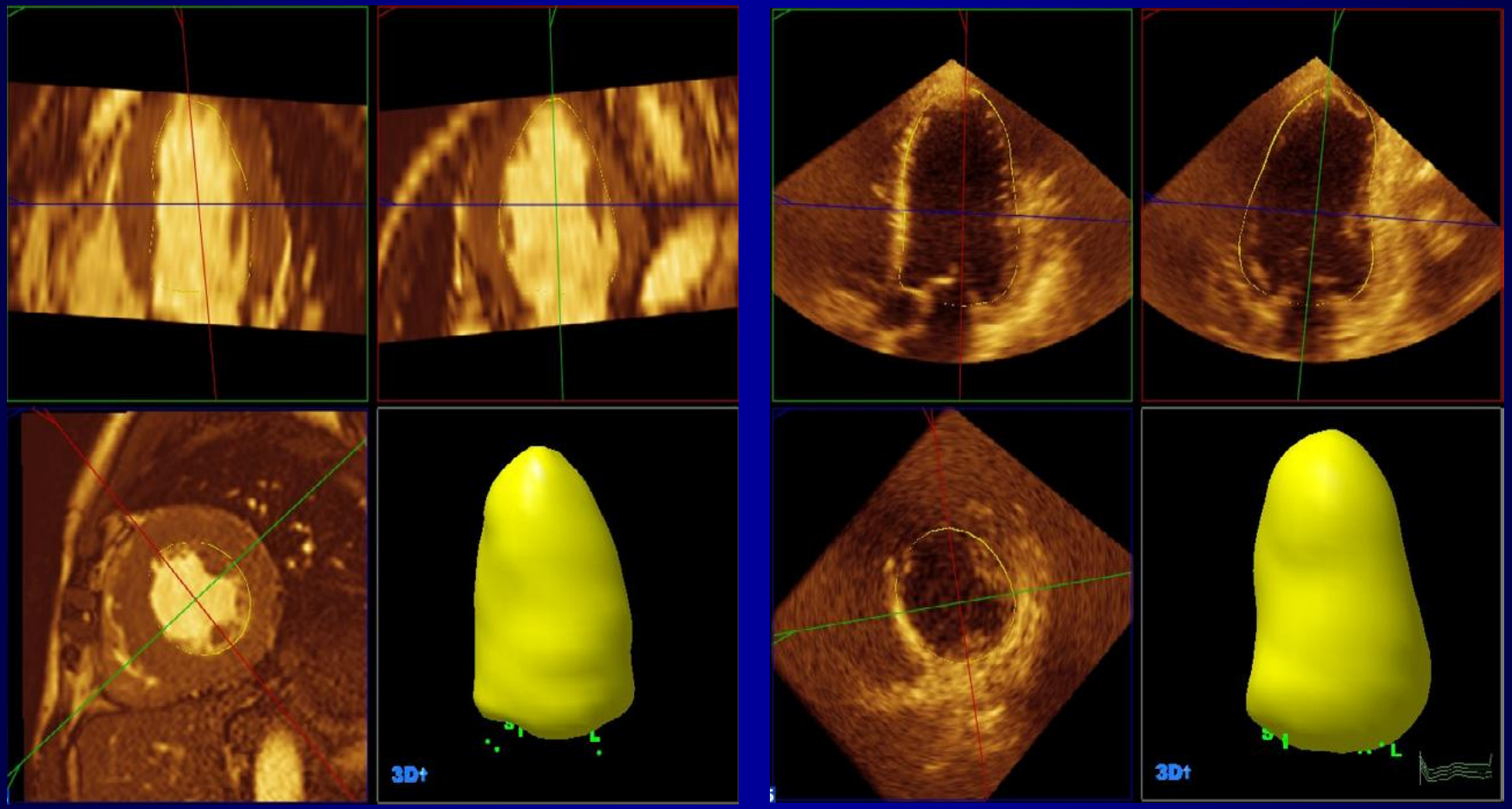
Florence and Rome, Italy; Minneapolis, Minnesota; and Boston, Massachusetts

JACC 2008

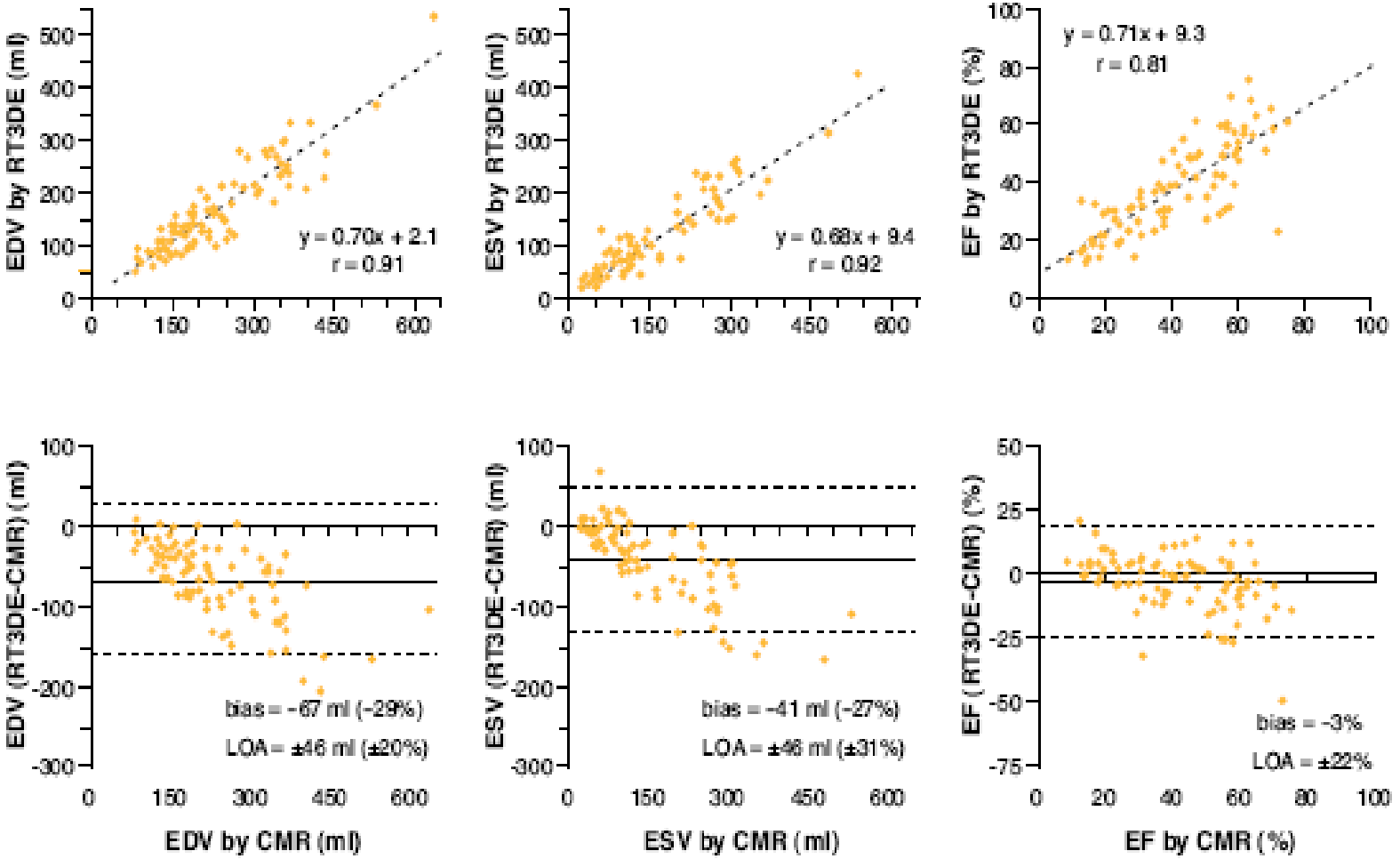

Max. LV Wall Thickness (mm) - CMR
Max. LV Wall Thickness (mm) - Echo
r^2=0.70
p<0.0001
10
20
30
40
50


LV Mass Index:
Normal / Mildly Increased
Markedly Increased
p=0.019
Cumulative Survival Free of HCM-Related Death (%)
Follow-Up after CMR (Years)
100
90
80
70
60
50
0
1
2
3
4

Calcoli di volume e funzione
CMR vs 3D Echo



Mor Avi et Al. *J. Am. Coll. Cardiol. Img.* 2008



Mor Avi et Al. *J. Am. Coll. Cardiol. Img.* 2008

	EDV		ESV	
	r	Bias	r	Bias
All Patients	**0.91**	**−67 ± 47 ml** **−29 ± 20%**	**0.93**	**−41 ± 46 ml** **−27 ± 30%**
Site A	0.93	−37 ± 27 ml −19 ± 13%	0.92	−18 ± 30 ml −15 ± 25%
Site B	0.95	−63 ± 43 ml −29 ± 20%	0.96	−31 ± 42 ml −24 ± 32%
Site C	0.92	−72 ± 55 ml −29 ± 22%	0.94	−44 ± 54 ml −26 ± 32%
Site D	0.89	−89 ± 33 ml −36 ± 13%	0.90	−63 ± 39 ml −39 ± 24%

Correlation with CMR values and difference from CMR values averaged over patients (bias) ± standard deviation. Data are shown for the entire study group, as well as for patients studied at each site separately (sites arranged in descending order of experience with volumetric analysis software).
CMR = cardiac magnetic resonance; EDV = end-diastolic left ventricular volume; ESV = end-systolic left ventricular volume; LV = left ventricular; RT3DE = real-time 3-dimensional echocardiographic.

Table 2. Results of Reproducibility Analysis of LV Volumes Obtained From CMR Images and RT3DE Datasets

		Interobserver (%)		Intraobserver (%)	
EDV	CMR	5 ± 4	0–21	4 ± 5	0–26
	RT3DE	8 ± 8	0–38	5 ± 5	0–20
ESV	CMR	7 ± 7	0–36	4 ± 4	0–19
	RT3DE	13 ± 14	0–70	10 ± 11	0–62

Interobserver and intraobserver variability values (percentage of the mean of 2 repeated measurements) averaged over patients ± standard deviations shown with ranges of values noted in individual patients.

Mor Avi et Al. *J. Am. Coll. Cardiol. Img.* 2008

QUANDO?

3. Cardiac Resynchronisation Therapy (CRT) in Patients with Heart Failure

Recommendations for the use of cardiac resynchronization therapy by biventricular pacemaker (CRT-P) or biventricular pacemaker combined with an ICD (CRT-D) in HF patients.

Heart failure patients who remain symptomatic in NYHA Class IIHV despite optimal pharmacological treatment, with low ejection fraction (LVEF ≤ 35%), left ventricular dilatation*, normal sinus rhythm and wide QRS complex (≥ 120 ms)

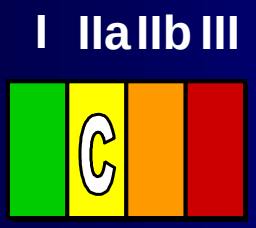
- Class I - Level of evidence A for CRT-P to reduce morbidity and mortality.
- CRT-D is an acceptable option for patients who have expectancy of survival with a good functional status for more than 1 year, Class I - Level of evidence B.

* Left ventricular dilatation/Different criteria have been used to define LV dilatation in controlled studies on CRT: LV end diastolic diameter > 55 mm; LV end diastolic diameter > 30 mm/m², LV end diastolic diameter > 30 mm/m (height).

Cardiac Resynchronization Therapy* in Patients With Severe Systolic Heart Failure

For patients who have left ventricular ejection fraction (LVEF) less than or equal to 35%, a QRS duration greater than or equal to 0.12 seconds, and sinus rhythm, cardiac resynchronization therapy (CRT) with or without an ICD is indicated for the treatment of New York Heart Association (NYHA) functional Class III or ambulatory Class IV heart failure symptoms on optimal recommended medical therapy.

For patients who have LVEF less than or equal to 35%, a QRS duration greater than or equal to 0.12 seconds, and AF, CRT with or without an ICD is reasonable for the treatment of NYHA functional Class III or ambulatory Class IV heart failure symptoms on optimal recommended medical therapy.



For patients with LVEF less than or equal to 35% with NYHA functional Class III or ambulatory Class IV symptoms who are receiving optimal recommended medical therapy and who have frequent dependence on ventricular pacing, CRT is reasonable.

*All primary SCD prevention ICD recommendations apply only to patients who are receiving optimal medical therapy and have reasonable expectation of survival with good functional capacity for more than 1 year.

Implantable Cardioverter-Defibrillators

ICD therapy is indicated in patients with LVEF less than 35% due to prior MI who are at least 40 days post-MI and are in NYHA functional Class II or III.

ICD therapy is indicated in patients with nonischemic DCM who have an LVEF less than or equal to 35% and who are in NYHA functional Class II or III.

ICD therapy is indicated in patients with LV dysfunction due to prior MI who are at least 40 days post-MI, have an LVEF less than 30%, and are in NYHA functional Class I.

ICD therapy is indicated in patients with nonsustained VT due to prior MI, LVEF less than 40%, and inducible VF or sustained VT at electrophysiological study.

All primary SCD prevention ICD recommendations apply only to patients who are receiving optimal medical therapy and have reasonable expectation of survival with good functional capacity for more than 1 year.

Europace (2006) 8, 746–837
doi:10.1093/europace/eul108

EUROPEAN SOCIETY OF CARDIOLOGY®

ACC/AHA/ESC Guidelines

ACC/AHA/ESC 2006 guidelines for management of patients with ventricular arrhythmias and the prevention of sudden cardiac death

A report of the American College of Cardiology/American Heart Association Task Force and the European Society of Cardiology Committee for Practice Guidelines (Writing Committee to Develop Guidelines for Management of Patients With Ventricular Arrhythmias and the Prevention of Sudden Cardiac Death)
Developed in collaboration with the European Heart Rhythm Association and the Heart Rhythm Society

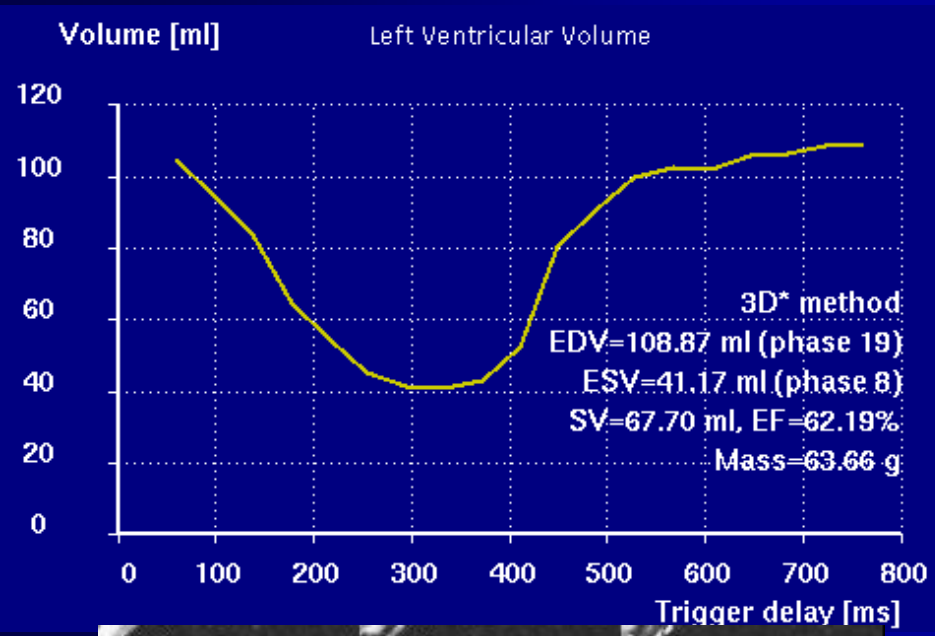
Class IIa

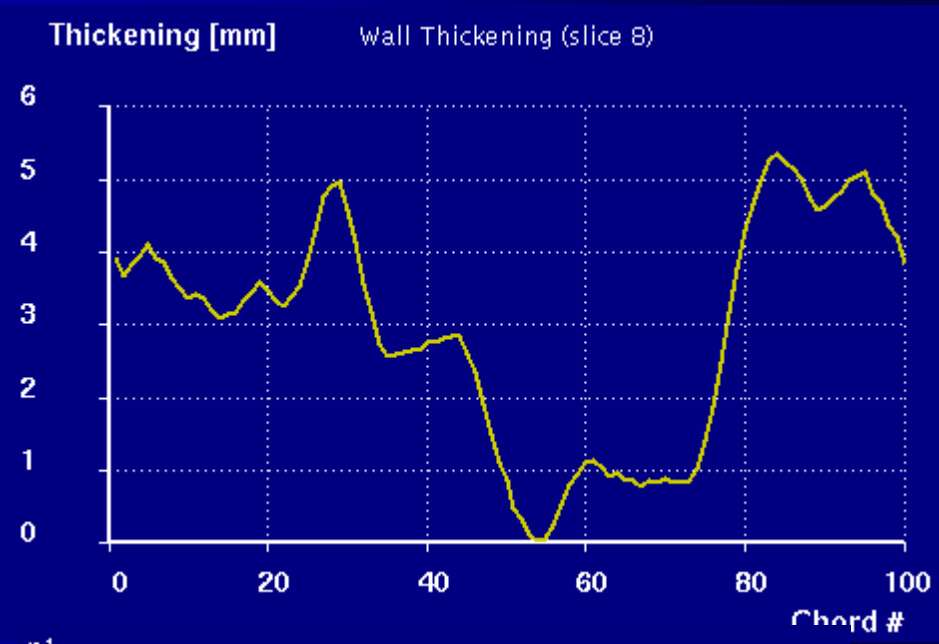
(1) MRI, cardiac computed tomography (CT), or radionuclide angiography can be useful in patients with ventricular arrhythmias when echocardiography does not provide accurate assessment of LV and RV function and/or evaluation of structural changes. *(Level of Evidence: B)*

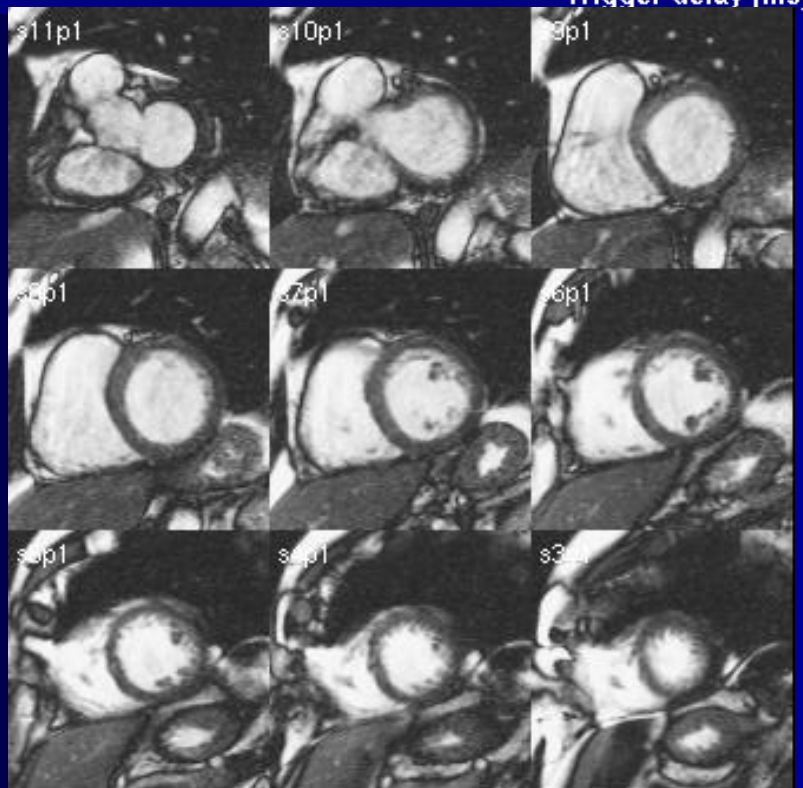
- Additional non invasive testing: In pts in whom echocardiography at rest has not provided adequate information or in patients with suspected CAD further non invasive imaging may include MRI, CT or MPI.

ESC Guidelines for CHF, update 2008

COME?


Volume [ml]
Left Ventricular Volume
120
100
80
60
40
20
0
0
100
200
300
400
500
600
700
800
Trigger delay [ms]
3D* method
EDV=108.87 ml (phase 19)
ESV=41.17 ml (phase 8)
SV=67.70 ml, EF=62.19%
Mass=63.66 g


Thickening [mm]
Wall Thickening (slice 8)
6
5
4
3
2
1
0
0
20
40
60
80
100
Chord #


s11p1
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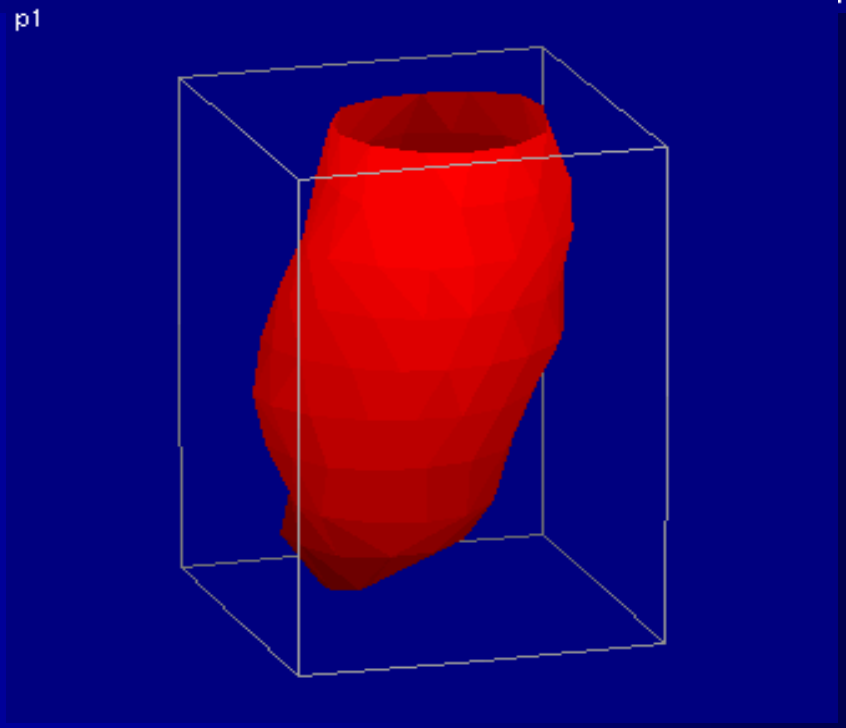
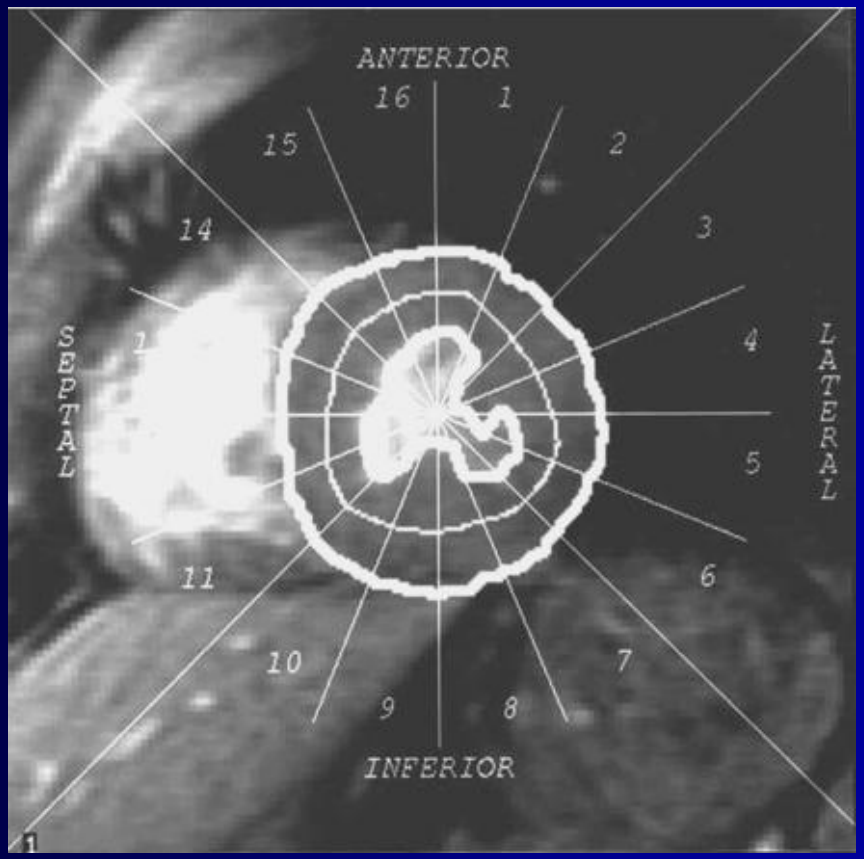
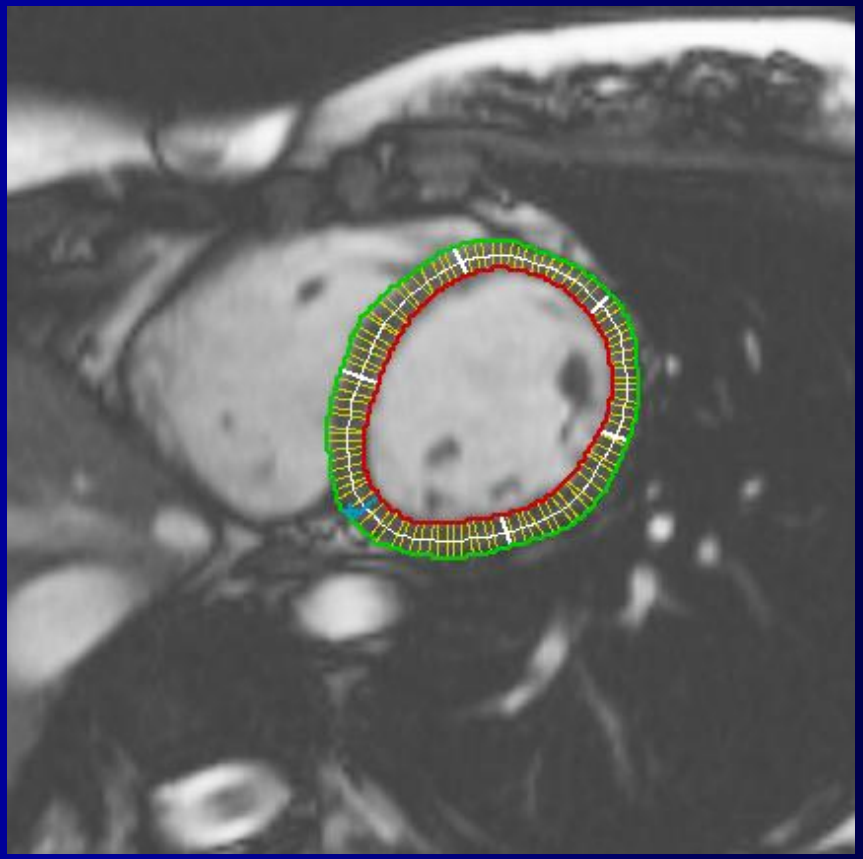
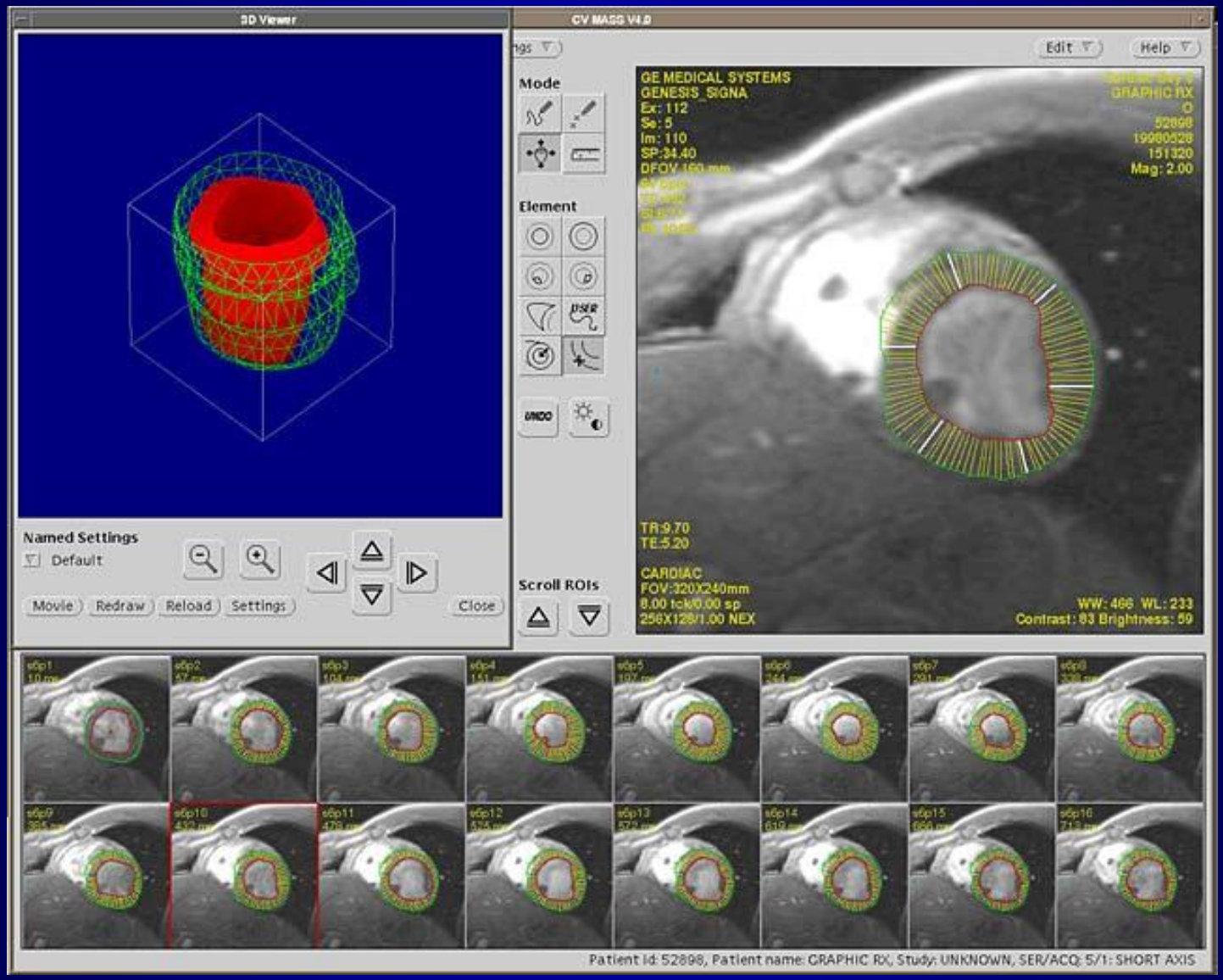
s8p1
s7p1
s6p1
s5p1
s4p1
s3p1

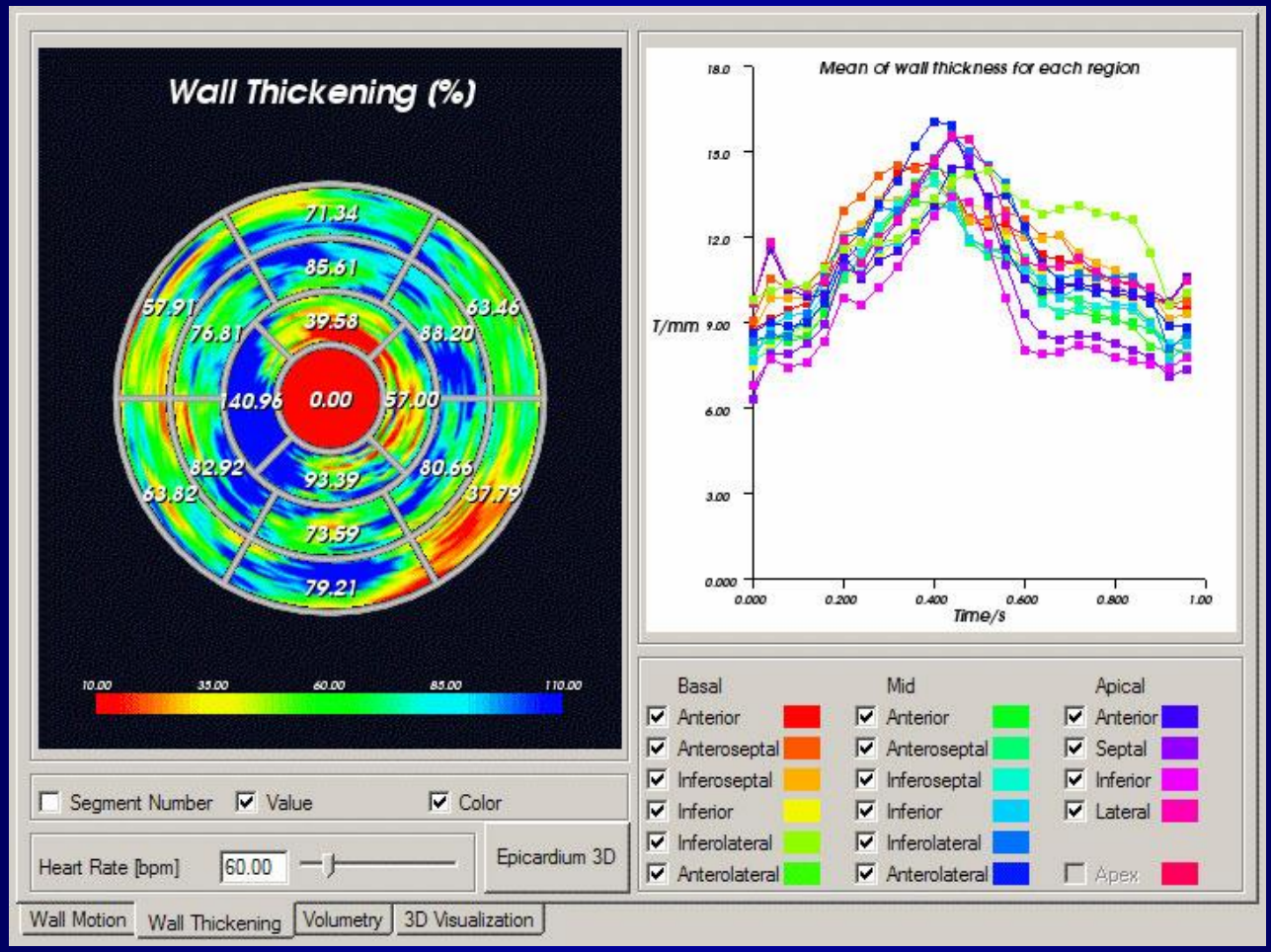

p1

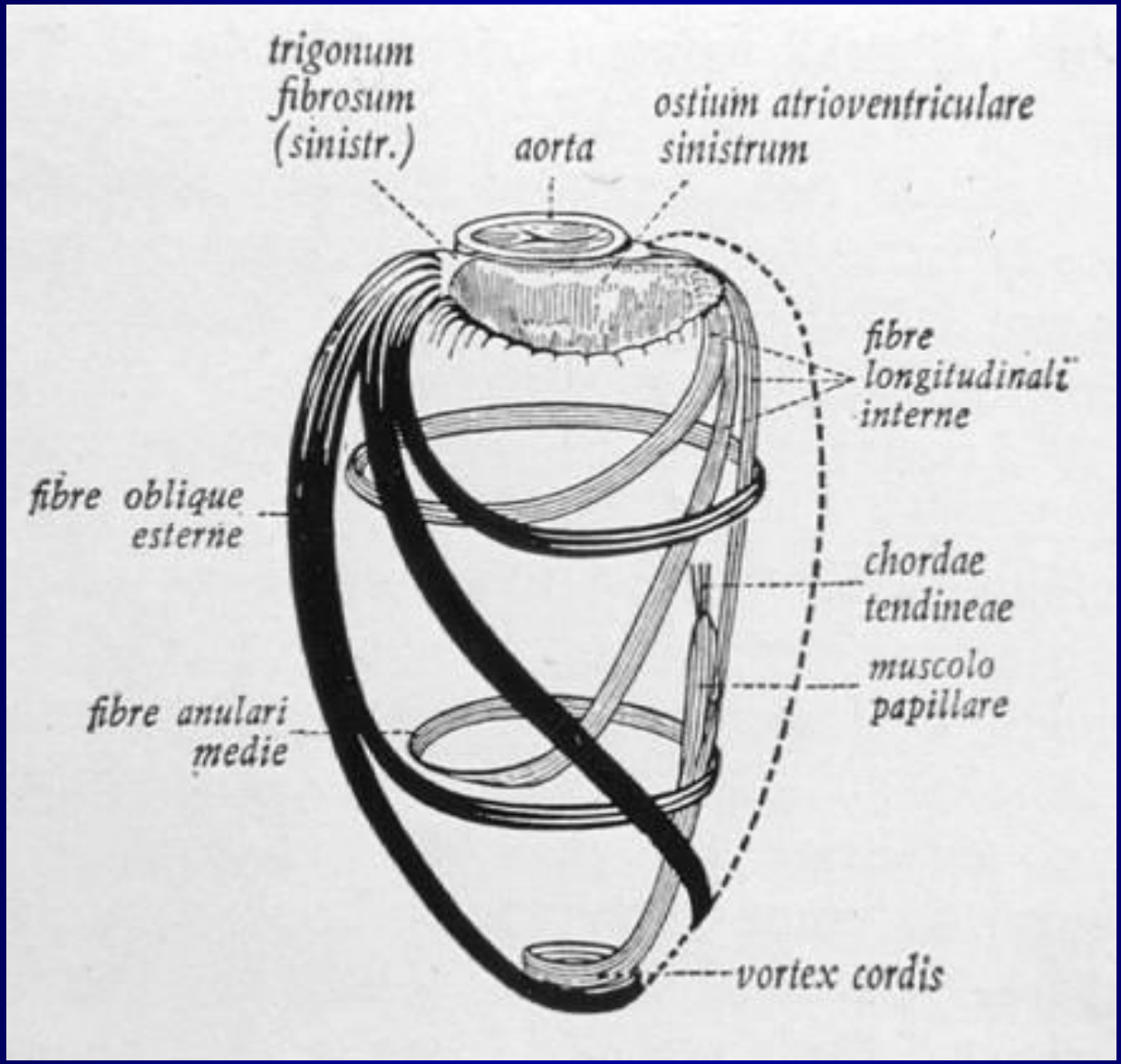

ANTERIOR
16
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
SEPTAL
LATERAL
INFERIOR

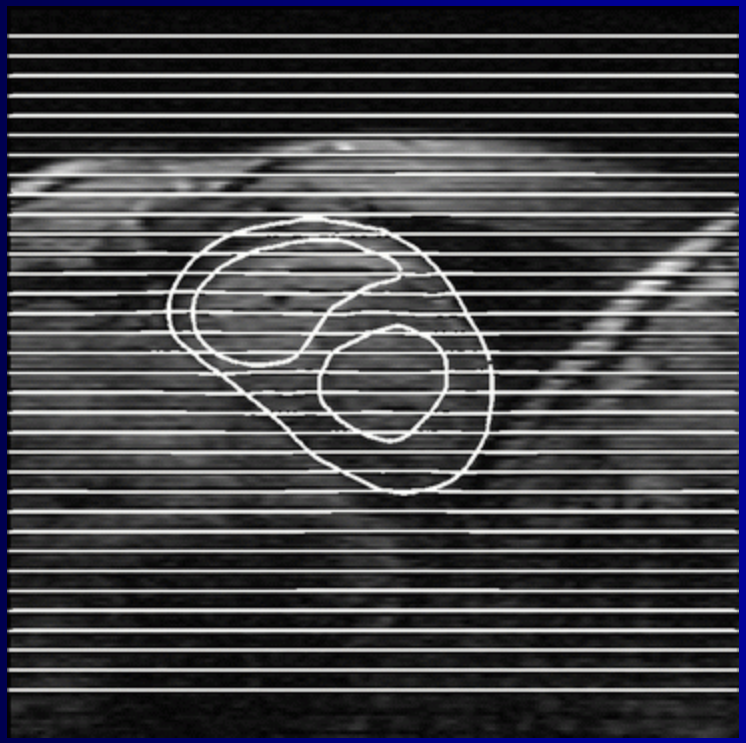


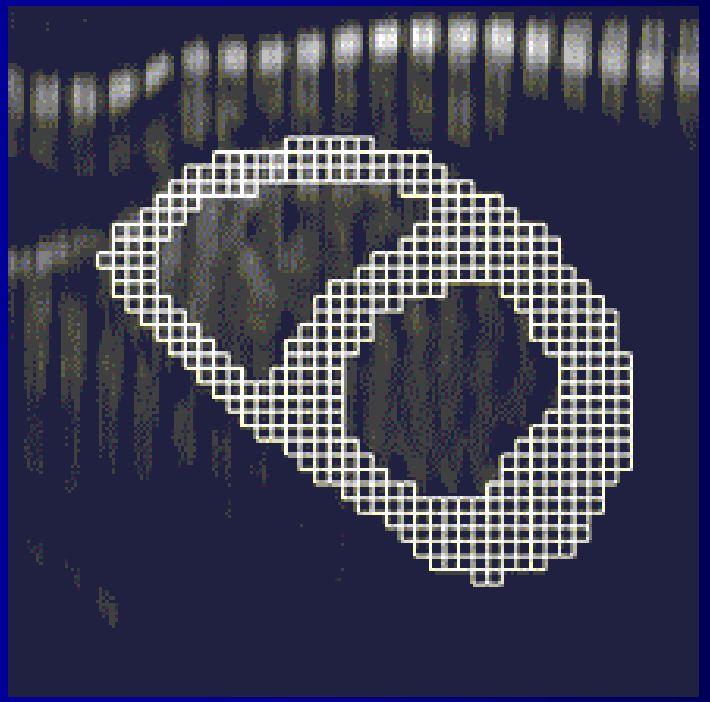

3D Viewer
CV MASS V4.0
Edit
Help
Mode
Element
UNDO
Scroll ROIs
GE MEDICAL SYSTEMS
GENESIS_SIGNA
Ex: 112
Se: 5
Im: 110
SP:24.40
GRAPHIC RX
Mag: 2.00
TR:9.70
TE:5.20
CARDIAC
FOV:320X240mm
8.00 tck/0.00 sp
256X128/1.00 NEX
WW: 466 WL: 233
Contrast: 83 Brightness: 59
Named Settings
Default
Movie
Redraw
Reload
Settings
Close
Patient Id: 52898, Patient name: GRAPHIC RX, Study: UNKNOWN, SER/ACQ: 5/1: SHORT AXIS

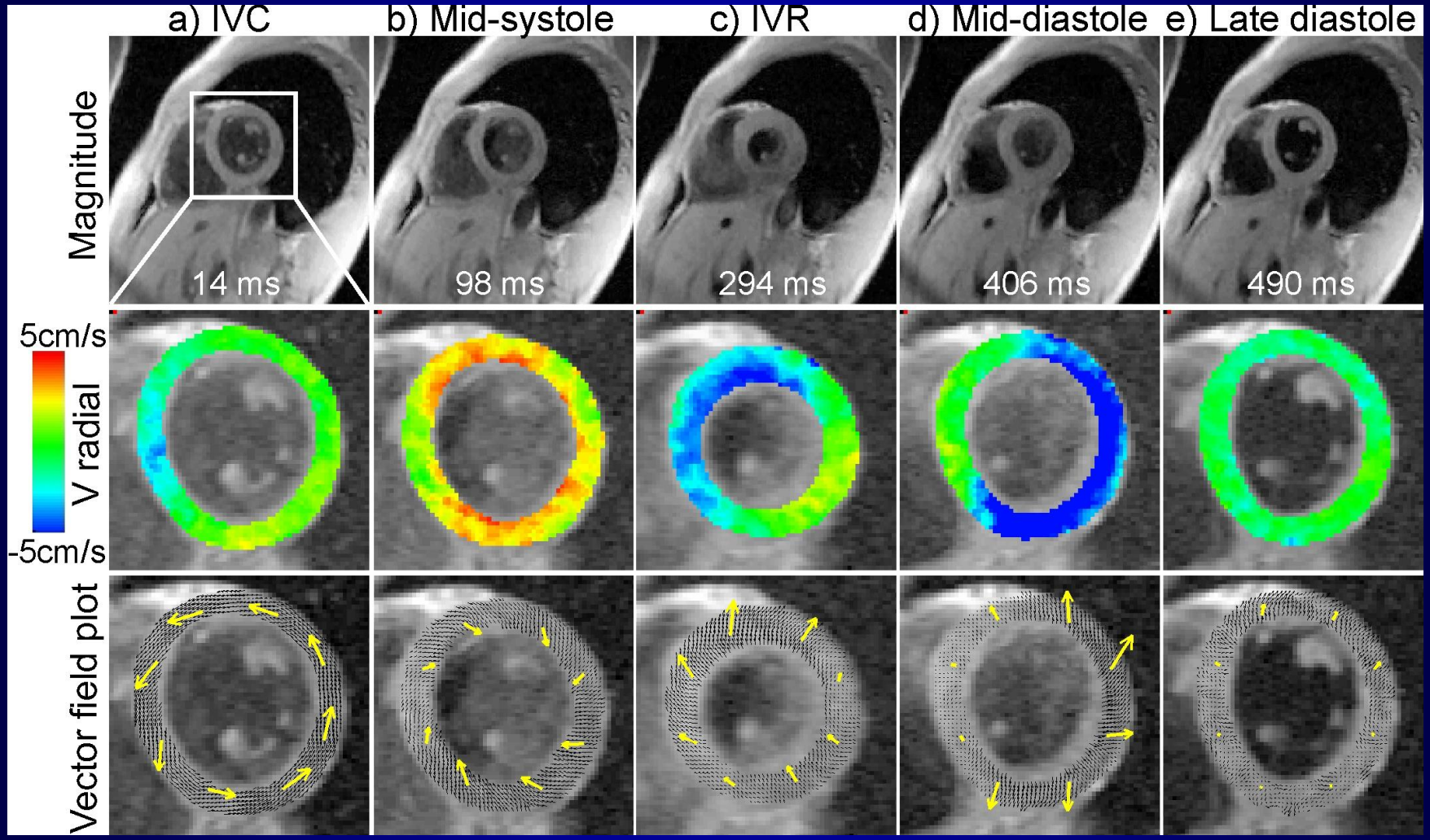
Funzione regionale

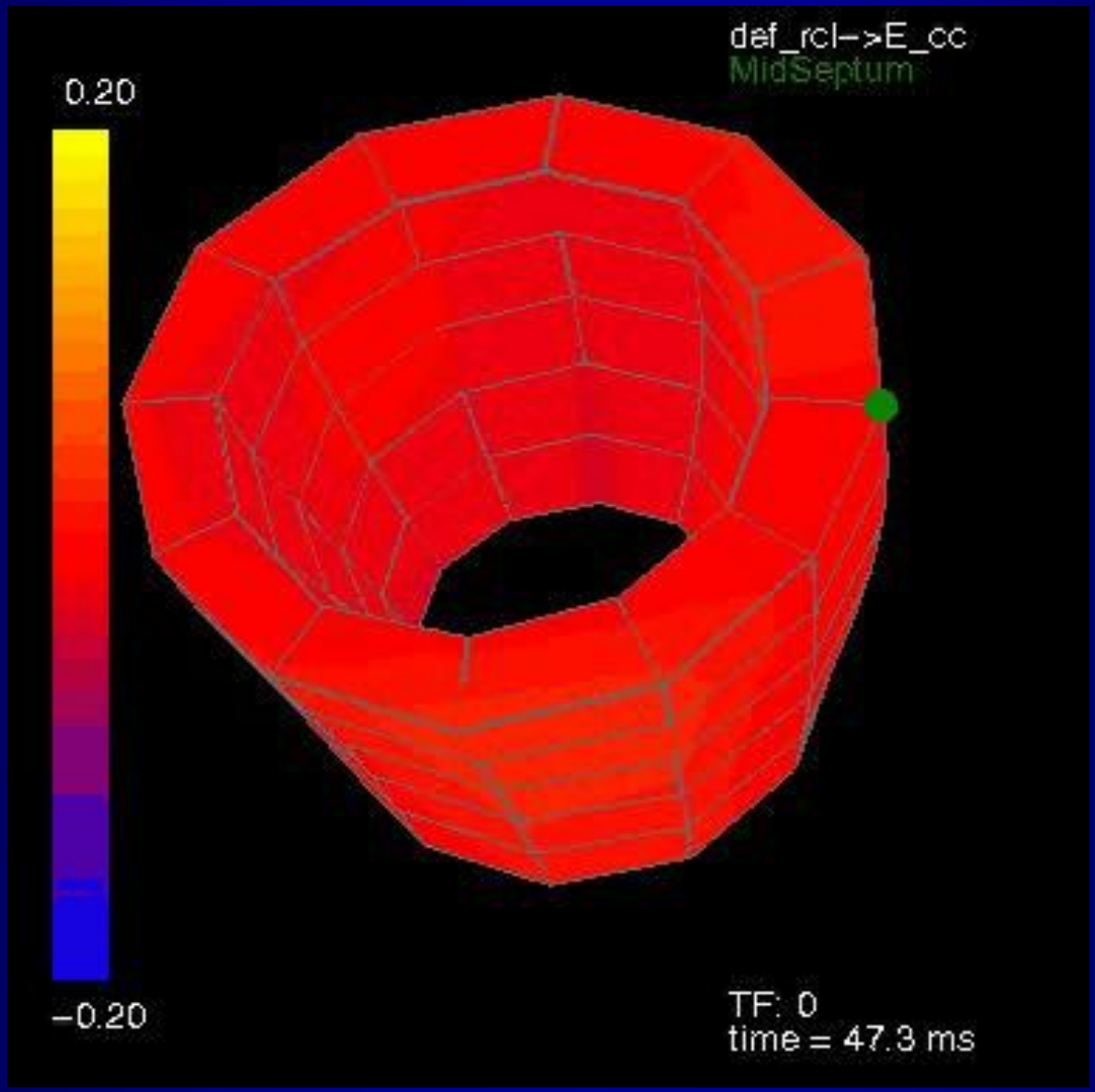


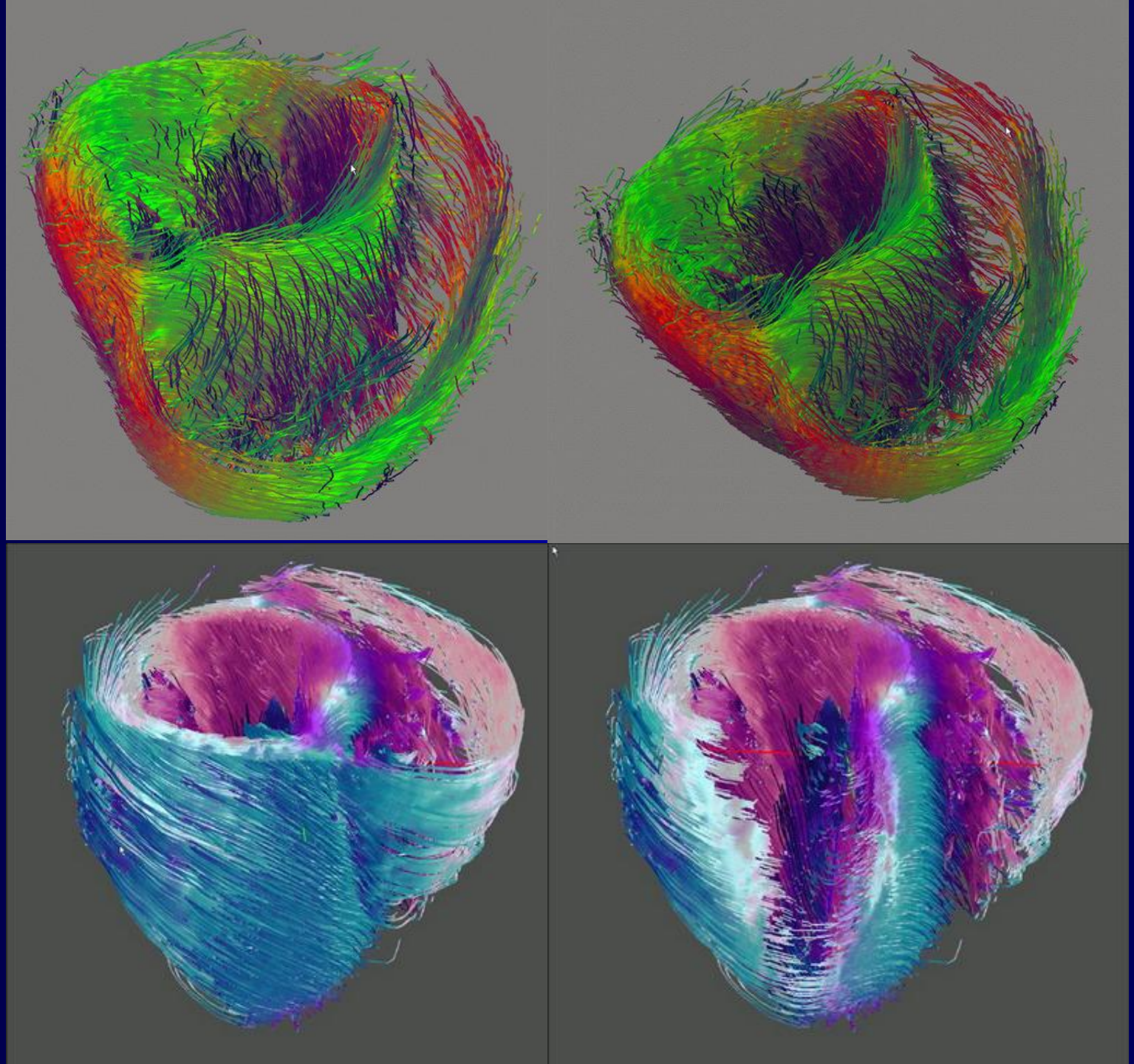

trigonum fibrosum (sinistr.)
aorta
ostium atrioventriculare sinistrum
fibre longitudinali interne
fibre oblique esterne
chordae tendineae
muscolo papillare
fibre anulari medie
vortex cordis



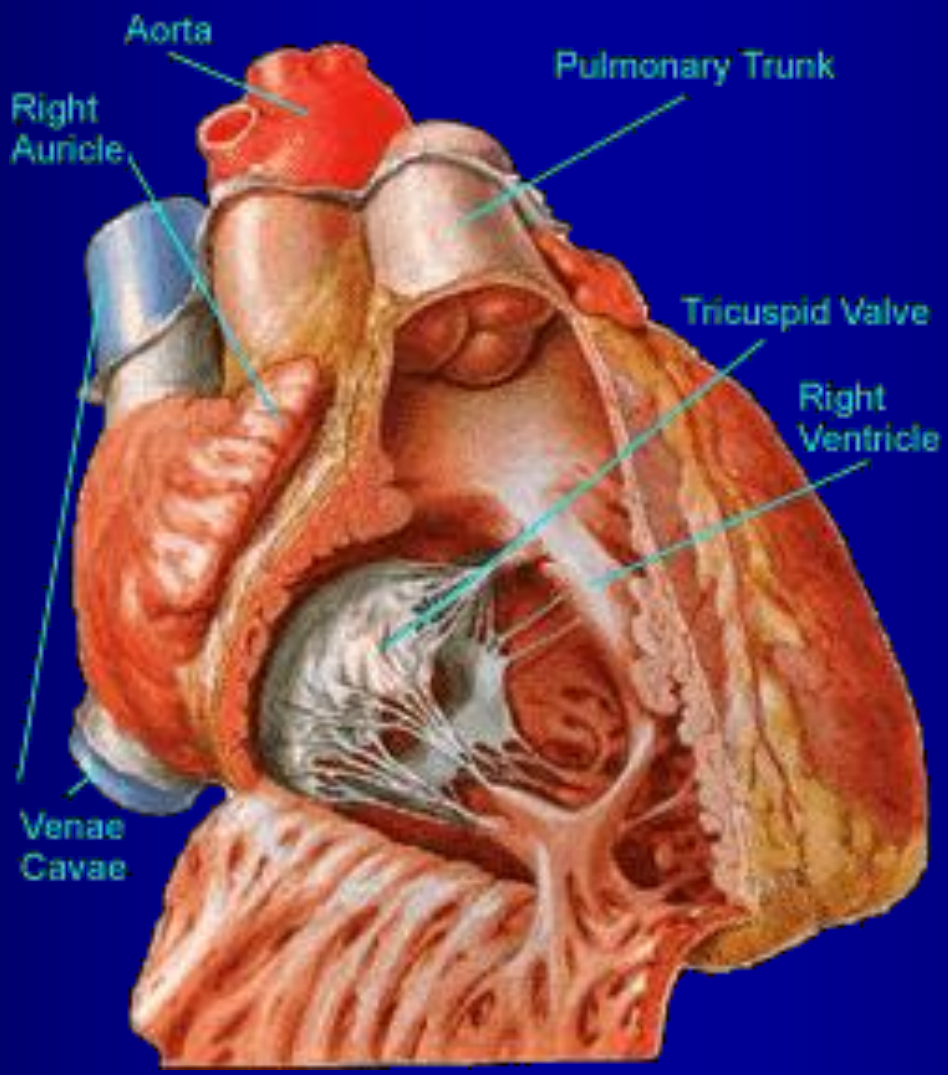



a) IVC
b) Mid-systole
c) IVR
d) Mid-diastole
e) Late diastole
Magnitude
14 ms
98 ms
294 ms
406 ms
490 ms
5cm/s
V radial
-5cm/s
Vector field plot


def_rcl->E_cc
MidSeptum
0.20
−0.20
TF: 0
time = 47.3 ms



Il ventricolo destro



Riproducibilità tra studi

	Normals	CHF	LVH	Total
EDV (mL)				
Mean difference ± SD	1.1 ± 6.5	0.4 ± 10.9	3.7 ± 8.5	1.7 ± 8.8
EDV index (mL/m^2)				
Mean difference ± SD	0.6 ± 3.5	0.1 ± 5.8	1.8 ± 4.5	0.9 ± 4.7
Coefficient of variability	4.2%	7.8%	6.2%	6.2%
ESV (mL)				
Mean difference ± SD	−0.3 ± 4.7	1.2 ± 10.6	2.1 ± 9.6	1.0 ± 8.6
ESV index (mL/m^2)				
Mean difference ± SD	−0.2 ± 2.7	0.5 ± 5.5	1.1 ± 5.0	0.5 ± 4.5
Coefficient of variability	8.1%	14.5%	18.1%	14.1%
Stroke volume (mL)				
Mean difference ± SD	1.3 ± 5.4	−0.8 ± 5.0	1.3 ± 9.1	0.6 ± 6.7
Stroke volume index (mL/m^2)				
Mean difference ± SD	0.7 ± 2.8	−0.4 ± 2.7	−0.6 ± 4.8	0.3 ± 3.5
Coefficient of variability	4.3%	7.5%	10.8%	8.2%
EF (%)				
Mean difference ± SD	0.6 ± 2.7	−0.8 ± 5.4	0.0 ± 6.2	−0.1 ± 4.9
Coefficient of variability	4.3%	10.4%	10.0%	8.3%
Mass (g)				
Mean difference ± SD	−0.4 ± 4.7	0.7 ± 6.0	−1.4 ± 5.8	−0.4 ± 5.5
Mass index (g/m^2)				
Mean difference ± SD	−0.1 ± 2.4	0.3 ± 3.2	−0.7 ± 2.9	−0.2 ± 2.9
Coefficient of variability	7.8%	9.0%	9.4%	8.7%

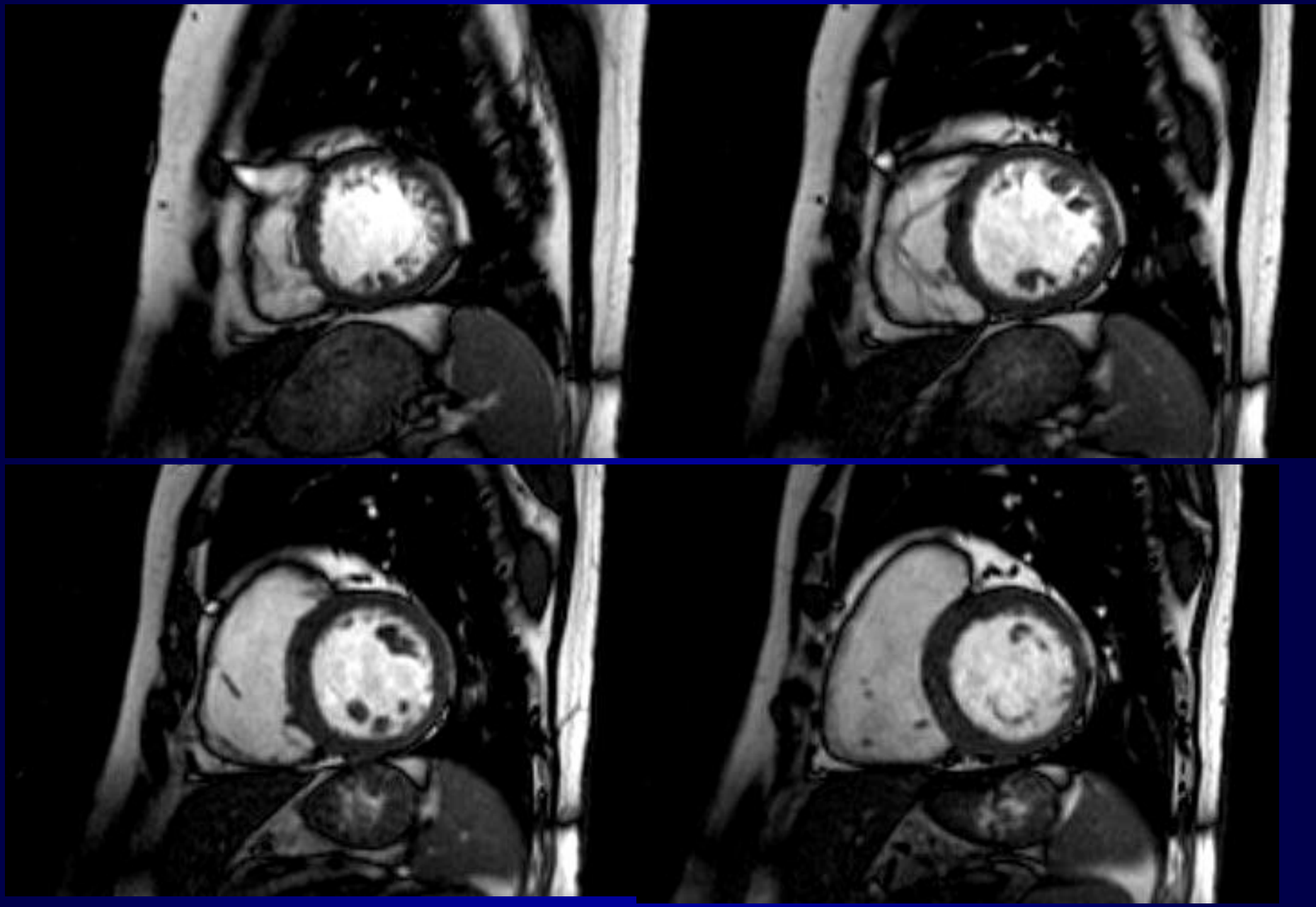
Grouthes et Al. Am Heart J 2004

Quando?

- Pazienti con cattiva finestra acustica

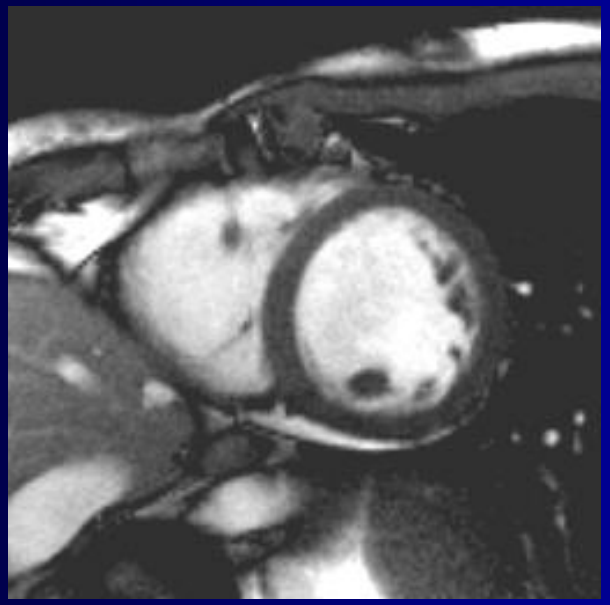
Quando?

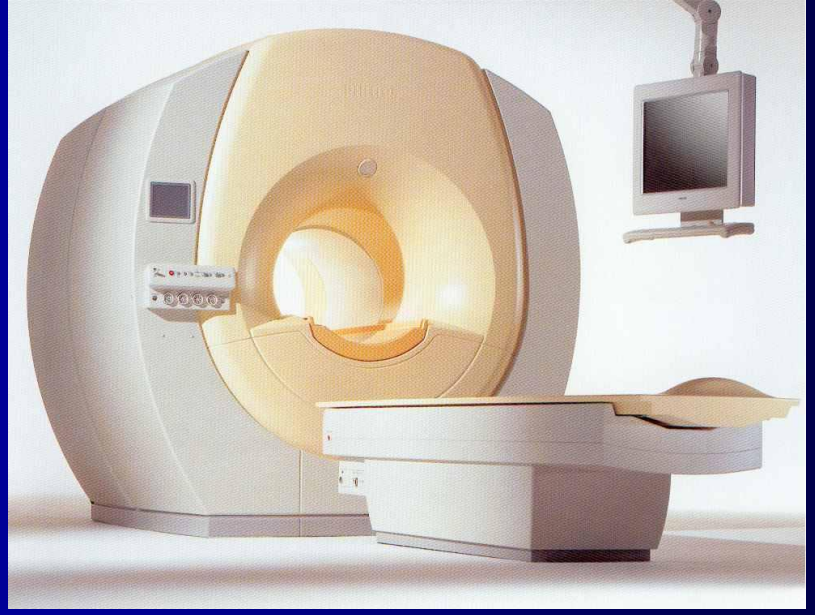
- Pazienti in cui è necessaria massima precisione di calcolo

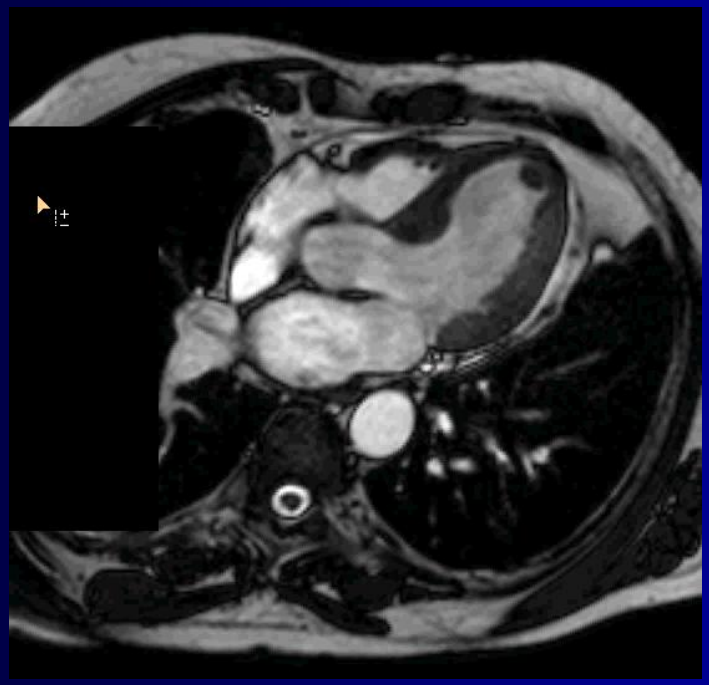


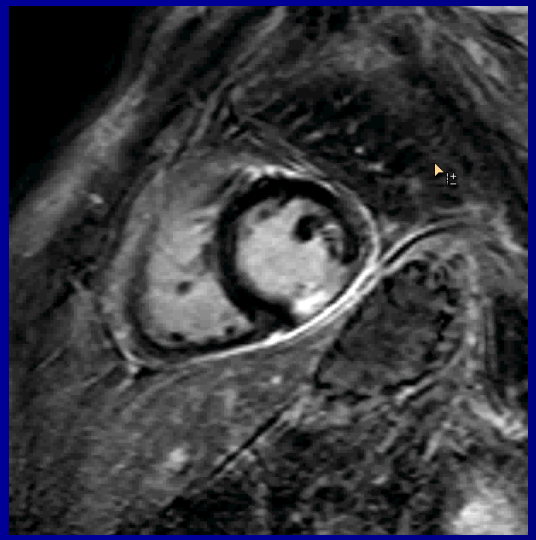
Quando?

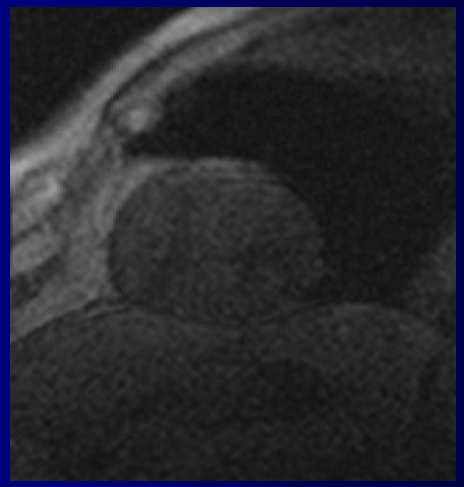
- Se vogliamo integrazione di informazioni











Lt. Hiroo Onoda

On December 26, 1944 (age 23), Hiroo Onoda was sent to the small island of Lubang Island, approximately seventy-five miles southwest of Manila in the Philippines

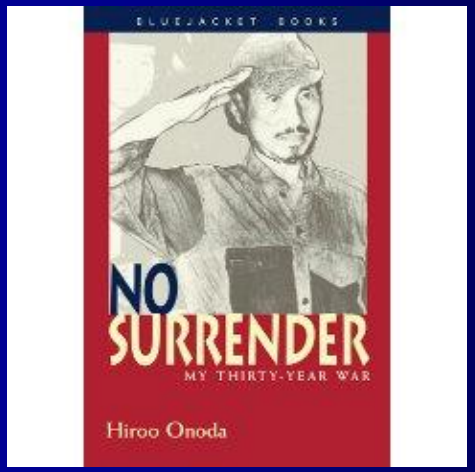
Shortly after Americans landed, all but four of the Japanese soldiers had either died or surrendered. Hiroo Onda was also with three other holdouts, who all died over the decades

Despite the efforts of the Philippine Army, letters and newspapers left for them, radio broadcasts, and even a plea from Onoda's brother, he did not belive the war was over

He surrendered 29 years after Japan's formal surrender, and 15 years after being declared legally dead in Japan. When he accepted that the war was over, he wept openly.

Dove

- In Cardiologia?
- In Radiologia?
- Ovunque?



Training in Multimodality Imaging: Challenges and Opportunities
William A. Zoghbi, and Jagat Narula
J. Am. Coll. Cardiol. Img. 2009;2;249-250
doi:10.1016/j.jcmg.2008.11.007

JACC cardiovascular Imaging

La RM ha alcuni limiti rilevanti

Costo
Claustrofobia
Controindicazioni
Necessità di expertees

Mdc (sclerosi sistema progressiva)