



Stress Echocardiography in VHD: is myocardial contraction a reliable marker for ischemia?

Rosa Sicari

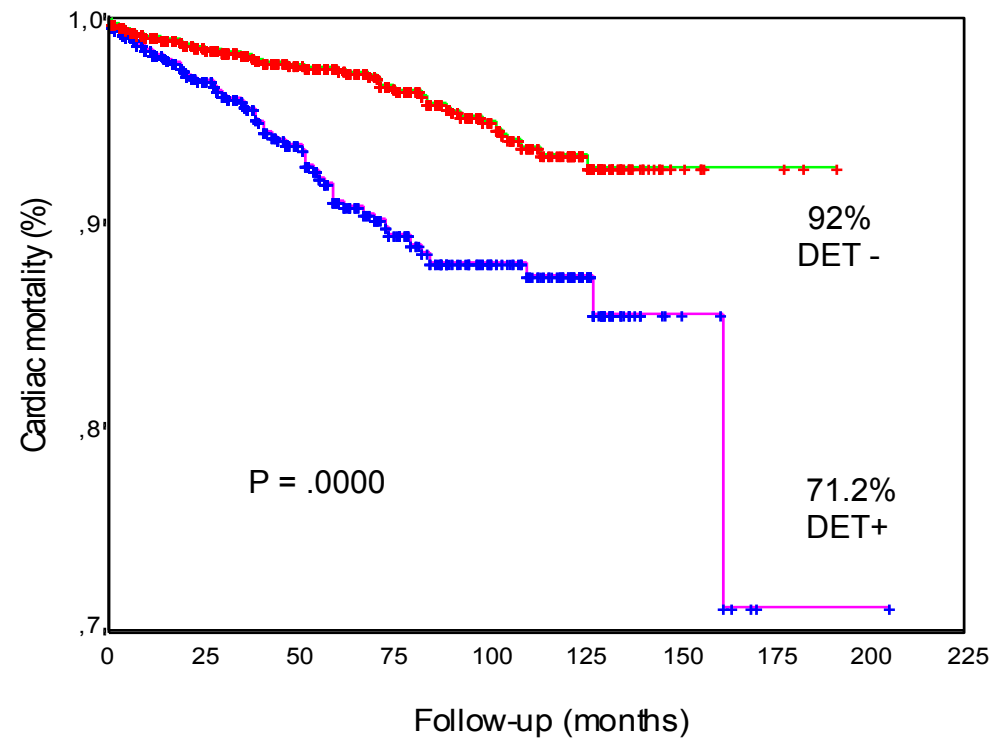
CNR, Institute of Clinical Physiology, Pisa,
Italy

Milano 8 maggio 2012

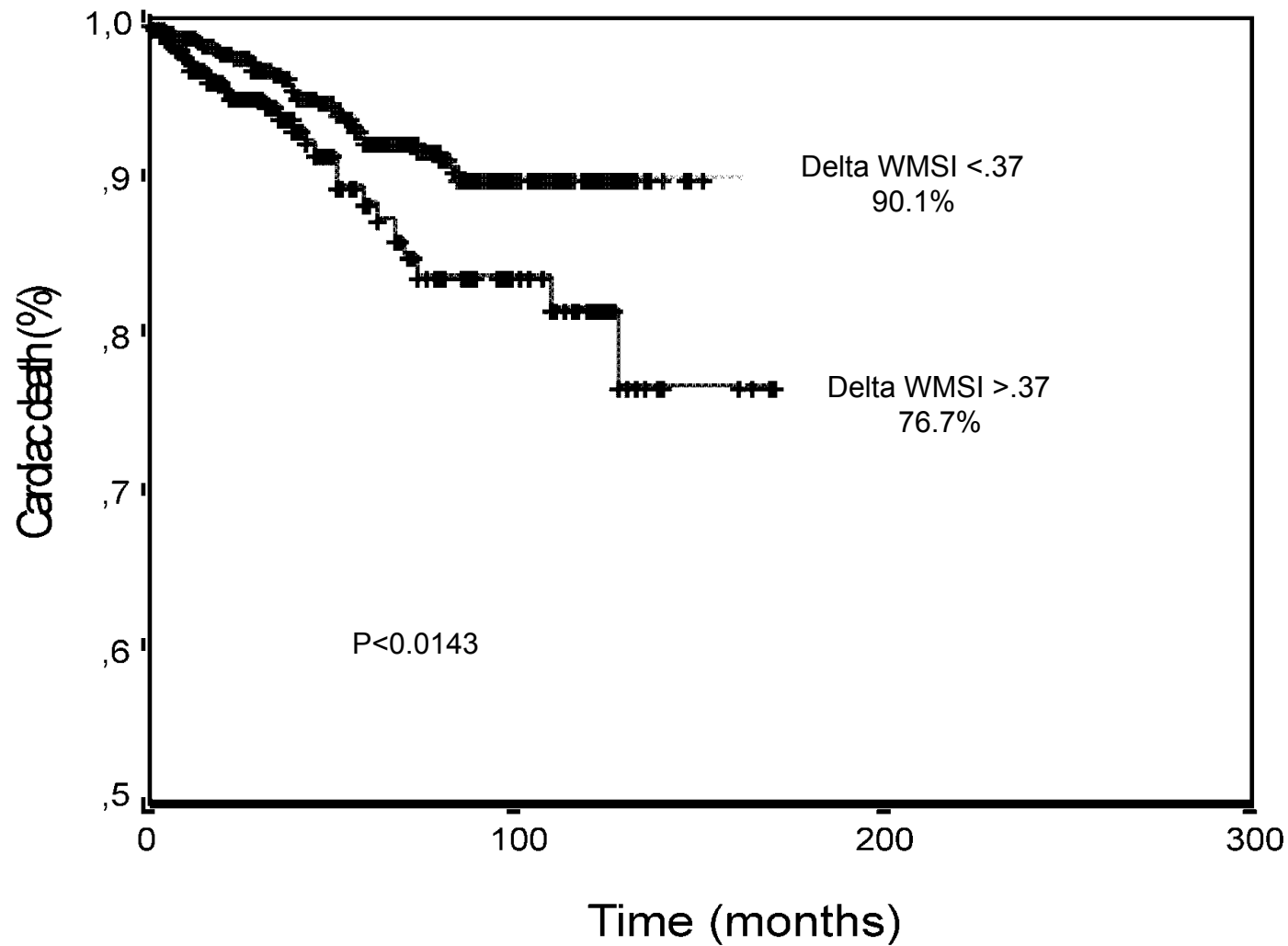


Consiglio Nazionale delle Ricerche

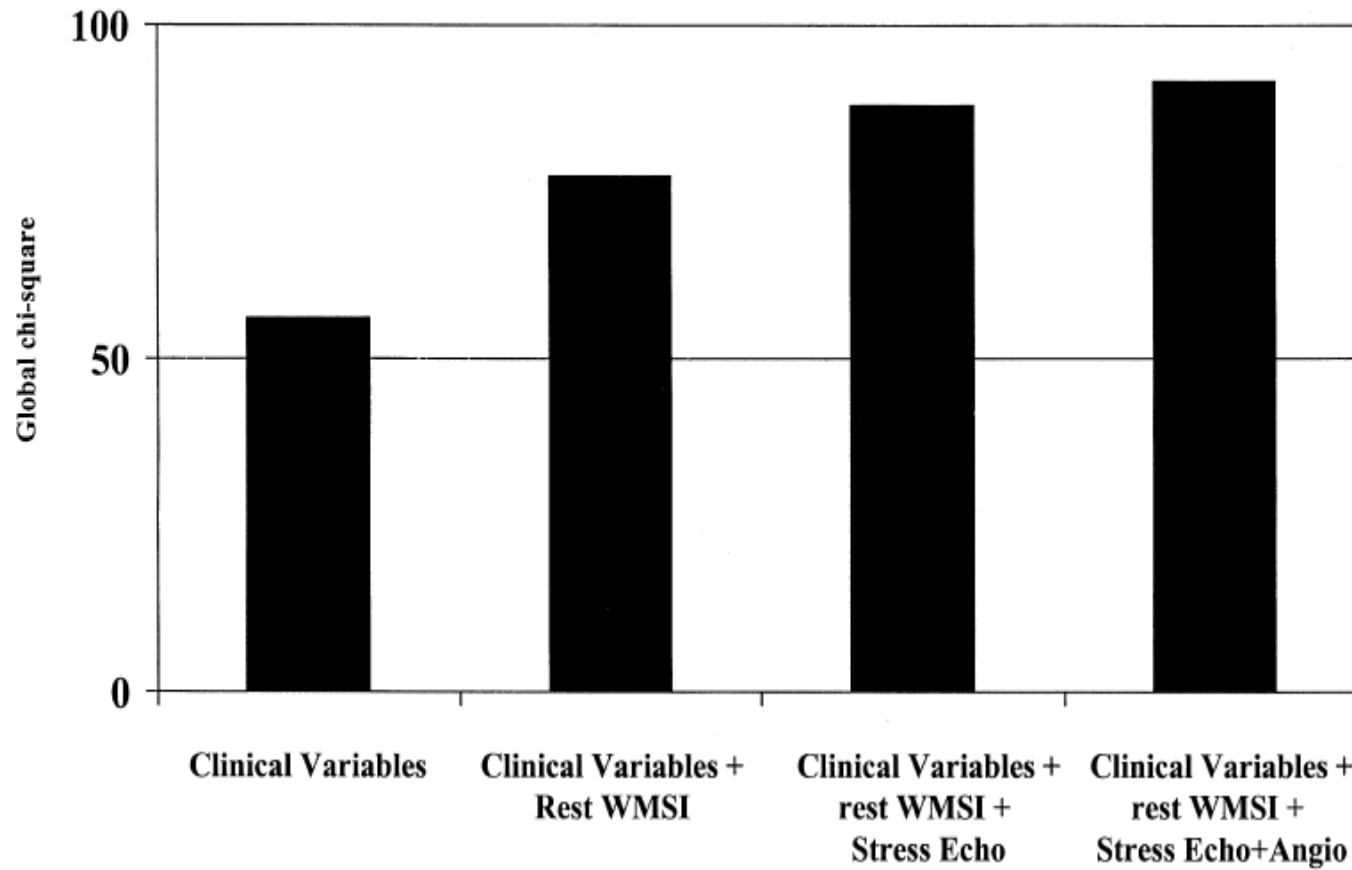
Stress Echo and Cardiac death



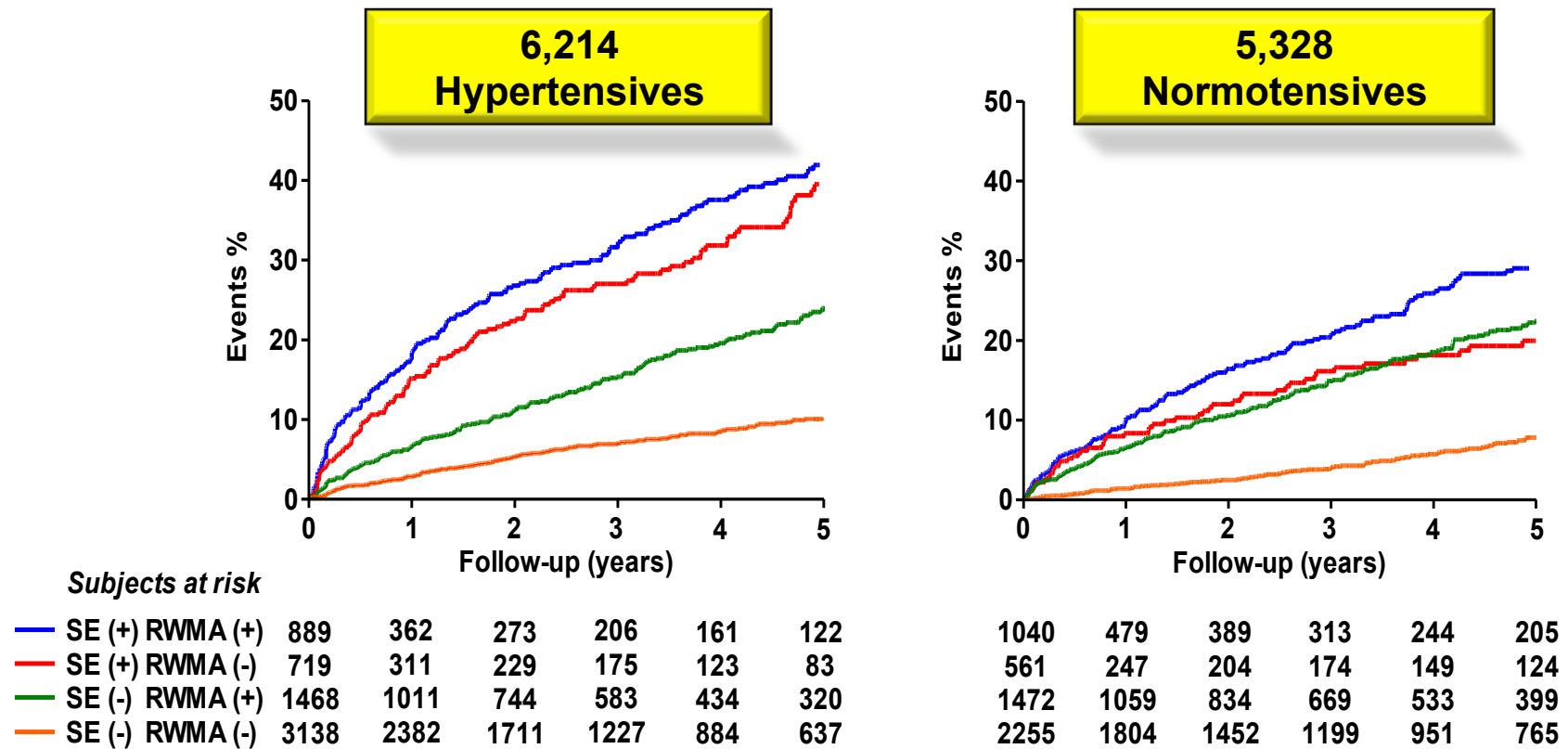
Stress Echo and Extent of Ischemia



Ischemia vs. Anatomy



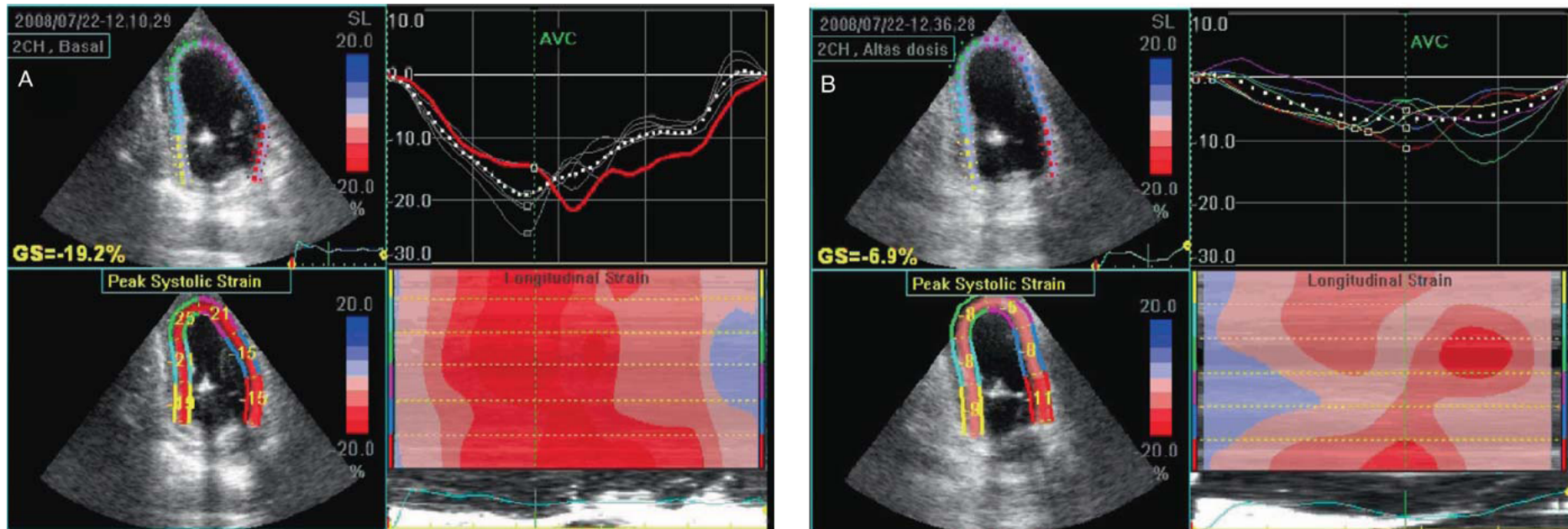
Prognostic value of stress echocardiography



Current and Evolving Echocardiographic Techniques for the Quantitative Evaluation of Cardiac Mechanics: ASE/EAE Consensus Statement on Methodology and Indications Endorsed by the Japanese Society of Echocardiography

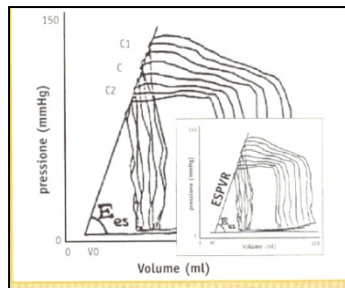
Victor Mor-Avi, PhD, FASE*, Roberto M. Lang, MD, FASE†, Luigi P. Badano, MD, FESC, Marek Belohlavek, MD, PhD, FESC, Nuno Miguel Cardim, MD, PhD, FESC, Genevieve Derumeaux, MD, PhD, FESC, Maurizio Galderisi, MD, FESC, Thomas Marwick, MBBS, PhD, Sherif F. Nagueh, MD, FASE, Partho P. Sengupta, MBBS, FASE, Rosa Sicari, MD, PhD, FESC, Otto A. Smiseth, MD, PhD, FESC, Beverly Smulevitz, BS, RDCS, Masaaki Takeuchi, MD, PhD, FASE, James D. Thomas, MD, FASE, Mani Vannan, MBBS, Jens-Uwe Voigt, MD, FESC, and Jose Luis Zamorano, MD, FESC†

Myocardial Ischemia



The direct observation of a developing systolic dysfunction combined with a post-systolic shortening indicates acute myocardial ischemia. However, the lack of clinical trials does not allow recommending specific parameters for differentiating various states of acute and chronic ischemia when baseline data are not available

School of Athens in the stress echo lab



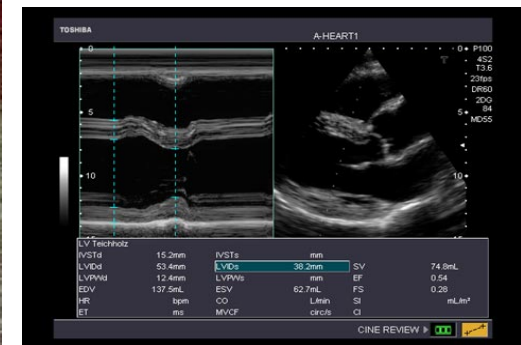
Contractility

**Pressure –
Volume loops:**

**Beautiful and
impossible**

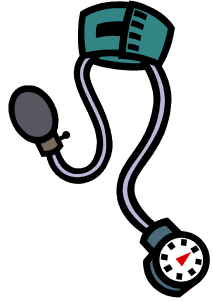


Systolic
thickening:
quick and
dirty



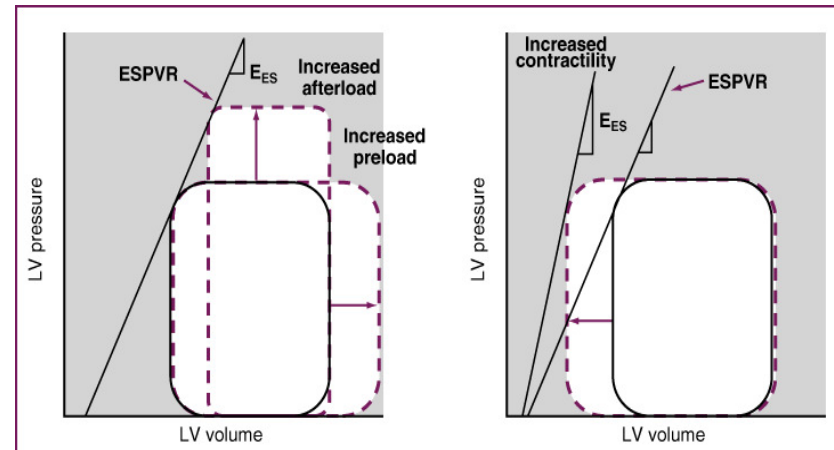
Regional wall function

Stress echo lab: contractility me too?



**Peak systolic pressure =
cuff sphygmomanometer ($r=.92$)**

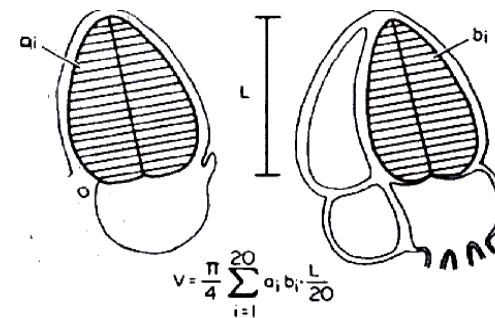
Slutsky R et al. Peak systolic blood pressure/end-systolic volume ratio: assessment at rest and during exercise Am J Cardiol, 1980 46: 813



Force = SP/ESVIndex

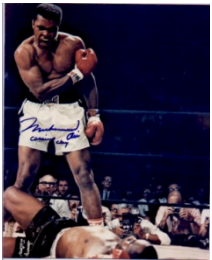
Suga H, Sagawa K, Shoukas AA.

Load independence of the instantaneous pressure-volume ratio of the canine left ventricle and effects of epinephrine and heart rate on the ratio. Circ Res, 1973 Mar;32:314



Contractility in stress echo lab: simplify for success

Systolic Blood Pressure	+ 1/	End - systolic volume	=	Contractility
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$$\uparrow \text{ SP} \quad + \quad \downarrow \text{ ESV} \quad = \quad \uparrow \uparrow \text{ Contractility}$$

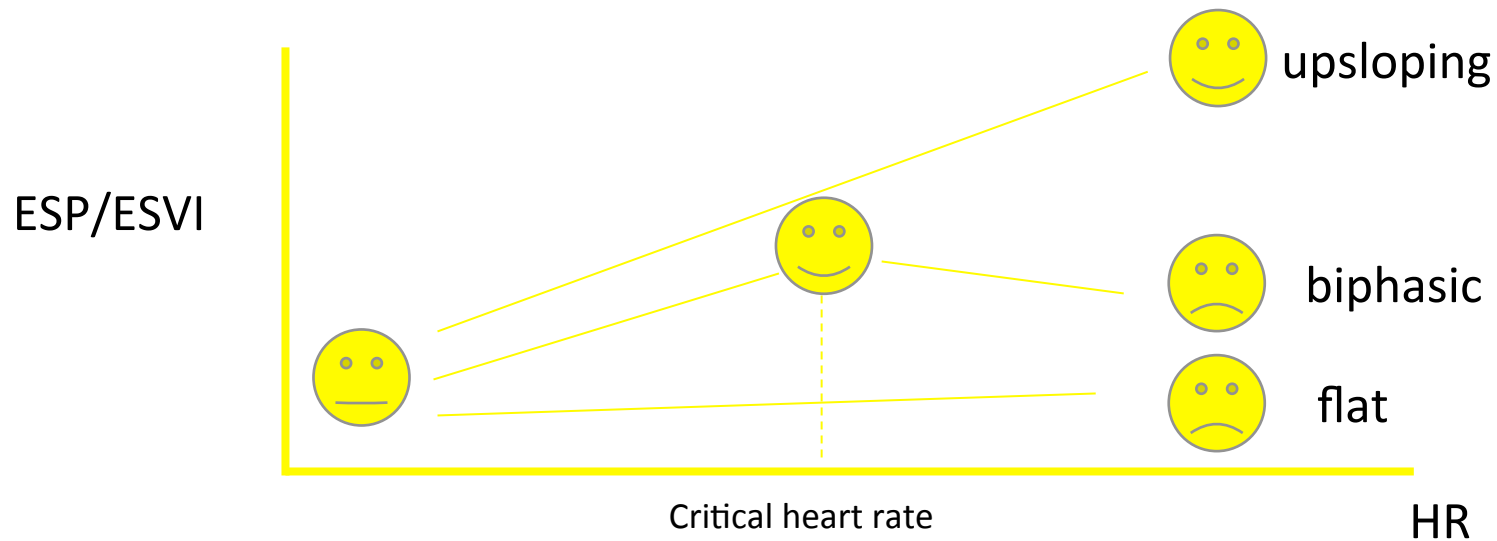


$$\uparrow \text{ SP} \quad + \quad = \text{ ESV} \quad = \quad \uparrow \text{ Contractility}$$

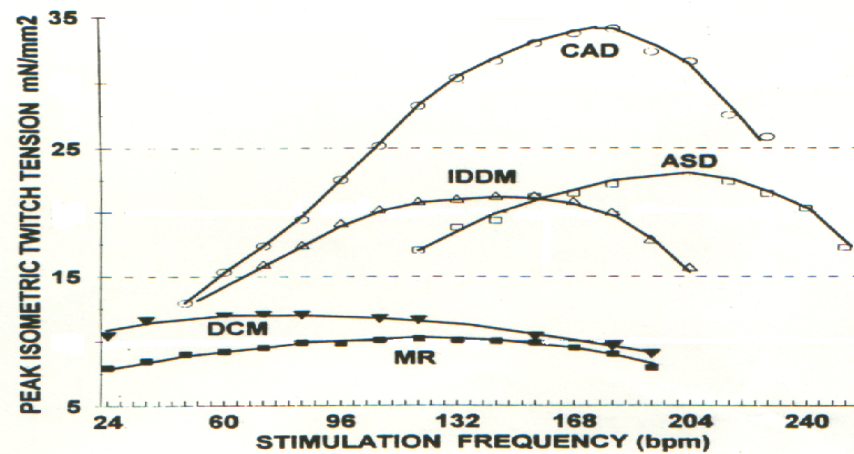


$$= / \downarrow \text{ SP} \quad + \quad \uparrow / = \text{ ESV} \quad = \quad \downarrow \text{ Contractility}$$

Time sequence during stress



Critical heart rate is the heart rate beyond which ESP/ESVI declines by 5%.
Inagaki et al. Circulation 1999

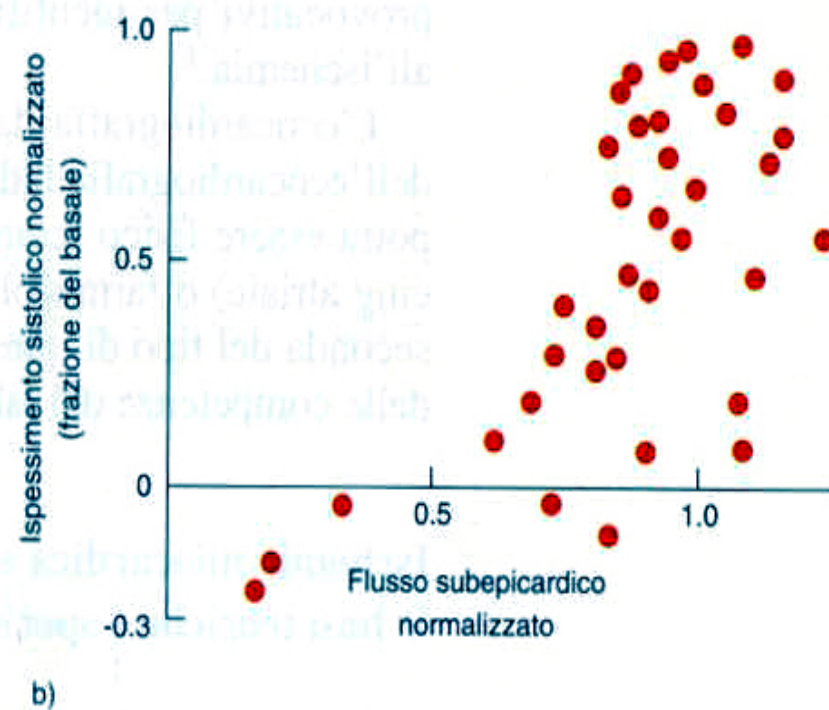
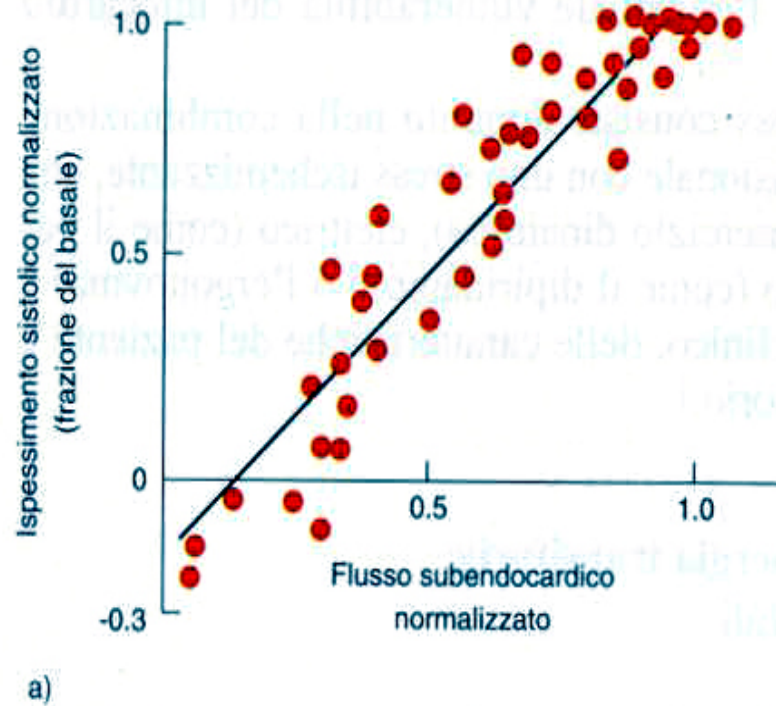


modificato da Mulleri AL. In "Heart Metabolism in Failure" RA Howart Ed. 1997.
The role of myocardial force-frequency relation in left ventricular function and progression of human heart failure

Mulieri AL in "Heart Metabolism in Failure" RA Howart Ed. 1997

Subepicardial flow : beyond regional wall motion

Gallagher KP, Ross J Jr et al. Am J Physiol 1084



- Lower LV volumes for any given pressure increase (Sabbah, Marzilli. Am J Physiol 1981)
- Possible anti-arrhythmic and anti-remodeling effect of subepicardium (Kaul S. Circulation 1995)

Inotropic reserve in the stress echo lab

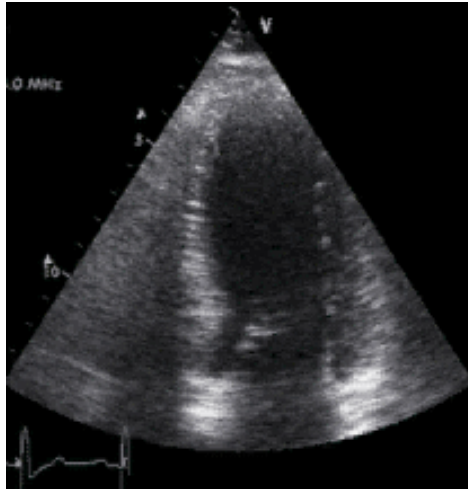
	EXERCISE	DOBUTAMINE	PACEMAKER
<i>Contractility</i>	+	+	+
<i>Inotropic reserve</i>	+	+	-
<i>Bowditch treppe</i>	+	+	++
<i>User-friendly</i>	+	++	+++
<i>Requisites</i>	Capability to exercise	Intravenous line	Permanent pacemaker

JASE 2003

EHJ 2005

Eur J Heart Failure
2004

Force-Frequency Relationship (negative normal)



HF = 80 bmp

ESV = 30 ml

SBP = 140 mmHg

SBP/ESV = 4.6

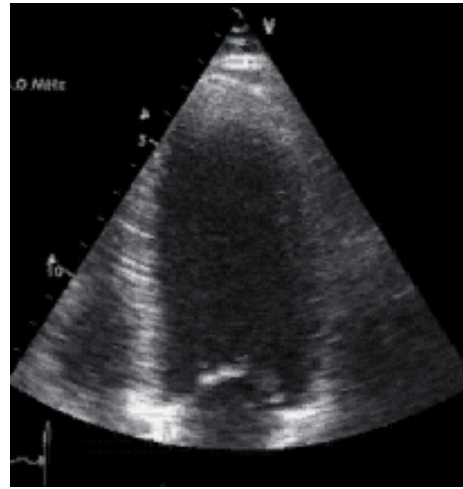


HF = 115 bmp

ESV = 25 ml

SBP = 170 mmHg

SBP/ESV = 6.8

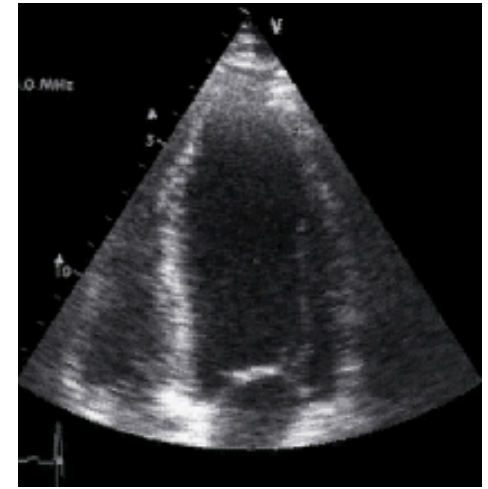


HF = 130 bmp

ESV = 23 ml

SBP = 190 mmHg

SBP/ESV = 8.2

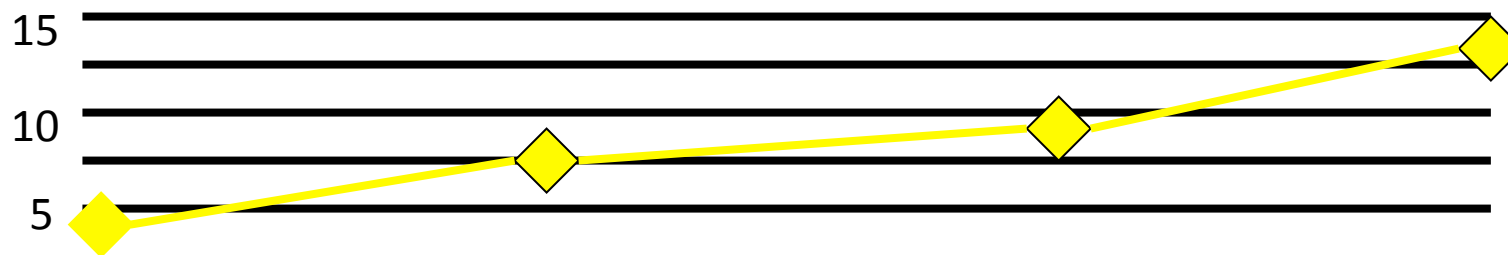


HF = 140 bmp

ESV = 16 ml

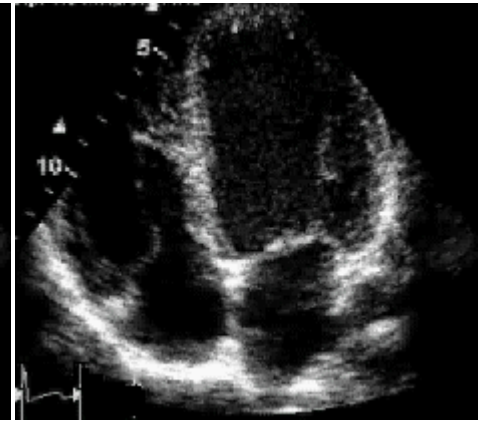
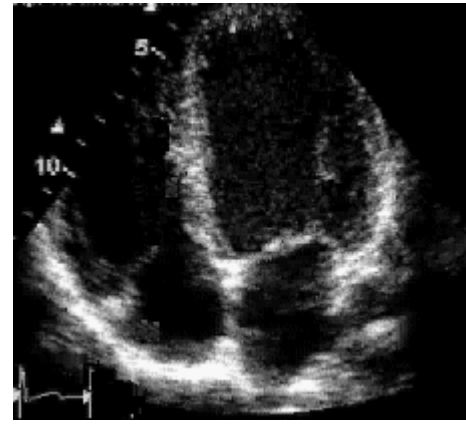
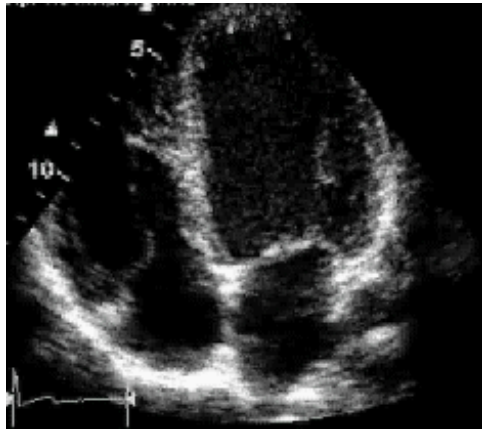
SBP = 210 mmHg

SBP/ESV = 13



$$\text{Delta SBP/ESV} = 13 / 4.6 = 2.8$$

Force-Frequency Relationship (negative abnormal)



HF = 60 bmp

HF = 80 bmp

HF = 100 bmp

HF = 120 bmp

ESV = 120 ml

ESV = 100 ml

ESV = 81 ml

ESV = 95 ml

SBP = 110 mmHg

SBP = 120 mmHg

SBP = 130 mmHg

SBP = 140 mmHg

SBP/ESV = 0.9

SBP/ESV = 1.2

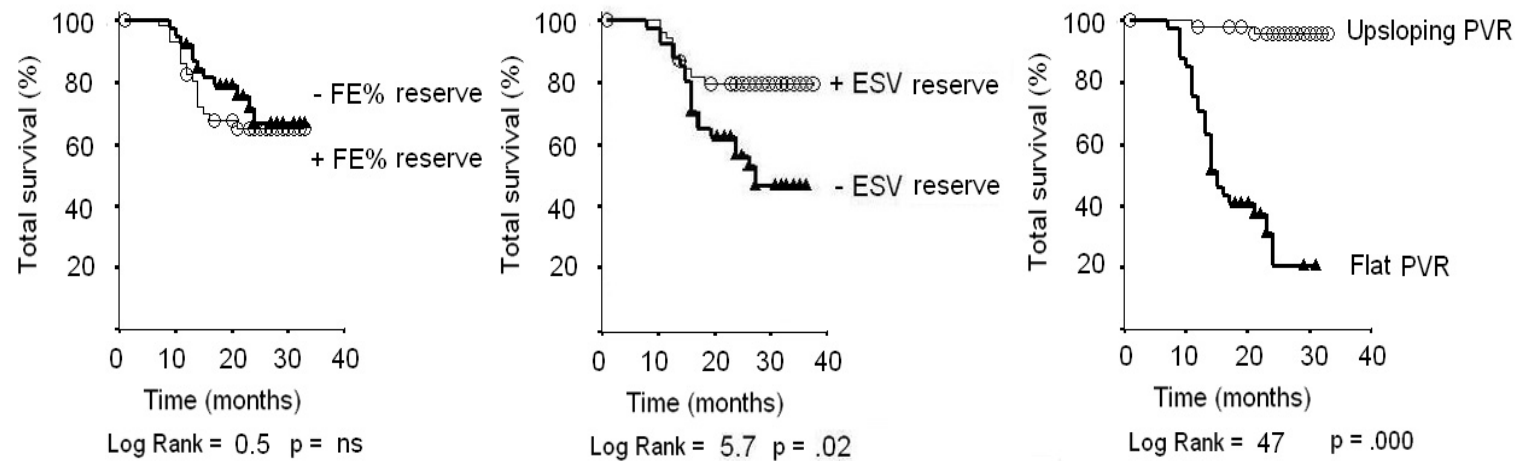
SBP/ESV = 1.6

SBP/ESV = 1.5



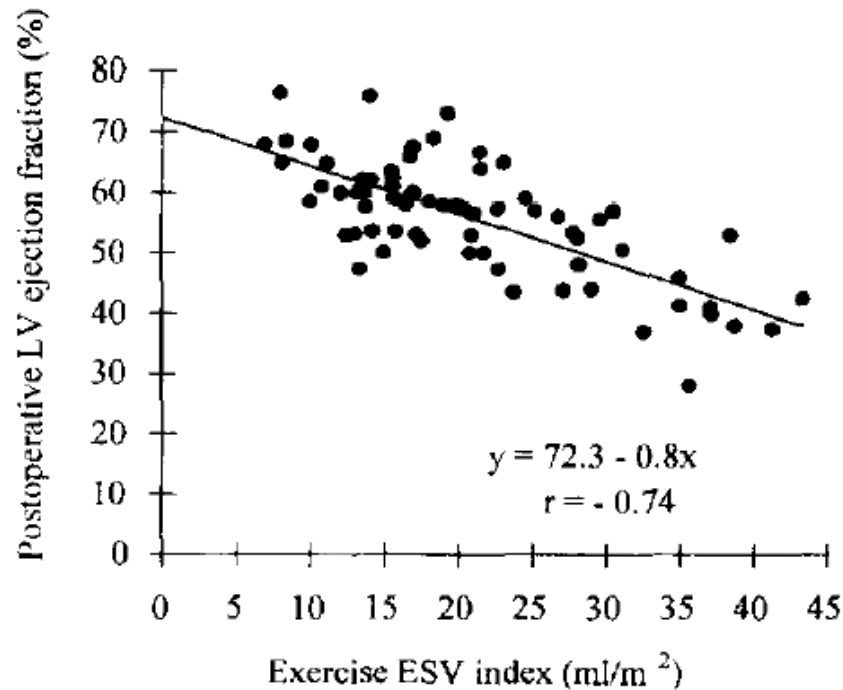
$$\text{Delta SBP/ESV} = 1.5 / 0.9 = 1.6$$

Contractility and Prognosis in Negative Stress Testing



Bombardini T et al. Int J Cardiol, 2007

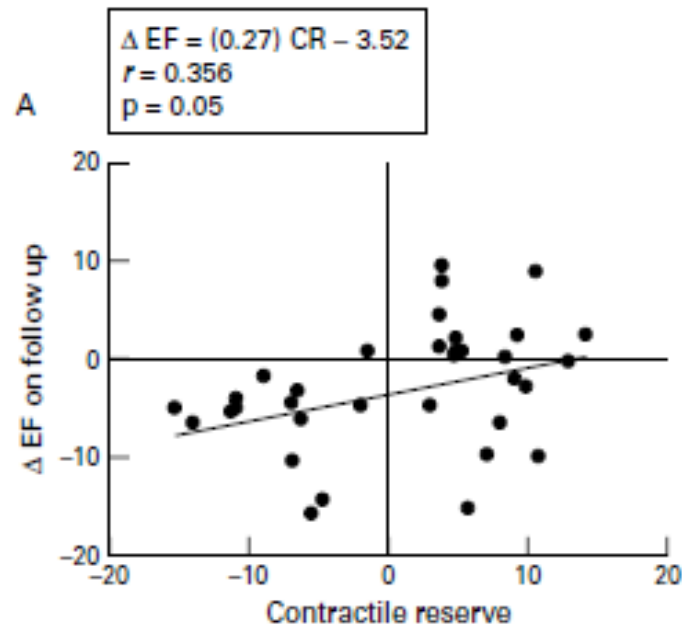
Chronic Mitral Insufficiency: the role of LV function



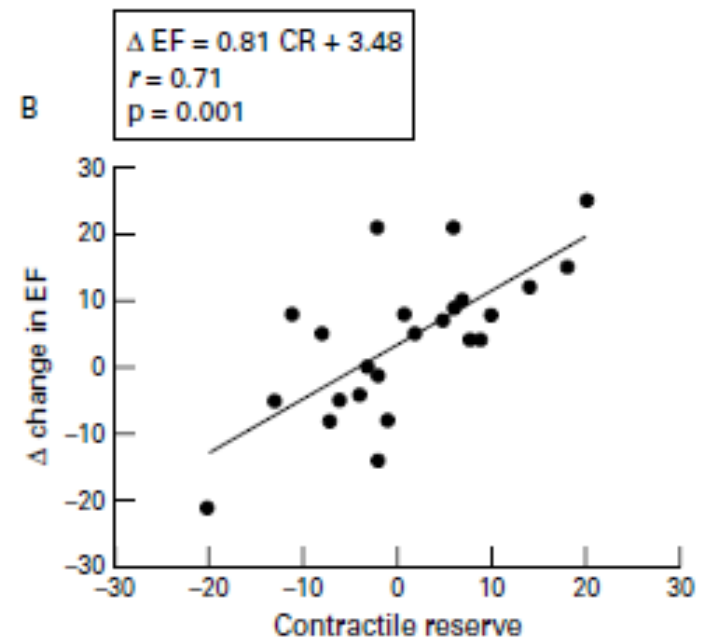
Predictors of LV dysfunction

- Indexed End-Systolic Volume during exercise > 25 ml/m²
- Ejection Fraction < 68%
- Increment of EF < 4% during exercise

Exercise Echocardiography predicts LV dysfunction in asymptomatic AR



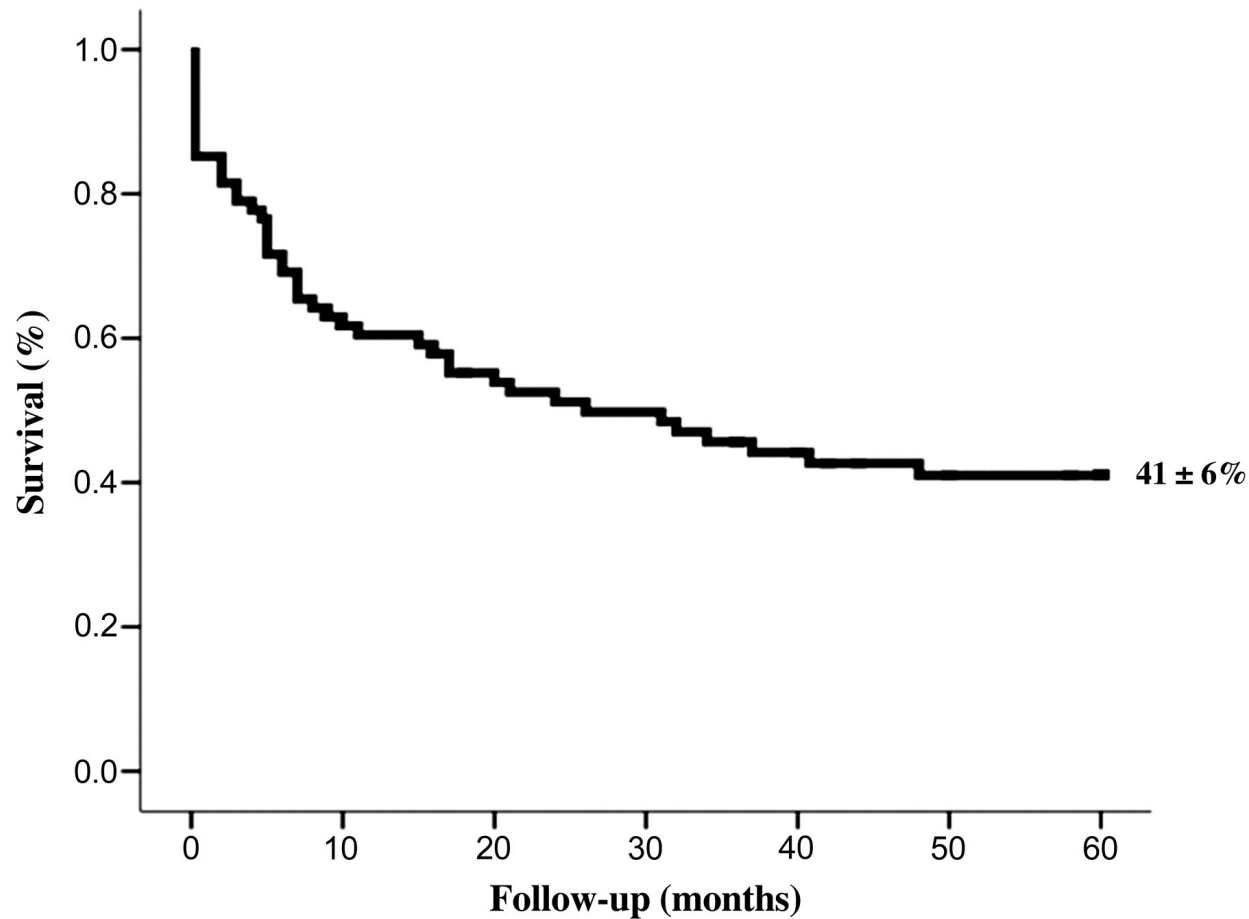
Medically treated



Valve Replacement

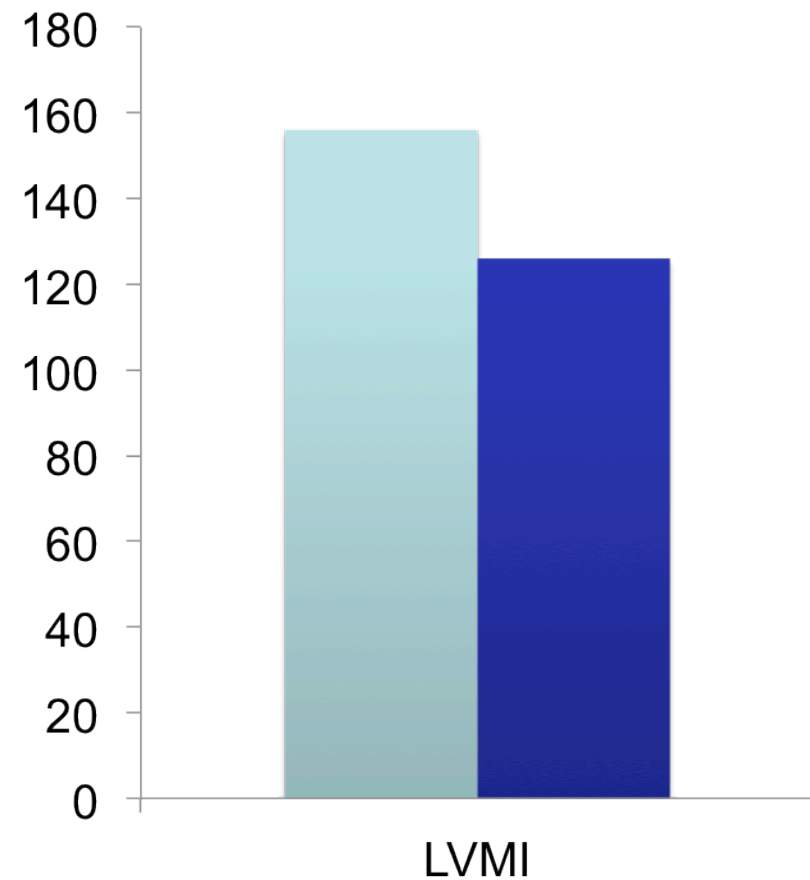
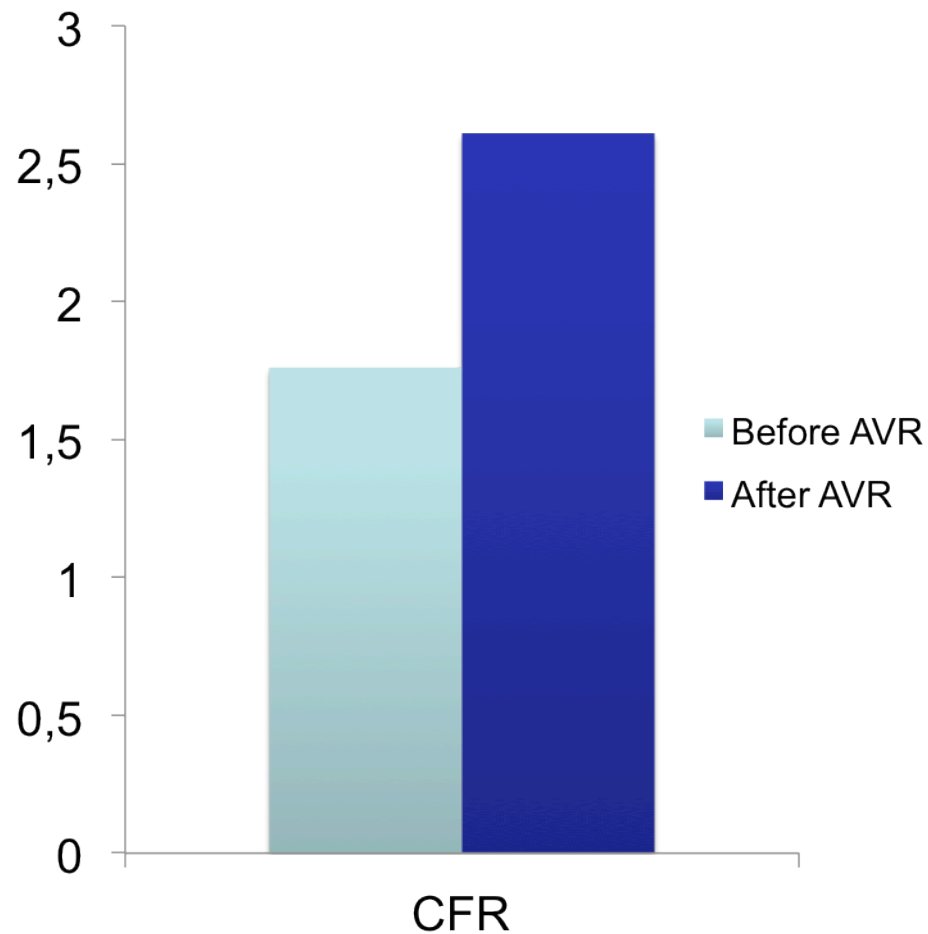
Marwick T et al. Heart 2000

Probability of Survival in Low Flow/Low Gradient Aortic Stenosis Patients Without CR on DSE



Tribouilloy et al. JACC 2009

Coronary flow reserve improves after aortic valve replacement for aortic stenosis



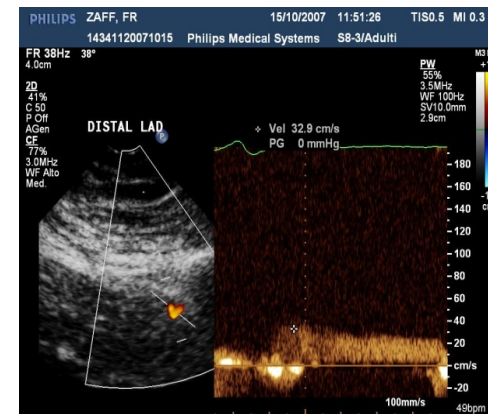
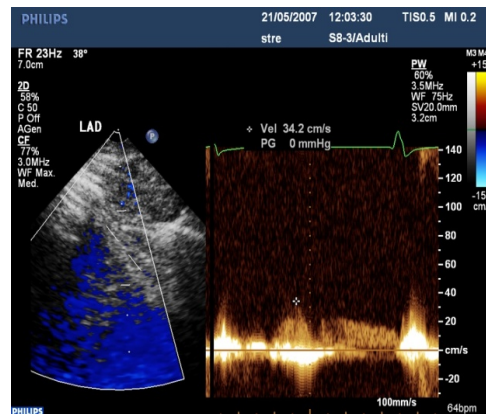
Hildick-Smith D et al. JACC 2000

Heart Valve Disease and CFR

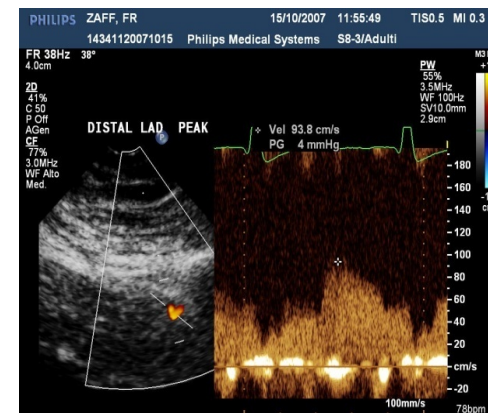
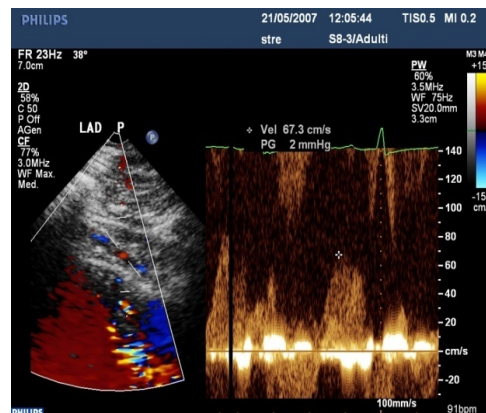
Pre-AVR

6 months post-AVR

REST



PEAK



$$\text{CFR} = 67 / 34 = 1.9$$

$$\text{CFR} = 94 / 33 = 2.9$$

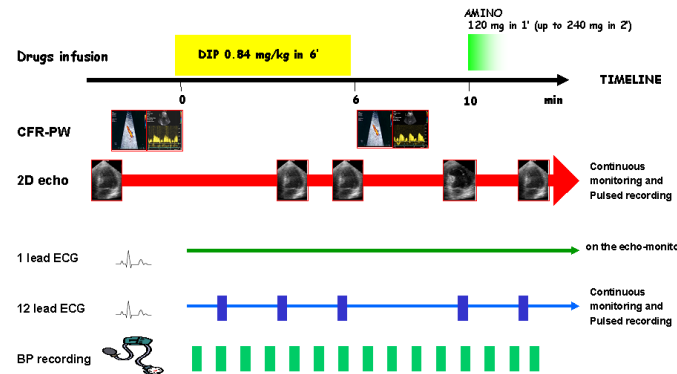
ADONHERS

Eligible

Normal
baseline echo

CANDIDATE DONORS

Study Protocol – the Last Generation 2006



PARAMETERS:

- HR (ECG)
- BP (cuff sphygmo)
- WMSI
- SP/ESV ratio

Donor
excluded

CAD positivity
(new wall motion abnormality
of ≥ 1 segment)

Abnormal contractile reserve
(Peak SP / ESV < than
baseline)

Donor
excluded

WMSI stress = 1
SP / ESV stress > than baseline

Eligible for donor

Negative stress: Wolf in Sheep clothes?



RISK	<i>Not-so-low</i>	<i>Very low</i>
Dose/Load	Submaximal	Maximal
Diabetes	+	-
Therapy	+	-
Mitral Insufficiency	+	-
Ultrasound Lung Comets	+	-
Coro Flow Reserve	<2	>2
Force-Frequency Relationship	Flat-Biphasic	Steep
Death/year	>3%	<1%

Cortigiani, JACC 2006

Sicari, Circulation 2004

Pierard, NEJM 2005

Agricola, JASE 2006

Rigo, AHJ 2006

Bombardini, EHJ 2005

Negative stress echo and normal CFR: “A whiter shade of pale”

