# L'ECO da sforzo nello studio delle valvulopatie e dell'insufficienza cardiaca


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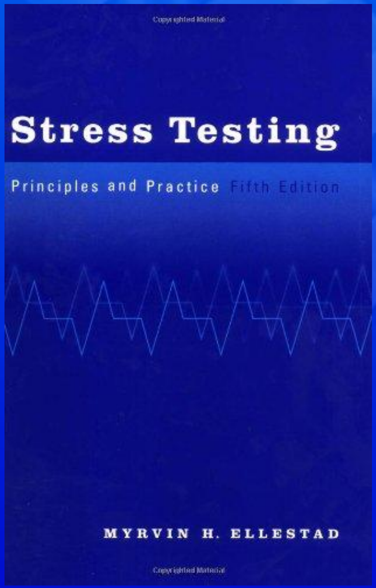




BRUCE R.A. per primo intuì l' importanza della monitorizzazione della F.C. e della P.A. durante il test da sforzo. Pediatrics 1963; 32: 742.


Clin. Cardiol. 10, 189-200 (1987)

# Current Review of Exercise Testing: Application and Interpretation

T. FULLER, M.A. Ed., PA-C, A. MOVAHED, M.D., F.A.C.C.

Medical Service, Cardiology Section, Veterans Administration Medical Center, Hampton; Department of Medicine, Eastern Virginia Medical School, Norfolk, Virginia, USA

| | | Sheffield (1984) | Froelicher (1982,1983) | Ellestad (1980) | Jones/Campbell (1982) |
|---|---|---|---|---|---|
| Absolute | | | | | |
| 1 | Acute MI or recent ECG change | X | X | X | X |
| 2 | Unstable angina | X | X | X | X |
| 3 | Acute myocarditis, pericarditis, and/or endocarditis | X | X | X | X |
| 4 | Known ominous CAD pattern | X | | | |
| 5 | Severe aortic stenosis | X | X | | |
| 6 | Congestive heart failure | X | | X[b] | X |
| 7 | Severe hypertension | X | | | X |
| 8 | Significant cardiac arrhythmias[a] | X | X | X | |
| 9 | Heart block > 1° | X | | X | |
| 10 | Acute systemic illness or serious noncardiac disorder | X | X | X | X |
| 11 | Unwillingness to sign consent | X | | | |
| 12 | Severe LV dysfunction | | X | | |
| 13 | Acute PE, pulmonary infarct or edema | | X | | X |
| 14 | Severe physical handicap | | X | | |
| Relative | | | | | |
| 1 | Known left main disease or equivalent | X | X | X | |
| 2 | Severe hypertension | X | X | X | |
| 3 | Moderate aortic, valvular, or myocardial heart diseases | | X | X | X |
| 4 | Cardiomyopathy, hypertrophic obstructive | X | | X | |
| 5 | Ventricular conducting defects | | X | | |
| 6 | Tachy/bradyarrhythmias < serious | | X | | X |
| 7 | Noncardiac disease < serious (i.e., diabetes, epilepsy, etc.) | | X | | X |
| 8 | Drug effect or electrolyte abnormality | | X | | X |
| 9 | Fixed rate artificial pacemaker | | X | | |
| 10 | Psychiatric disorder/inability to cooperate | | X | | |
| 11 | Recent MI < 4 weeks | | | | X |
| 12 | Resting ECG abnormaility | | | X | X |

# Arguments for an assessment of exercise SE adaptation in VHD

1. Mismatch between resting valve dysfunction and patient symptoms is not uncommon
2. Difficulty in interpreting symptoms
3. Often clinically silent progression

# Am Heart J. 1998

## Valvular aortic stenosis: which measure of severity is best?

In my opinion, rather than Catherine M.Otto pursuing an elusive anatomic or hemodynamic standard, we should use clinical outcome as the reference standard for aortic stenosis severity

Catherine M.Otto

# ESC/EACTS Guidelines for the Management of Valvular Heart Disease

**Echocardiographic criteria for the definition of severe valve stenosis: *an integrative approach***

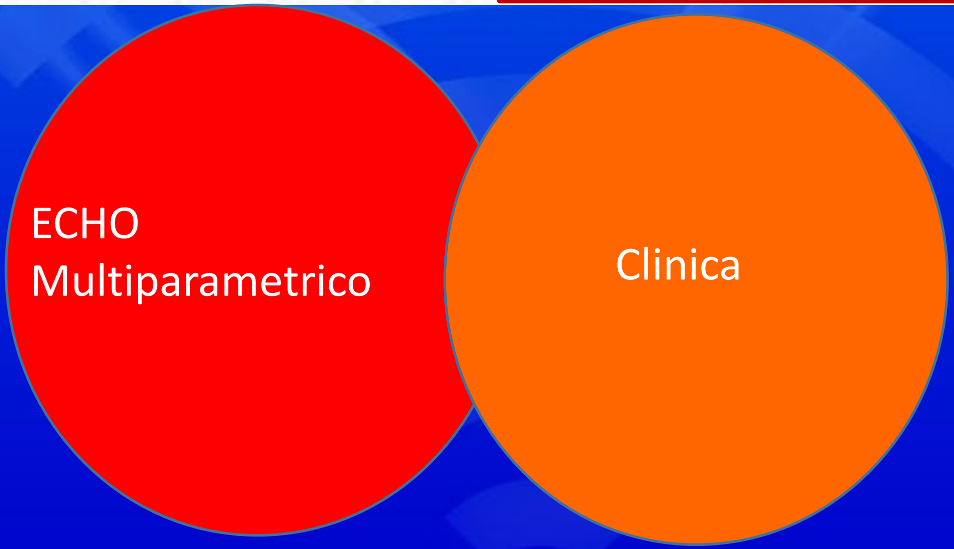


**Table 1. Impact of Exercise Testing on Outcome and Clinical Decision Making in Patients With Asymptomatic AS**

| Stress Data | Parameters | Impact on Outcome | Ref. # | Impact on Clinical Decision (AVR): ESC Guidelines | Impact on Clinical Decision (AVR): ACC/AHA Guidelines |
|---|---|---|---|---|---|
| Clinical | Symptoms (dizziness, dyspnea at low workload, angina, syncope) | Onset of symptoms, cardiac-related death, AVR dictated by symptoms | (19,21,45) | Class I (level of evidence: C) | Class IIb (level of evidence: C) |
| | Abnormal blood pressure response (fall in blood pressure) | | | Class IIa (level of evidence: C) | Class IIb (level of evidence: C) |
| Electrocardiographic | Ventricular arrhythmias ST-segment depression (≥2 mm) | Onset of symptoms, cardiac-related death, AVR dictated by symptoms | (19,21,45) | — | Class IIb (level of evidence: C) |
| Echocardiographic | Increase in mean aortic pressure gradient: >18 or 20 mm Hg | Spontaneous symptoms, cardiac-related death, AVR dictated by symptoms, hospitalization for heart failure | (14,22) | Class IIb (level of evidence: C) | — |
| | Decrease/small increase in LV ejection fraction | Spontaneous symptoms, cardiac-related death, abnormal exercise test | (18) | — | — |
| | Exercise PHT | Reduced cardiac event-free survival, high rate of cardiac death | (13) | — | — |

ACC/AHA = American College of Cardiology/American Heart Association; AS = aortic stenosis; AVR = aortic valve replacement; ESC = European Society of Cardiology; LV = left ventricular; PHT = pulmonary arterial hypertension.

Magne, Lancellotti P et al. JACC cardiovascular imaging vol.7,2.2014 ;126:851–859

**2014 AHA/ACC Guideline for the Management of Patients With Valvular Heart Disease: Executive Summary: A Report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines**

Rick A. Nishimura, Catherine M. Otto, Robert O. Bonow, Blase A. Carabello, John P. Erwin III, Robert A. Guyton, Patrick T. O'Gara, Carlos E. Ruiz, Nikolaos J. Skubas, Paul Sorajja, Thoralf M. Sundt III and James D. Thomas

**Table 3. Stages of Progression of VHD**

| Stage | Definition | Description |
|---|---|---|
| A | At risk | Patients with risk factors for development of VHD |
| B | Progressive | Patients with progressive VHD (mild-to-moderate severity and asymptomatic) |
| C | Asymptomatic severe | Asymptomatic patients who have the criteria for severe VHD:<br>C1: Asymptomatic patients with severe VHD in whom the left or right ventricle remains compensated<br>C2: Asymptomatic patients with severe VHD, with decompensation of the left or right ventricle |
| D | Symptomatic severe | Patients who have developed symptoms as a result of VHD |

VHD indicates valvular heart disease.

| Stage | Definition | Valve Anatomy | Valve Hemodynamics |
| --- | --- | --- | --- |
| **A** | **At risk of AS** | • Bicuspid aortic valve (or other congenital valve anomaly)<br>• Aortic valve sclerosis | • Aortic $V_{max}$ <2 m/s |
| **B** | **Progressive AS** | • Mild-to-moderate leaflet calcification of a bicuspid or trileaflet valve with some reduction in systolic motion or<br>• Rheumatic valve changes with commissural fusion | • Mild AS: Aortic $V_{max}$ 2.0–2.9 m/s or mean ΔP <20 mm Hg<br>• Moderate AS: Aortic $V_{max}$ 3.0–3.9 m/s or mean ΔP 20–39 mm Hg |
| **C: Asymptomatic severe AS** | | | |
| **C1** | **Asymptomatic severe AS** | • Severe leaflet calcification or congenital stenosis with severely reduced leaflet opening | • Aortic $V_{max}$ ≥4 m/s or mean ΔP ≥40 mm Hg<br>• AVA typically is ≤1.0 $cm^2$ (or AVAi ≤0.6 $cm^2/m^2$)<br>• Very severe AS is an aortic $V_{max}$ ≥5 m/s or mean ΔP ≥60 mm Hg |
| **C2** | **Asymptomatic severe AS with LV dysfunction** | • Severe leaflet calcification or congenital stenosis with severely reduced leaflet opening | • Aortic $V_{max}$ ≥4 m/s or mean ΔP ≥40 mm Hg<br>• AVA typically ≤1.0 $cm^2$ (or AVAi ≤0.6 $cm^2/m^2$) |
| **D: Symptomatic severe AS** | | | |
| **D1** | **Symptomatic severe high-gradient AS** | • Severe leaflet calcification or congenital stenosis with severely reduced leaflet opening | • Aortic $V_{max}$ ≥4 m/s or mean ΔP ≥40 mm Hg<br>• AVA typically ≤1.0 $cm^2$ (or AVAi ≤0.6 $cm^2/m^2$) but may be larger with mixed AS/AR |
| **D2** | **Symptomatic severe low-flow/low-gradient AS with reduced LVEF** | • Severe leaflet calcification with severely reduced leaflet motion | • AVA ≤1.0 $cm^2$ with resting aortic $V_{max}$ <4 m/s or mean ΔP <40 mm Hg<br>• Dobutamine stress echocardiography shows AVA ≤1.0 $cm^2$ with $V_{max}$ ≥4 m/s at any flow rate |
| **D3** | **Symptomatic severe low-gradient** | • Severe leaflet calcification | • AVA ≤1.0 $cm^2$ with aortic $V_{max}$ <4 m/s or |

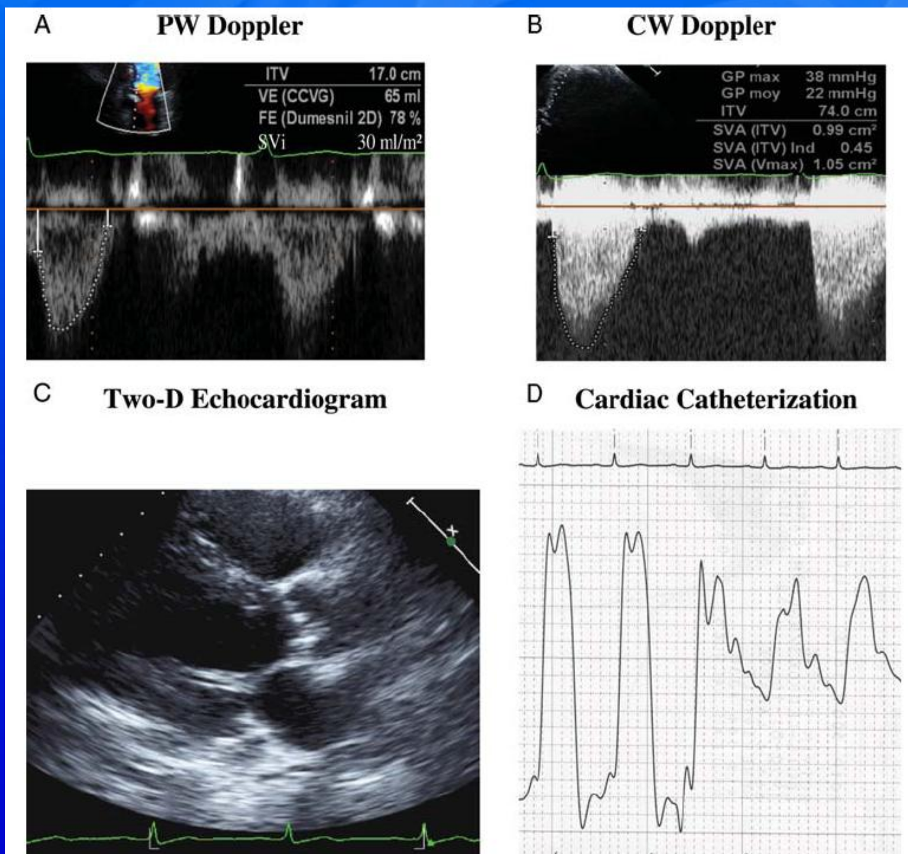
# UK National Health Service survey

| Units which perform stress echo for assessment of valvular heart disease | *n* (%) |
|---|---|
| Low-flow, low-gradient aortic stenosis | 81 (95.3) |
| Asymptomatic severe aortic stenosis | 34 (40) |
| Asymptomatic severe mitral regurgitation | 26 (30.6) |
| Asymptomatic severe mitral stenosis | 21 (24.7) |
| Symptomatic mild/moderate mitral regurgitation | 32 (37.6) |
| Symptomatic mild/moderate mitral stenosis | 24 (28.2) |
| Asymptomatic severe aortic regurgitation | 15 (17.6) |

Eur Heart J Cardiovasc Imaging 2014;15:158–163

# Paradoxical low flow and/or low gradient severe aortic stenosis despite preserved left ventricular ejection fraction: implications for diagnosis and treatment

Jean G. Dumesnil[1*], Philippe Pibarot[1*], and Blase Carabello[2]




**"Il paradosso"**


European Heart Journal (2010) **31**, 281–289

**Paradoxical Lo**
**Low-Gradient A**

Adding New Pieces

Philippe Pibarot, DVM,
Jean G. Dumesnil, MD


JACC Vol. 58, No. 4, 2011
July 19, 2011:413–5

In this co ... at the main pitfall associ ... diagnosis of paradoxical l ... an error in the calculati ... is measurement is inc ... parameters including A ... nd valvulo-arterial impe ... 2 separate measuremen ... er and LV outflow trac ... aving their potential for error. Hence, a comprehensive Doppler echo-

# $Z_{VA}$ index

$$Z_{va} = \frac{SAP + MG_{net}}{SVi}$$

$$\frac{\text{PA sistolic + Mean gradient}}{\text{Stroke volume index ml/m}^2}$$

$> 4,5$ mmHg/ml/$m^2$: Severe AS

$< 4,5$ mmHg/ml/$m^2$: Non severe AS

# Paradoxical Low-Flow, Low-Gradient Aortic Stenosis

Adding New Pieces to the Puzzle*

Philippe Pibarot, DVM, PhD,
Jean G. Dumesnil, MD

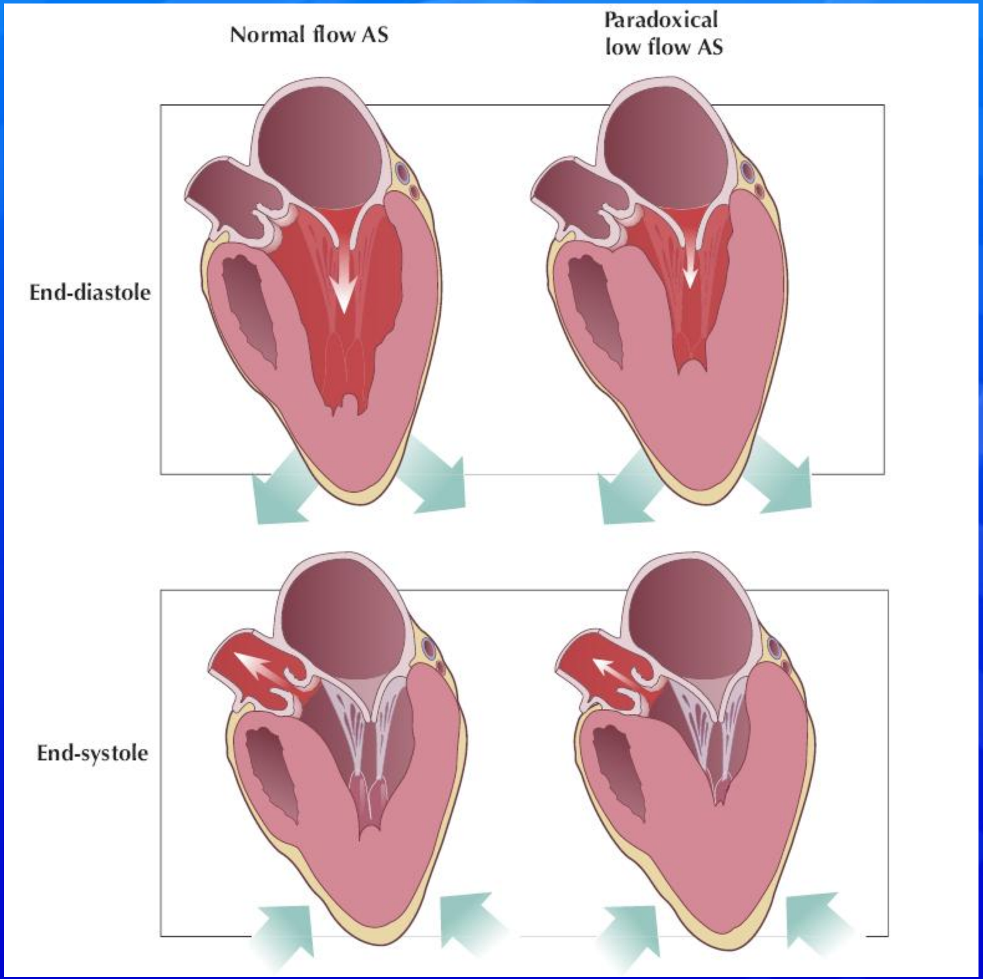
JACC Vol. 58, No. 4, 2011
July 19, 2011:413–5

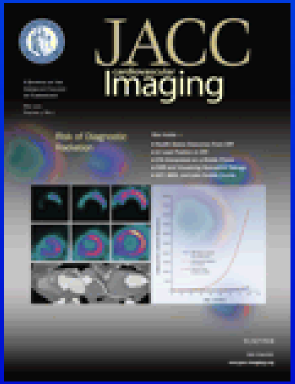
**Table 1** Typical Characteristics of the 3 Main Entities of Severe Aortic Stenosis

| | Severe AS | | |
|---|---|---|---|
| | Normal-Flow, High-Gradient | Preserved LVEF (Paradoxical), Low-Flow, Low-Gradient | Reduced LVEF, Low-Flow, Low-Gradient |
| Aortic valve area, $cm^2$ | ≤1.0 | ≤1.0 | ≤1.0 |
| Indexed aortic valve area, $cm^2/m^2$ | <0.6 | <0.6 | <0.6 |
| Mean gradient, mm Hg | >40 | <40 | <40 |
| $Z_{va}$, mm $Hg \cdot ml^{-1} \cdot m^2$ | >4.5 | >4.5 | >4.5 |
| LV end-diastolic diameter, mm | 45–55 | <47 | >50 |
| Relative wall thickness | >0.43 | >0.50 | 0.35–0.55 |
| LVEF, % | >50 | >50 | <50 |
| Mitral ring displacement, mm | 5–15 | <8 | <8 |
| Global longitudinal strain, % | 14–20 | <14 | <14 |
| Stroke volume index, $ml/m^2$ | >35 | <35 | <35 |
| Mean flow rate, ml/s | >200 | <200 | <200 |
| Myocardial fibrosis | + | ++ | +++ |
| CT valve calcium score, AU | >1,650 | >1,650 | >1,650 |
| Plasma NT-proBNP, pg/ml | <1,500 | >1,500 | >1,500 |

# Aortic Stenosis: Look Globally, Think Globally*

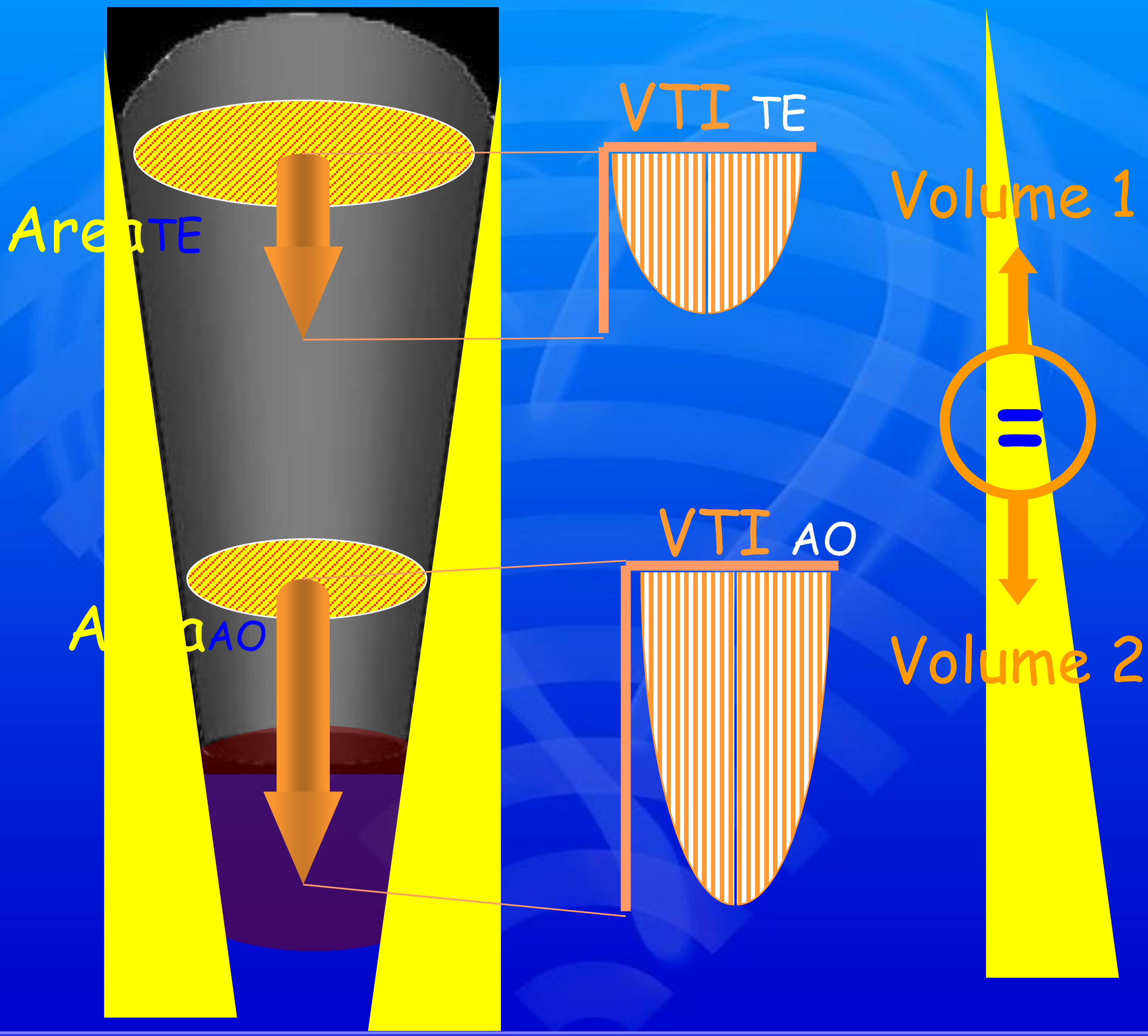
Philippe Pibarot, DVM, PhD, Jean G. Dumesnil, MD
*Québec, Canada*



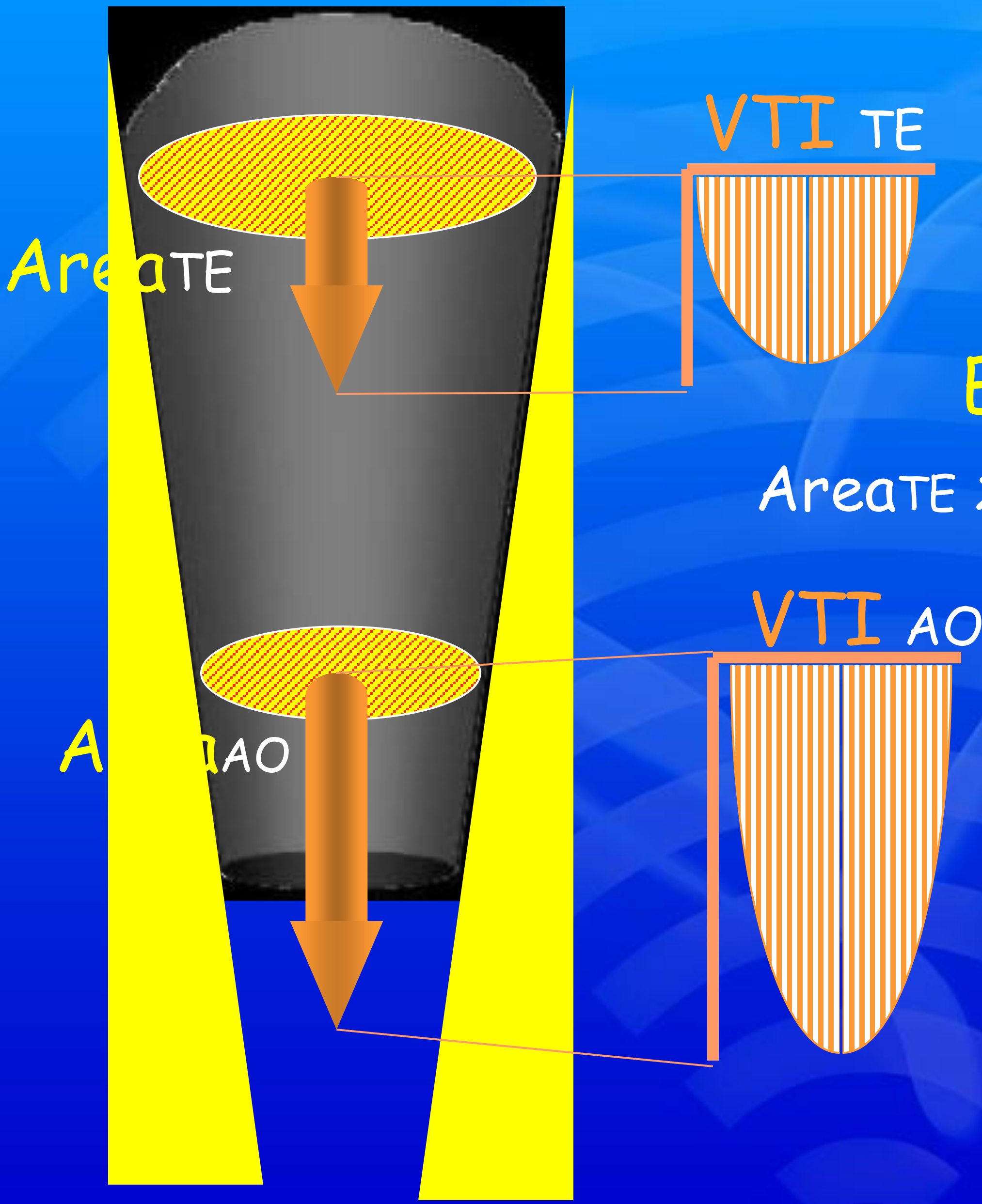




JACC: CARDIOVASCULAR IMAGING, VOL. 2, NO. 4, 2009
APRIL 2009:400–3

# Calcolo dell'area valvolare



# Calcolo dell'area valvolare




## Equazione di continuità

$$Area_{TE} \times VTI_{TE} = Area_{AO} \times VTI_{AO}$$

**Area valvolare aortica**

$$\frac{Area_{TE} \times VTI_{TE}}{VTI_{AO}}$$

## Table 2 Measures of AS severity obtained by Doppler echocardiography

| | Units | Formula / Method | Cutoff for Severe | Concept | Advantages | Limitations |
|---|---|---|---|---|---|---|
| AS jet velocity [8-10, 12] | m/s | Direct measurement | 4.0 | Velocity increases as stenosis severity increase. | Direct measurement of velocity. Strongest predictor of clinical outcome. | Correct measurement requires parallel alignment of ultrasound beam. Flow dependent. |
| Mean gradient [8-10] | mm Hg | $\Delta P = \sum 4v^2 / N$ | 40 or 50 | Pressure gradient calculated from velocity using the Bernoulli equation | Mean gradient is averaged from the velocity curve. Units comparable to invasive measurements. | Accurate pressure gradients depend on accurate velocity data. Flow dependent |
| Continuity equation valve area [16, 17, 23] | $cm^2$ | $AVA = (CSA_{LVOT} \times VTI_{LVOT}) / VTI_{AV}$ | 1.0 | Volume flow proximal to and in the stenotic orifice is equal. | Measures effective orifice area. Feasible in nearly all patients. Relatively flow independent. | Requires LVOT diameter and flow velocity data, along with aortic velocity. Measurement error more likely. |
| Simplified continuity equation [18 23] | $cm^2$ | $AVA = (CSA_{LVOT} \times V_{LVOT}) / V_{AV}$ | 1.0 | The ratio of LVOT to aortic velocity is similar to the ratio of VTIs with native aortic valve stenosis. | Uses more easily measured velocities instead of VTIs. | Less accurate if shape of velocity curves is atypical. |
| Velocity Ratio [15, 18] | none | $VR = \frac{V_{LVOT}}{V_{AV}}$ | 0.25 | Effective aortic valve area expressed as a proportion of the LVOT area. | Doppler-only method. No need to measure LVOT size, less variability than continuity equation. | Limited longitudinal data. Ignores LVOT size variability beyond patient size dependence |
| Planimetry of Anatomic Valve Area [26, 34] | $cm^2$ | TTE, TEE, 3D-echo | 1.0 | Anatomic (geometric) cross-sectional area of the aortic valve orifice as measured by 2D or 3D echo. | Useful if Doppler measurements are unavailable. | Contraction coefficient (anatomic / effective valve area) may be variable. Difficult with severe valve calcification. |

Table 1 Recommendations for data recording and measurement for AS quantitation

| Data element | Recording | Measurement |
|---|---|---|
| LVOT diameter | • 2D parasternal long-axis view<br>• Zoom mode<br>• Adjust gain to optimize the blood tissue interface | • Inner edge to inner edge<br>• Mid-systole<br>• Parallel and adjacent to the aortic valve or at the site of velocity measurement (see text)<br>• Diameter is used to calculate a circular CSA |
| *LVOT velocity* | • Pulsed-wave Doppler<br>• Apical long axis or five-chamber view<br>• Sample volume positioned just on LV side of valve and moved carefully into the LVOT if required to obtain laminar flow curve<br>• Velocity baseline and scale adjusted to maximize size of velocity curve<br>• Time axis (sweep speed) 100 mm/s<br>• Low wall filter setting<br>• Smooth velocity curve with a well-defined peak and a narrow velocity range at peak velocity | • Maximum velocity from peak of dense velocity curve<br>• VTI traced from modal velocity |
| AS jet velocity | • CW Doppler (dedicated transducer)<br>• Multiple acoustic windows (e.g. apical, suprasternal, right parasternal, etc)<br>• Decrease gains, increase wall filter, adjust baseline, and scale to optimize signal<br>• Gray scale spectral display with expanded time scale<br>• Velocity range and baseline adjusted so velocity signal fits but fills the vertical scale | • Maximum velocity at peak of dense velocity curve<br>• Avoid noise and fine linear signals<br>• VTI traced from outer edge of dense signal curve<br>• Mean gradient calculated from traced velocity curve<br>• Report window where maximum velocity obtained |
| Valve anatomy | • Parasternal long- and short-axis views<br>• Zoom mode | • Identify number of cusps in systole, raphe if present<br>• Assess cusp mobility and commisural fusion<br>• Assess valve calcification |

Journal of the American Society of Echocardiography
January 2009

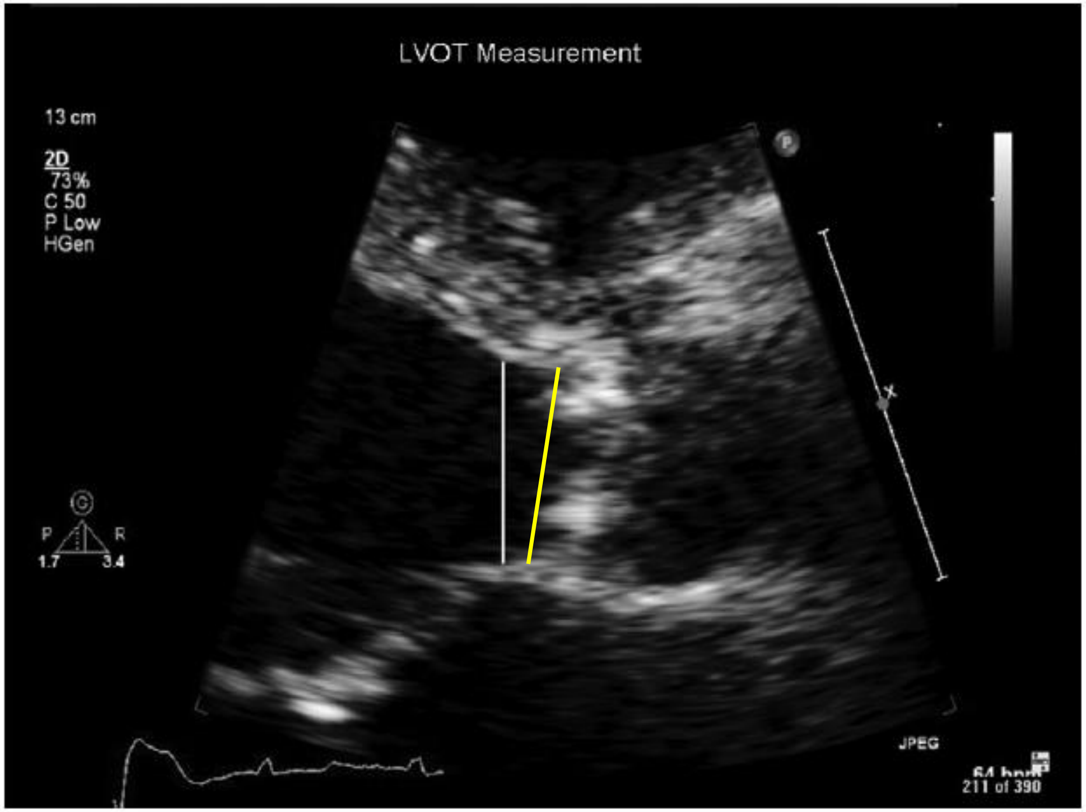



**Figure 5** Left ventricular outflow tract diameter is measured in the parasternal long-axis view in mid-systole from the white–black interface of the septal endocardium to the anterior mitral leaflet, parallel to the aortic valve plane and within 0.5–1.0 cm of the valve orifice.

# ESC/EACTS Guidelines for the Management of Valvular Heart Disease

| | Aortic stenosis | Mitral stenosis | Tricuspid stenosis |
|---|---|---|---|
| Valve area ($cm^2$) | < 1.0 | < 1.0 | – |
| Indexed valve area ($cm^2/m^2$ BSA) | < 0.6 | – | – |
| Mean gradient (mmHg) | > 40 | > 10 | ≥ 5 |
| Maximum jet velocity (m/s) | > 4.0 | – | – |
| Velocity ratio | < 0.25 | – | – |

Adapted from Baumgartner, EAE/ASE recommendations. *Eur J Echocardiogr.* 2010;10:1-25

European Heart Journal 2012 - doi:10.1093/eurheartj/ehs109 & European Journal of Cardio-Thoracic Surgery 2012 - doi:10.1093/ejcts/ezs455).

European Heart Journal (2008) 29, 1043–1048
doi:10.1093/eurheartj/ehm543

CLINICAL RESEARCH
*Valvular heart disease*

# Inconsistencies of echocardiographic criteria for the grading of aortic valve stenosis

Jan Minners*, Martin Allgeier, Christa Gohlke-Baerwolf, Roland-Peter Kienzle, Franz-Josef Neumann, and Nikolaus Jander

Severe stenosis?

**Table 1** Percentage of patients diagnosed with severe aortic stenosis depending on which echocardiographic criterion was used

| Guidelines/ recommendations | Parameter | Patients with severe stenosis |
|---|---|---|
| AHA/ACC[3] | AVA $<1.0\ cm^2$ | 69% |
| ESC[2] | AVA/BSA $<0.6\ cm^2$ | 76% |
| Otto[4] | $V_{max} > 4.0$ m/s | 45% |
| AHA/ACC[3] | $\Delta P_m > 40$ mmHg | 40% |

AVA, aortic valve area; BSA, body surface area; $V_{max}$, peak flow velocity; $\Delta P_m$, mean pressure gradient.

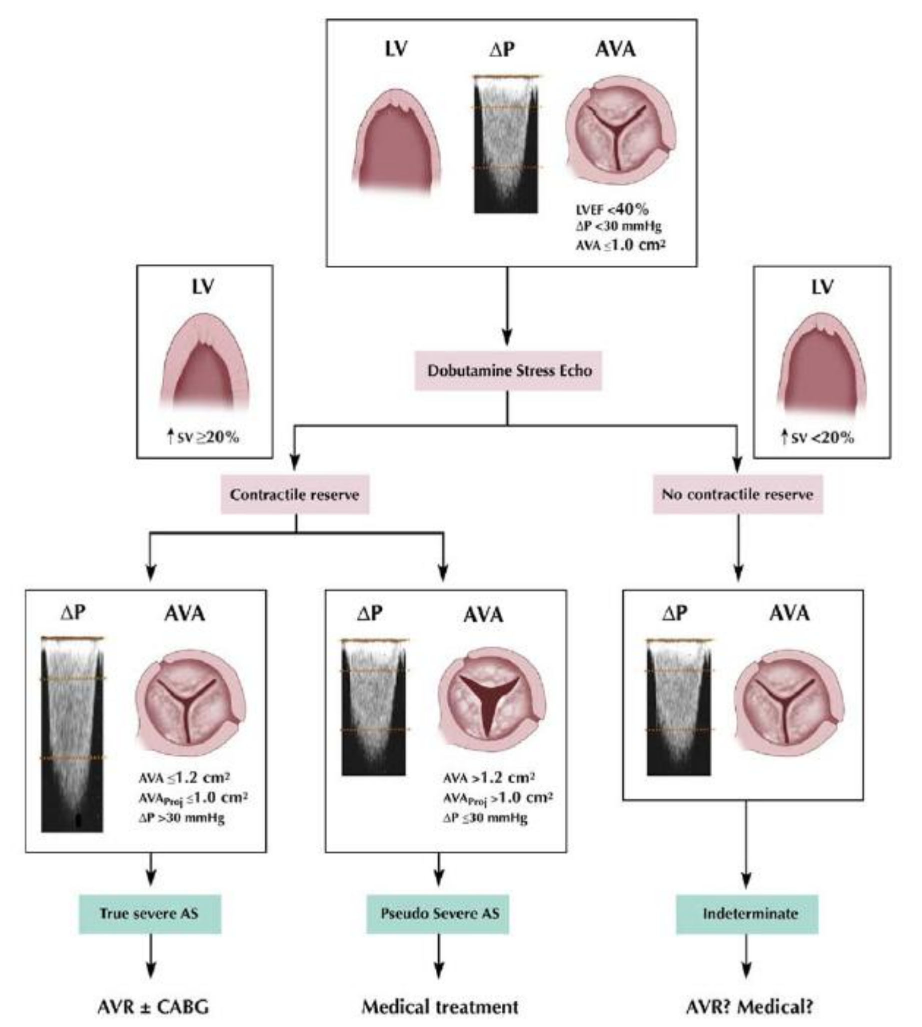
# Other Techniques

- **Exercise testing**
  - Objective assessment if equivocal or no symptoms.
  - Prognosis in asymptomatic AS.
- **Stress echocardiography**
  - Low dose dobutamine echocardiography in AS with low gradient and LV dysfunction.
  - Exercise echocardiography may provide additional information in AS, MR, MS.
- **Magnetic resonance imaging**
  - To assess regurgitation/LV function if echocardiography is inadequate.
  - As a reference method for evaluation of RV.
- **Multislice CT**
  - For imaging of thoracic aorta.
  - For work-up before TAVI.
- **Cardiac catheterisation (to evaluate valve function)**
  - Only if non-invasive findings inconsistent or discordant with clinical assessment.

European Heart Journal 2012 - doi:10.1093/eurheartj/ehs109 & European Journal of Cardio-Thoracic Surgery 2012 - doi:10.1093/ejcts/ezs455).

# The Emerging Role of Exercise Testing and Stress Echocardiography in Valvular Heart Disease

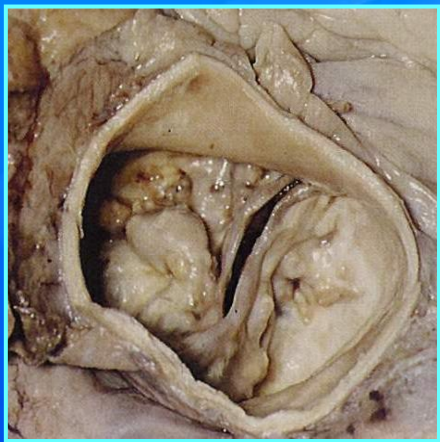
Eugenio Picano, MD, PhD,* Philippe Pibarot, MD, PhD,† Patrizio Lancellotti, MD, PhD,‡ Jean Luc Monin, MD, PhD,§ Robert O. Bonow, MD||

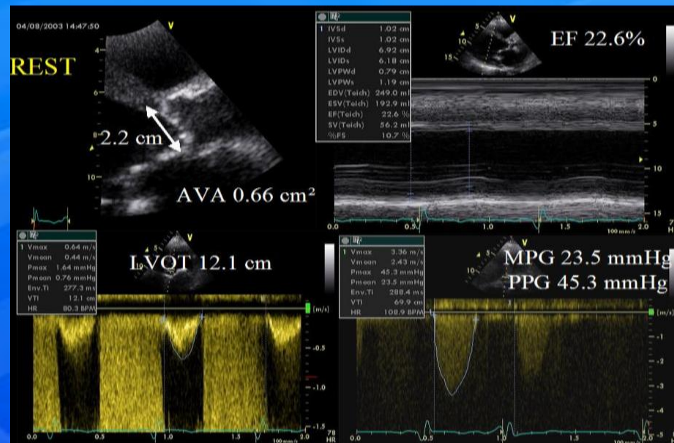


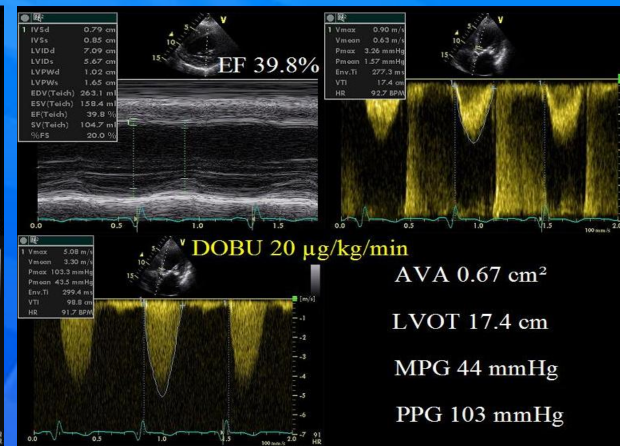


J Am Coll Cardiol 2009;54:2251–60

# STRESS ECHO in Aortic Stenosis with low gradient






Low-gradient AS

mean gradient < 25 - 30 mm Hg
calculated AVA < 1.0 cm $^2$

dobutamine-responsiveness :
contractile reserve → ↑ SV ≥ 20%

Operative mortality

5% ( 3 of 64 pts) if CR ↑

32% (10 of 35 pts) if CR ↓

Monin et al , Circ 2003

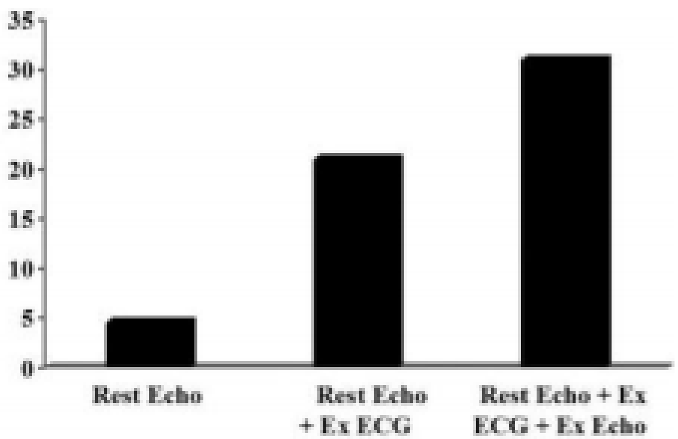
Circulation
JOURNAL OF THE AMERICAN HEART ASSOCIATION

American Heart Association

**Prognostic Importance of Quantitative Exercise Doppler Echocardiography in Asymptomatic Valvular Aortic Stenosis**

Patrizio Lancellotti, Florence Lebois, Marc Simon, Christophe Tombeux, Christophe Chauvel and Luc A. Pierard

*Circulation*. 2005;112:I-377-I-382




Incremental prognostic value of exercise Doppler

**TABLE 3. Multivariate Predictors of Events**

| Categorical Variables | χ | *P* Value |
|---|---|---|
| Mean aortic pressure gradient diff ≥18 mm Hg | 10 | 0.015 |
| Abnormal exercise test | 9.1 | 0.0026 |
| Aortic valve area <0.75 cm | 8.7 | 0.0031 |

Diff indicates difference between exercise and rest.

Exercise Doppler echocardiographic findings provided incremental prognostic value over resting echocardiographic and exercise electrocardiographic parameters.

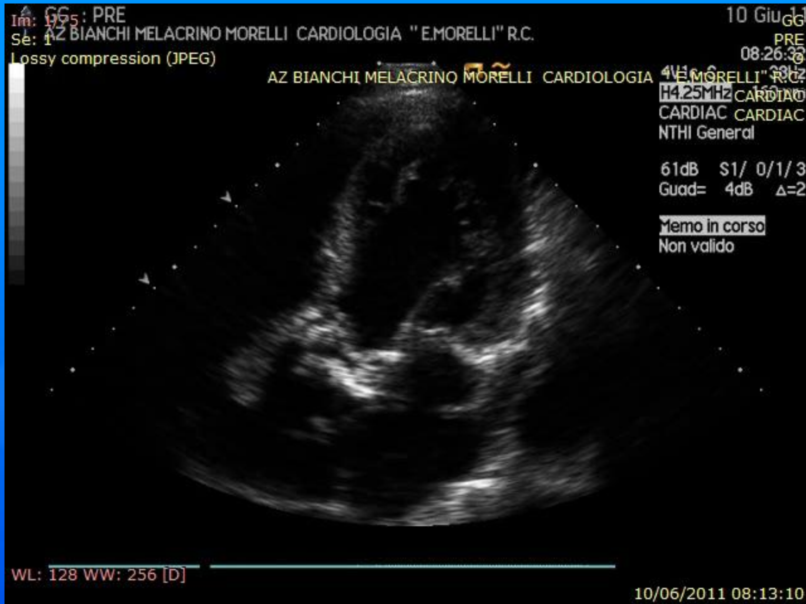
# 2.Who to test?

1. When symptoms do not match the VHD severity (Stage C vs D)
2. Truly asymptomatic severe VHD who are on the cusp of clinical deterioration (Stage C1 vs C2)
3. Special cases

# Contraindications that should be strictly respected

- Truly symptomatic severe VHD
- Clear indication for surgery
- Physical or mental disability to adequately perform an exercise stress test
- High BP (systolic arterial pressure >200 mm Hg or diastolic arterial pressure >110 mm Hg)
- Uncontrolled or symptomatic arrhythmias
- Systemic illness

J Am Coll Cardiol Img 2014;7:188–99, modified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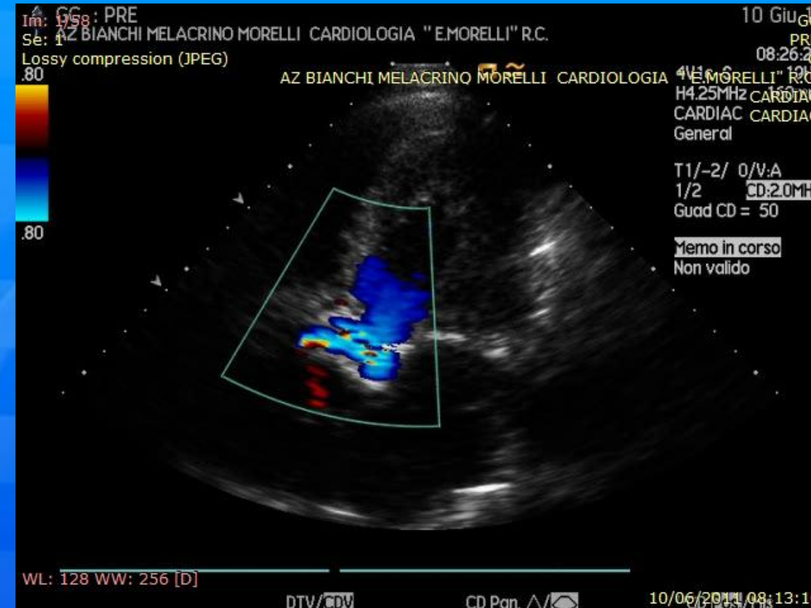
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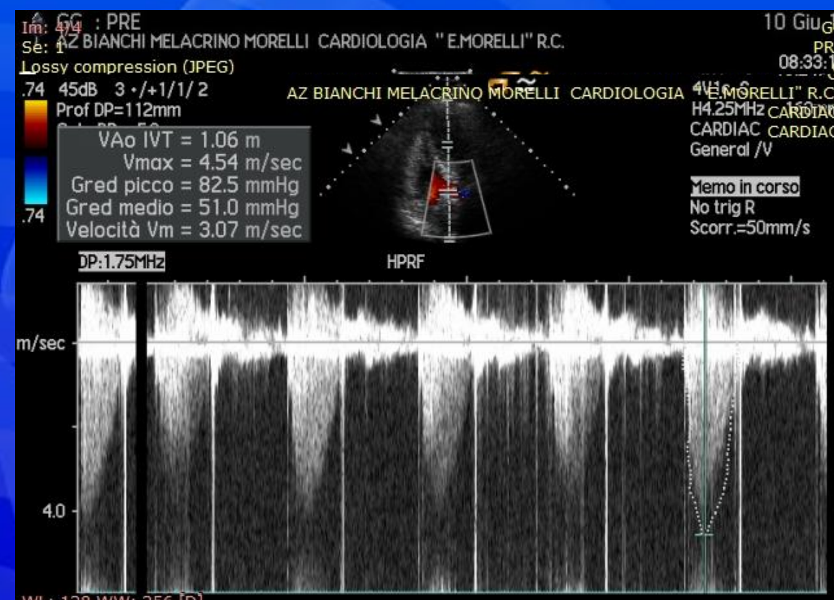
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Vmax = 4.54 m/sec
Gred picco = 82.5 mmHg
Gred medio = 51.0 mmHg
Velocità Vm = 3.07 m/sec
H4.25MHz
CARDIAC
General /V
Memo in corso
No trig R
Scorr.=50mm/s
DP:1.75MHz
HPRF
m/sec
4.0
WL: 128 WW: 256 [D]

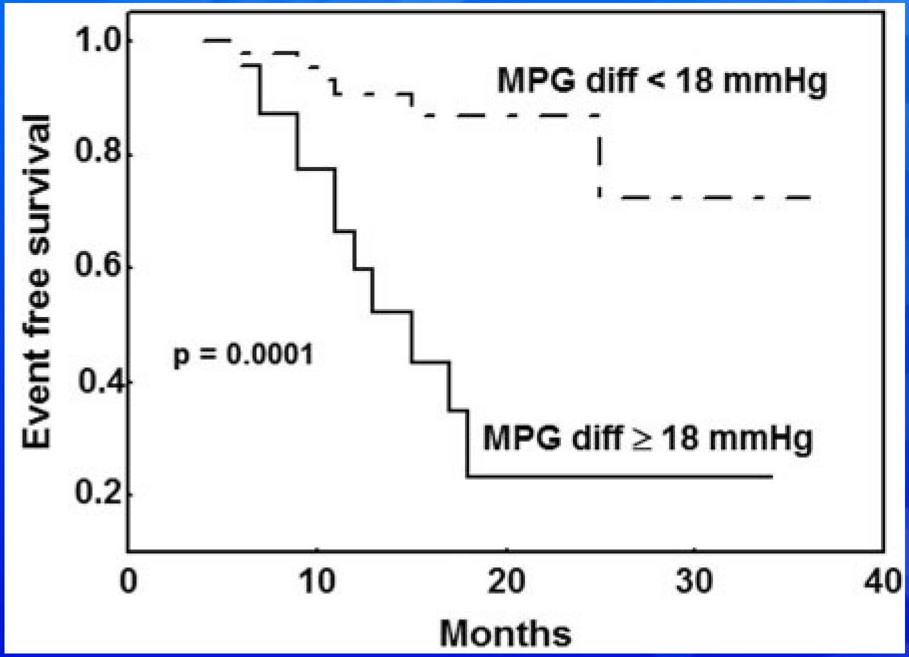
# 3.Which parameters?

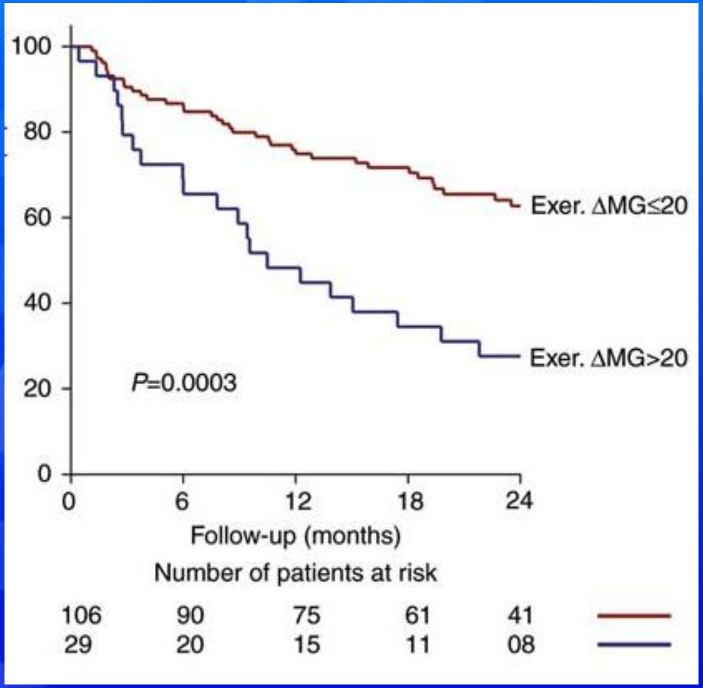
- Development of symptoms during exercise
- Altered exercise capacity (METs)
- Aggravation of VHD severity
- Impaired LV systolic and diastolic reserve
- Exercise-induced PHT
- (Pulmonary congestion)
- (Inducible ischemia, dynamic LV dyssynchrony)

# Exercise-induced increase in transvalvular gradient

69 Pts, age 66±12 Yrs

186 Pts, age 64±15 Yrs

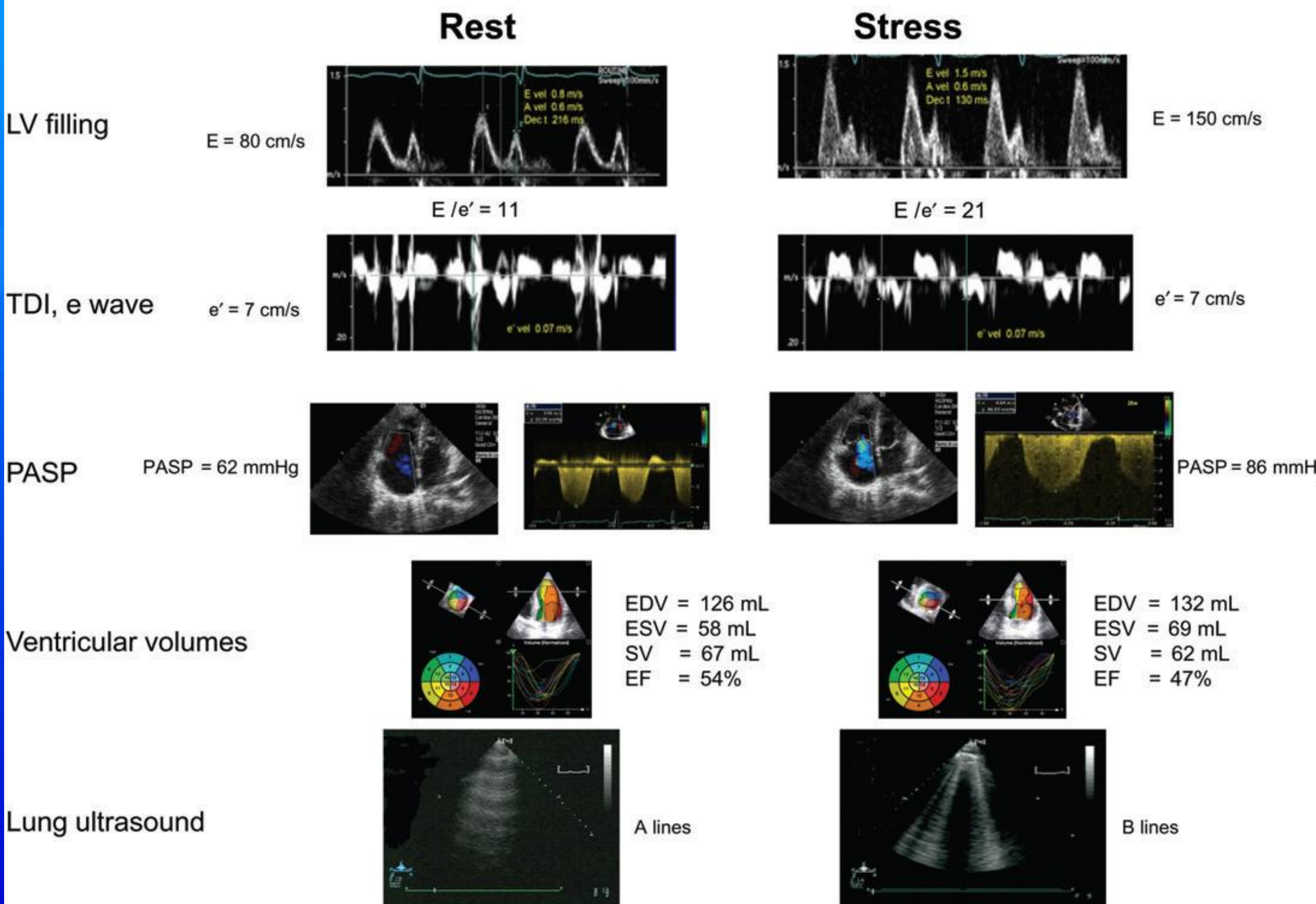



Lancellotti P et al.
Circulation 2005;112(9 Suppl):I377–I382

Maréchaux S et al.
Eur Heart J 2010;31:1390–1397

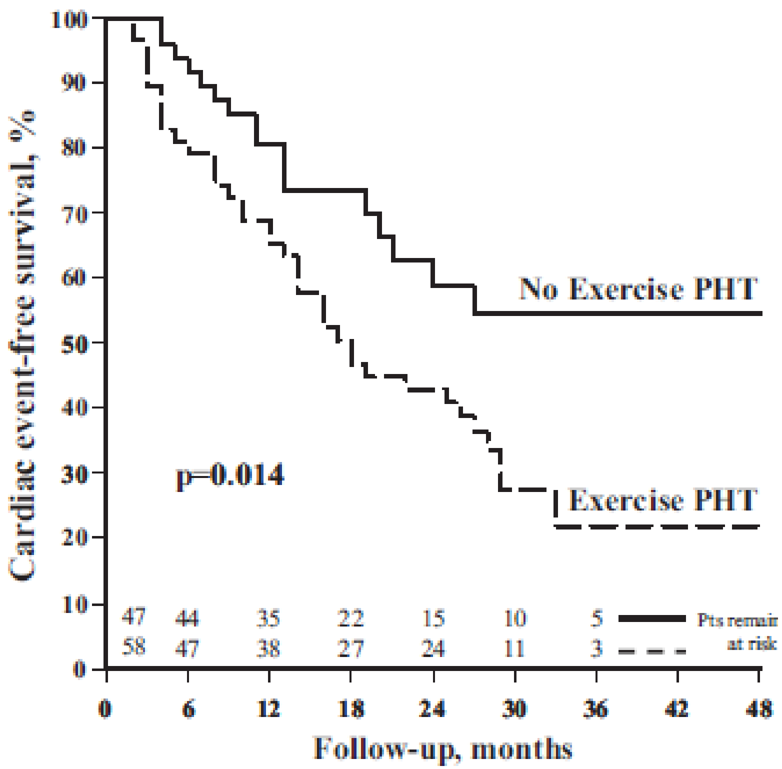
# Ventricular pressures, filling, volumes and lung water

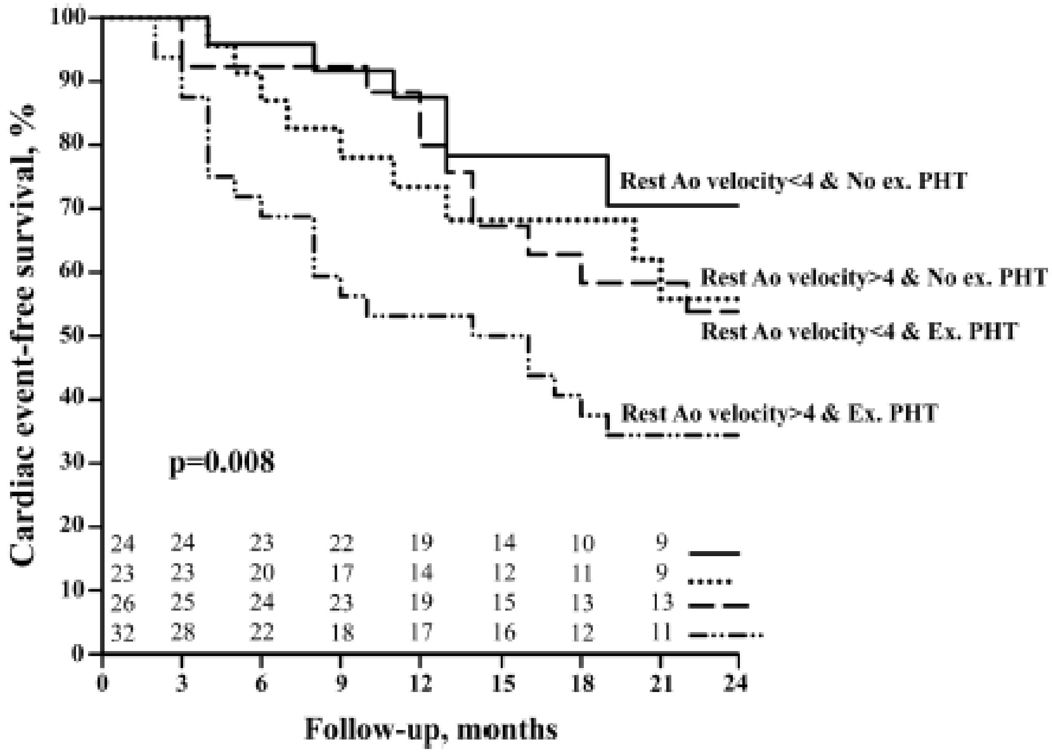



Picano E, Pellika PA. Eur Heart J October 14, 2013

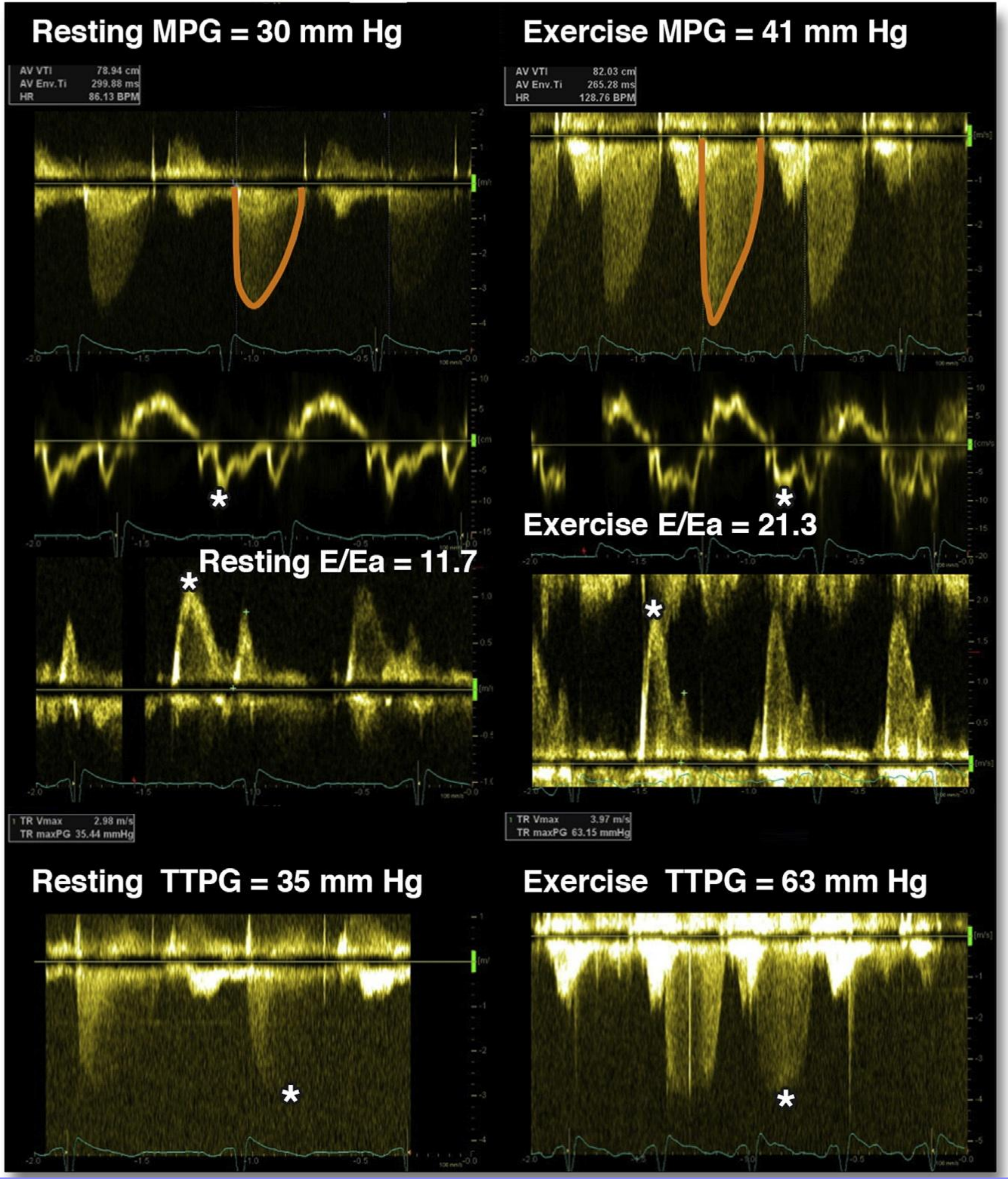
# Exercise-induced PH

105 Pts, age 71±9 Yrs

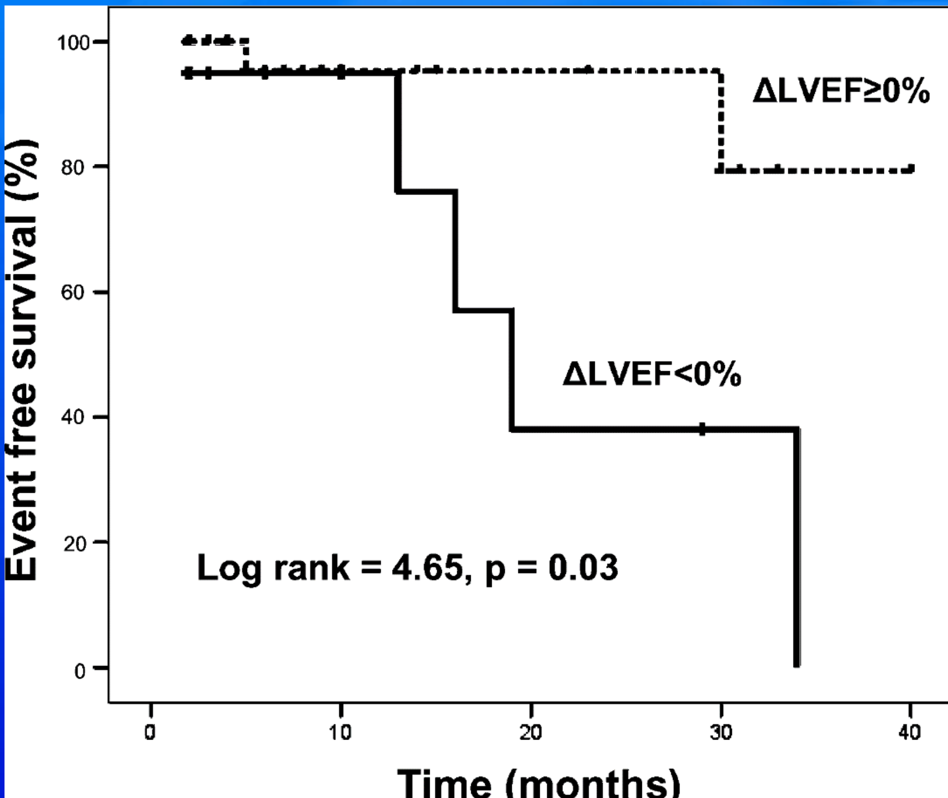


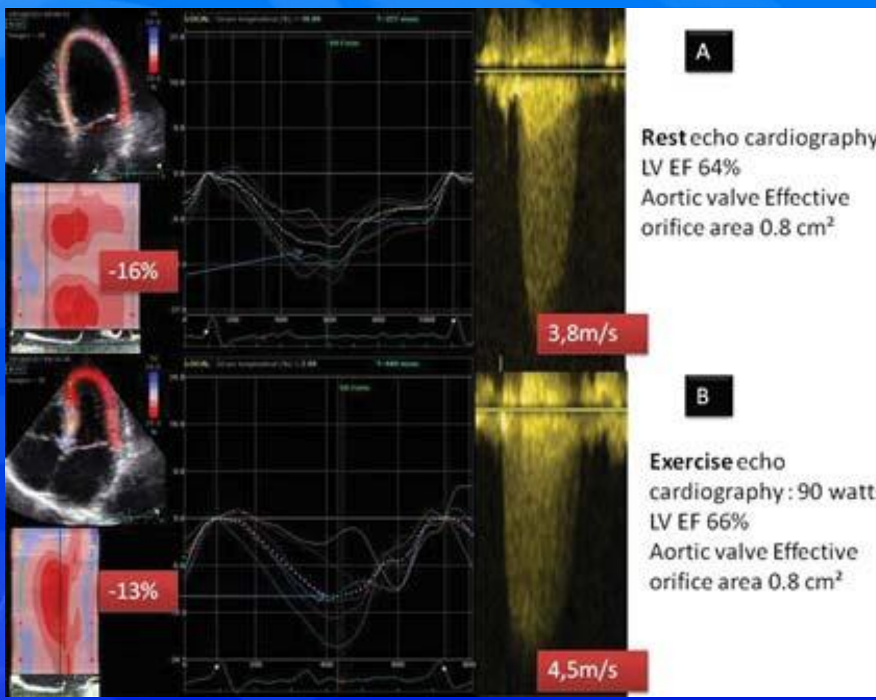




Lancellotti P et al. Circulation 2012;126:851–859


Resting MPG = 30 mm Hg
Exercise MPG = 41 mm Hg
AV VTI 78.94 cm
AV Env.Ti 299.88 ms
HR 86.13 BPM
AV VTI 82.03 cm
AV Env.Ti 265.28 ms
HR 128.76 BPM
Resting E/Ea = 11.7
Exercise E/Ea = 21.3
TR Vmax 2.98 m/s
TR maxPG 35.44 mmHg
TR Vmax 3.97 m/s
TR maxPG 63.15 mmHg
Resting TTPG = 35 mm Hg
Exercise TTPG = 63 mm Hg

# Ex-induced changes in LV systolic function

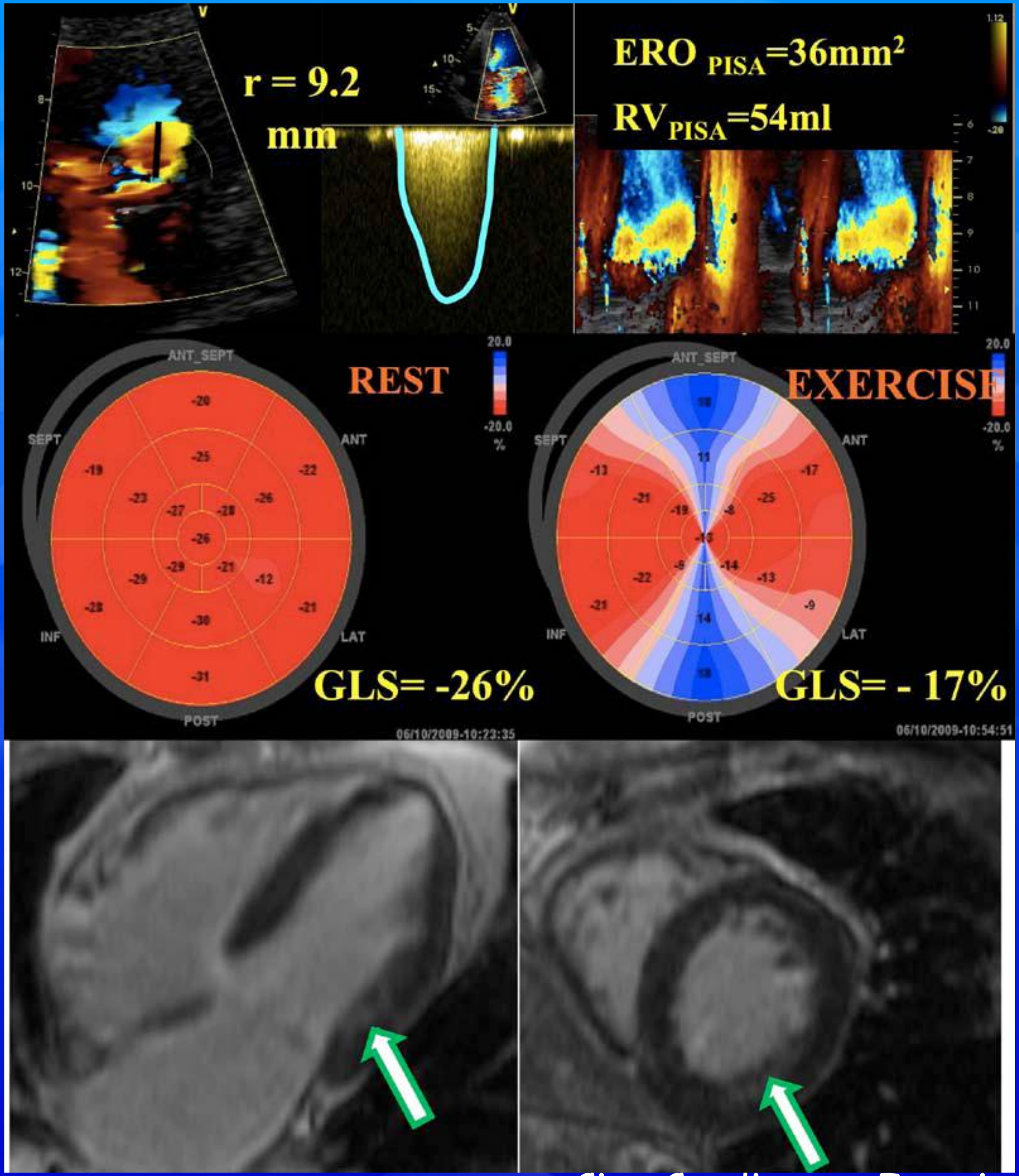


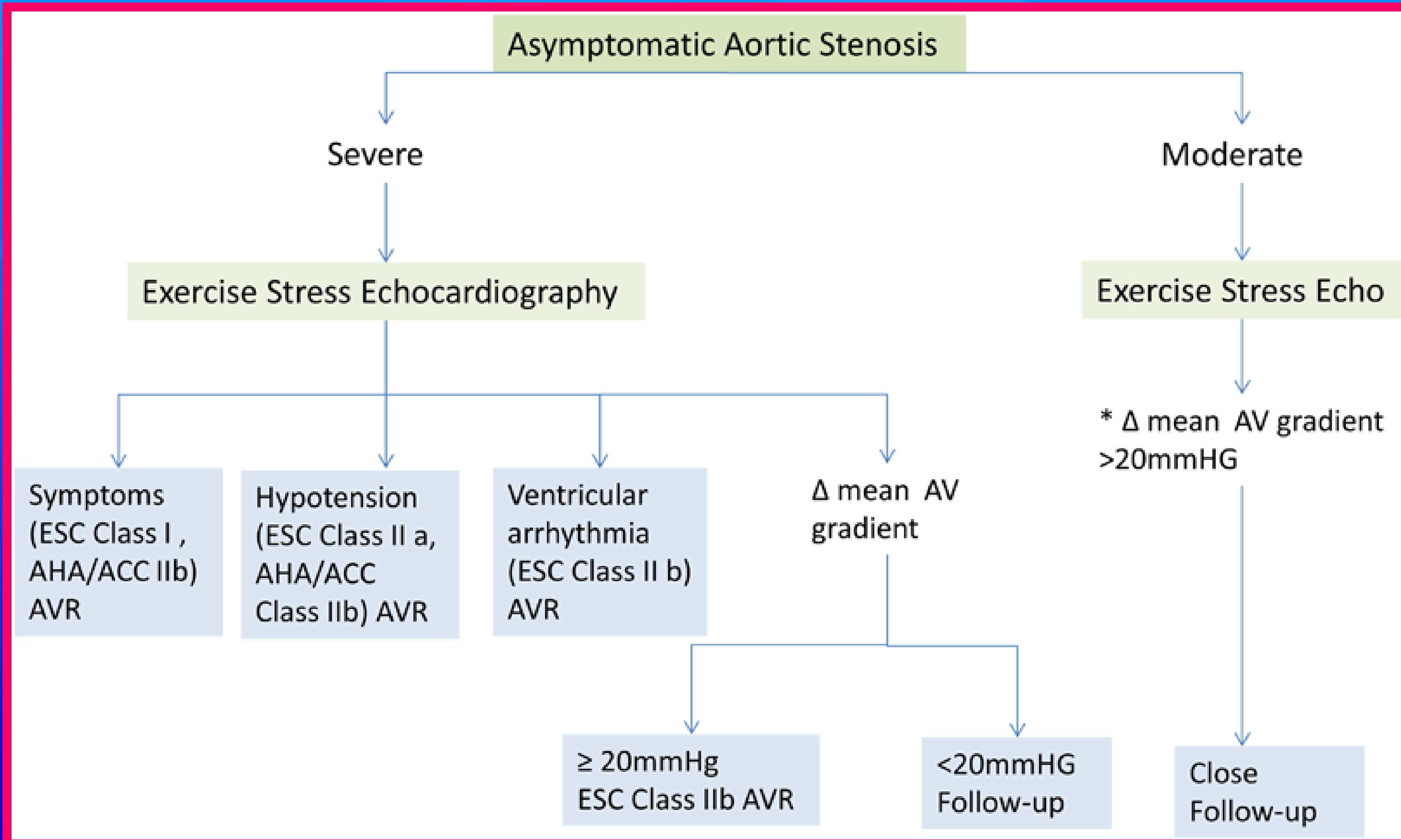

Maréchaux et al
Echocardiography 2007;24:955-9

Donal E et al.
Eur J of Echocardiogr 2011;12:235-241

# Contractile functional reserve




Circ Cardiovasc Imaging 2013;6:840-849




Circ Cardiovasc Imaging 2013;6:583-589

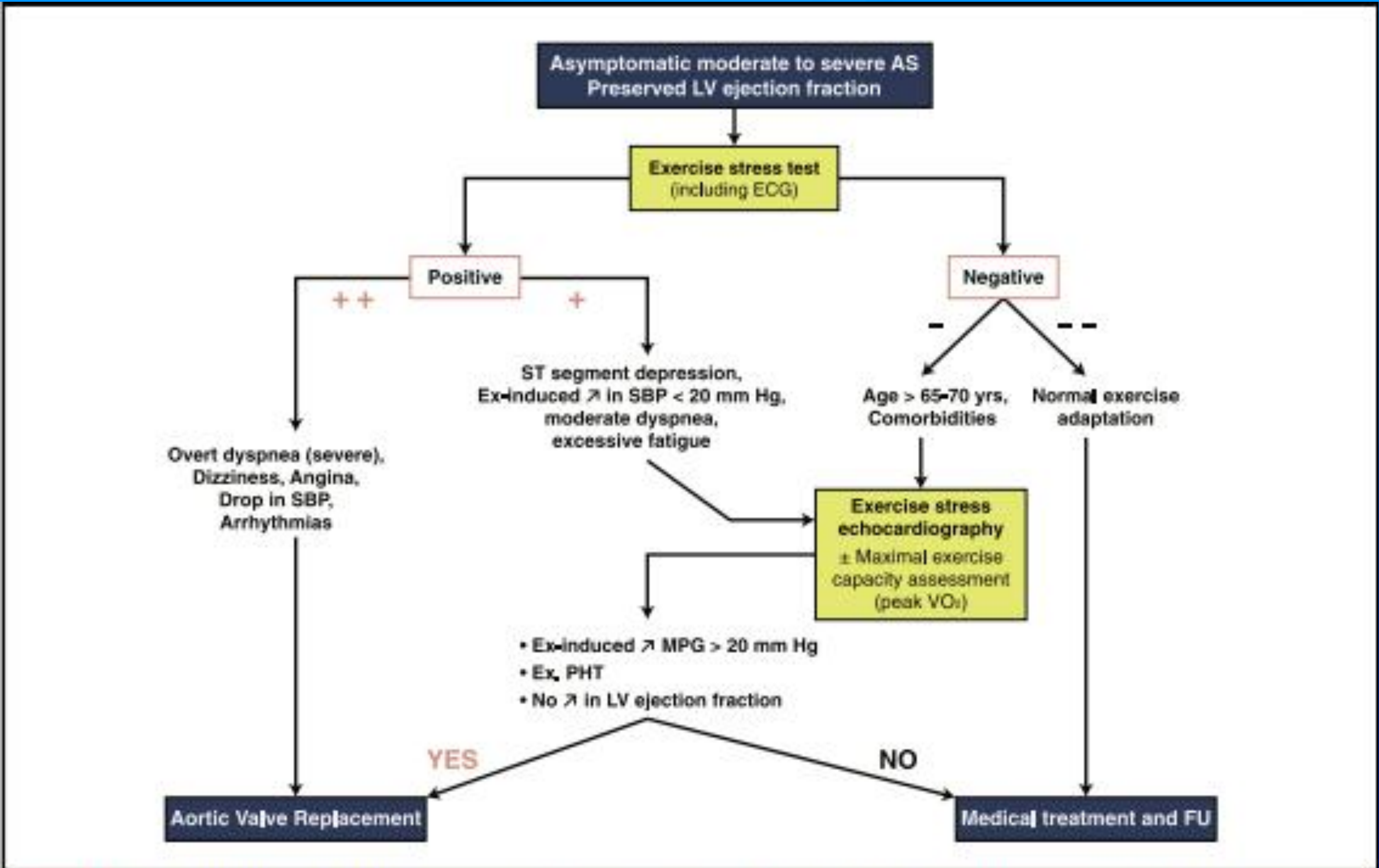
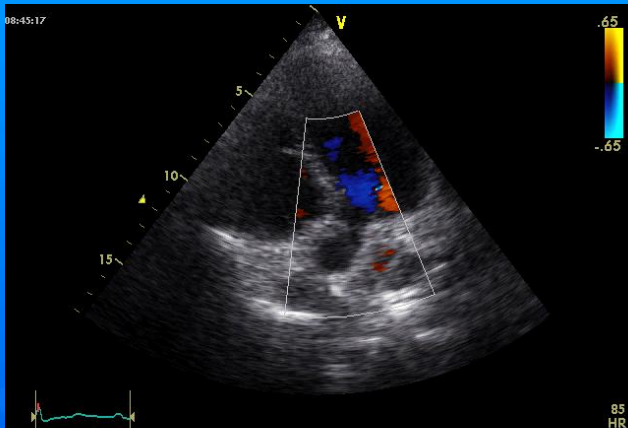
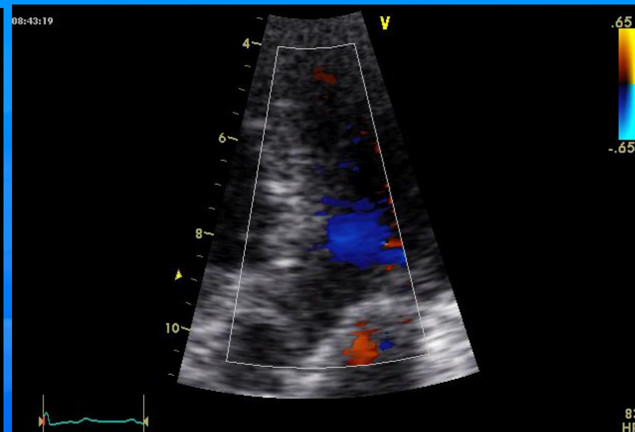


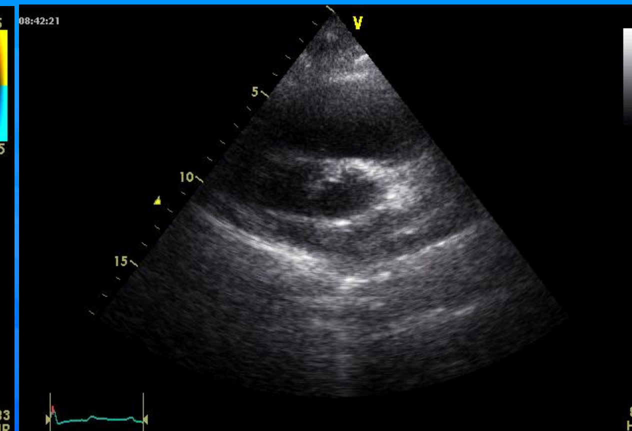

**Figure 5. Decisional Algorithm for the Management of Asymptomatic Patients With Preserved LV Ejection Fraction (>50%)**

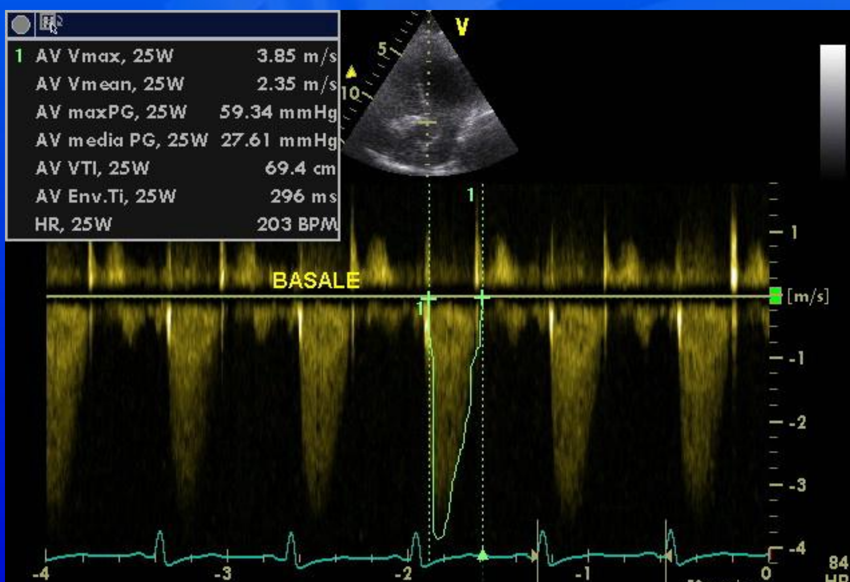
AS = aortic stenosis; ECG = electrocardiogram; FU = follow-up; LV = left ventricular; MPG = mean aortic pressure gradient; PHT = pulmonary hypertension; SBP = systolic blood pressure; $VO_2$ = maximal oxygen uptake.

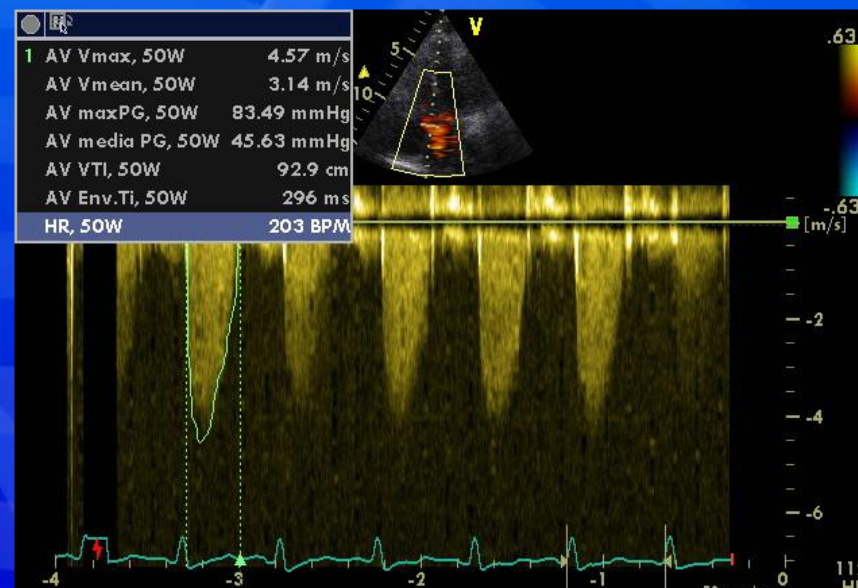
J Am Coll Cardiol Img 2014;7:188–99



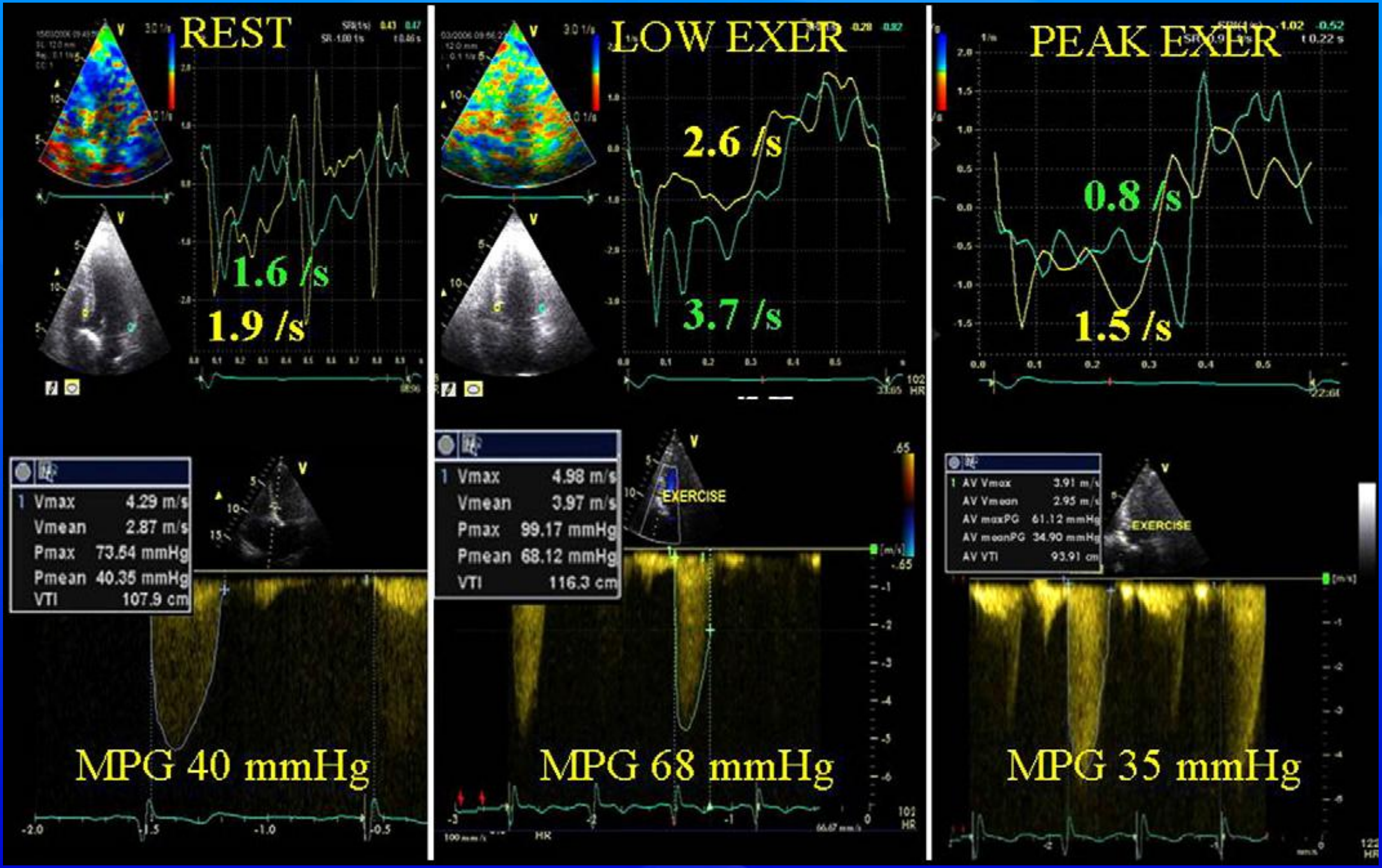




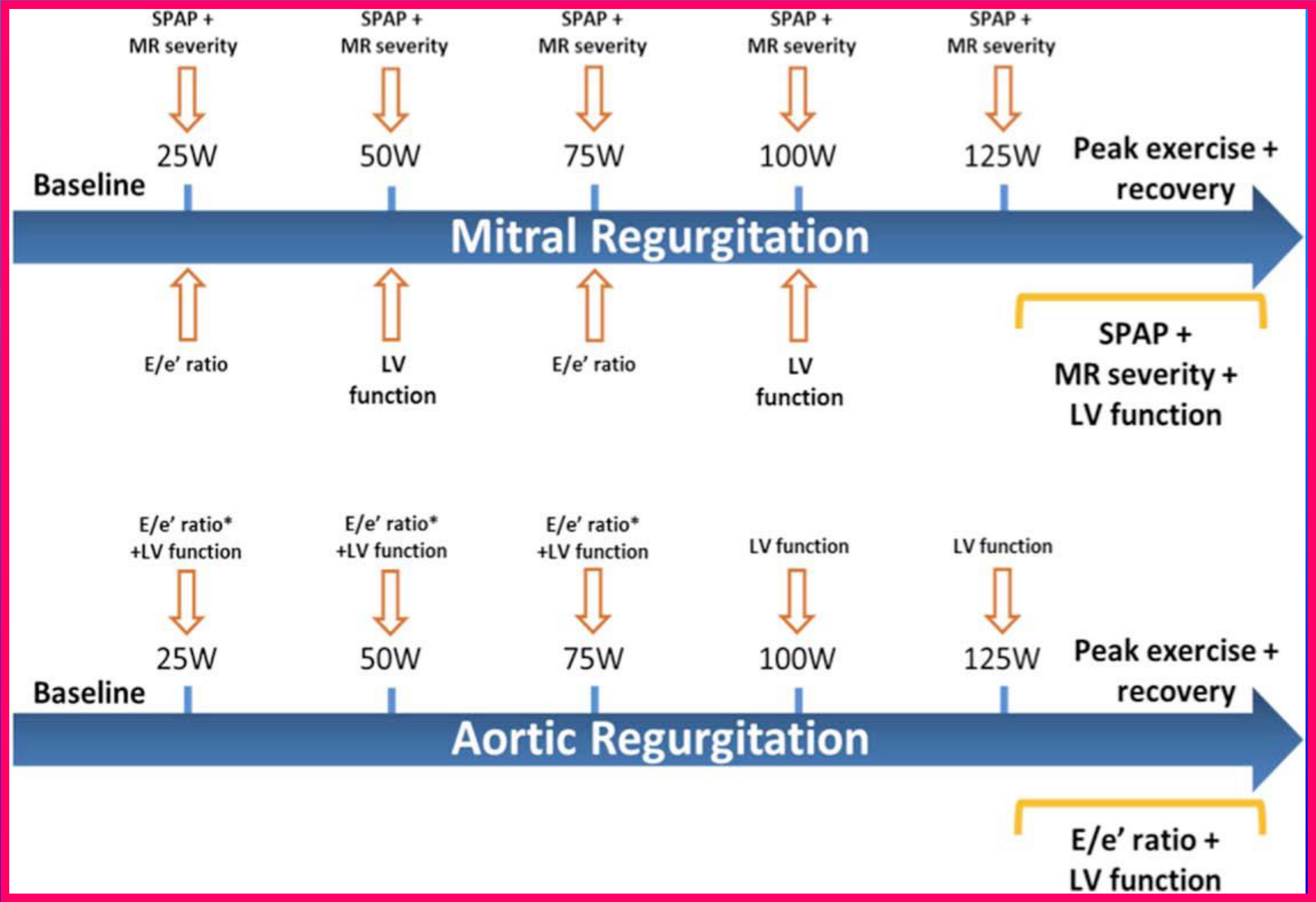

1 AV Vmax, 25W 3.85 m/s
AV Vmean, 25W 2.35 m/s
AV maxPG, 25W 59.34 mmHg
AV media PG, 25W 27.61 mmHg
AV VTI, 25W 69.4 cm
AV Env.Ti, 25W 296 ms
HR, 25W 203 BPM
BASALE


1 AV Vmax, 50W 4.57 m/s
AV Vmean, 50W 3.14 m/s
AV maxPG, 50W 83.49 mmHg
AV media PG, 50W 45.63 mmHg
AV VTI, 50W 92.9 cm
AV Env.Ti, 50W 296 ms
HR, 50W 203 BPM

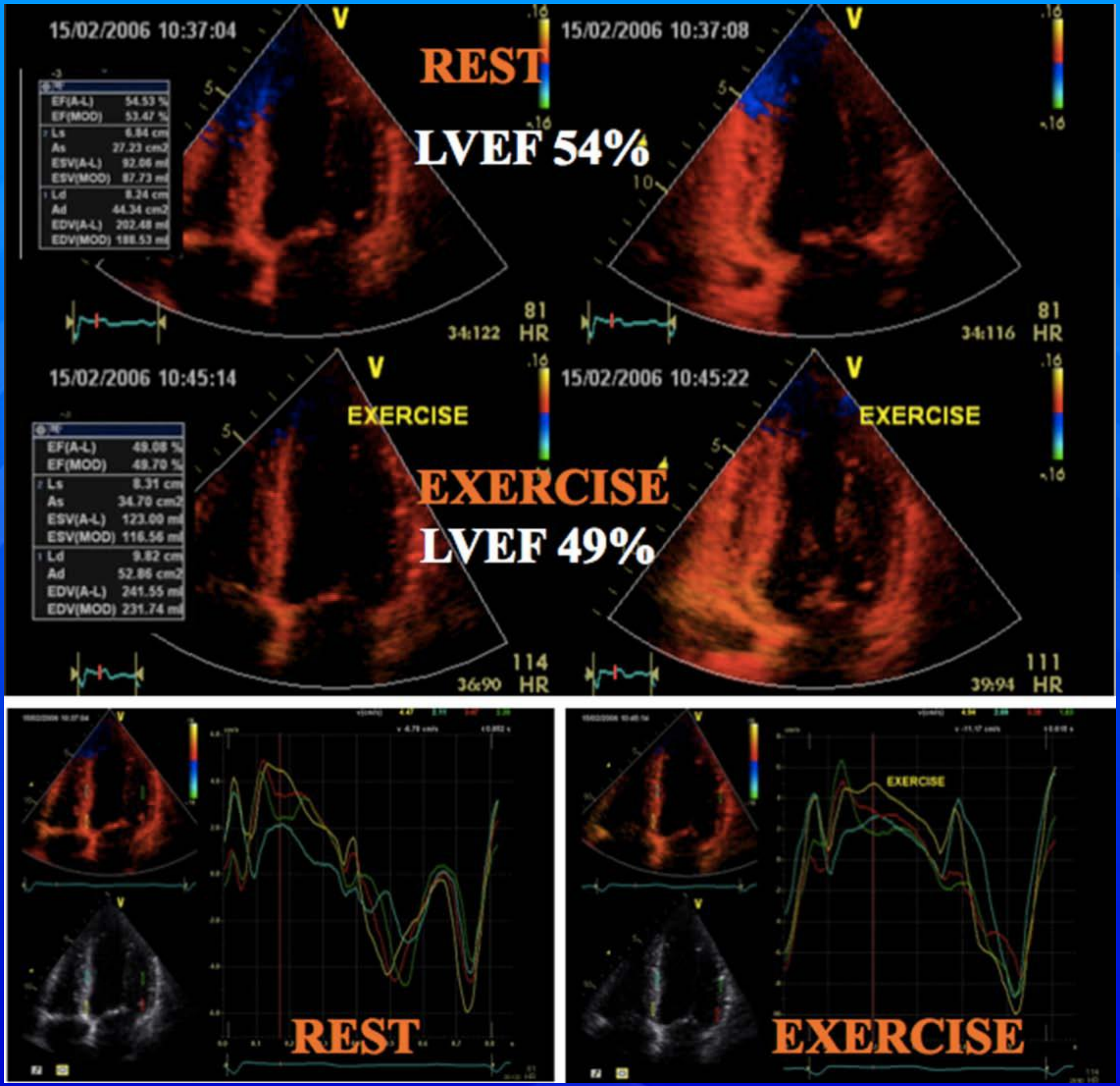
# Biphasic response



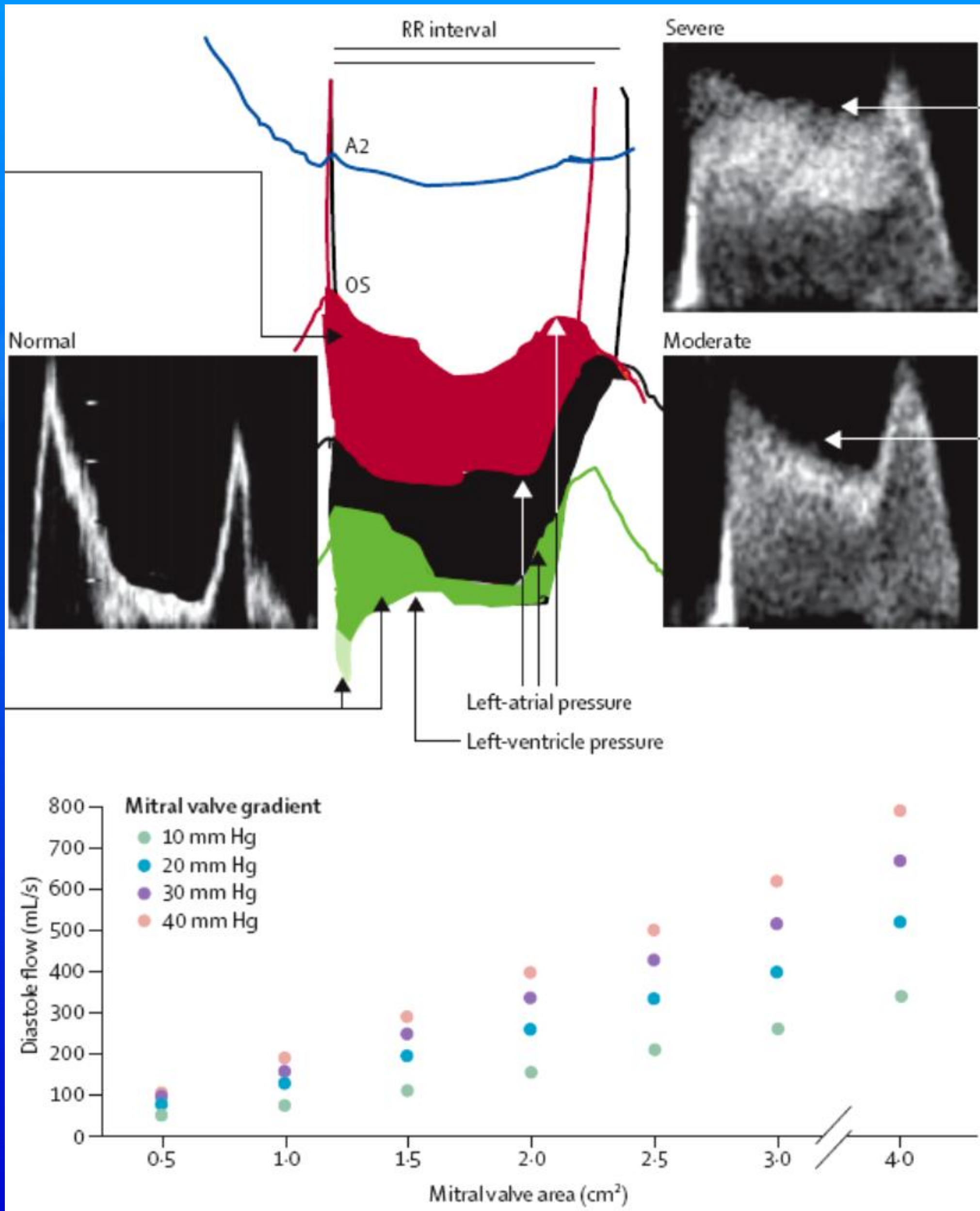

Arch Cardiovasc Dis 2009;102:593-594




Circ Cardiovasc Imaging 2013;6:840-849




Circ Cardiovasc Imaging 2013;6:840-849




# Mitral stenosis

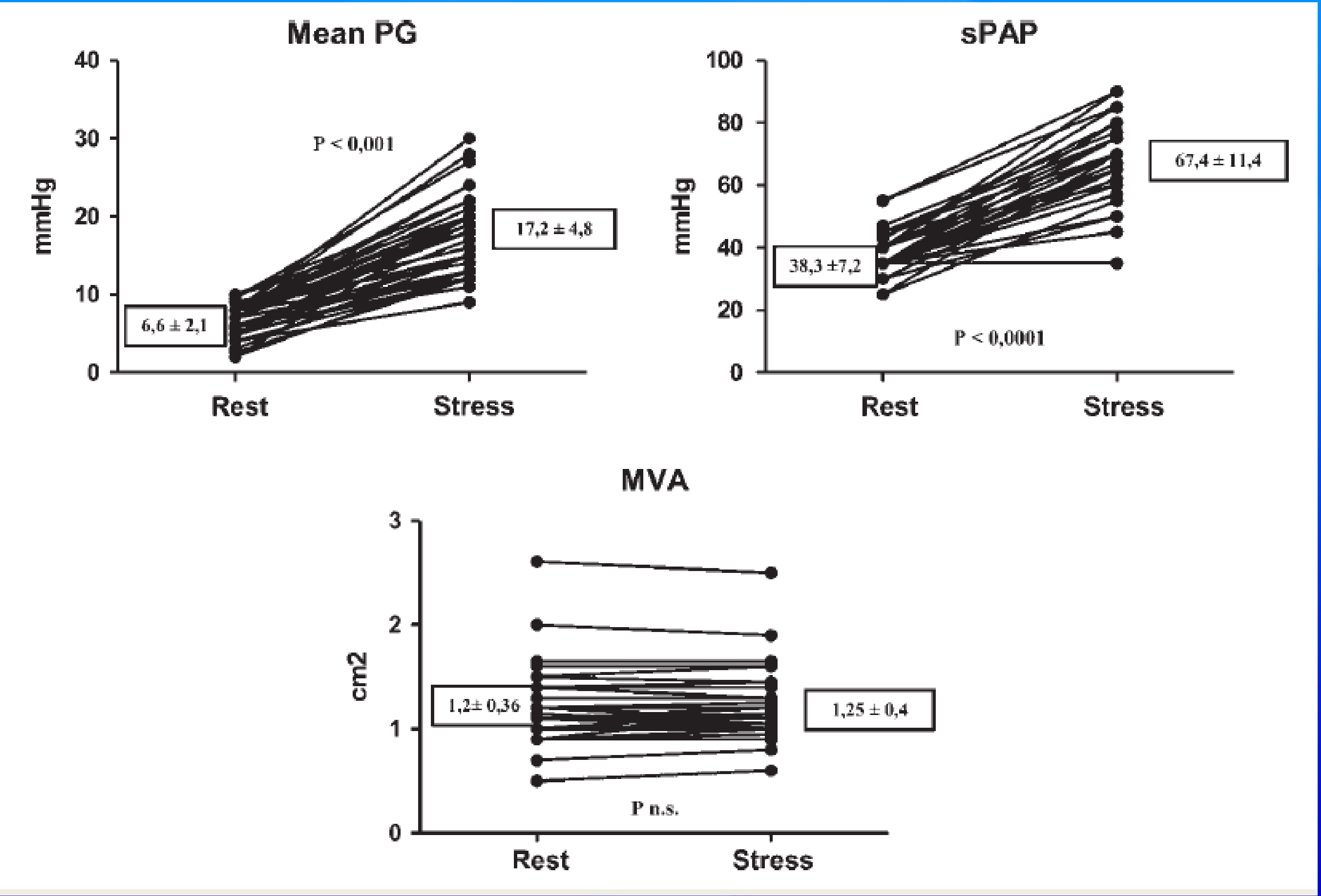
European Heart Journal – Cardiovascular Imaging (2012) **13**, 476–482
doi:10.1093/ejechocard/jer269

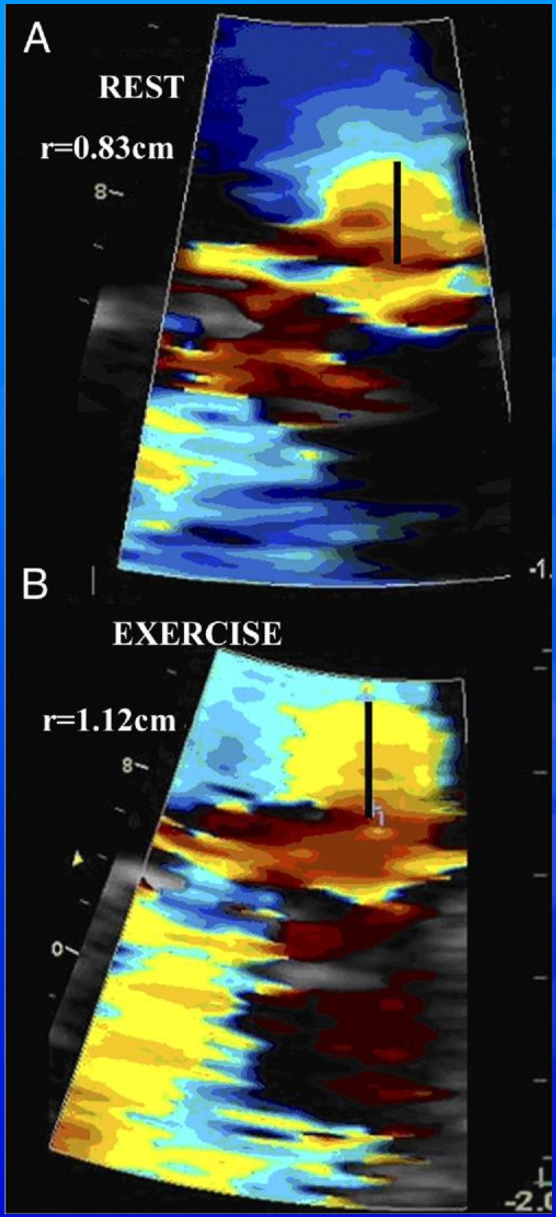
# Dynamic assessment of 'valvular reserve capacity' in patients with rheumatic mitral stenosis

**Antonio Grimaldi[1*], Iacopo Olivotto[2], Filippo Figini[1], Federico Pappalardo[1], Elvia Capritti[1], Enrico Ammirati[1], Francesco Maisano[1], Stefano Benussi[1], Andrea Fumero[1], Alessandro Castiglioni[1], Michele De Bonis[1], Anna Chiara Vermi[1], Antonio Colombo[1], Alberto Zangrillo[1], and Ottavio Alfieri[1]**

[1]Cardiovascular and Thoracic Department, San Raffaele Scientific Institute and Università Vita-Salute San Raffaele, Milan, Italy; and [2]Referral Center for Myocardial Diseases, Azienda Ospedaliera Universitaria Careggi, Florence, Italy

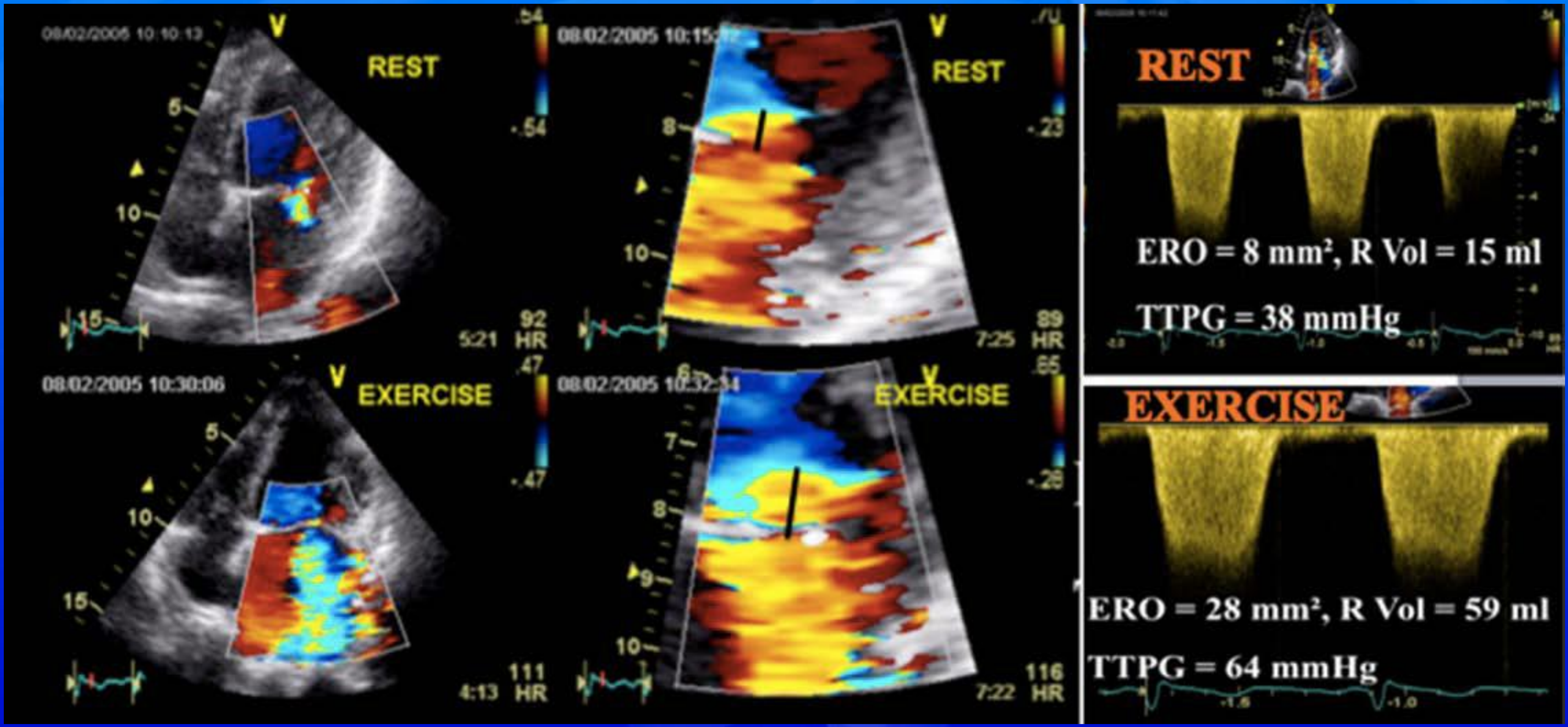
*Received 13 September 2011; revised 3 November 2011; accepted after revision 7 November 2011; online publish-ahead-of-print 5 December 2011*


Mean PG
mmHg
40
30
20
10
0
P < 0,001
17,2 ± 4,8
6,6 ± 2,1
Rest
Stress
sPAP
mmHg
100
80
60
40
20
0
67,4 ± 11,4
38,3 ±7,2
P < 0,0001
Rest
Stress
MVA
cm2
3
2
1
0
1,2± 0,36
1,25 ± 0,4
P n.s.
Rest
Stress




# Chronic primary MR

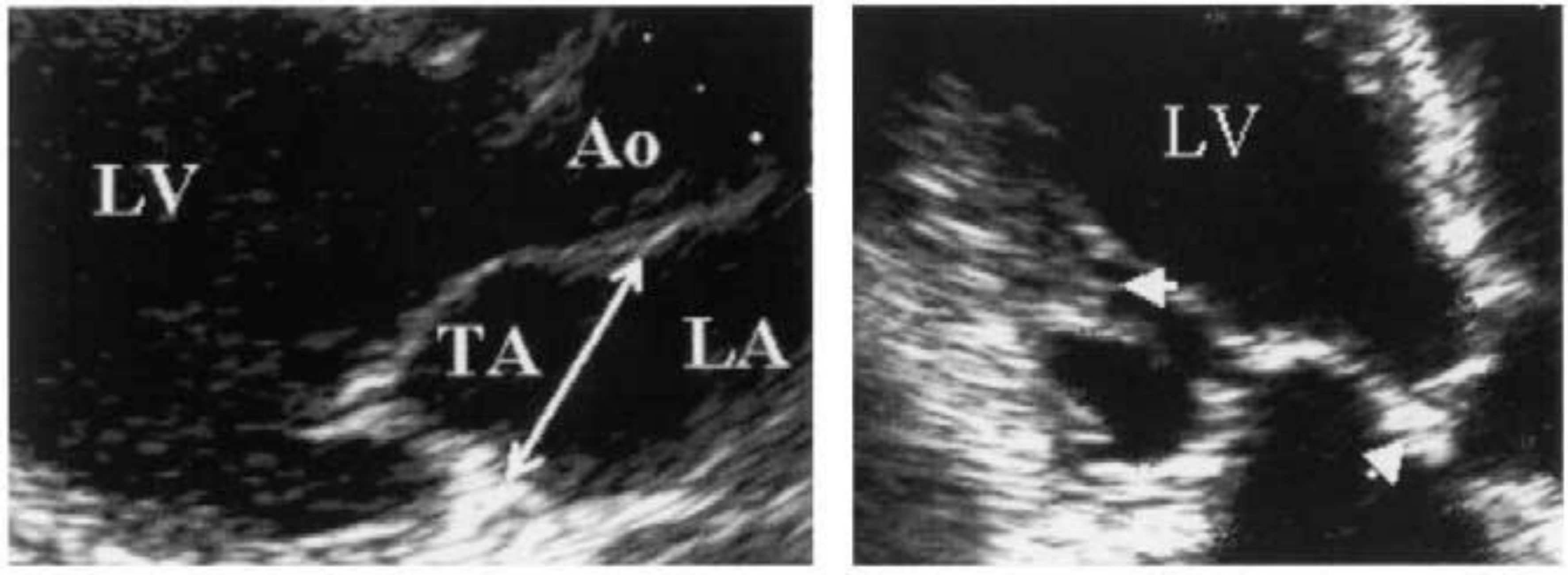
# Dynamic increase in MR and PH during exercise




Circ Cardiovasc Imaging 2013;6:840-849

# Chronic secondary ischemic MR

# Exercise-induced changes in mitral deformation




Lancellotti P et al. J Am Coll Cardiol 2003,42:1921-1928

# Take Home messages

- La velocità >4 m/sec, la progressione >0.3 m/sec/anno e la presenza di calcificazioni valvolari stratificano un significativo rischio di eventi.

- La velocità >5.5 m/sec è da considerarsi indicativa di SA estrema e codifica un elevato rischio di eventi a breve termine indipendentemente dai valori di area valvolare.

- La normalizzazione del gradiente per le condizioni di flusso e di impedenza vascolare può definire in maniera più accurata l'entità della stenosi aortica e caratterizzare un profilo prognostico differenziato.

- L'ECO sforzo, a parità di ostruzione in condizioni basali, può stratificare il rischio di eventi.

- La riserva valvolare aortica, valutata mediante TEE con stimolo inotropo o con vasodilatatore può, rappresentare un meccanismo dell'adattamento emodinamico allo sforzo.