Milano 9 Aprile, 2015

I PROBLEMI DELLA VALVOLA AORTICA: LA DIAGNOSTICA

La stenosi valvolare aortica. La diagnosi con ECO2DColorDoppler. Cosa, dove e come misurare. Parametri primari ed ancillari per la corretta selezione dei pazienti da inviare al cardiochirurgo. Il 3D

Manuela Muratori
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Milano

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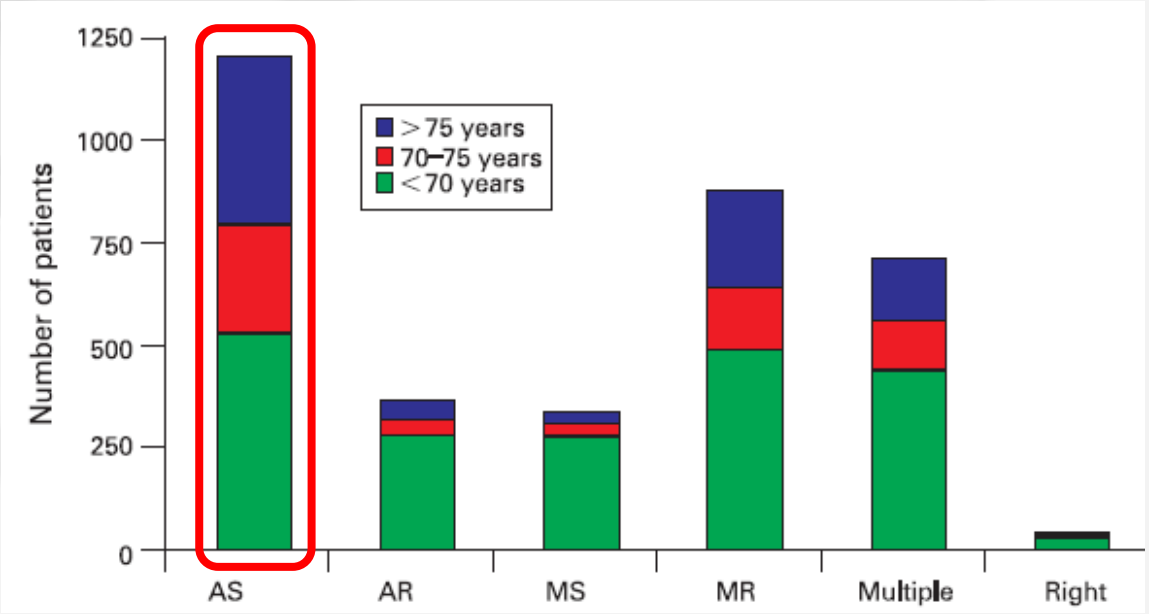
Aortic valve Stenosis

Aortic valve stenosis has already reached endemic proportions in western countries.

The prevalence is estimated to be:
- 2% in people older than 65
- 4% in people older than 80



Euro Heart Survey 2008

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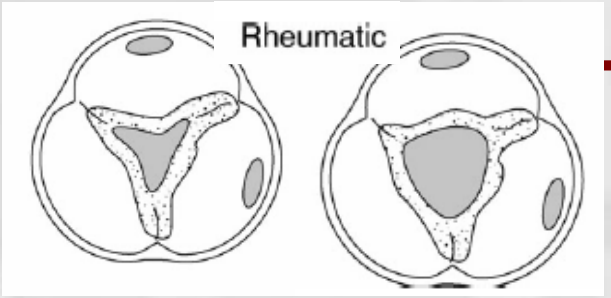
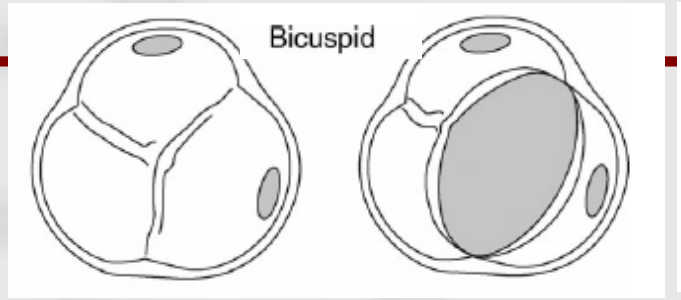
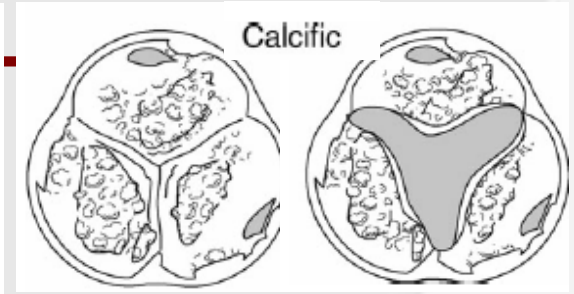
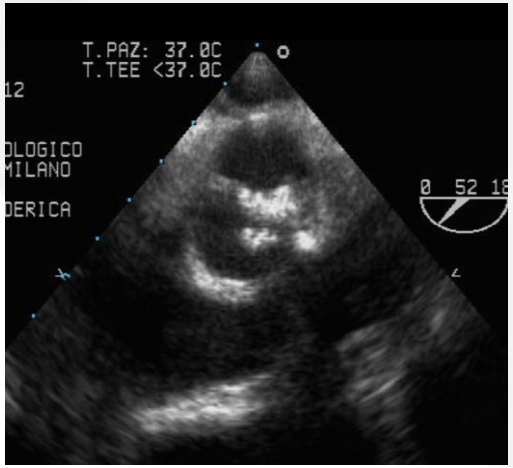
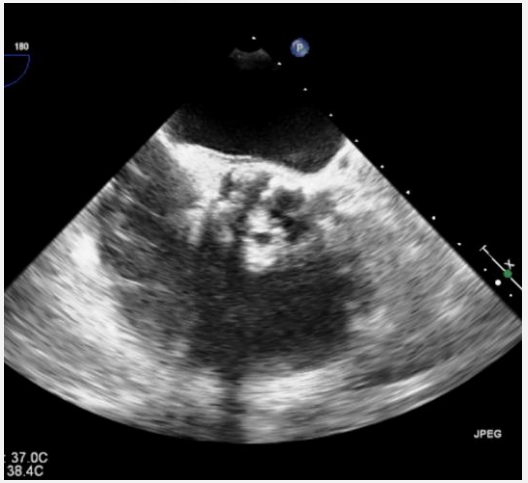
Aortic Valve Stenosis: Etiology





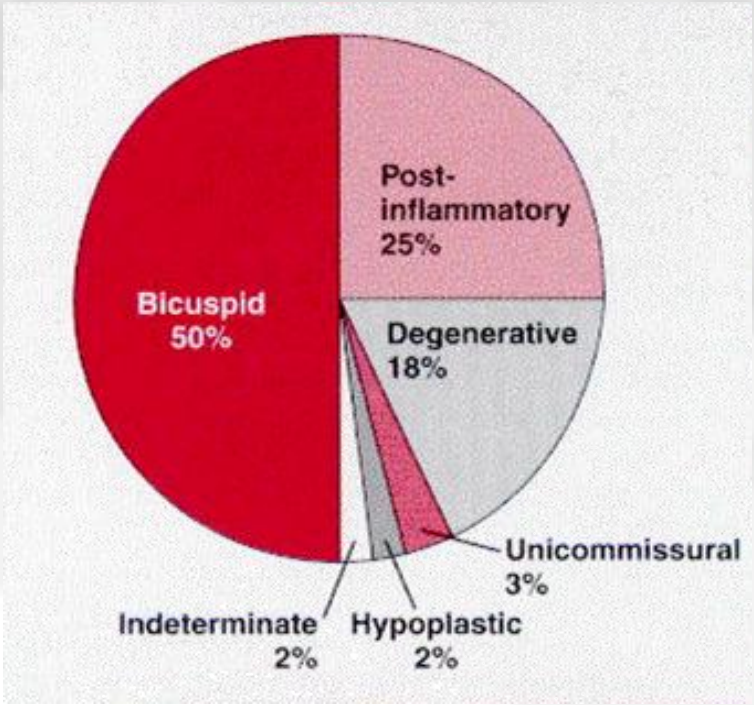




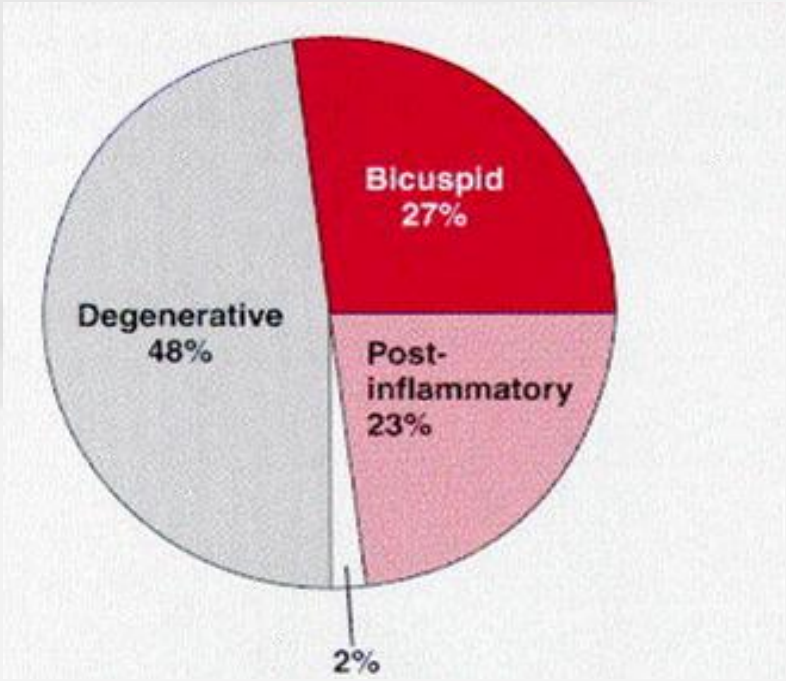


Aortic Valve Stenosis: Etiology

< 70 Years old



> 70 Years old



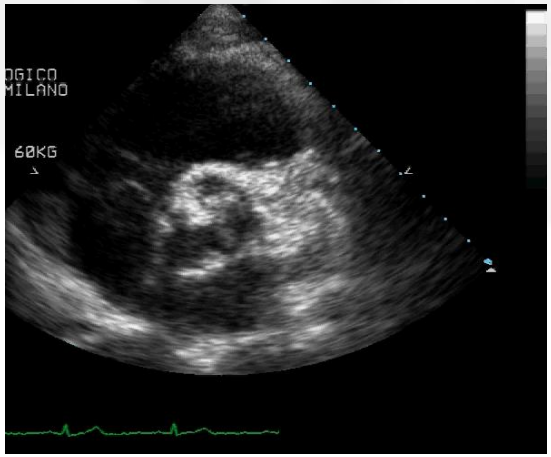
Passik et al. Mayo Clin Proc 1987

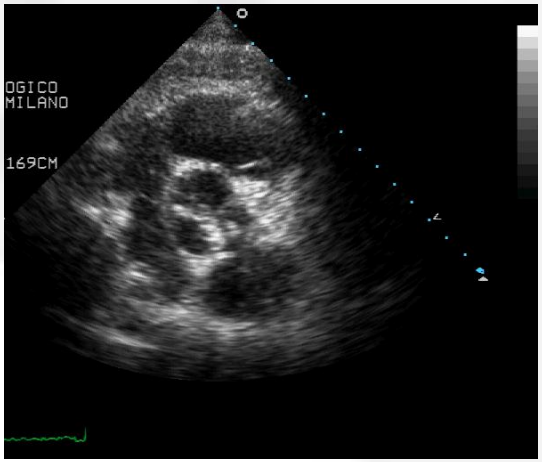
2014 AHA/ACC Guideline for the Management of Patients With Valvular Heart Disease: A Report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines

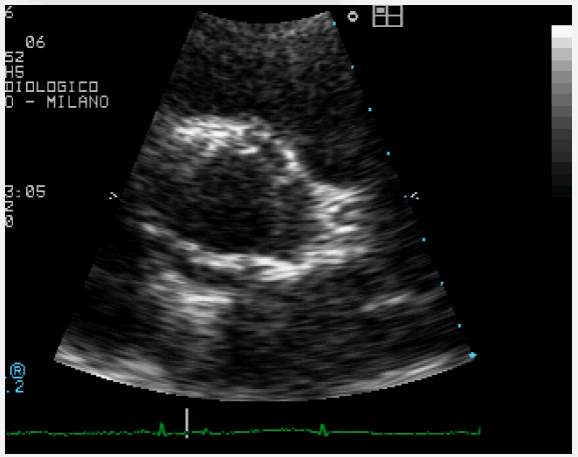
Rick A. Nishimura, Catherine M. Otto, Robert O. Bonow, Blase A. Carabello, John P. Erwin III, Robert A. Guyton, Patrick T. O'Gara, Carlos E. Ruiz, Nikolaos J. Skubas, Paul Sorajja, Thoralf M. Sundt III and James D. Thomas *Circulation*. 2014;129:e521-e643;

Table 8. Stages of Valvular AS

Stage	Definition	Valve Anatomy	Valve Hemodynamics	Hemodynamic Consequences	Symptoms
A	At risk of AS	• Bicuspid aortic valve (or other congenital valve anomaly) • Aortic valve sclerosis	• Aortic V_{max} <2 m/s	• None	• None
B	Progressive AS	• Mild-to-moderate leaflet calcification of a bicuspid or trileaflet valve with some reduction in systolic motion or • Rheumatic valve changes with commissural fusion	• Mild AS: Aortic V_{max} 2.0–2.9 m/s or mean ΔP <20 mm Hg • Moderate AS: Aortic V_{max} 3.0–3.9 m/s or mean ΔP 20–39 mm Hg	• Early LV diastolic dysfunction may be present • Normal LVEF	• None







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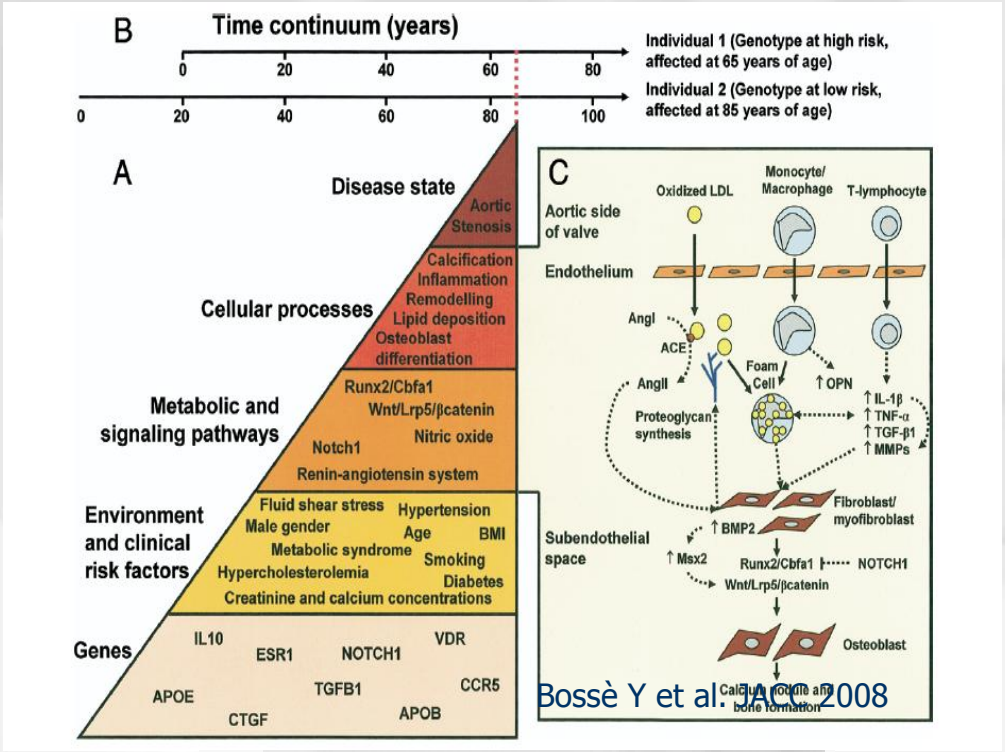
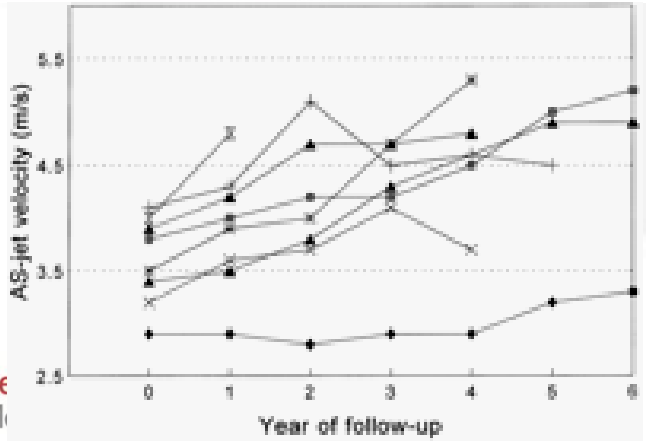
Aortic Valve Stenosis: Natural History



Bossè Y et al. JACC 2008



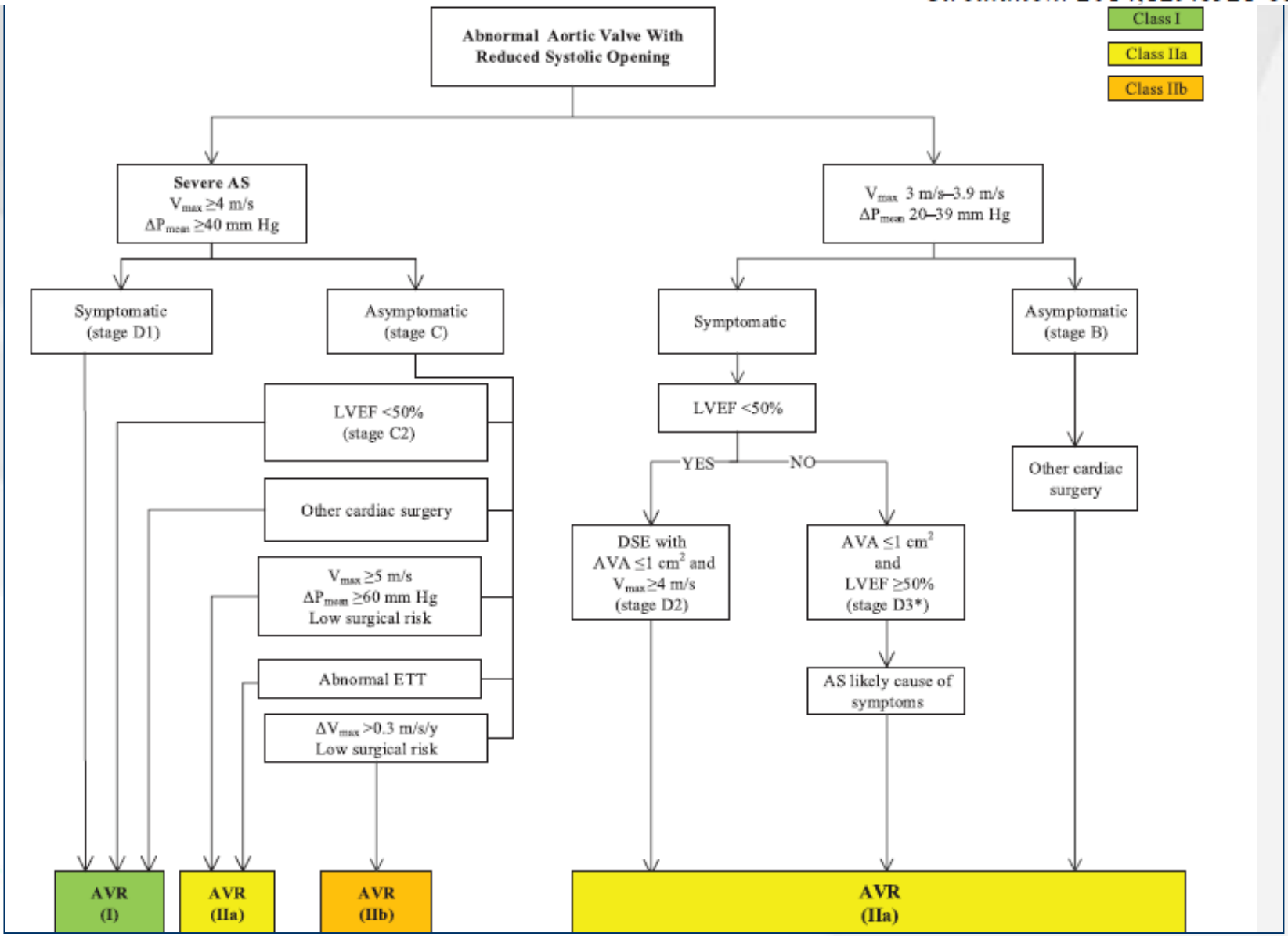
The early lesions of calcific degenerative disease resemble coronary atheroma and many of the risk factors for AS are common to other atheroscerotic process

Around 16% of patients with aortic sclerosis progress to stenosis within 7 years.

The rate of progression varies, but the average reduction in orfice area is 0.1 cm2 each years

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

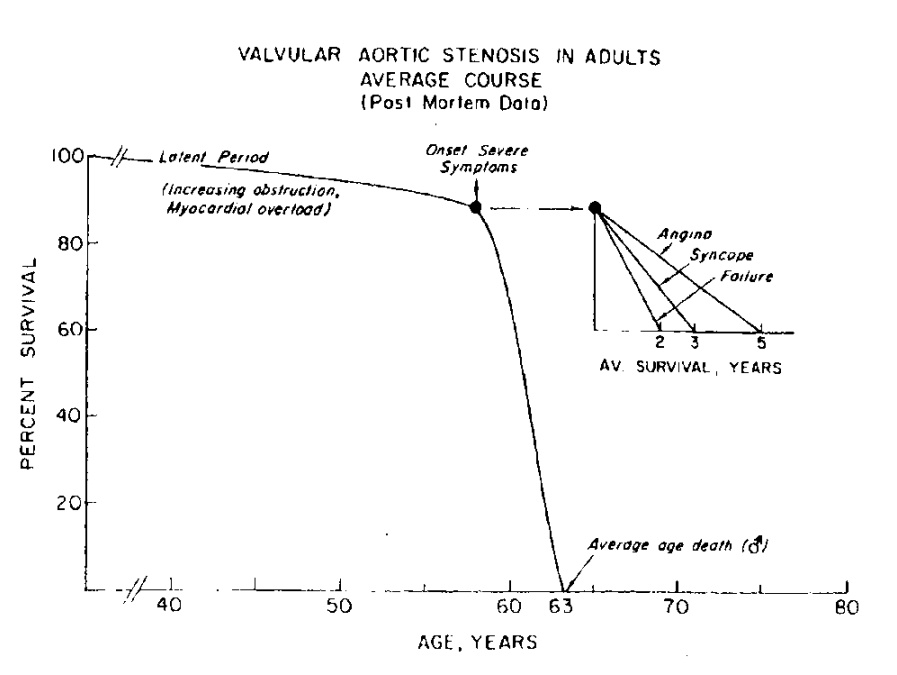
Circulation. 2014;129:e521-e643;

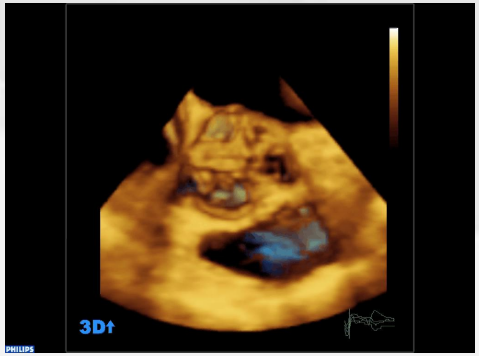


2014 AHA/ACC Guideline for the Management of Patients With Valvular Heart Disease: A Report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines

Circulation. 2014;129:e521-e643;

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 • AVA typically ≤1.0 cm² (or AVAi ≤0.6 cm²/m²) but may be larger with mixed AS/AR	• LV diastolic dysfunction • LV hypertrophy • Pulmonary hypertension may be present	• Exertional dyspnea or decreased exercise tolerance • Exertional angina • Exertional syncope or presyncope





Ross J Jr, Braunwald E. *Circulation* 1968

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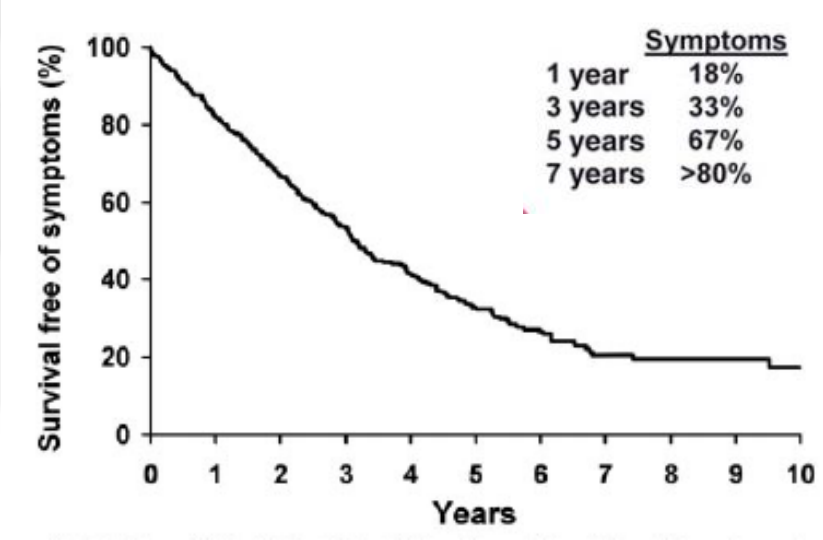
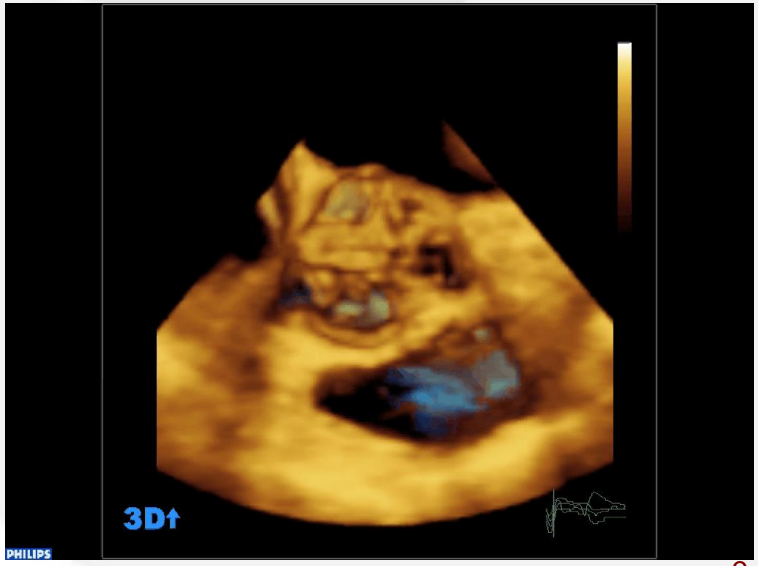
Asymptomatic Aortic Valve Stenosis: Natural History

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 • AVA typically is ≤1.0 cm² (or AVAi ≤0.6 cm²/m²) • Very severe AS is an aortic V_{max} ≥5 m/s or mean ΔP ≥60 mm Hg	• LV diastolic dysfunction • Mild LV hypertrophy • Normal LVEF	• None: Exercise testing is reasonable to confirm symptom status
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 • AVA typically ≤1.0 cm² (or AVAi ≤0.6 cm²/m²)	• LVEF <50%	• None



Pellikka et al Circulation 2005

Only **33%** of patients with severe aortic stenosis remains **asymptomatic after 5 years**



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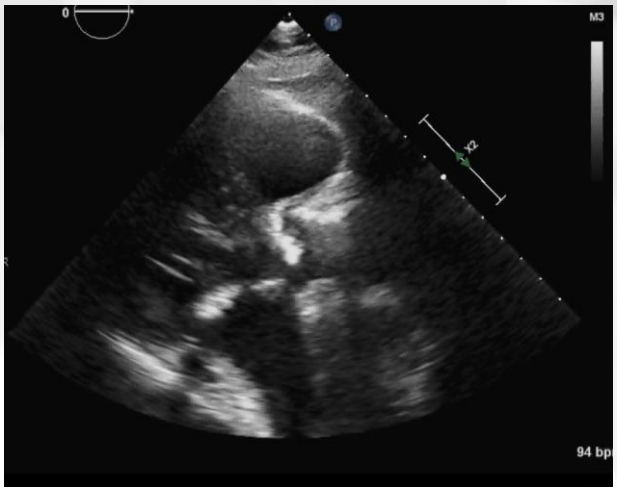
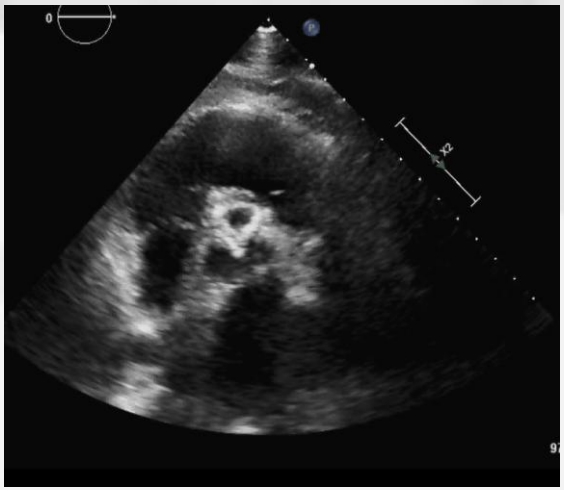
Echocardiographic assessment of the Aortic valve Stenosis

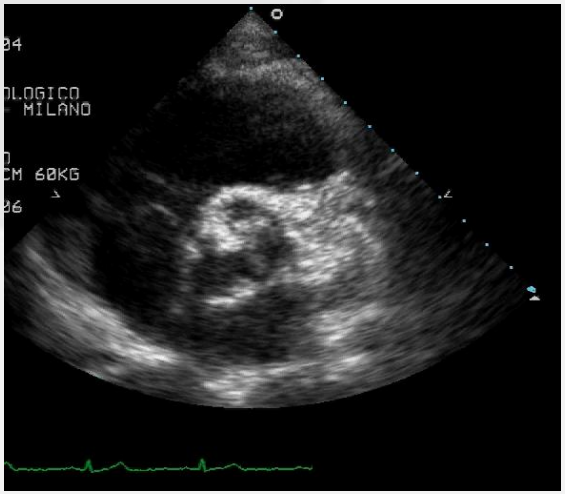
Valve anatomy:

- Parasternal long and short axis view
- Zoom mode

Identify number of cusps in systole
Assess cusp mobility
Assess valve calcification





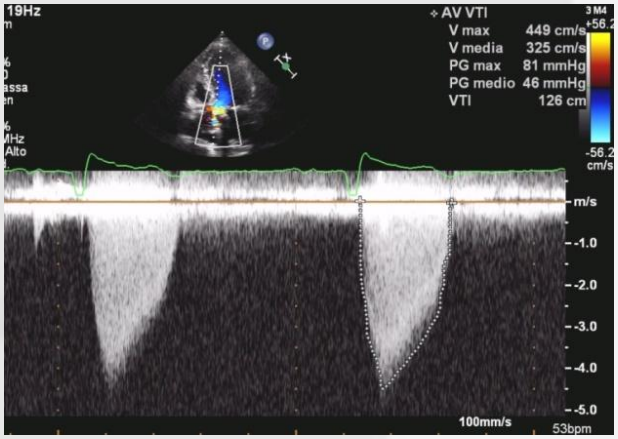


Echocardiographic assessment of the Aortic valve Stenosis: Doppler evaluation

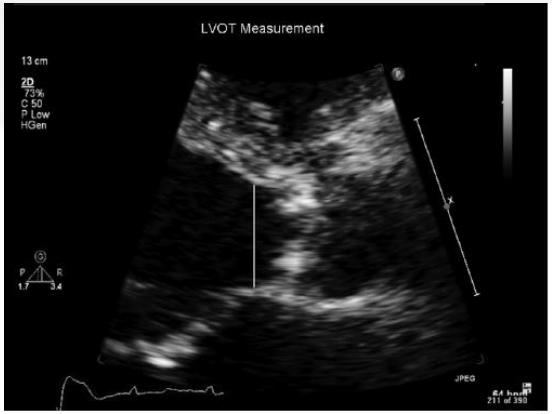
Table 2 Grading aortic stenosis

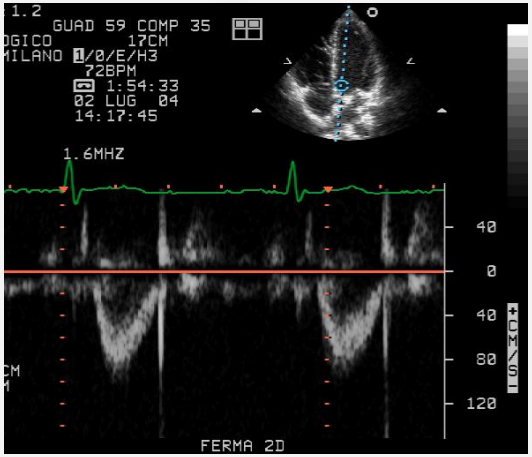
	Mild	Moderate	Severe
AoV_{max} (m/s)	2.5–3.0	3.0–4.0	>4.0
Peak gradient (mmHg)	<40	40–65	>65
Mean gradient (mmHg)	<20	20–40 (50)[a]	>40 (50)[a]
EOA (cont eq) (cm^2)	>1.5	1.0–1.5	<1.0
EOAi (cm^2/m^2)	>0.85	0.60–0.85	<0.60
Velocity ratio	>0.50	0.25–0.50	<0.25

[a]EAE guidelines only,[20] otherwise both EAE and ASE.[19,20]



$$EOA = \frac{VTI_{LVOT}}{VTI_{AO}} \times AREA_{LVOT}$$





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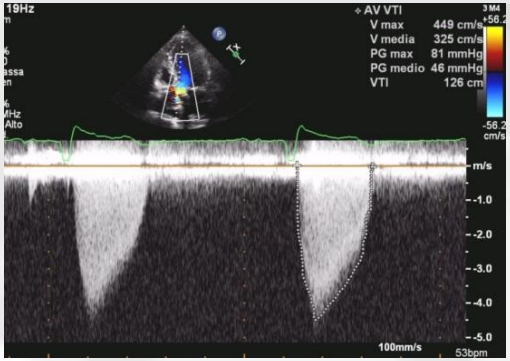
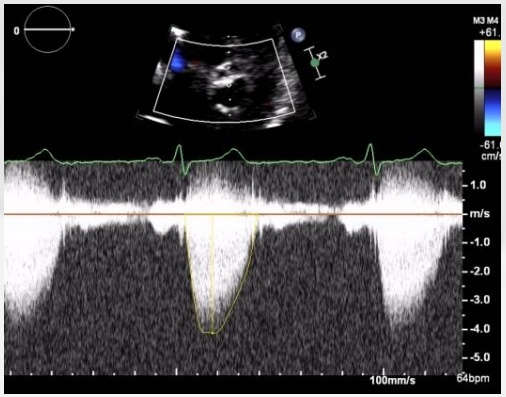
Echocardiographic assessment of valve stenosis: EAE/ASE recommendations for clinical practice

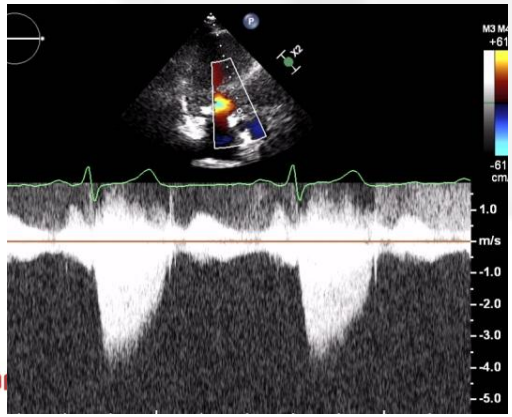
European Journal of Echocardiography (2009) 10, 1–25

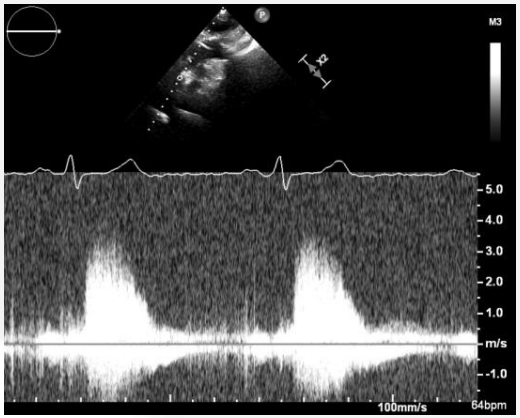
AS jet velocity

- CW Doppler (dedicated transducer)
- Multiple acoustic windows (e.g. apical, suprasternal, right parasternal, etc)
- Decrease gains, increase wall filter, adjust baseline, and scale to optimize signal
- Gray scale spectral display with expanded time scale
- Velocity range and baseline adjusted so velocity signal fits but fills the vertical scale
- Maximum velocity at peak of dense velocity curve
- Avoid noise and fine linear signals
- VTI traced from outer edge of dense signal curve
- Mean gradient calculated from traced velocity curve
- Report window where maximum velocity obtained









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Echocardiographic assessment of the Aortic valve Stenosis: Continuity equation

$$SV_{AV} = SV_{LVOT}.$$

Because volume flow rate through any CSA is equal to the CSA times flow velocity over the ejection period (the VTI of the systolic velocity curve), this equation can be rewritten as:

$$AVA \times VTI_{AV} = CSA_{LVOT} \times VTI_{LVOT}$$

Solving for AVA yields the continuity equation[14,15]

$$AVA = \frac{CSA_{LVOT} \times VTI_{LVOT}}{VTI_{AV}}$$

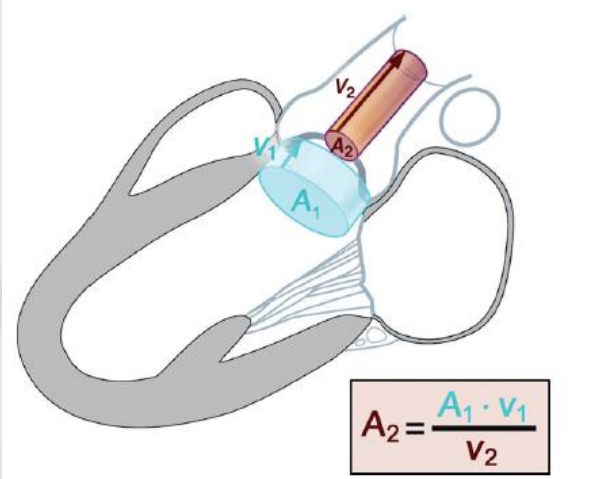
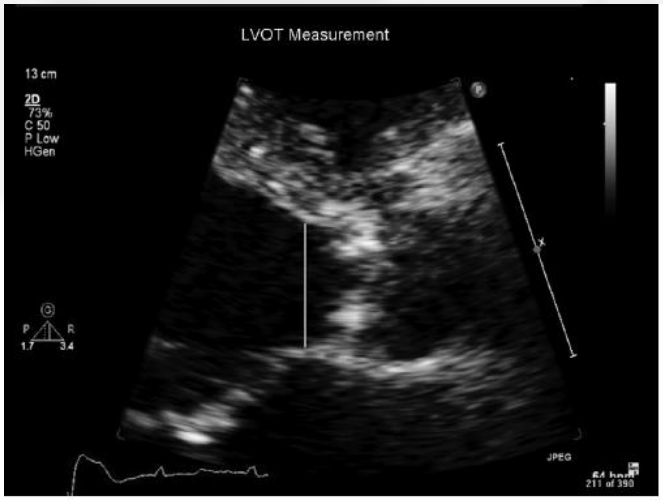
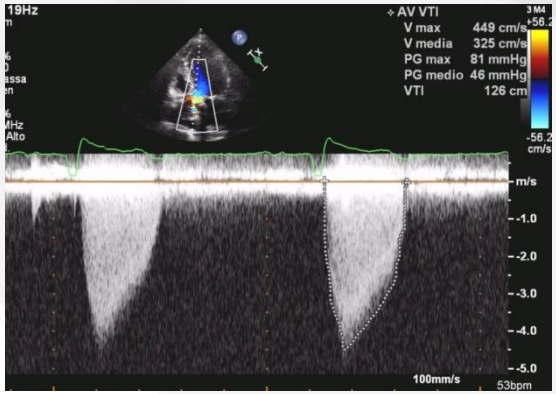
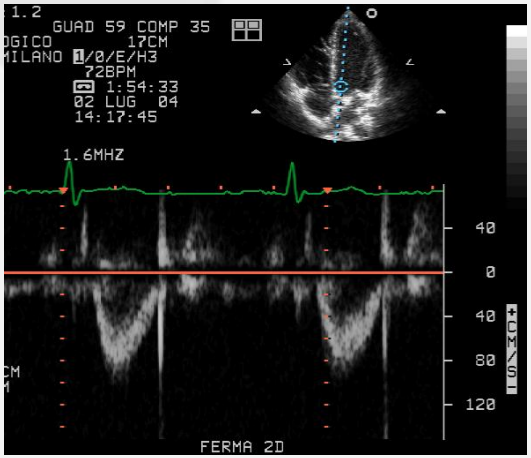


Figure 4 Schematic diagram of continuity equation.







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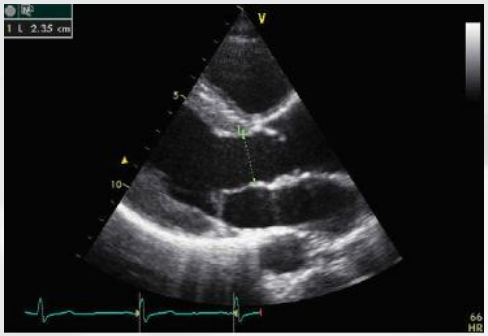
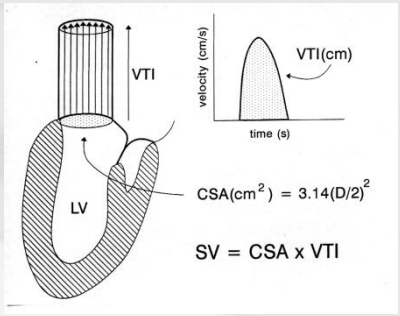
Echocardiographic assessment of valve stenosis: EAE/ASE recommendations for clinical practice

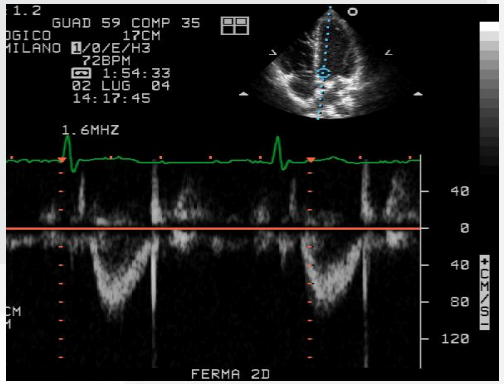
European Journal of Echocardiography (2009) 10, 1–25

Table 1 Recommendations for data recording and measurement for AS quantitation

Data element	Recording	Measurement
LVOT diameter	• 2D parasternal long-axis view • Zoom mode • Adjust gain to optimize the blood tissue interface	• Inner edge to inner edge • Mid-systole • Parallel and adjacent to the aortic valve or at the site of velocity measurement (see text) • Diameter is used to calculate a circular CSA
LVOT velocity	• Pulsed-wave Doppler • Apical long axis or five-chamber view • Sample volume positioned just on LV side of valve and moved carefully into the LVOT if required to obtain laminar flow curve • Velocity baseline and scale adjusted to maximize size of velocity curve • Time axis (sweep speed) 100 mm/s • Low wall filter setting • Smooth velocity curve with a well-defined peak and a narrow velocity range at peak velocity	• Maximum velocity from peak of dense velocity curve • VTI traced from modal velocity







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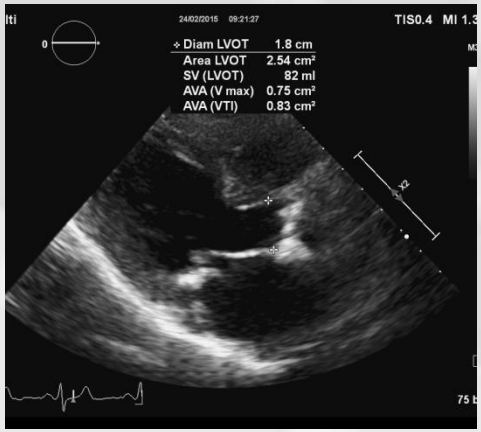
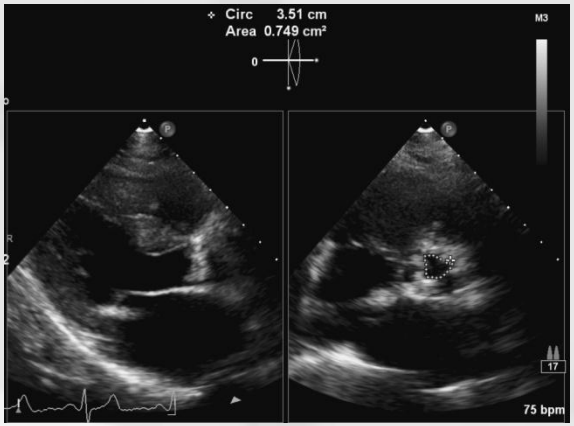
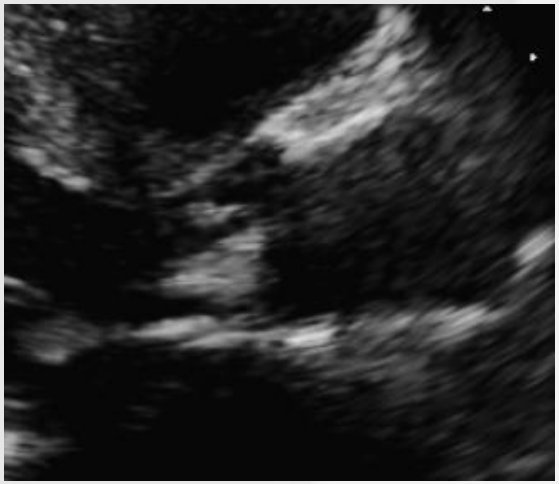
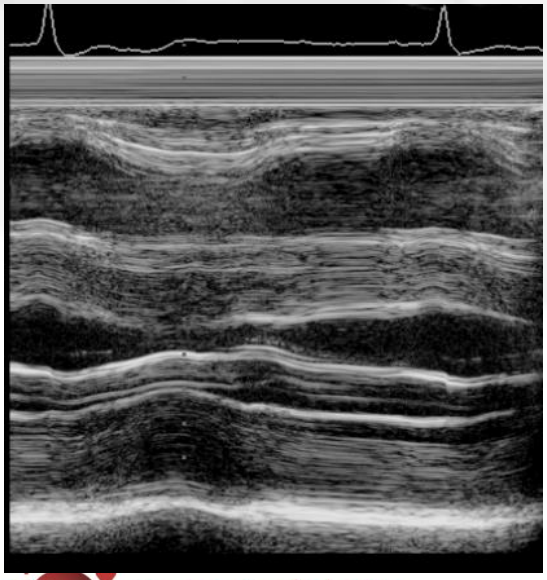
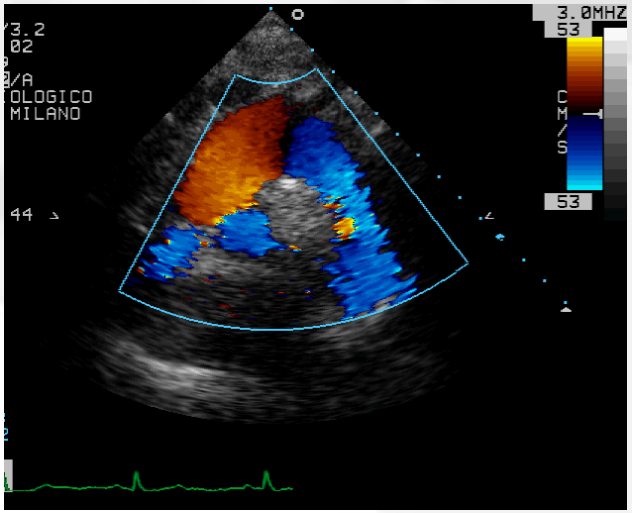
AS: Vmax > 4 m/sec, DP mean > 40 mmHg, EOA < 1 cm2,

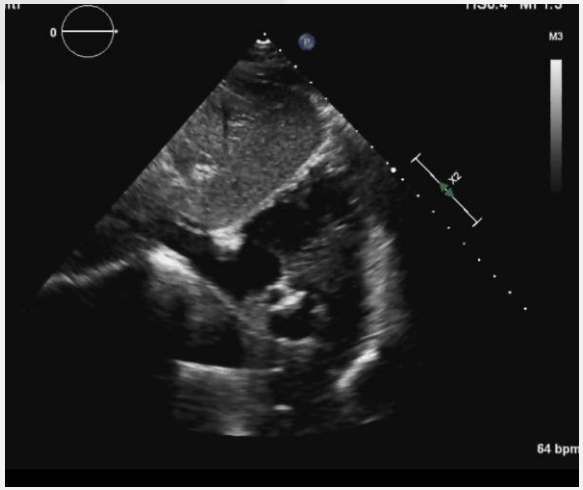












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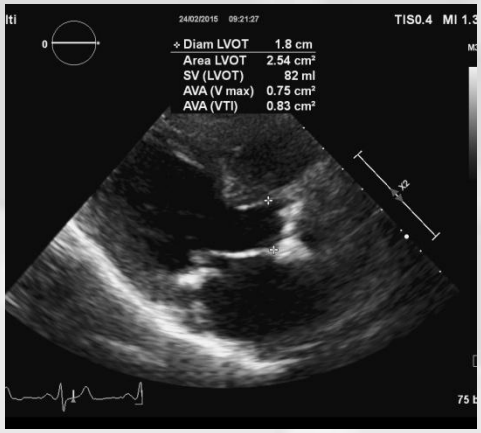
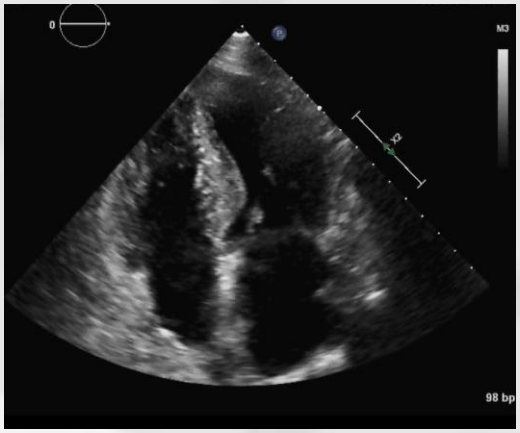
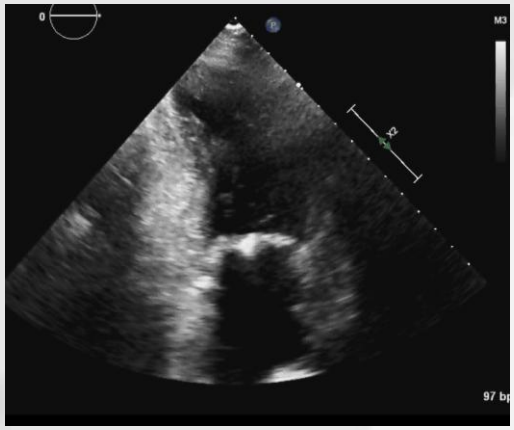
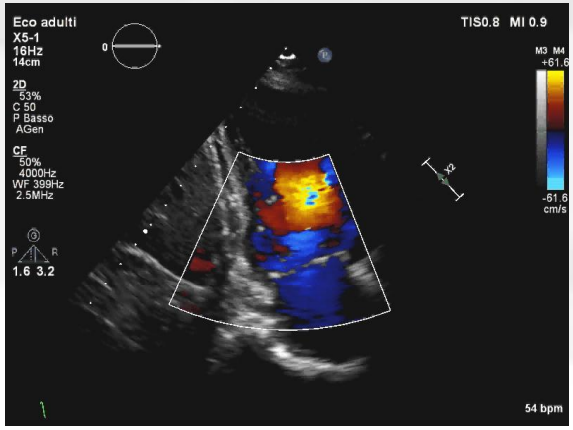
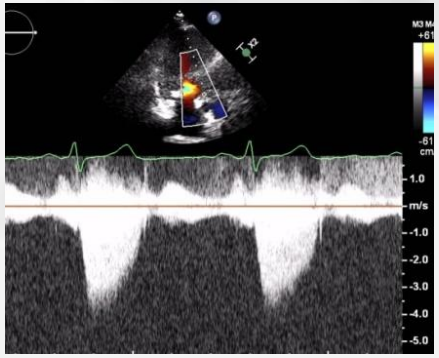
AS: Vmax > 4 m/sec, DP mean > 40 mmHg, EOA < 1 cm2,

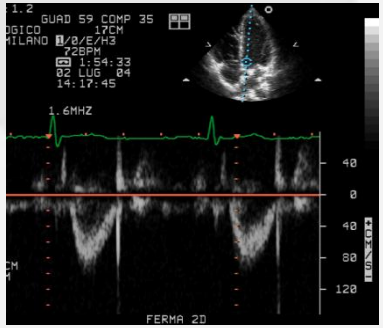


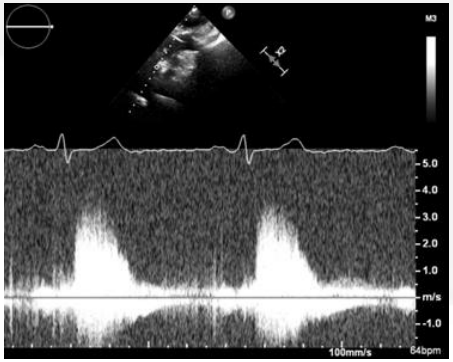


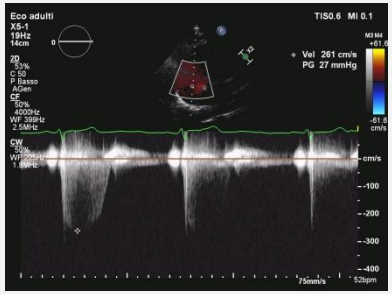












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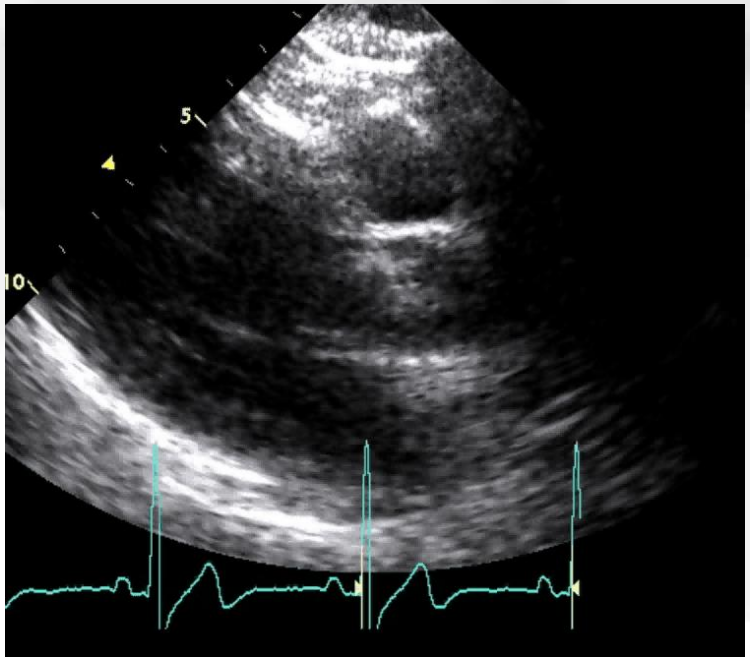
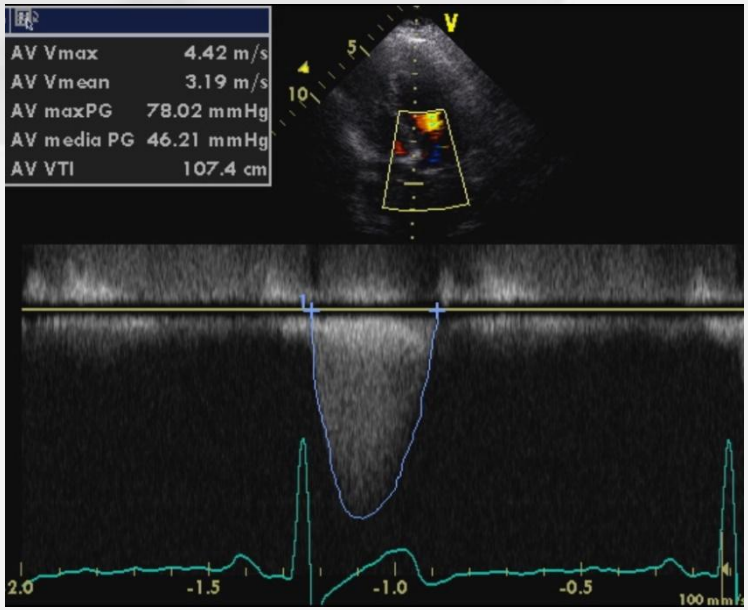
AS: *The problem of Vmax > 4 m/sec and EOA > 1 cm2*

Likely causes:
a) High output state
b) Moderate-severe AR
c) Large body size (EOAi < 0.6 cm2/m2)

Check the valve appearance
Check the LVOT





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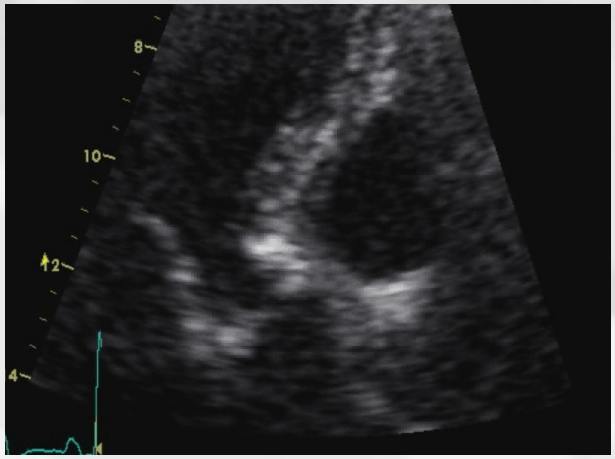
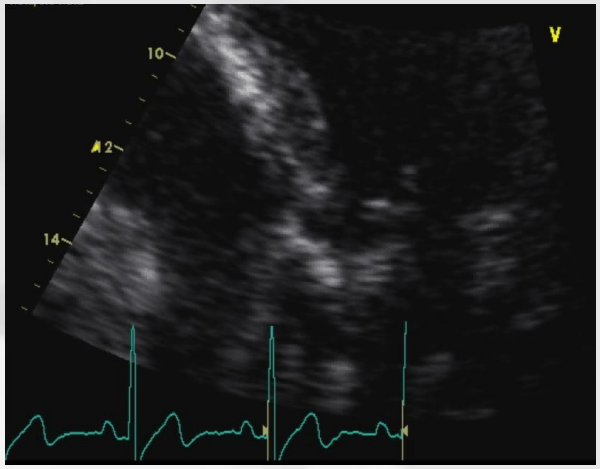
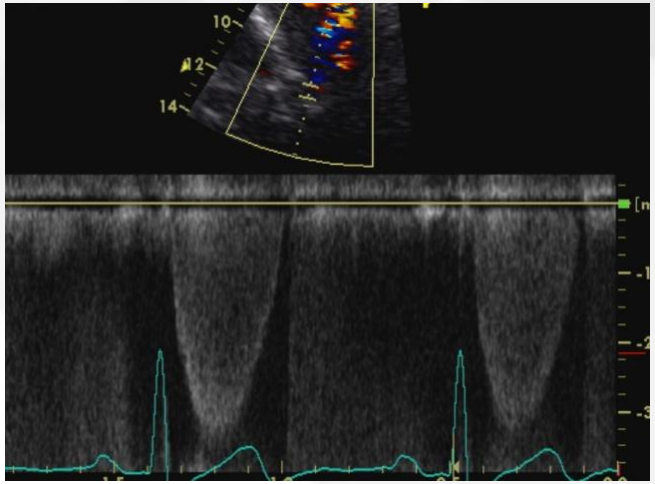
AS: The problem of Vmax > 4 m/sec and EOA > 1 cm2

Subvalvular aortic stenosis







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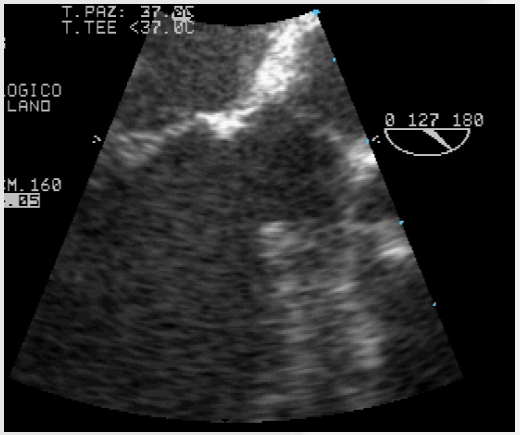
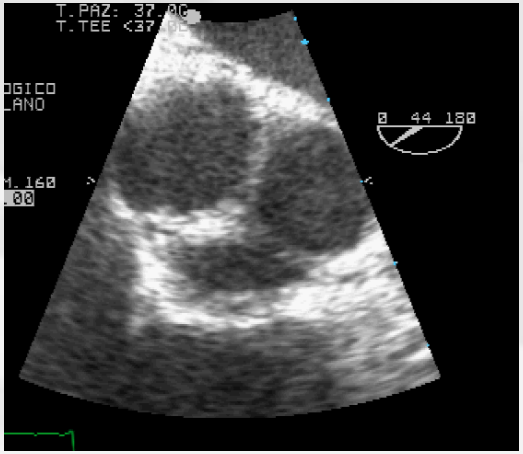
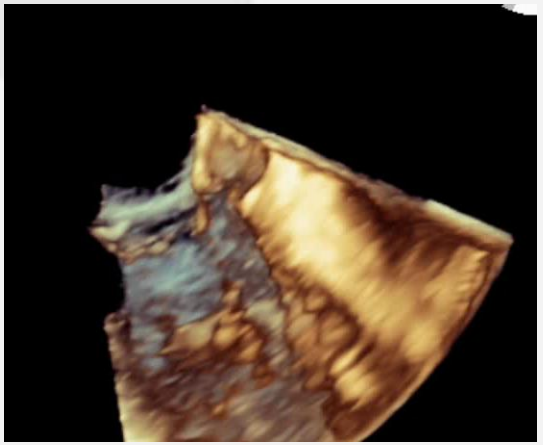
AS: *The problem of Vmax > 4 m/sec and EOA > 1 cm2*

Subvalvular aortic stenosis

- Thin , fibrous membrane or ridge that forms a crescentic barrier within the LVOT
- The membrane usualy extends from the anterior septum to the anterior MV
- The cusps of the aortic valve are thickened, without significant valve stenosis
- very frequently (50%) aortic regurgitation coexists







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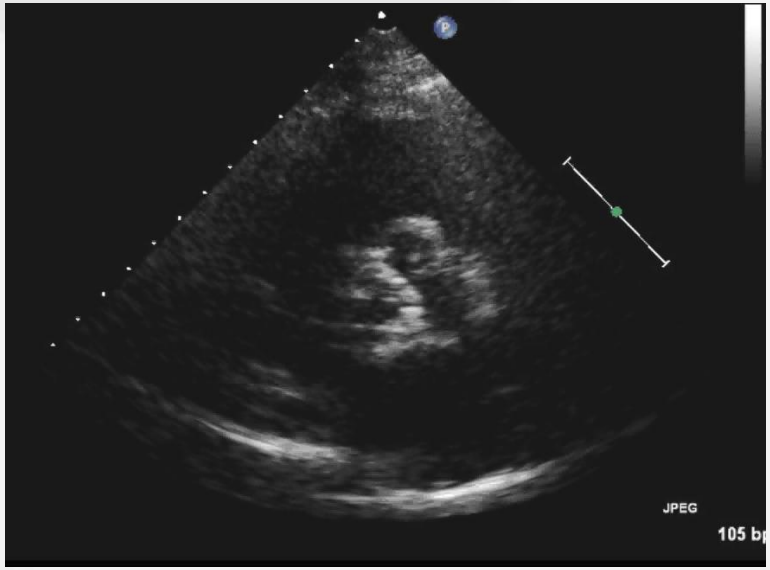
AS: *The problem of Vmax < 4 m/sec, and EOA < 1 cm2*

Likely causes: a) Low cardiac output (FE < 40%; Severe MR; Mitral stenosis)
b) Small body size (EOAi > 0.6 cm2/m2)

Check the valve appearance
Check the LVOT



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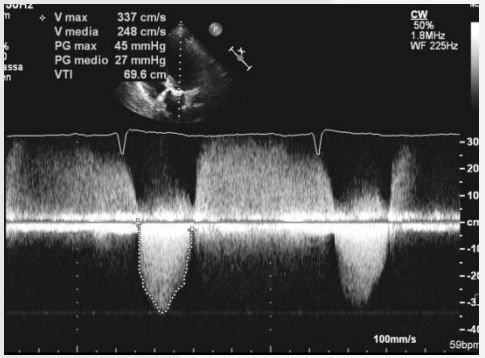
AS: *The problem of Vmax < 4 m/sec, and EOA < 1 cm2*

D2	Symptomatic severe low-flow/low-gradient AS with reduced LVEF	• Severe leaflet calcification with severely reduced leaflet motion	• AVA ≤1.0 cm² with resting aortic V_{max} <4 m/s or mean ΔP <40 mm Hg • Dobutamine stress echocardiography shows AVA ≤1.0 cm² with V_{max} ≥4 m/s at any flow rate	• LV diastolic dysfunction • LV hypertrophy • LVEF <50%	• HF • Angina • Syncope or presyncope

Low transaortic flow volume:

- Stroke volume < 35 ml/m2; EF < 40%



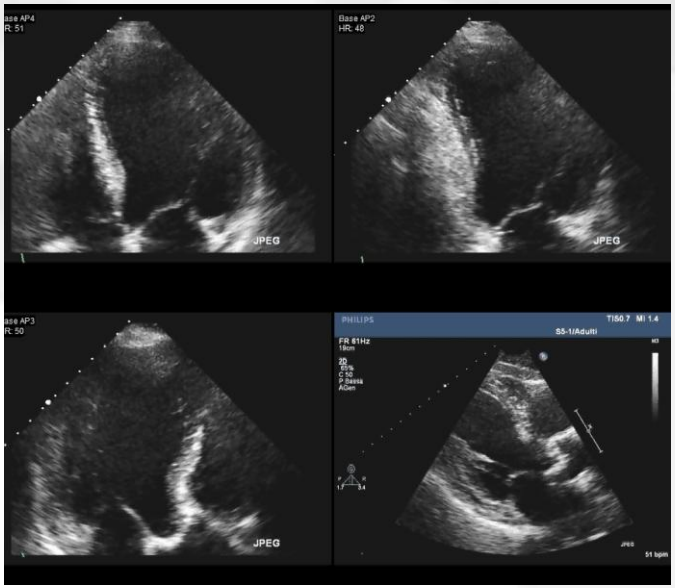
FE < 40%

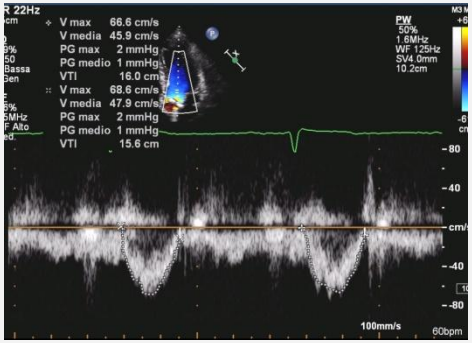
SV 35 ml/m2

Dp max 45 mmHg

Dp mean 27 mmHg

AVA 0,68 cm2





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Dobutamine Stress-Echocardiography (DSE): Vmax < 4 m/sec, EOA < 1 cm2; FE < 50%

Dobutamine Low dose : 5-20 gamma/kg/min

PARAMETERS:

- Stroke volume
- Mean Gradient
- Aortic Area

True –Severe AS:

Δ AVA ≤ 0. 3 cm2 or

AVA ≤ 1-1.2 cm2

Peak stress mean gradient > 30 mmHg

LV flow reserve:

Δ SV > 20 %

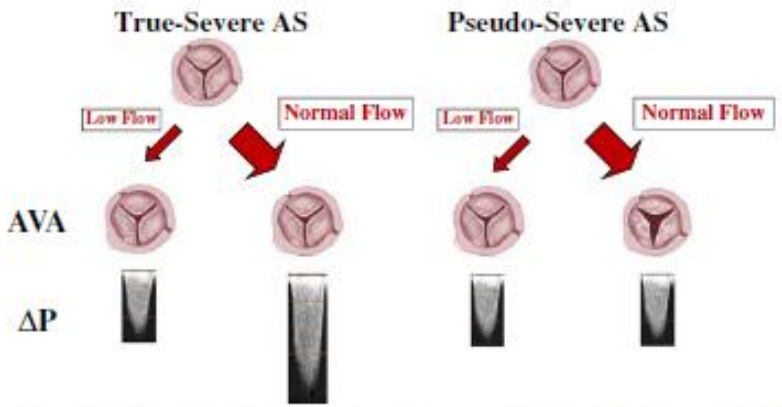

Figure 2. The behavior of aortic valve area (AVA) and transvalvular gradient (ΔP) with increasing flow in true-severe versus pseudosevere aortic stenosis (AS).

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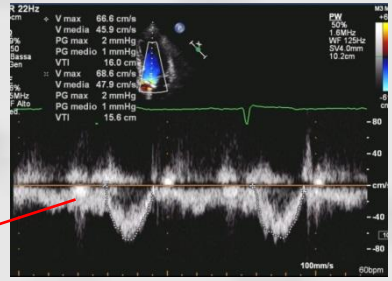
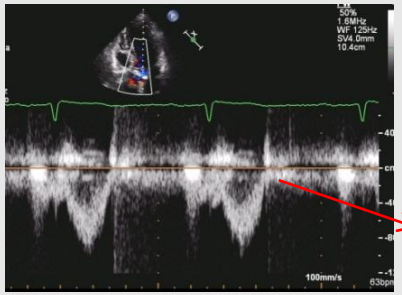
Dobutamine stress-echocardiography (DSE): Vmax < 4 m/sec, EOA < 1 cm2; FE < 50%

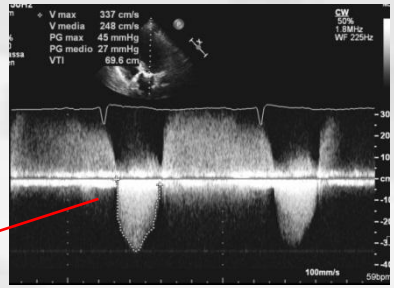
REST *PEAK STRESS*

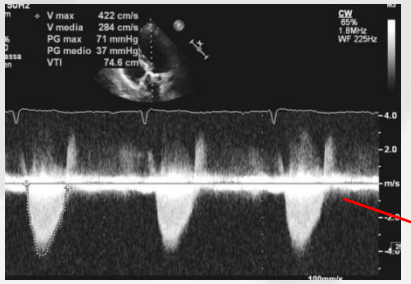




LVOT VTI 15 cm

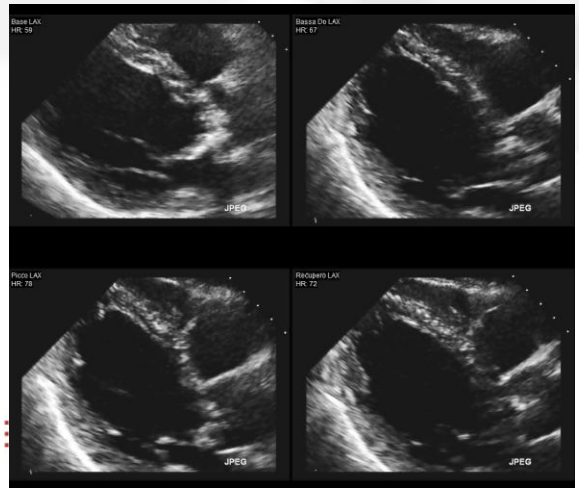
LVOT VTI 21 cm





AO VTI 69 cm
DP 27 mmHg

AO VTI 75 cm
DP 37 mmHg



SV 35 ml/m2
AVA 0,68 cm2

SV 52 ml/m2
AVA 0,87 cm2

Δ SV > 20 %: LV flow reserve

Δ Area < 0,3 cm2 and Area < 1 cm2 : True Aortic Stenosis

Outcome After Aortic Valve Replacement for Low-Flow/Low-Gradient Aortic Stenosis Without Contractile Reserve on Dobutamine Stress Echocardiography

(J Am Coll Cardiol 2009;53:1865–73)

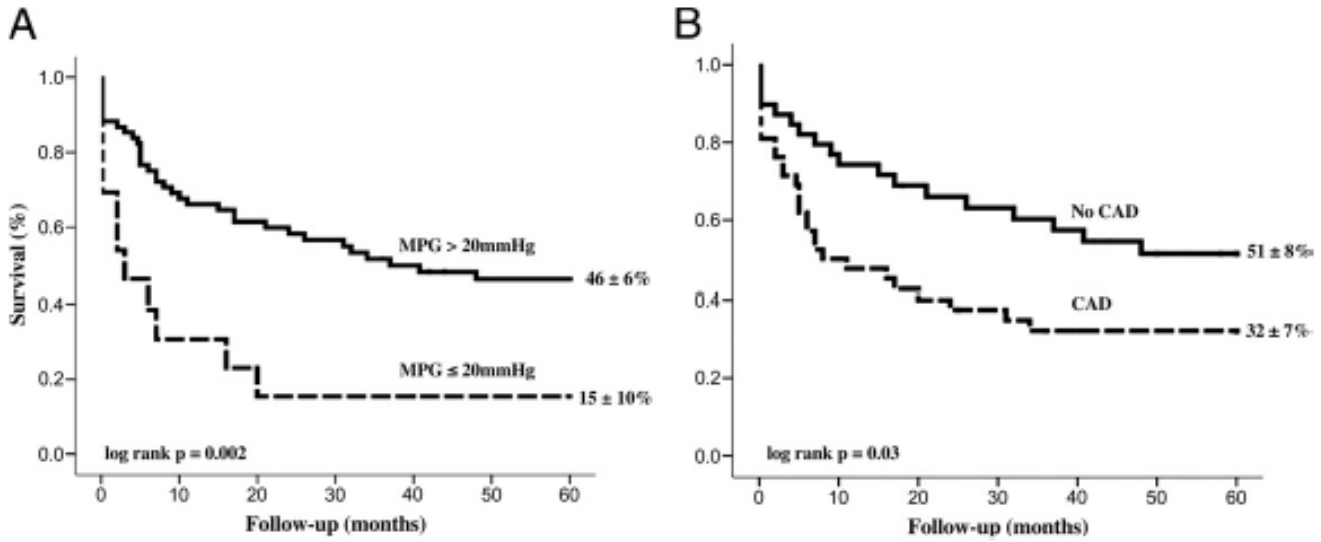


Figure 2 **Influence of MPG and CAD on Survival in LF/LGAS Patients Without CR on DSE**

Kaplan-Meier estimates of the probability of survival of the total population (n = 81) according to: **(A)** mean pre-operative transvalvular gradient (MPG) ≤20 and >20 mm Hg, and **(B)** presence of significant coronary artery disease (CAD). Abbreviations as in Figure 1.

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AS: *The problem of Vmax < 4 m/sec, and EOA < 1 cm2*

D3	Symptomatic severe low-gradient AS with normal LVEF or paradoxical low-flow severe AS	• Severe leaflet calcification with severely reduced leaflet motion	• AVA ≤1.0 cm² with aortic V_{max} <4 m/s or mean ΔP <40 mm Hg • Indexed AVA ≤0.6 cm²/m² and • Stroke volume index <35 mL/m² • Measured when patient is normotensive (systolic BP <140 mm Hg)	• Increased LV relative wall thickness • Small LV chamber with low stroke volume • Restrictive diastolic filling LVEF ≥50%	• HF • Angina • Syncope or presyncope

Low transaortic flow volume:

- Stroke volume < 35 ml/m2; EF ≥ 50%;

- MR or Small LV Chamber with low SV

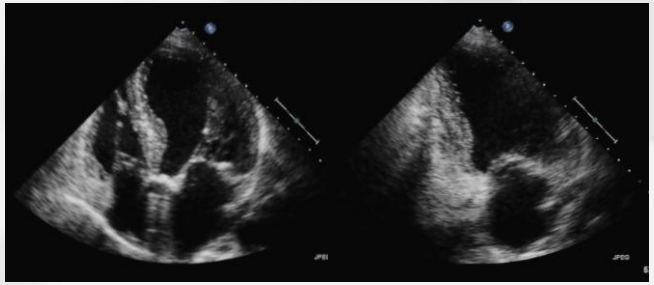
FE = 50%

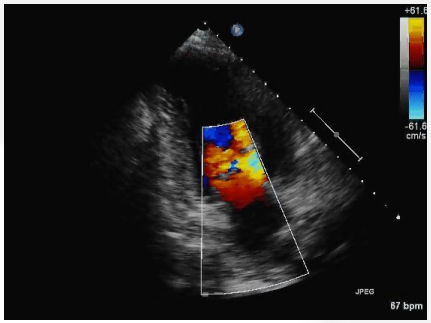
SV < 35 ml/m2

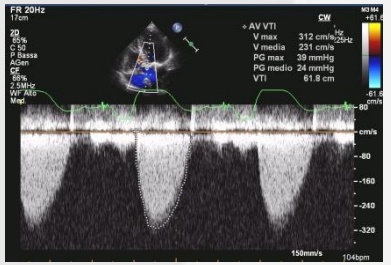
Dp max 39 mmHg

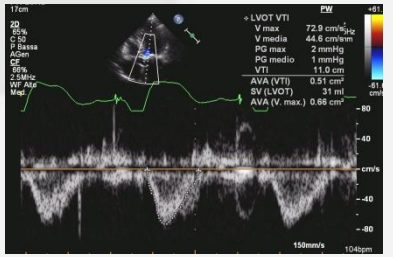
Dp med 24 mmHg

AVA 0,51 cm2









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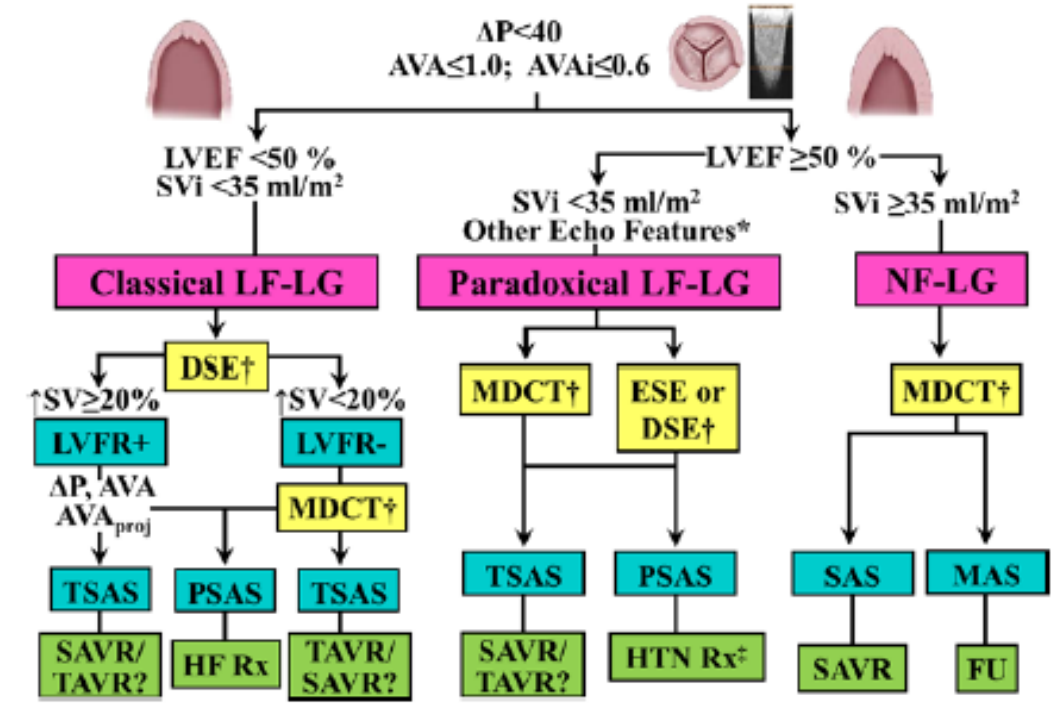
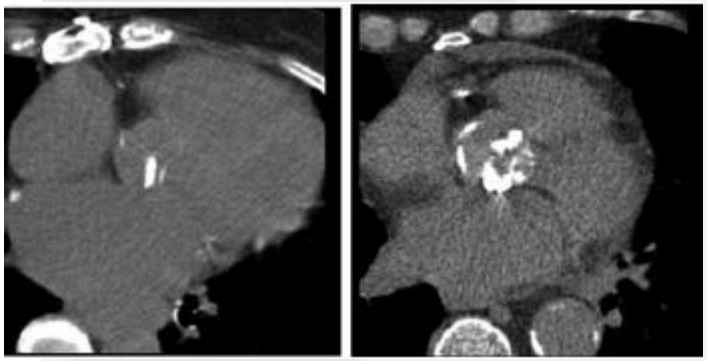
Aortic Stenosis Suspected to Be Severe Despite Low Gradients

Circ Cardiovasc Imaging. 2014;7:545-551





LF-LG and NF–LG patients: quantification of valve calcification by multislice computed tomography may be useful.

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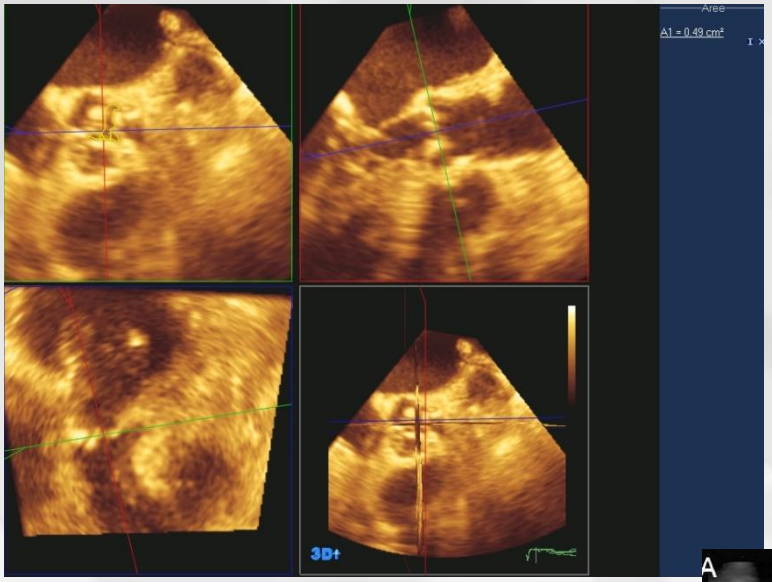
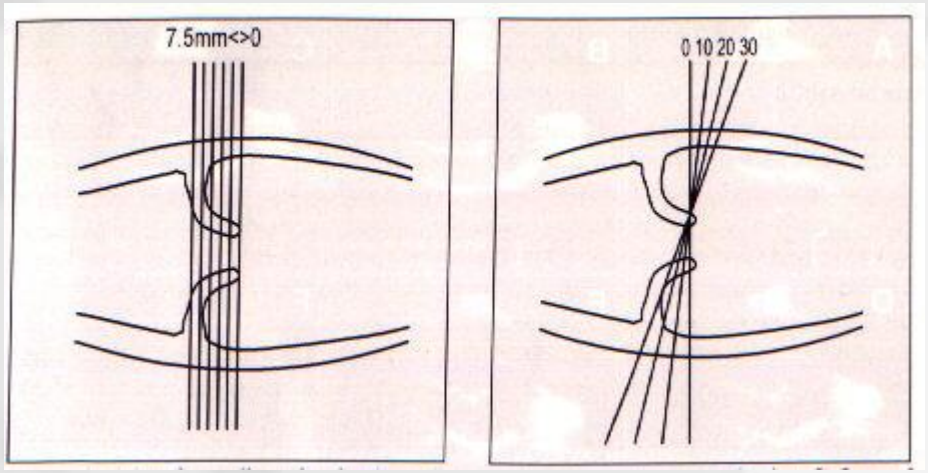
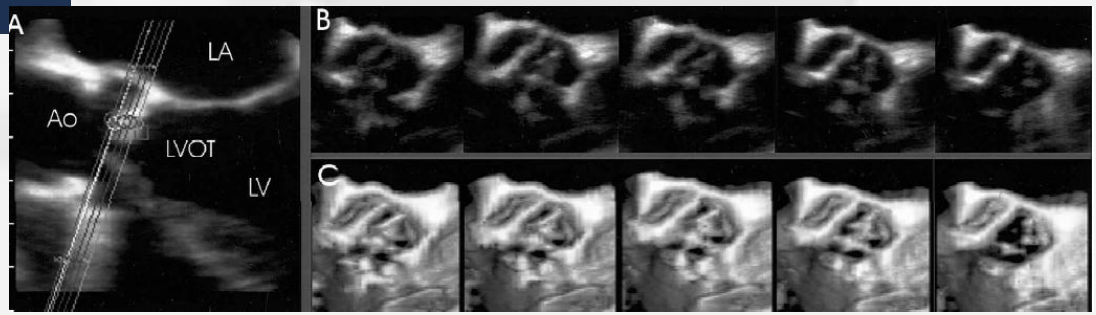
3D Role: Aortic valve planimetry







Handke M. et al. Echocardiography 2002

3D Echocardiography: facilitates measurements of the orificial stenotic area (improvement of the planimetric area evaluation)

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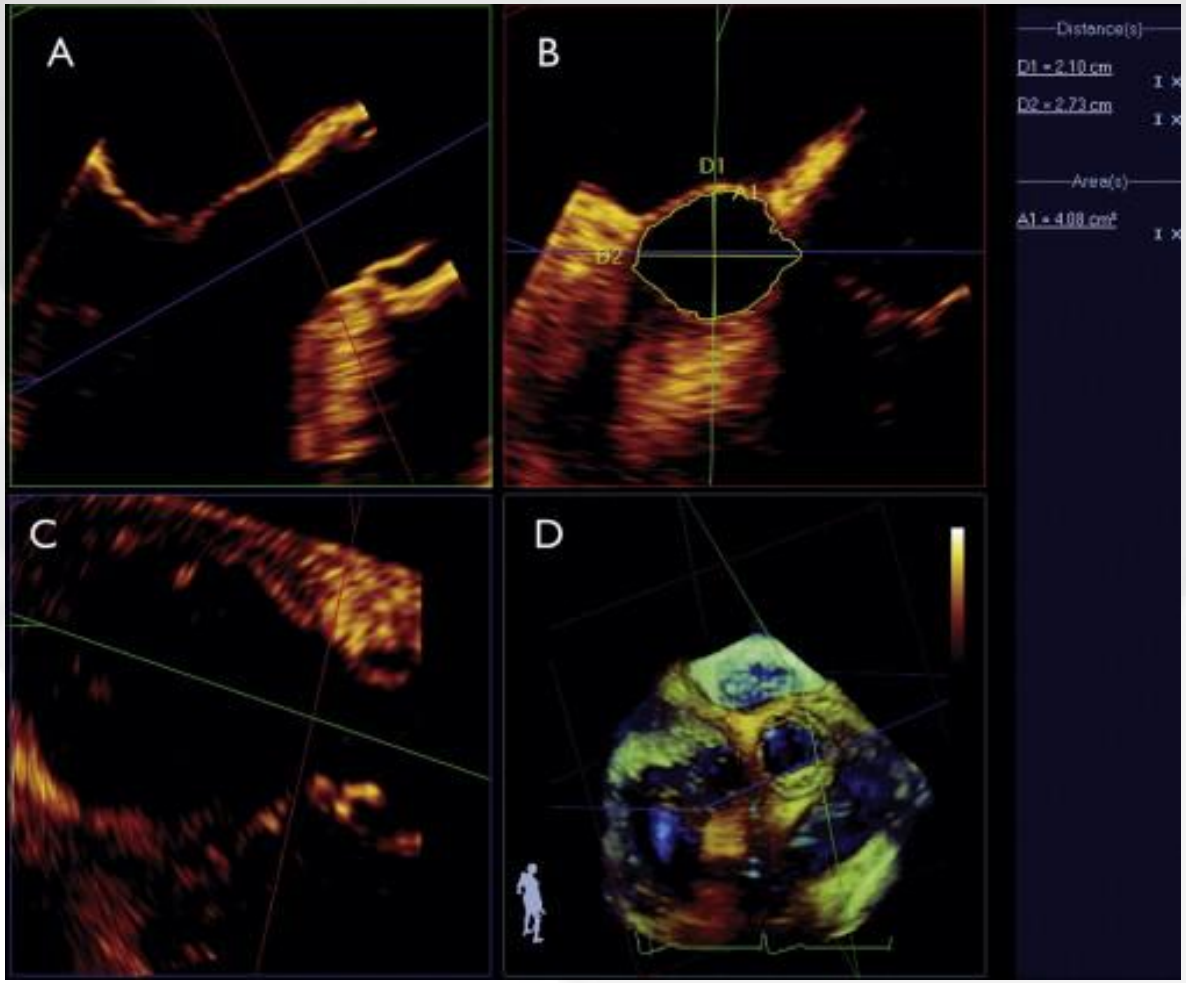
Impact of Three-Dimensional Echocardiography on Classification of the Severity of Aortic Stenosis

(Ann Thorac Surg 2013;96:1343–8)



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Quantification of Aortic Valve Area Using Three-Dimensional Echocardiography. Leopoldo Pérez et al. Rev Esp Cardiof 2010

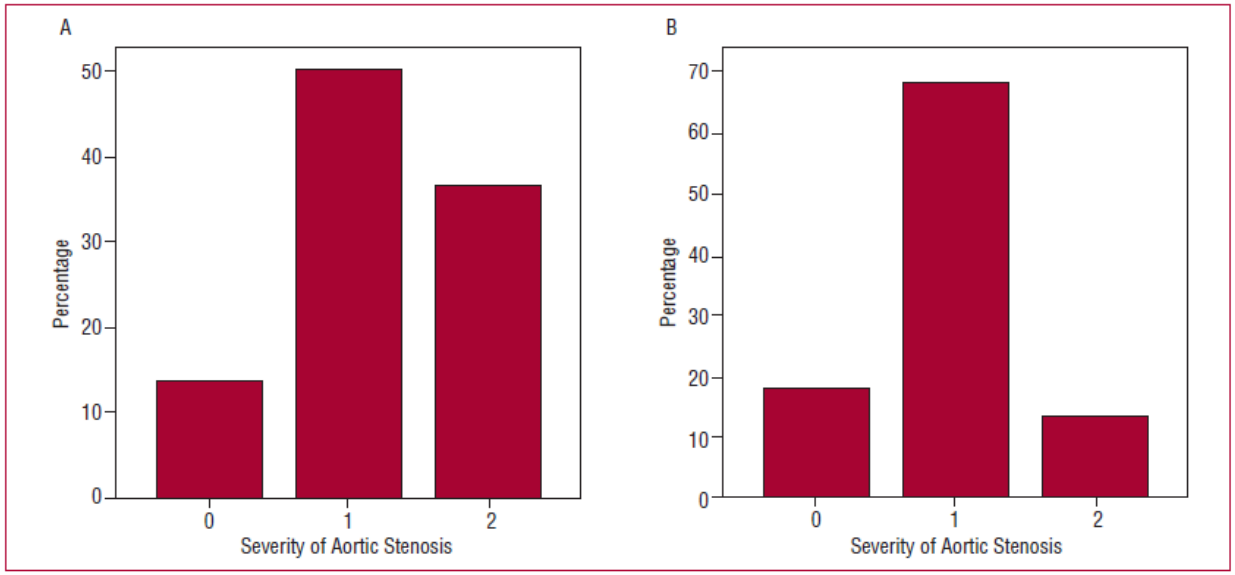

Figure 3. Severity of aortic valve stenosis using the estimate of the left ventricular outflow tract area. A: with 2-dimensional echocardiography. B: with 3-dimensional echocardiography. Horizontal axis, 0: valve area >1 cm^2; 1: valve area, 1-0.75 cm^2; 2: valve area <0.75 cm^2.

Measurement of the LVOT area using 3D-echo is more reproducible than with 2D-echo. Therefore, this is probably a more accurate method for the evaluation of LVOT area. 3D-echo techniques show that the LVOT has an elliptical form and that its circularity does not depend on size. It may be that 3D-echo can provide a more accurate classification of the degree of severity of aortic valve stenosis than 2D-echo techniques.

European Heart Journal (2008) 29, 1296–1306
doi:10.1093/eurheartj/ehm467

CLINICAL RESEARCH
Imaging

Real-time three-dimensional echocardiography in aortic stenosis: a novel, simple, and reliable method to improve accuracy in area calculation

Juan Luis Gutiérrez-Chico[1]*, José Luis Zamorano[2], Elsa Prieto-Moriche[2], Rosa Ana Hernández-Antolín[2], Marisol Bravo-Amaro[1], Leopoldo Pérez de Isla[2], Marcelo Sanmartín-Fernández[1], José Antonio Baz-Alonso[1], and Andrés Íñiguez-Romo[1]

$$\text{Aortic area (cm}^2) = \frac{SV_{3D\ (cm^3)}}{TVI_{Ao\ (cm)}}$$

SV_{3D} : stroke volume by 3D
TVI_{Ao} : time-velocity integral by Doppler in the aortic valve

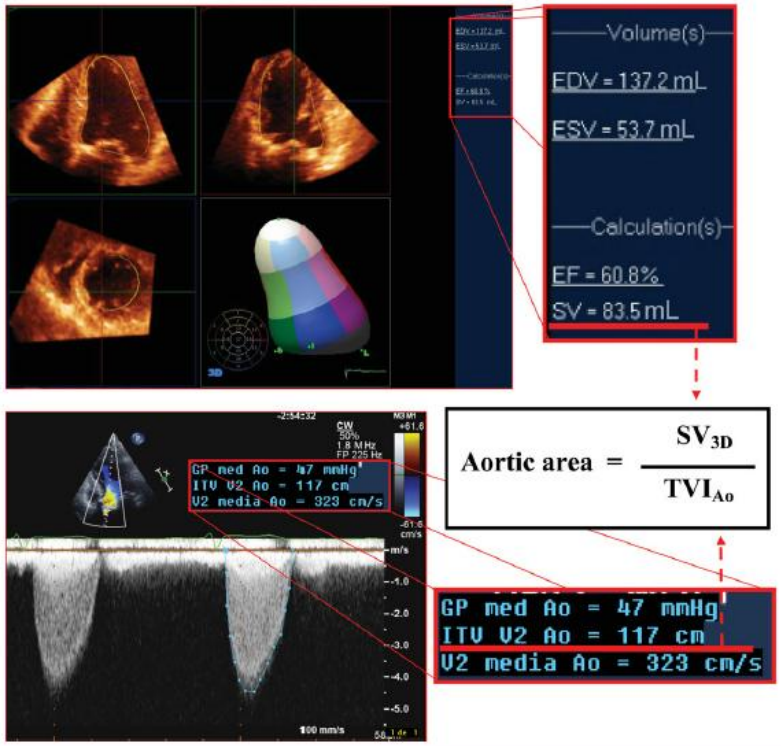

Figure 1 Formula for aortic area calculation with three-dimensional echo, proposed by Gutiérrez *et al*[18]

Conclusions RT3D is more accurate than CE and than two-dimensional volumetric methods to calculate area and to grade the severity of aortic stenosis. Area obtained by three-dimensional echo is slightly underestimated, but its range is clinically negligible.

CONCLUSIONS: ECHOCARDIOGRAPHIC ASSESSMENT OF AORTIC VALVE STENOSIS

- 2D and 3D valve anatomy
- 3D can be useful in SV evaluation and LVOT area
- DSE/TAC and RMN are complementary test to identify True aortic stenosis vs pseudo aortic stenosis in the presence of Low flow-Low gradient aortic stenosis .