



**ECOCARDIOCHIRURGIA®**  
ECO-RM-TC CHIRURGIA-INTERVENTISTICA

***IL PARTICOLARE PROBLEMA DELLA STENOSI  
VALVOLARE AORTICA LOW FLOW  
LOW GRADIENT CON FE CONSERVATA***

Dott.ssa Chiara Bencini

Ospedale Bassini – ICP

Milano

# VALUTAZIONE DI SEVERITA' DELLA STENOSI AORTICA



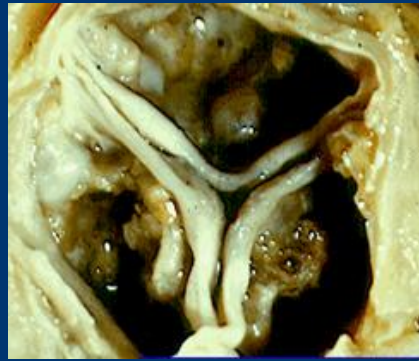
## *Aspetto della valvola*

- cuspidi molto ispessite
- estese calcificazioni
- cuspidi immobili

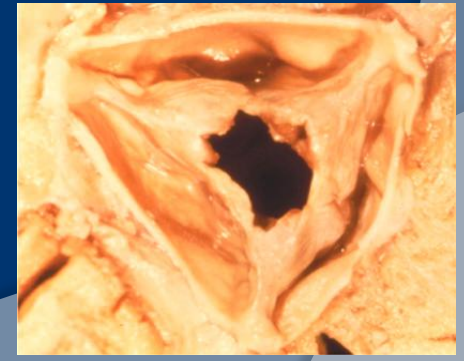
Suggeriscono stenosi aortica severa



BICUSPIDE



STENOSI DEGENERATIVA

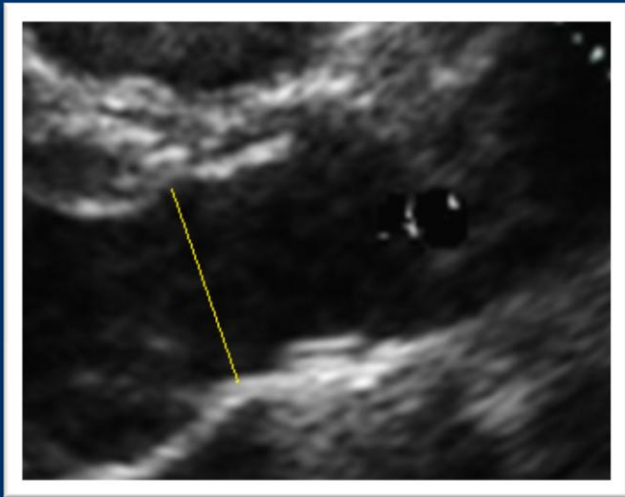


STENOSI REUMATICA

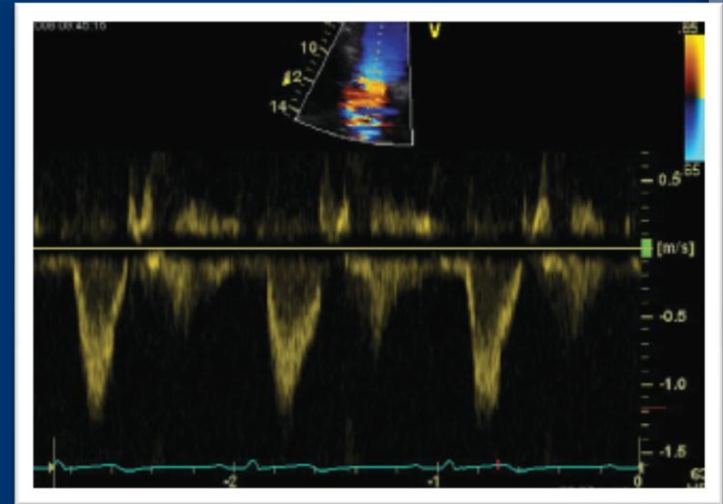
# VALUTAZIONE DI SEVERITA' DELLA STENOSI AORTICA

L'area valvolare aortica si deriva con l'equazione di continuità: importante perché relativamente indipendente dal flusso

$$AVA = 3.14 \times (D/2)^2 \times VTI_{TEVS} / VTI_{AO}$$

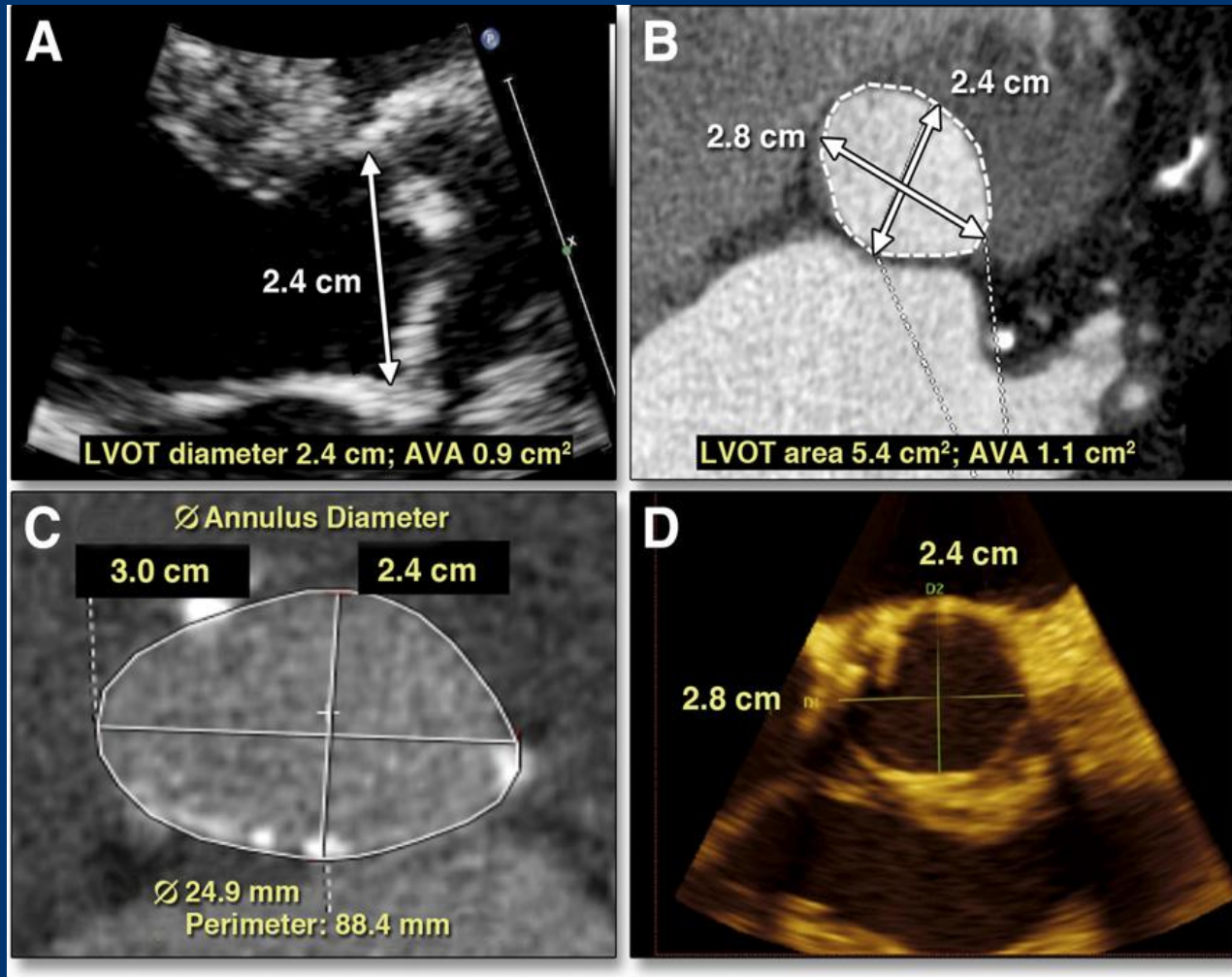


ILTEVS si misura a valvola aperta!



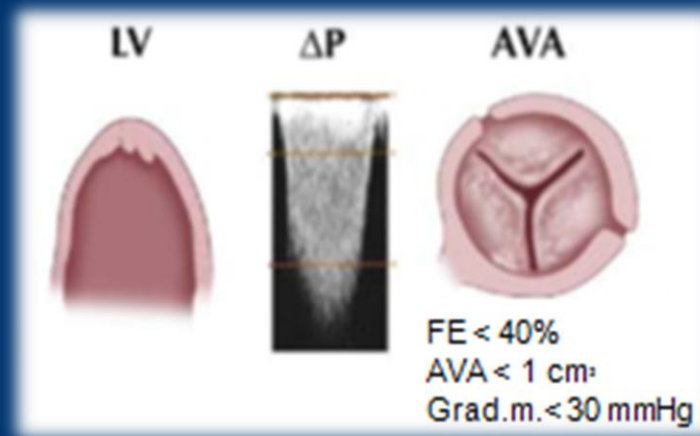
Media di almeno 3 misurazioni -  
5 misurazioni se in corso di fibrillazione  
atriale

# VALUTAZIONE DI SEVERITA' DELLA STENOSI AORTICA



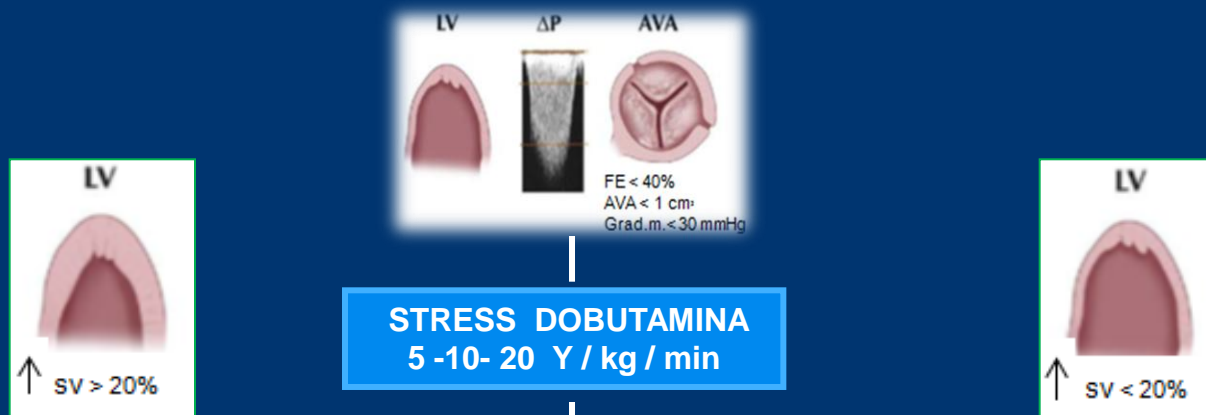
# LOW FLOW - LOW GRADIENT AORTIC STENOSIS (FE < 50%)

La stenosi è ispettivamente severa ma i gradienti transvalvolari non sono critici e la funzione sistolica globale del ventricolo sinistro è compromessa (FE < 50%)



LA VALVOLA E' STENOTICA O SI APRE POCO PERCHE' E' RIDOTTA  
LA FUNZIONE SISTOLICA GLOBALE?  
COME MI ORIENTO?

# LOW FLOW - LOW GRADIENT AORTIC STENOSIS (FE < 50%)



**riserva contrattile**

**NO riserva contrattile**

AVA < 1 cm<sup>2</sup>/  
Gradiente medio >  
40 mmHg

AVA > 1 cm<sup>2</sup>/  
Gradiente medio <  
40 mmHg

?

**Stenosi aortica  
severa vera**

**Stenosi aortica  
pseudosevera**

**Indeterminata**

**Table 8. Stages of Valvular AS**

Stage	Definition	Valve Anatomy	Valve Hemodynamics	Hemodynamic Consequences	Symptoms
<b>A</b>	<b>At risk of AS</b>	<ul style="list-style-type: none"> <li>Bicuspid aortic valve (or other congenital valve anomaly)</li> <li>Aortic valve sclerosis</li> </ul>	<ul style="list-style-type: none"> <li>Aortic <math>V_{max}</math> <math>&lt; 2</math> m/s</li> </ul>	<ul style="list-style-type: none"> <li>None</li> </ul>	<ul style="list-style-type: none"> <li>None</li> </ul>
<b>B</b>	<b>Progressive AS</b>	<ul style="list-style-type: none"> <li>Mild-to-moderate leaflet calcification of a bicuspid or trileaflet valve with some reduction in systolic motion or</li> <li>Rheumatic valve changes with commissural fusion</li> </ul>	<ul style="list-style-type: none"> <li>Mild AS: Aortic <math>V_{max}</math> 2.0–2.9 m/s or mean <math>\Delta P</math> <math>&lt; 20</math> mm Hg</li> <li>Moderate AS: Aortic <math>V_{max}</math> 3.0–3.9 m/s or mean <math>\Delta P</math> 20–39 mm Hg</li> </ul>	<ul style="list-style-type: none"> <li>Early LV diastolic dysfunction may be present</li> <li>Normal LVEF</li> </ul>	<ul style="list-style-type: none"> <li>None</li> </ul>
<b>C: Asymptomatic severe AS</b>					
<b>C1</b>	<b>Asymptomatic severe AS</b>	<ul style="list-style-type: none"> <li>Severe leaflet calcification or congenital stenosis with severely reduced leaflet opening</li> </ul>	<ul style="list-style-type: none"> <li>Aortic <math>V_{max}</math> <math>\geq 4</math> m/s or mean <math>\Delta P</math> <math>\geq 40</math> mm Hg</li> <li>AVA typically is <math>\leq 1.0</math> cm<sup>2</sup> (or AVAI <math>\leq 0.6</math> cm<sup>2</sup>/m<sup>2</sup>)</li> <li>Very severe AS is an aortic <math>V_{max}</math> <math>\geq 5</math> m/s or mean <math>\Delta P</math> <math>\geq 60</math> mm Hg</li> </ul>	<ul style="list-style-type: none"> <li>LV diastolic dysfunction</li> <li>Mild LV hypertrophy</li> <li>Normal LVEF</li> </ul>	<ul style="list-style-type: none"> <li>None: Exercise testing is reasonable to confirm symptom status</li> </ul>
<b>C2</b>	<b>Asymptomatic severe AS with LV dysfunction</b>	<ul style="list-style-type: none"> <li>Severe leaflet calcification or congenital stenosis with severely reduced leaflet opening</li> </ul>	<ul style="list-style-type: none"> <li>Aortic <math>V_{max}</math> <math>\geq 4</math> m/s or mean <math>\Delta P</math> <math>\geq 40</math> mm Hg</li> <li>AVA typically <math>\leq 1.0</math> cm<sup>2</sup> (or AVAI <math>\leq 0.6</math> cm<sup>2</sup>/m<sup>2</sup>)</li> </ul>	<ul style="list-style-type: none"> <li>LVEF <math>&lt; 50\%</math></li> </ul>	<ul style="list-style-type: none"> <li>None</li> </ul>
<b>D: Symptomatic severe AS</b>					
<b>D1</b>	<b>Symptomatic severe high-gradient AS</b>	<ul style="list-style-type: none"> <li>Severe leaflet calcification or congenital stenosis with severely reduced leaflet opening</li> </ul>	<ul style="list-style-type: none"> <li>Aortic <math>V_{max}</math> <math>\geq 4</math> m/s or mean <math>\Delta P</math> <math>\geq 40</math> mm Hg</li> <li>AVA typically <math>\leq 1.0</math> cm<sup>2</sup> (or AVAI <math>\leq 0.6</math> cm<sup>2</sup>/m<sup>2</sup>) but may be larger with mixed AS/AR</li> </ul>	<ul style="list-style-type: none"> <li>LV diastolic dysfunction</li> <li>LV hypertrophy</li> <li>Pulmonary hypertension may be present</li> </ul>	<ul style="list-style-type: none"> <li>Exertional dyspnea or decreased exercise tolerance</li> <li>Exertional angina</li> <li>Exertional syncope or presyncope</li> </ul>
<b>D2</b>	<b>Symptomatic severe low-flow/low-gradient AS with reduced LVEF</b>	<ul style="list-style-type: none"> <li>Severe leaflet calcification with severely reduced leaflet motion</li> </ul>	<ul style="list-style-type: none"> <li>AVA <math>\leq 1.0</math> cm<sup>2</sup> with resting aortic <math>V_{max}</math> <math>&lt; 4</math> m/s or mean <math>\Delta P</math> <math>&lt; 40</math> mm Hg</li> <li>Dobutamine stress echocardiography shows AVA <math>\leq 1.0</math> cm<sup>2</sup> with <math>V_{max}</math> <math>\geq 4</math> m/s at any flow rate</li> </ul>	<ul style="list-style-type: none"> <li>LV diastolic dysfunction</li> <li>LV hypertrophy</li> <li>LVEF <math>&lt; 50\%</math></li> </ul>	<ul style="list-style-type: none"> <li>HF</li> <li>Angina</li> <li>Syncope or presyncope</li> </ul>
<b>D3</b>	<b>Symptomatic severe low-gradient AS with normal LVEF or paradoxical low-flow severe AS</b>	<ul style="list-style-type: none"> <li>Severe leaflet calcification with severely reduced leaflet motion</li> </ul>	<ul style="list-style-type: none"> <li>AVA <math>\leq 1.0</math> cm<sup>2</sup> with aortic <math>V_{max}</math> <math>&lt; 4</math> m/s or mean <math>\Delta P</math> <math>&lt; 40</math> mm Hg</li> <li>Indexed AVA <math>\leq 0.6</math> cm<sup>2</sup>/m<sup>2</sup> and</li> <li>Stroke volume index <math>&lt; 35</math> mL/m<sup>2</sup></li> <li>Measured when patient is normotensive (systolic BP <math>&lt; 140</math> mm Hg)</li> </ul>	<ul style="list-style-type: none"> <li>Increased LV relative wall thickness</li> <li>Small LV chamber with low stroke volume</li> <li>Restrictive diastolic filling</li> <li>LVEF <math>\geq 50\%</math></li> </ul>	<ul style="list-style-type: none"> <li>HF</li> <li>Angina</li> <li>Syncope or presyncope</li> </ul>

AR indicates aortic regurgitation; AS, aortic stenosis; AVA, aortic valve area; AVAI, aortic valve area indexed to body surface; LVEF, left ventricular ejection fraction;  $\Delta P$ , pressure gradient; and  $V_{max}$ , maximum aortic velocity.



## D: Symptomatic severe AS

<b>D1</b>	<b>Symptomatic severe high-gradient AS</b>	<ul style="list-style-type: none"><li>Severe leaflet calcification or congenital stenosis with severely reduced leaflet opening</li></ul>	<ul style="list-style-type: none"><li>Aortic <math>V_{max} \geq 4</math> m/s or mean <math>\Delta P \geq 40</math> mm Hg</li><li>AVA typically <math>\leq 1.0</math> cm<sup>2</sup> (or AVAI <math>\leq 0.6</math> cm<sup>2</sup>/m<sup>2</sup>) but may be larger with mixed AS/AR</li></ul>	<ul style="list-style-type: none"><li>LV diastolic dysfunction</li><li>LV hypertrophy</li><li>Pulmonary hypertension may be present</li></ul>	<ul style="list-style-type: none"><li>Exertional dyspnea or decreased exercise tolerance</li><li>Exertional angina</li><li>Exertional syncope or presyncope</li></ul>
<b>D2</b>	<b>Symptomatic severe low-flow/low-gradient AS with reduced LVEF</b>	<ul style="list-style-type: none"><li>Severe leaflet calcification with severely reduced leaflet motion</li></ul>	<ul style="list-style-type: none"><li>AVA <math>\leq 1.0</math> cm<sup>2</sup> with resting aortic <math>V_{max} &lt; 4</math> m/s or mean <math>\Delta P &lt; 40</math> mm Hg</li><li>Dobutamine stress echocardiography shows AVA <math>\leq 1.0</math> cm<sup>2</sup> with <math>V_{max} \geq 4</math> m/s at any flow rate</li></ul>	<ul style="list-style-type: none"><li>LV diastolic dysfunction</li><li>LV hypertrophy</li><li>LVEF <math>&lt; 50\%</math></li></ul>	<ul style="list-style-type: none"><li>HF</li><li>Angina</li><li>Syncope or presyncope</li></ul>
<b>D3</b>	<b>Symptomatic severe low-gradient AS with normal LVEF or paradoxical low-flow severe AS</b>	<ul style="list-style-type: none"><li>Severe leaflet calcification with severely reduced leaflet motion</li></ul>	<ul style="list-style-type: none"><li>AVA <math>\leq 1.0</math> cm<sup>2</sup> with aortic <math>V_{max} &lt; 4</math> m/s or mean <math>\Delta P &lt; 40</math> mm Hg</li><li>Indexed AVA <math>\leq 0.6</math> cm<sup>2</sup>/m<sup>2</sup> and</li><li>Stroke volume index <math>&lt; 35</math> mL/m<sup>2</sup></li><li>Measured when patient is normotensive (systolic BP <math>&lt; 140</math> mm Hg)</li></ul>	<ul style="list-style-type: none"><li>Increased LV relative wall thickness</li><li>Small LV chamber with low stroke volume</li><li>Restrictive diastolic filling</li><li>LVEF <math>\geq 50\%</math></li></ul>	<ul style="list-style-type: none"><li>HF</li><li>Angina</li><li>Syncope or presyncope</li></ul>

AR indicates aortic regurgitation; AS, aortic stenosis; AVA, aortic valve area; AVAI, aortic valve area indexed to body surface area; BP, blood pressure; HF, heart failure; LV, left ventricular; LVEF, left ventricular ejection fraction;  $\Delta P$ , pressure gradient; and  $V_{max}$ , maximum aortic velocity.

PRACTICE GUIDELINE - 2014 AHA/ACC Guideline for the Management of Patients With Valvular Heart Disease



# PARADOXICAL LOW FLOW SEVERE AORTIC STENOSIS – Cos'è?

La valvola appare severamente stenotica ma i gradienti non sono critici in presenza di conservata FE (> 50%)

-AVA  $\leq$  1.0 cm<sup>2</sup>/ Indexed AVA  $\leq$  0.6 cm<sup>2</sup>/m<sup>2</sup>

- Aortic Vmax <4 m/s or Aortic pressure gradient  $<$ 40 mm Hg

-Stroke volume index  $<$ 35 mL/m<sup>2</sup>, measured when patient is normotensive (systolic BP  $<$  140 mmHg)

# PARADOXICAL LOW FLOW SEVERE AORTIC STENOSIS

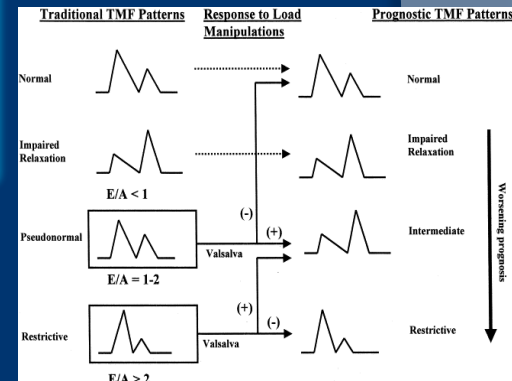
## CARATTERISTICHE

- ✓ donne anziane ipertese
- ✓ ventricolo sinistro di piccole dimensioni
- ✓ rimodellamento concentrico del VS
- ✓ disfunzione diastolica severa
- ✓ fibrosi subendocardica diffusa
- ✓ disfunzione sistolica latente (global longitudinal strain)



**IL RIDOTTO GRADIENTE E' SECONDARIO ALLA  
RIDUZIONE DI STROKE VOLUME!**

→ stroke volume index < 35ml/m<sup>2</sup>



# PARADOXICAL LOW FLOW SEVERE AORTIC STENOSIS

PERCHE' LO SV E' RIDOTTO?

- ✓ **DISFUNZIONE DIASTOLICA** (+ disfunzione sistolica)
- ✓ **IPERTENSIONE ARTERIOSA**
- ✓ **STENOSI MITRALICA**
- ✓ **INSUFFICIENZA MITRALICA**
- ✓ **FIBRILLAZIONE ATRIALE**
- ✓ **INSUFFICIENZA TRICUSPIDALE**

DIAGNOSI IMPROBABILE SE:  
V max < 3 m/sec  
GRADIENTE MEDIO < 20 mmHg

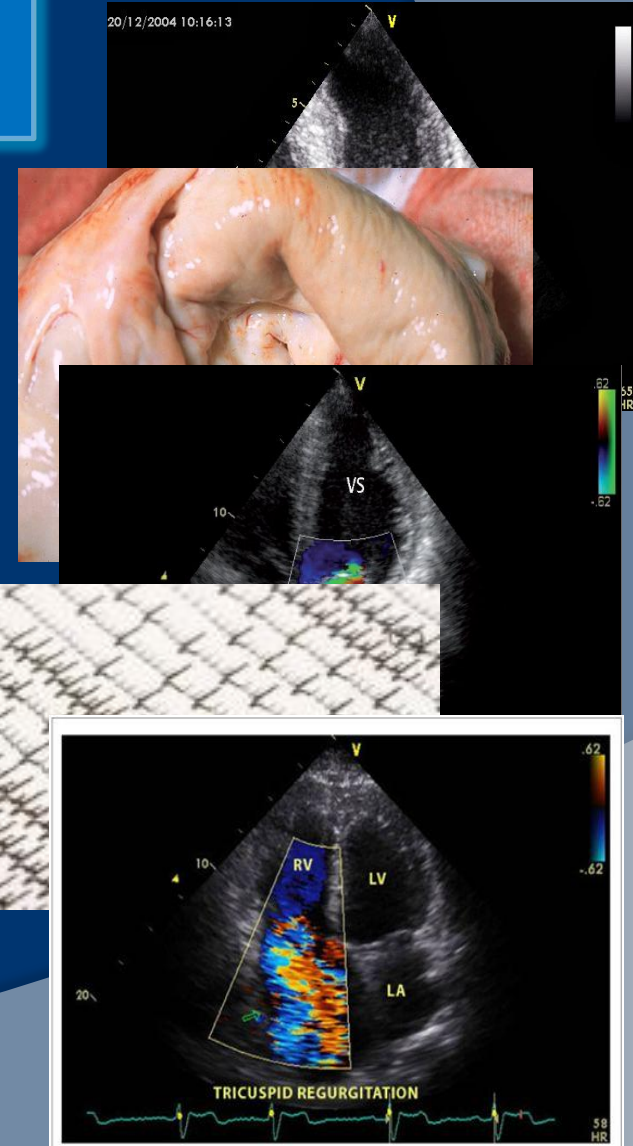


Figure 2 - Apical 4-chamber view at the echocardiogram, showing significant tricuspid regurgitation at the color Doppler.



# Normal flow low gradient aortic stenosis (NF -LG)

La valvola appare severamente stenotica ma i gradienti non sono critici in presenza di conservata FE (> 50%).

Stroke volume index > 35 ml/m<sup>2</sup>

## INCONGRUENZA DELLE LINEE GUIDA

un paziente con SV normale e AVA 0.8 -1 cm<sup>2</sup> sviluppa un gradiente medio di 30 – 35 mmHg.

AVA < 0.8 cm<sup>2</sup> → gradiente medio > 40 mmHg

## RIDOTTA SUPERFICIE CORPOREA

## ERRORE DI MISURAZIONE



# Paradoxical low flow severe AS CARATTERISTICHE ECOCARDIOGRAFICHE

AVA < 1 cm<sup>2</sup> - < 0.6 cm<sup>2</sup>/m<sup>2</sup>

Doppler velocity index < 0.25

VALVOLA SEVERAMENTE CALCIFICA / ISPESSITA

GRADIENTE MEDIO < 40 mmHg - FE > 50%

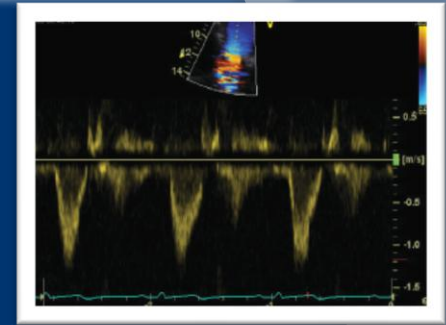
SVi < 35 ml/m<sup>2</sup> - DTVS < 47 mm - VOL TDVS < 55 ml/m<sup>2</sup>

RELATIVE WALL THICKNESS > 0.50

GLOBAL LONGITUDINAL STRAIN < 15%

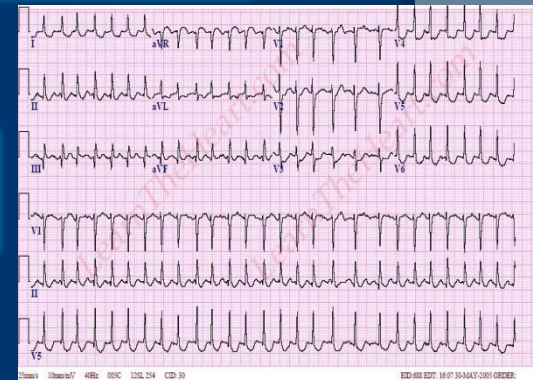
# Paradoxical low flow severe AS NON E' COSÌ SEMPLICE!

IL GRADIENTE MEDIO E' DAVVERO RIDOTTO?



LO SVi E' DAVVERO RIDOTTO? (attenzione a dove  
misuro LVOT e a dove posiziono il PW)

SONO RIUSCITO AD IDENTIFICARE UNA CAUSA DI  
RIDUZIONE DELLO SVi?



HO ELIMINATO TUTTI I POSSIBILI FATTORI  
CONFONDENTI?

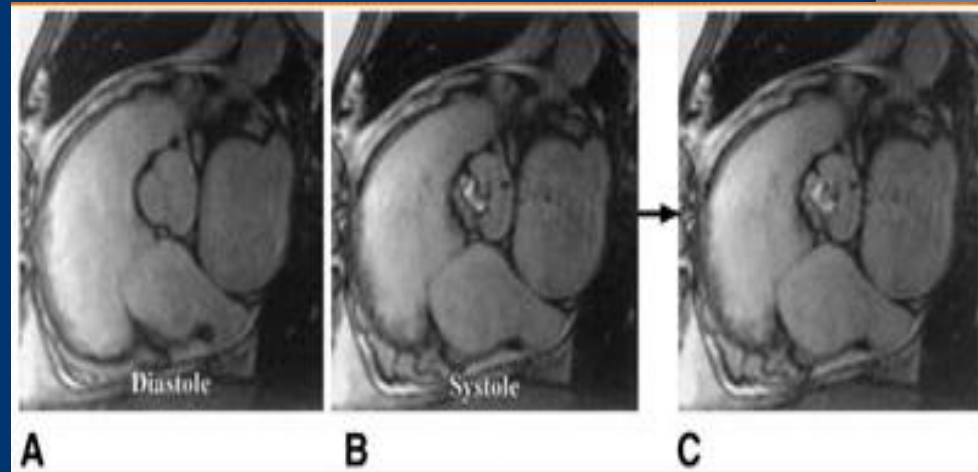




# Paradoxical low flow severe AS NON E' COSÌ SEMPLICE! LIMITI INTRINSECI DELLA METODICA

L'AVA DERIVATA SOTTOSTIMA L'AREA ANATOMICA  
(confronto con RMN)

RISPETTO AL CATETERISMO CARDIACO CON  
L'ECOCARDIOGRAFIA I GRADIENTI SONO  
SOVRASTIMATI E L'AREA SOTTOSTIMATA



# E SE FOSSE UNA PSEUDO SEVERA? (30%!)

## STRESS ECO

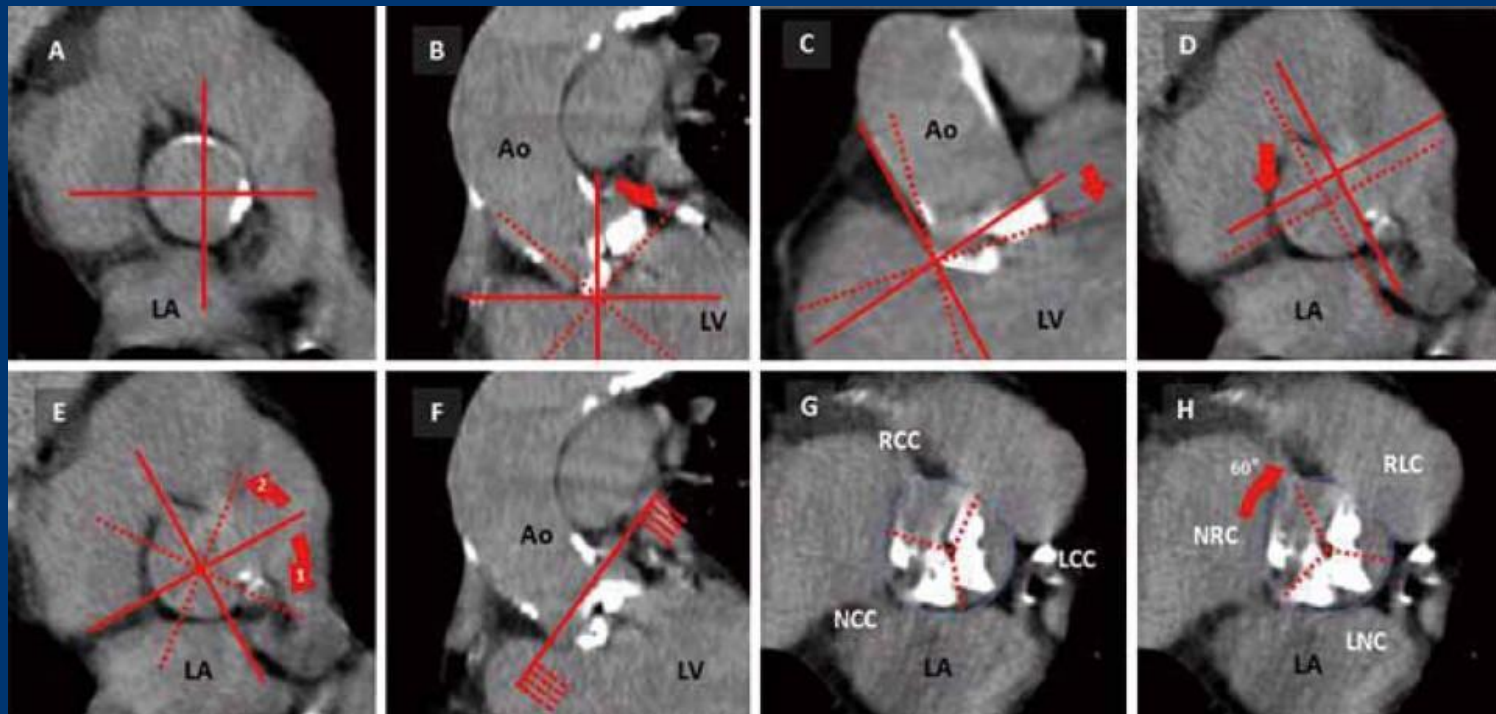
Calcolo di projected AVA (flow rate 250 ml/sec)

Clavel et al. JACC. CARDIOVASCULAR IMAGING. VOL 6 N 2, 2013



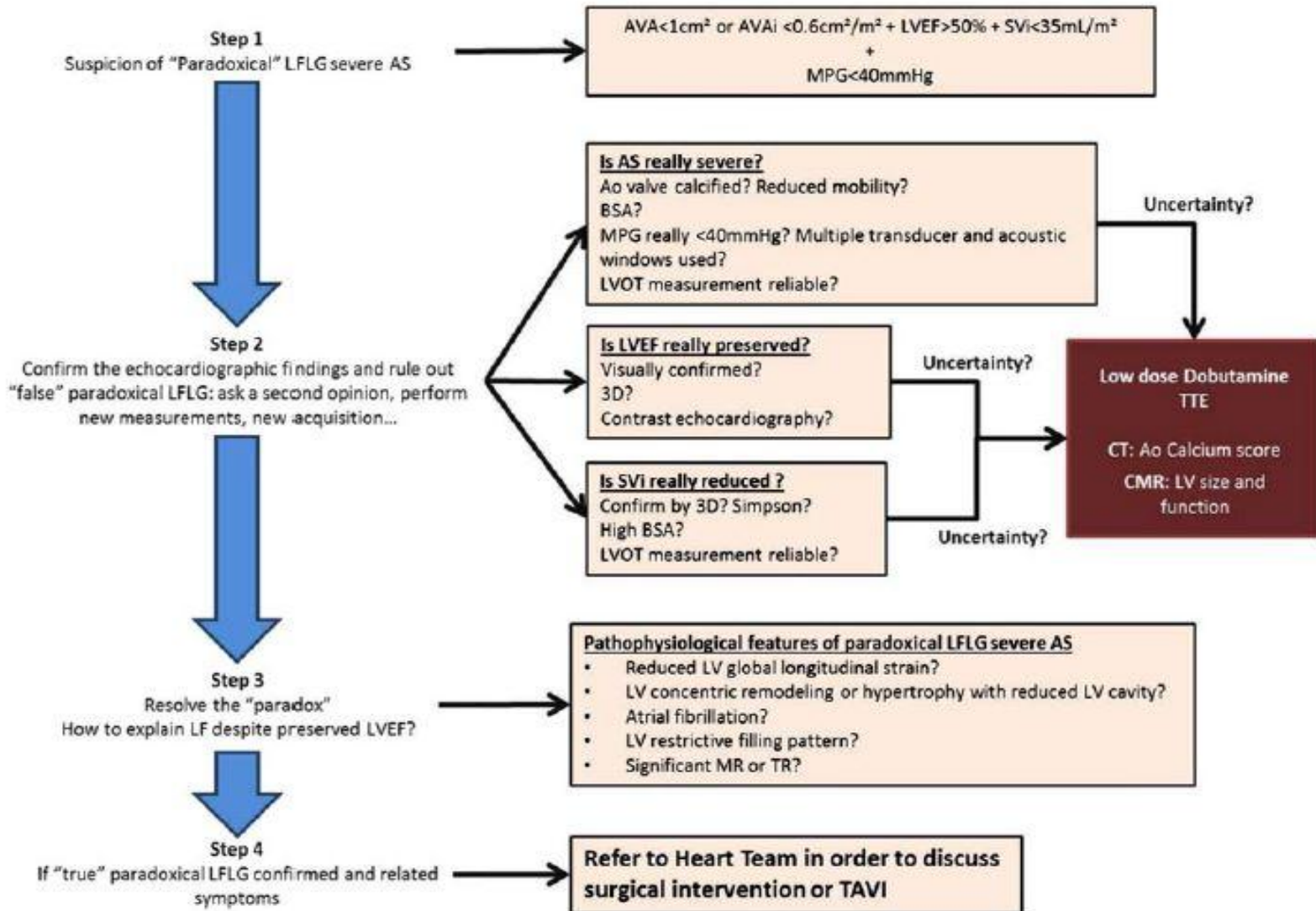
# E SE FOSSE UNA PSEUDO SEVERA? (30%!)

## MULTISLICE CT (AVC – aortic valve calcification)



Clavel et al, JACC 2013; 62: 2329-38

# FLOW CHART DIAGNOSTICA



# FLOW CHART DIAGNOSTICA

## Step 1

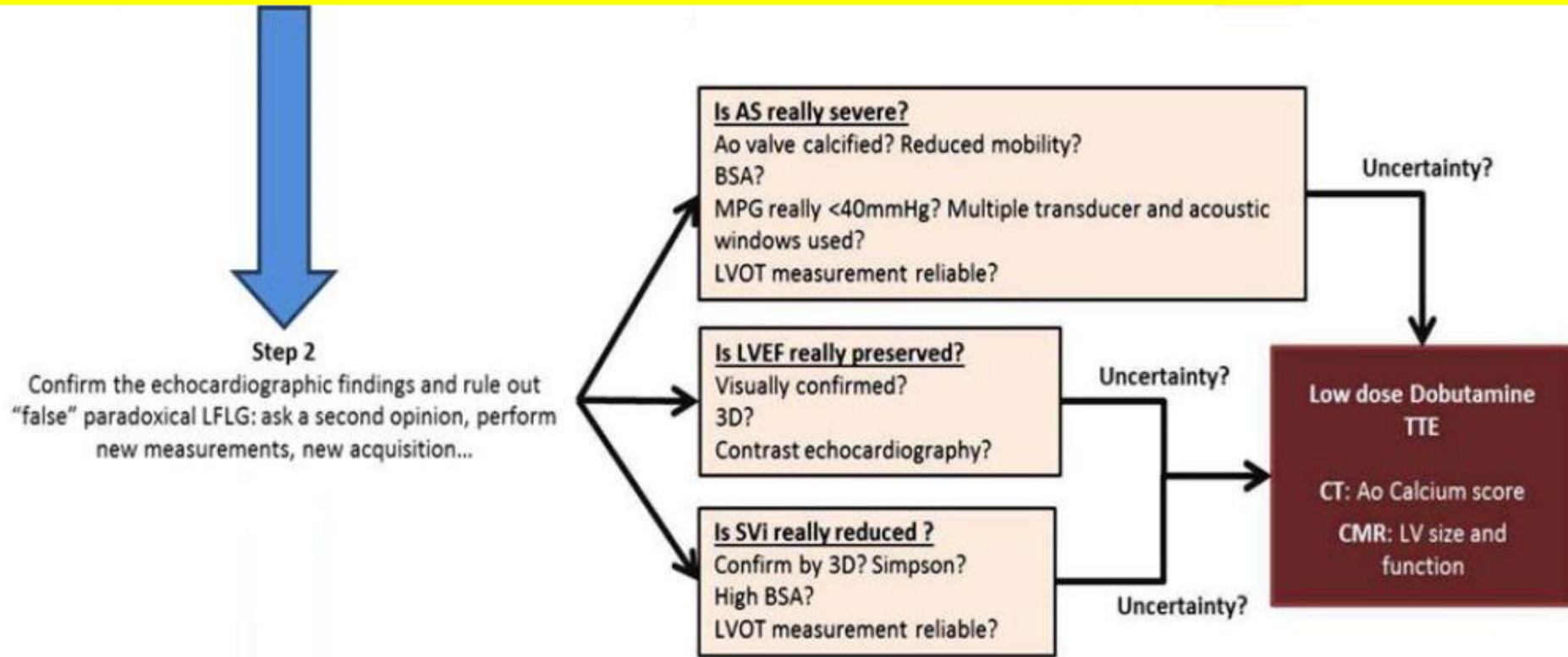
Suspicion of "Paradoxical" LFLG severe AS



$AVA < 1\text{cm}^2$  or  $AVA_i < 0.6\text{cm}^2/\text{m}^2$  +  $LVEF > 50\%$  +  $SV_i < 35\text{mL}/\text{m}^2$   
+  
 $MPG < 40\text{mmHg}$



# FLOW CHART DIAGNOSTICA



# FLOW CHART DIAGNOSTICA



## Step 3

Resolve the "paradox"  
How to explain LF despite preserved LVEF?



### Pathophysiological features of paradoxical LFLG severe AS

- Reduced LV global longitudinal strain?
- LV concentric remodeling or hypertrophy with reduced LV cavity?
- Atrial fibrillation?
- LV restrictive filling pattern?
- Significant MR or TR?



## Step 4

If "true" paradoxical LFLG confirmed and related symptoms



**Refer to Heart Team in order to discuss surgical intervention or TAVI**

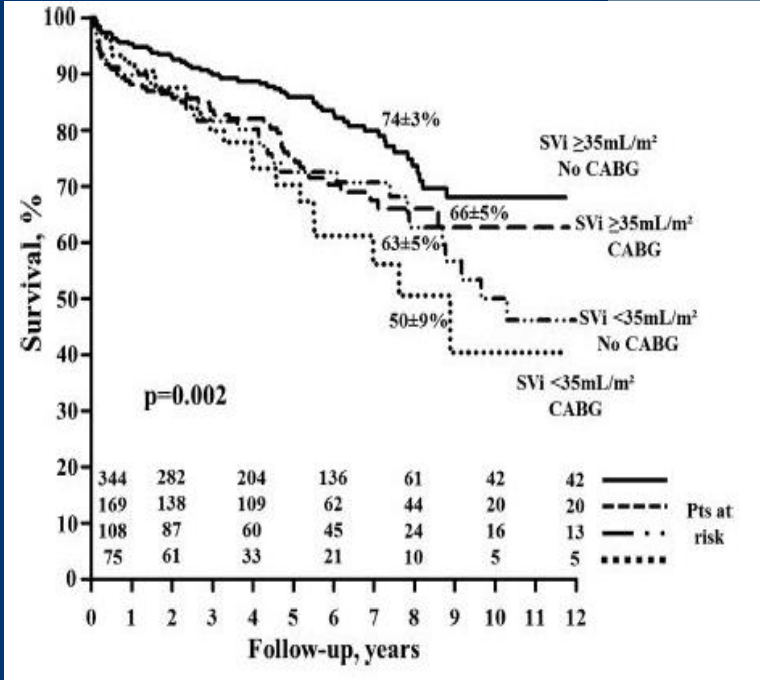
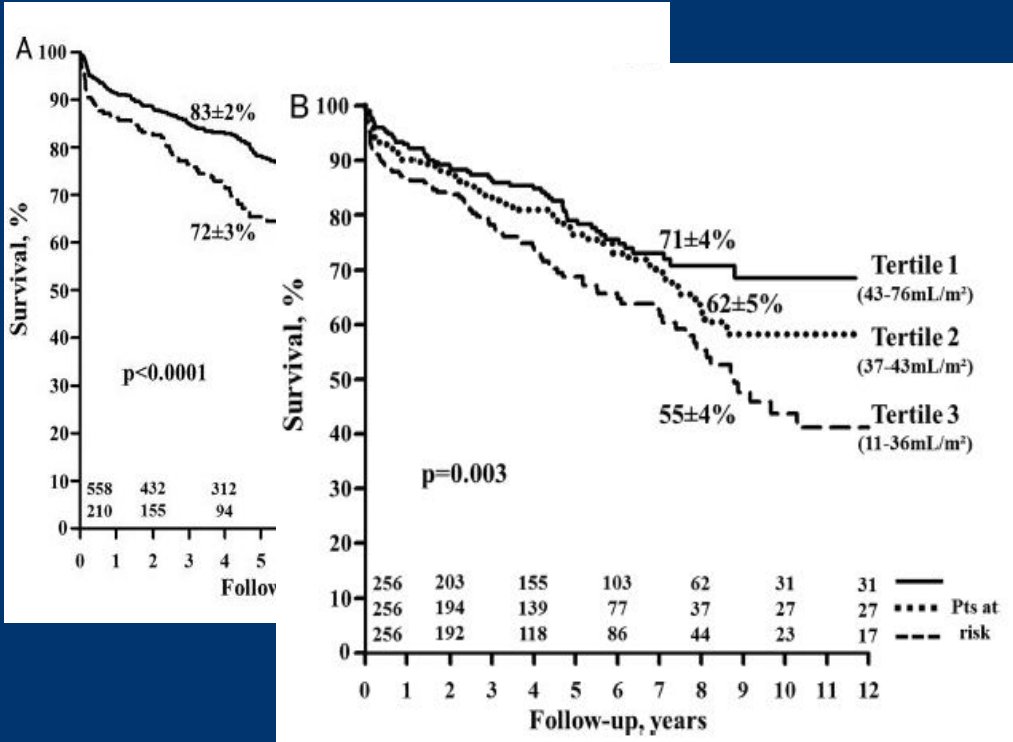


# NEL FRATTEMPO...





# PROGNOSI!



Overall survival according to low and high LV indexed stroke volume (panel A) and to SVi tertiles (panel B)

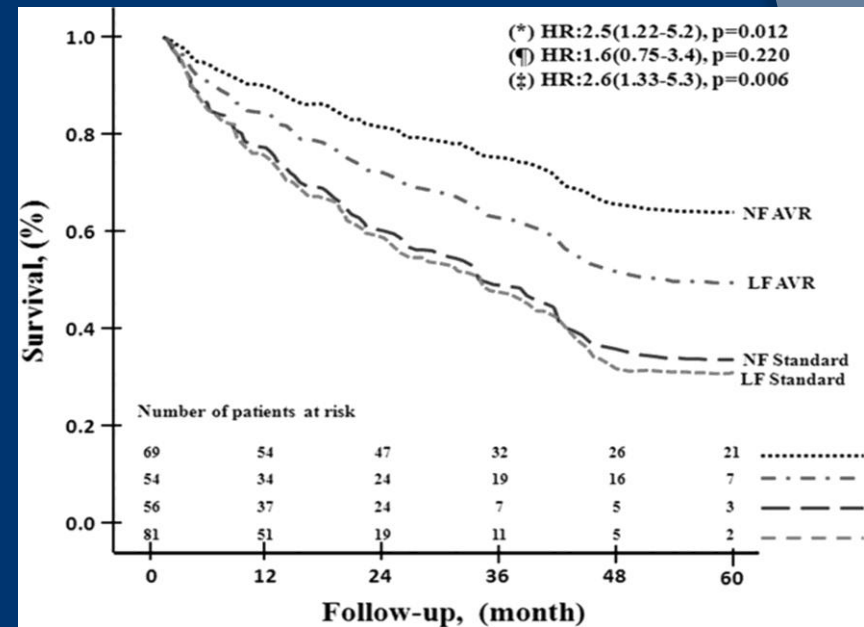
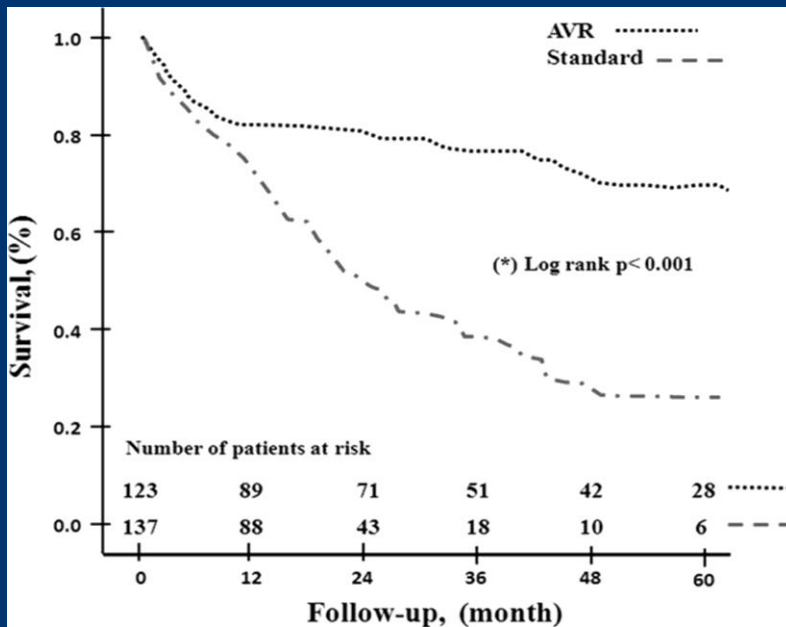
Overall survival in patients having undergone surgery according to LV indexed stroke volume and stratified for the concomitant presence of CABG (survival rate at 8 yrs follow-up)

Magne et al. Heart 2015;0:1 -7. doi: 10.1136/heartjnl-2014-306953

# Low flow - low gradient AS

## Impact of Aortic Valve Replacement on Outcome of Symptomatic Patients With Severe Aortic Stenosis With Low Gradient and Preserved Left Ventricular Ejection Fraction

Ozkan et al. Circulation 2013; 128:622-631



Unadjusted analysis of survival of patients who underwent aortic valve replacement (AVR) and those who received standard medical therapy.

After age, sex, treatment, and propensity score adjustment, patients who underwent aortic valve replacement (AVR) had a better outcome regardless of flow pattern.

# Low flow - low gradient AS

[Circulation](#). 2013 Jun 11;127(23):2316-26.

## Predictors of mortality and outcomes of therapy in low-flow severe aortic stenosis: a Placement of Aortic Transcatheter Valves (PARTNER) trial analysis

[Herrmann HC](#), [Pibarot P](#), [Hueter I](#), [Gertz ZM](#), [Stewart WJ](#), [Kapadia S](#), [Tuzcu EM](#), [Babaliaros V](#), [Thourani V](#), [Szeto WY](#), [Bavaria JE](#), [Kodali S](#), [Hahn RT](#), [Williams M](#), [Miller DC](#), [Douglas PS](#), [Leon MB](#).

-Survival is improved with TAVR compared with medical management in inoperable patients.

-Survival at 6 months in high risk patients is better with TAVR compared to SAVR.

## LE LINEE GUIDA

AVR is reasonable in symptomatic patients with low-flow/low-gradient severe AS (stage D3) with an LVEF 50% or greater, a calcified aortic valve with significantly reduced leaflet motion, and a valve area 1.0 cm<sup>2</sup> or less **only if clinical, hemodynamic, and anatomic data support valve obstruction as the most likely cause of symptoms and data recorded when the patient is normotensive (systolic BP <140 mm Hg)**

CLASSE IIa

A sunset over the ocean. The sky is a mix of orange, yellow, and blue, with dark clouds silhouetted against the bright horizon. The water in the foreground is dark and textured with small waves. At the bottom center, there is a blue rectangular box with a white border containing the text "GRAZIE PER L'ATTENZIONE!".

**GRAZIE PER L'ATTENZIONE!**