Uppsala, Sweden

Table 4 Echocardiographic criteria for the definition of severe valve stenosis: an integrative approach

	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[a]	>10[b]	≥5
Maximum jet velocity (m/s)	>4.0[a]	–	–
Velocity ratio	<0.25	–	–

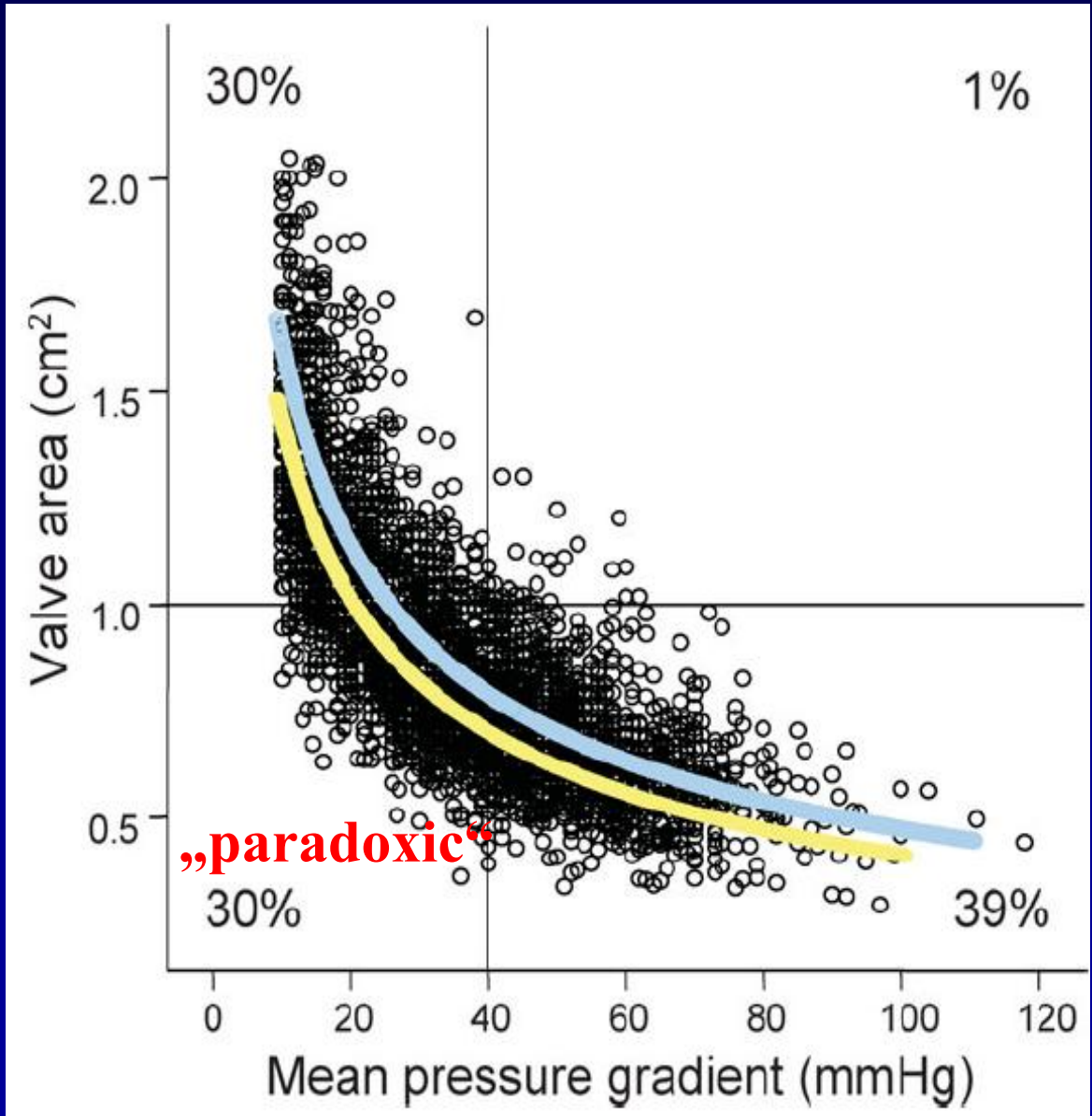
[a]In patients with normal cardiac output/transvalvular flow.

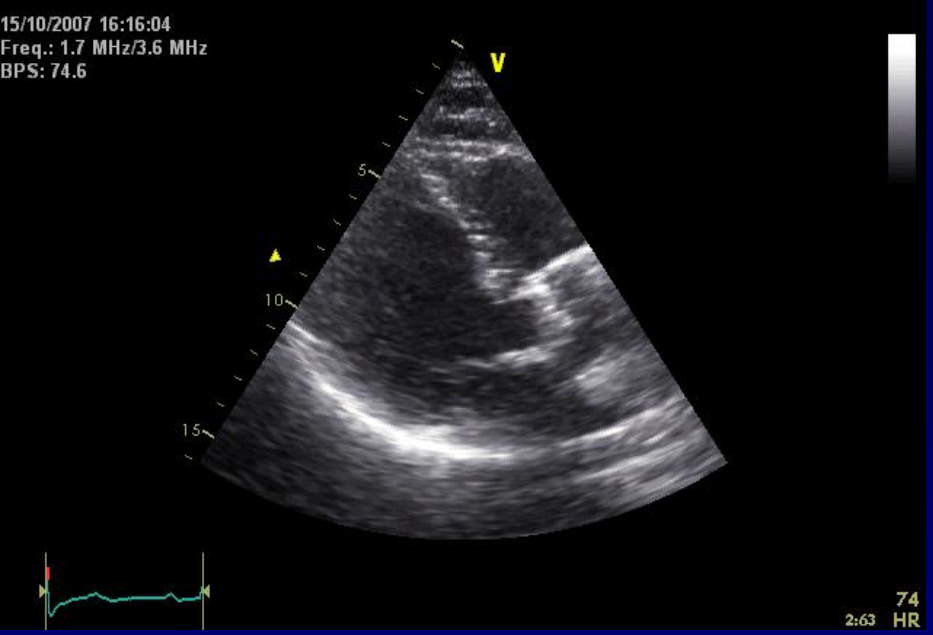
ESC guidelines VHD 2012

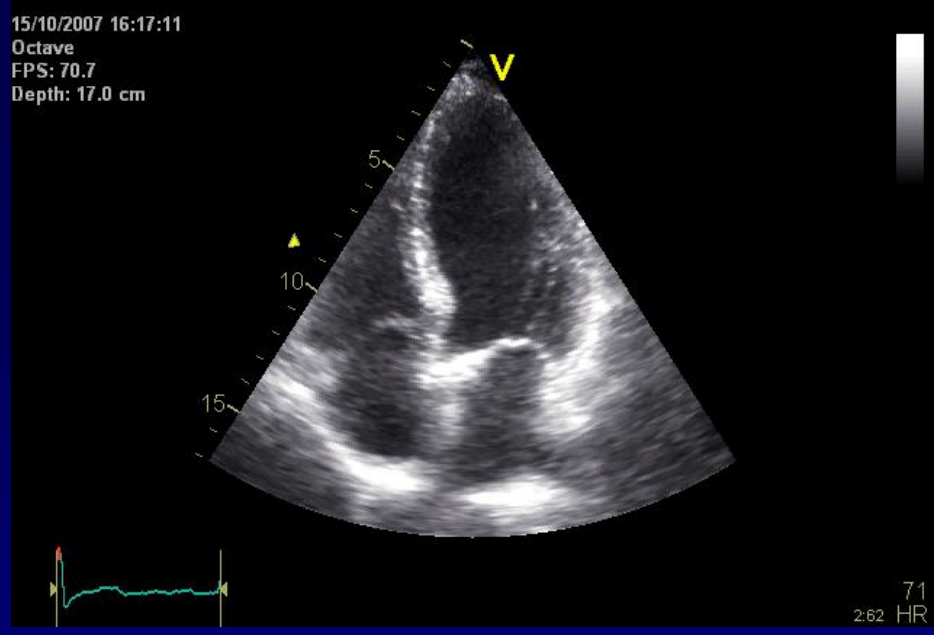
“Paradoxic” aortic stenosis

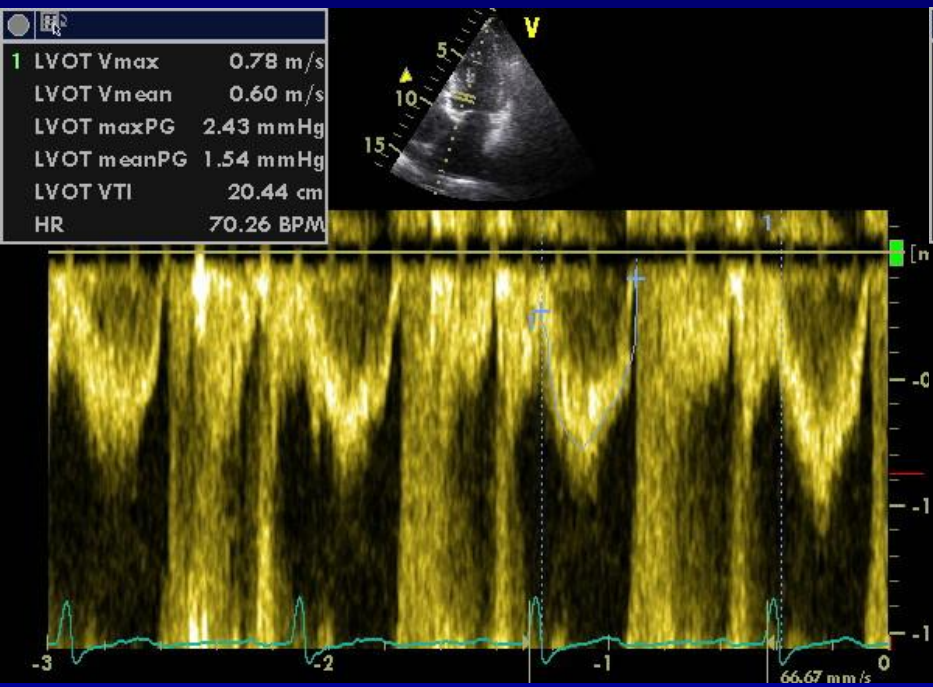
3483 echos in pts with AS and normal shortening fraction

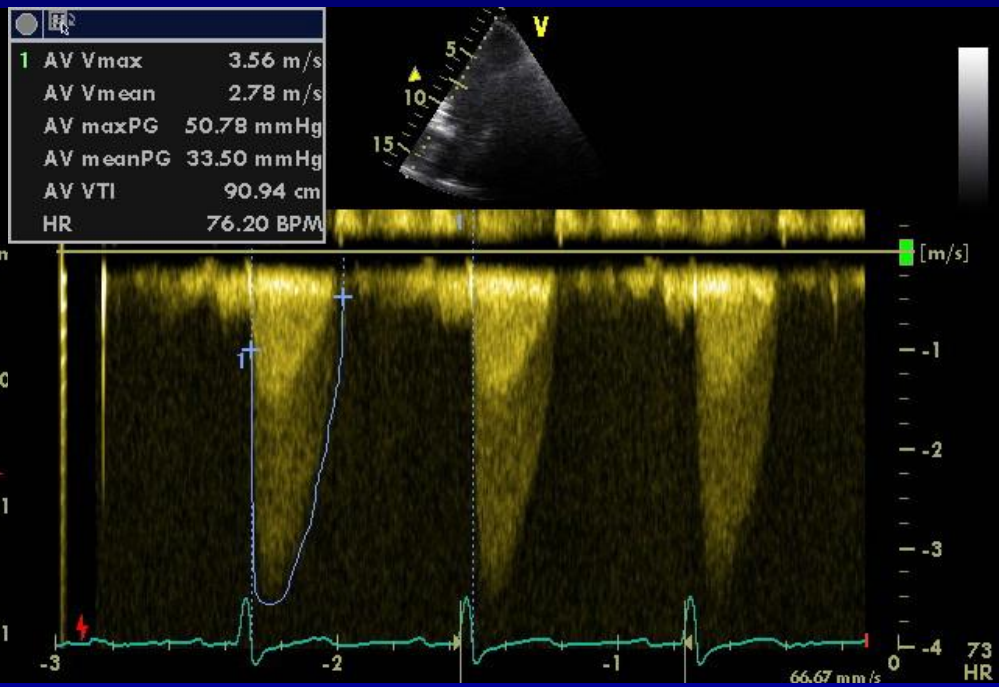
Minners EHJ 2008;29:1043









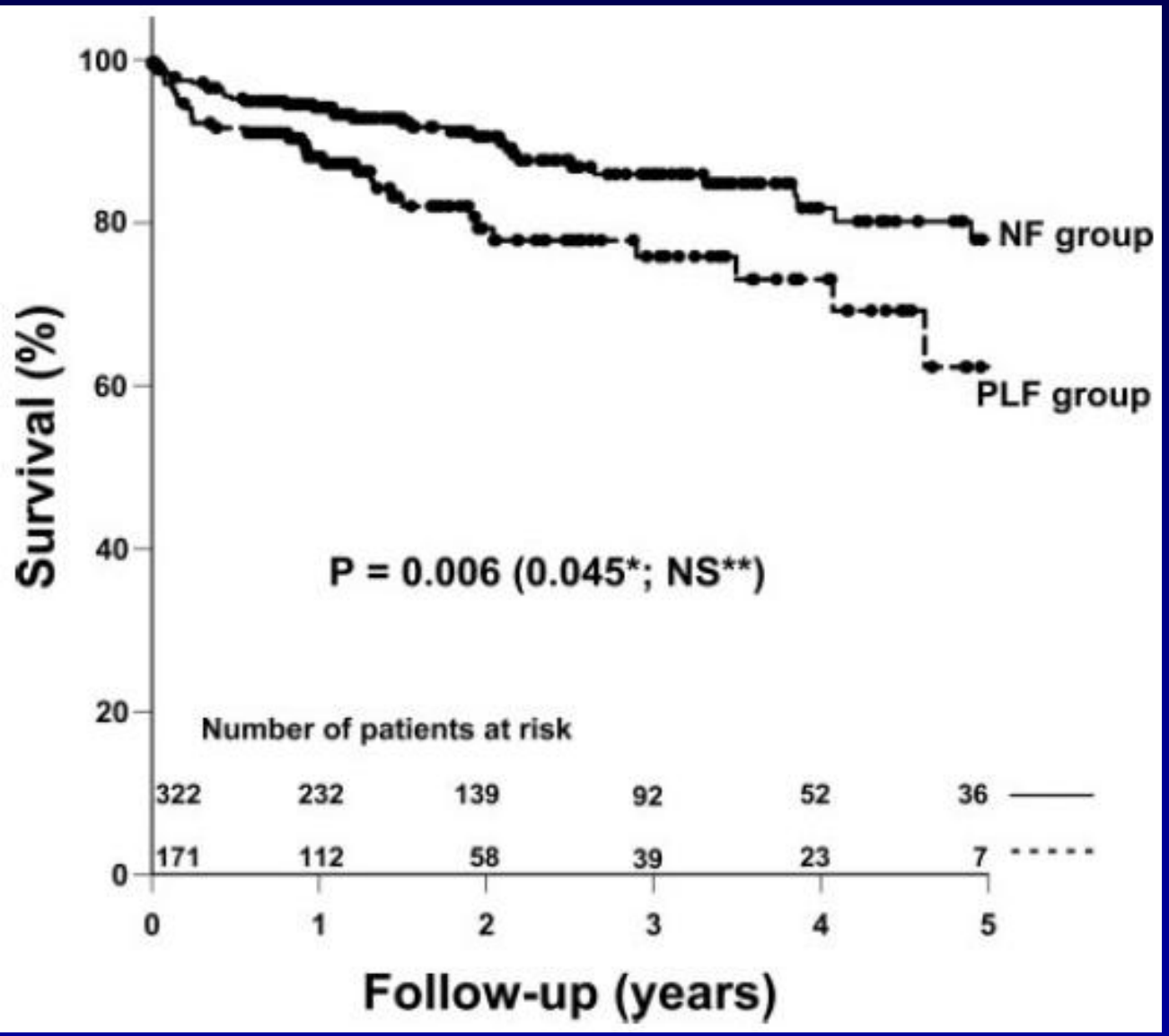


Ann.diameter 2.2 cm; AVA 0.8 cm^2, mean gradient 33 mmHg

AVR is indicated in patients with severe AS and any symptoms related to AS.	I	B
AVR is indicated in patients with severe AS undergoing CABG, surgery of the ascending aorta or another valve.	I	C
AVR is indicated in asymptomatic patients with severe AS and systolic LV dysfunction (LVEF <50%) not due to another cause.	I	C
AVR is indicated in asymptomatic patients with severe AS and abnormal exercise test showing symptoms on exercise clearly related to AS.	I	C
AVR should be considered in high risk patients with severe symptomatic AS who are suitable for TAVI, but in whom surgery is favoured by a 'heart team' based on the individual risk profile and anatomic suitability.	IIa	B
AVR should be considered in asymptomatic patients with severe AS and abnormal exercise test showing fall in blood pressure below baseline.	IIa	C
AVR should be considered in patients with moderate AS[d] undergoing CABG, surgery of the ascending aorta or another valve.	IIa	C
AVR should be considered in symptomatic patients with low flow, low gradient (<40 mmHg) AS with normal EF only after careful confirmation of severe AS.[e]	IIa	C
AVR should be considered in symptomatic patients with severe AS, low flow, low gradient with reduced EF, and evidence of flow reserve.[f]	IIa	C
AVR should be considered in asymptomatic patients, with normal EF and none of the above mentioned exercise test abnormalities, if the surgical risk is low, and one or more of the following findings is present: • Very severe AS defined by a peak transvalvular velocity >5.5 m/s or, • Severe valve calcification and a rate of peak transvalvular velocity progression ≥0.3 m/s per year.	IIa	C
AVR may be considered in symptomatic patients with severe AS low flow, low gradient, and LV dysfunction without flow reserve.[f]	IIb	C

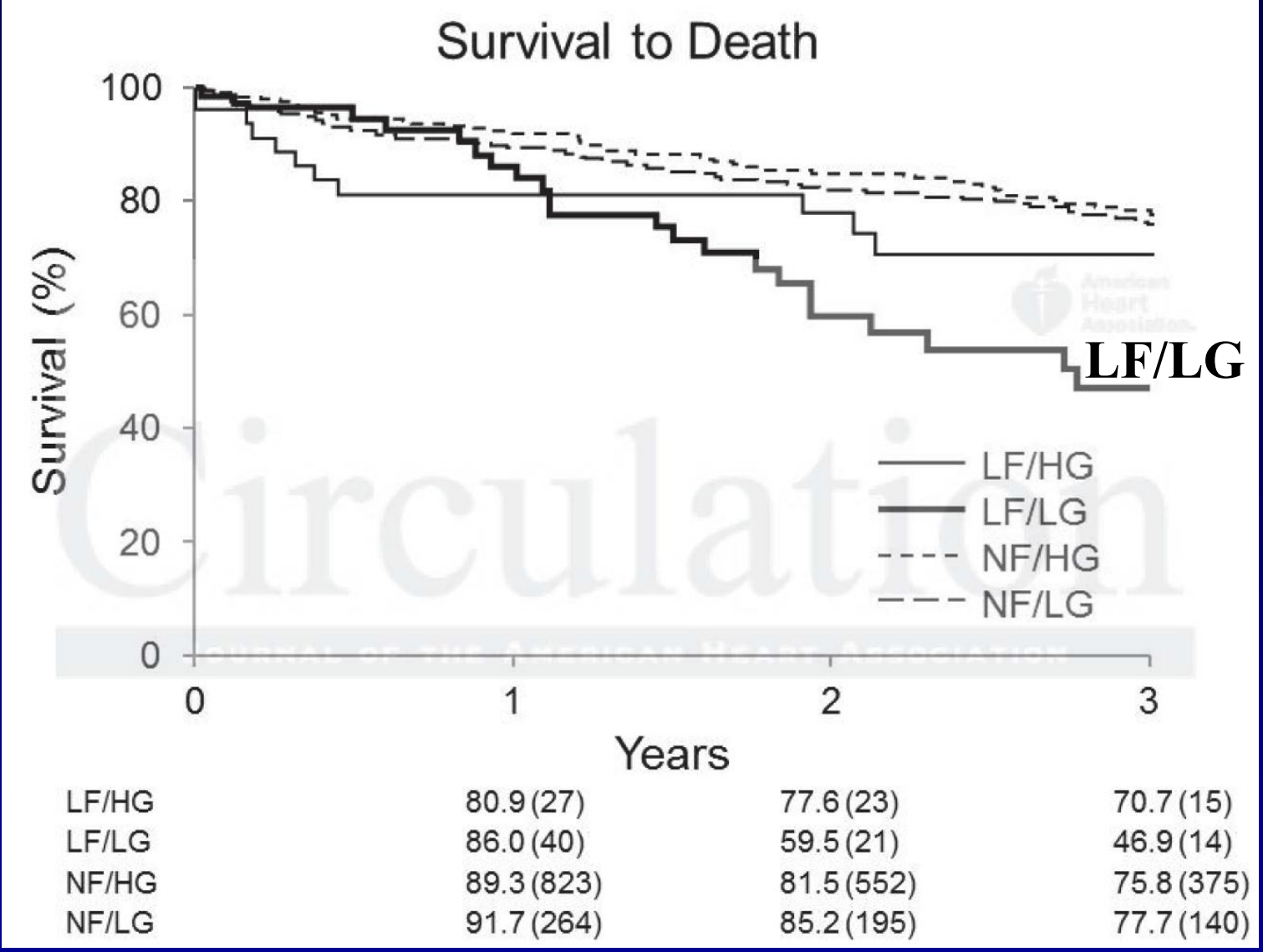
[e]In patients with a small valve area but low gradient despite preserved LVEF, explanations for this finding (other than the presence of severe AS) are frequent and must be carefully excluded. See text (evaluation of AS).

Hachicha Circulation 07;115:2856
observational study of 512 pts with AS $\leq$ 0.6 cm^2/m^2 and EF $\geq$ 50%



NF = stroke volume index > 35 mL/m^2 gradients 40 ± 15 mmHg

PLF = stroke volume index $\leq$ 35 mL/m^2 gradients 32 ± 17 mmHg



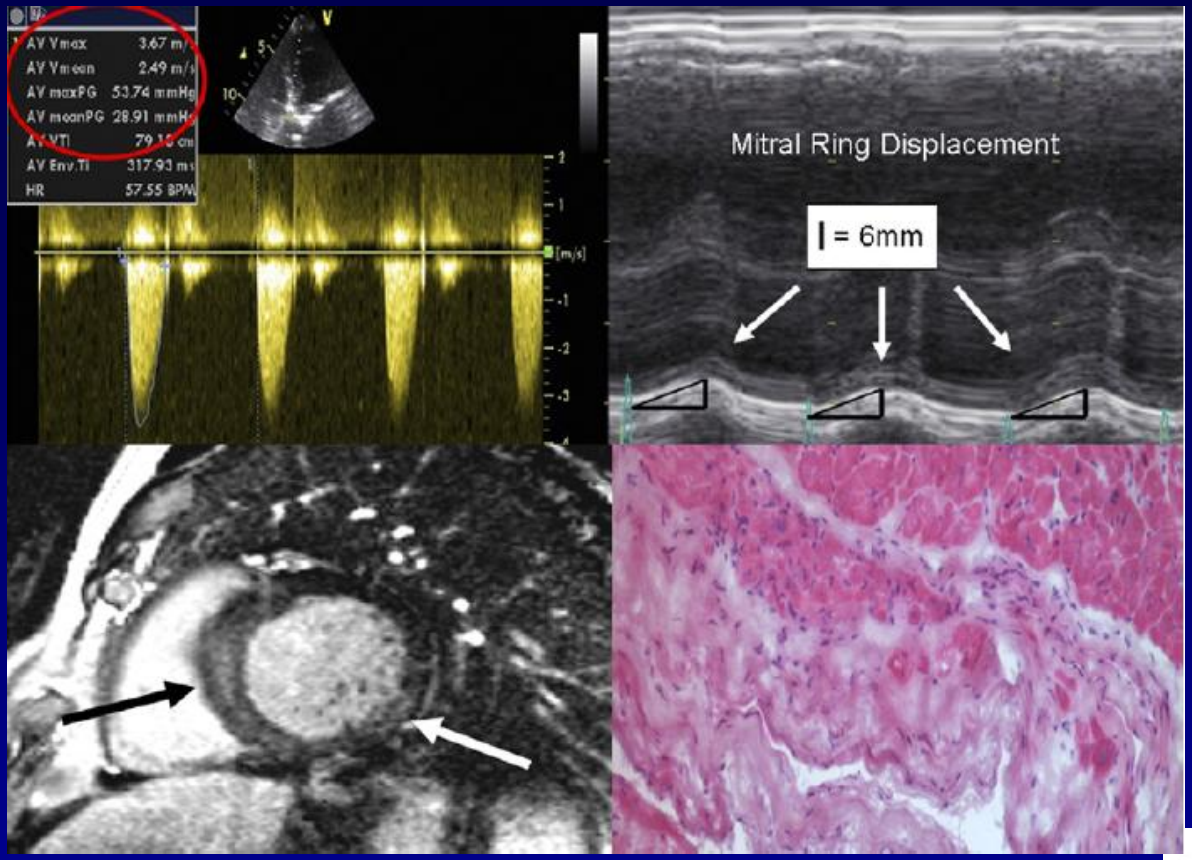
LF/HG	80.9 (27)	77.6 (23)	70.7 (15)
LF/LG	86.0 (40)	59.5 (21)	46.9 (14)
NF/HG	89.3 (823)	81.5 (552)	75.8 (375)
NF/LG	91.7 (264)	85.2 (195)	77.7 (140)

mean grad. < > 40 mmHg

stroke volume index < > 35 mL/m²

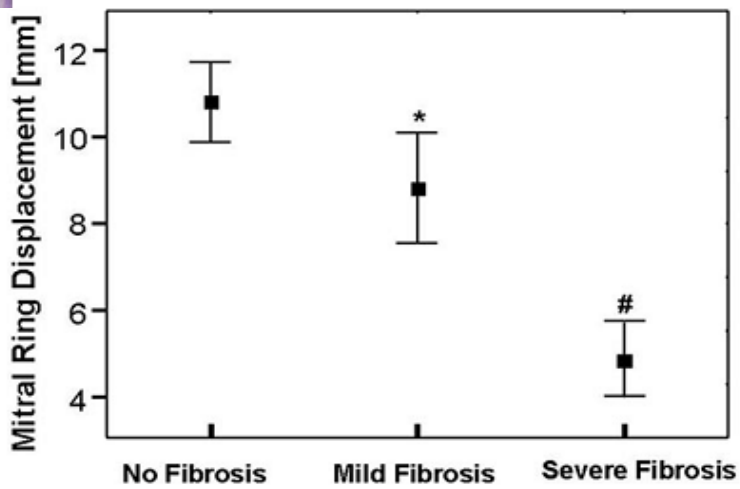
Eleid, Pellikka Circulation 2013
n=1704 pts w AS < 1 cm² and EF ≥ 50%

Explanatory concepts for “paradoxic” AS: fibrosis



Herrmann
JACC 11;58:401
AVA 0.9 cm^2, EF 60%
max./mean grad.
54/29 mmHg

Weidemann Circ 09;120:577



Explanatory concepts for “paradoxic”AS: geometry

- smaller hearts (influence of age and gender)
- 50% EF is less stroke volume in a concentrically remodelled than in a normal ventricle

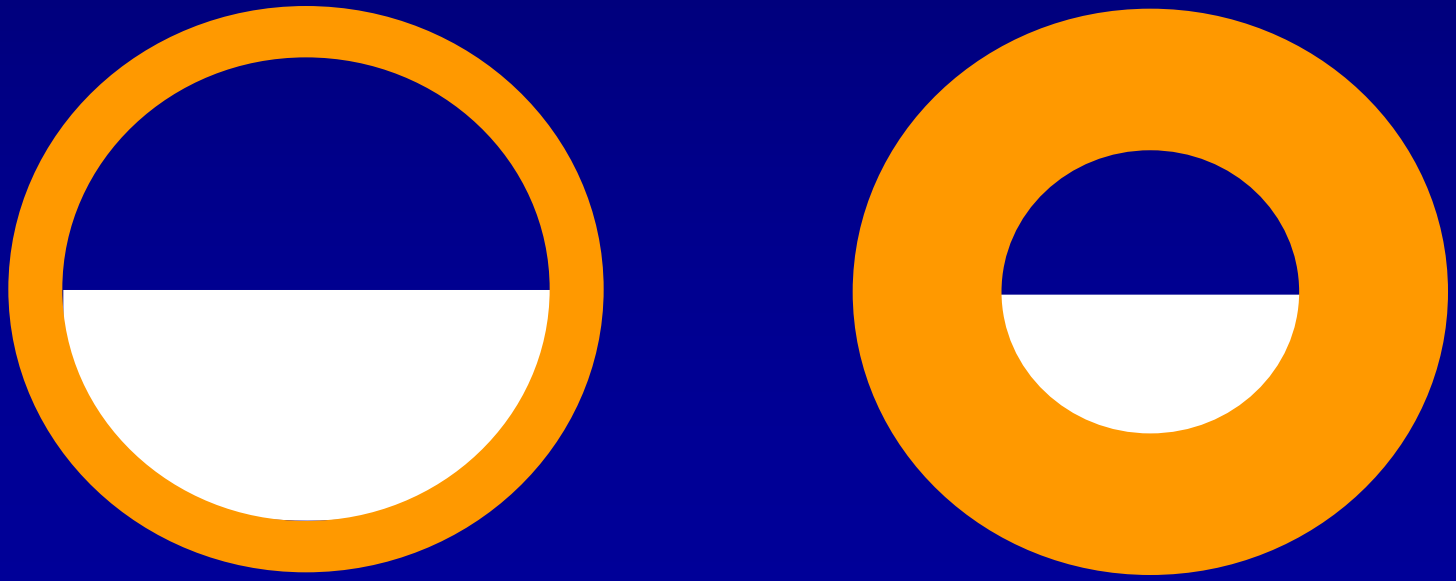


TABLE 2. Comparison of Doppler Echocardiographic Data in NF and PLF Groups

	NF Group (n=331)	PLF Group (n=181)	*P*
Aortic stenosis severity			
Aortic valve area, cm^2	0.84±0.18	0.76±0.23	<0.001
Indexed aortic valve area, $cm^2 \cdot m^{-2}$	0.46±0.08	0.42±0.11	<0.001
Peak aortic velocity, $m \cdot s^{-1}$	4.0±0.7	3.5±0.9	<0.001
LV systolic function			
Ejection fraction, %§	68±7	62±8	<0.001
Ejection fraction by Simpson method, %¶		65±11	<0.001
Midwall fractional shortening, %		20±15	0.012
LVOT stroke volume,		56±10	<0.001
LV end-diastolic interna	48±5	45±5	<0.001
LV end-diastolic volume index, $mL \cdot m^{-2}$	59±13	52±12	<0.001
LV end-diastolic volume indexed to $height^{2.7}$, $mL \cdot m^{-2.7}$	28±7	25±6	<0.001
LV mass index, $g \cdot m^{-2}$	121±33	111±29	0.005

"smaller hearts" lower, but still normal EF

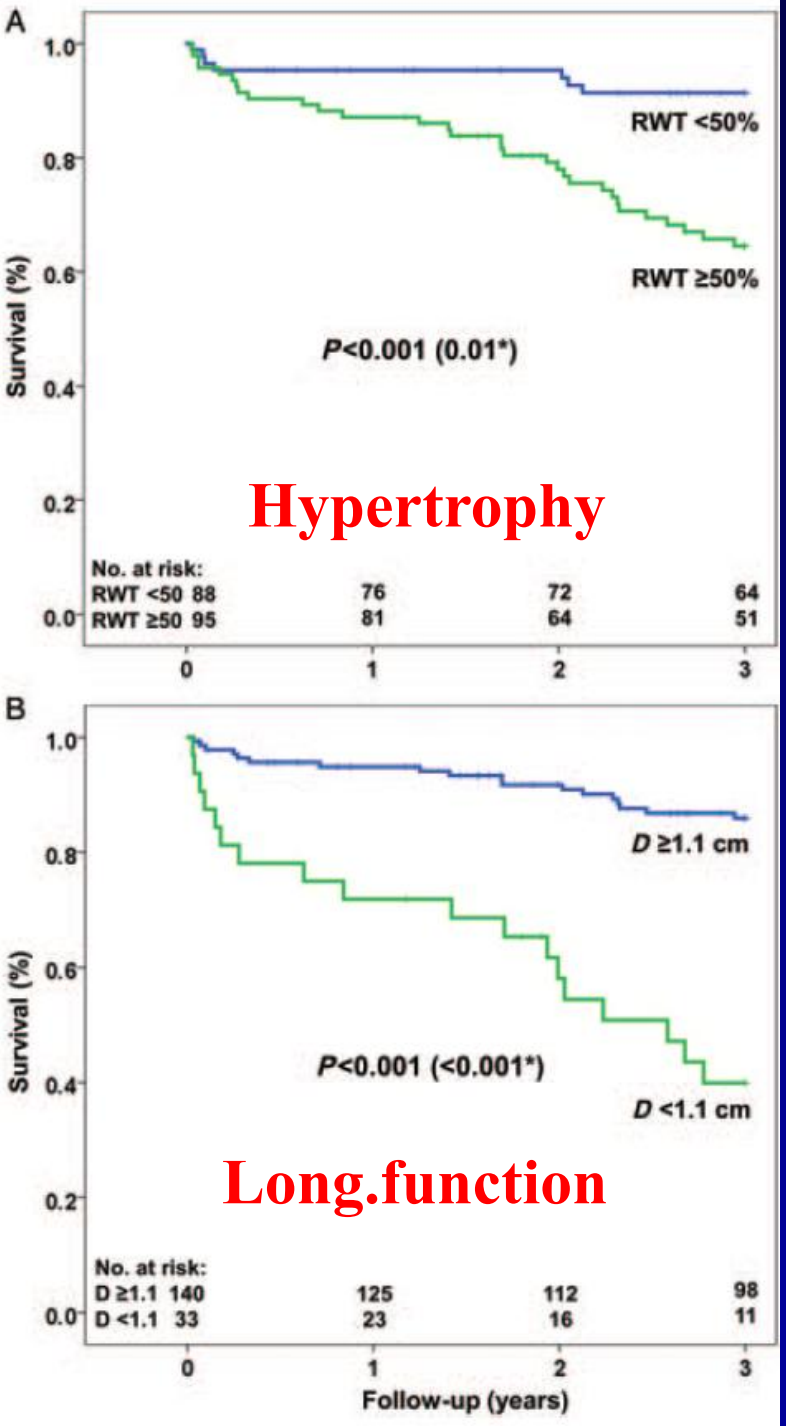
Hachicha Circulation 07;115:2856

Explanatory concepts for "paradoxic" AS: afterload

TABLE 1. Comparison of Clinical and Systemic Arterial Data in NF and PLF Groups

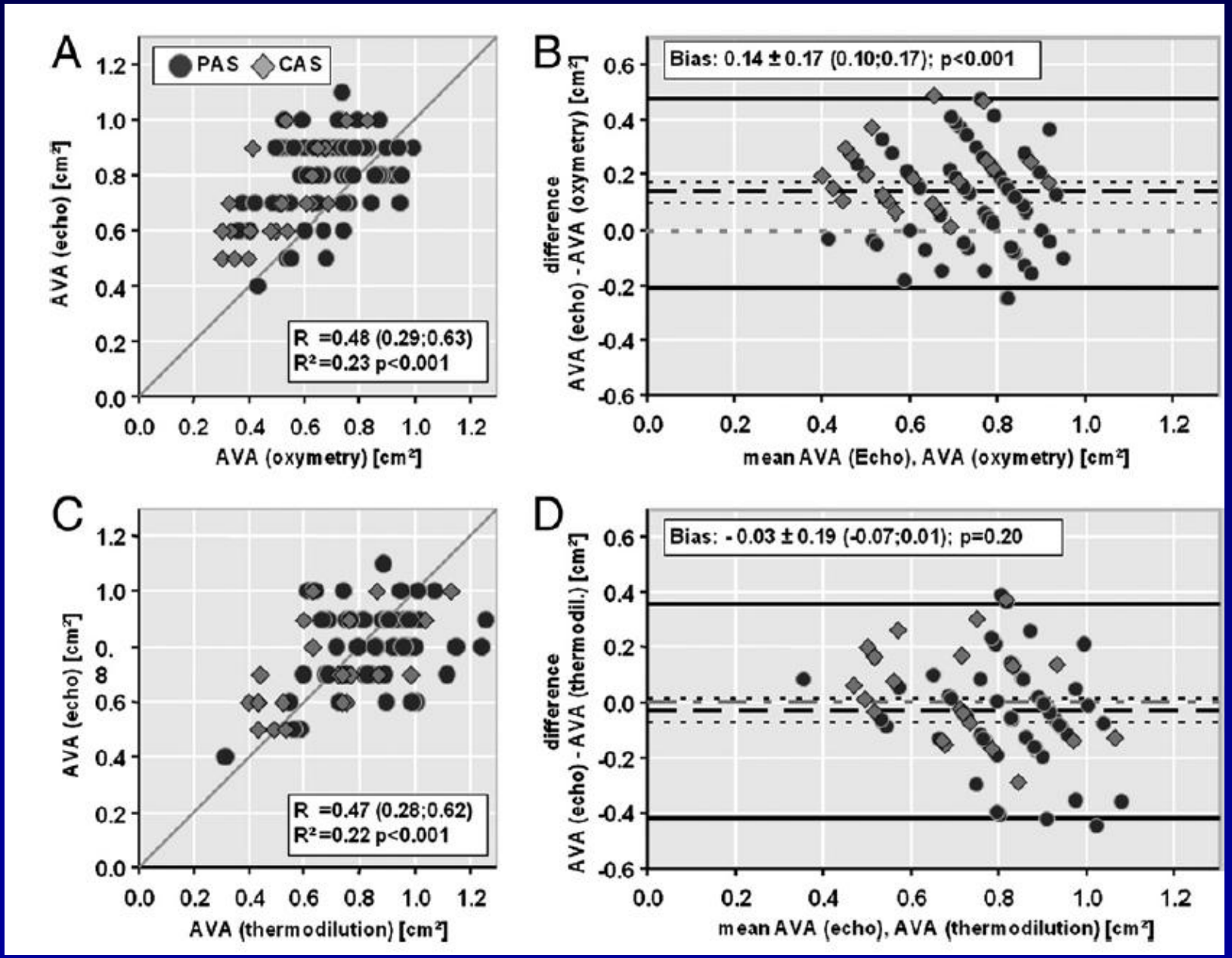
	NF Group (n=331)	PLF Group (n=181)	*P*
Gender, %			
Females	39	51	<0.05
Males	61	49	
Age, y	69±14	73±13	0.004
Body surface area, m	1.8±0.2	1.8±0.2	NS
Systemic arterial hemodynamics			
Systolic arterial pressure. mm Hg‡	134±22	131±21	NS
Diastolic arterial pressure, mm Hg‡	72±10	74±11	NS
Systemic vascular resistance, mm Hg · min · L^{-1}‡	1508±380	1986±677	<0.001
Valvulo-arterial impedance, mm Hg · mL^{-1} · m^{-2}‡	4.1±0.7	5.3±1.3	<0.001

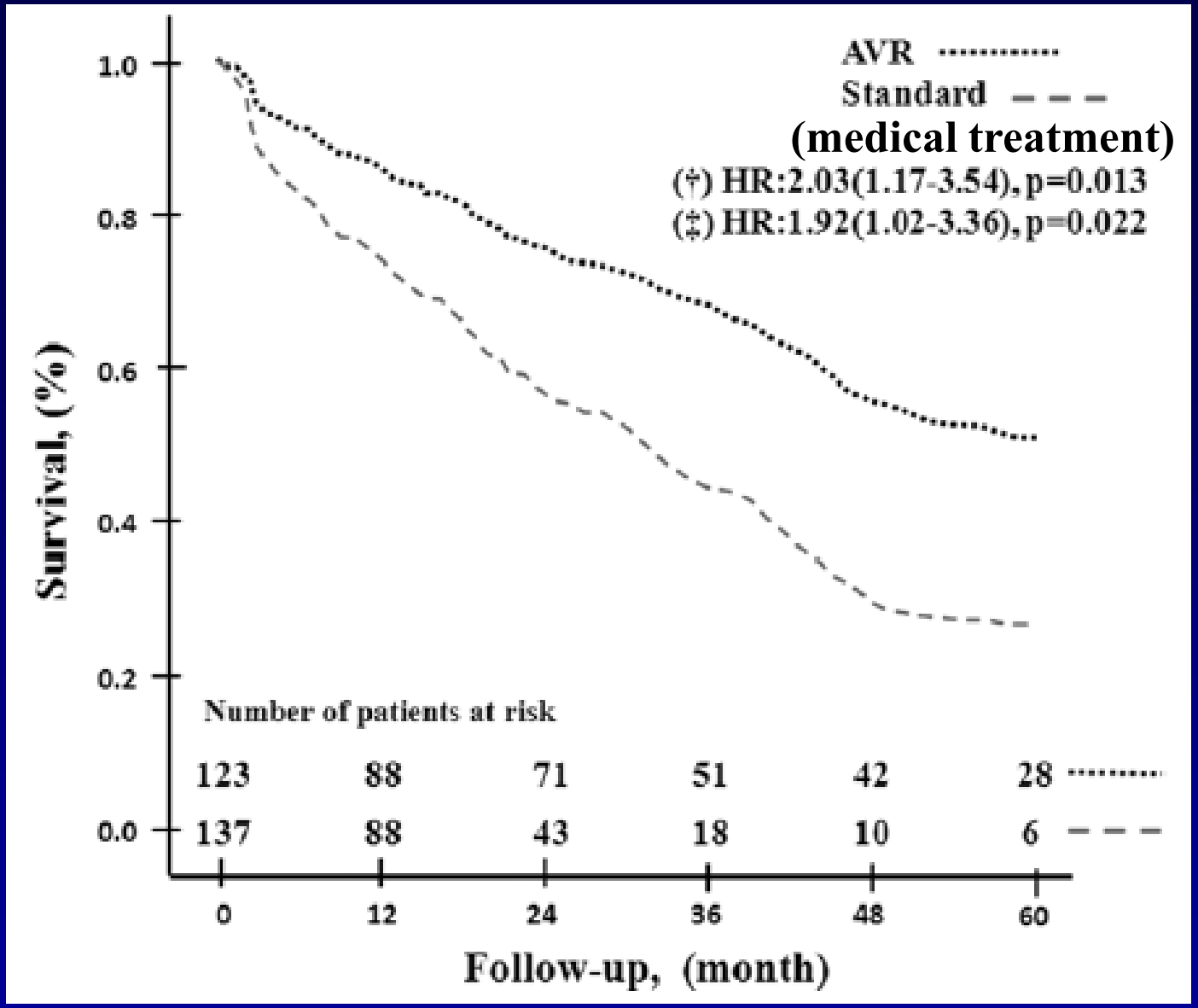
Hachicha Circulation 07;115:2856



Mehrotra, Hung EHJ 2013
n=183 pts w low gradient AS (moderate or severe)

Lauten J Am Coll Cardiol 2013;61:1799
58 pts w paradoxic AS and 22 pts w “classic” AS





Ozkan, Marwick Circ Cardiovasc Img 2013;128:622
n=260 pts w low grad. severe AS w preserved EF
123 underwent AVR; propensity analysis

Summary

- **paradoxical aortic stenosis (area < 1 cm^2, EF > 50%, mn.grad.<40 mmHg, SVI < 35 mL/m^2) is a subgroup of aortic stenosis which needs to be recognized and treated as severe aortic stenosis**

- **several factors contribute to a "paradoxically" decreased stroke volume in the presence of preserved ejection fraction: fibrosis, small hearts, hypertrophy, impaired longitudinal function, possibly others (MR ?)**

- **however, errors in the echo diagnosis should be anticipated and measurements carefully checked**

Paradoxical Low-Flow, Low-Gradient Severe Aortic Stenosis Despite Preserved Ejection Fraction Is Associated With Higher Afterload and Reduced Survival

Zeineb Hachicha, MD; Jean G. Dumesnil, MD; Peter Bogaty, MD; Philippe Pibarot, DVM, PhD

(*Circulation*. 2007;115:2856-2864.)

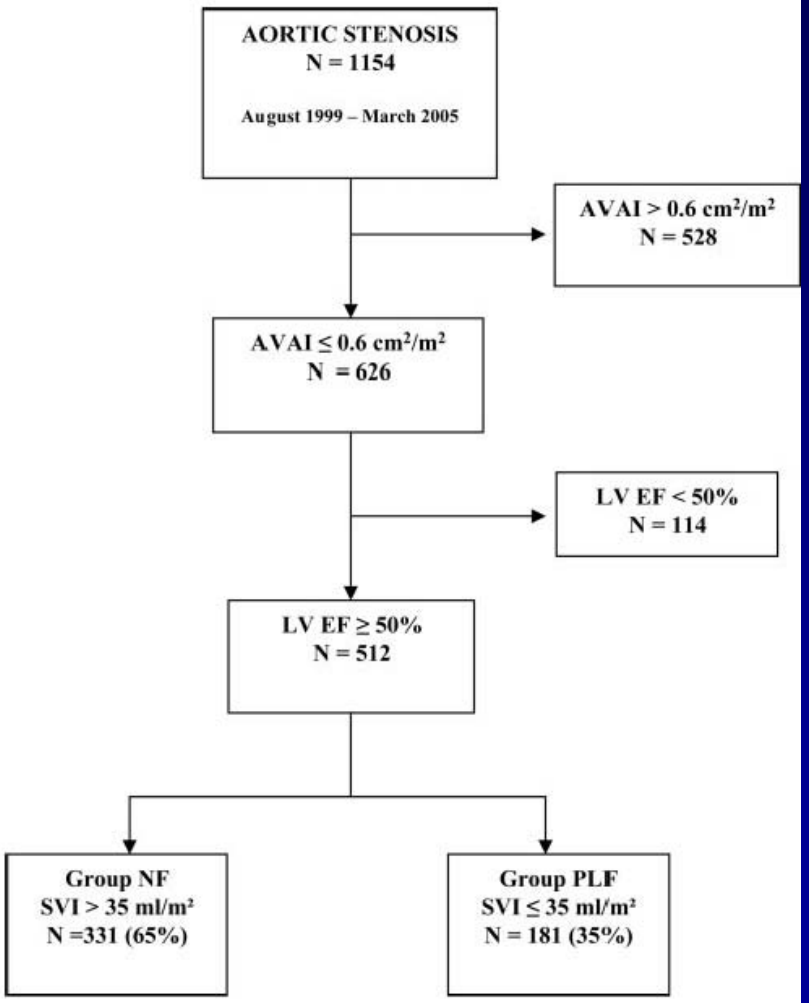


Figure 1. Description of the patient population. AVAI indicates indexed aortic valve area; SVI, stroke volume index; NF, normal flow; and PLF, paradoxical low flow.

SVI = 35 ml/m² ≈ 4.4 l/min CO

Table 11. Mean normal values for cardiac index and stroke index as a function of age*

	Age (yrs)	*No. of subjects*	*BSA (m^2)*	*HR (beat/min)*	*CI ($L/min/m^2$)*	*SI ($ml/beat/m^2$)*
	23.6	9	1.75	76.9 ± 4.6	3.72 ± 0.28	48.9 ± 3.1
	34.1	10	1.86	71.7 ± 3.4	3.54 ± 0.30	49.4 ± 3.8
	43.3	11	1.81	69.1 ± 3.0	2.96 ± 0.17	43.3 ± 2.5
	54.8	11	1.67	69.8 ± 2.8	2.78 ± 0.13	40.3 ± 2.2
	65.4	10	1.67	63.0 ± 3.2	2.58 ± 0.15	41.5 ± 2.4
	73.3	9	1.61	65.8 ± 3.6	2.54 ± 0.18	39.3 ± 3.2
	82.0	7	1.64	67.0 ± 7.5	2.36 ± 0.23	36.5 ± 3.3
Mean ±SD	52.5	67	1.72	69.1 ± 12.1	2.94 ± 0.78	43.0 ± 9.5

*From Brandfonbrener, M., Landowne, M., and Shock, N. W.: Changes in cardiac output with age. Circulation 12:557, 1955, Table 1, by permission of The American Heart Association, Inc.

Table 3 Classification of Patient Data According to Mean Transaortic Gradient (Low Gradient ≤40 mm Hg, High Gradient >40 mm Hg) and Stroke Volume Index (Low Flow <35 ml/m^2, High Flow ≥35 ml/m^2) Measured by Echocardiography

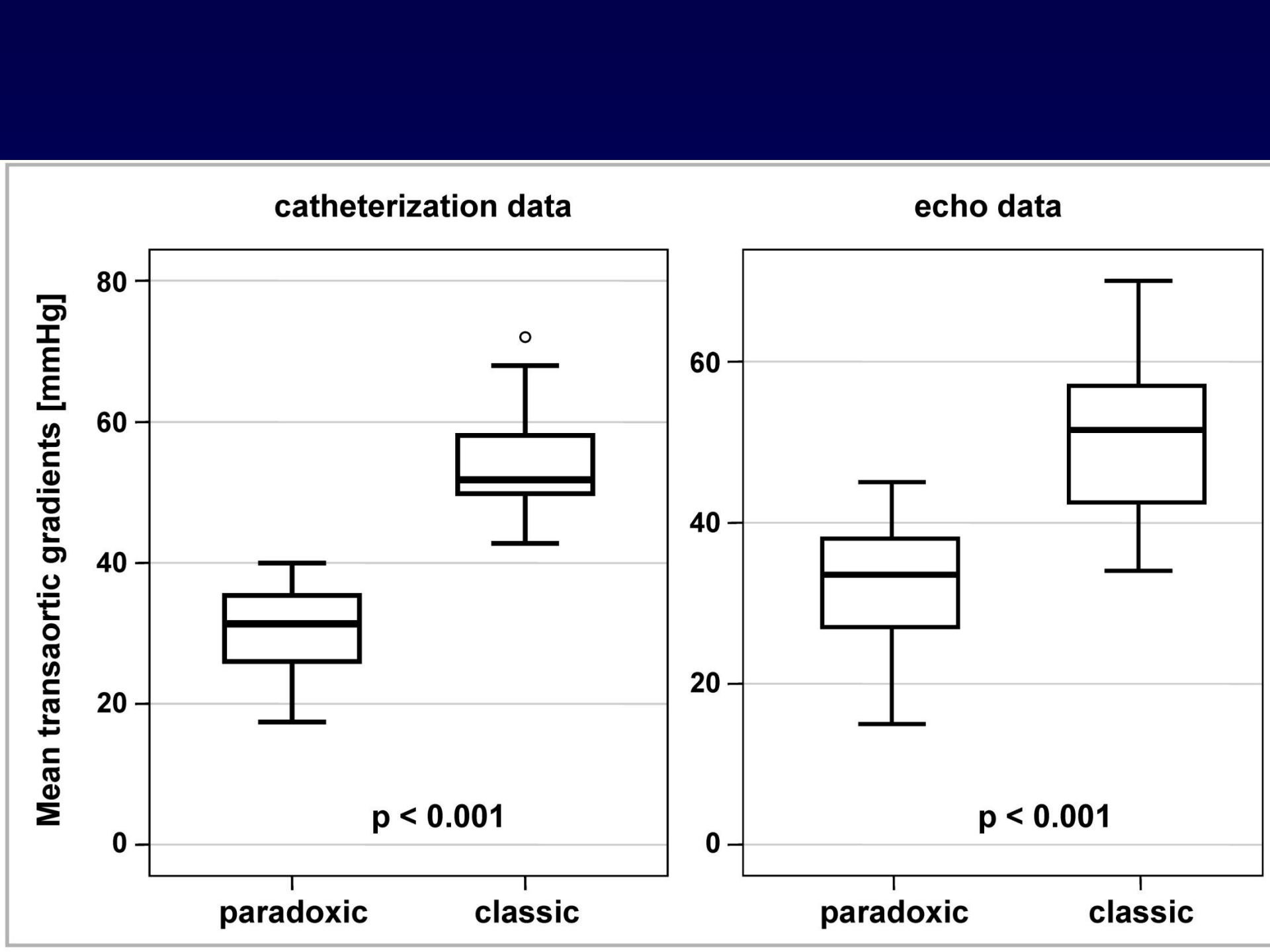
	Low Gradient Severe Aortic Stenosis Despite Preserved Ejection Fraction		Conventionally Defined Severe Aortic Stenosis	
	LG/LF	LG/HF	HG/LF	HG/HF
n	53	5	18	4
Female/male	31/22	2/3	11/7	1/3
Aortic valve area (echocardiography), cm^2	0.79 ± 0.15	0.84 ± 0.13	0.71 ± 0.16	0.78 ± 0.22
Mean systolic transvalvular gradient (echocardiography),* mm Hg	32 ± 7	31 ± 9	51 ± 11	50 ± 2
Left ventricular mass index, g/m^2	124 ± 27	136 ± 17	143 ± 36	139 ± 26
Relative wall thickness	0.56 ± 0.13	0.50 ± 0.05	0.60 ± 0.09	0.54 ± 0.08
End-systolic volume index, ml/m^2	13 ± 6	23 ± 9 LG/LF†	15 ± 6	17 ± 2
End-diastolic volume index, ml/m^2	38 ± 11	65 ± 10 vs. LG/LF† vs. HG/LF†	41 ± 11	54 ± 2 vs. LG/LF†
Stroke volume index (echocardiography),* ml/m^2	24 ± 6	42 ± 5	26 ± 6	37 ± 2
Energy loss index, cm^2/m^2	0.51 ± 0.12 vs. HG/LF†	0.53 ± 0.09	0.42 ± 0.09	0.44 ± 0.14

Lauten J Am Coll Cardiol 2013;61:1799

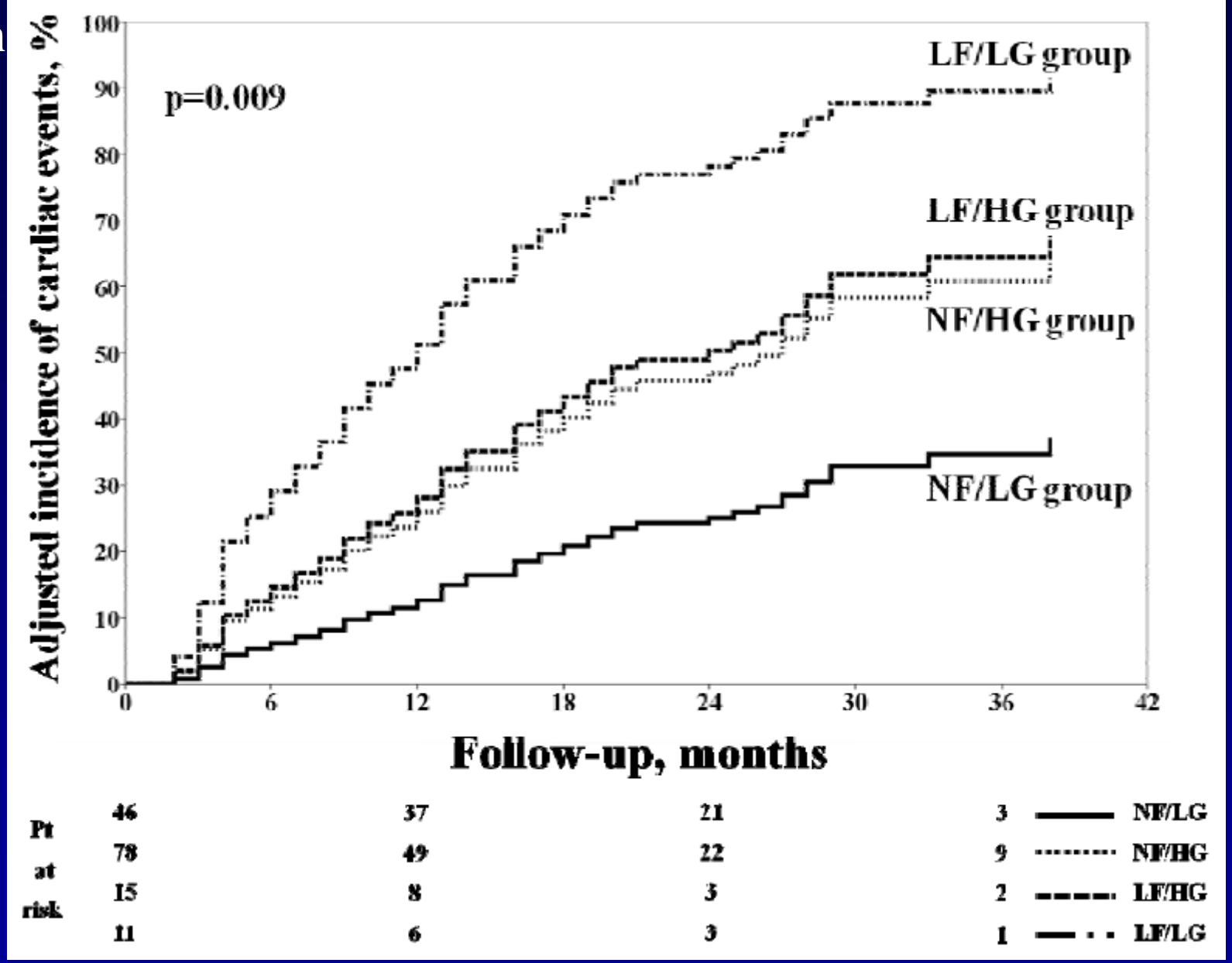
PLF group: EF ≥ 50% and AOA ≤ 0.6 cm^2/m^2 stroke volume index ≤ 35 ml/m^2, mean gradient 32 ± 17 mmHg

TABLE 1. Comparison of Clinical and Systemic Arterial Data in NF and PLF Groups

	NF Group (n=331)	PLF Group (n=181)	*P*
Gender, %			
Females	39	51	<0.05
Males	61	49	
Age, y	69±14	73±13	0.004
Body surface area, m	1.8±0.2	1.8±0.2	NS
Risk factors and concomitant diseases, %			
Obesity	34	31	NS
Hypertension	68	74	NS
Diabetes	26	28	NS
Hypercholesterolemia	57	52	NS
Coronary artery disease	56	65	NS
Previous myocardial infarction	21	26	NS
Systemic arterial hemodynamics			
Systolic arterial pressure. mm Hg‡	134±22	131±21	NS
Diastolic arterial pressure, mm Hg‡	72±10	74±11	NS

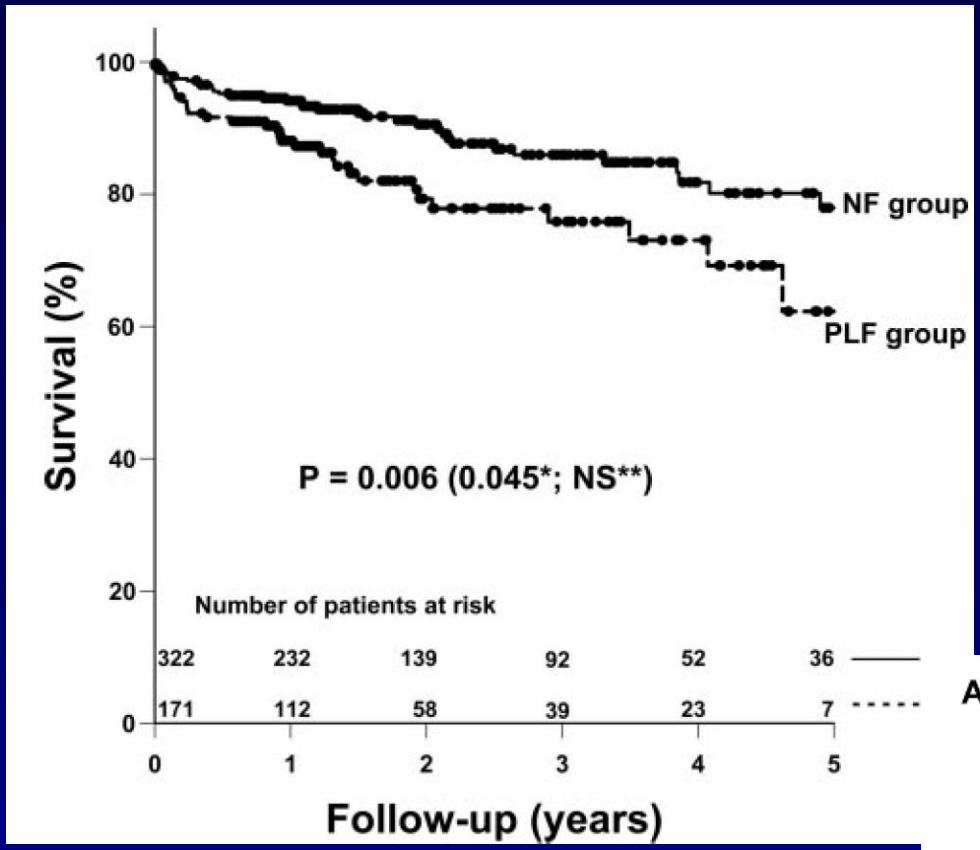

catheterization data
echo data
Mean transaortic gradients [mmHg]
80
60
40
20
0
p < 0.001
p < 0.001
paradoxic
classic
paradoxic
classic

death or AVR



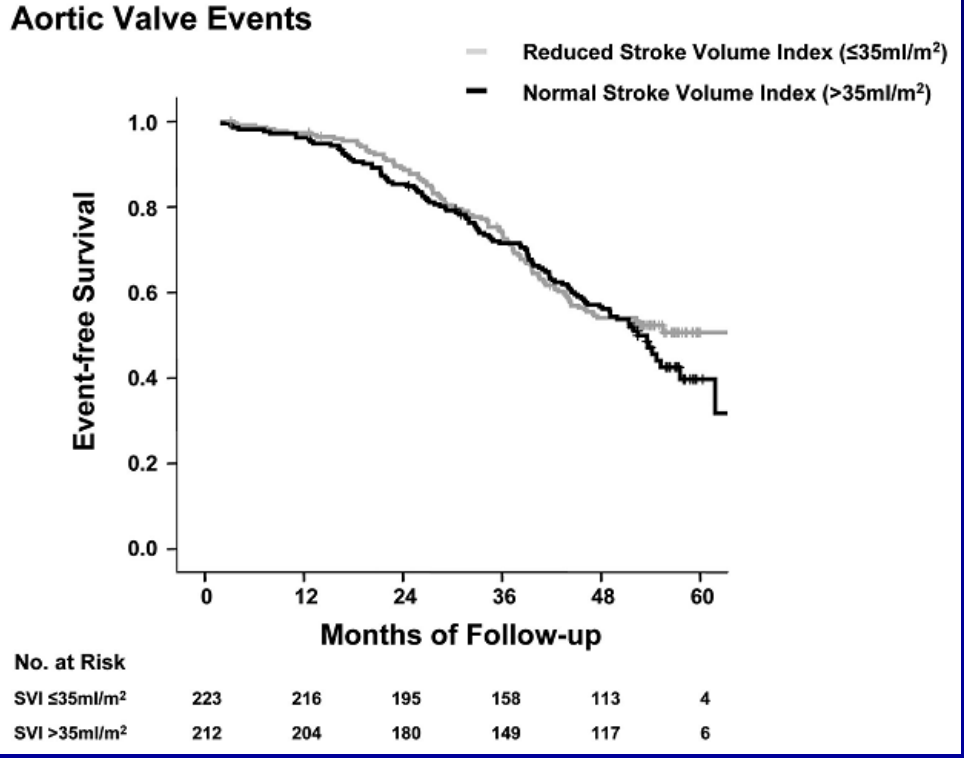
Lancellotti et al., J Am Coll Cardiol 2012;59:235

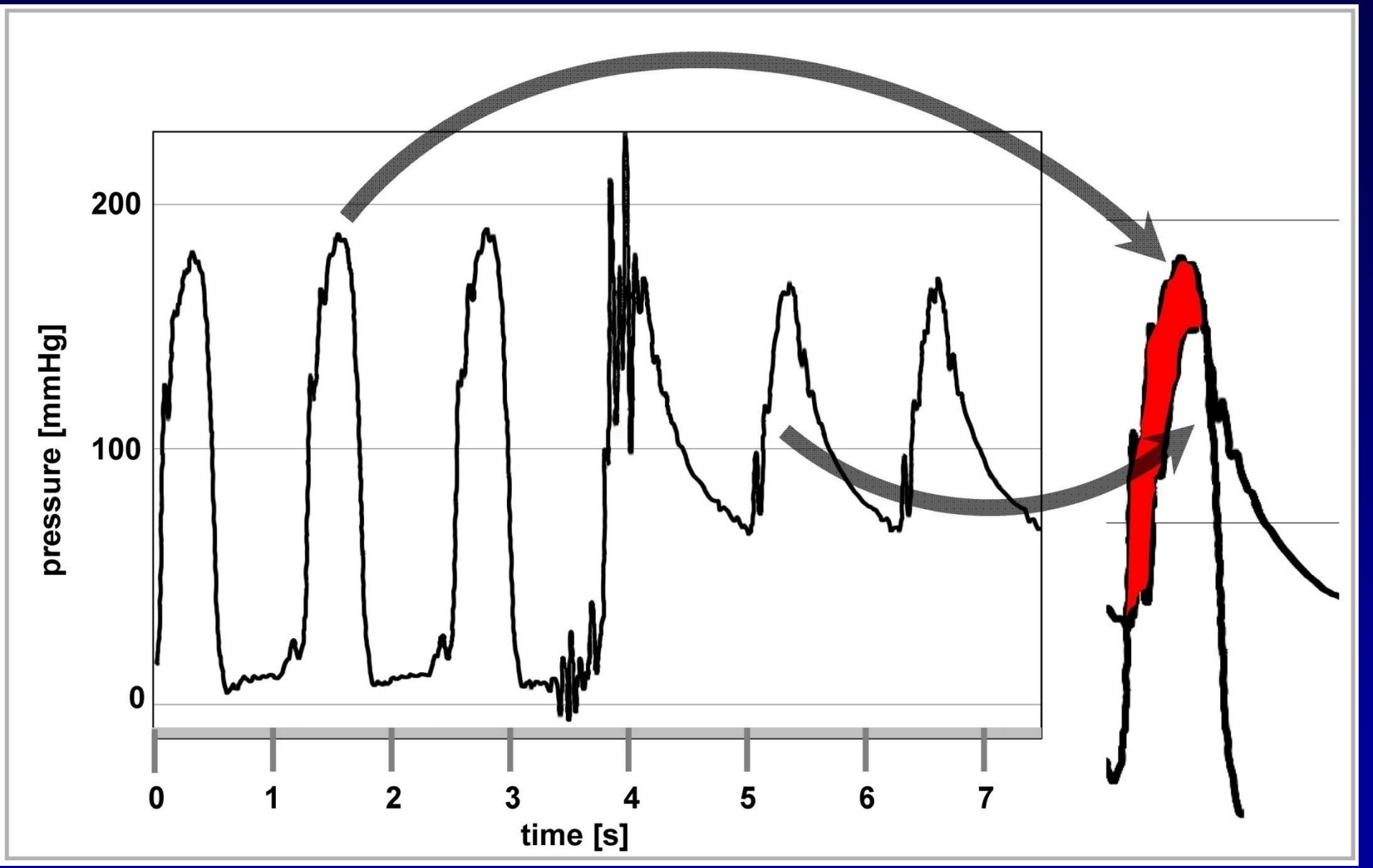
n=150 pts w. AS < 1 cm^2 and EF>50%; LF < 35 ml/m^2; LG < 40mmHg



Hachicha Circulation 07;115:2856

Jander Circulation 11;123:887




200
100
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pressure [mmHg]
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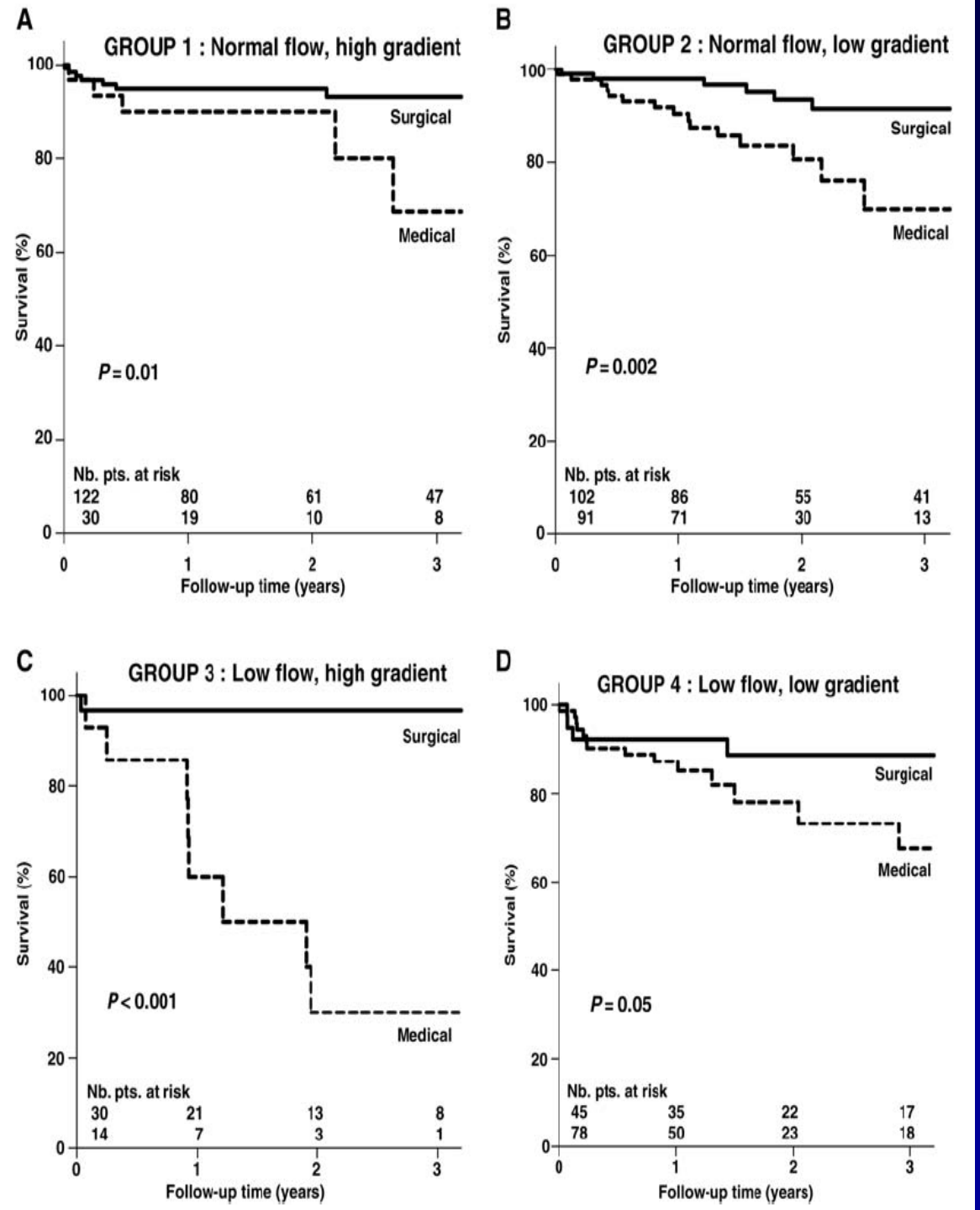

Hachicha Circulation 07;115:2856
Dumesnil EHJ 10;31:281

observational study of 512 pts with AS ≤ 0.6 cm2/m2 and EF ≥ 50%

mean grad. < > 40 mmHg

"flow" = stroke volume index < > 35 mL/m2