LOW FLOW AORTIC STENOSIS IN HEART FAILURE: HOW TO EVALUATE AND PROCEED

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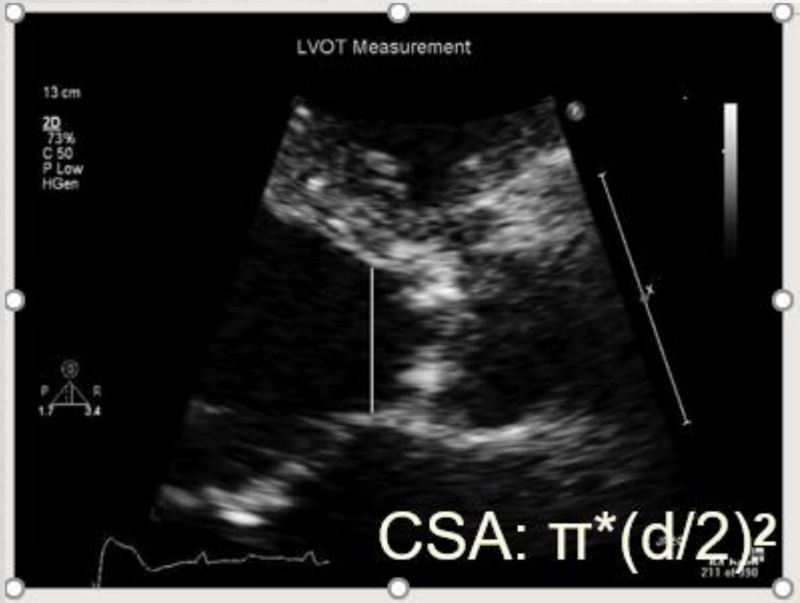
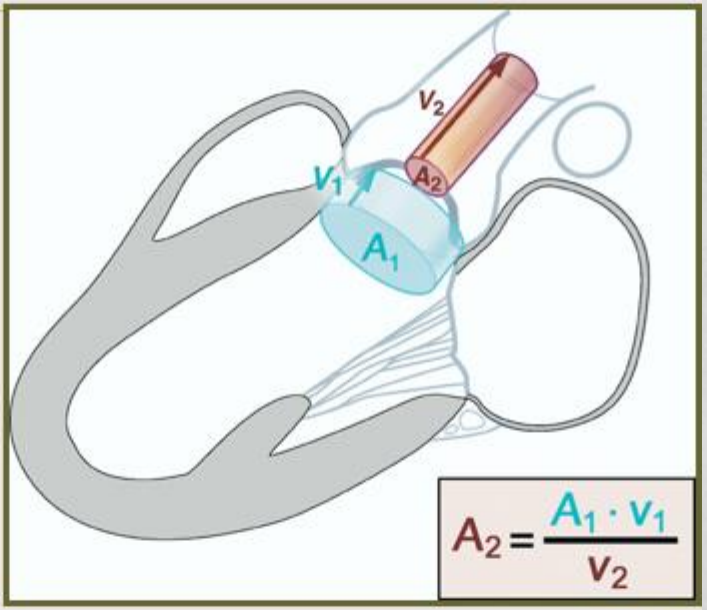
- No conflict of interest to declare

ISSUES

- AS severity evaluation (flow dependency)
- When, in whom and how to intervene
- Are there pts inoperable?
- How has TAVR changed our options?
- Expanding intervention options

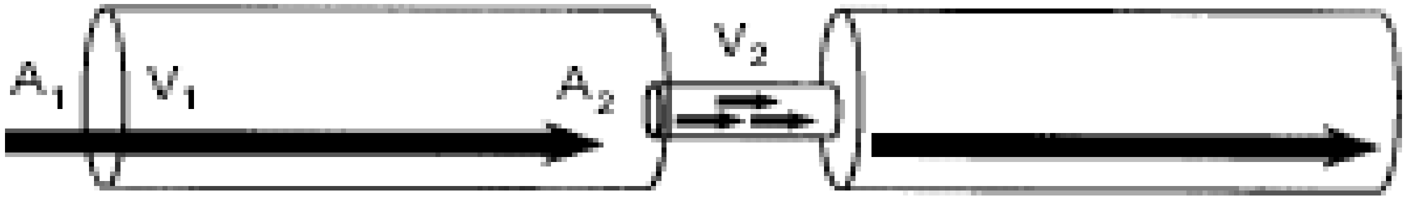
SEVERITY





	Moderate	Severe
Aortic jet velocity (m/s)	3.0–4.0	>4.0
Mean gradient (mmHg)	20–40[b] (30–50[a])	>40[b] (>50[a])
AVA (cm^2)	1.0–1.5	<1.0
Indexed AVA (cm^2/m^2)	0.60–0.85	<0.6
Velocity ratio	0.25–0.50	<0.25

SEVERITY



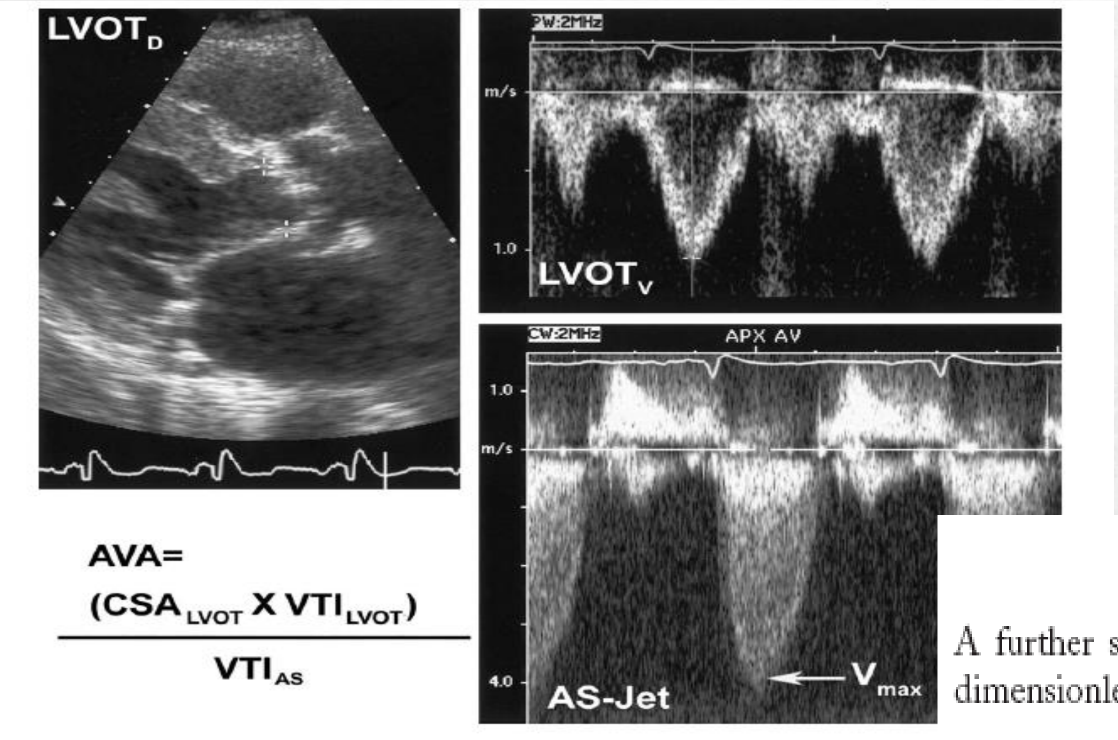
$$A_1 \times V_1 = A_2 \times V_2$$

Figure 1. Principles of the Use of Doppler Ultrasonography and the Continuity Equation in Estimating Aortic-Valve Area.

For blood flow ($A_1 \times V_1$) to remain constant when it reaches a stenosis (A_2), velocity must increase to V_2. Doppler examination of the stenosis detects the increase in velocity, which can be used to calculate the aortic-valve gradient or to solve the continuity equation for A_2. A denotes area, and V velocity.

Carabello NEJM 1997;337:32

SEVERITY



$$\Delta P_{max} = 4V^2_{max}$$

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

$$AVA = (CSA_{LVOT} \times VTI_{LVOT}) / VTI_{AS}$$

$$AVA = (CSA_{LVOT} \times V_{LVOT}) / V_{AS}$$

A further simplification of the continuity equation is the dimensionless ratio of outflow tract to aortic velocity:

$$\text{Velocity ratio} = (V_{LVOT})/V_{AS}$$

Velocity ratio< 0,25 indicates severe AS
Useful when LVOT diameter is difficult to obtain

Otto CM, JACC 2006;47:2141

ECHO/Doppler Pit Falls

- Flow dependent
- Will underestimate AS if Doppler beam is not parallel to AS velocity jet

  <u>(need to use multiple windows)</u>

- Will rarely over-estimate mean gradient
  - Severe anemia (hemoglobin <8.0 g/dl)
  - Small aortic root (pressure recovery)
  - Sequential stenoses in parallel (coexistent LVOT and valvular obstruction)

BP

- Report BP
- PG can be underestimated when BP (and vascular stiffness) is increased

VENTRICULAR-VASCULAR COUPLING

- Valvuloarterial impedance takes into account the degree of valve stenosis and the systemic arterial impedance (might be affected in AH, AR, CAD) and how LV is affected

$$Z_{va} = (SAP + \Delta P_{net})/SVi$$

The ΔP_{net} takes into account post-stenotic pressure recovery, based on measurement of the aortic CSA at the sinotubular junction (AoA):

$$\Delta P_{net} = \text{Doppler } \Delta P_{mean} - \{4v^2 \times [2(AVA/AoA) \times (1 - AVA/AoA)]\}$$

Zva>5 mmHG/ml/m2 suggests excessive ventricular load

Briand M, JACC 2005;46:291-8

LOW OUTPUT-LOW GRADIENT AS

Low flow-Low Gr-Low EF

Low flow-Low Gr-Normal EF

LOW GRADIENT

- Carabello (2000): mean APG < 30 mmHg
- Monin (2001) : mean APG < 40 mmHg
- Nishimura (2002) : mean APG < 35 mmHg

TRUE OR PSEUDO AS ?

Mean gradient and AVA

are flow dependent

NON FLOW DEPENDENT PARAMETERS

AVResistance=√Mean Gr x 1,333/Q

Q:SV/SEP

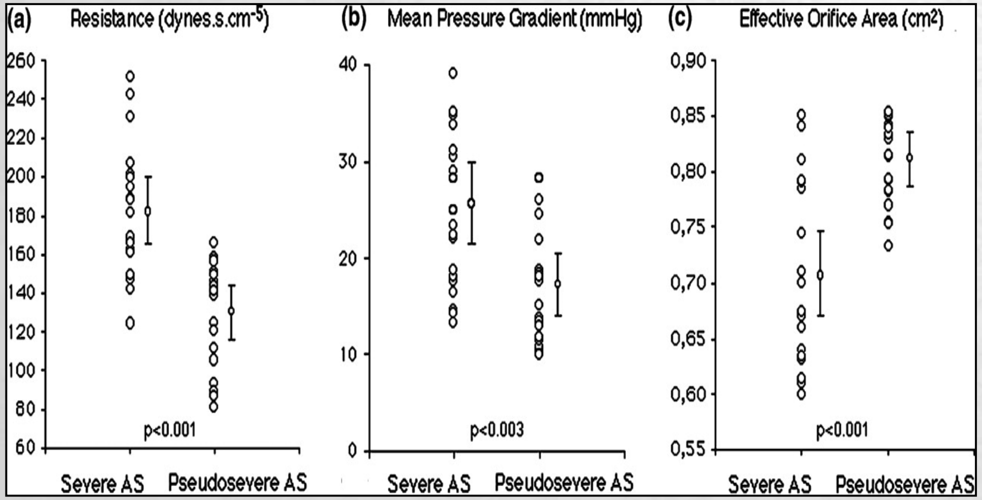
or = 28 x √Mean Gr/AVA

SWL=(Mean Gr/Mean Gr+SPB) x100

AVR and AS SEVERITY

- **SEVERE AS :**

AVR>220 dyn.s.cm^{-5}



- **NOT SEVERE AS :**

AVR<160 dyn.s.cm^{-5}

gray zone:
160-220 dyn.s.cm^{-5}

Mascherbauer J, EHJ 2004;25:787-793

SWL

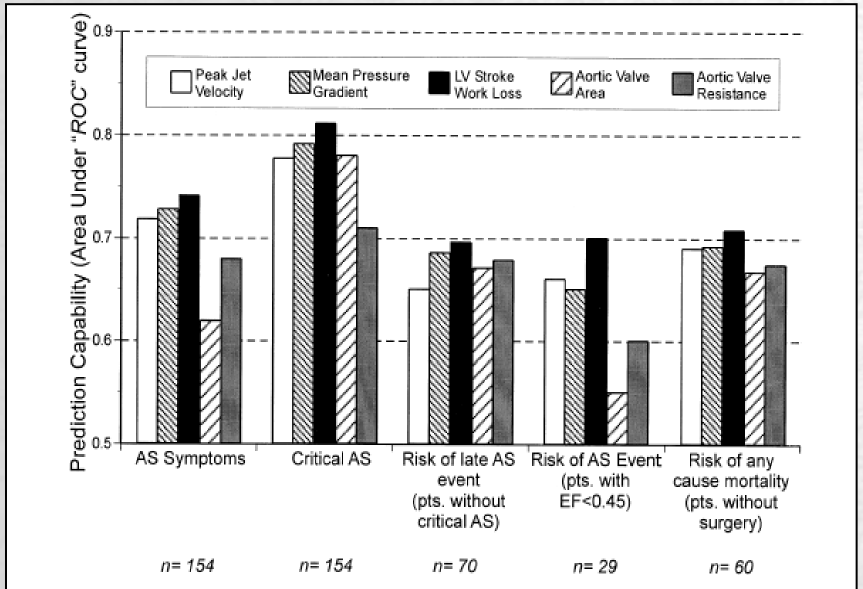
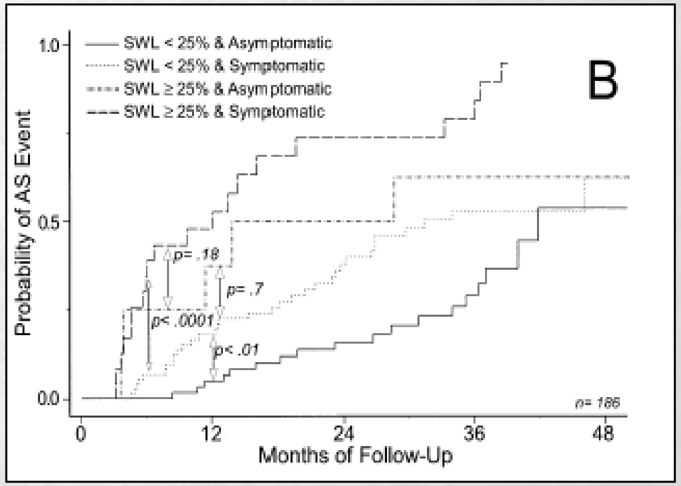


Figure 3. Clinical efficacy of aortic stenosis indices. Prediction capability is shown for the clinical objectives of predicting: 1) symptomatic status, 2) critical aortic stenosis (AS), 3) late AS events, 4) early or late AS events in patients with depressed left ventricular function, and 5) any-cause mortality in unoperated patients. Clinical efficacy is assessed by receiver-operator characteristic analysis for populations derived from Group B (see methods section). EF = ejection fraction.



Bermejo J JACC 2003;41:142

Projected EOA

patients with normal LV function.[8,13] Hence, the EOA_{proj} at a standardized flow of 250 mL/s was calculated as follows

(3) $$EOA_{proj} = EOA_{rest} + VC \times (250 - Q_{rest})$$

where EOA_{rest} and Q_{rest} are the EOA and Q at rest and VC is the valve compliance corresponding to the slope of the EOA-flow relationship (Figure 2B) and representing the rate of change in EOA in relation

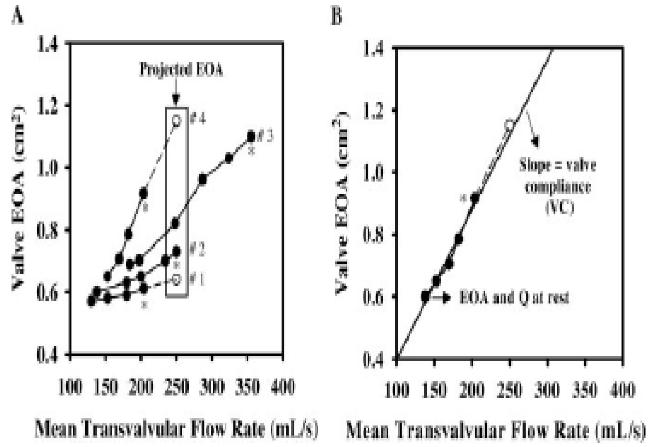
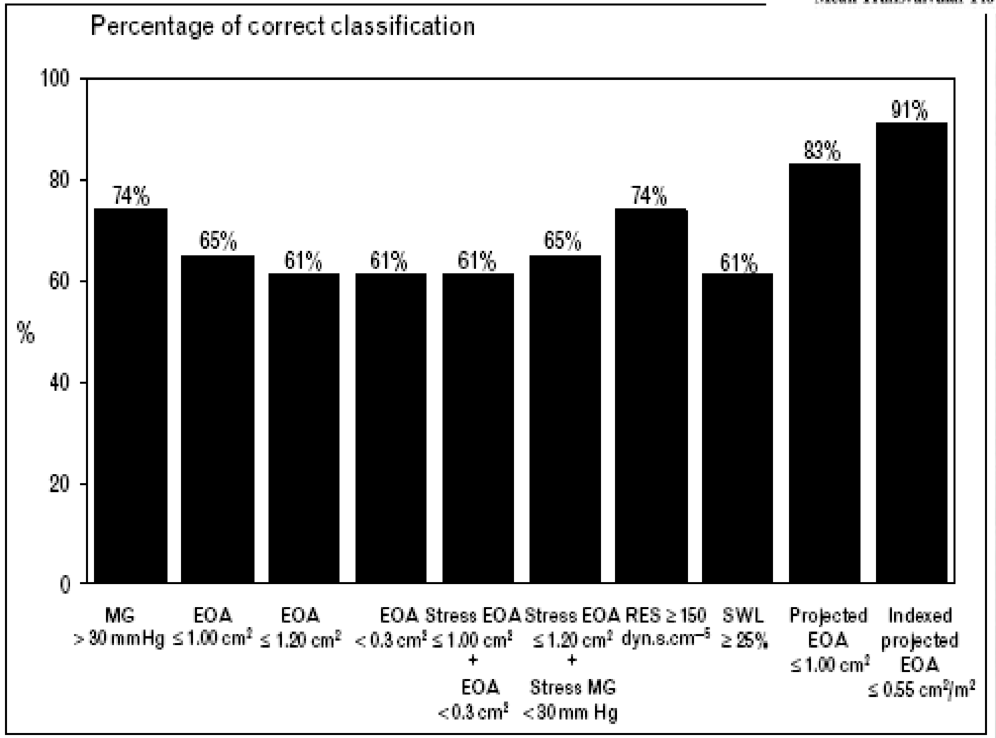
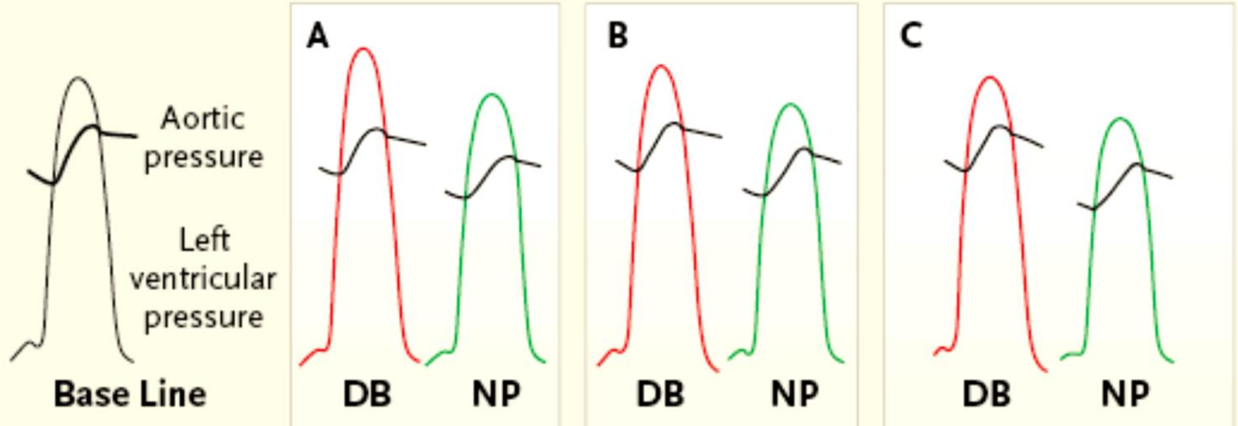


Figure 2. Concept of the EOA_{proj} in 4 different patients (A) and calculation of the projected EOA at a flow rate of 250 mL/s (B) with the use of Equation 3. *Peak valve EOA obtained during DSE.



Blais C,Circulation 2006;113:711

Heart Failure in Aortic Stenosis — Improving Diagnosis and Treatment



	A DB	A NP	B DB	B NP	C DB	C NP
Stroke volume	↑↑	↑	↑↑	↑	0 or ↑	0 or ↑
Pressure gradient	↑↑	↑	↑	0	0	0
Aortic-valve area	0	0	↑	↑	0	0
Diagnosis	True aortic stenosis		Relative aortic stenosis		Severe left ventricular dysfunction	
Benefit from aortic-valve replacement	Yes		Possible		No	

Zile MR NEJM 2003;348:1735-6

MYOCARDIAL RESERVE

Increase of SV 20%

Monin JL et al JACC 2001;37:2101-2107

DIAGNOSIS

SEVERE AS

↑ systolic flow and

↑ Vmax

⇒no or **↑AVA <0.29cm²**

remaining <1 cm^2

MODERATE AS

↑ systolic flow

↑ Vmax, ⇒

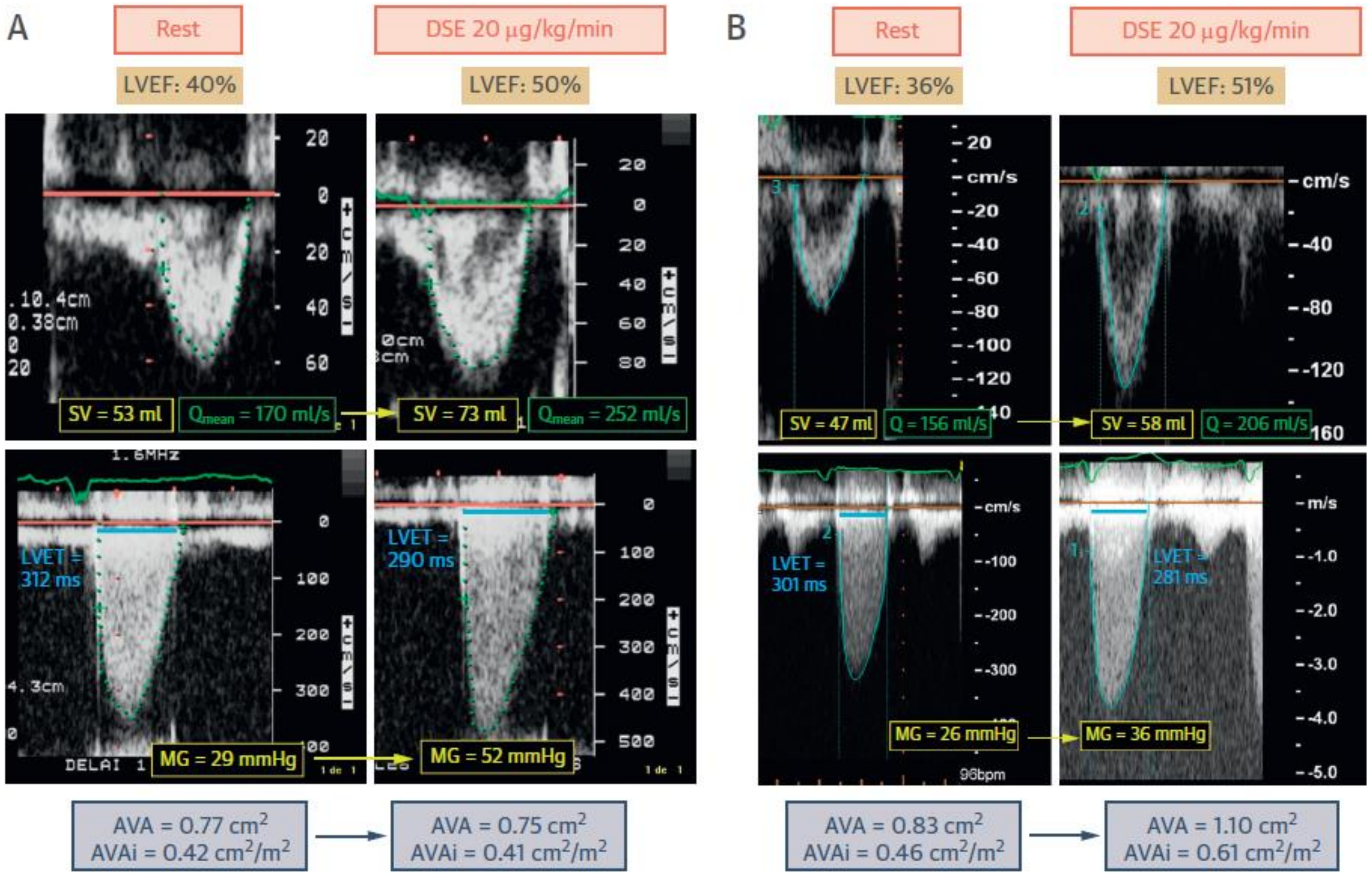
↑ AVA ≥ 0.3 cm^2

reaching at least 1 cm^2

$$AVA_{Proj} = AVA_{Rest} + [(\Delta AVA/\Delta Q) \times (250 - Q_{Rest})]$$

where AVA_{Rest} and Q_{Rest} are the AVA and mean transvalvular flow rate (Q) at rest and ΔAVA and ΔQ are the absolute increases in AVA and Q during DSE. The value of 250 ml/s included in the formula corresponds to the median value of the normal flow range.

FIGURE 2 Utility of Dobutamine Stress Echocardiography to Confirm Stenosis Severity in Low Gradient AS

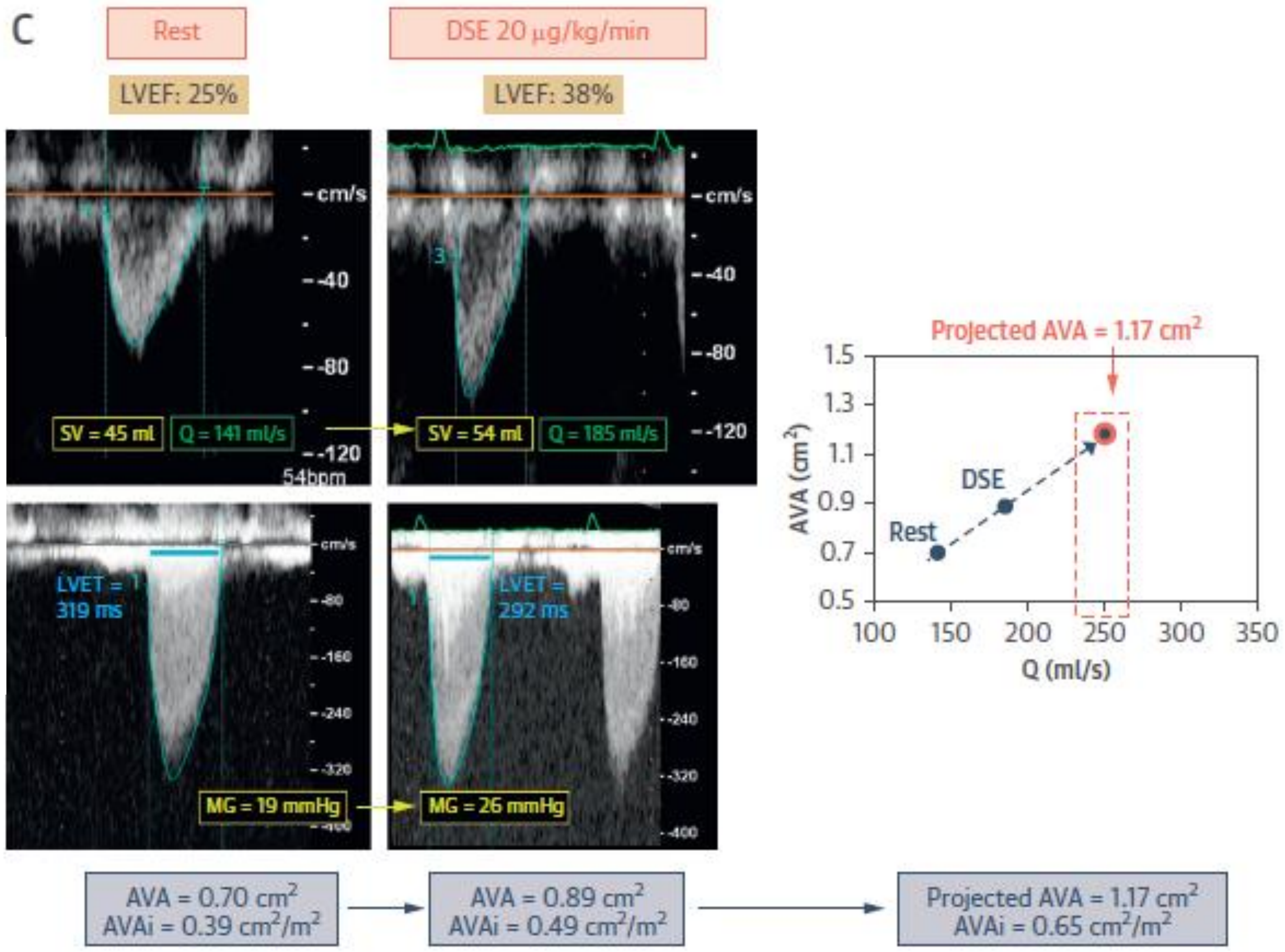


(A) Discordant grading of AS severity at resting echocardiography: small AVA consistent with severe AS but low MG consistent with moderate AS. With DSE, the SV, Q and MG increase, whereas AVA remains unchanged; both the AVA and MG are now within the severe range, confirming the presence of severe AS. Q is calculated by dividing the SV by the LVET, which is measured on the continuous-wave Doppler signal of transvalvular flow velocity (blue lines). **(B)** Discordant grading at resting echocardiography: AVA consistent with severe AS but low MG consistent with moderate AS. With DSE, the SV and mean Q increase and both the AVA and MG are now within the moderate range, confirming the presence of moderate AS. **(C)** Discordant grading at rest (similar to case in panel A) but that persists at the end of DSE. Indeed, although the SV and Q increase significantly with DSE, the Q at peak DSE remains below normal (<200 ml/s). The gradient increases but remains in the moderate range and the AVA increases but remains in the severe range. In such case, the calculation of the projected AVA at normal flow rate (250 ml/s) may be useful to confirm stenosis severity: $AVA_{Proj} = AVA_{Rest} + \Delta AVA/\Delta Q \times (250 - QRest) = 0.69 + 0.19/44 \times (250 - 141) = 1.17\ cm^2$. The projected AVA confirms the presence of moderate AS in this case. **(D)** Discordant grading with AVA in the moderate range but MG in the mild range. With DSE, the MG increases but remains in the mild range and the AVA increases to the mild range. In this case, DSE confirms that the stenosis is mild. LVET = left ventricular ejection time; Q = mean transvalvular flow rate; other abbreviations as in Figure 1.

and AVR may be reasonable (48). In contrast, a projected AVA between 1.0 and 1.5 cm^2 is consistent with moderate AS (Figure 1). Of note, a ≥15% increase in flow rate is required to obtain a reliable estimate of AVA_{Proj} (50). The majority of patients with no flow reserve (i.e., increase in SV<20%) actually achieve this minimum requirement because the shortening of LV ejection time compensates for the absent or minimal increase in SV. In the recent report of the multicenter TOPAS (True or Pseudo Severe Aortic Stenosis) study (24), 44% of the patients with classical low-flow, low-gradient AS had no evidence of flow reserve on DSE, but only 11% had <15% increase in mean flow rate, thus precluding the determination of AVA_{Proj}. In the same study (24), the percentage of correct classification of true versus pseudo-severe AS was 48% for stress MG ≥40 mm Hg, 60% for stress AVA ≤1.0 cm^2, and 70% for AVA_{Proj} ≤1.0 cm^2.

If DSE results are consistent with severe AS, AVR is indicated (2,3). Transfemoral TAVR may be the preferred intervention in many elderly patients with low-flow, low-gradient AS and HFrEF, especially if they have no flow reserve on DSE, although guidelines do not specifically address the choice of surgical

FIGURE 2 Continued



CONSIDERATIONS

DIAGNOSTIC

True or Pseudosevere Stenosis

PROGNOSTIC

from those having true severe AS who would benefit from AVR ?

PERIOPERATIVE MORTALITY LOW OUTPUT-LOW GRADIENT AS

DSE-NO RESERVE

33% Brogan (JACC;1993)

11% Blitz (Am J Card;1998)

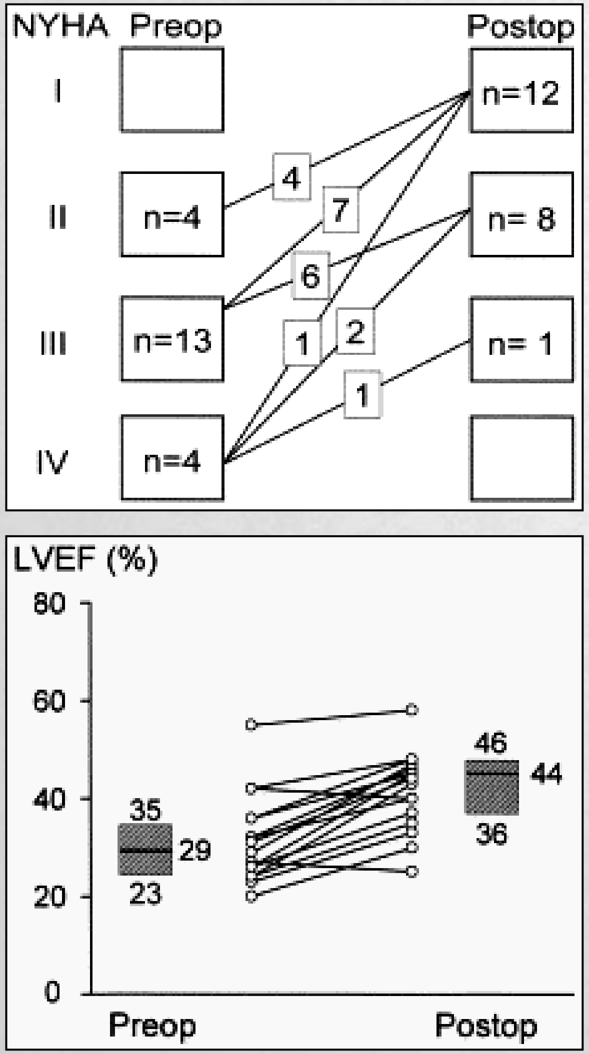
21% Connolly (Circ;2000)

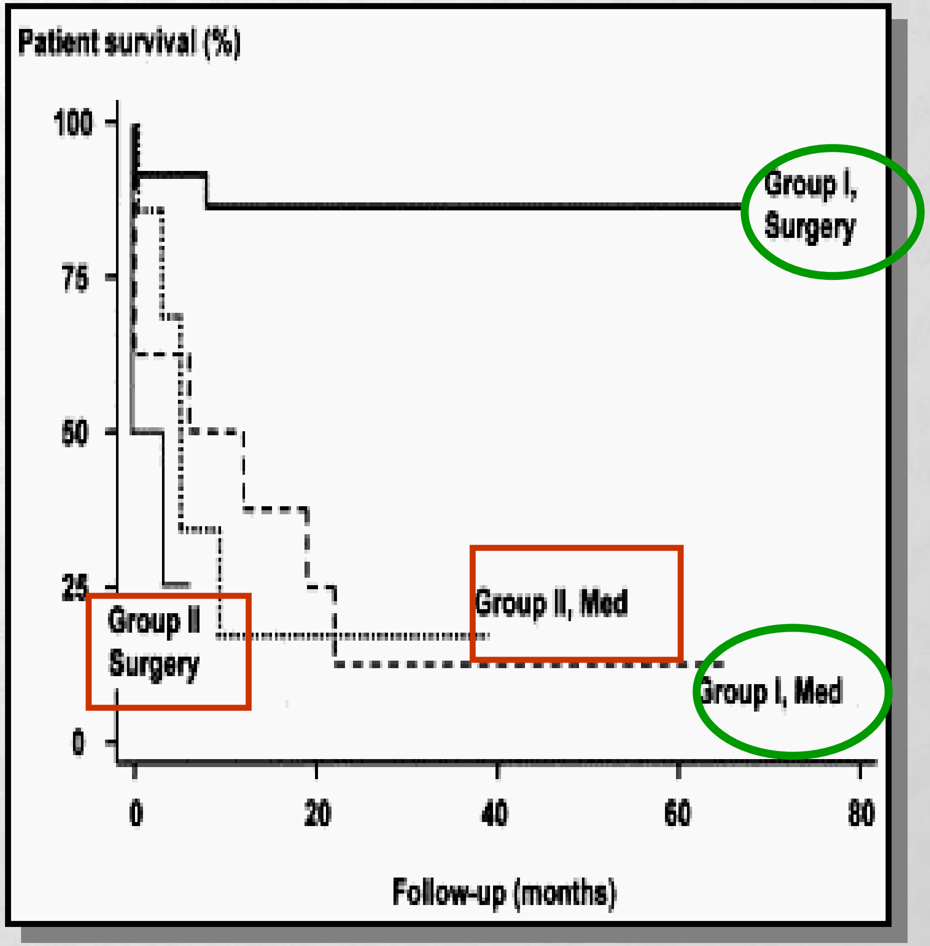
47% Powell (Arch Intern Med; 2000) [+MI]

DSE-MYOCARDIAL RESERVE

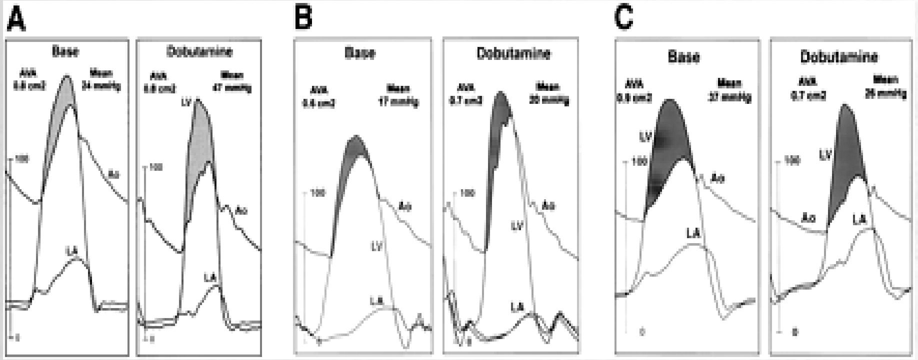
8% Monin (JACC;2001)

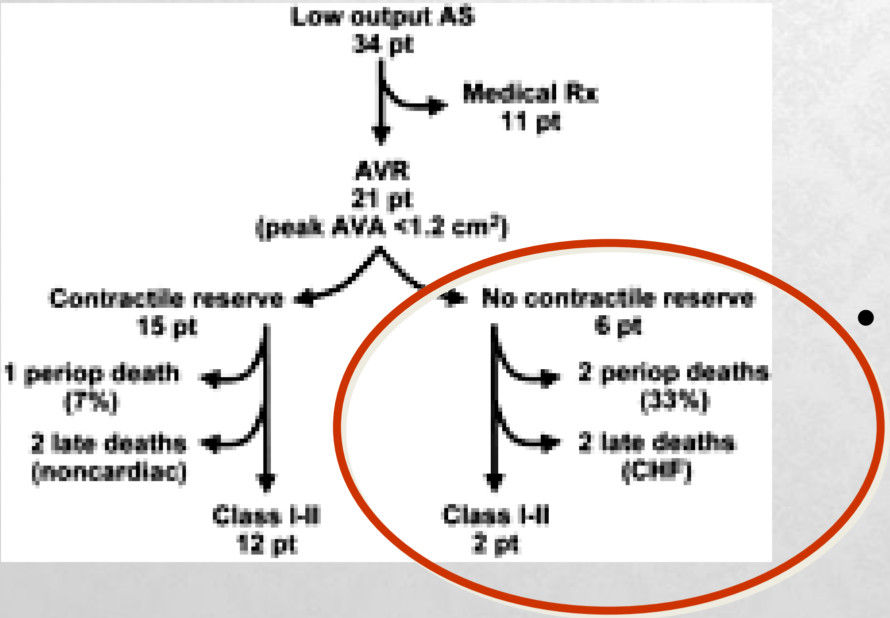
7% Nishimura *(Circulation 2002)*





Monin JL et al JACC 2001;37:2101-2107





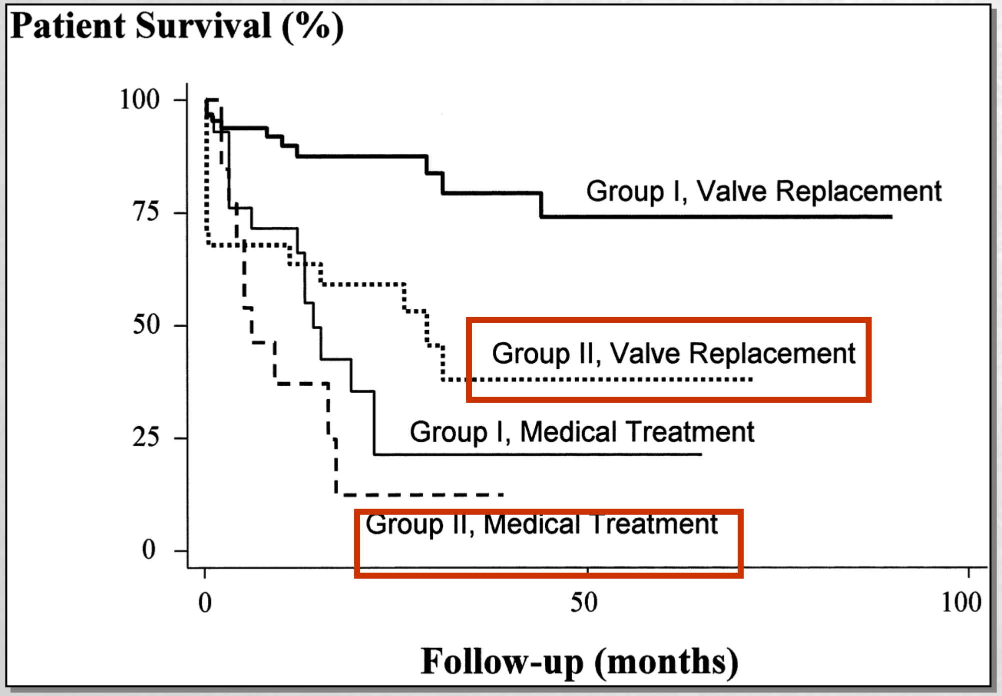
- Increased output causes an increase in aortic valve area (no severe AS)
- Increased output produces a substantial increase gradient (severe AS-AVR)
- No response to inotropic stimulation (poor outcome)

Nishimura R et al Circulation 2002;106:809-813

Low Gradient Aortic Stenosis

Operative risk stratification and predictors for long term outcome

A multicenter study using DSE hemodynamics



Operative mortality

G1: 5% G2: 32%

Predictors for Operative Mortality

LV systolic Reserve

Mean AoV PG <20mmHg (10 vs44%)

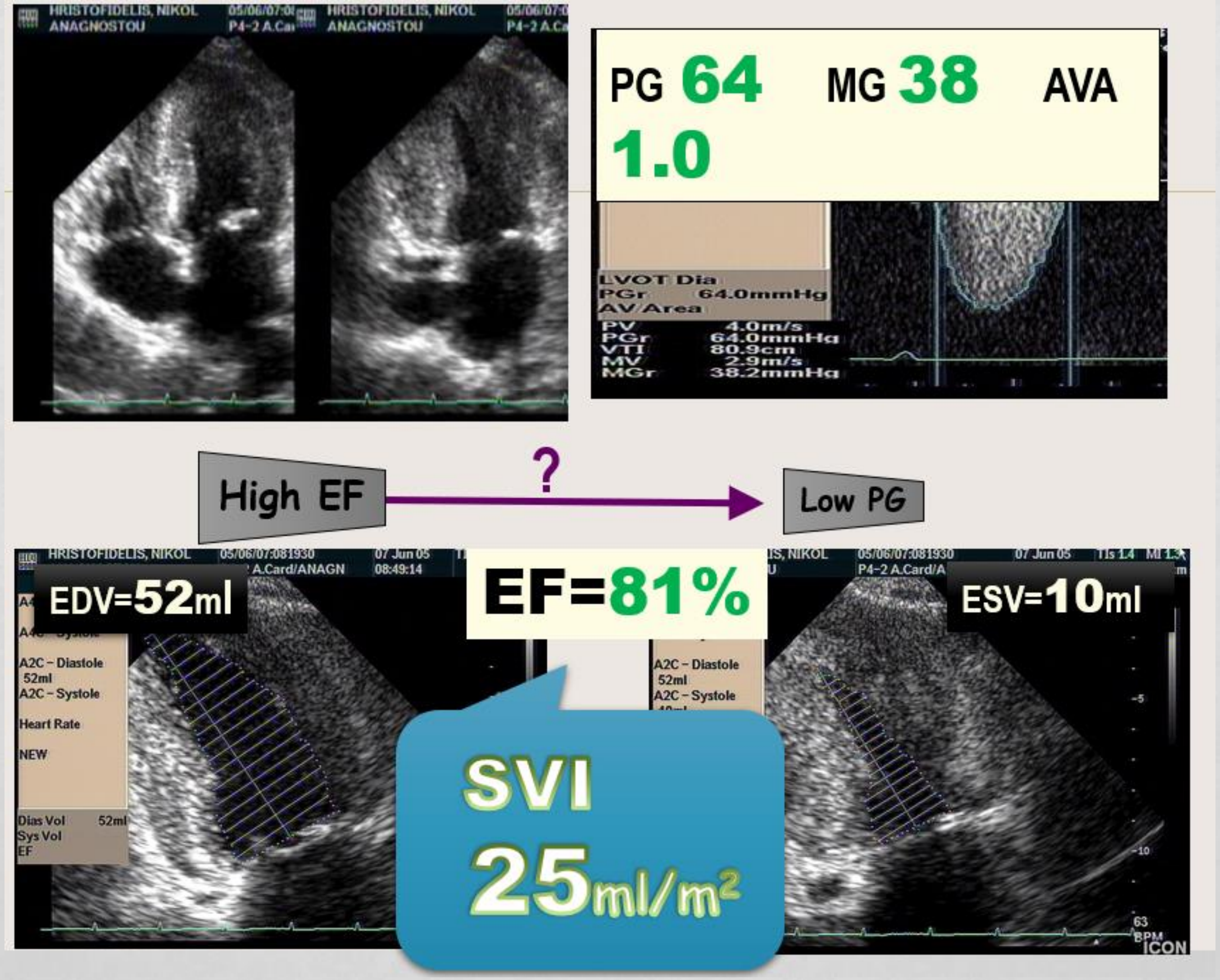
Predictors for long term mortality

AVR

LV systolic Reserve

Monin et al Circulation 2003; 108:319

LOW FLOW PRESERVED EF



Integration of Flow-Gradient Patterns Into Clinical Decision Making for Patients With Suspected Severe Aortic Stenosis and Preserved LVEF

A Systematic Review of Evidence and Meta-Analysis

Chirag Bavishi, MD, MPH, Kiruthika Balasundaram, MD, Edgar Argulian, MD, MPH

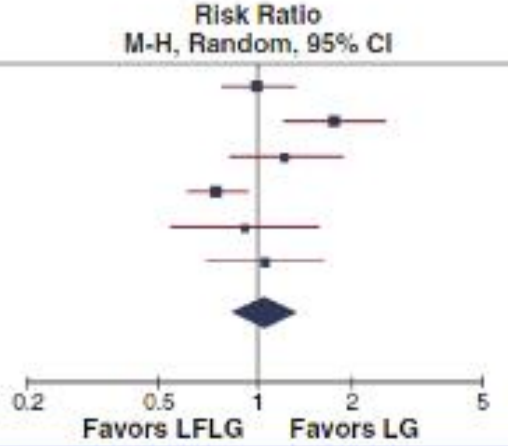
FIGURE 3 **Comparison of Subgroups of Patients With SAS**

(A) Low-flow Low-gradient vs. High-gradient SAS

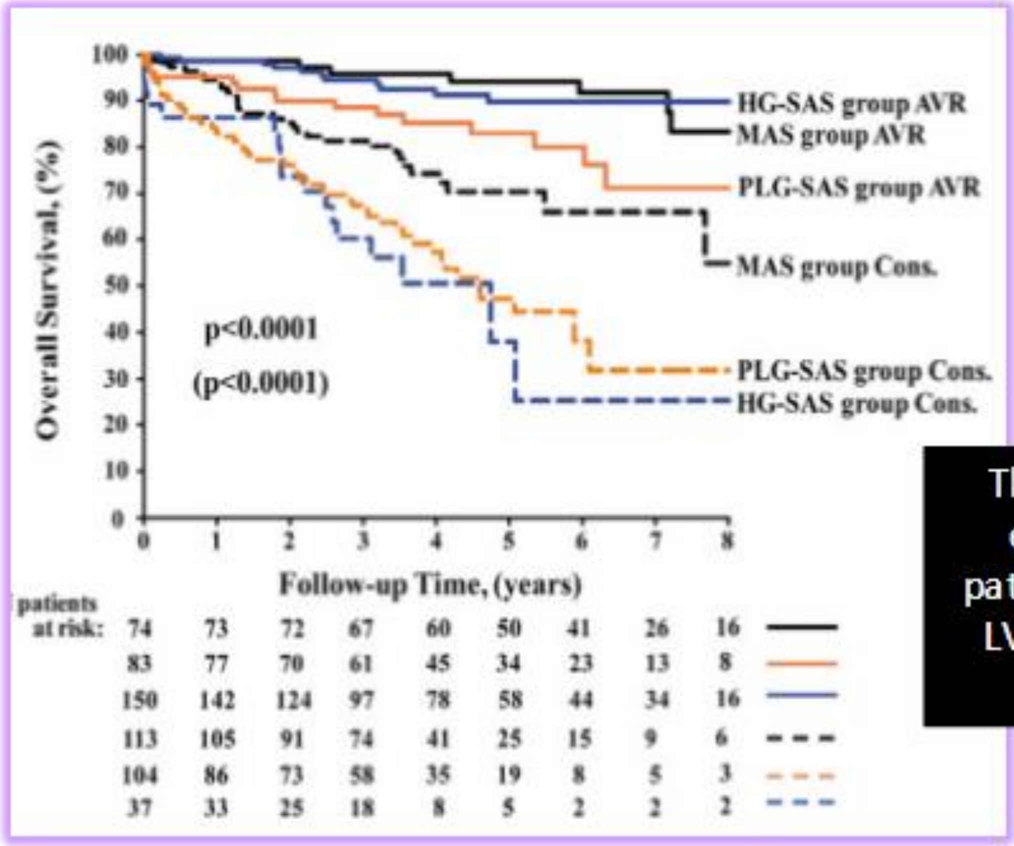
Study or Subgroup	LFLG Events	LFLG Total	HG Events	HG Total	Weight	Risk Ratio M-H, Random, 95% CI
Clavel, 2012	71	104	25	37	19.7%	1.01 [0.78, 1.31]
Eleid, 2013	16	28	91	279	16.5%	1.75 [1.22, 2.52]
Lancellotti, 2012	8	11	55	93	15.4%	1.23 [0.82, 1.83]
Maes, 2014	60	115	99	144	21.3%	0.76 [0.62, 0.93]
Melis, 2013	10	23	36	76	12.1%	0.92 [0.54, 1.55]
Tribouilloy, 2015	19	57	77	247	15.0%	1.07 [0.71, 1.61]
Total (95% CI)		**338**		**876**	**100.0%**	**1.07 [0.83, 1.38]**
Total events	184		383			

Heterogeneity: $Tau^2 = 0.07$; $Chi^2 = 17.31$, df = 5 ($P = 0.004$); $I^2 = 71\%$

Test for overall effect: $Z = 0.52$ ($P = 0.60$)



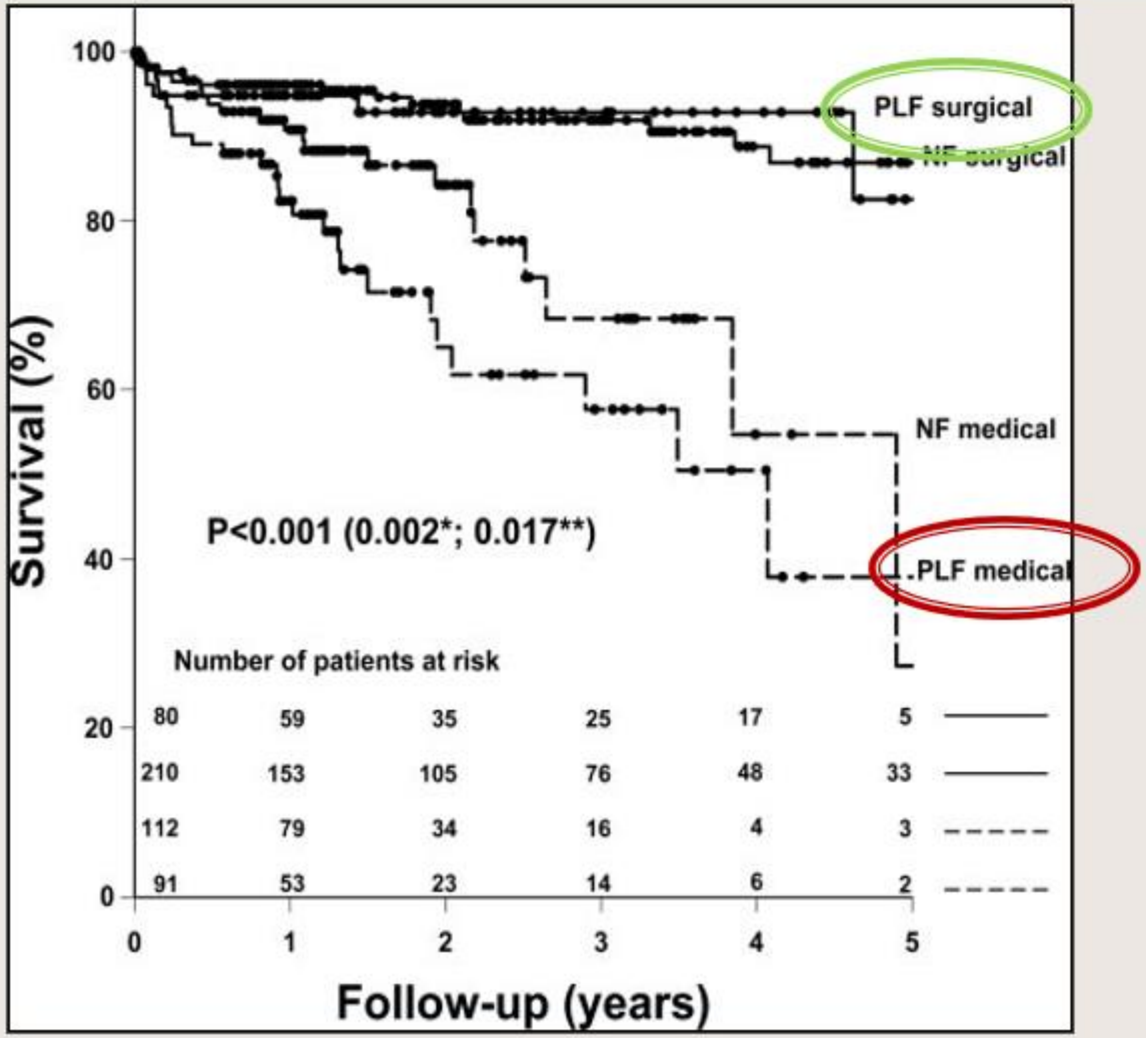
J Am Coll Cardiol Img 2016;9:1255–63



The finding of a low gradient cannot exclude the presence of a SAS in a patient with a small AVA and preserved LVEF and should mandatorily prompt further investigation.

J Am Coll Cardiol 2012;60:1259–67

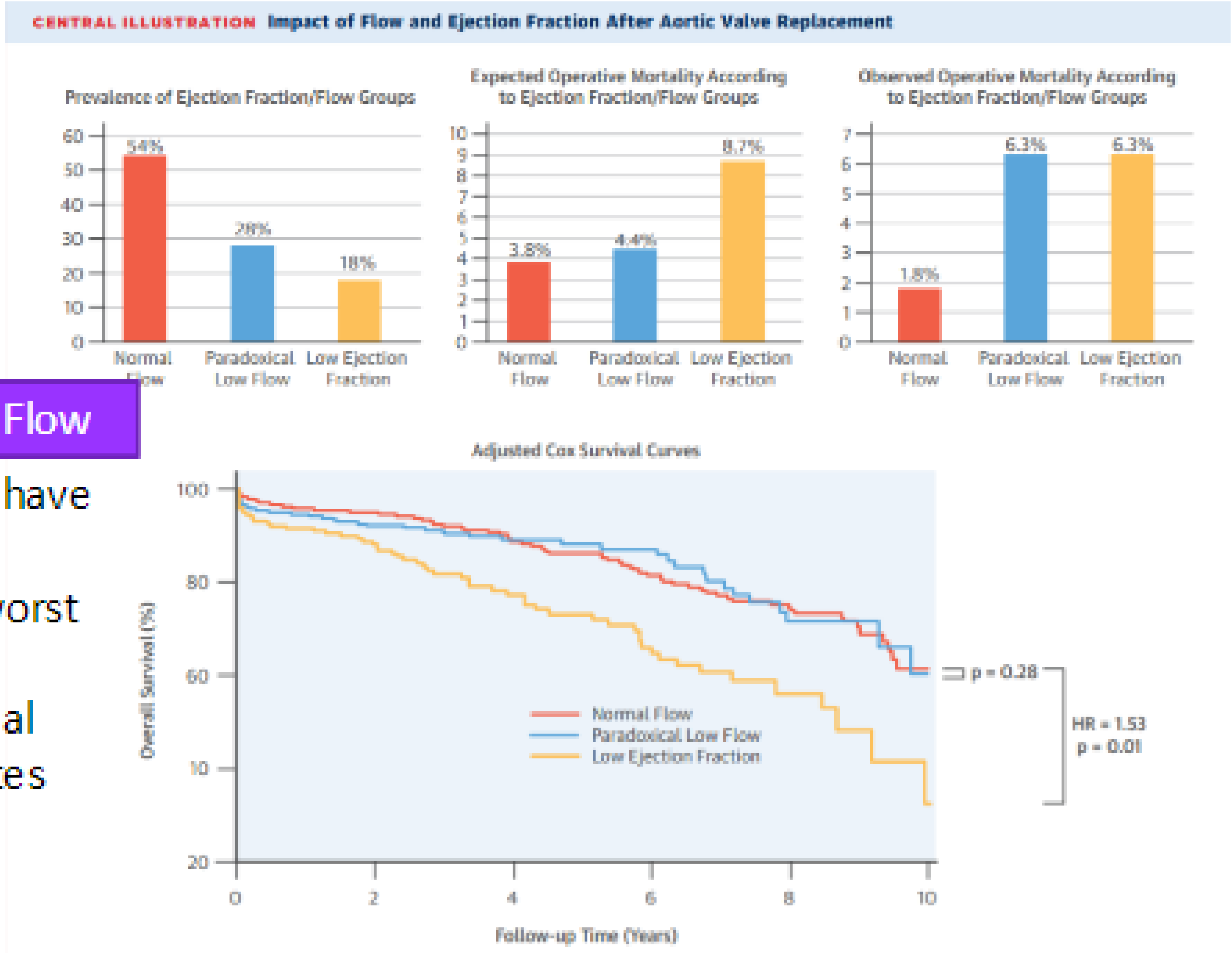
Survival in NF and in PLF as a function of the type of treatment:
Medical vs Surgical.



1,154 patients with severe aortic stenosis (AS) who underwent AVR with or without coronary artery bypass grafting

Think about the pre-operative Flow

- Patients with LEF or PLF AS have a higher operative risk.
- Patients with LEF had the worst survival outcome, whereas patients with PLF and normal flow had similar survival rates after AVR



Clavel, M-A. et al. J Am Coll Cardiol. 2015; 65(7):645-53.

Consider the flow

Severe AS (effective orifice area < $1cm^2$ or $\leq 0.6cm^2/m^2$)

Normal Flow / Low gradient AS (SVi≥ $35ml/m^2$, Mean gradient < 40 mm Hg) **Preserved GLS (> |-16%|)** **Preserved LV EF (> 50%)** ○ If 'no symptom' → medical follow-up ○ If 'symptom' linked to AS → surgery ➢ **"Good" prognosis**	**Low Flow / High gradient AS** (SVi< $35ml/m^2$, Mean gradient ≥ 40 mm Hg) **Depressed GLS (<|-16%|)** **Preserved or depressed LV EF** ○ Low dose dobutamine +/- calcium scoring to exclude any pseudo-stenosis due to the low flow ○ If severe AS → Surgery or TAVR ➢ **"risky" prognosis**
Normal Flow / High gradient AS (SVi≥ $35ml/m^2$, Mean gradient ≥ 40 mm Hg) **Depressed GLS (< |-16%|)** **Preserved LV EF (> 50%)** ○ If 'no symptom' → very close medical follow-up and preparing the aortic valve replacement ○ If 'symptom' linked to the AS → surgery ➢ **"Risky" prognosis**	**Low Flow / Low gradient AS** (SVi< $35ml/m^2$, Mean gradient < 40 mm Hg) **Depressed GLS (< |-16%|)** **Preserved or depressed LV EF** ○ Low dose dobutamine +/- calcium scoring required to exclude any pseudo-stenosis due to the low flow ○ If severe AS → Surgery or TAVR ➢ **"Worse" prognosis**

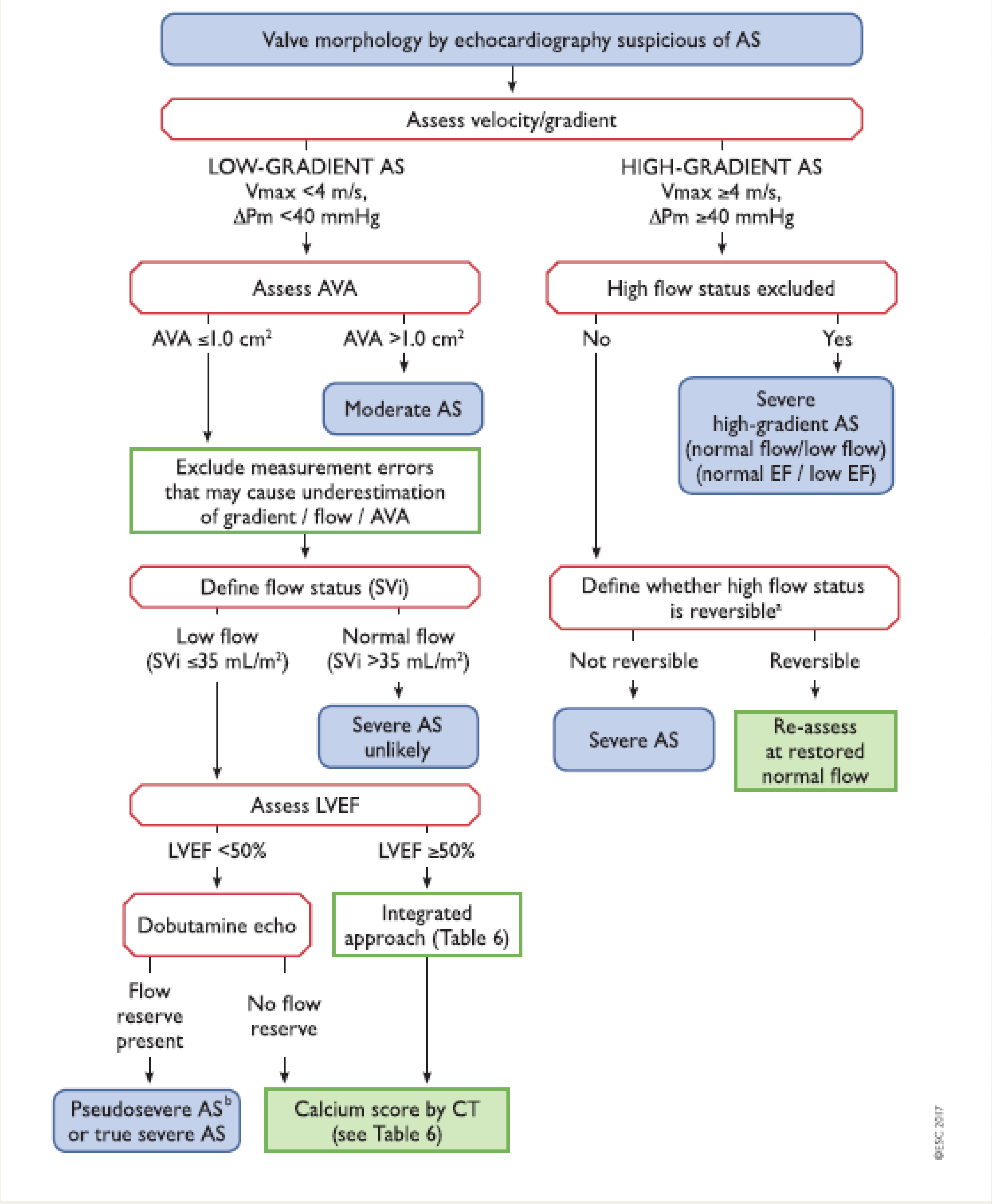


Table 6 Criteria that increase the likelihood of severe aortic stenosis in patients with AVA <1.0 cm² and mean gradient <40 mmHg in the presence of preserved ejection fraction (modified from Baumgartner *et al.*[4])

Criteria	
Clinical criteria	• Typical symptoms without other explanation • Elderly patient (>70 years)
Qualitative imaging data	• LV hypertrophy (additional history of hypertension to be considered) • Reduced LV longitudinal function without other explanation
Quantitative imaging data	• Mean gradient 30–40 mmHg[a]
	• AVA ≤0.8 cm²
	• Low flow (SVi <35 mL/m²) confirmed by techniques other than standard Doppler technique (LVOT measurement by 3D TOE or MSCT; CMR, invasive data)
	• Calcium score by MSCT[b] Severe aortic stenosis very likely: men ≥3000; women ≥1600 Severe aortic stenosis likely: men ≥2000; women ≥1200 Severe aortic stenosis unlikely: men <1600; women <800

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ESC European Society of Cardiology
European Heart Journal (2017) 38, 2739–2791
doi:10.1093/eurheartj/ehx391
ESC/EACTS GUIDELINES

2017 ESC/EACTS Guidelines for the management of valvular heart disease

Valvular Heart Disease

Comparison Between Transcatheter and Surgical Prosthetic Valve Implantation in Patients With Severe Aortic Stenosis and Reduced Left Ventricular Ejection Fraction

M.A. Clavel, DVM, MS; J.G. Webb, MD; J. Rodés-Cabau, MD; J.B. Masson, MD; E. Dumont, MD; R. De Larochellière, MD; D. Doyle, MD; S. Bergeron, MD; H. Baumgartner, MD; I.G. Burwash, MD; J.G. Dumesnil, MD; G. Mundigler, MD; R. Moss, MD; A. Kempny, MD; R. Bagur, MD; J. Bergler-Klein, MD; R. Gurvitch, MD; P. Mathieu, MD; P. Pibarot, DVM, PhD

Background—Patients with severe aortic stenosis and reduced left ventricular ejection fraction (LVEF) have a poor prognosis with conservative therapy but a high operative mortality when treated surgically. Recently, transcatheter aortic valve implantation (TAVI) has emerged as an alternative to surgical aortic valve replacement (SAVR) for patients considered at high or prohibitive operative risk. The objective of this study was to compare TAVI and SAVR with respect to postoperative recovery of LVEF in patients with severe aortic stenosis and reduced LV systolic function.

Methods and Results—Echocardiographic data were prospectively collected before and after the procedure in 200 patients undergoing SAVR and 83 patients undergoing TAVI for severe aortic stenosis (aortic valve area $\leq$1 cm^2) with reduced LV systolic function (LVEF $\leq$50%). TAVI patients were significantly older (81±8 versus 70±10 years; P<0.0001) and had more comorbidities compared with SAVR patients. Despite similar baseline LVEF (34±11% versus 34±10%), TAVI patients had better recovery of LVEF compared with SAVR patients (ΔLVEF, 14±15% versus 7±11%; P=0.005). At the 1-year follow-up, 58% of TAVI patients had a normalization of LVEF (>50%) as opposed to 20% in the SAVR group. On multivariable analysis, female gender (P=0.004), lower LVEF at baseline (P=0.005), absence of atrial fibrillation (P=0.01), TAVI (P=0.007), and larger increase in aortic valve area after the procedure (P=0.01) were independently associated with better recovery of LVEF.

Conclusion—In patients with severe aortic stenosis and depressed LV systolic function, TAVI is associated with better LVEF recovery compared with SAVR. TAVI may provide an interesting alternative to SAVR in patients with depressed LV systolic function considered at high surgical risk. (*Circulation*. **2010;122:1928-1936.**)

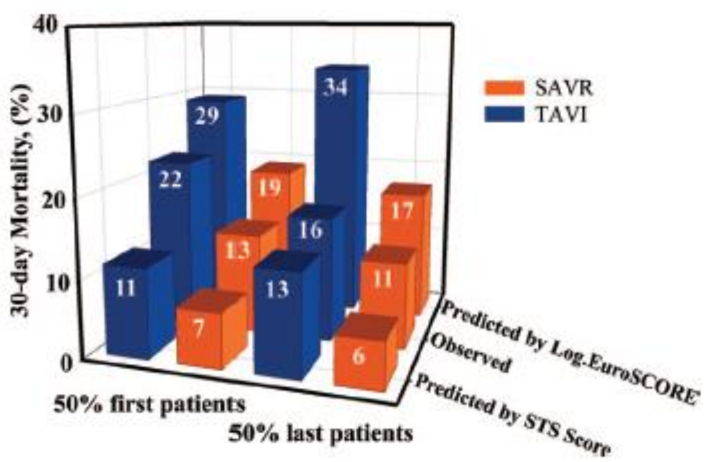

Figure 1. Predicted and observed 30-day mortality rates in the first half versus second half of the patients treated in each of the participating center. Blue bars show TAVI; orange bars, SAVR.

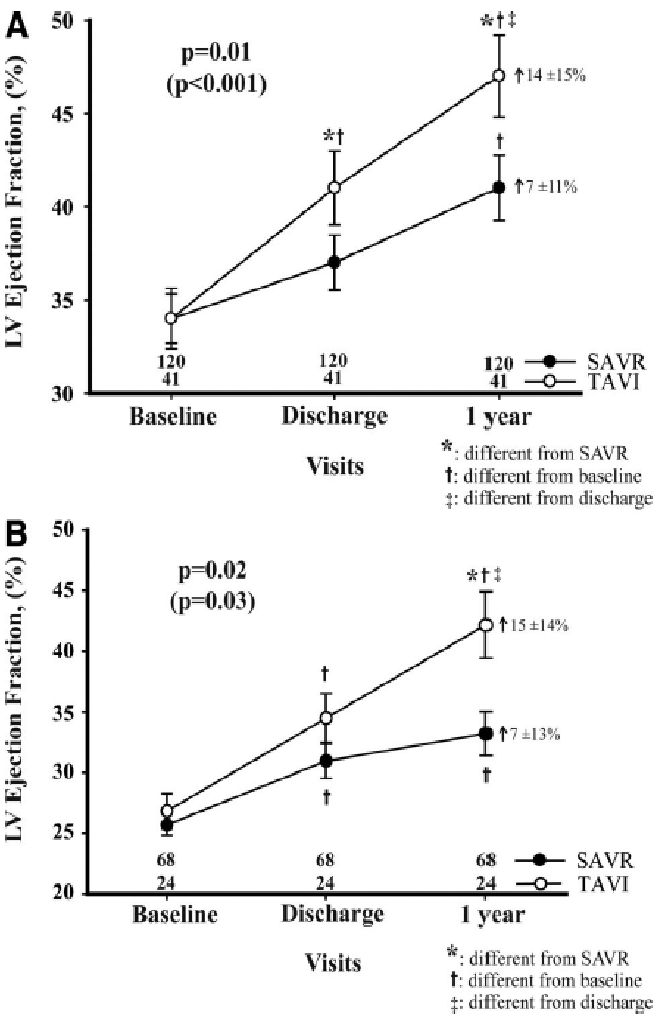

Figure 2. Comparison of the postprocedural change in LVEF in TAVI vs SAVR groups. A and B, Average LVEF at baseline, discharge, and 1-year follow-up in the whole cohort and in the subset of patients with preprocedural LVEF ≤35%, respectively. The *P* value is for the group-by-time ANOVA. The *P* value between brackets is for the ANCOVA with propensity score used as a covariate. Error bars represent the SEM. Numbers above the *x* axis represent the number of patients at risk. Tukey posthoc test: $^*P<0.05$ vs SAVR; $†P<0.05$ vs baseline; $‡P<0.05$ vs discharge.

Table 2. Postprocedural Changes in AVA and Gradient

Variable	SAVR Group	TAVI Group	*P*, ANOVA	*P*, ANCOVA
AVA, cm^2			<0.001	0.0009
Baseline	0.71±0.17	0.64±0.18*		
Discharge	1.43±0.42†	1.65±0.55*†		
1-y follow-up	1.39±0.40†	1.56±0.38*†		
Indexed AVA, cm^2/m^2			<0.001	0.0003
Baseline	0.38±0.09	0.36±0.10*		
Discharge	0.76±0.22†	0.92±0.32*†		
1-y follow-up	0.71±0.19†	0.87±0.20*†		
Mean gradient, mm Hg			0.005	0.04
Baseline	35±14	37±14		
Discharge	13±5†	10±5*†		
1-y follow-up	14±6†	9±4*†		

Tukey posthoc test: $^*P<0.05$ versus SAVR; $†P<0.05$ versus baseline.

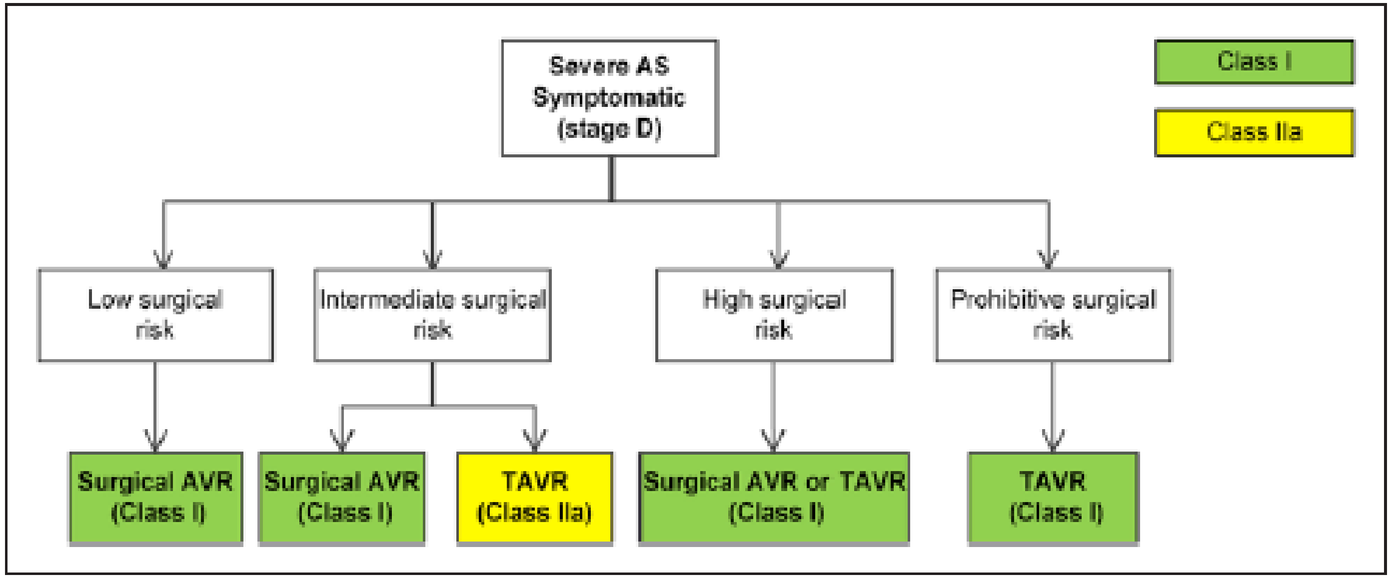

Figure 1. Choice of TAVR Versus Surgical AVR in the Patient With Severe Symptomatic AS.
AS indicates aortic stenosis; AVR, aortic valve replacement; and TAVR, transcatheter aortic valve replacement.

AHA/ACC GUIDELINE

2017 AHA/ACC Focused Update of the 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 Clinical Practice Guidelines

JOURNAL OF THE AMERICAN COLLEGE OF CARDIOLOGY
VOL. 71, NO. 12, 2018
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PUBLISHED BY ELSEVIER

ORIGINAL INVESTIGATIONS

Transcatheter Aortic Valve Replacement in Patients With Low-Flow, Low-Gradient Aortic Stenosis

The TOPAS-TAVI Registry

Henrique Barbosa Ribeiro, MD, PhD,[a] Stamatios Lerakis, MD,[b] Martine Gilard, MD, PhD,[c] João L. Cavalcante, MD,[d]

ABSTRACT

BACKGROUND Few data exist on patients with low-flow, low-gradient aortic stenosis (LFLG-AS) undergoing transcatheter aortic valve replacement (TAVR). Also, very scarce data exist on the usefulness of dobutamine stress echocardiography (DSE) before TAVR in these patients.

OBJECTIVES The authors sought to evaluate clinical outcomes and changes in left ventricular ejection fraction (LVEF) following TAVR in patients with classical LFLG-AS.

METHODS This multicenter registry included 287 patients with LFLG-AS undergoing TAVR. DSE was performed before TAVR in 234 patients and the presence of contractile reserve was defined as an increase of ≥20% in stroke volume. Transthoracic echocardiography was repeated at hospital discharge and at 1-year follow-up. Clinical follow-up was obtained at 1 and 12 months, and yearly thereafter.

RESULTS The median Society of Thoracic Surgeons score of the study population was 7.7% (interquartile range 5.3% to 12.0%), and the mean LVEF and transvalvular gradient were 30.1 ± 9.7% and 25.4 ± 6.6 mm Hg, respectively. The presence of contractile reserve was observed in 45% of patients at DSE. Mortality rates were 3.8%, 20.1%, and 32.3% at 30 days, 1 year, and 2 years, respectively. On multivariable analysis, chronic obstructive pulmonary disease ($p = 0.022$) and lower hemoglobin values ($p < 0.001$) were associated with all-cause mortality. Lower hemoglobin values ($p = 0.004$) and moderate-to-severe aortic regurgitation post-TAVR ($p = 0.018$) were predictors of the composite of mortality and rehospitalization due to heart failure. LVEF increased by 8.3% (95% confidence interval: 6% to 11%) at 1-year follow-up, and the lack of prior coronary artery bypass graft ($p = 0.004$), a lower LVEF at baseline ($p < 0.001$), and a lower stroke volume index at baseline ($p = 0.019$) were associated with greater increase in LVEF. The absence of contractile reserve at baseline DSE was not associated with any negative effect on clinical outcomes or LVEF changes at follow-up.

CONCLUSIONS TAVR was associated with good periprocedural outcomes in patients with LFLG-AS. However, approximately one-third of LFLG-AS TAVR recipients died at 2-year follow-up, with pulmonary disease, anemia, and residual paravalvular leaks associated with poorer outcomes. LVEF improved following TAVR, but DSE failed to predict clinical outcomes or LVEF changes over time. (Multicenter Prospective Study of Low-Flow Low-Gradient Aortic Stenosis [TOPAS Study]; NCT01835028) (J Am Coll Cardiol 2018;71:1297-308) © 2018 by the American College of Cardiology Foundation.

TABLE 1 Clinical, Echocardiographic, and Procedural Characteristics of the Study Population (N = 287)

Age, yrs	80 ± 7
Male	207 (72.1)
Body mass index, kg/m^2	26 (23-30)
NYHA functional class III-IV	241 (84.0)
Hypertension	239 (83.3)
Diabetes mellitus	121 (42.2)
Coronary artery disease	218 (76.0)
Prior myocardial infarction	107 (37.3)
Prior PCI	130 (45.3)
Prior CABG	115 (40.1)
History of atrial fibrillation	139 (48.4)
Cerebrovascular disease	54 (18.8)
Peripheral vascular disease	88 (30.7)
COPD	103 (35.9)
Hemoglobin levels, g/dl	11.9 ± 1.7
eGFR, ml/min/m^2	55.1 (40.3-69.0)
CKD (eGFR <60 ml/min/m^2)	156 (54.4)
EuroSCORE 2, %	10.5 (5.5-17.3)
STS-PROM, %	7.7 (5.3-12.0)
Echocardiographic variables	
LVEF, %	30.1 ± 9.7
Mean aortic gradient, mm Hg	25.4 ± 6.6
Peak aortic gradient, mm Hg	43.0 ± 10.5
Aortic valve area, cm^2	0.76 ± 0.20
Moderate-severe AR	31 (10.8)
Moderate-severe MR	100 (34.8)
Stroke volume, ml	54.4 ± 15.7
Stroke volume index, ml/m^2	29.7 ± 8.3
Pulmonary systolic artery pressure, mm Hg	46.6 ± 14.6
Procedural variables	
Procedural success*	251 (87.5)
Prosthesis type	
Sapien	118 (41.1)
Sapien XT	87 (30.3)
Sapien 3	24 (8.4)
CoreValve	48 (16.7)
Evolut R	2 (0.7)
Others (Portico, Lotus, DirectFlow)	5 (1.7)
Prosthesis size, mm	
20	1 (0.3)
23	50 (17.4)
26	126 (43.9)
27	2 (0.7)
29	84 (29.3)
31	17 (5.9)
Approach	
Transfemoral	198 (69.0)
Transapical	59 (20.6)
Transaortic	16 (5.6)
Trans-subclavian	11 (3.8)
Transcaval	3 (1.0)
Post-dilation	50 (17.4)

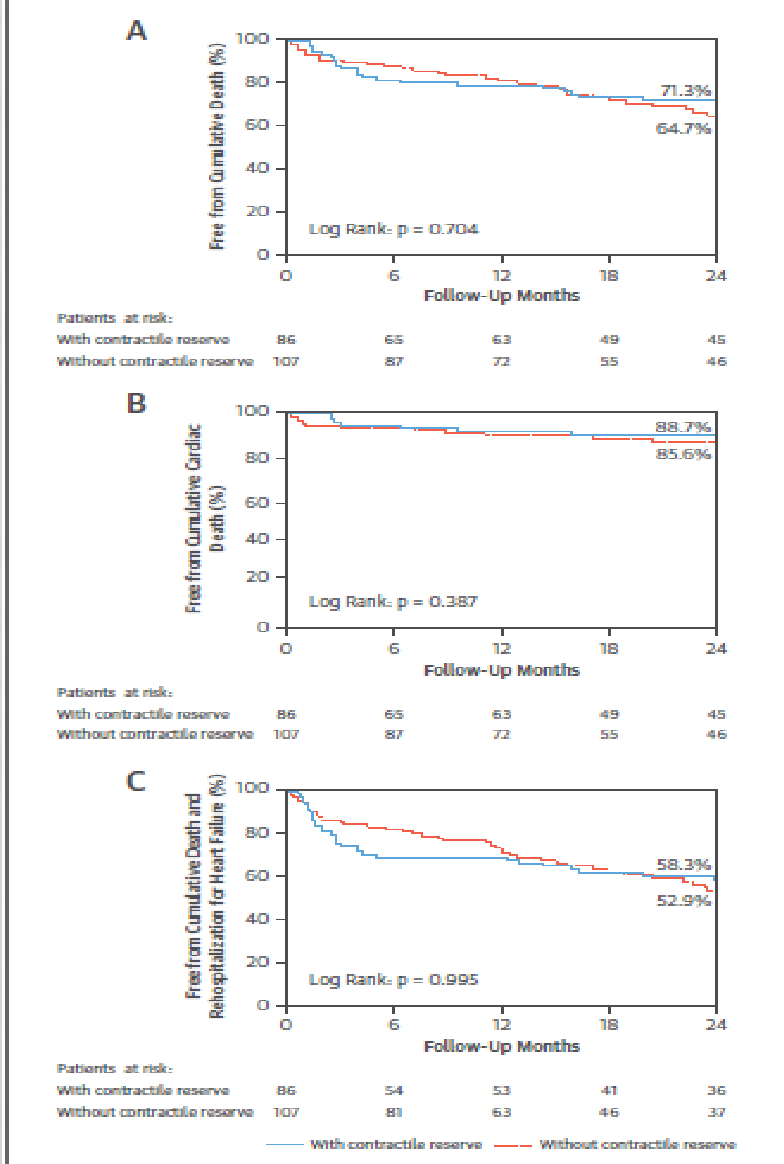
Continued in the next column

TABLE 1 Continued

Values are mean ± SD, n (%), or median (interquartile range). *Following VARC-2 criteria (24).

AR = aortic regurgitation; CABG = coronary artery bypass graft; CKD = chronic kidney disease; COPD = chronic obstructive pulmonary disease; eGFR = estimated glomerular filtration rate; IQR = interquartile range; LVEF = left ventricular ejection fraction; MR = mitral regurgitation; NYHA = New York Heart Association; PCI = percutaneous coronary intervention; STS-PROM = Society of Thoracic Surgeons Predicted Risk of Mortality.

FIGURE 2 Clinical Events at 2-Year Follow-Up, According to the Presence of Contractile Reserve as Evaluated by DSE Pre-TAVR

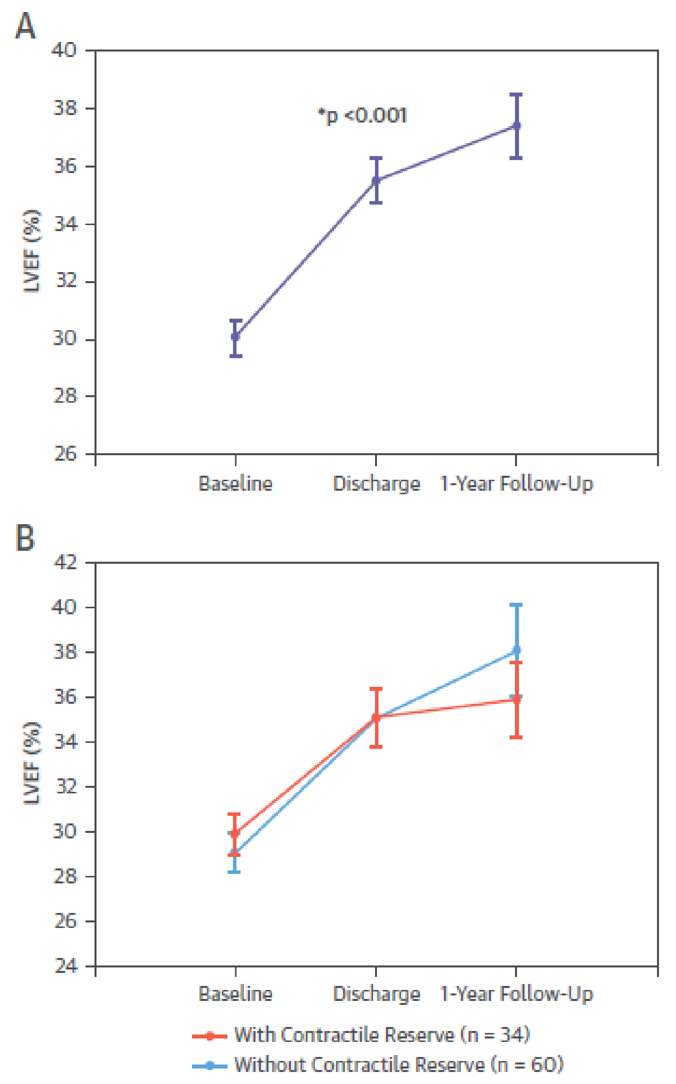


Kaplan-Meier curves at 2-year follow-up, according to the presence of contractile reserve at dobutamine stress echocardiography (DSE) for (A) global mortality, (B) cardiac mortality, and (C) combined global mortality or rehospitalization for heart failure. TAVR = transcatheter aortic valve replacement.

TABLE 3 30-Day Clinical and Echocardiographic Outcomes (N = 287)

30-day outcomes	
All stroke	6 (2.1)
Disabling stroke	3 (1.0)
Nondisabling stroke	3 (1.0)
Myocardial infarction	4 (1.4)
Major vascular complications	13 (4.5)
Major or life-threatening bleeding	19 (6.6)
Need for a second valve	10 (3.5)
Need for hemodynamic support	17 (5.9)
Coronary obstruction	1 (0.3)
Annulus rupture	1 (0.3)
Cardiac tamponade	1 (0.3)
Conversion to open-heart surgery	3 (1.0)
Permanent pacemaker implantation	12 (4.2)
Death	11 (3.8)
Hospitalization length, days	6 (3–8)
Echocardiography post-procedure	
LVEF, %	35.5 ± 11.8
Mean aortic gradient, mm Hg	8.8 ± 3.9
Peak aortic gradient, mm Hg	16.4 ± 7.2
Aortic valve area, cm^2	1.71 ± 0.56
Moderate-severe AR	23 (8.2)
Moderate-severe MR	89 (31.9)
Stroke volume, ml	60.9 ± 19.1
Stroke volume index, ml/m^2	32.9 ± 10.1
Pulmonary systolic artery pressure, mm Hg	44.0 ± 13.1

FIGURE 3 Changes in LVEF Over Time



Changes in LVEF over time for **(A)** overall population and **(B)** according to the presence of contractile reserve at DSE. $p = 0.418$ for changes over time between groups. $p < 0.001$ for changes over time in the "with contractile reserve" group. $p < 0.001$ for changes over time in the "without contractive reserve" group. *Changes over time. DSE = dobutamine stress echocardiography; LVEF = left ventricular ejection fraction.

TABLE 5 Predictors of Clinical Outcomes After TAVR (Univariable and Multivariable Analyses)

	Univariable Model HR (95% CI)	p Value	Multivariable Model HR (95% CI)	p Value
Cumulative mortality (n = 112)				
COPD	1.50 (1.00-2.25)	0.048	1.67 (1.08-2.58)	0.022
Previous CAD	1.62 (0.94-2.78)	0.082	—	—
NYHA functional class III-IV	2.91 (1.22-6.91)	0.016	—	—
eGFR <60 ml/min/m^2	1.53 (0.99-2.33)	0.053	—	—
Hemoglobin levels*	1.25 (1.08-1.43)	0.001	1.27 (1.11-1.45)	<0.001
Moderate-severe MR baseline	1.70 (1.05-2.73)	0.030	—	—
Cumulative cardiac mortality (n = 54)				
Previous PCI	2.26 (1.24-4.11)	0.008	—	—
NYHA functional class III-IV	3.80 (1.14-12.7)	0.030	—	—
Hemoglobin levels*	1.23 (1.02-1.49)	0.033	1.23 (1.02-1.52)	0.037
Moderate-severe MR baseline	1.86 (0.89-3.88)	0.098	—	—
Cumulative mortality and/or rehospitalization for heart failure (n = 143)				
NYHA functional class III-IV	1.69 (0.91-3.14)	0.096	—	—
eGFR <60 ml/min/m^2	1.38 (0.95-2.01)	0.088	—	—
Hemoglobin levels*	1.15 (1.03-1.30)	0.011	1.23 (1.06-1.43)	0.004
LVEF baseline, %	1.02 (1.00-1.04)	0.055	—	—
Moderate/severe AR post-TAVR	1.95 (1.06-3.48)	0.031	2.15 (1.14-4.05)	0.018

*For each decrease of 1 g/dl in hemoglobin levels.

CAD = coronary artery disease; HR = hazard ratio; TAVR = transcatheter aortic valve replacement; other abbreviations as in Tables 1 and 2.

JAMA Cardiology | Brief Report

Outcomes From Transcatheter Aortic Valve Replacement in Patients With Low-Flow, Low-Gradient Aortic Stenosis and Left Ventricular Ejection Fraction Less Than 30%

A Substudy From the TOPAS-TAVI Registry

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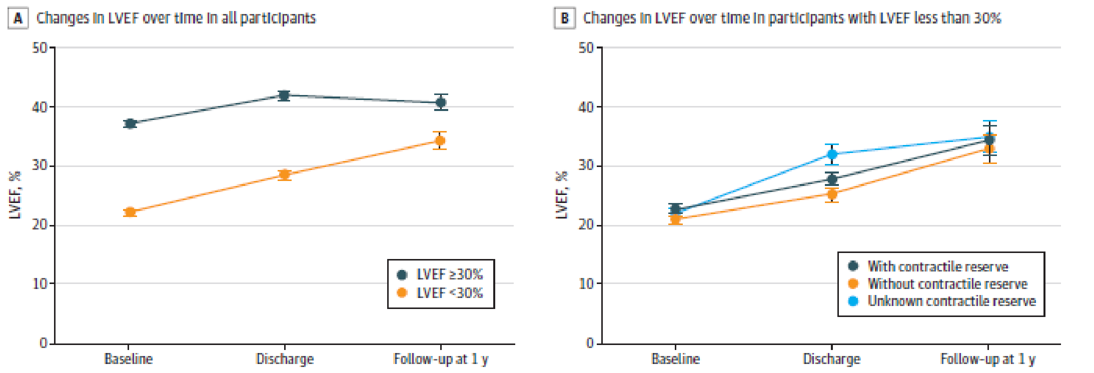
RESULTS A total of 293 patients were included, including 128 (43.7%) with very low LVEF and 165 with low LVEF (56.3%). Their mean (SD) age was 80 (7) years, and most (214 [73.0%]) were men. The mean (SD) LVEF in the very low LVEF group was 22% (5%), compared with 37% (7%) in the low LVEF group ($P < .001$). There were no differences between groups in rates of periprocedural mortality and late mortality (median [interquartile range], 23 [6-38] months). Patients with very low LVEF displayed a greater increase in LVEF at the 1-year follow-up examination (mean absolute increase, 11.9% [95% CI, 8.8%-15.1%]), than the low LVEF group (3.6% [95% CI, 1.1%-6.1%]; $P < .001$). In 92 patients with very low LVEF who had preprocedural DSE, results showed a lack of contractile reserve in 45 (49%), but this had no effect on clinical outcomes or changes in LVEF over time.

CONCLUSIONS AND RELEVANCE In patients with LFLG AS and severe left ventricular dysfunction, TAVR was associated with similar clinical outcomes as in counterparts with milder left ventricular dysfunction. The TAVR procedure was associated with a significant increase in LVEF, irrespective of contractile reserve. These results support TAVR for LFLG AS, irrespective of the severity of left ventricular dysfunction and DSE results.

Figure. Changes in Left Ventricular Ejection Fraction (LVEF) Over Time



A, Changes in LVEF over time according to the severity of left ventricular dysfunction (<30% vs ≥30%); The LVEF increased mean (SD) from 37% (7%) at baseline to 41% (12%) at 1-year follow-up in the group with LVEF of 30% or greater and from 22% (5%) to 34% (12%) in the group with LVEF less than 30% ($P < .001$). B, Changes in LVEF over time in patients with severe left ventricular dysfunction (LVEF<30%), according to the presence, absence, or unknown status of contractile reserve at dobutamine stress echocardiography before transcatheter aortic valve replacement; $P < .001$ for changes over time between groups. In patients with contractile reserve, the LVEF increased from a mean (SD) of 23% (5%) at baseline to 35% (12%) at 1-year follow-up ($P < .001$). In patients without contractile reserve, the LVEF increased from 21% (5%) at baseline to 33% (13%) at 1-year follow-up ($P < .001$). In patients with unknown contractile reserve, the LVEF increased from 22% (5%) at baseline to 35% (13%) at 1-year follow-up ($P < .001$).

Open access Valvular heart disease

openheart

Transcatheter aortic valve implantation in decompensated aortic stenosis within the same hospital admission: early clinical experience

Mahmoud Abdelaziz, Saib Khogali, James M Cotton, Antonella Meralgia, Maciej Matuszewski, Heyman Luckraz

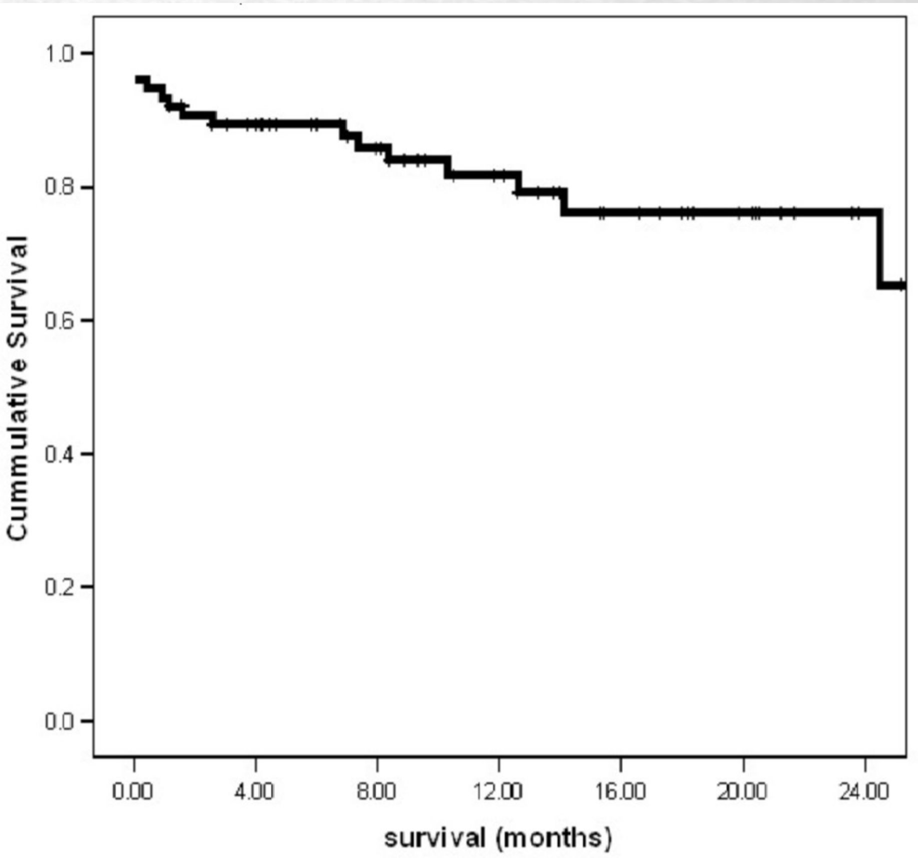
ABSTRACT

Objective Severe decompensated aortic valve stenosis is associated with noticeable reduction in survival. Until recently the options for such patients were either high-risk surgery or percutaneous balloon valvuloplasty and medical therapy which does not add any survival benefits and associated with high rate of complications. We present our experience in the use of transcatheter aortic valve implantation (TAVI) in patients with decompensated severe aortic stenosis requiring urgent intervention in the same hospital admission.

Methods In this observational study, all patients who were admitted with decompensated severe aortic stenosis were enrolled. Elective patients were excluded from the study. Perioperative records were analysed and clinical, echocardiographic and survival data were presented.

Results 76 patients with a mean age of 81±6 years were enrolled. All patients presented with New York Heart Association (NYHA) IV status. Femoral approach was performed in 86.8%. Median postoperative hospital stay was 6 days and intensive care unit admission rate was 15%. At follow-up, 61.8% of patients were in NYHA status I/II. Moderate or more paravalvular leak occurred in 5.2% of patients. Permanent pacemaker was required in 14.4% of patients. The incidence of in-hospital death was 2.6%. Kaplan-Meier analysis indicated a survival rate of 81% at 1 year.

Conclusions Urgent in-hospital TAVI is feasible as the first-line treatment in decompensated severe aortic stenosis. In our cohort, it showed to be safe and achieved satisfactory survival rates and symptom control.



RESEARCH ARTICLE

Outcome of patients with heart failure after transcatheter aortic valve implantation

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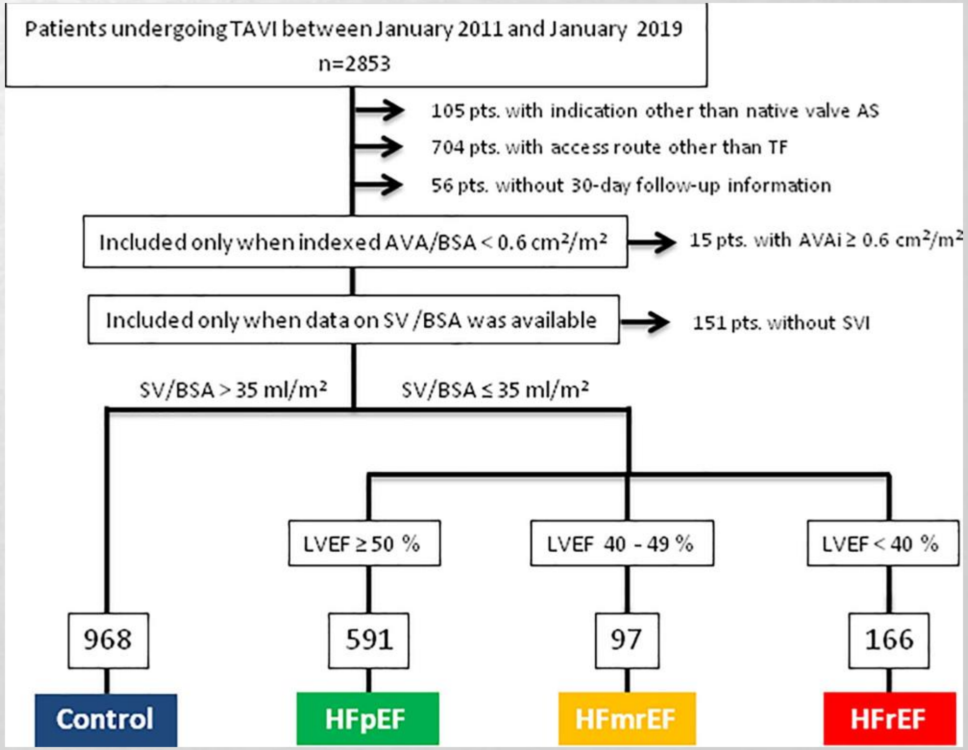
Methods and results

Patients treated by transfemoral TAVI at our center (n = 1822) were classified as 1) 'HF with preserved ejection fraction (EF)' (HFpEF, EF ≥50%), 2) 'HF with mid-range EF' (HFmrEF, EF 40–49%), or 3) 'HF with reduced EF' (HFrEF, EF <40%). Patients with SVI >35 ml/m^2 served as controls. The prevalence of cardiovascular disease and symptoms increased stepwise from controls (n = 968) to patients with HFpEF (n = 591), HFmrEF (n = 97), and HFrEF (n = 166). Mortality tended to be highest in HFrEF patients 30 days post-procedure, and it became significant after one year: 10.2% (controls), 13.5% (HFpEF), 13.4% (HFmrEF), and 23.5% (HFrEF). However, symptomatic improvement in survivors of all groups was achieved in the majority of patients without differences among groups.

Conclusions

Patients with AS and HF benefit from TAVI with respect to symptom alleviation. TAVI in patients with HFpEF and HFmrEF led to an identical, favorable post-procedural prognosis that was significantly better than that of patients with HFrEF, which remains a high-risk population.



ESC European Society of Cardiology
European Heart Journal (2020) 41, 2759–2767
doi:10.1093/eurheartj/ehaa170

CLINICAL RESEARCH
TAVI

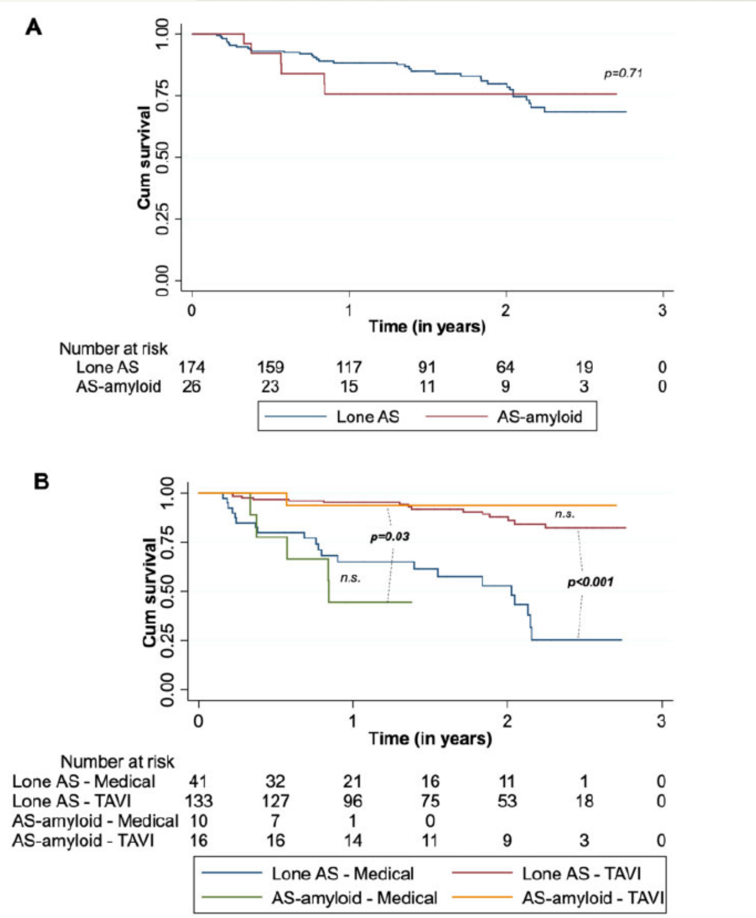
Prevalence and outcome of dual aortic stenosis and cardiac amyloid pathology in patients referred for transcatheter aortic valve implantation

Paul R. Scully[1,2], Kush P. Patel[1,2], Thomas A. Treibel[1,2],

Aims Cardiac amyloidosis is common in elderly patients with aortic stenosis (AS) referred for transcatheter aortic valve implantation (TAVI). We hypothesized that patients with dual aortic stenosis and cardiac amyloid pathology (AS-amyloid) would have different baseline characteristics, periprocedural and mortality outcomes.

Methods and results Patients aged ≥75 with severe AS referred for TAVI at two sites underwent blinded bone scintigraphy prior to intervention (Perugini Grade 0 negative, 1–3 increasingly positive). Baseline assessment included echocardiography, electrocardiogram (ECG), blood tests, 6-min walk test, and health questionnaire, with periprocedural complications and mortality follow-up. Two hundred patients were recruited (aged 85 ± 5 years, 50% male). AS-amyloid was found in 26 (13%): 8 Grade 1, 18 Grade 2. AS-amyloid patients were older (88 ± 5 vs. 85 ± 5 years, $P = 0.001$), with reduced quality of life (EQ-5D-5L 50 vs. 65, $P = 0.04$). Left ventricular wall thickness was higher (14 mm vs. 13 mm, $P = 0.02$), ECG voltages lower (Sokolow–Lyon 1.9 ± 0.7 vs. 2.5 ± 0.9 mV, $P = 0.03$) with lower voltage/mass ratio (0.017 vs. 0.025 mV/g/m^2, $P = 0.03$). High-sensitivity troponin T and N-terminal pro-brain natriuretic peptide were higher (41 vs. 21 ng/L, $P < 0.001$; 3702 vs. 1254 ng/L, $P = 0.001$). Gender, comorbidities, 6-min walk distance, AS severity, prevalence of disproportionate hypertrophy, and post-TAVI complication rates (38% vs. 35%, $P = 0.82$) were the same. At a median follow-up of 19 (10–27) months, there was no mortality difference ($P = 0.71$). Transcatheter aortic valve implantation significantly improved outcome in the overall population ($P < 0.001$) and in those with AS-amyloid ($P = 0.03$).

Conclusions AS-amyloid is common and differs from lone AS. Transcatheter aortic valve implantation significantly improved outcome in AS-amyloid, while periprocedural complications and mortality were similar to lone AS, suggesting that TAVI should not be denied to patients with AS-amyloid.



STATE-OF-THE-ART PAPER

Moderate Aortic Stenosis and Heart Failure With Reduced Ejection Fraction

Can Imaging Guide Us to Therapy?

Philippe Pibarot, DVM, PhD,[a] David Messika-Zeitoun, MD,[b] Ori Ben-Yehuda, MD,[c,d] Rebecca T. Hahn, MD,[c,d] Ian G. Burwash, MD,[b] Nicolas M. Van Mieghem, MD, PhD,[e] Ernest Spitzer, MD,[e,f] Martin B. Leon, MD,[c] Jeroen Bax, MD,[g] Catherine M. Otto, MD[h]

ABSTRACT

Clinical management of patients with only moderate aortic stenosis (AS) but symptoms of heart failure with a reduced left ventricular ejection fraction (HFrEF) is challenging. Current guidelines recommend clinical surveillance with multimodality imaging; aortic valve replacement (AVR) is deferred until the stenosis becomes severe. Given the known benefits of afterload reduction in management of patients with HFrEF, it has been hypothesized that AVR may be beneficial in patients with only moderate AS who present with HFrEF. In this article, we first review the current approach for management of patients with moderate AS and HFrEF based on close clinical and imaging surveillance with AVR delayed until AS is severe. We then discuss the case for transcatheter AVR (TAVR) earlier in the disease course, when AS is moderate, based on stress echocardiographic data. We conclude with a detailed summary of the TAVR UNLOAD (Transcatheter Aortic Valve Replacement to UNload the Left Ventricle in Patients With ADvanced Heart Failure) trial, in which patients with moderate AS and HFrEF are randomized to guideline-directed heart failure therapy alone versus guideline-directed heart failure therapy plus TAVR. (J Am Coll Cardiol Img 2019;12:172-84)
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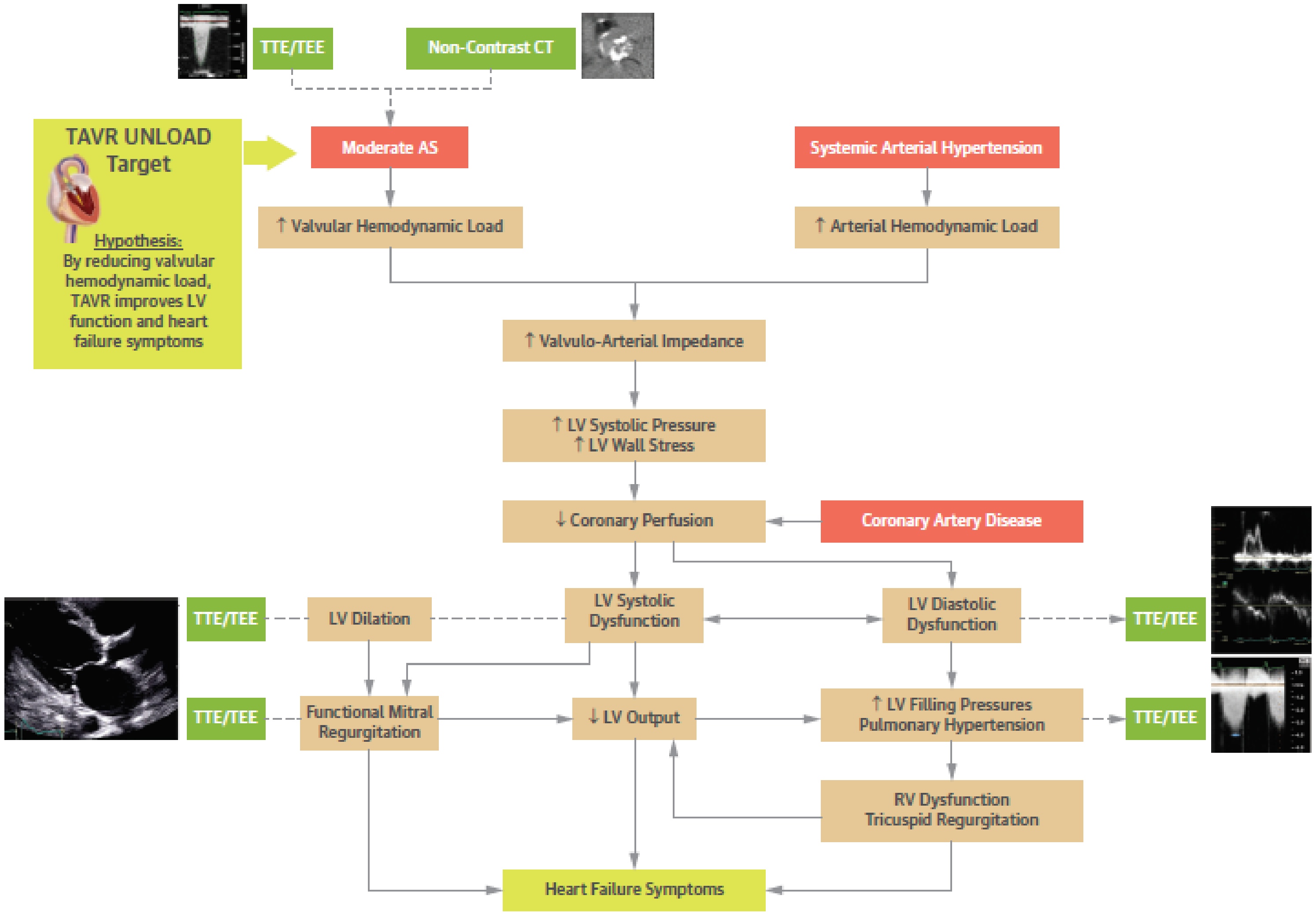
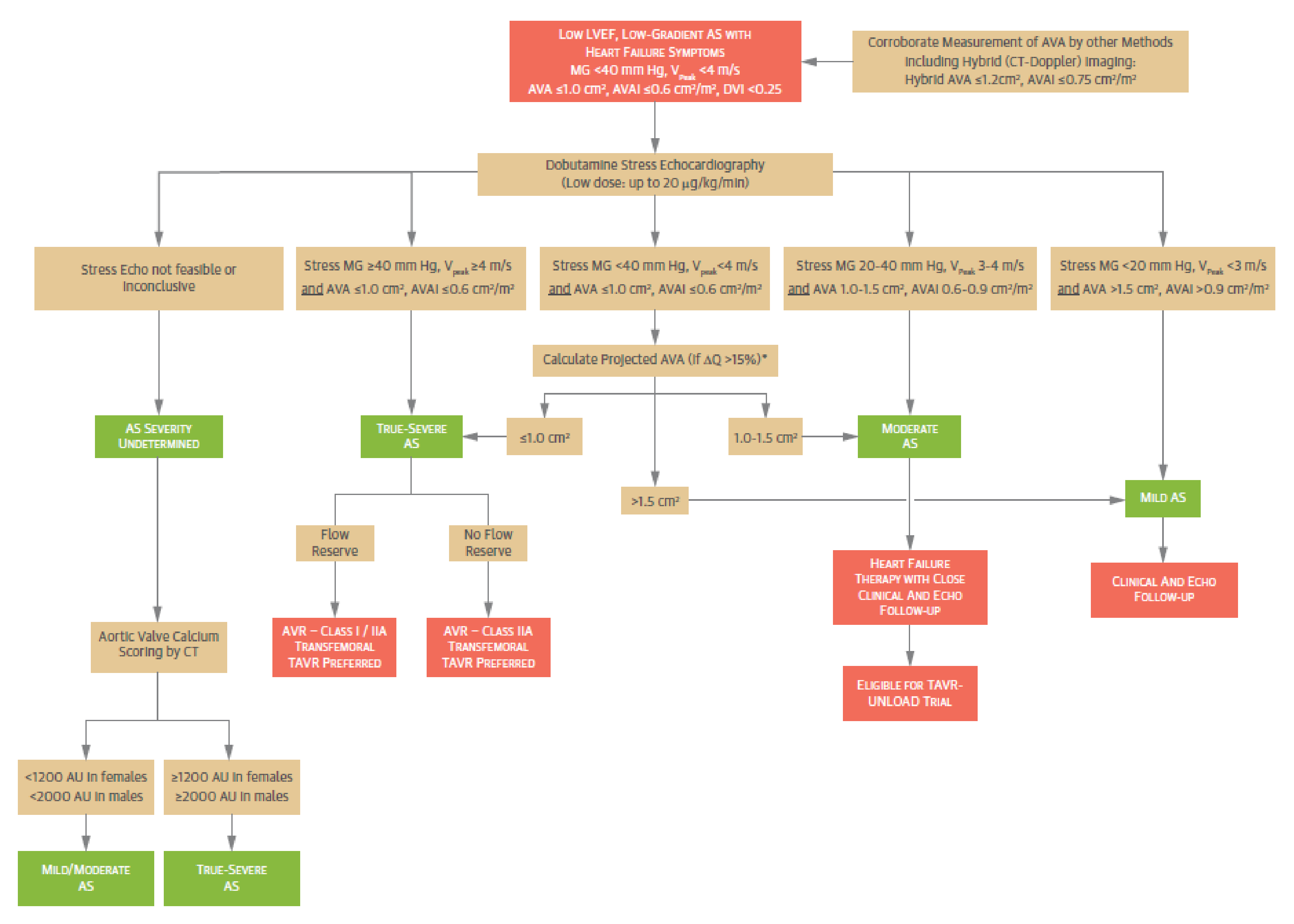
CENTRAL ILLUSTRATION Moderate Aortic Stenosis and Heart Failure With Reduced Ejection Fraction: Pathophysiology and Role of Imaging



Pibarot, P. et al. J Am Coll Cardiol Img. 2019;12(1):172-84.

FIGURE 1 Proposed Approach to Use of Stress Echocardiography and Aortic Valve Calcium Scoring by CT in the Management of Low Gradient AS, Low LVEF, and Heart Failure Symptoms



The proposed management approach is based on the authors' experience and review of the literature and is not included in current guidelines. *The calculation of the projected AVA at normal transvalvular flow rate is not included in the guidelines (2) to confirm AS severity and indication of AVR in patients with low LVEF and low gradient AS. Recent studies suggest however that this parameter may be useful in patients with persistent discordant grading at DSE (24,50). AS = aortic stenosis; AVA = aortic valve area; AVAi = indexed AVA; AVR = aortic valve replacement; DSE = dobutamine stress echocardiography; DVI = Doppler velocity index; MG = mean pressure gradient; ΔQ = percent increase in mean transvalvular flow rate during DSE; LVEF = left ventricular ejection fraction; V_{Peak} = peak aortic jet velocity.

FIGURE 3 Design of the TAVR-UNLOAD Trial

TAVR UNLOAD n = 600
1:1 Randomization

Key Inclusion Criteria

- NYHA class ≥2
- NT-proBNP >1500 pg/mL

OR

hospitalization for HF <1 year

- Guideline-directed HF therapy
- LVEF 20 - 50%
- Anatomically suitable for SAPIEN 3

Moderate AS

- MG ≥20 mm Hg and <40 mm Hg at rest and AVA >1.0 cm^2 and ≤1.5 cm^2 (or AVA <1.0 cm^2 but indexed AVA >0.6 cm^2)

OR

- MG ≥20 mm Hg and <40 mm Hg and AVA ≤1.0 cm^2 at rest AND MG <40 mm Hg and AVA >1.0 cm^2 (or AVA <1.0 cm^2 but indexed AVA >0.6 cm^2) with low dose DSE

Key Exclusion Criteria

- Continued inotropic support
- CRT or coronary revascularization <3 months
- Aortic bioprosthesis or congenital bicuspid
- Severe aortic regurgitation
- Severe degenerative mitral regurgitation
- Severe RV dysfunction, COPD, CKD, GI bleeding, Cirrhosis

GDHFT + TAVR	Control = GDHFT

Primary Endpoint @ 1 year = hierarchical occurrence of

- All-cause death
- Disabling stroke
- Hospitalizations related to HF, symptomatic aortic valve disease or non-disabling stroke
- Change in the Kansas City Cardiomyopathy Questionnaire

CKD = chronic kidney disease; COPD = chronic obstructive pulmonary disease; CRT = cardiac resynchronization therapy; HF = heart failure; GDHFT = guideline-directed heart failure therapy; GI = gastrointestinal; NYHA = New York Heart Association; RV = right ventricular; TAVR UNLOAD = Transcatheter Aortic Valve Replacement to Unload the Left Ventricle in Patients With Advanced Heart Failure; other abbreviations as in Figure 1.

EUROPEAN SOCIETY OF CARDIOLOGY®

European Heart Journal (2016) **37**, 2217–2225
doi:10.1093/eurheartj/ehv756

REVIEW

Clinical update

TAVI or No TAVI: identifying patients unlikely to benefit from transcatheter aortic valve implantation

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Table 1 Medical comorbidities and factors predicting poorer outcomes post-transcatheter aortic valve implantation

Medical comorbidity	Factors specifically associated with futility
CLD	6MWT $<$ 150 m[13] Oxygen-dependency[14]
Advanced CKD	Atrial fibrillation[21] Dialysis dependence[21]
Frailty	$>$2 frailty indices (Katz activities of daily living + mobility status[a])[30]
Cardiovascular conditions	LVEF $<$ 30% Pre-capillary or combined PH[b] (mean PAP $>$ 25 mmHg)[44] Low trans-aortic gradient Impaired contractile reserve Low flow state ($<$35 mL/m^2)[40] Organic severe MR

6MWT, 6-min walk test; LVEF, left ventricular ejection fraction; PH, pulmonary hypertension; PAP, pulmonary artery pressures; MR, mitral regurgitation.
[a]Time taken to walk 5 m is $>$6 s.
Katz indices are: independence in feeding, bathing, dressing, transferring, toileting, urinary incontinence.
[b]Measured invasively. Combined PH defined as post-capillary PH (measured by LV end-diastolic pressure $>$ 15 mmHg) with a diastolic pulmonary artery pressure $\geq$ 7 mmHg than LV end-diastolic pressure.

Table 2 Transcatheter aortic valve implantation-specific risk scores and their specific features

Risk score	Number of patients	End point	Predictive factors[a]	c-statistics
PARTNER[58]	2137	6-month death or poor outcome[b]	*Positive predictors*: history of major arrhythmia, serum creatinine, and oxygen-dependent lung disease *Inverse predictors*: diabetes mellitus, mean aortic valve gradient, mini-mental status exam, and KCCQ Overall Summary Score	Derivation: 0.66 Validation: 0.64
FRANCE 2[59]	3833	30-day or in-hospital mortality	Age $\geq$ 90 years, BMI $<$ 30 kg/m^2, NYHA class IV, PH, critical haemodynamic state, $\geq$2 pulmonary oedema presentations/year, respiratory insufficiency, dialysis, and non-transfemoral access	Derivation: 0.67 Validation: 0.59
TARIS[61]	845	1-year mortality	BMI, low eGFR (per mL/min/1.73 m^2), low Hb (per g/dL), PH, low mean baseline trans-aortic gradient, LVEF $<$ 45%	Derivation: 0.66 Validation: 0.60 Sensitivity analysis: 0.71[c]

Cr, creatinine; CLD, chronic lung disease; BMI, body-mass index; NYHA, New York Heart Association; PH, pulmonary hypertension; eGFR, estimated glomerular filtration rate; Hb, haemoglobin; LVEF, left ventricular ejection fraction.
[a]Those with associations of $P < 0.05$.
[b]Defined as Kansas City Cardiomyopathy Questionnaire Overall Summary Scale score $\leq$ 45 or $\geq$10-point decrease compared with baseline.
[c]Following the addition of frailty.

Table 3 Integrated approach for estimating transcatheter aortic valve implantation-specific risk and futility

Criteria	Low risk	Intermediate risk	High risk	Prohibitive risk
PARTNER TAVI score[a], OR FRANCE 2 TAVI score	<25% risk of mortality or lack of QOL improvement at 6 months Risk score: 0 (30-day mortality risk < 5%)	25–50% risk of mortality or lack of QOL improvement at 6 months Risk score: 1–5 (30-day mortality risk 5–15%)	>50% risk of mortality or lack of QOL improvement at 6 months Risk score: 6–7 (30-day mortality risk 15–25%)	Risk score ≥ 8 (30-day mortality risk > 25%)
Frailty[b]	None	1 index	≥2 indices	≥4 indices
Specific major organ system compromise not to be improved post-TAVI[c]	None	1 organ system	2 organ systems	≥3 organ systems

[a]http://h-outcomes.com/tavi-risk-calculator/.
[b]Frailty based on Katz Index (independence in feeding, bathing, dressing, transferring, toileting, and urinary incontinence)[30] and independence in ambulation (walk 5 m in < 6 s).
[c]Examples of major organ system compromise:[34] Cardiac—severe LV systolic or diastolic dysfunction or RV dysfunction, and fixed pulmonary hypertension; CKD stage 3 or worse; pulmonary dysfunction with FEV1 < 50% or DLCO < 50% of predicted; CNS dysfunction (dementia, Alzheimer's disease, Parkinson's disease, and CVA with persistent physical limitation); GI dysfunction—Crohn's disease, ulcerative colitis, nutritional impairment, or serum albumin < 3.0; cancer—active malignancy; and liver—any history of cirrhosis, variceal bleeding, or elevated INR in the absence of VKA therapy.

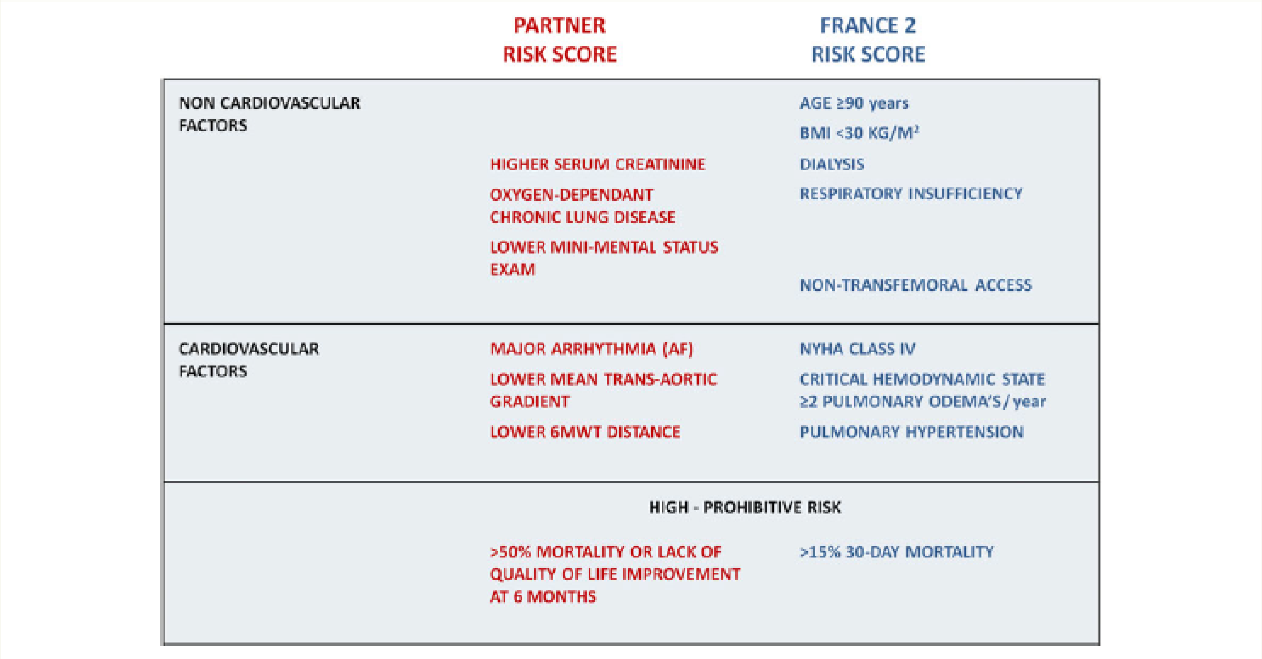

Figure 3 Cardiovascular and non-cardiovascular factors linked with transcatheter aortic valve implantation-related futility featured within the PARTNER and FRANCE 2 transcatheter aortic valve implantation-risk score models. 6MWT, 6-min walk test; BMI, body-mass index; Cr, creatinine; CLD, chronic lung disease; AF, atrial fibrillation.

Transcatheter management of severe aortic stenosis during the COVID-19 pandemic

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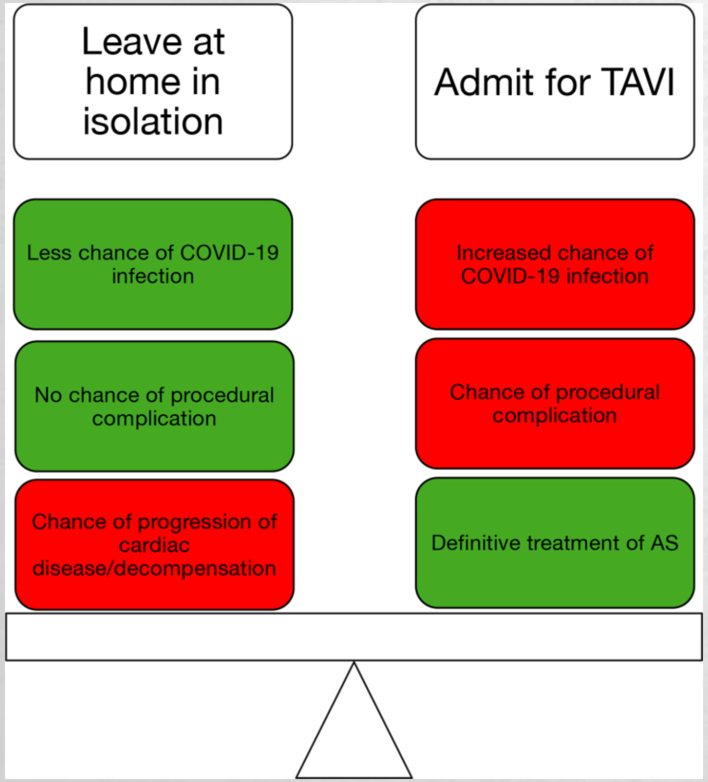

Table 1 Factors to consider doing differently along the patient pathway for AS during the COVID-19 crisis

Phase of patient pathway	Alterations to practice during the COVID-19 crisis
	Review TAVI waiting list and triage for highest risk.
	Review sAVR waiting list.
	Convert intermediate risk patients to TAVI if appropriate.
	Convert low-risk patients to TAVI only with Heart Team consensus.
Case selection	Consider risk to patient of nosocomial COVID-19 infection.
	Avoid TOE.
	Use CTCA instead of invasive coronary angiography.
	Consider risk to patient of COVID-19 when attending for tests.
TAVI work-up	Do all tests in a single attendance.
	Keep it simple.
	Use devices the operator/team is familiar with.
	Transfemoral procedures only.
Procedure	Consider appropriateness/ethics of surgical bail-out.
	Early safe discharge.
Post-TAVI	No need for follow-up echo until 6 months.

CTCA, CT coronary angiogram; sAVR, surgical valve replacement ; TAVI, transcatheter aortic valve implantation; TOE, transoesophageal echo.

CONCLUSIONS

- Estimation of flow is paramount in AS evaluation
- DSE is a useful tool especially in evaluating low-flow depressed EF pts
- TAVR is an option with acceptable risk even in pts without contractile reserve
- TAVR maybe even considered for HF pts with moderate AS