How Can We Tackle Small Annulus?

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Disclosure

- Consulting:
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  - Medtronic, Cook Medical, Abbott, Cordis
- Proctoring:
  - Medtronic, Edwards

What is Small Aortic Annulus?

- No clear consensus regarding the cutoff value for defining SAA
- Annular diameter ≤23 mm
- Surgical prosthesis ≤ 21 mm
- Annular area <400 mm^2 or perimeter <72 mm

⇒ *Prevalence 22~44%* of the SVR cases

⇒ *More common in southern Europe and Asia*

⇒ *Women make up ~90% of the small annulus population*

⇒ *Frequent in patients undergoing TAVR in SAV*

Freitas-Ferraz A, Circulation. 2019;139:2685

Problems Associated with TAVR in Small Aortic Annulus

- Patient prosthesis mismatch

  => increased mortality & morbidity

  => linked to an increase in structural valve deterioration (SVD)

- Potential risk of procedural complications

  - Annular rupture

  - Coronary obstruction

  - AV conduction disturbance/PPI

Patient-Prosthesis Mismatch

- When the effective orifice area (EOA) of a prosthetic valve is too small in relation to body size.
- Unable to meet the patient's cardiac output requirements
- Lower cut point values for obese patients (BMI ≥30 kg/m2) because the indexed EOA may overestimate the severity of PPM.

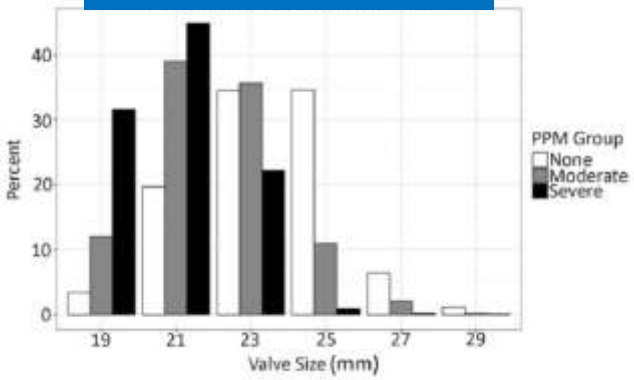
TABLE 3 Definitions for Prosthesis-Patient Mismatch

	Severe, cm^2/m^2	Moderate, cm^2/m^2
ASE guidelines[26]	<0.65	0.65-0.85
VARC-2[105]	<0.65	0.65-0.85
BMI ≥30 kg/m^2	<0.60	0.60-0.70
EACVI recommendations[80]	<0.65	0.65-0.85
BMI ≥30 kg/m^2	<0.55	0.55-0.70
VARC 3[6]	≤0.65	0.66-0.85
BMI ≥30 kg/m^2	<0.55	0.55-0.70

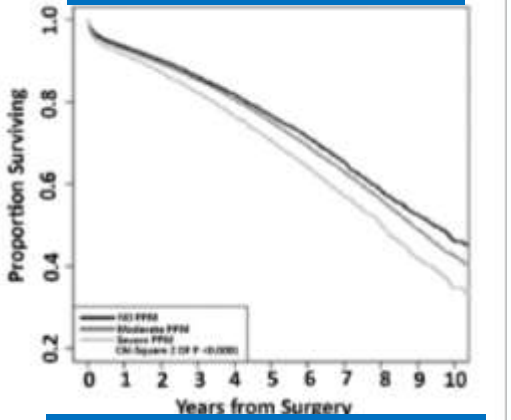
PPM is characterized by
- high transprosthetic velocity and gradients
- normal EOA
- small indexed EOA
- normal leaflet morphology and mobility

PPM after AVR Decreased Long-term Survival and Increased Readmission Rates for HF and Re-OP

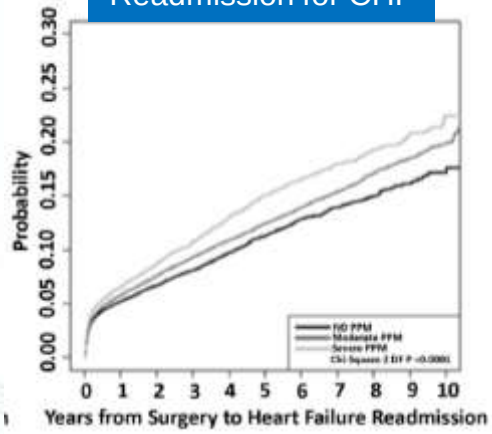
Prevalence of PPM



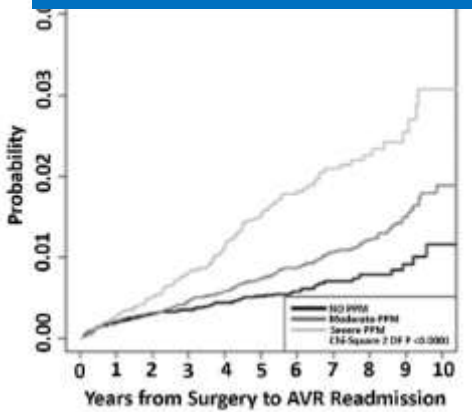
Survival



Readmission for CHF



Readmission for Re-do AVR

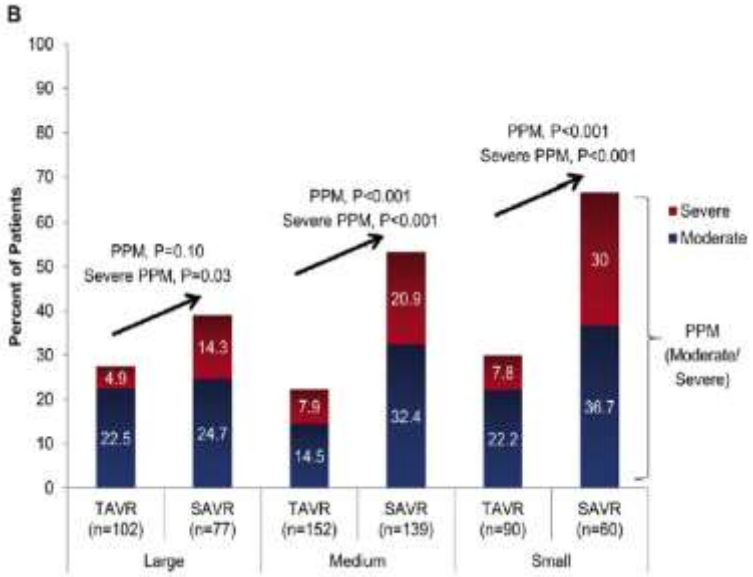


Fallon JM, Ann Thorac Surg 2018;106:14

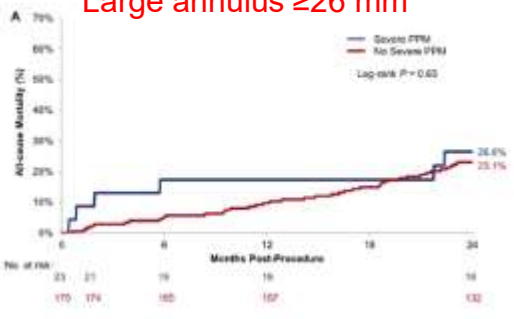
Impact of Annular Size on Outcomes After Surgical or Transcatheter AVR

Study population
from CoreValve US Pivotal High Risk Trial

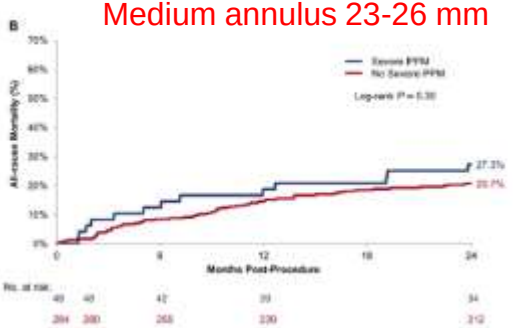
All-cause mortality



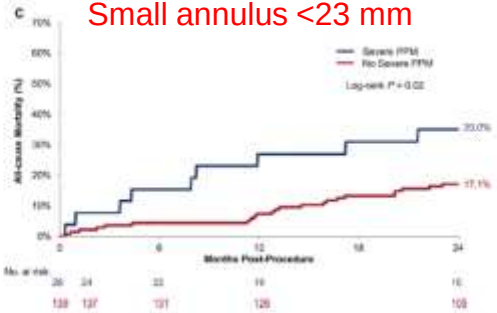
Large annulus ≥26 mm



Medium annulus 23-26 mm



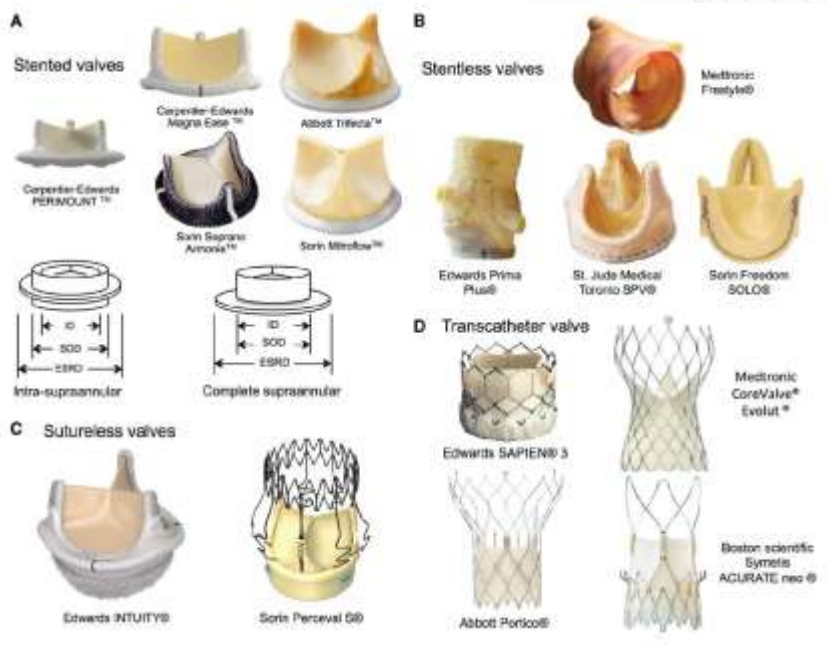
Small annulus <23 mm



Deeb GM, Ann Thorac Surg 2018;105:1129

Superior Hemodynamic Profile with TAVR vs SAVR

- Systematic transcatheter valve oversizing
  - ~20% for self-expanding valves
  - ~10% for balloon-expanding valves
- Absence of a sewing ring
- Thin struts

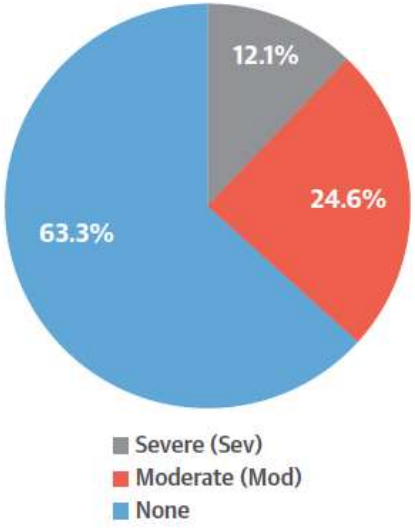


Freitas-Ferraz A, Circulation. 2019;139:2685

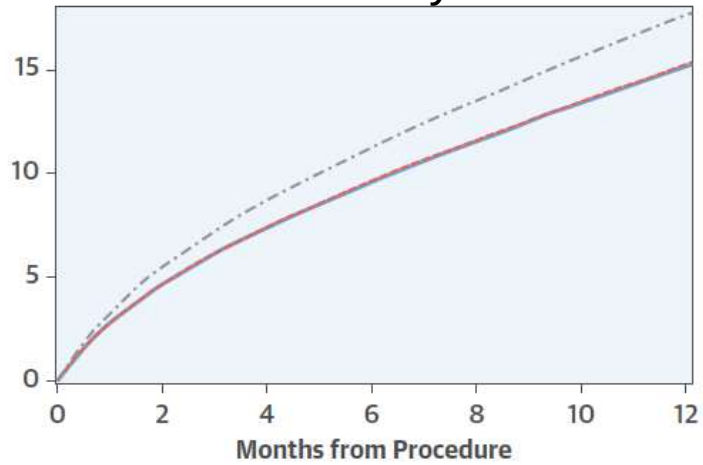
TVT Registry: Incidence and Effect on Survival of Severe PPM After TAVR

PPM was associated with higher mortality and HF rehospitalization

PPM



Mortality



PPM

Sev PPM (EOAi <0.65 cm²/m²) Mod PPM (EOAi 0.65-0.85 cm²/m²)

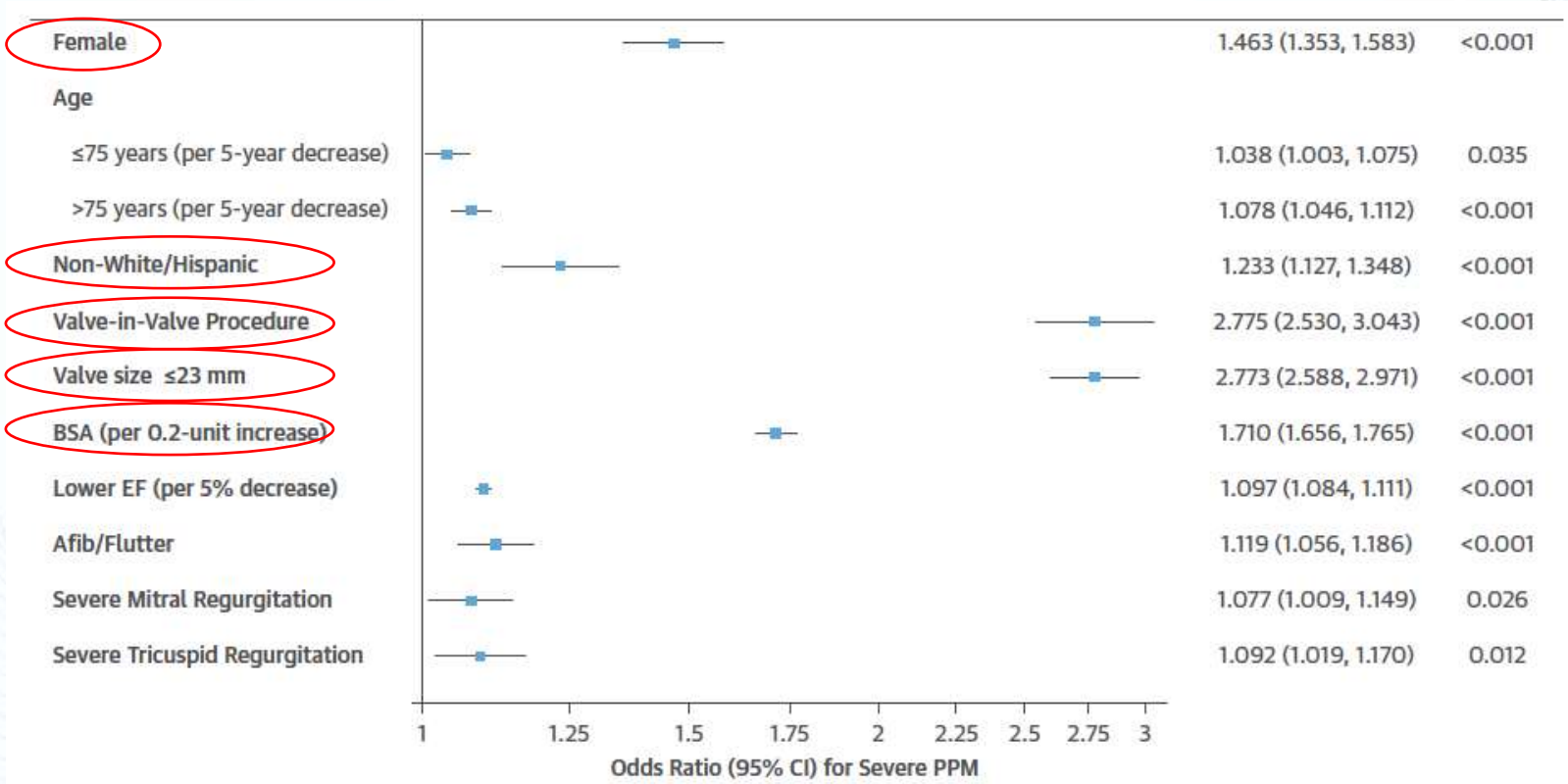
No PPM (EOAi >0.85 cm²/m²)

Number at Risk Adjusting for Baseline Covariates:

	Day 0	Month 4	Month 8	Month 12
No PPM	23,635	21,080	16,734	13,136
Mod PPM	8,983	7,995	6,277	4,831
Sev PPM	4,152	3,626	2,976	2,130

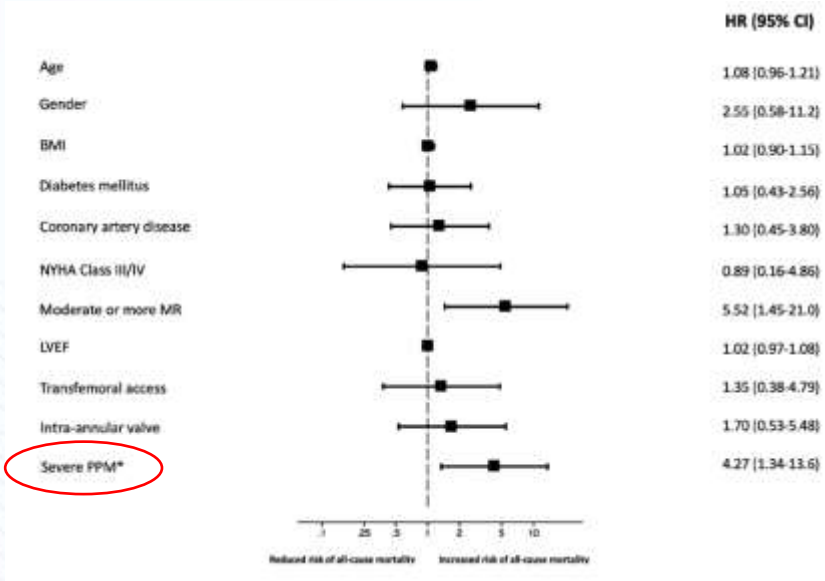
Herrmann HC, JACC 2018;72:2701

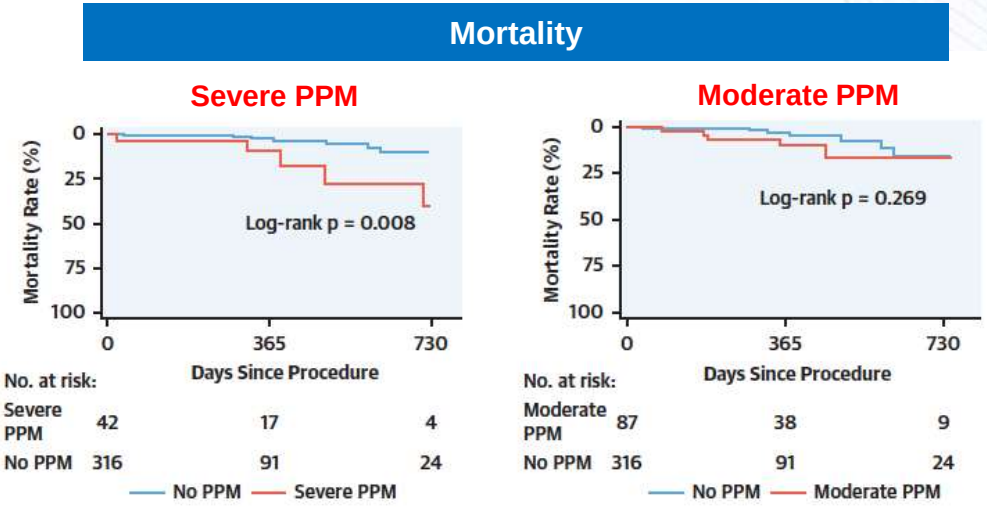
Predictors of Severe PPM



Herrmann HC, JACC 2018;72:2701

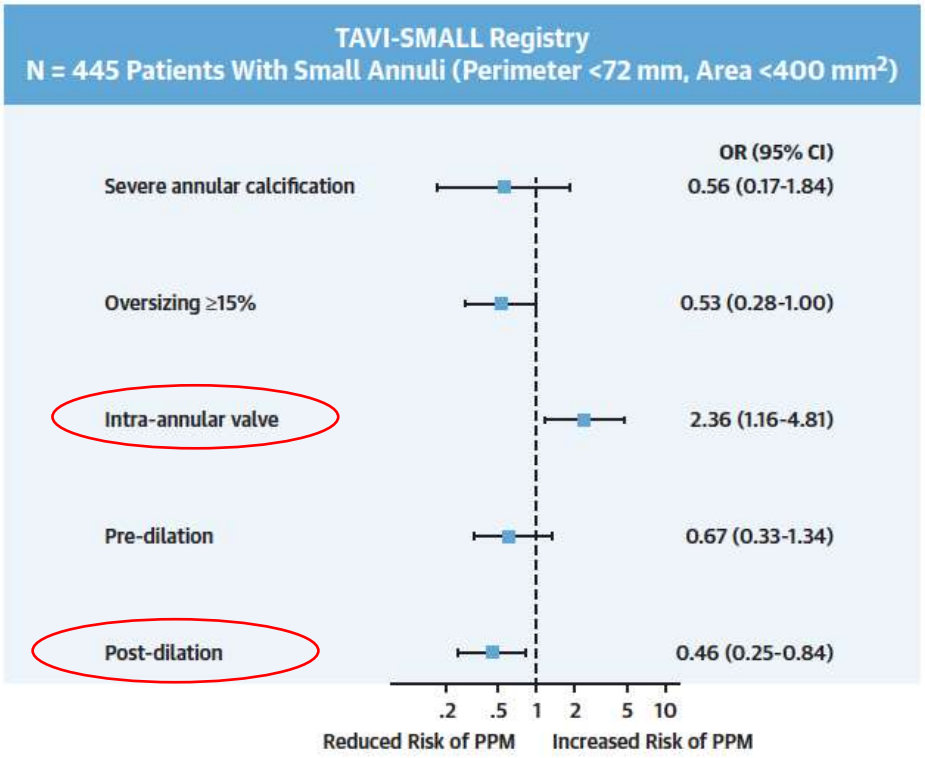
TAVI-Small Registry (SEV): Predictors of Mortality after TAVR





Leone PP, JACC Intv. 2021;14:1218

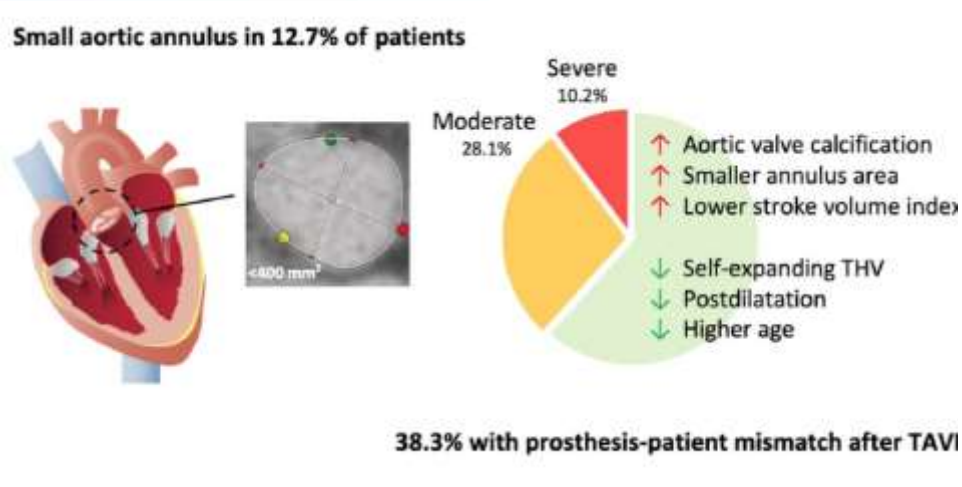
TAVI-Small Registry: Predictors of PPM for Self-expanding Valves

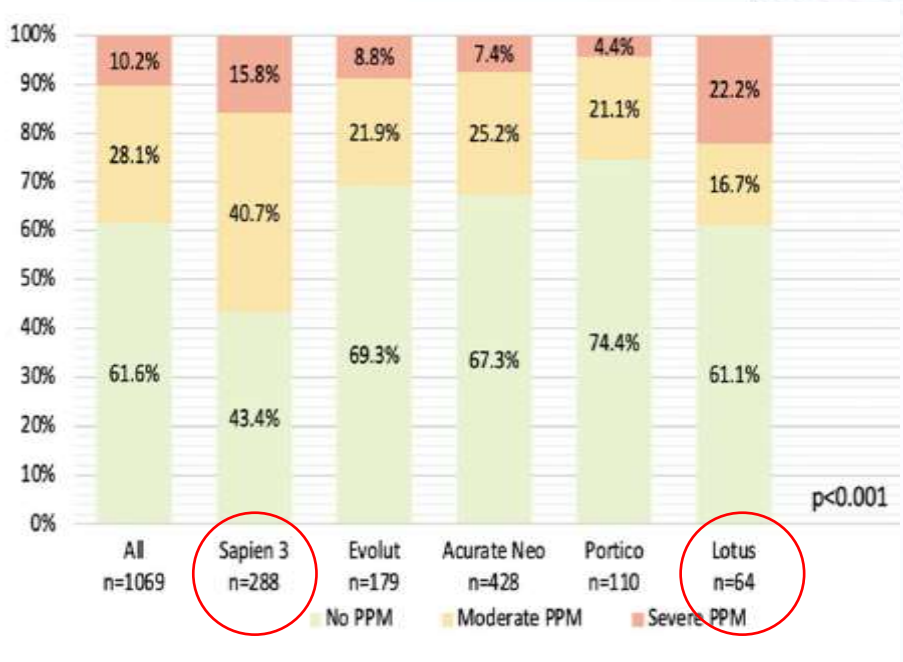


Leone PP, JACC Intv. 2021;14:1218

Risk Factors of PPM after TAVR

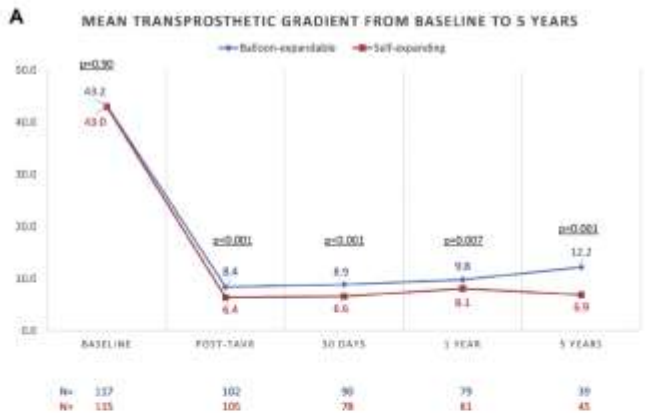
N=8411, from 4 German centers





Voigtländer L, Clin Res Cardio 2021;110:1957

Balloon-Expandable (Sapien XT) vs. Self-Expanding (CoreValve) Valves: CHOICE Randomized Clinical Trial



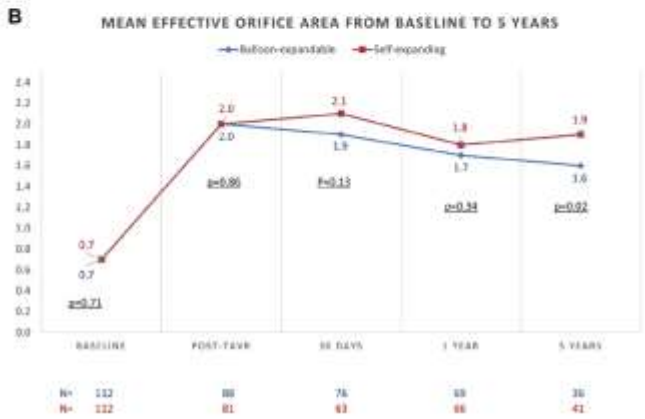
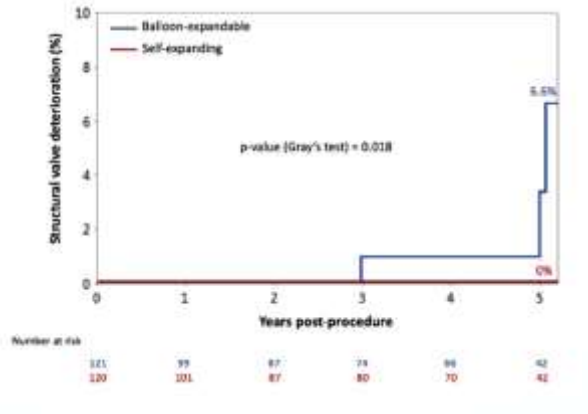
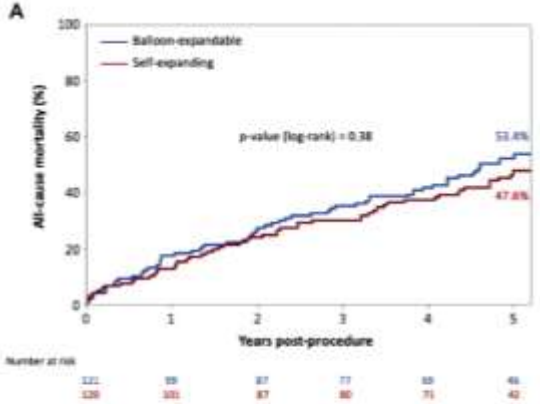
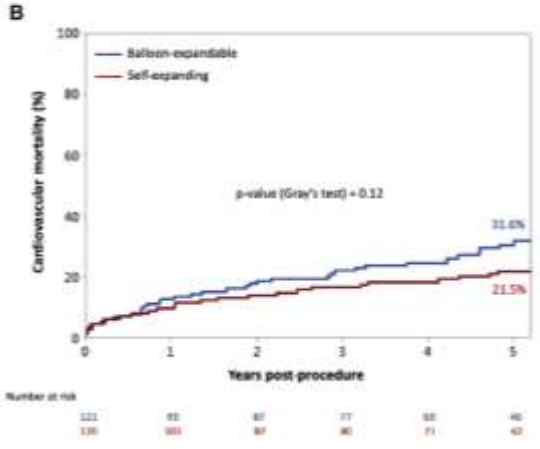


TABLE 3 BVD and Its Components Through 5 Years

	Balloon-Expandable Valve (n = 121)	Self-Expanding Valve (n = 120)	p Value
Bioprosthetic valve dysfunction	28 (22.5)	26 (20.9)	0.91
Components			
SVD	6 (6.6)	0 (0.0)	0.018
Moderate SVD	4 (5.6)	0 (0.0)	0.047
Severe SVD	2 (0.9)	0 (0.0)	0.20
NSVD	17 (17.8)	23 (26.7)	0.20
Moderate/severe PPM	14 (15.9)	13 (16.0)	1.0
Moderate/severe PVL	3 (2.5)	10 (8.5)	0.08
Valve thrombosis	6 (7.3)	1 (0.8)	0.06
Endocarditis	2 (1.6)	4 (3.4)	0.39

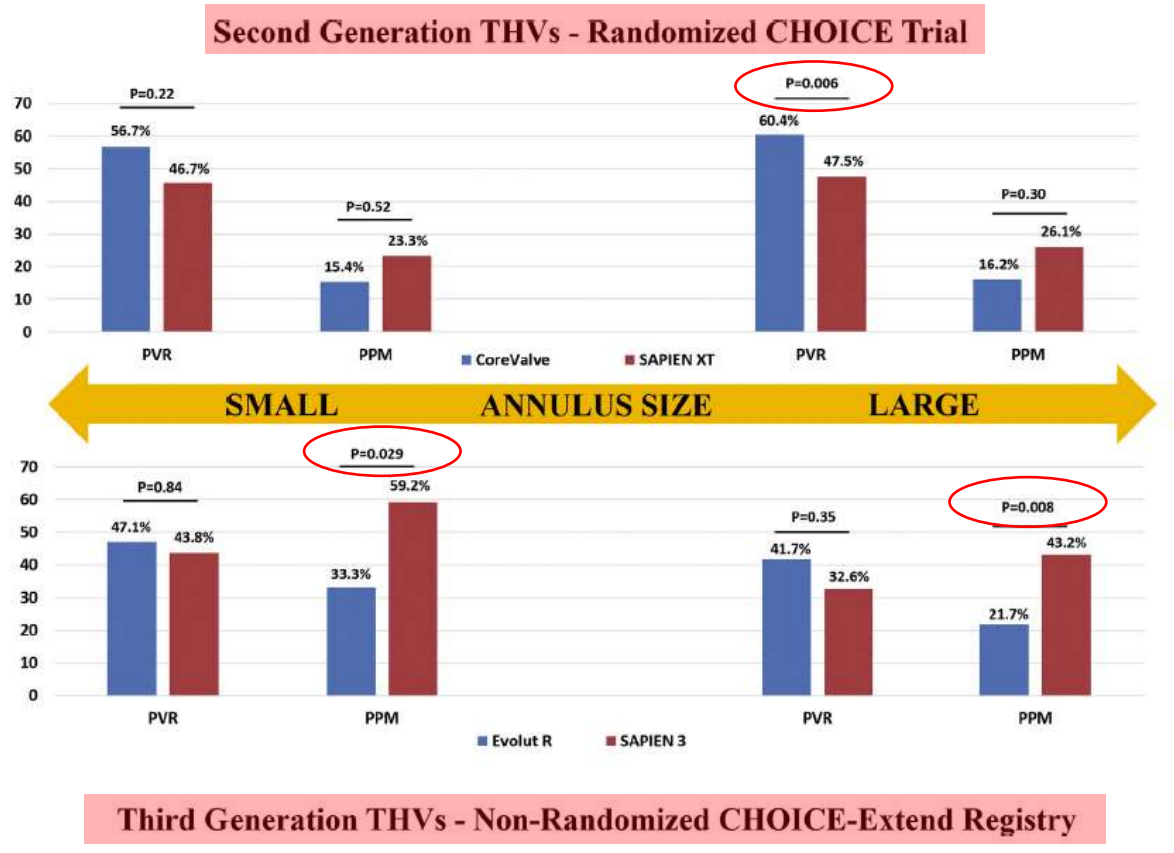






Abdel-Wahab M, JACC Intv 2020;13:1071

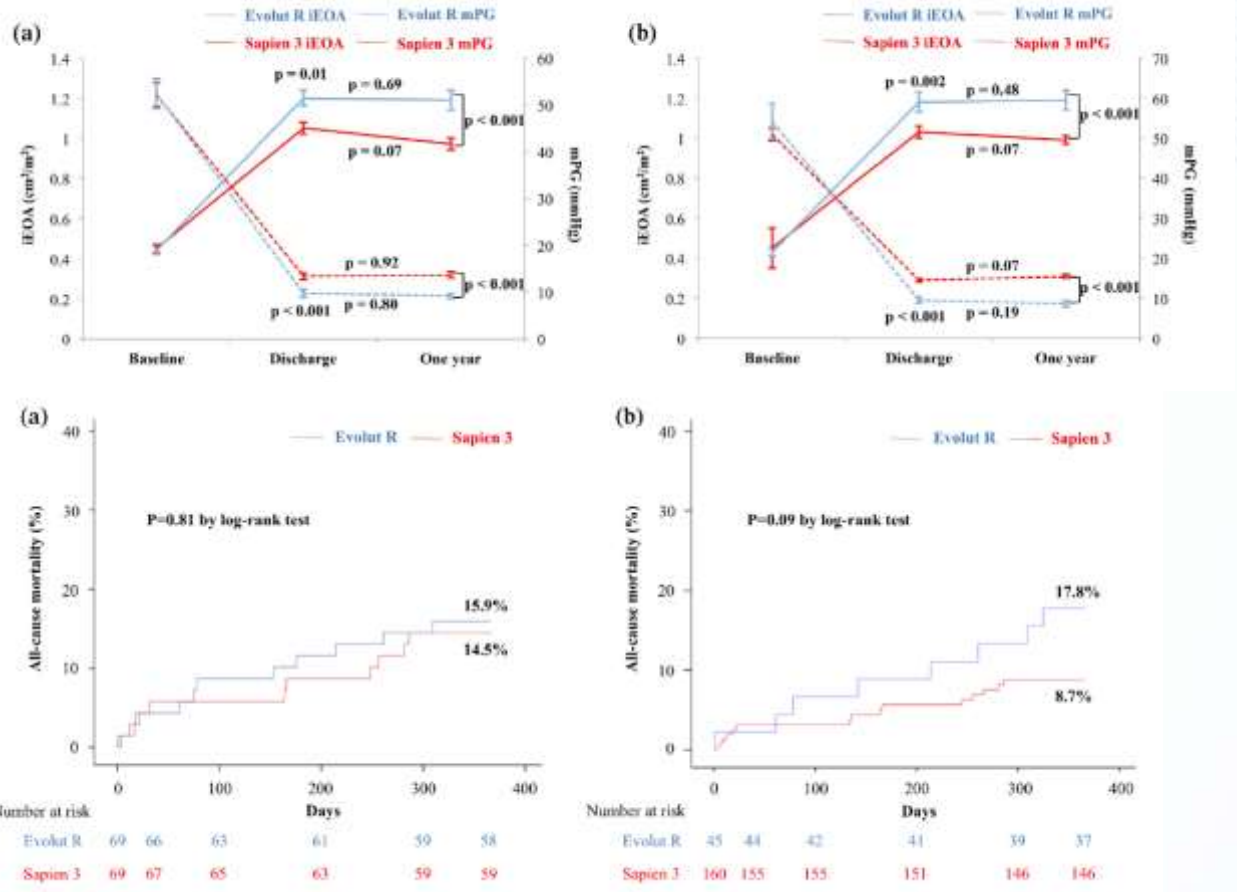
Rates of PVR and PPM According to Aortic Annulus Size



Abdelghani M, JACC Intv. 2018;11:2507 Pivarot P, JACC Intv 2018;11:2519

Evolut R vs. Sapien 3 in Japanese patients with a small aortic annulus: The OCEAN-TAVI registry

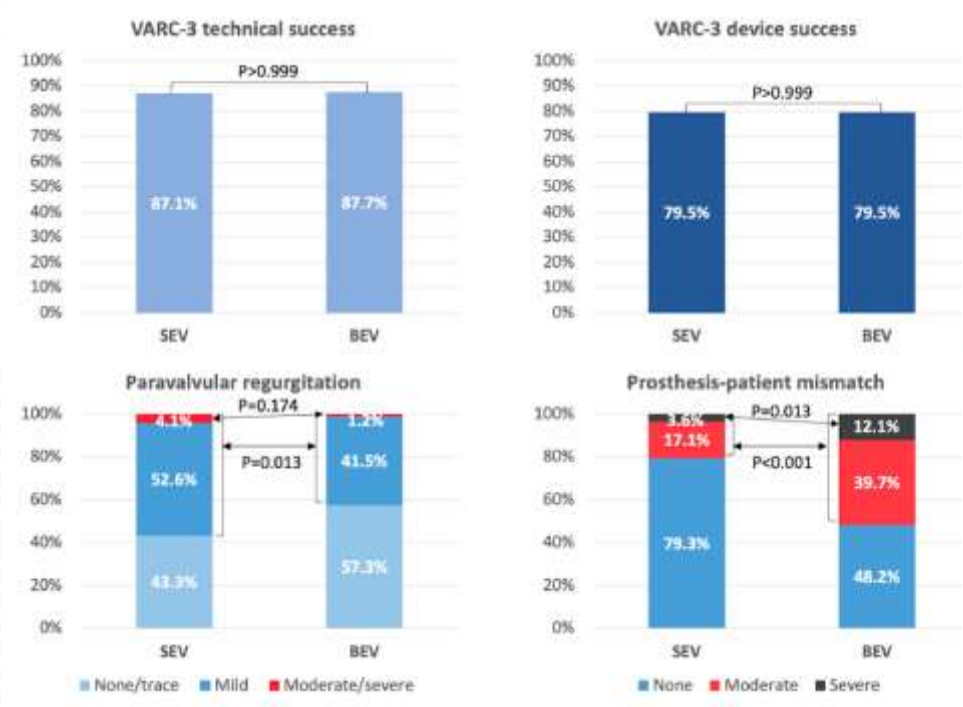
a) small annulus ≦23 mm matched cohort, b) small annulus ≦21 mm cohort

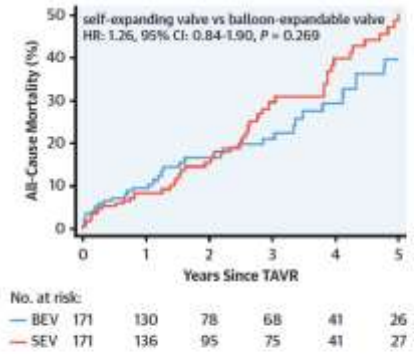


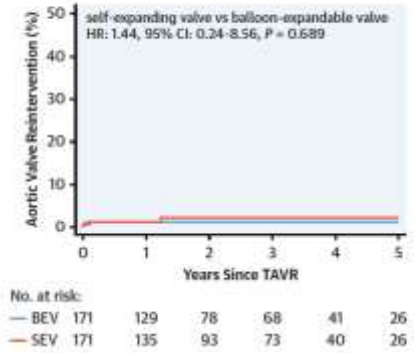
Hase H,
Catheter Cardiovasc Interv.
2021;97:E875

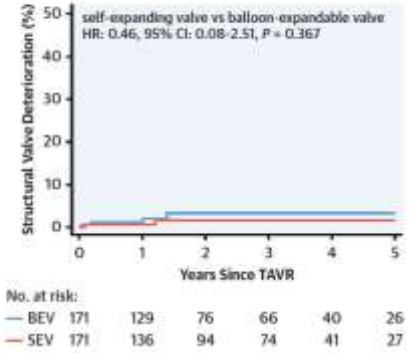
BEV vs. SEV in Patients with Small Annuli

Matched cohort from Bern TAVI registry





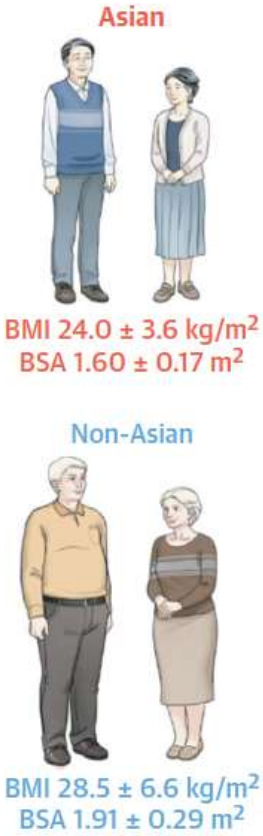


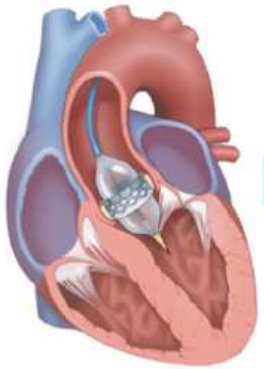


Okuno T, JACC Intv. 2023;16:429

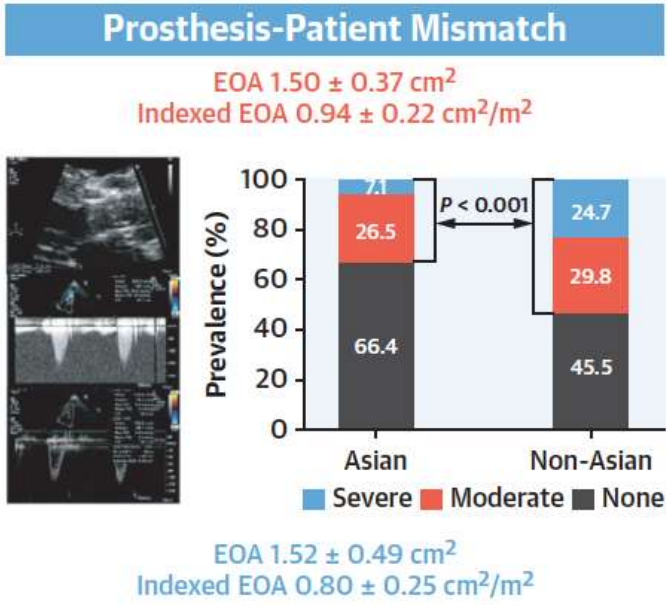
PPM: Asian vs. Non-Asian

N=1,101
from Asan
medical center
& 2 US centers



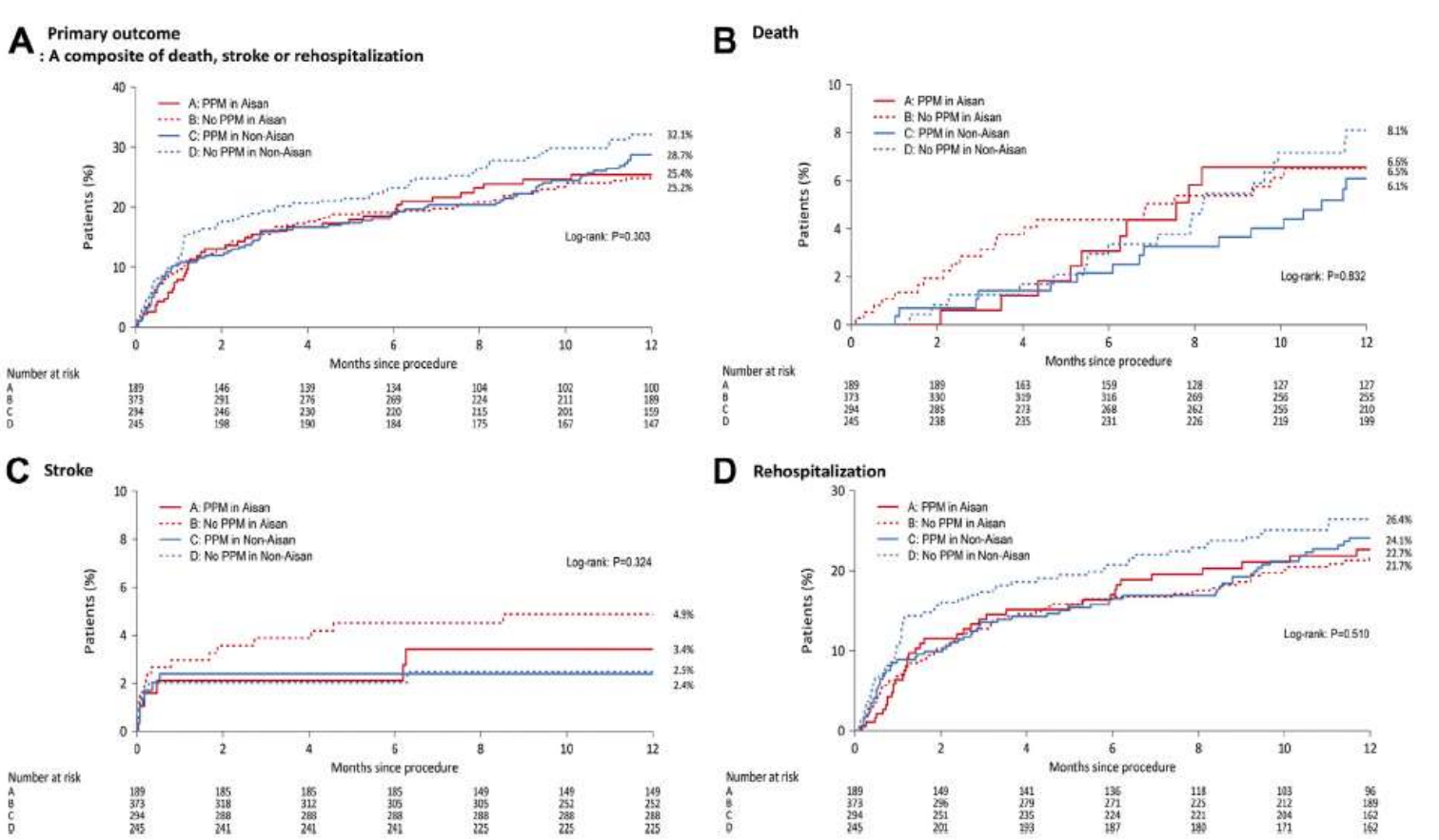


Annulus perimeter: 75.7 vs. 78.4 mm
Annulus area: 441 vs. 461 mm²



Park H, J Am Coll Cardiol Intv 2021;14:2670

Clinical Outcomes According to PPM and Race



Park H, J Am Coll Cardiol Intv 2021;14:2670

Bioprosthetic AV Hemodynamic: Evidence Gaps

Bioprosthetic Aortic Valve Hemodynamics: Definitions, Outcomes, and Evidence Gaps

JACC State-of-the-Art Review

TABLE 2 Summary of Reasons for Discordance Between Echocardiographic and Invasive Hemodynamic Measurement of Bioprosthetic Valve Function

Echocardiographic
Failure to align Doppler sector parallel to maximal velocity
Simplified Bernoulli equation fails to account for a. Laminar/average flow with lower velocity adjacent to vessel wall b. Proximal LV velocity c. Variability of contraction coefficient d. Nonconvective forces of flow acceleration, viscosity, and convective acceleration
Not corrected for pressure recovery
Invasive hemodynamic
Inaccuracies introduced by a. Fluid-filled catheters b. Use of pigtail instead of end-hole catheters c. Improper positioning within LV and aorta
Timing of measurements immediately post-TAVR

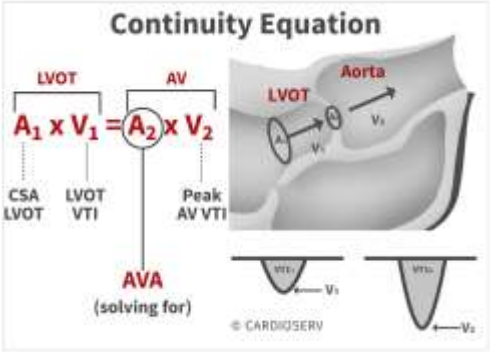
TABLE 4 Summary of Reasons for Discrepancy in Effects of Severe PPM on Outcomes

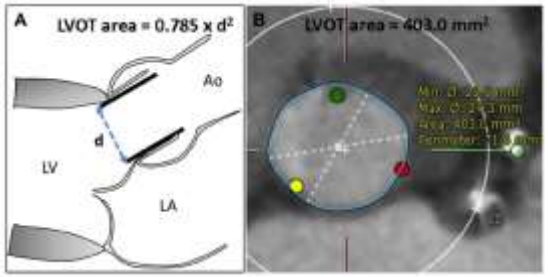
Reasons why the reported incidence of PPM varies after AVR
Method of EOA calculation (measured vs predicted)
Correction or not for obesity
Timing of measurement (immediate vs later)
Effect of underlying flow state
Method of gradient determination (echocardiographic vs hemodynamic)
Reasons why the effects of severe PPM on outcomes are conflicting
Measurements and calculations differ as above
Incomplete correction for confounding and competing outcome variables
Paravalvular aortic regurgitation
Low flow state
Older patients or other survival limitations
Underpowered analyses
Limited follow-up (1 year may not be sufficient)

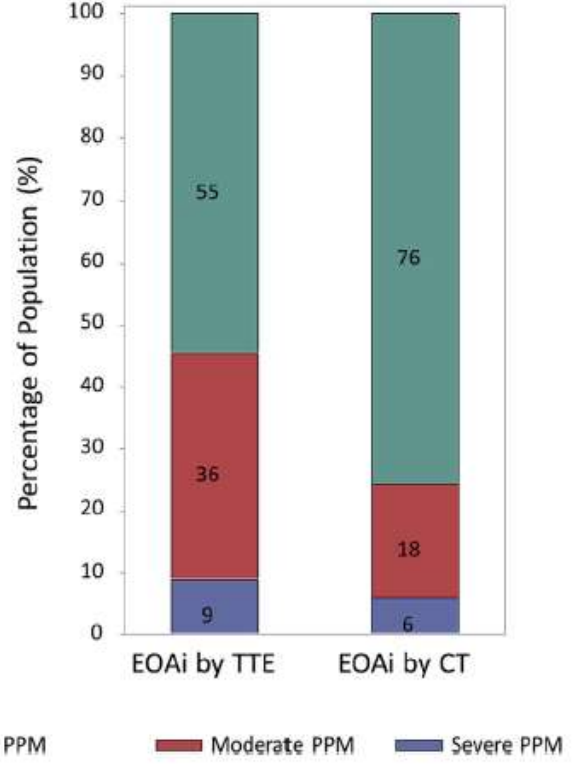
CT-Defined Prosthesis–Patient Mismatch Downgrades Frequency and Severity of PPM

Continuity equation errors by 2D echo

$$AVA = \frac{\pi(radius\ LVOT)^2 \times (Vmax_{LVOT})}{(Vmax_{AV})}$$

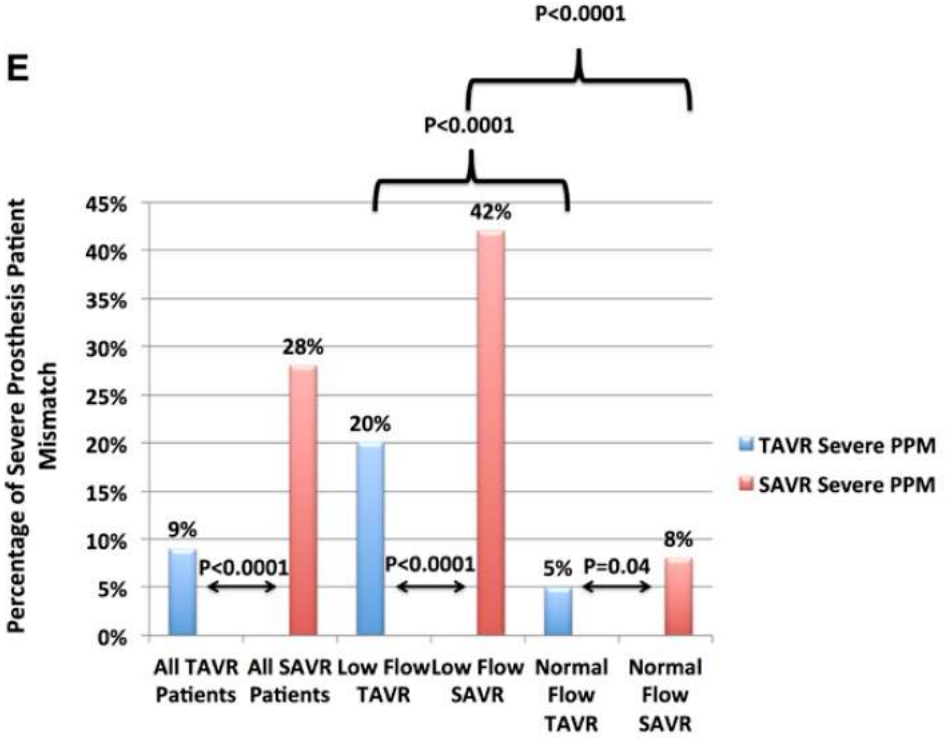






Mooney J, JACC Intv 2017;10:1578

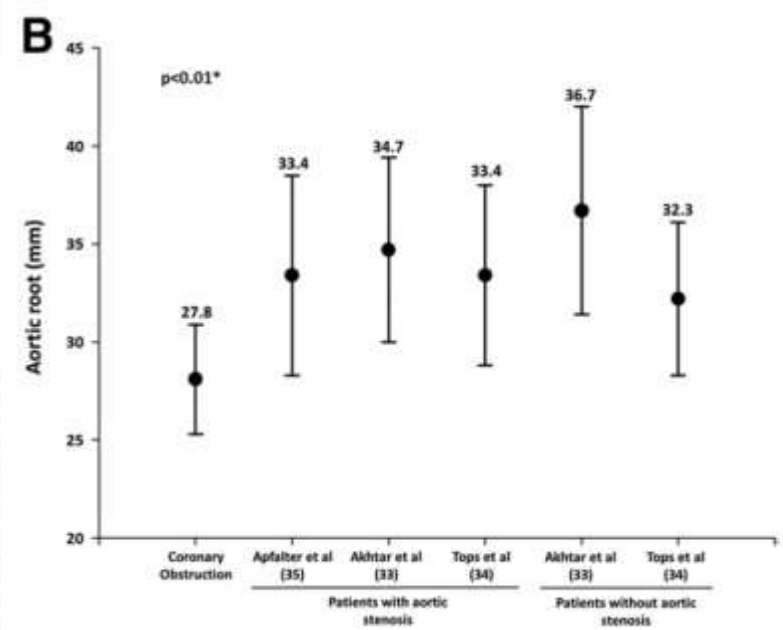
Impact of Flow on PPM Following TAVR and SAVR



Abbas AE, Circ Cardiovasc Imaging 2021;14:e012364

Rare Complications Related to Small Annulus

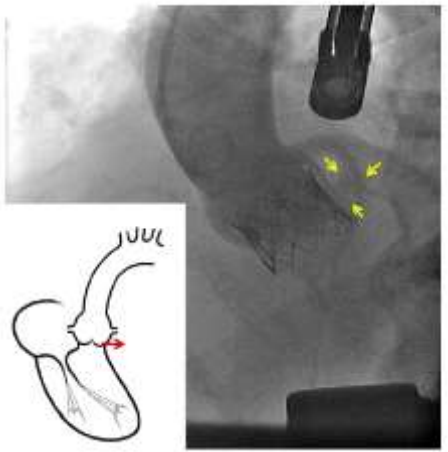
Coronary Obstruction



Ribeiro HB,
JACC Cardiovasc Interv. 2013;6:452

Annular Rupture

- Oversized ballooning
- Especially when calcified



Pasic M,
JACC Cardiovasc Interv. 2015;8:1

Take Home Messages

- Small aortic annulus is prone to develop PPM after TAVR or SAVR.
- Diagnosis of PPM based on TTE is often inaccurate.
- Self-expanding valves especially with supra-annular design show superior hemodynamics than balloon-expanding valves .
- However, the impact of PPM on clinical outcomes after TAVR appears to be inconsistent.
- If severe PPM is expected after TAVR, self-expanding valves need to be preferred in cases of young and physically active patients and patients with low LVEF, severe LVH, or significant MR.
- Otherwise, selection of valves for small annuli doesn’t need to be different than for large annuli.