Permanent Pacemaker and Paravalvular Leakage: How to Avoid?

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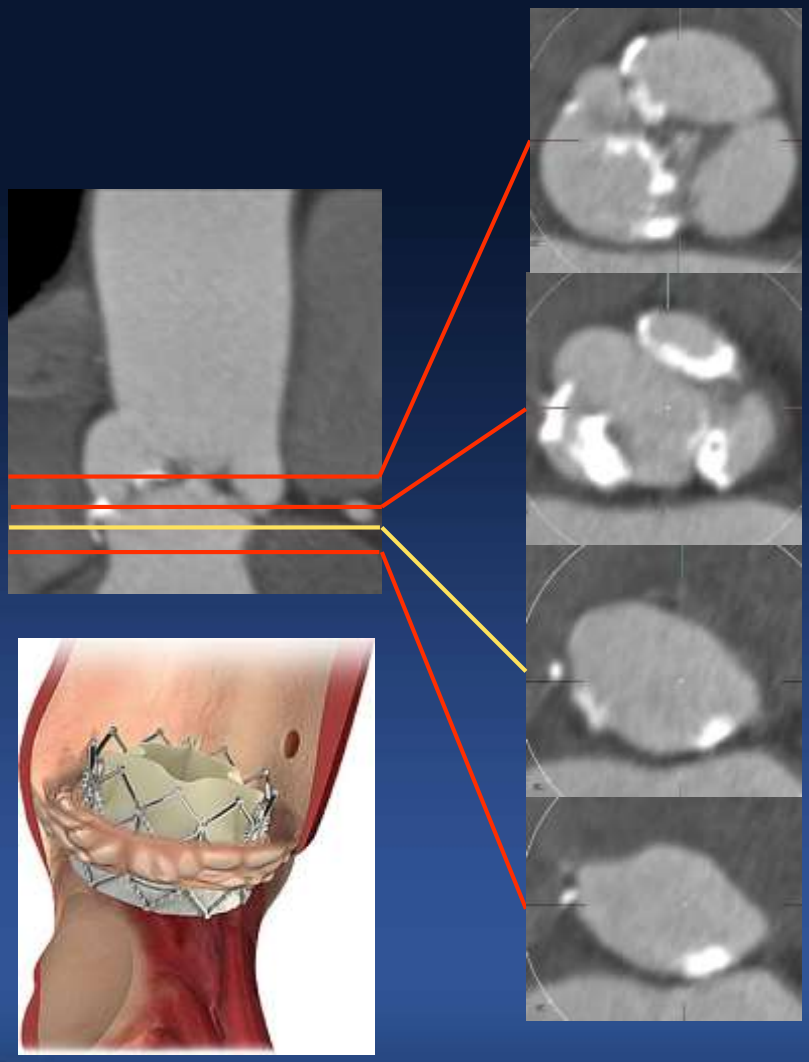
Conflict of Interest Statement

Within the past 12 months, I or my spouse/partner have had a financial interest/arrangement or affiliation with the organization(s) listed below.

Affiliation/Financial Relationship	Company
Consulting Fees/Honoraria	Edwards LifeSciences
Consulting Fees/Honoraria	Medtronic Inc
Consulting Fees/Honoraria	Boston Scientific

Aortic Valve Complex



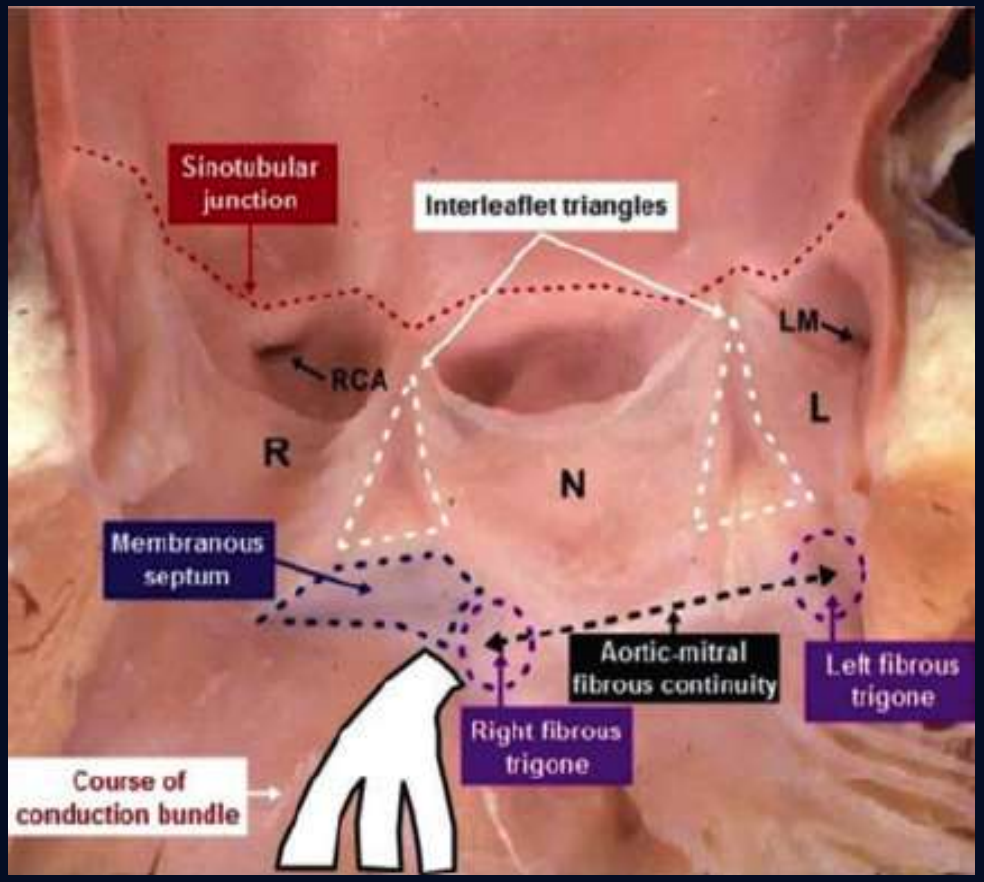
Sinus of Valsalva

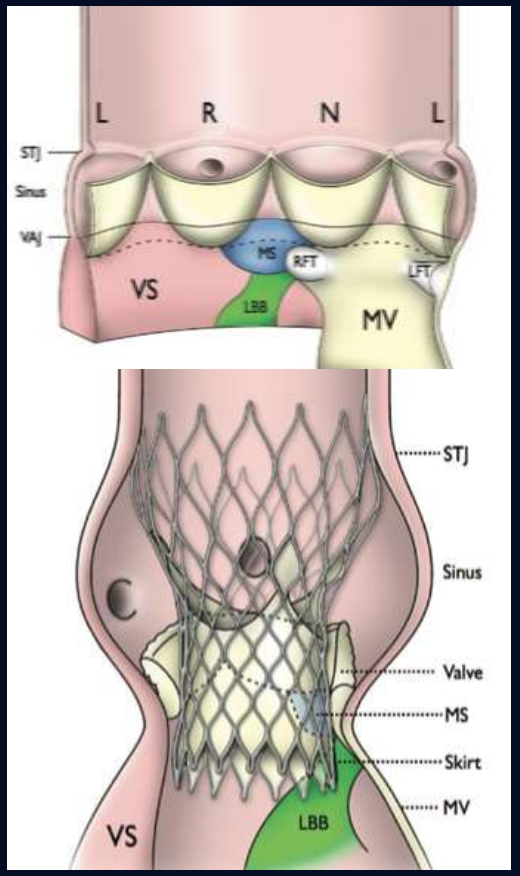
Leaflet

Annulus

LVOT

TAVR and Cardiac Conduction





New LBBB and complete heart block (PPM) remain among most frequent complications of TAVR

Ferreira et al. PACE 2010;33:1364-72

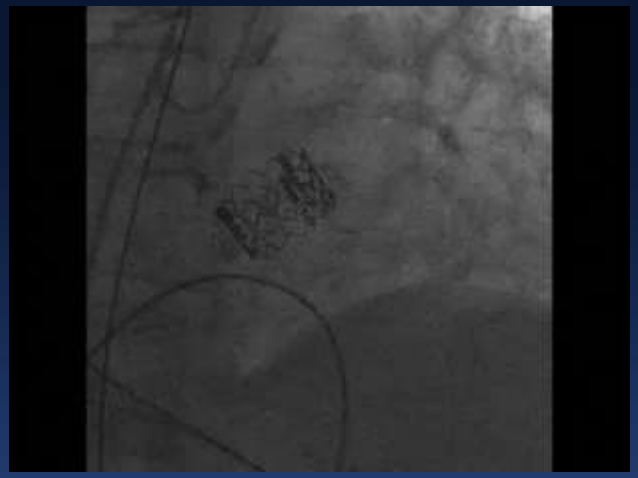
TAVR Sizing Matters ??

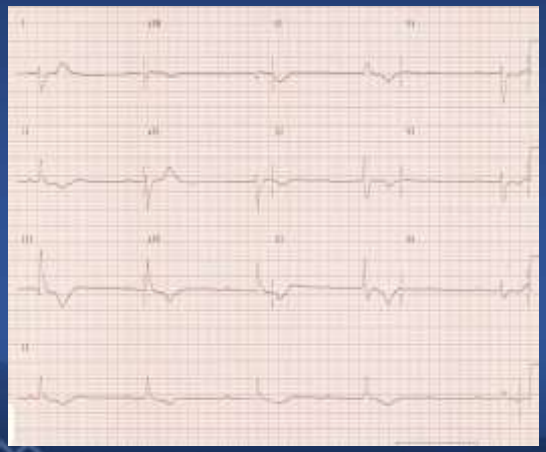
Oversize ⟷ **Undersize**

Annulus Rupture

VS.

PVL



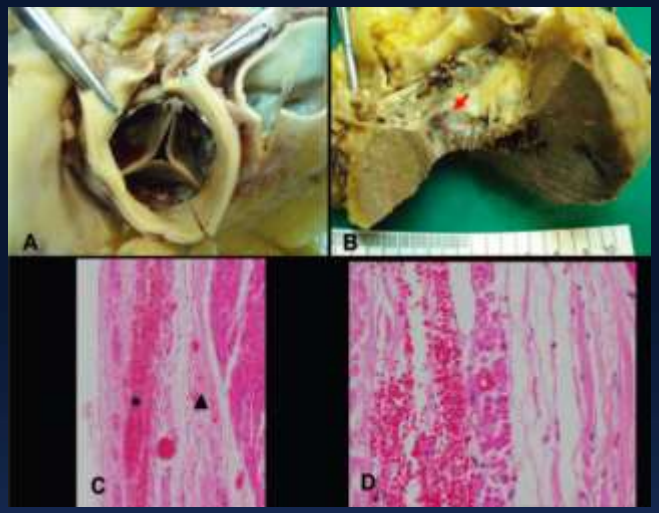


Complete AV Block

Embolization

Mechanism of Conduction Disturbances

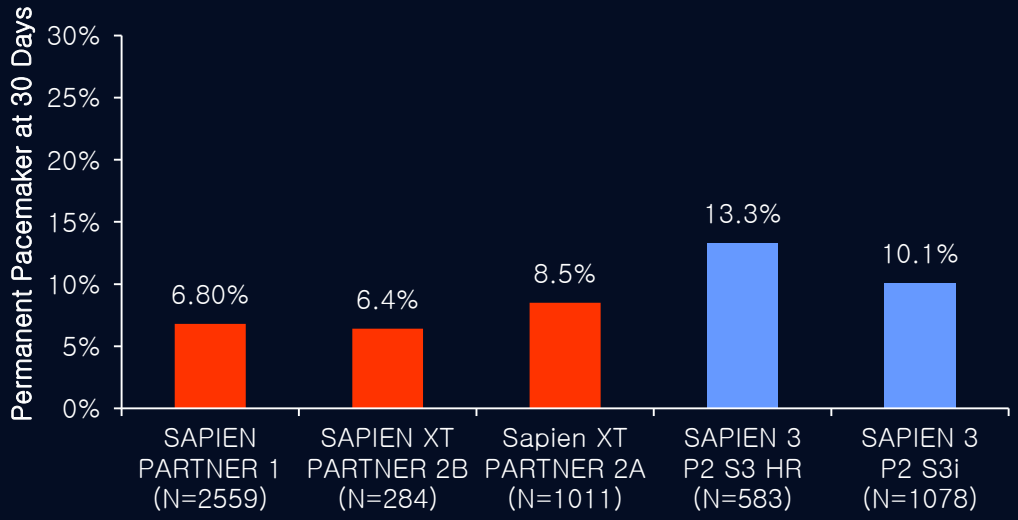
Autopsy Study



Mechanical Injury	Ischemic Injury
• Direct compression: wall tension due to radial force • Procedural Inflammation • Hemorrhage/edema	• Tissue compression during BAV • Hypotension during rapid pacing (BAV procedure) • Other hypotensive episodes

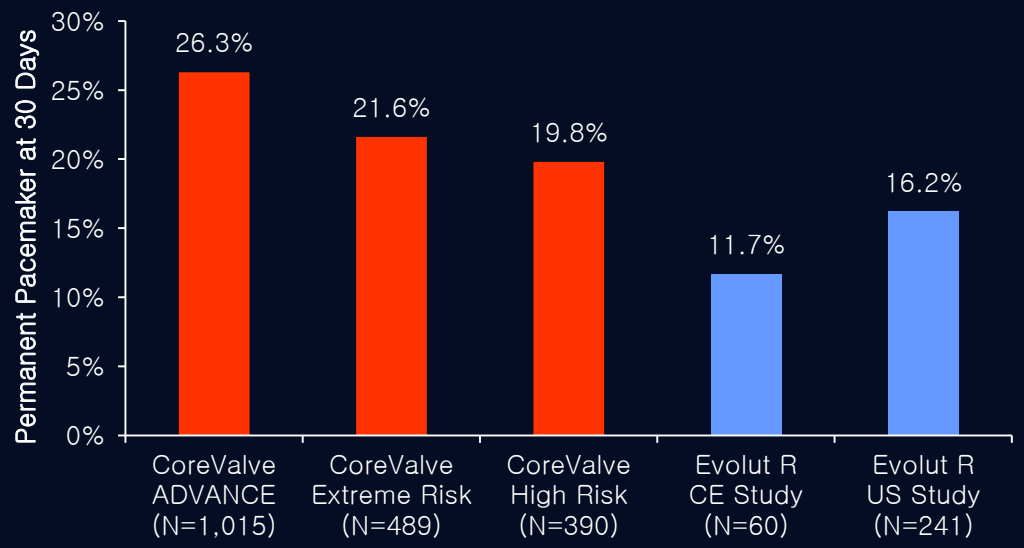
Moreno. Circulation 2009
Sinhal. JACC Cardiovasc Interv 2008
Saji. Cardiovasc Interv Ther 2013

Edwards SAPIEN 3 – PPM at 30 days



Nazif TM. J Am Coll Cardiol Intv 2015;8:60-9.; Webb JG. J Am Coll Cardiol Intv 2015;8:1797-806.; Leon MB. N Engl J Med 2016;374:1609-20.; Kodali S. Eur Heart J. 2016;37:2252-62.

Medtronic Evolut R – PPM at 30 days



Linke A. Eur Heart J 2014;35:2672-84; Popma J. J Am Coll Cardiol 2014;63:1972-81; Adams D. N Engl J Med 2014;370:1790-8; Manoharan G. J Am Coll Cardiol Intv 2015;8:1359-67; Williams MR presented at ACC 2016, Forrest J presented at ACC 2017

Predictors of Conduction Disturbances

Clinical	Anatomical	Procedure
• Male gender • Age>75 years • Previous MI • **RBBB** • **Pre-existing conduction disturbance**	• Variation in location of LBBB exit point • Septum thickness • Thickness of the non-coronary cusp • **Elevated left coronary cusp calcium** • **Membranous septum length**	• Radial force of the prosthesis • **Oversizing** • **Implant depth** • Balloon aortic valvuloplasty • Application of PPI guidelines • **Learning curve**

Barbanti M. Expert Review of Medical Devices 2017

Predictors of new PPM after TAVR

Table 2. Main Predictors of Permanent Pacemaker Implantation After Transcatheter Aortic Valve Replacement

Variable	Multivariable Odds Ratio*	References
Baseline right bundle-branch block	2.8–46.7	10, 34, 45, 51, 55, 61, 68, 69, 111, 122, 145, 146, 148, 156–170
Implantation of a Medtronic CoreValve (vs Edwards SAPIEN/ SAPIEN XT valves)	2.6–25.7	34, 75, 87, 91, 153, 156, 160, 161, 163, 165
Depth of implantation	1.1–1.5/1 mm	10, 44, 51, 61, 111, 146, 157–159, 169, 171–173
Oversizing/stretching of the aortic annulus/ left ventricular outflow tract	1.02–1.5/1%	42, 44, 87, 122, 148, 159, 166, 171, 174
First-degree atrioventricular block	4.0–11.4	157, 164, 175

*Ranges of odds ratio are from published studies with a multivariable analysis.

Auffret. Circulation 2017;136:1049-69.

Pacemaker Implantation

Calcium Location and Burden

Table 4 Univariate and multivariate regression analysis to identify independent associations between potential risk factors and the need for PPI after TAVI

	Univariate		Multivariate	
	OR (95% CI)	P	OR (95% CI)	P
Age	1.001 (0.91–1.10)	0.98		
Gender	1.52 (0.54–4.27)	0.43		
BMI	1.11 (0.99–1.24)	0.06		
LVEF	1.01 (0.96–1.07)	0.66		
CAD	1.54 (0.51–4.65)	0.45		
Previous MI	1.25 (0.26–6.03)	0.78		
Hypertension	1.98 (0.25–15.93)	0.52		
Previous heart surgery	1.41 (0.58–3.43)	0.45		
Diabetes mellitus	2.38 (0.83–6.84)	0.11		
COPD	1.05 (0.35–3.21)	0.93		
Carotid stenosis	1.54 (0.46–5.15)	0.49		
Pulmonary hypertension	0.38 (0.05–2.99)	0.36		
Heart rhythm	2.36 (0.82–6.78)	0.11		
Heart rate	0.99 (0.96–1.03)	0.73		
PQ interval	1.01 (0.99–1.03)	0.40		
QRS duration	1.03 (1.004–1.05)	0.02	0.99 (0.97–1.03)	0.75
AV block I	3.12 (0.84–11.62)	0.09		
RBBB	11.17 (3.56–35.06)	<0.001	12.61 (2.38–66.80)	0.003
LBBB	0.45 (0.06–3.57)	0.45		
LCC calcification >209	7.60 (1.67–34.64)	0.009	7.45 (1.54–36.12)	0.01

RBBB and ***LCC calcification*** remained significantly associated with PPI in multivariate regression (RBBB: OR 12.61, 95% CI 2.38–66.80, P < 0.003; LCC calcium >209 mm^3: OR 7.45, 95% CI 1.54–36.12, P = 0.01)

Eur Heart J Cardiovasc Imaging. 2016;17(12):1385-1393

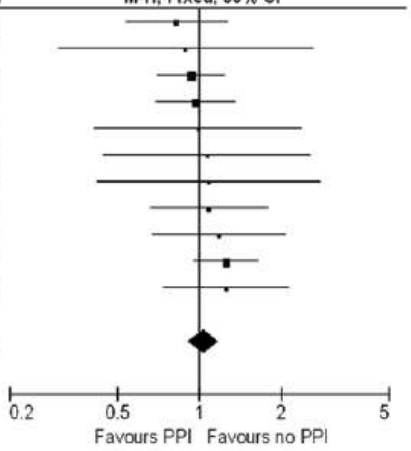
Clinical Impact of PPM after TAVR

No Impact of Mortality

A 1-year RR of all-cause death

Study or Subgroup	PPI following TAVR Events	PPI following TAVR Total	No PPI following TAVR Events	No PPI following TAVR Total	Weight	Risk Ratio M-H, Fixed, 95% CI
Houthuizen, et al. 2012	20	118	140	679	12.3%	0.82 [0.54, 1.26]
D'Ancona, et al. 2011	3	20	51	302	1.9%	0.89 [0.30, 2.60]
Urena, et al. 2014	46	239	272	1317	24.9%	0.93 [0.70, 1.23]
Mouillet, et al. 2015	41	252	98	581	17.6%	0.96 [0.69, 1.35]
Biner, et al. 2014	6	58	18	172	2.7%	0.99 [0.41, 2.37]
De Carlo, et al. 2012	6	44	16	125	2.5%	1.07 [0.44, 2.55]
Pereira, et al. 2013	5	19	9	37	1.8%	1.08 [0.42, 2.78]
Buellesfield, et al. 2012	19	98	37	207	7.1%	1.08 [0.66, 1.79]
Kawaguchi, et al. 2015	10	28	40	132	4.2%	1.18 [0.67, 2.06]
Nazif, et al. 2015	45	173	374	1800	19.5%	1.25 [0.96, 1.64]
Schymik, et al. 2015	13	69	85	565	5.5%	1.25 [0.74, 2.12]
Total (95% CI)		**1118**		**5917**	**100.0%**	**1.03 [0.90, 1.18]**
Total events	214		1140			

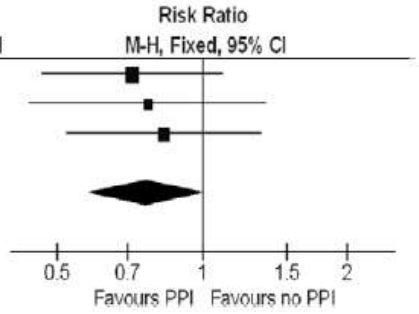
Heterogeneity: $Chi^2 = 4.64$, df = 10 (P = 0.91); $I^2 = 0\%$
Test for overall effect: Z = 0.46 (P = 0.64)



B 1-year RR of cardiac death

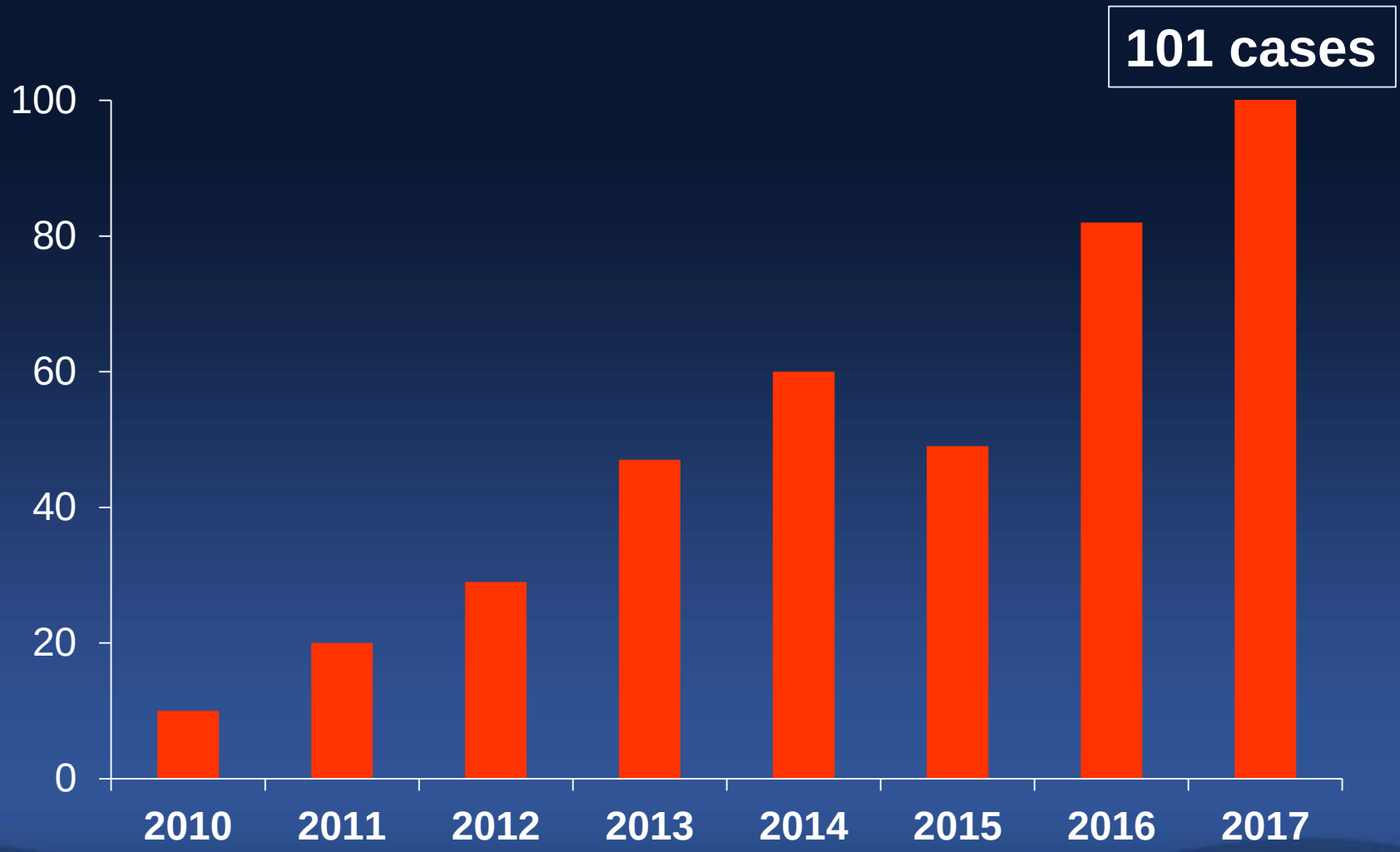
Study or Subgroup	PPI following TAVR Events	PPI following TAVR Total	No PPI following TAVR Events	No PPI following TAVR Total	Weight	Risk Ratio M-H, Fixed, 95% CI
Urena, et al. 2014	21	239	162	1317	43.2%	0.71 [0.46, 1.10]
Nazif, et al. 2015	12	173	162	1800	24.7%	0.77 [0.44, 1.36]
Mouillet, et al. 2015	22	252	61	581	32.1%	0.83 [0.52, 1.32]
Total (95% CI)		**664**		**3698**	**100.0%**	**0.77 [0.58, 1.01]**
Total events	55		385			

Heterogeneity: $Chi^2 = 0.22$, df = 2 (P = 0.90); $I^2 = 0\%$
Test for overall effect: Z = 1.89 (P = 0.06)

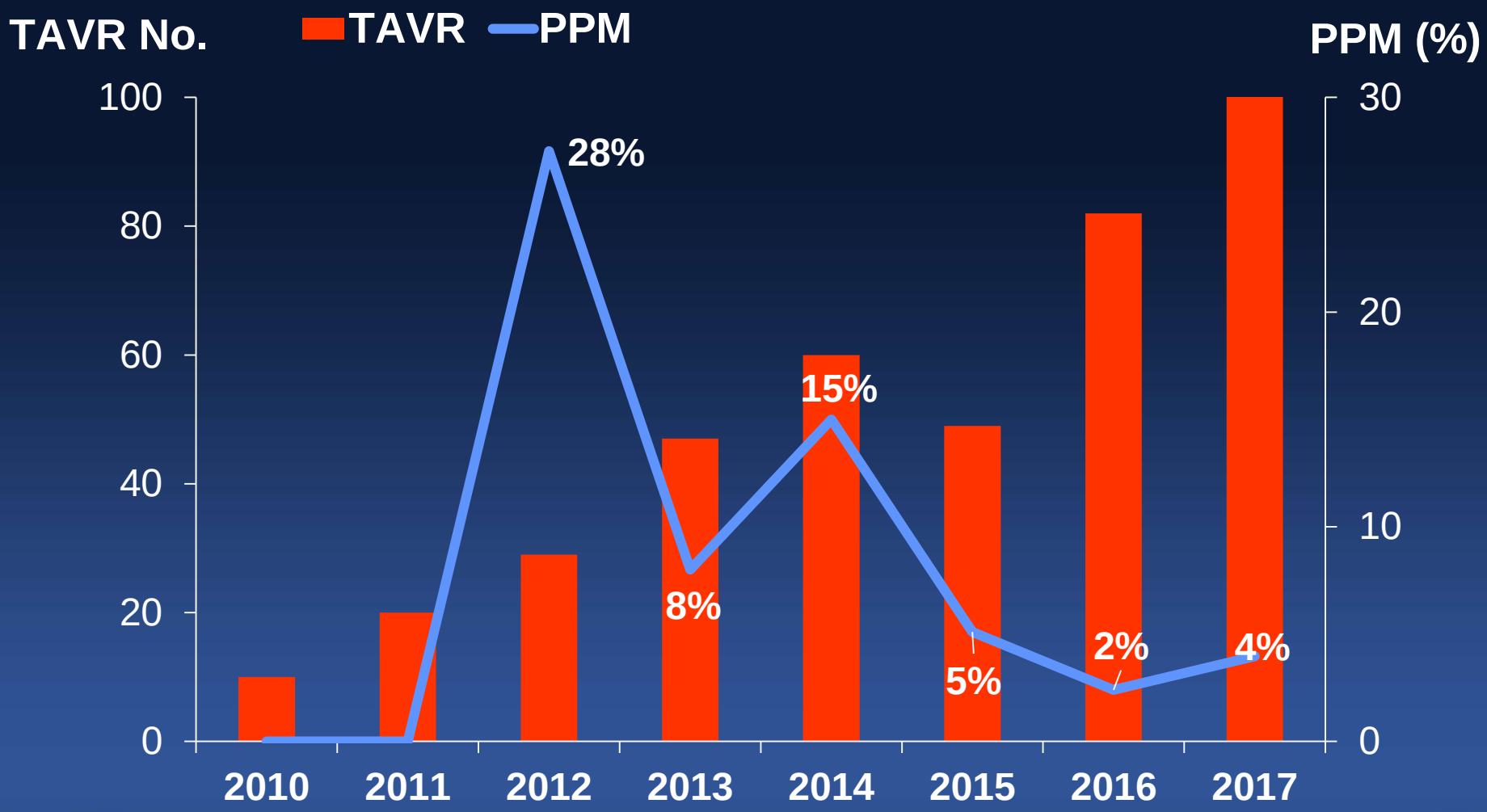


Rigueiro, A, et al. Circ Cardiovas Interv 2016;9:e003635

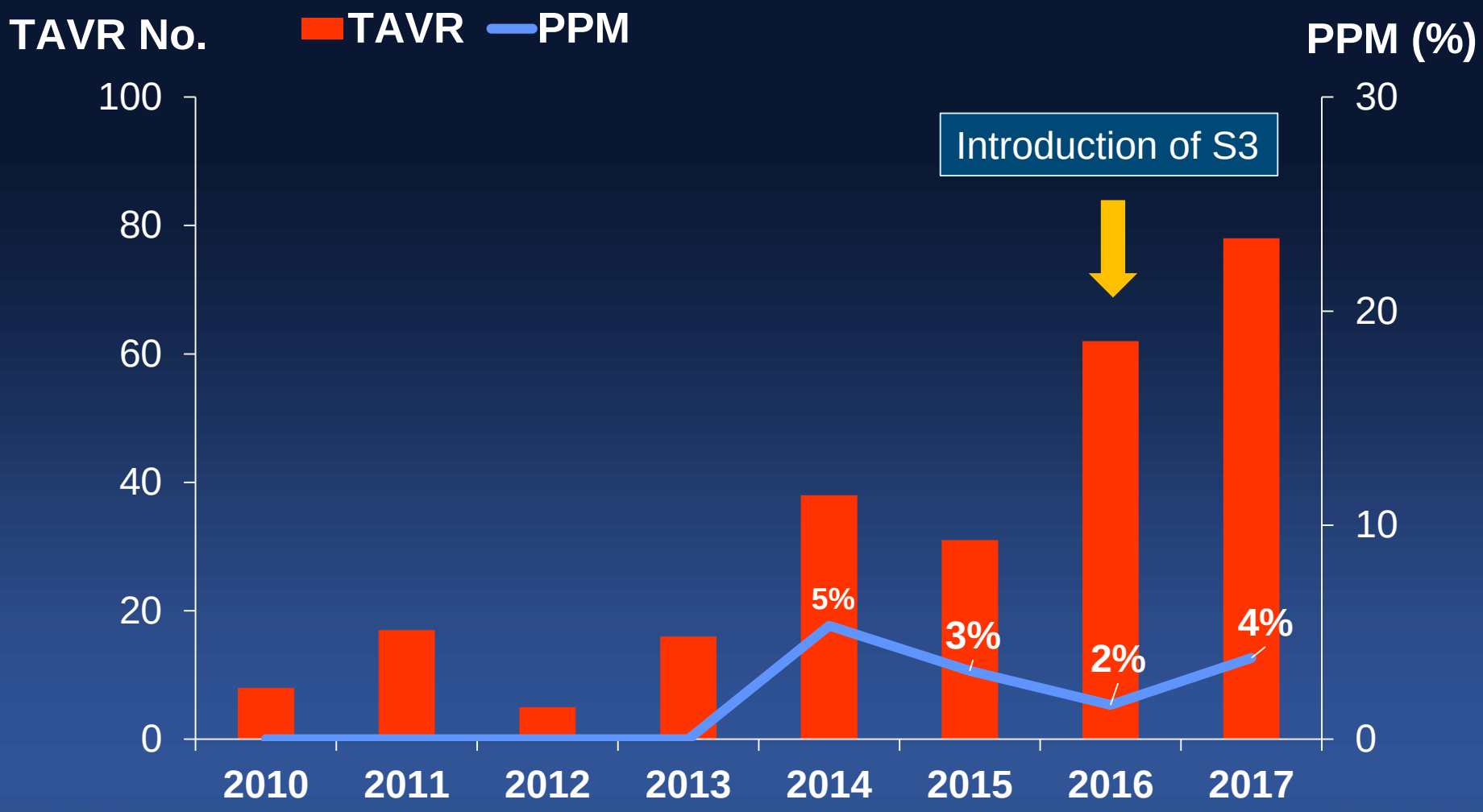
Annual Volume of TAVR in AMC



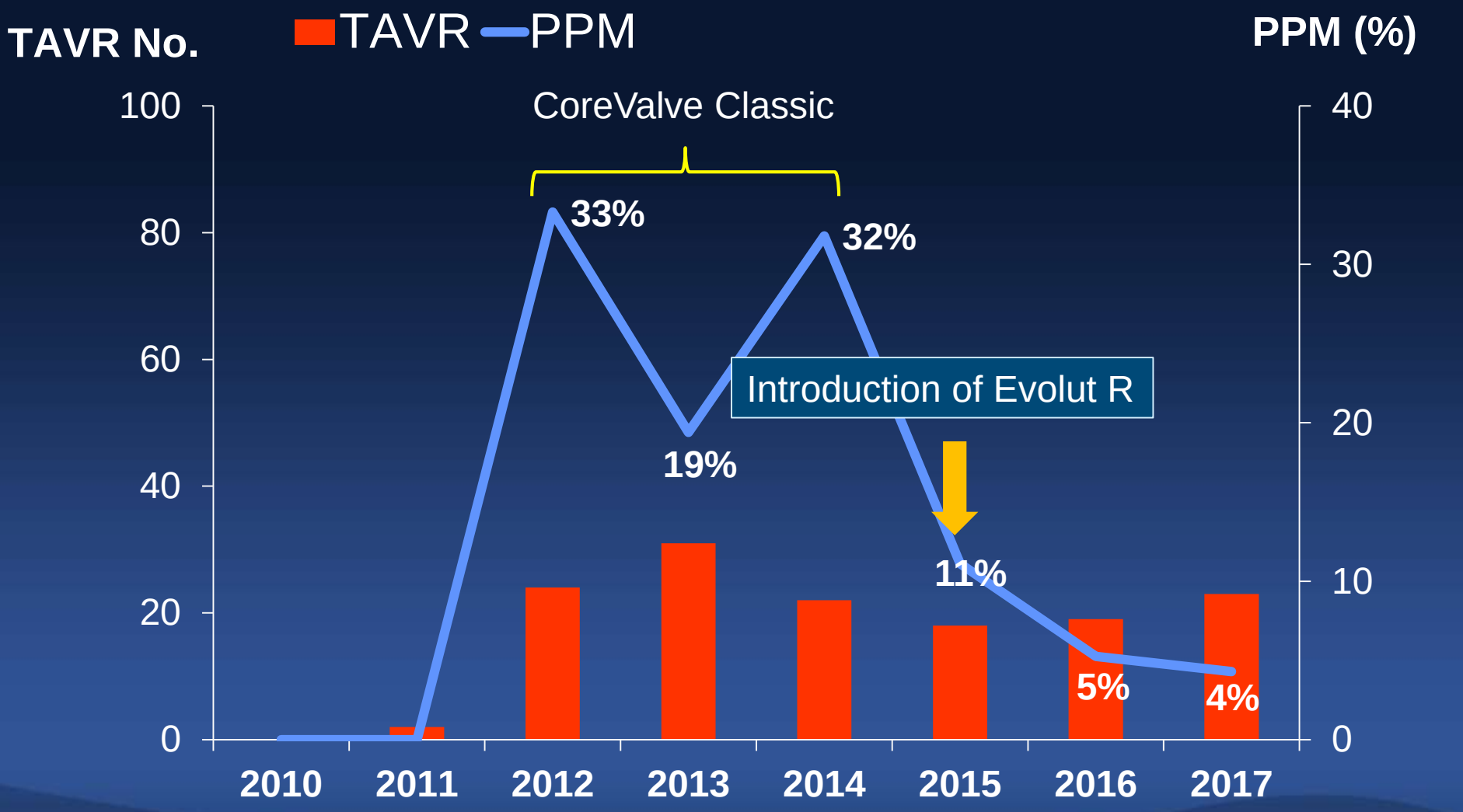
PPM After TAVR in AMC



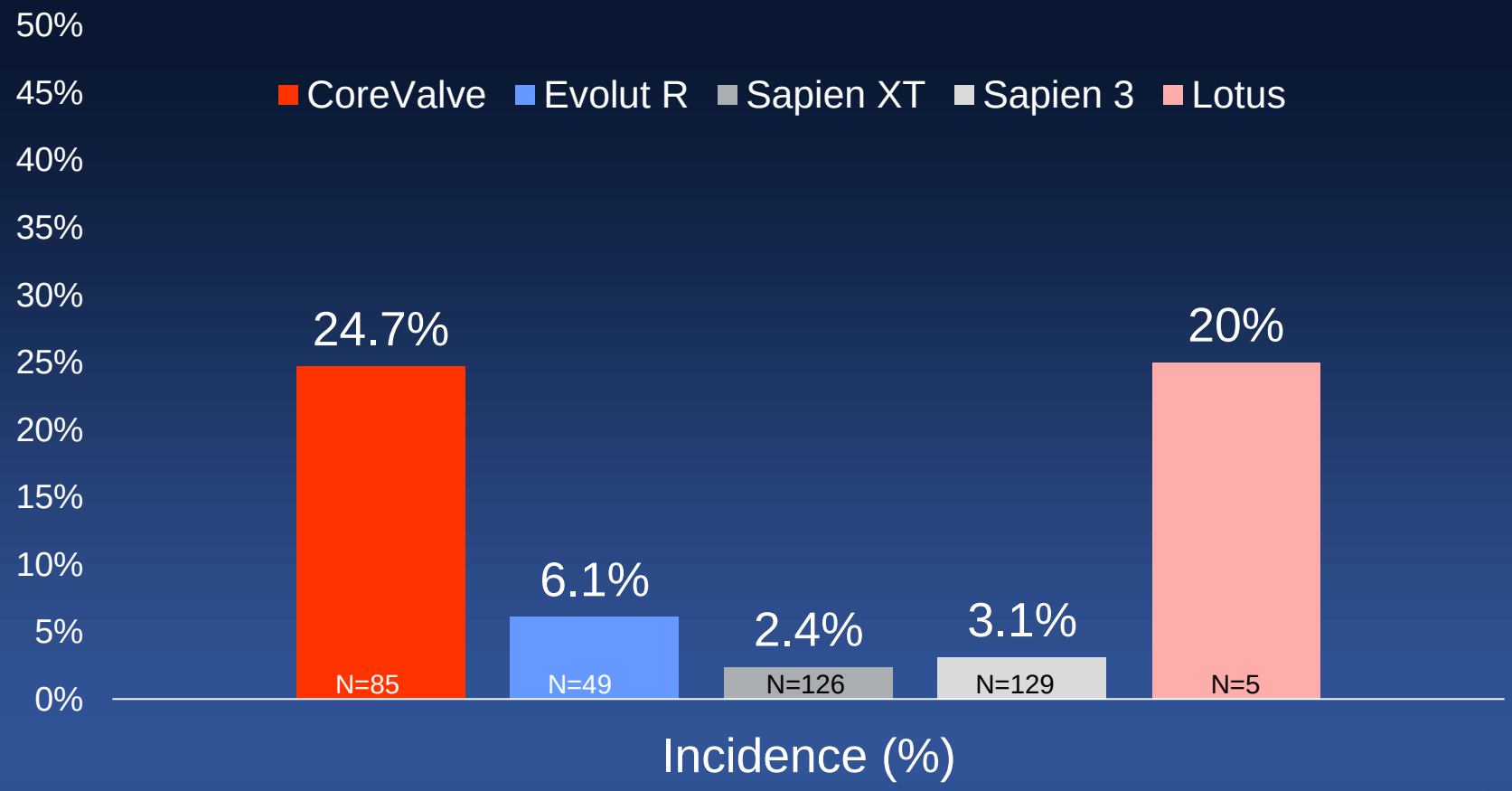
Balloon-Expandable Valve and PPM



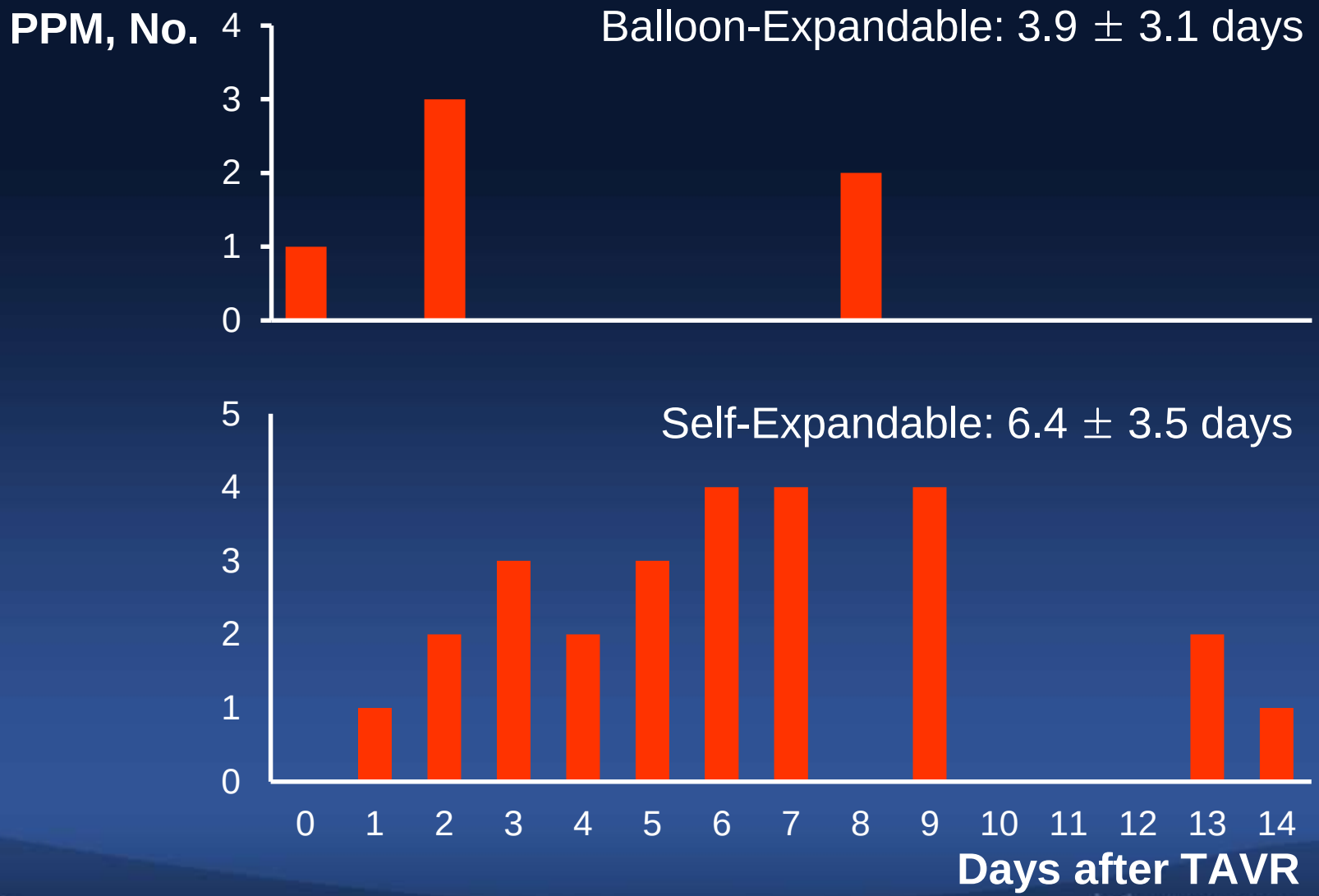
Self-Expandable Valve and PPM



Incidence of PPM



Days Between TAVR and PPM

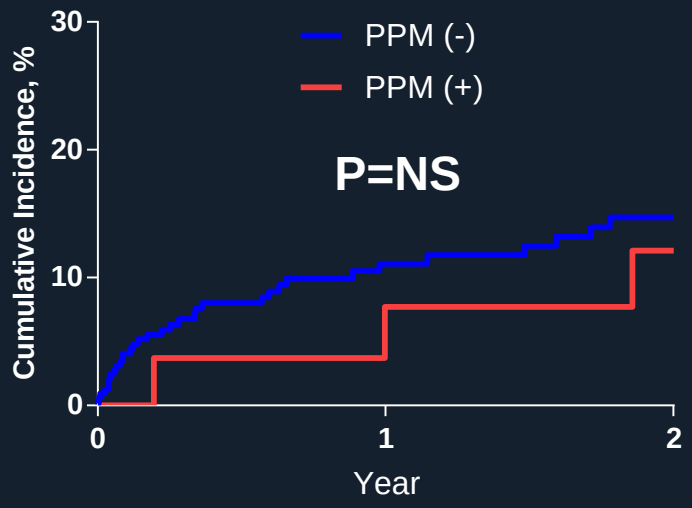


Independent Predictors of PPM

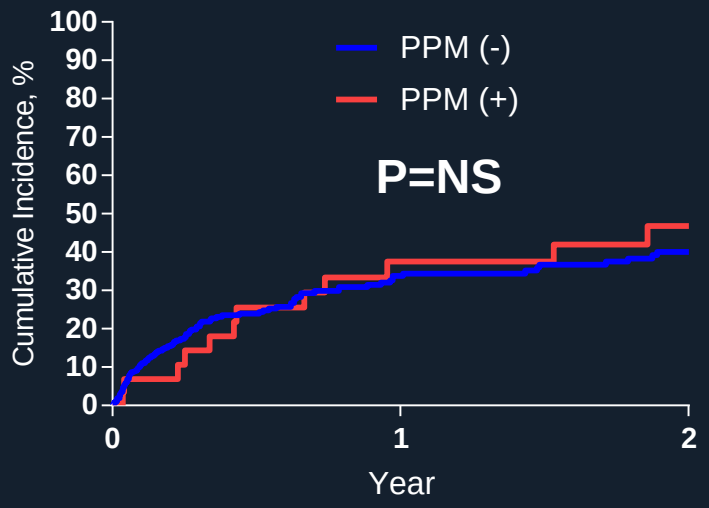
- RBBB at Baseline: HR 5.0 (2.1-12.1), P<0.001
- NYHA III or IV: HR 2.2 (1.0-4.9), P=0.044
- Balloon Expandable: HR 0.12 (0.04-0.29), P<0.001

Clinical Impact of PPM

- **Overall Mortality**



- **Rehospitalization**



How To Avoid PPM in TAVR?

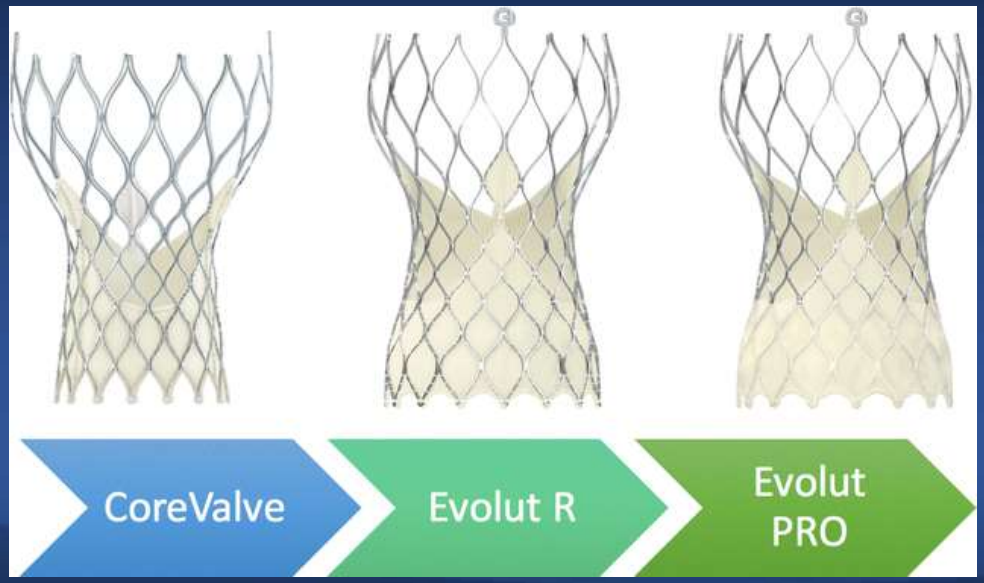
- Conduction disturbances, LBBB and PPM, are a frequent complication of TAVR
- Be aware of risk factors (i.e, older age, baseline RBBB, severe calcification, membranous septum length, and procedural factors).
- Careful attention to modifiable predictors (i.e. device selection, oversizing, depth of implantation, and BAV).
- Optimal device selection and strategies to minimize PPM implantation, particularly for the indication extension toward younger population.

Device Advancement for PVL Reduction : “Sealing Skirt”

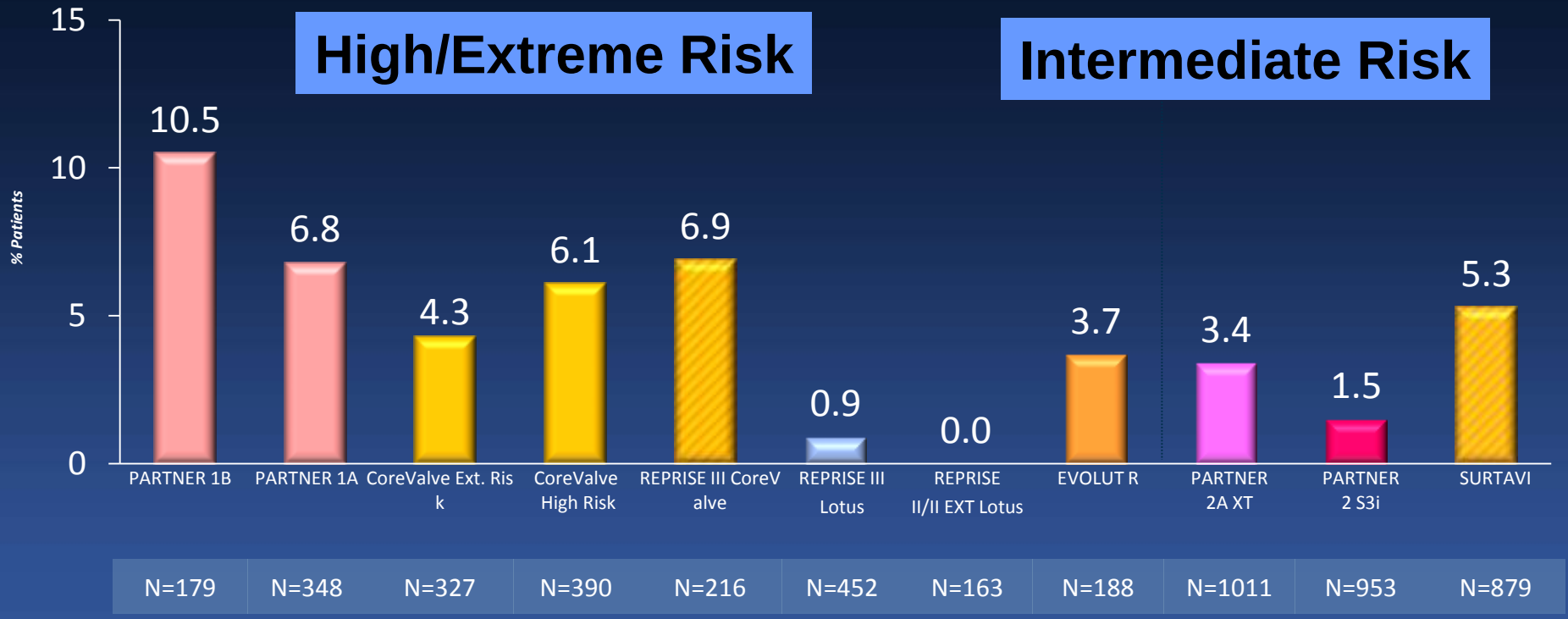
SAPIEN XT

Skirt to Prevent Paravalvular Leakage

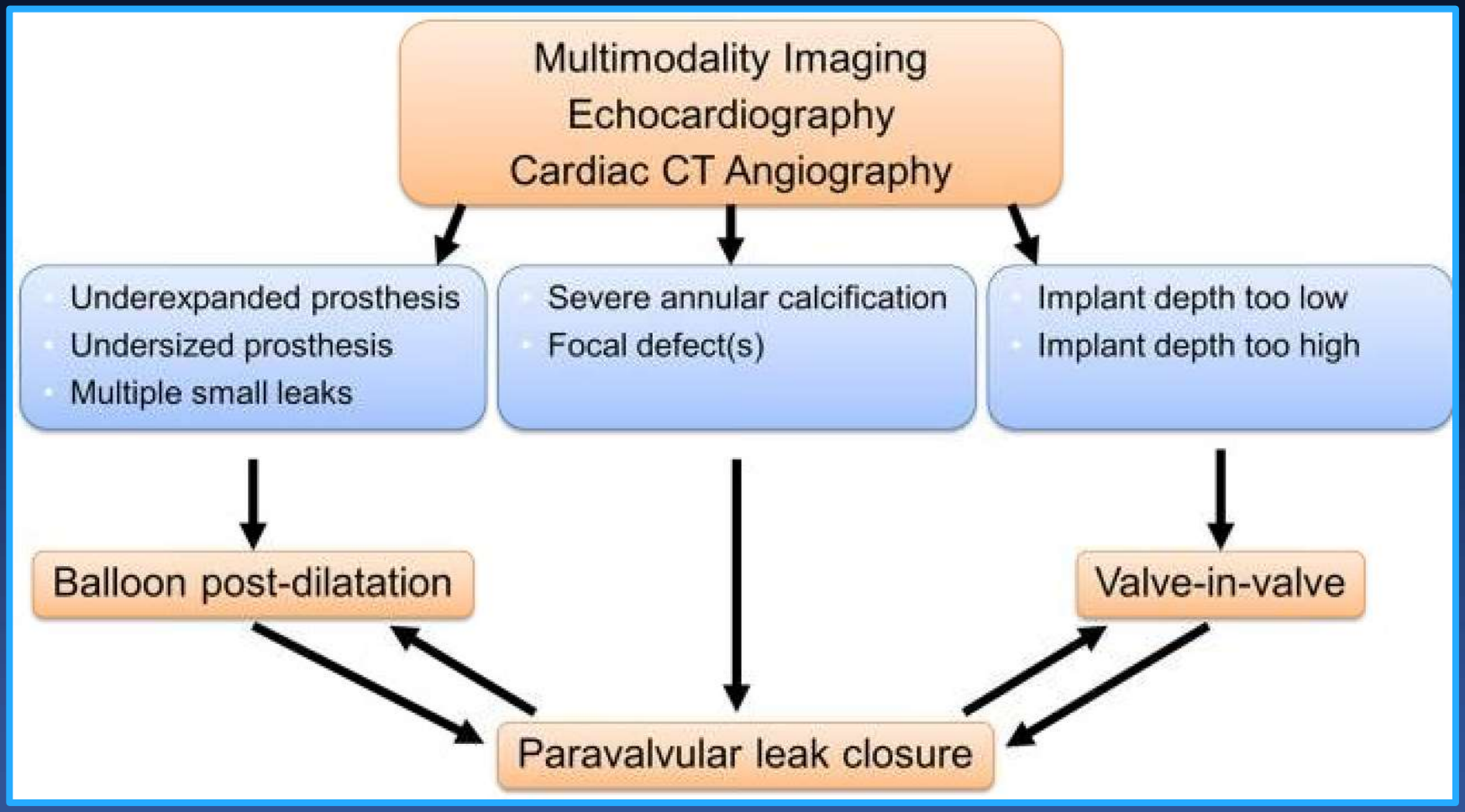
SAPIEN 3



Moderate/Severe PVL to 1 Year
TAVR Clinical Trials



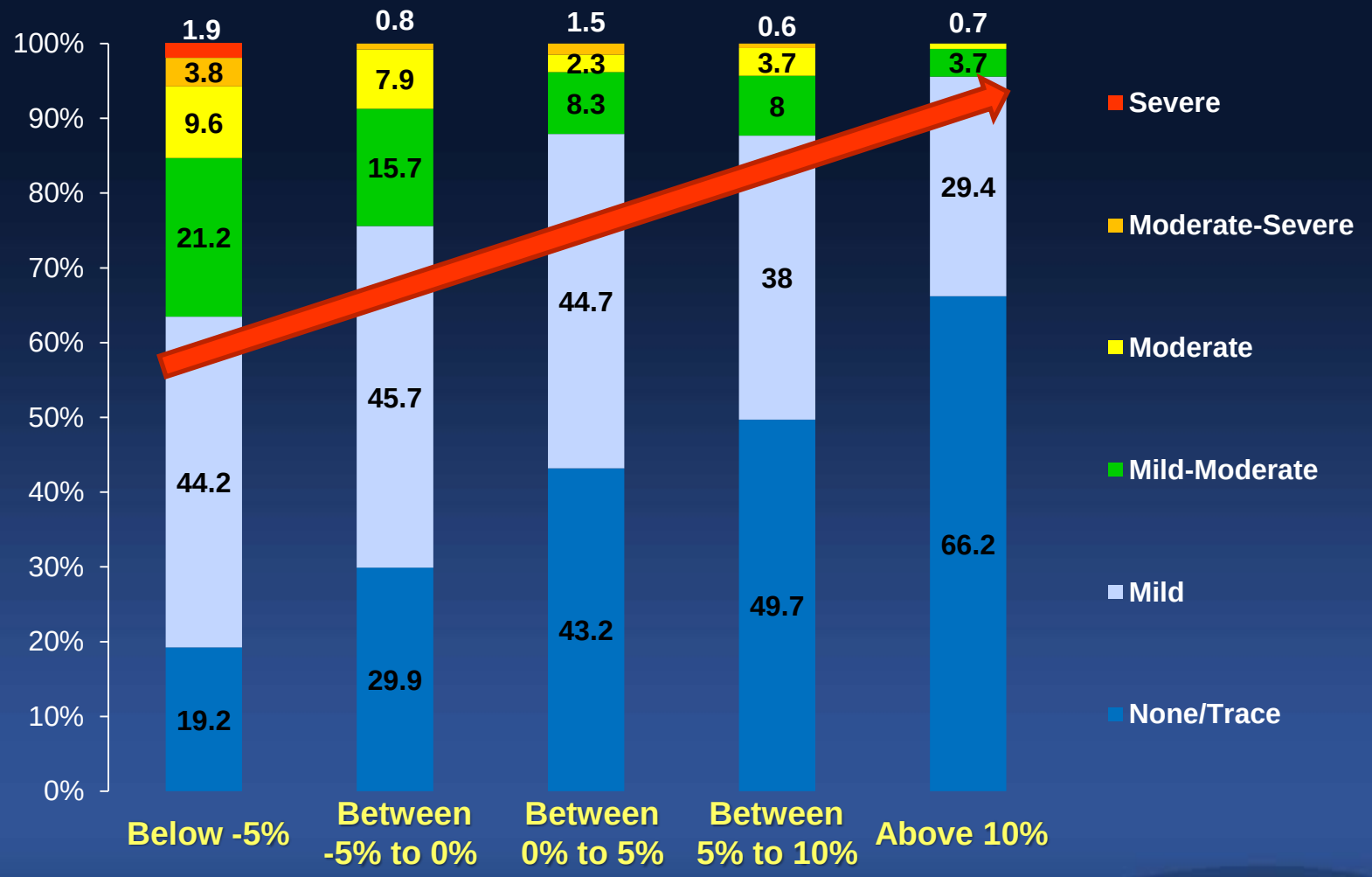
PVL Mechanism and Management



Waterbury TM, et al.. *Catheter Cardiovasc Interv*. 2017;90:870–877

Paravalvular Leak by Area Oversizing

Data from PARTNER trial

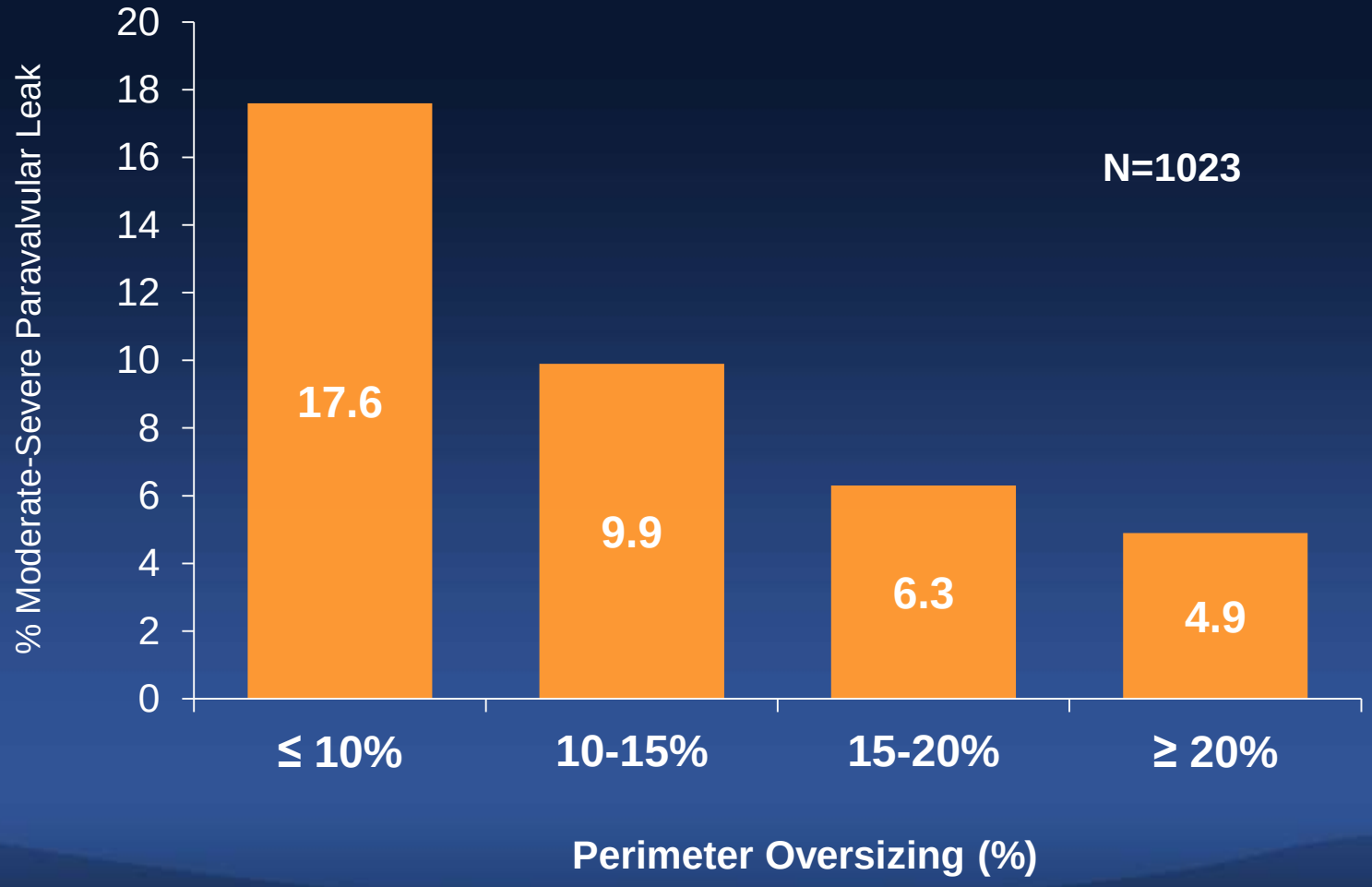


No annular rupture

Perimeter Oversizing and Paravalvular Leak

Data from CoreValve US Clinical Trials

Moderate-Severe Paravalvular Leak



Optimal Target for Area Oversizing : SAPIEN 3

PVL

Optimal

Annulus Rupture

PPM

AMC S3 Sizing Algorithm: Minimizing PVL and PPM Insertion

Based on the CT Assessment

Severe AS with Tricuspid	*10~15% Area Oversizing*
Heavy Calcification (Ca volume > 400 mm3)	5% Lesser Oversizing
Sinus of Valsalva to Annulus Area ratio < 1.5 & Coronary Height <10mn	5% Lesser Oversizing (or Self-Expandable Valve)
Small LVOT with Severe LVOT Calcification	Consider Lesser Oversizing

Adjusting S3 Size by Balloon Volume

TAVR in Perspective

Reduction in Complications

Standard Performance (VARC-2) for High-Risk AS patients (@ 30 days)*		*AMC 2017*
• All-cause mortality	< 3%	1.0%
• Major (disabling) strokes	< 2%	0%
• Major vascular complications	< 5%	1.0%
• New permanent pacemakers	< 10%	**4.0%**
• Mod-severe PVR	< 5%	**4.0%**

** VARC; The Vascular Academic Research Consortium*

PVL in TAVR

- Given current technology iterations, sizing using CTA, and technique optimization - PVL after TAVR is becoming less of an issue
- Pre-TAVR multimodality imaging (CT and echocardiography) provide a wealth of anatomical data that can optimize case selection, procedural safety, and outcomes.
- Definitely, pre-TAVR fine-tuning for valve sizing and post-TAVR balloon dilation on the basis of CT algorithm may be best option to minimize PVL.

Thank You !!

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