Transcatheter Aortic Valve Replacement in Bicuspid Aortic Valve Stenosis

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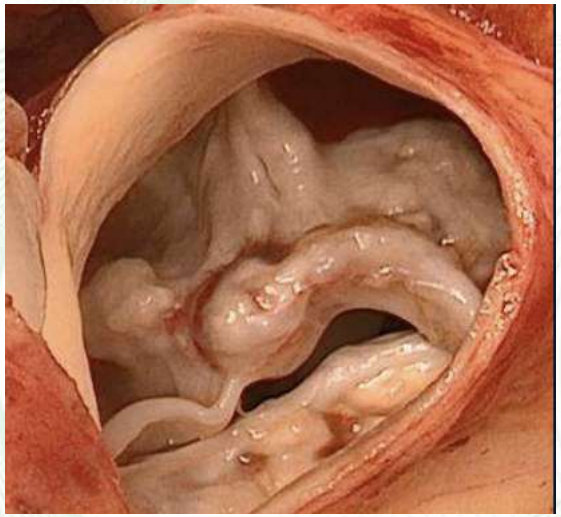
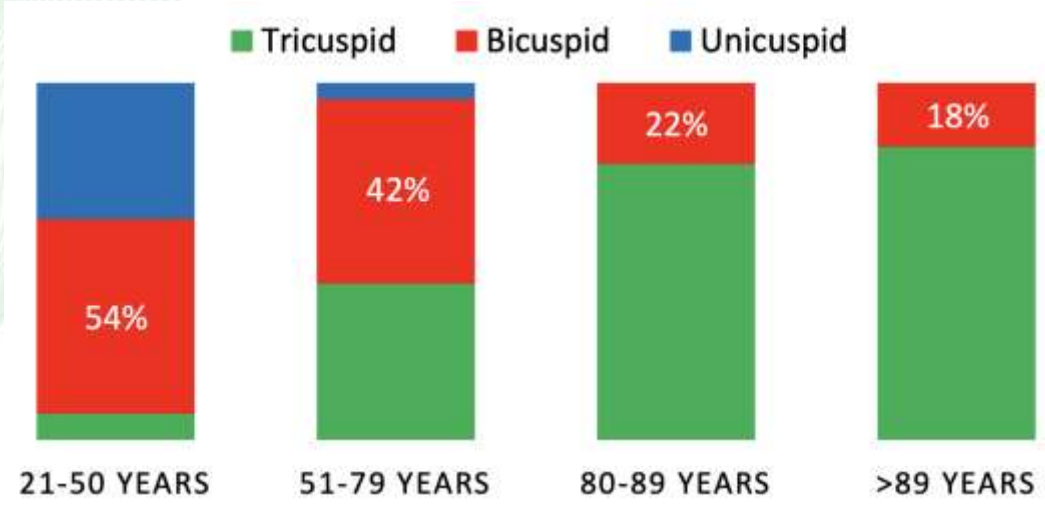
Prevalence of Bicuspid Aortic Valve Disease

- Bicuspid Aortic Valve disease (BAV) is a congenital defect affecting 1 to 2.0% of general population, 2 to 4 times more frequent in men (Tzemos et al. JAMA 2008; 300:1317-25.)
- Could be an heritable condition – mutation of gene NOTCH1 (Garg et al. Nature 2005; 437: 270-4)
- High Frequency in patients having sAVR (62% < 70y / 38% > 80y) (Roberts et al. Circulation 2005; 111: 920-5)
- Concominant aortopathy, seen in 20% to 84% of patients with BAV (Verma S, Siu SC. N Engl J Med. 2014;370(20):1920-1929)

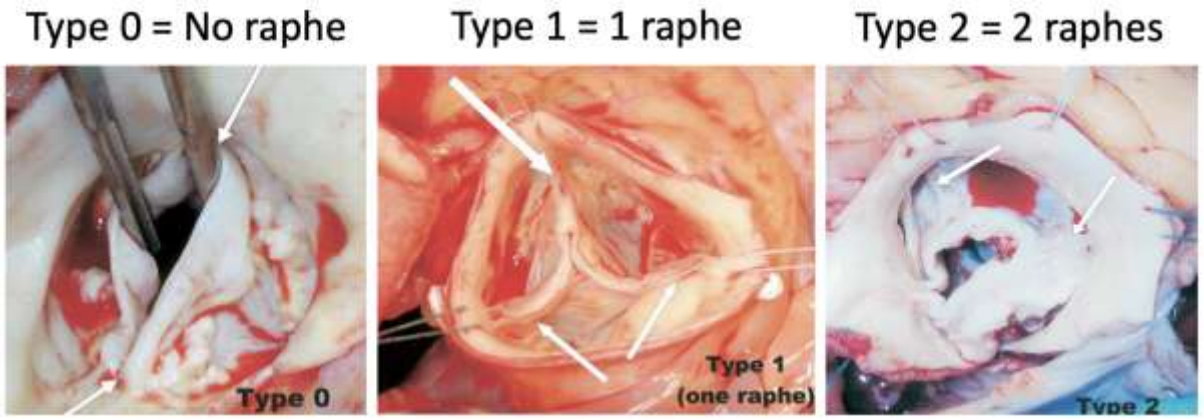


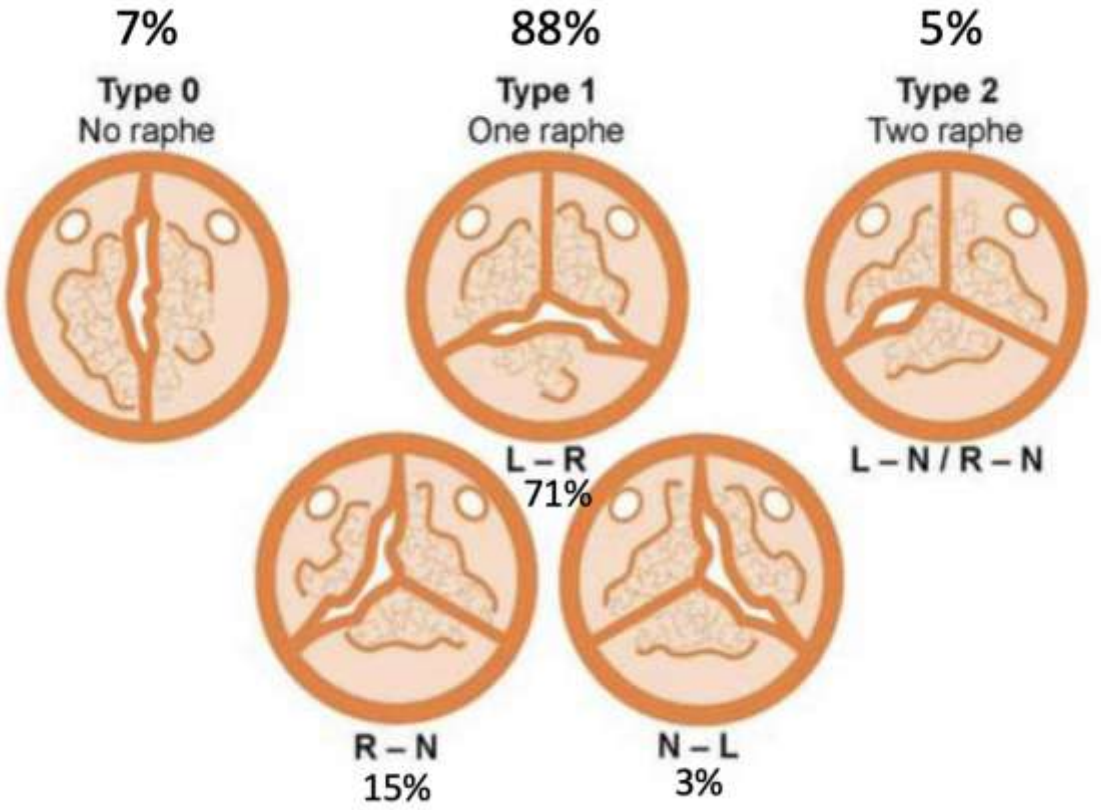


Roberts et al. AJC 2012; 109:1632-6

Sievers Classification of BAV

- Two leaflets of unequal size
- RL fusiun pattern is the most common form





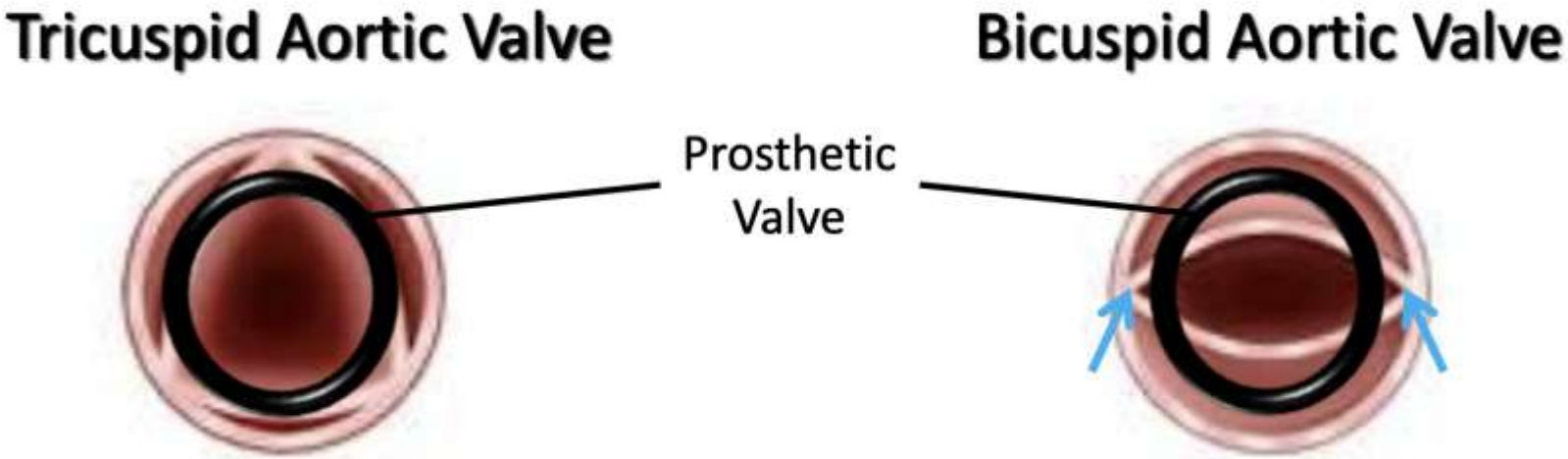
Sievers & Schmidtke. J Thorac Cardiovasc Surg 2007; 133:1266-33

Bicuspid Valve Anatomy: Challenges for TAVR

- Asymmetric Calcium
  - Most commonly fused raphe is asymmetrically calcified. Can cause valve to tilt or push lower during deployment
  - Increased risk of PVL?
- High calcium burden
  - Calcium in Bicuspid valve is metaplastic. “Senile” calcification is dysplastic/dystrophic.
  - Increased risk for stroke, pacemaker and root rupture?
- Elliptical annulus
  - More of an issue with Type 0 valves. New studies have shown Type I valves are less elliptical than we thought.
  - Larger annulus and valve sizes.
- Aortic aneurysm prevalence: 30-40%

Saad M et al., Front Cardiovasc Med. 2021 Apr 13;8:654554.

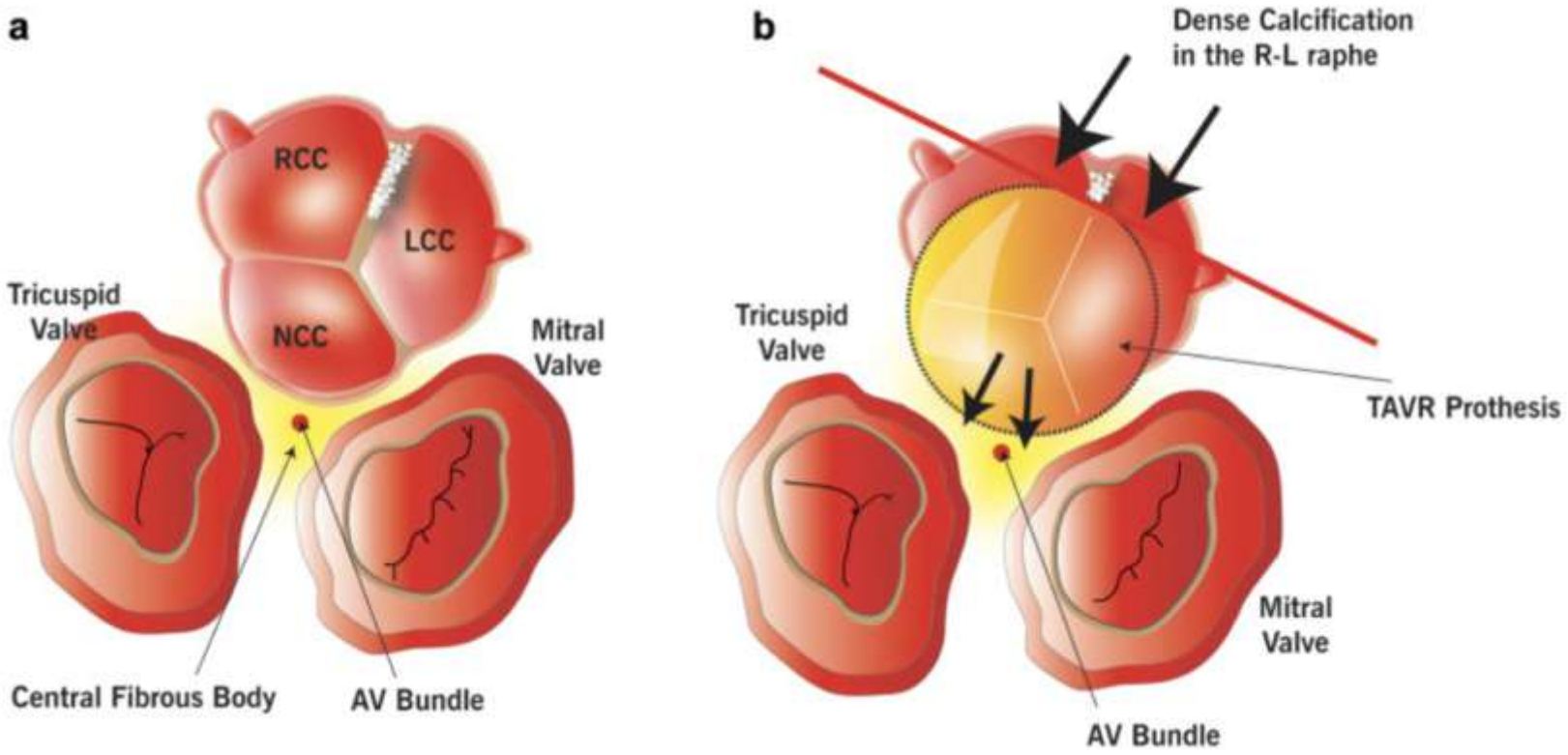
Increased risk of paravalvular leak and other complications related to irregular expansion of the prosthetic valve



Existing data with 1st generation valves indicates a higher postTAVI rate of moderate/severe PVL among patients with bicuspid valves (25%) compared with tricuspid valves (15%; P=0.05)

Guyton RA. J Am Coll Cardiol Intv 2016;9(8):825-827. Bauer T, et a;l. Am J Cardiol 2014;113(3):518-521. Image adapted from Valley Heart and Vasculature (an affiliate of Cleveland Clinic Heart and Vascular Institute), http://valleyheartandvascular.com/thoracic-aneurysm-program/bicuspid-aortic-valve-(bav).aspx.

Potential mechanism of higher rate of pacemaker in BAV



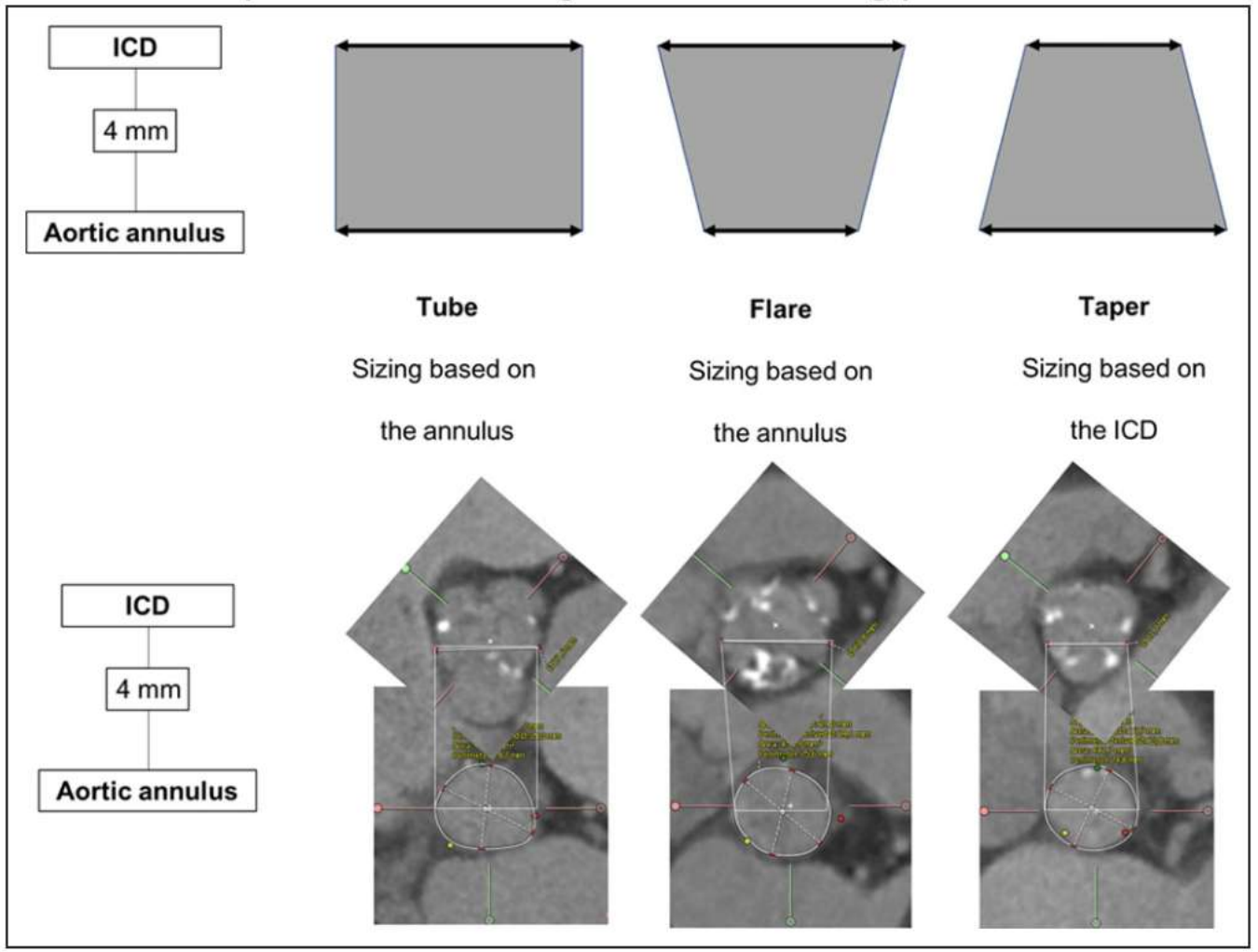
(a) Aortic valve complex in a BAV Sievers 1 configuration with R-L fusion with calcium. (b) The asymmetrical TAVR expansion resulting from resistant calcific raphe and leaflet fusion may compress the non-coronary cusp toward the conduction fiber pathway along the central fibrous body.

A. Kalra et al. Structural Heart 8 (2024) 100227

Annulus-based sizing was applicable to 88% of our BAV patients

Conclusions:

Second-generation prostheses similarly reshape the aortic annulus in TAV and BAV. Prostheses keep consistent diameters from distal edge to 12 mm in TAV and BAV. Prosthesis underexpansion is constantly observed in BAV. Annular-based sizing is accurate in BAV with minimal oversizing. The intercommissural distance, 4 mm above the annulus, could be integrated in gray zones.



Tchetche et al. Circulation: Cardiovascular Interventions 2019

Circulation
Volume 141, Issue 13, 31 March 2020; Pages 1071-1079
https://doi.org/10.1161/CIRCULATIONAHA.119.040333

American Heart Association.

ORIGINAL RESEARCH ARTICLE

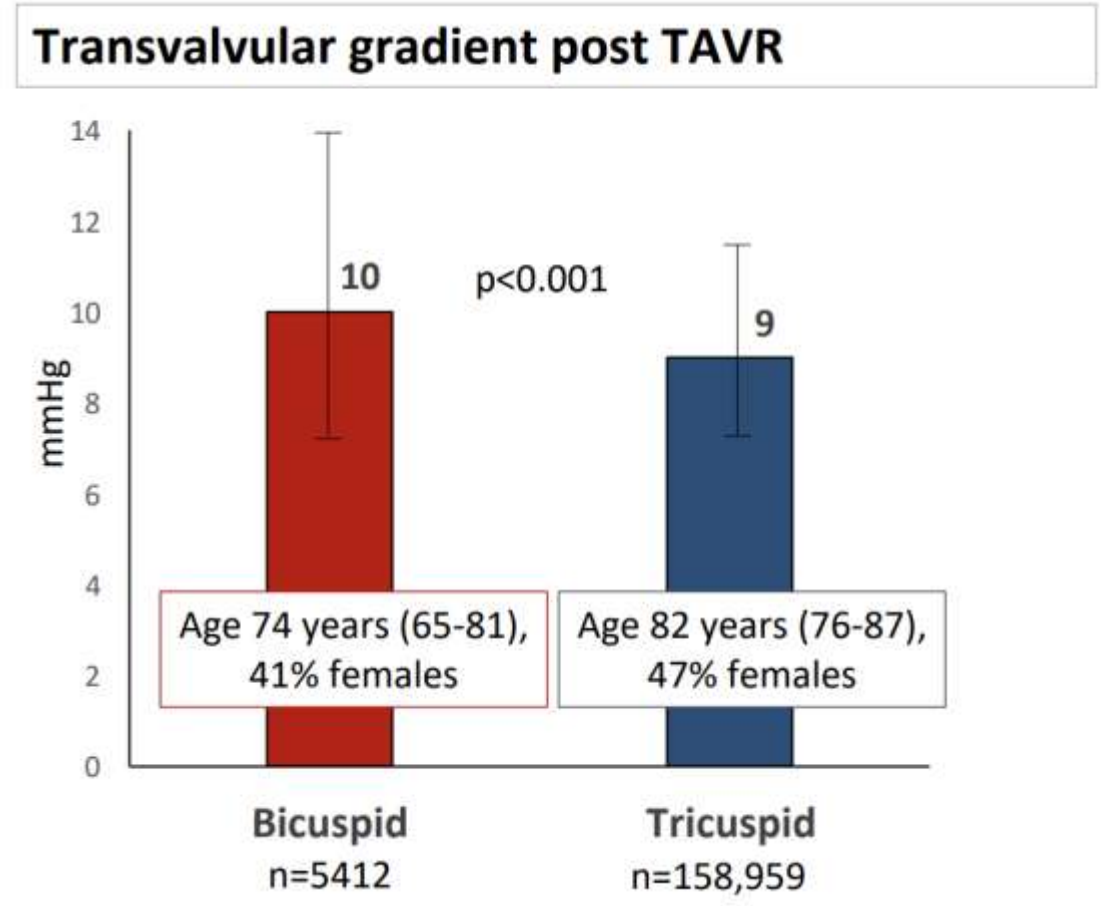
Outcomes of Transcatheter Aortic Valve Replacement in Patients With Bicuspid Aortic Valve Disease

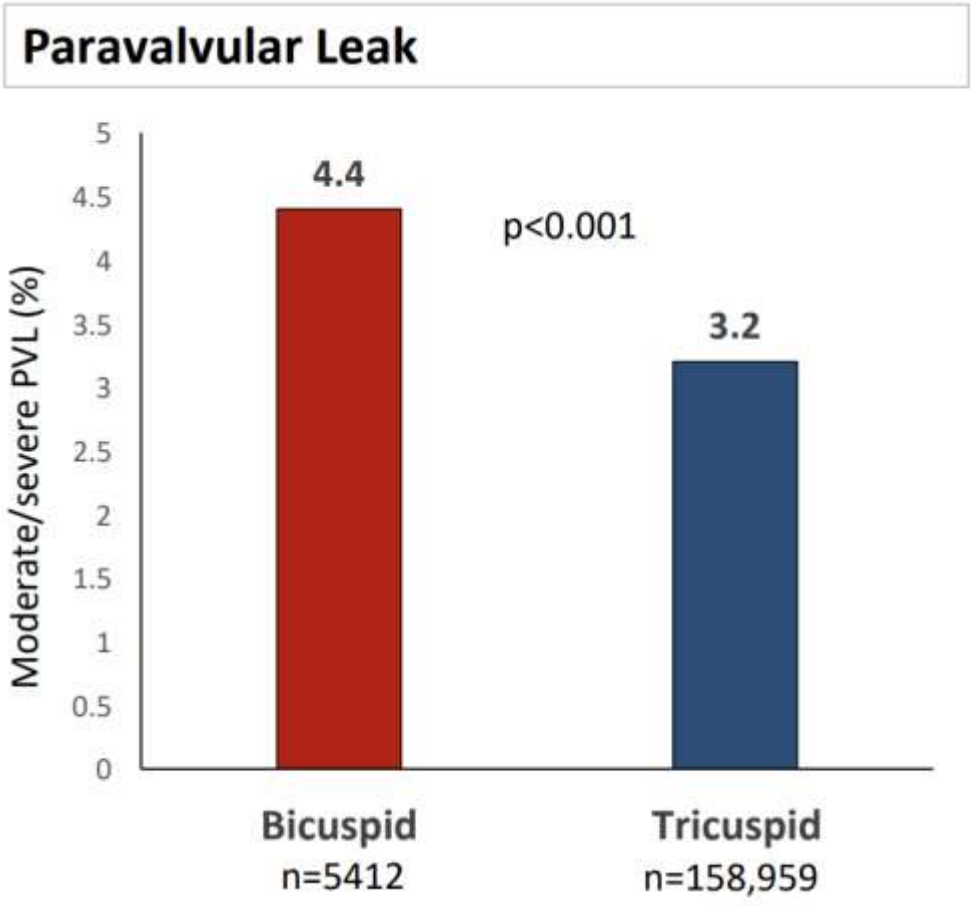
A Report From the Society of Thoracic Surgeons/American College of Cardiology Transcatheter Valve Therapy Registry

(November 2011 through November 2018)

Periprocedural complications of TAVR in bicuspid aortic stenosis

STS/ACC/TVT Registry 2011-2018

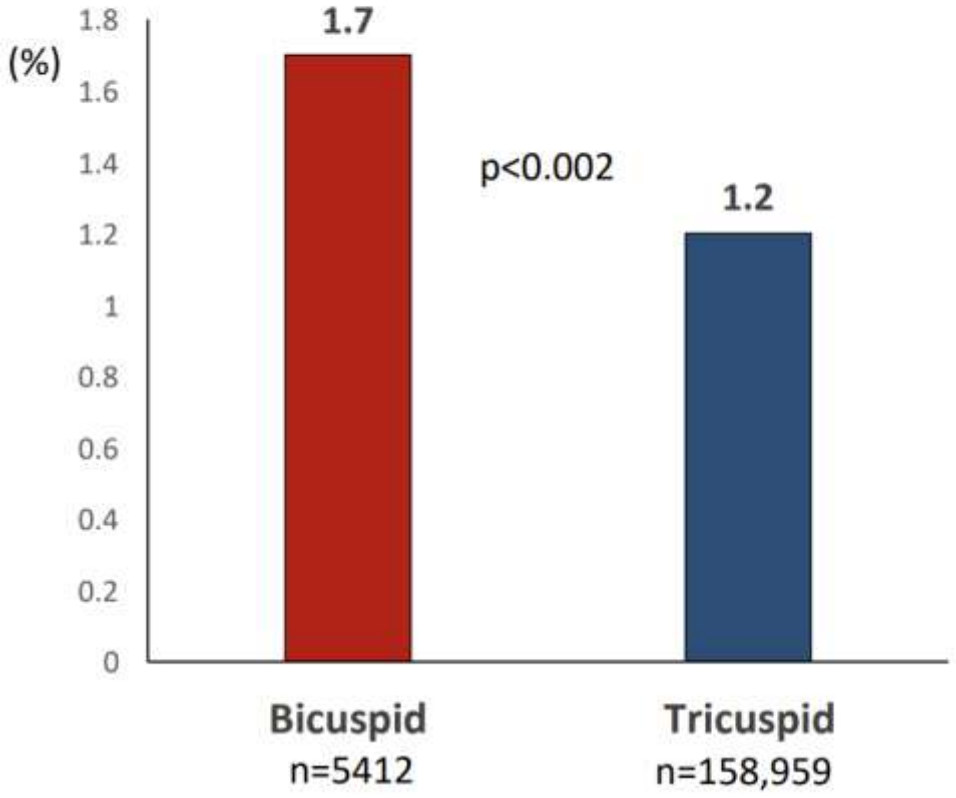




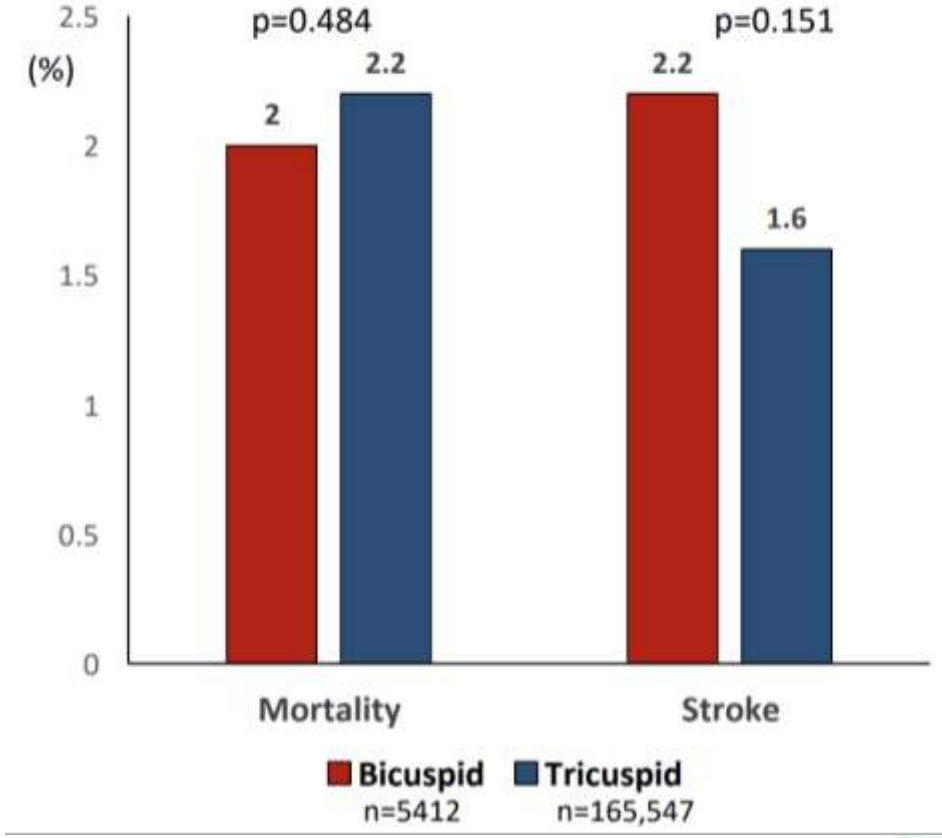
Halim SA, Circulation 2020;141(13):1071-1079

Periprocedural complications of TAVR in bicuspid aortic stenosis

Implantation of a second valve
STS/ACC/TVT Registry 2011-2018



In-hospital outcomes
STS/ACC/TVT Registry 2011-2018



Halim SA, Circulation 2020;141(13):1071-1079;

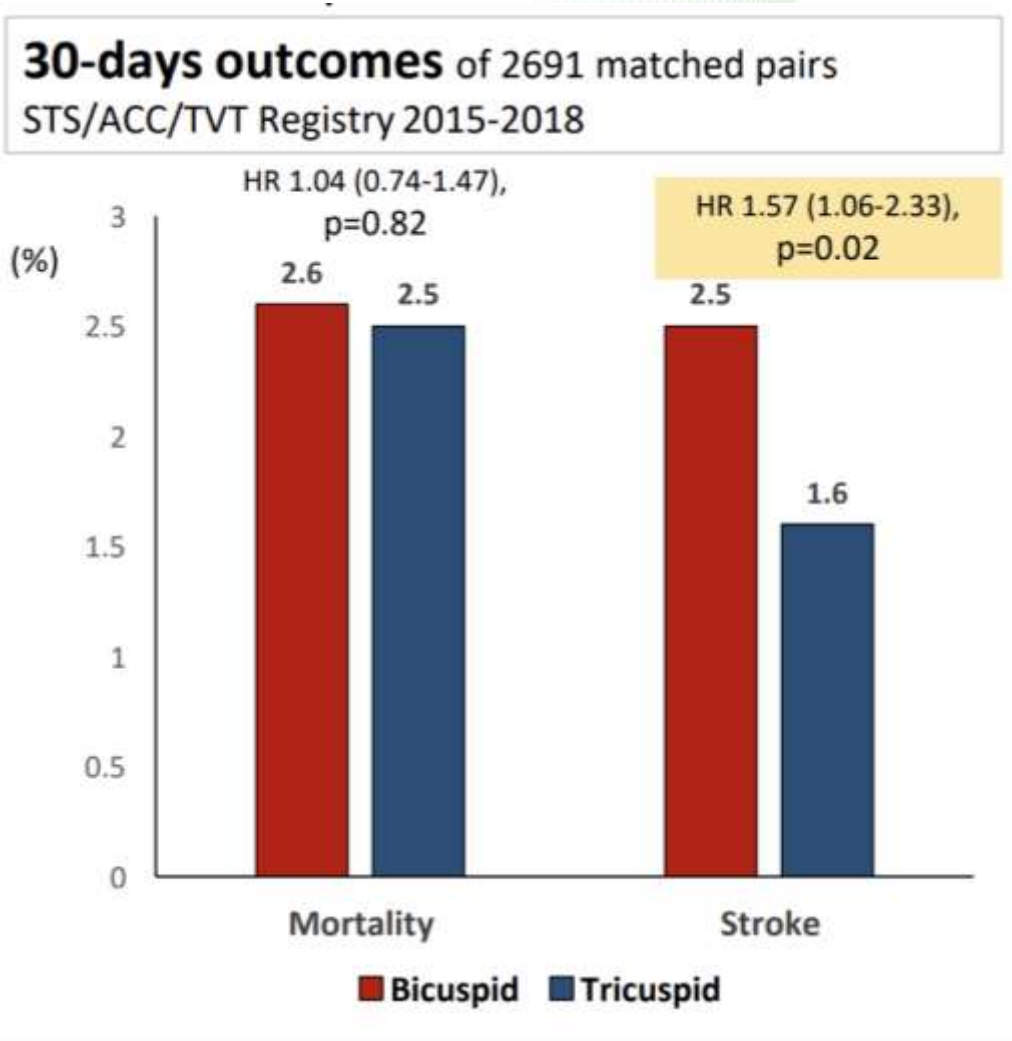
June 11, 2019

Association Between Transcatheter Aortic Valve Replacement for Bicuspid vs Tricuspid Aortic Stenosis and Mortality or Stroke

Raj R. Makkar, MD[1]; Sung-Han Yoon, MD[1]; Martin B. Leon, MD[2]; et al

» Author Affiliations | Article Information

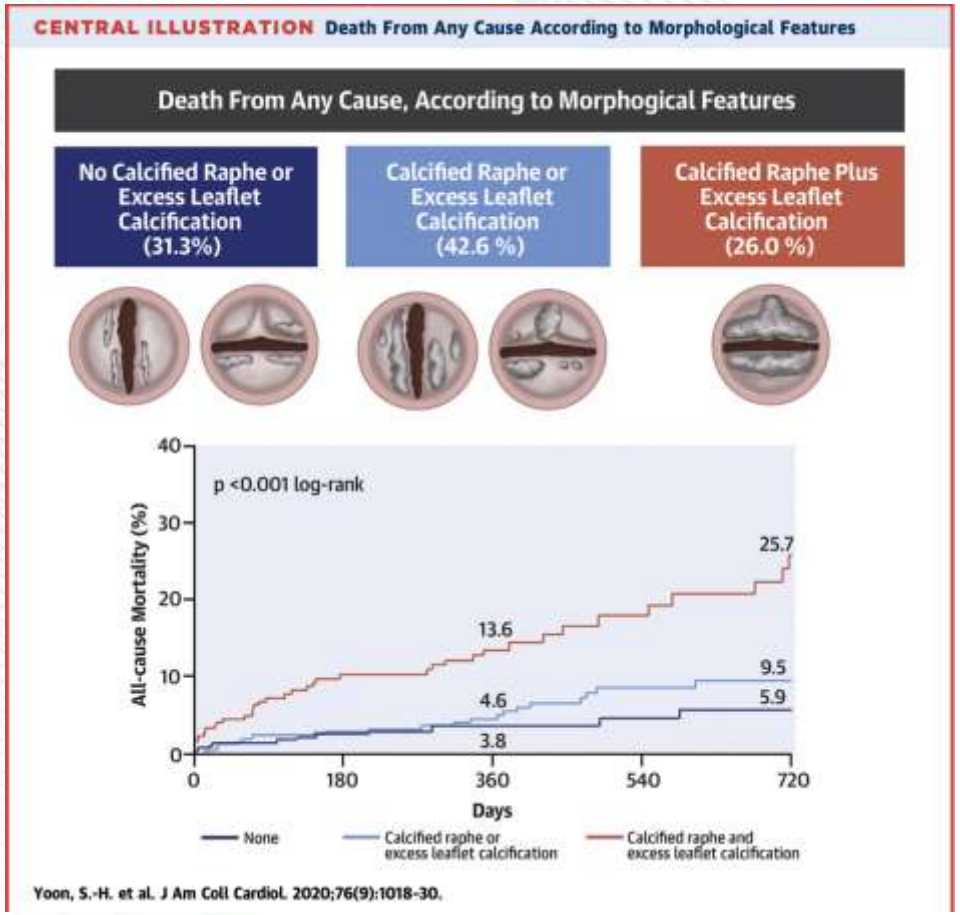
JAMA. 2019;321(22):2193-2202. doi:10.1001/jama.2019.7108



Makkar RR et al, JAMA. 2019 Jun 11;321(22):2193-2202

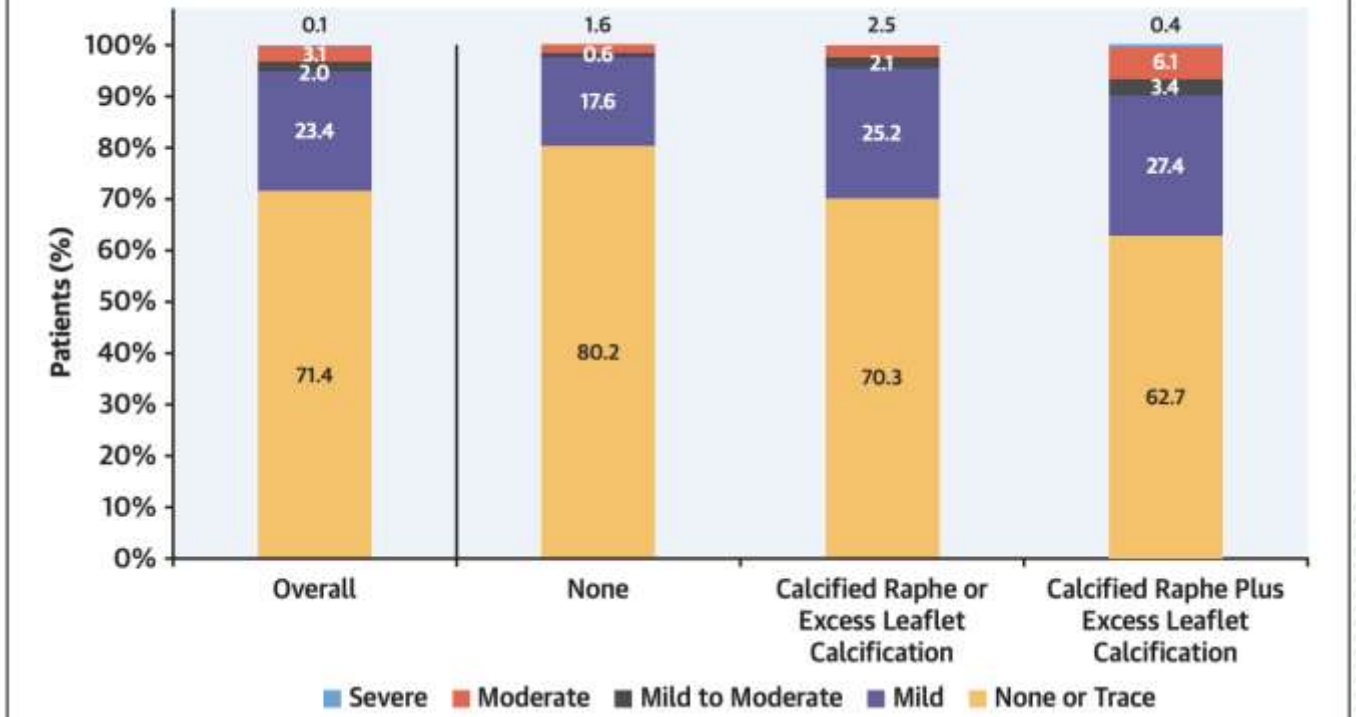
Bicuspid Aortic Valve Morphology and Outcomes After Transcatheter Aortic Valve Replacement

CENTRAL ILLUSTRATION Death From Any Cause According to Morphological Features



Yoon, S.-H. et al. J Am Coll Cardiol. 2020;76(9):1018-30.

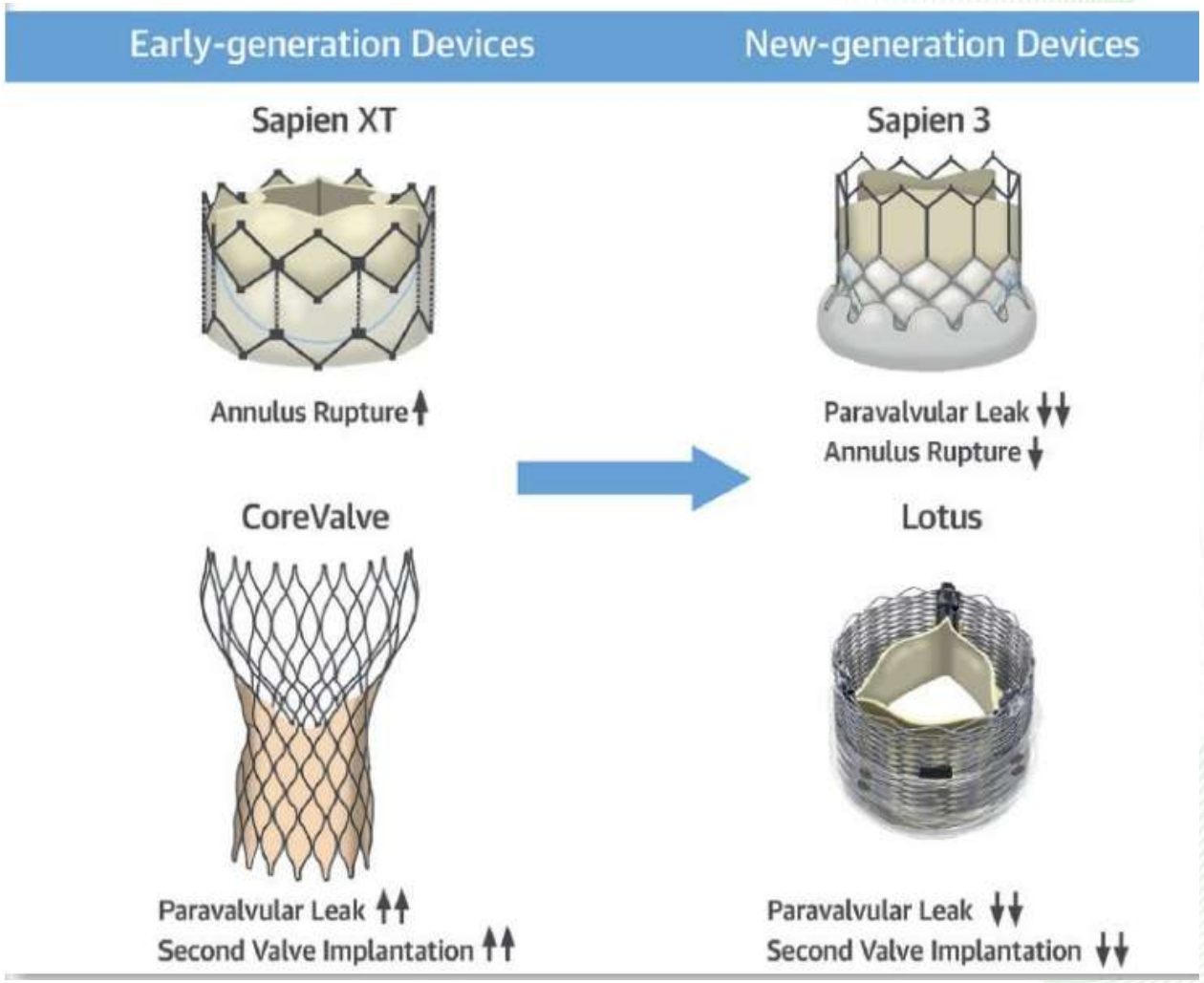
FIGURE 4 Paravalvular Aortic Regurgitation Stratified by Morphological Features



CONCLUSIONS: Outcomes of TAVR in bicuspid aortic stenosis depend on valve morphology. Calcified raphe and excess leaflet calcification were associated with increased risk of procedural complications and midterm mortality.

Yoon, S. et al. J Am Coll Cardiol. 2020 Sep 1;76(9):1018-1030.

Which device?

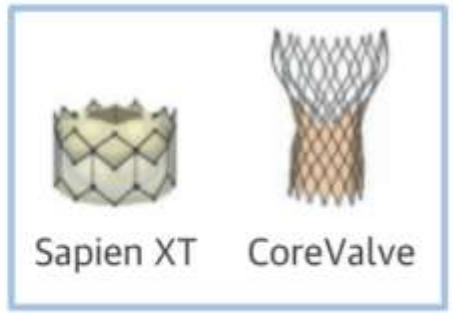


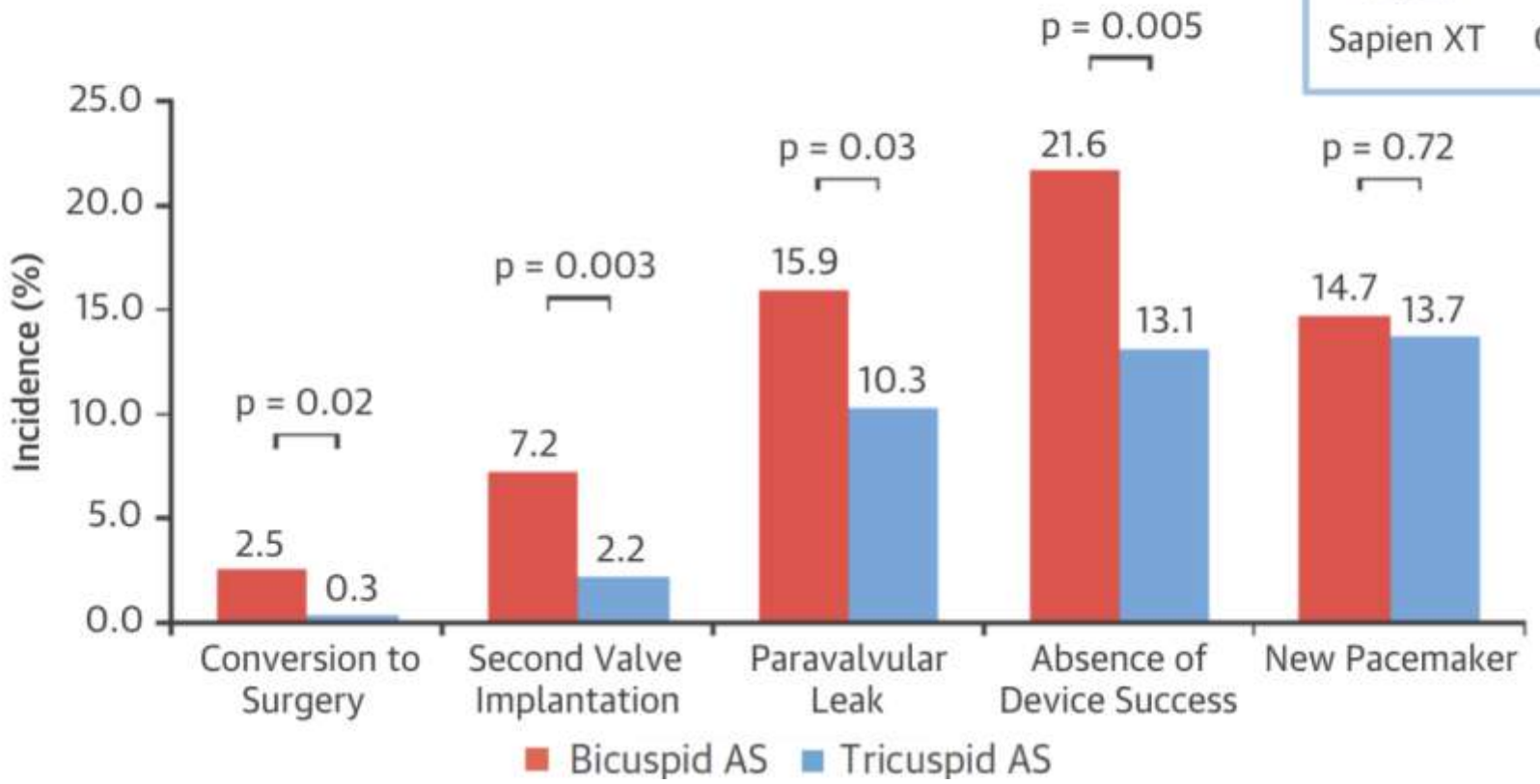
Yoon SH et al JACC. 2017 May, 69 (21) 2579–2589

Early versus newer generation THVs for the treatment of bicuspid AS

Propensity score matched analysis of 546 matched pairs;
320 patients with bicuspid aortic stenosis treated with **early generation devices**

Age 77±8 years,
37% females



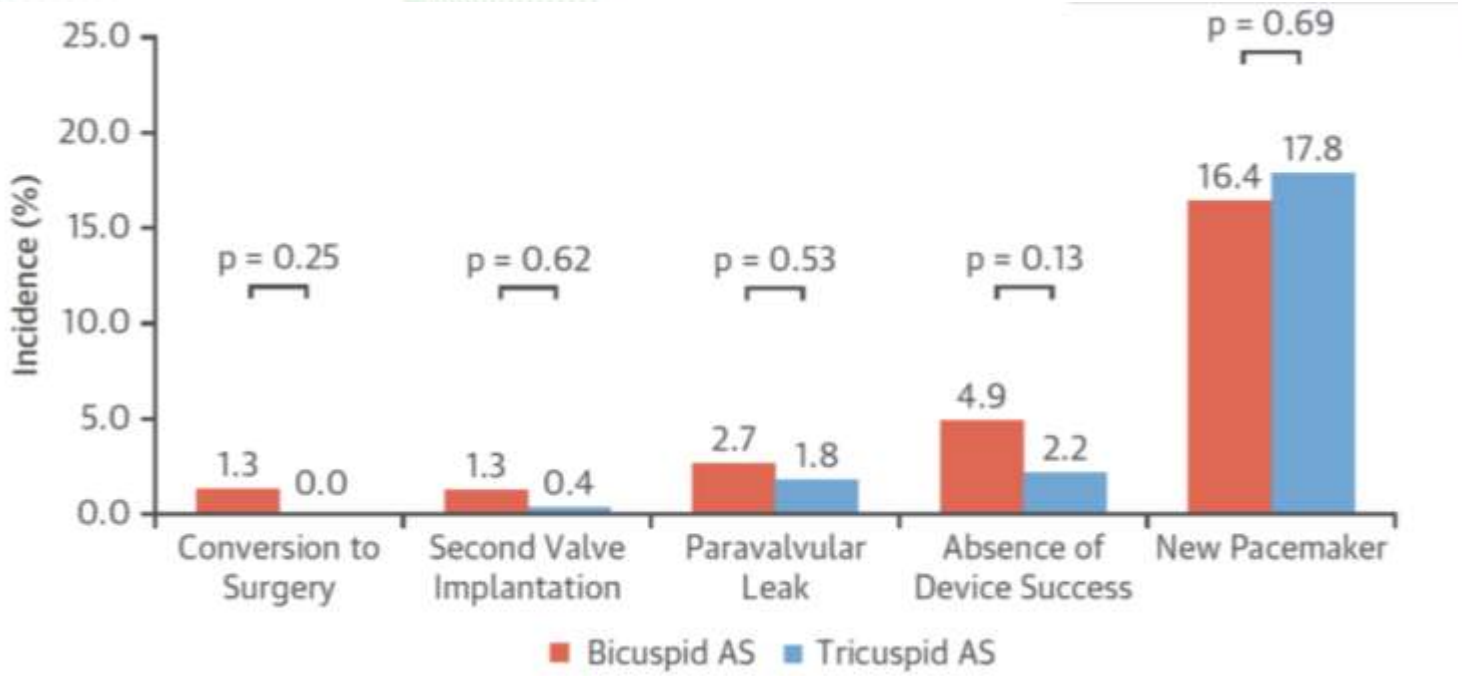


Yoon SH et al JACC. 2017 May, 69 (21) 2579–2589

Early versus newer generation THVs for the treatment of bicuspid AS

Propensity score matched analysis of 546 matched pairs;
226 patients with bicuspid aortic stenosis treated with **newer generation devices**

Age 77±8 years,
37% females

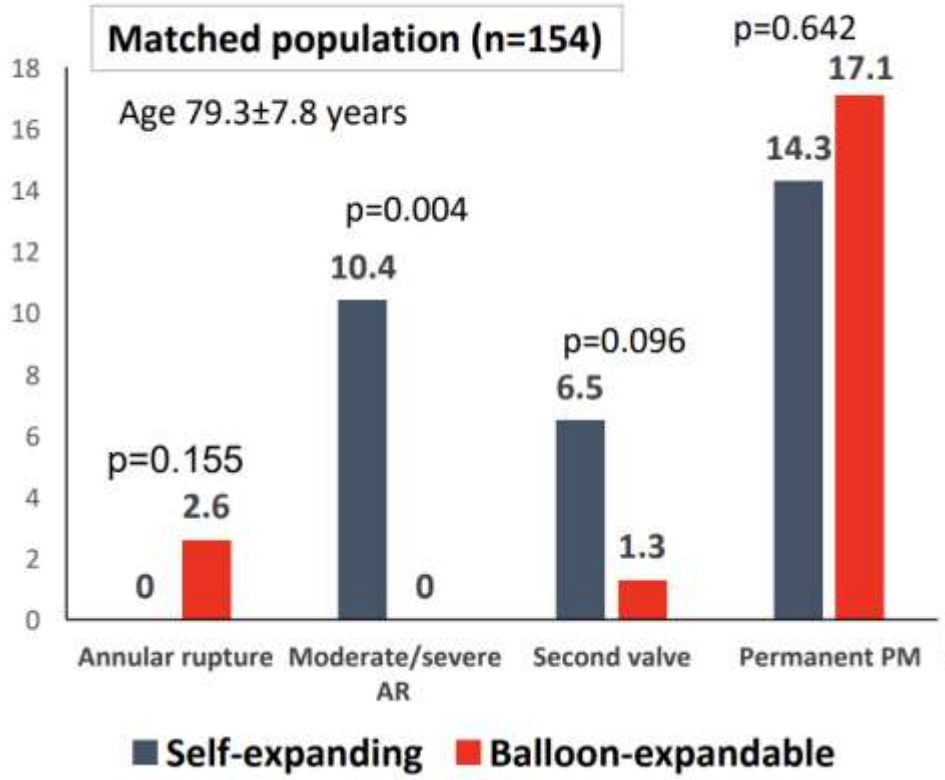


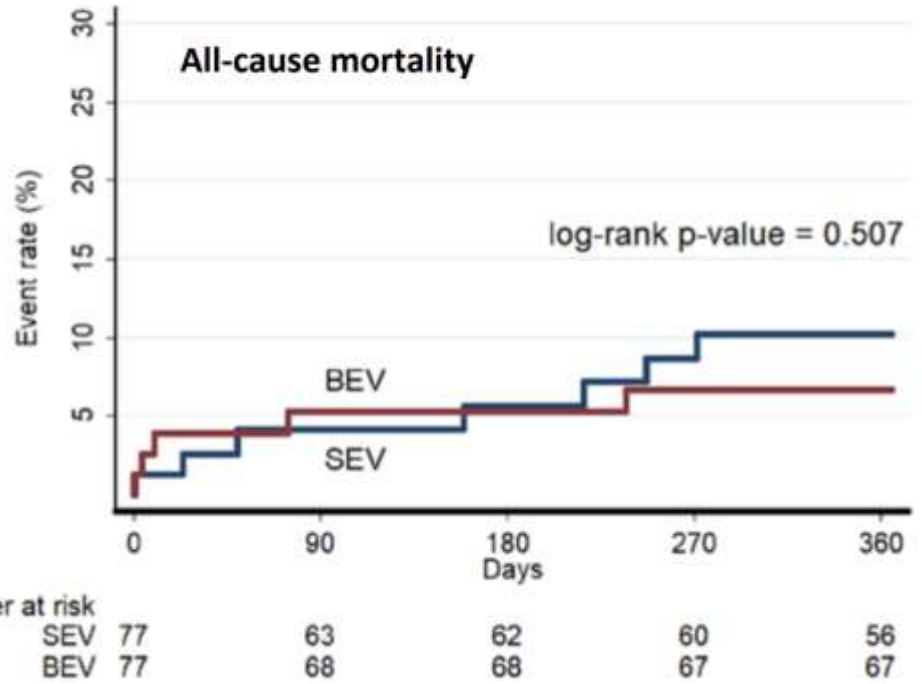
CONCLUSION: Compared with tricuspid AS, TAVR in bicuspid AS was associated with a similar prognosis, but lower device success rate. Procedural differences were observed in patients treated with the early-generation devices,whereas no differences were observed with the new-generation devices.

Yoon SH et al JACC. 2017 May, 69 (21) 2579–2589

Balloon-expendable vs self-espanding THVs for the treatment of bicuspid AS

BEAT registry, 353 patients undergoing TAVR for bicuspid aortic stenosis with **Evolut R/PRO** (n=111) or **Sapien 3** (n=242)





Conclusions: study confirms the feasibility of both Sapien 3 and Evolut R/PRO implantation in bicuspid aortic valve anatomy; a higher rate of moderate-severe paravalvular aortic regurgitation was observed in the Evolut R/PRO group at 1-year follow-up in the matched cohort, although patients treated with balloon-expandable valve had a higher rate of annular rupture.

Mangieri A et al; Circ Cardiovasc Interv. 2020Jul;13(7):e008714

Circulation: Cardiovascular Interventions
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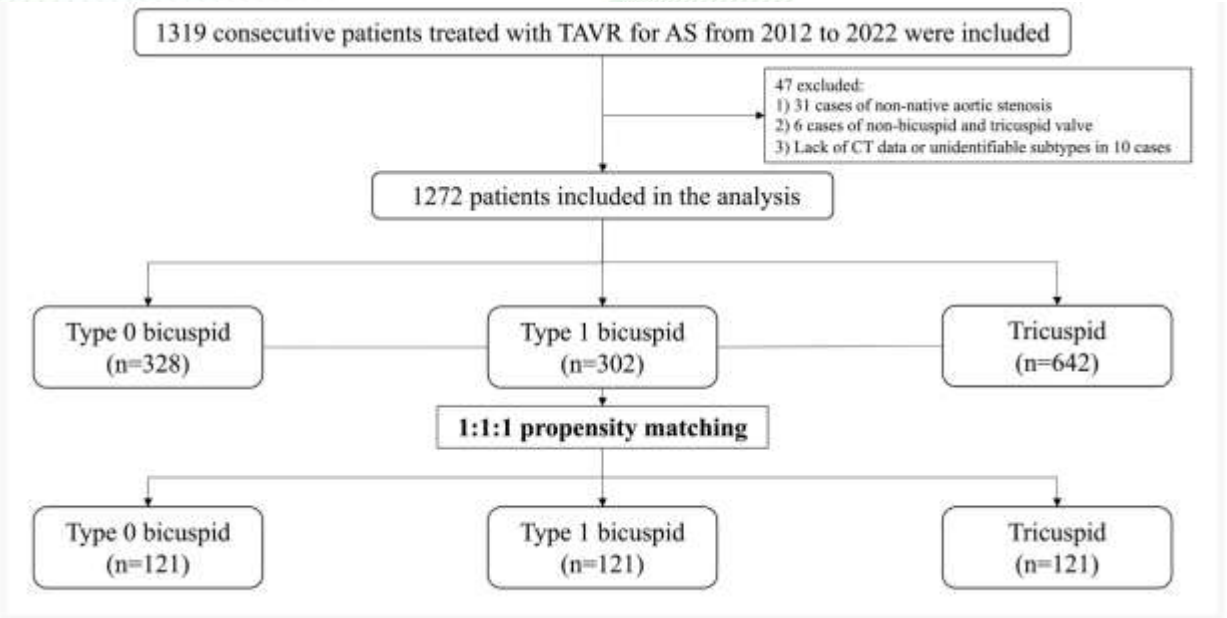
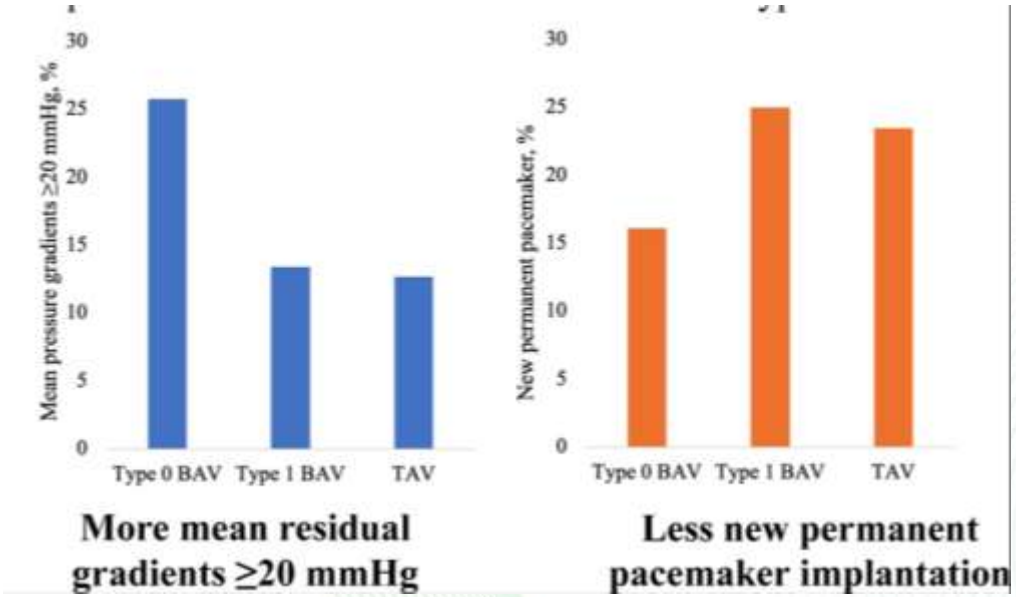
https://doi.org/10.1161/CIRCINTERVENTIONS.123.013083

STRUCTURAL HEART DISEASE

Outcomes Following Transcatheter Aortic Valve Replacement for Aortic Stenosis in Patients With Type 0 Bicuspid, Type 1 Bicuspid, and Tricuspid Aortic Valves

Jingjing He, MD*, Tian-Yuan Xiong, MD, PhD*, Yi-Jun Yao, MD, Yong Peng, MD, Jia-Fu Wei, MD, Zhen-Gang Zhao, MD, Guo Chen, MD, Yuan-Weixiang Ou, MD, PhD, Qi Liu, MD, Xi Wang, MD, PhD, Zhongkai Zhu, MD, Hao-Ran Yang, MD, PhD, Kaiyu Jia, MD, Darren Mylotte, MD, Nicolo Piazza, MD, PhD, Bernard Prendergast, MD, Yuan Feng, MD, and Mao Chen, MD, PhD





Conclusions

Comparable outcome can be achieved with TAVR in patients with BAV and TAV morphology using first-generation self-expanding valves, regardless of the BAV subtype. Type 0 BAV patients are associated with higher probability of elevated postprocedural valve gradients but lower likelihood of postprocedural PPI or PVL. These observations provide a foundation for improved patient selection and preprocedural planning in BAV patients undergoing TAVR.

Jingjing et al. Circulation: Cardiovascular Interventions December 2023

INTERVENTIONS FOR VALVULAR DISEASE AND HEART FAILURE
CLINICAL RESEARCH

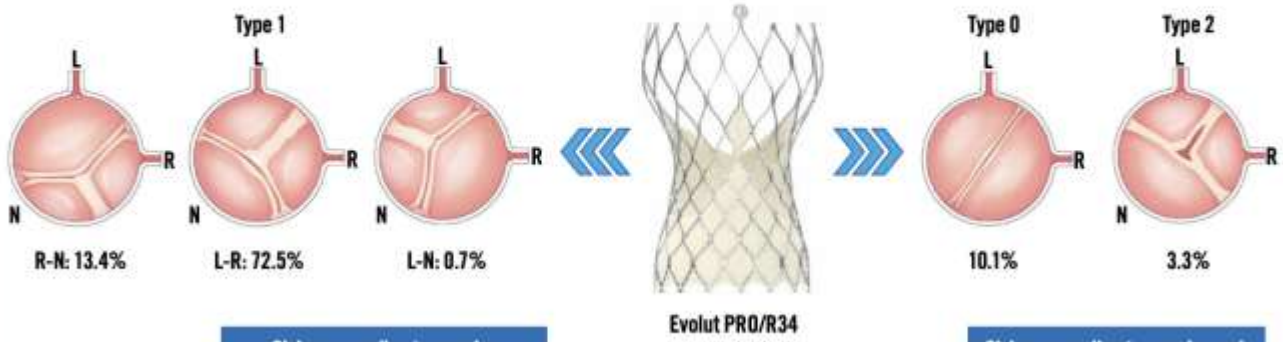
Transcatheter aortic valve implantation with the Evolut platform for bicuspid aortic valve stenosis: the international, multicentre, prospective BIVOLUTX registry

Didier Tchétché[1]*, MD; Francesca Ziviello[2], MD; Chiara De Biase[1], MD, PhD; Ole De Backer[3], MD, PhD; Thomas Hovasse[4], MD; Lionel Leroux[3], MD; Anna-Sonia Petronio[6], MD; Christophe Saint Etienne[7], MD; Rui Campante Teles[8], MD; Thomas Modine[5], MD; Arnaud Sudre[9], MD; Emmanuel Teiger[10], MD, PhD; Darren Mylotte[11], MD; Geraud Souteyrand[12], MD; Nicolo Piazza[13], MD; Frederic Casassus[14], MD; Lars Sondergaard[3], MD, PhD; Marco Angelilis[6], MD; Thiago Nolasco[8], MD; Saiffullah Siddiqui[1], MD; Isabella Kardys[2], MD, PhD; Nicolas Dumonteil[1], MD; Nicolas M. Van Mieghem[2], MD, PhD

Conclusions: BIVOLUTX demonstrated a favourable bioprosthetic valve performance and good clinical outcomes after TAVI with the Evolut platform in patients with bicuspid aortic stenosis. Further efforts should focus on reducing conduction disorders and neurological events.

EuroIntervention

CENTRAL **ILLUSTRATION** Clinical outcomes after TAVI with Evolut PRO/R34 in bicuspid patients.



n (%) or median (IQR)	Total (n=149)	Annular sizing (n=77)	Combined sizing (n=72)
Device success	136 (91.3%)	70 (90.9%)	66 (91.6%)
1-year mortality	15 (10.0%)	9 (12.9%)	6 (9.1%)
1-year disabling stroke	6 (4.0%)	4 (6.0%)	2 (3.2%)
30-day valve performance	142 (95.3%)		
1-year mean gradient, mmHg	8.1 (6.2-11.1)	8.7 (6.4-11.3)	8.0 (5.3-10.9)
1-year moderate to severe AR	1 (1.6%)	0 (0%)	1 (3.2%)
1-year severe PPM	3 (3.8%)	1 (2.2%)	2 (6.0%)

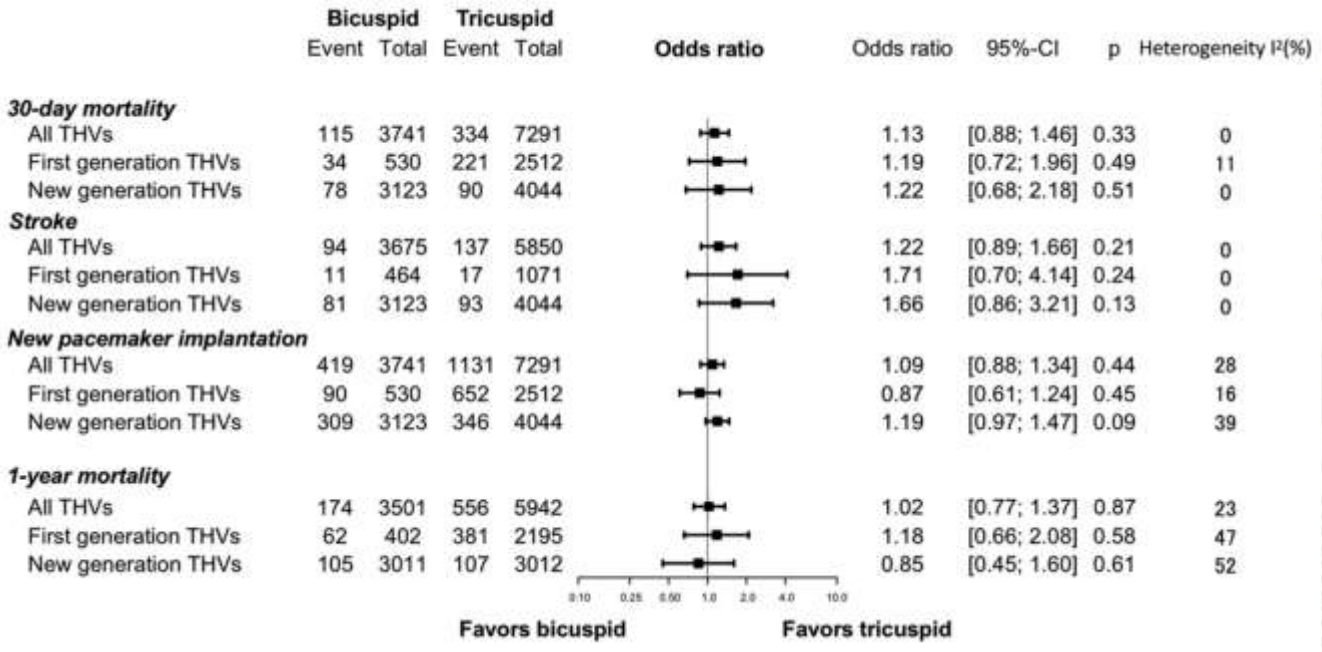
AR: aortic regurgitation; IQR: interquartile range; PPM: patient-prosthesis mismatch; TAVI: transcatheter aortic valve implantation

Tchétché et al. EuroIntervention 2023;19:502-511

Transcatheter aortic valve replacement for bicuspid aortic valve stenosis with first- and new-generation bioprostheses: A systematic review and meta-analysis

Daisuke Ueshima [a,1], Luca Nai Fovino [a,1], Sorin J. Brener [b], Tommaso Fabris [a], Andrea Scotti [a], Alberto Daniele Giacoppo [a], Andrea Pavei [a], Chiara Fraccaro [a], Massimo Napodano [a], Giuseppe Tarantini [a,*]

A total of 13 studies [25–36] (including 11,032 patients, 7291 with TAV and 3741 with BAV) met our inclusion criteria for the comparison between BAV and TAV, while 7 studies [11,12,26,37–40] (including 706 patients, 367 treated with a BE, 339 with a SE valve) were available for the comparison between BE and SE in BAV.



Conclusions: BAV patients treated with TAVR had similar 30-day and 1-year mortality as well as stroke and new pacemaker implantation rates compared to TAV subjects, but carried higher risk of moderate/severe PVL, conversion to surgery and device failure. Event rates significantly decreased with the use of new-generation devices, but TAVR still showed better procedural results in TAV compared to BAV.

Ueshima et al Int J Cardiol. 2020 Jan

The PARTNER 3 Bicuspid Registry forTranscatheter Aortic Valve Replacement in Low-Surgical-Risk Patients

Mathew R. Williams MD [a *], Hasan Jilaihawi MD [a *], Raj Makkar MD [b], William W. O'Neill MD [c], Robert Guyton MD [d], S. Chris Malaisrie MD [e], David L. Brown MD [f], Philipp Blanke MD [g], Jonathon A. Leipsic MD [g], Philippe Pibarot DVM, PhD [h], Rebecca T. Hahn MD [i j], Martin B. Leon MD [i j], David J. Cohen MD [j k], Jeroen J. Bax MD, PhD [l], Susheel K. Kodali MD [i], Michael J. Mack MD [f], Michael Lu PhD [m], John G. Webb MD [g]

CONCLUSIONS Among highly select bicuspid aortic stenosis low-surgical-risk patients without extensive raphe or subannular calcification, TAVR with the SAPIEN 3 valve demonstrated similar outcomes to a matched cohort of patients with tricuspid aortic stenosis.

TABLE 4 Clinical Outcomes in Matched Subjects

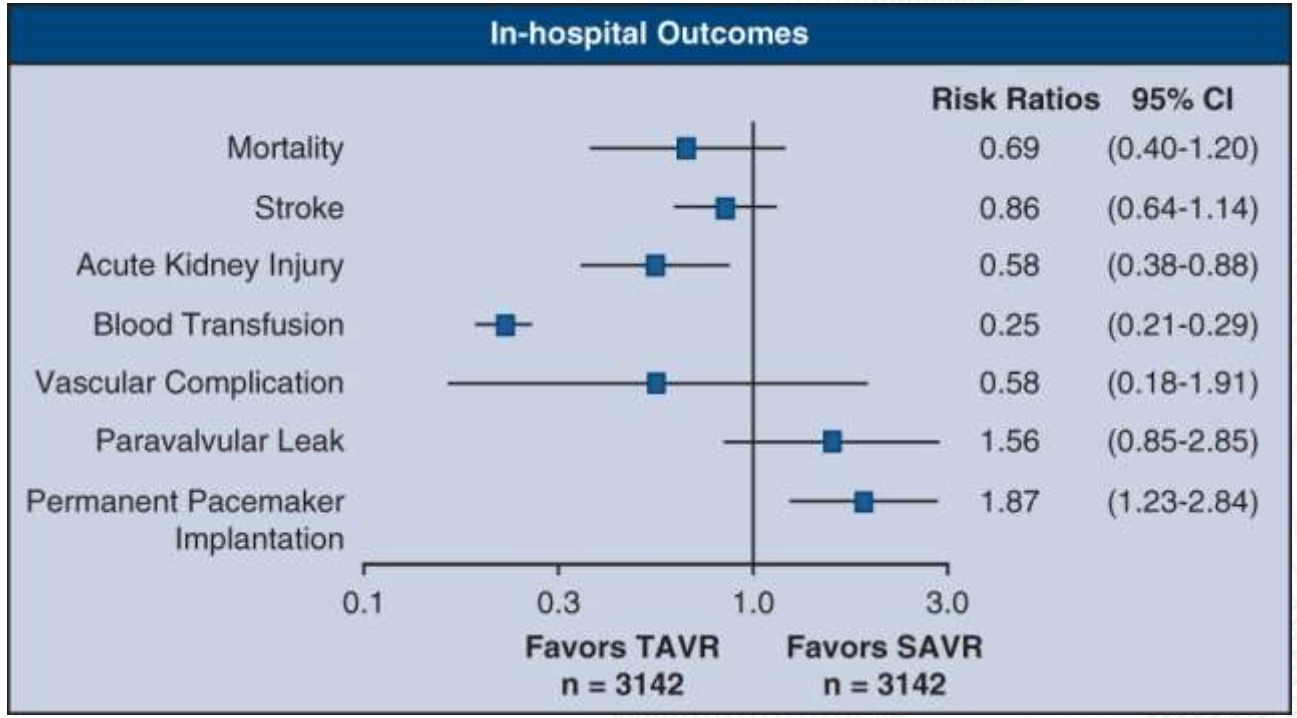
	Time Point	Bicuspid (n = 148)	Tricuspid (n = 148)	*P* Value
Death, stroke, or rehospitalization	30 d	10 (6.8)	7 (4.7)	0.44
	1 y	16 (10.9)	15 (10.2)	0.80
Death	30 d	0 (0.0)	0 (0.0)	NA
	1 y	1 (0.7)	2 (1.4)	0.58
Rehospitalization	30 d	8 (5.4)	6 (4.1)	0.58
	1 y	14 (9.6)	14 (9.5)	0.96
Stroke	30 d	2 (1.4)	2 (1.4)	0.99
	1 y	3 (2.1)	3 (2.0)	0.99
New permanent pacemaker	30 d	9 (6.1)	10 (6.8)	0.81
	1 y	10 (6.8)	11 (7.4)	0.82

Williams et al.JACC: CARDIOVASCULAR INTERVENTIONS VOL. 15, NO. 5, 2022

Transcatheter versus surgical aortic valve replacement for stenotic bicuspid aortic valve: Systematic review and meta-analysis

Yosuke Sakurai, MD,[a] Yujiro Yokoyama, MD,[b] Toshiki Kuno, MD, PhD,[c] Hisato Takagi, MD, PhD,[d] Amgad Mentias, MD,[e] Vinod H. Thourani, MD,[f] Azeem Latib, MD,[c] and Tsuyoshi Kaneko, MD[g]

Author	Publication year	Study period	Dataset	Adjustment
Elbadawi	2019	2012-2016	National Inpatient Sample	PSM
Mentias	2020	2015-2017	Medicare	PSM
Husso	2021	2008-2017	Finn Valve Registry	PSM
Majmunder	2022	2016-2018	Nationwide Readmission Database	PSM



Conclusions: In selected patients with severe bicuspid aortic valve stenosis, no significant differences in in-hospital mortality or stroke were observed between transcatheter aortic valve replacement and surgical aortic valve replacement. Further investigations with long-term follow-up and morphological features are warranted.

Sakurai et al. JTCVS Open. 2022 Dec 1;13:75–94

Guideline recommendations for interventions on patients with severe aortic stenosis with focus on BAV

Bicuspid aortic valve	AHA/ACC guidelines	ESC guidelines
Without aortopathy	Follow same recommendations for tricuspid-associated stenosis and/or regurgitation. TAVR may be considered as an alternative to SAVR after consideration of patient and procedural characteristics	Follow same recommendations for tricuspid-associated stenosis and/or regurgitation. TAVR is not specified as potential treatment option for BAV patients.
With aortopathy	Replacement of the ascending aorta is reasonable in patients with BAV undergoing AVR because of severe aortic stenosis or aortic regurgitation when the diameter of the ascending aorta is 4.5 cm or greater if the surgery is performed at Comprehensive Valve Centre (class IIa, level of evidence C-EO) Surgery is indicated in asymptomatic or symptomatic patients with BAV if the diameter of the aortic root or ascending aorta is greater than 5.5 cm (class I, level of evidence B-NR) Surgery is reasonable in asymptomatic patients with BAV if the diameter of the aortic root or ascending aorta is 5.0 to 5.5 cm and an additional risk factor for dissection is present (family history of aortic dissection or aortic growth rate ≥0.5 cm per year) if the surgery is performed at Comprehensive Valve Centre (class IIa, level of evidence B-NR) Surgery may be considered in asymptomatic patients with BAV if the diameter of the aortic root or ascending aorta is 5.0 to 5.5 cm and have no additional risk factors and the patient is at low surgical risk and the surgery is performed at Comprehensive Valve Centre (class IIb, level of evidence B-NR)	*Indication is primarily aortic valve disease:* Replacement of aortic root or tubular ascending aorta, alongside the aortic valve, should be considered when diameter ≥45mm (class IIa, level of evidence C) *Indication is primarily aortic root disease:* Surgery should be performed in patients with BAV, who have a maximal aortic diameter ≥55 mm (class IIa, level of evidence C) Replacement of the root or tubular ascending aorta should be considered if diameter ≥50mm in the presence of bicuspid aortic valve with additional risk factors (family history of aortic dissection [or personal history of spontaneous vascular dissection], severe aortic regurgitation or mitral regurgitation, desire for pregnancy, systemic hypertension, and/or aortic size increase >3 mm/year) (class IIa, level of evidence C)

Abbreviations: ACC, American College of Cardiology; AHA, American Heart Association; AVR, aortic valve replacement; BAV, bicuspid aortic valve; ESC, European Society of Cardiology; SAVR, surgical aortic valve replacement; TAVR, transcatheter aortic valve replacement.

A. Kalra et al.,Structural Heart 8 (2024) 100227

Take home message

- Bicuspid aortic stenosis carries potential technical challenges for TAVR.
- The BAV patient group is no longer eligible for TAVI exclusion.
- The result of TAVI in the BAV group is comparable to that of the TAV TAVI patient group due to the development of the valve and the experience of the practitioners.
- Patients in the BAV TAVI group are lower in age than those in the TAV TAVI group, and the condition itself is good, so it is not easy to perform the procedure, but the future plan needs to be devised more carefully.
- Adverse events of TAVR in BAV significantly decreased with new-generation THVs.

Thank you for attention!