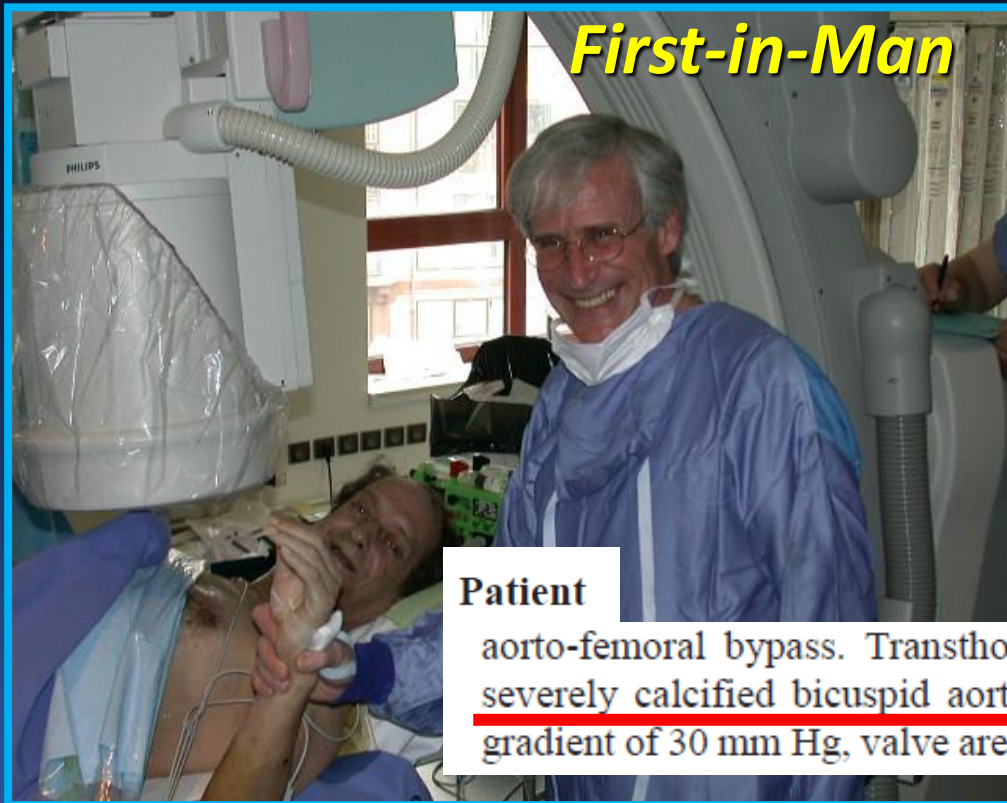


# TAVR Technique in Bicuspid Anatomy

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# First-In-Man TAVR was done in *Bicuspid AV* *By Balloon Expandable Valve*



**57 years old**

Cribier A, et al. Circulation. 2002;106:3006-3008

# TAVR Trials

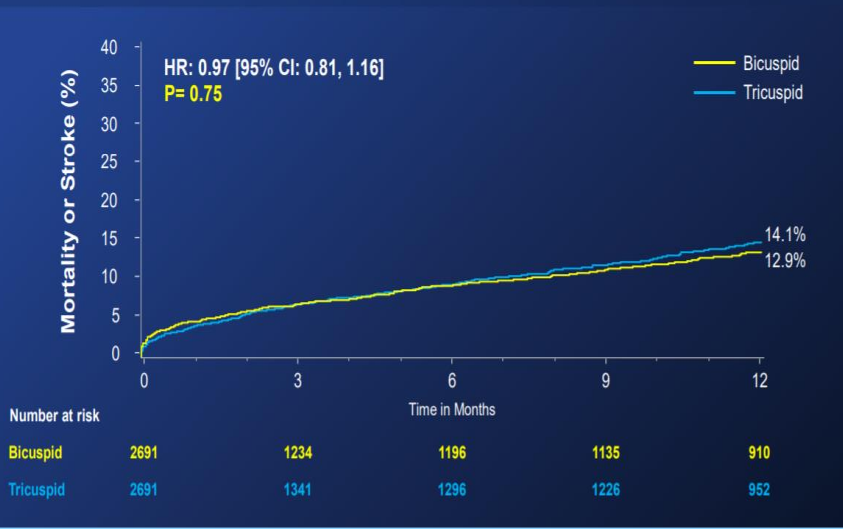
	STS Score	Age
<u><i>Inoperable Population</i></u>		
PARTNER IB Trial (2010)	11.6	83
<u><i>High Risk Population (&gt;8)</i></u>		
PARTNER IA Trial (2011)	11.8	84
CoreValve US Pivotal Trial (2014)	<b>7.4</b>	<b>83</b>
<u><i>Intermediate Risk Population (4-8)</i></u>		
PARTNER II Trial (2016)	5.8	82
<u><i>Low Risk Population (&lt;4)</i></u>		
NOTION Trial (2015)	3.0	79
PARTNER III (2019)	1.9	73
Evolut Low Risk Trial (2019)	1.9	74



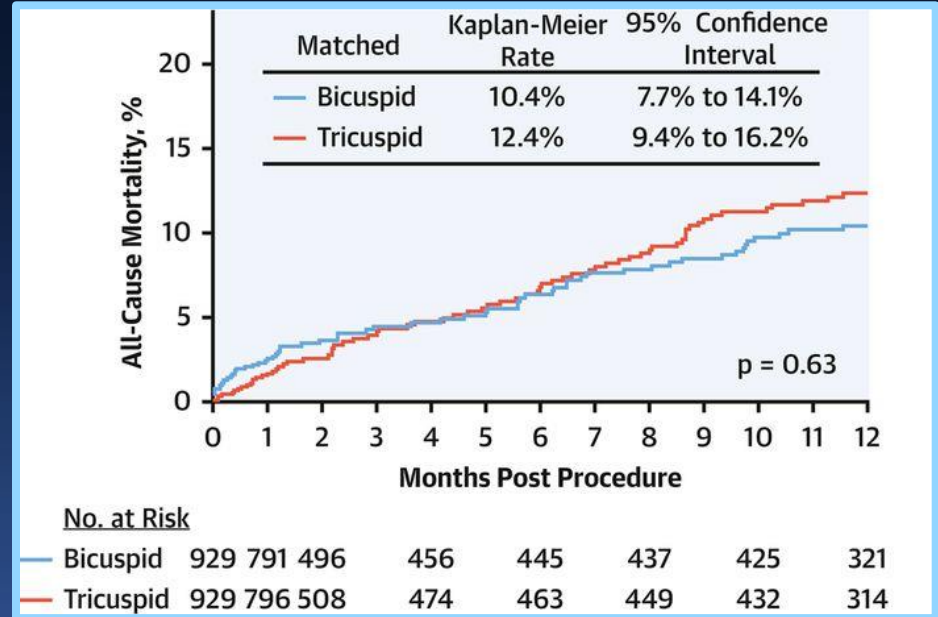
# STS/ACC TVT Registry

## Sapien 3

### 1-Year Mortality or Stroke – Matched



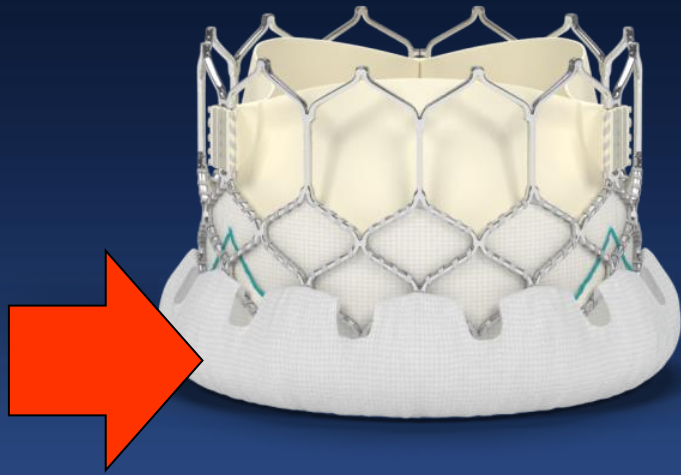
## Evolut R



JAMA 2019 Jun 11;321(22):2193-2202

JACC CVI 2020 May 23;S1936-8798(20)30763-9

# Which Device ?



**S3**

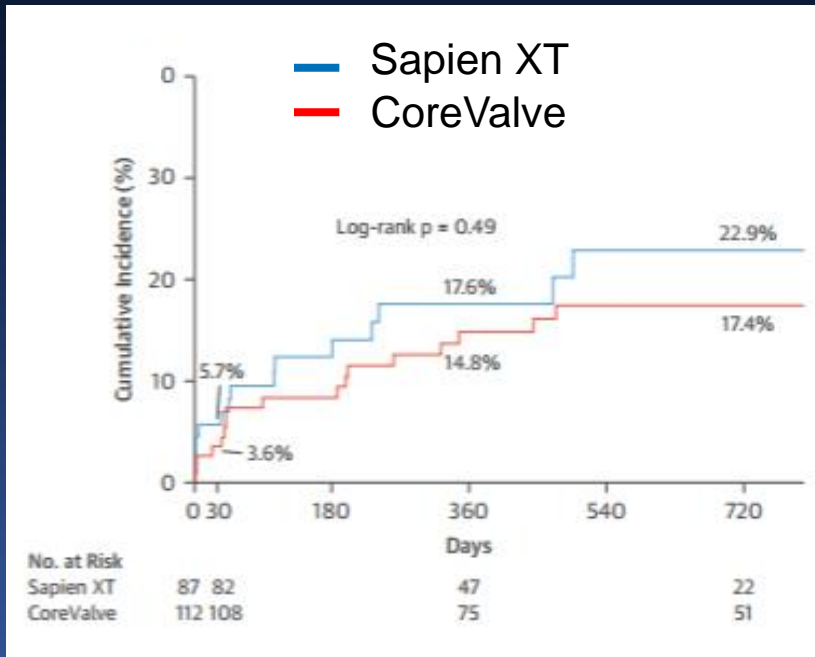


**Evolut R**

# SEV vs. BEV

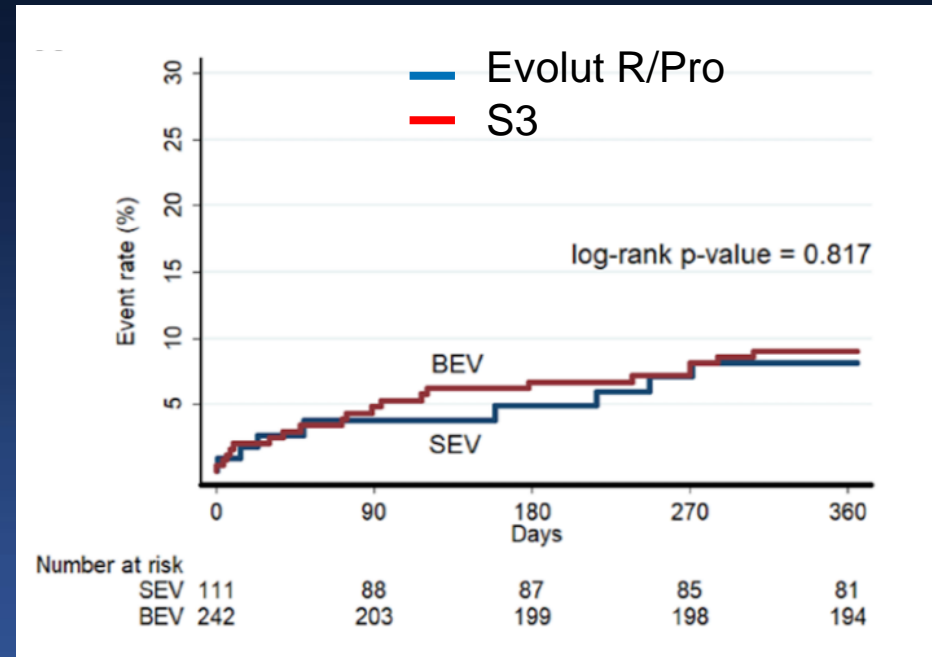
## All Cause Mortality

### The Bicuspid TAVR Registry



J Am Coll Cardiol 2016;68:1195–205

### The BEAT Registry

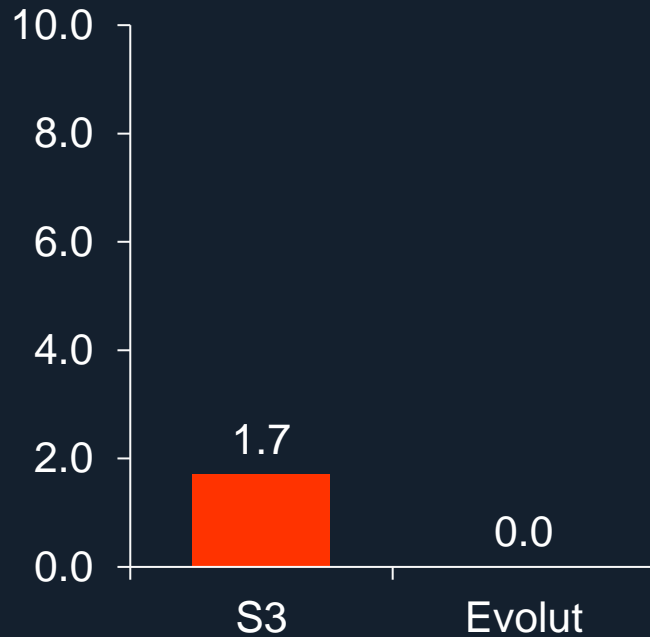


Circ Cardiovasc Interv. 2020;13:e008714

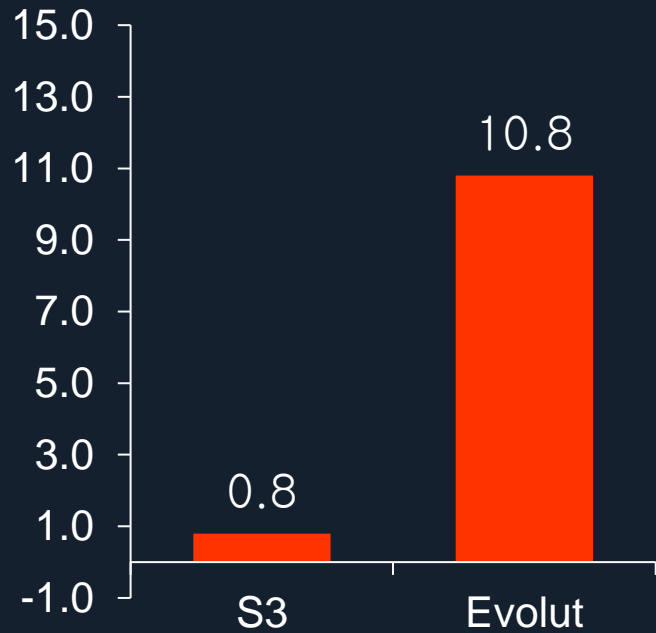
# S3 vs. Evolut R/PRO

## *The BEAT Registry*

### Annulus Rupture



### Mod-Severe PVL

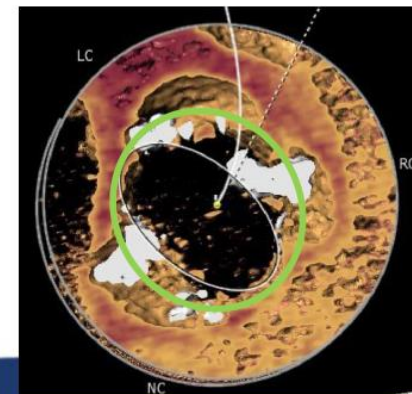
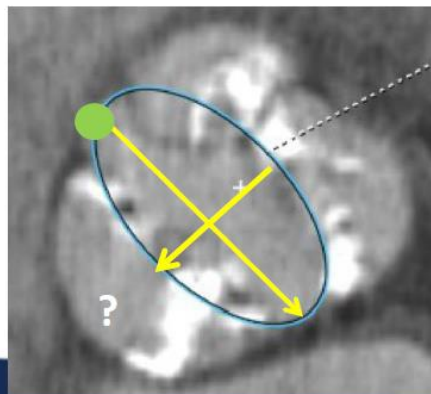
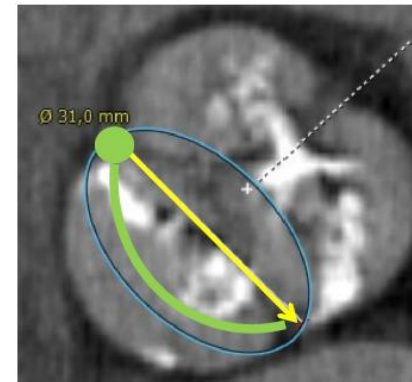
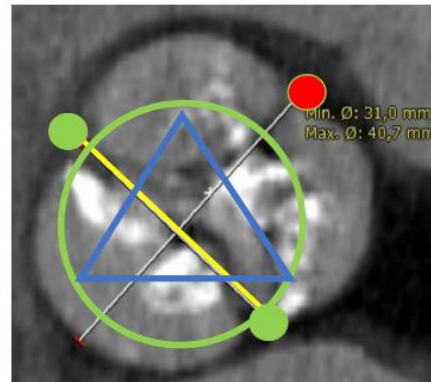
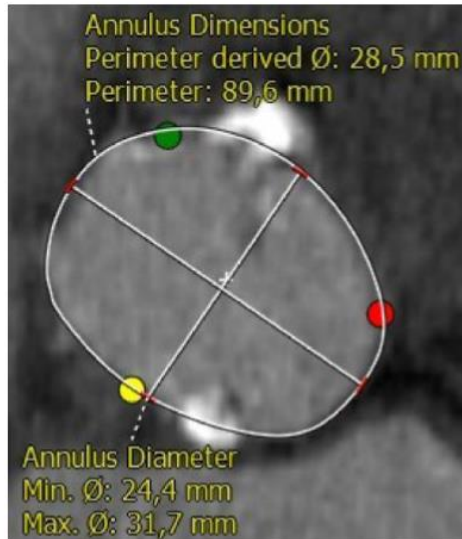


Circ Cardiovasc Interv. 2020;13:e008714



# Device Sizing

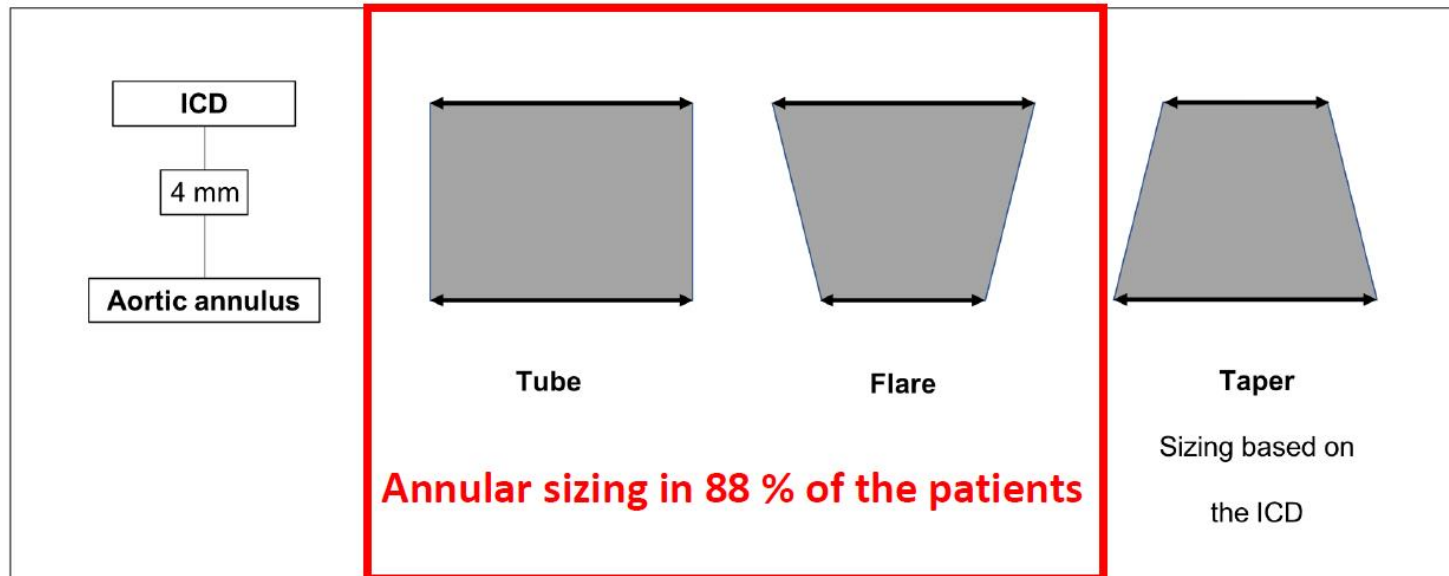
Various sizing methodologies are proposed for TAVR in BAV





# Device Sizing

Sizing according to the landing zone configuration

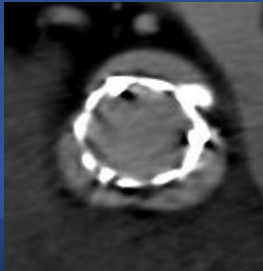


**BABARD Registry (N=96, S3 65, Lotus 10, Evolut R 21)**

# Device Sizing

## Annulus Sizing

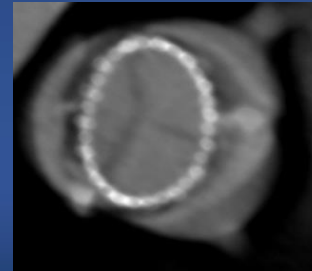
**S3**  
Don't Do  
Oversizing



BE “remodels”  
the annulus

## Supra-annulus Sizing

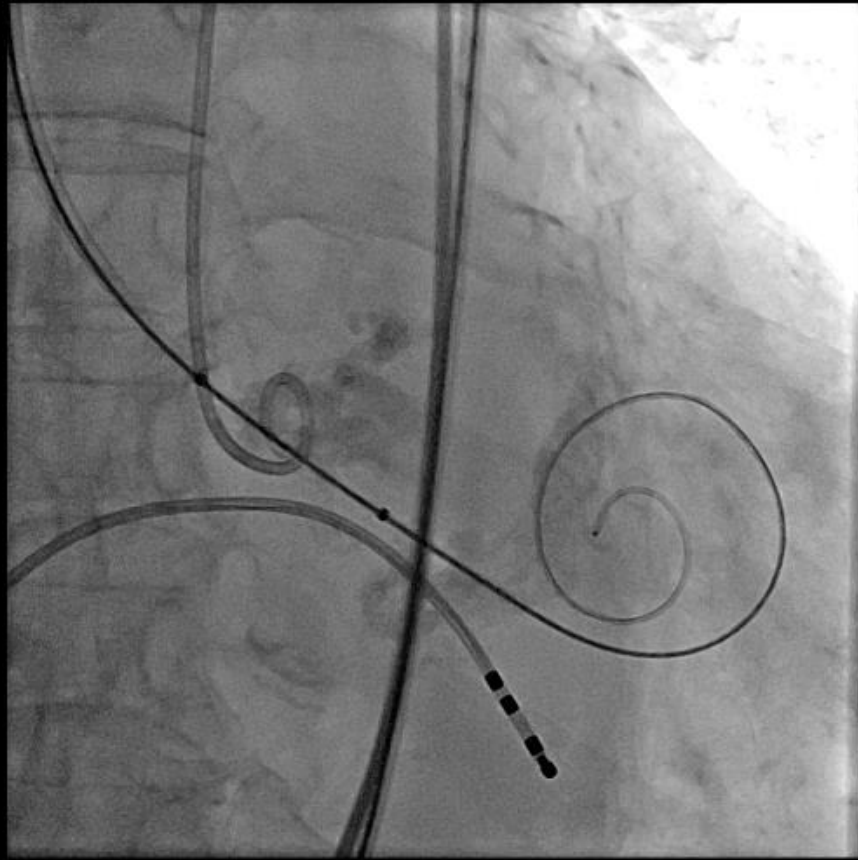
- Sequential balloon sizing
  - Intercommissural distance
  - LIRA method
  - CASPER method
- Evolut R/PRO**



The annulus  
“remodels” SE

# Balloon Aortic Valvuloplasty

## More Often in Bicuspid AS



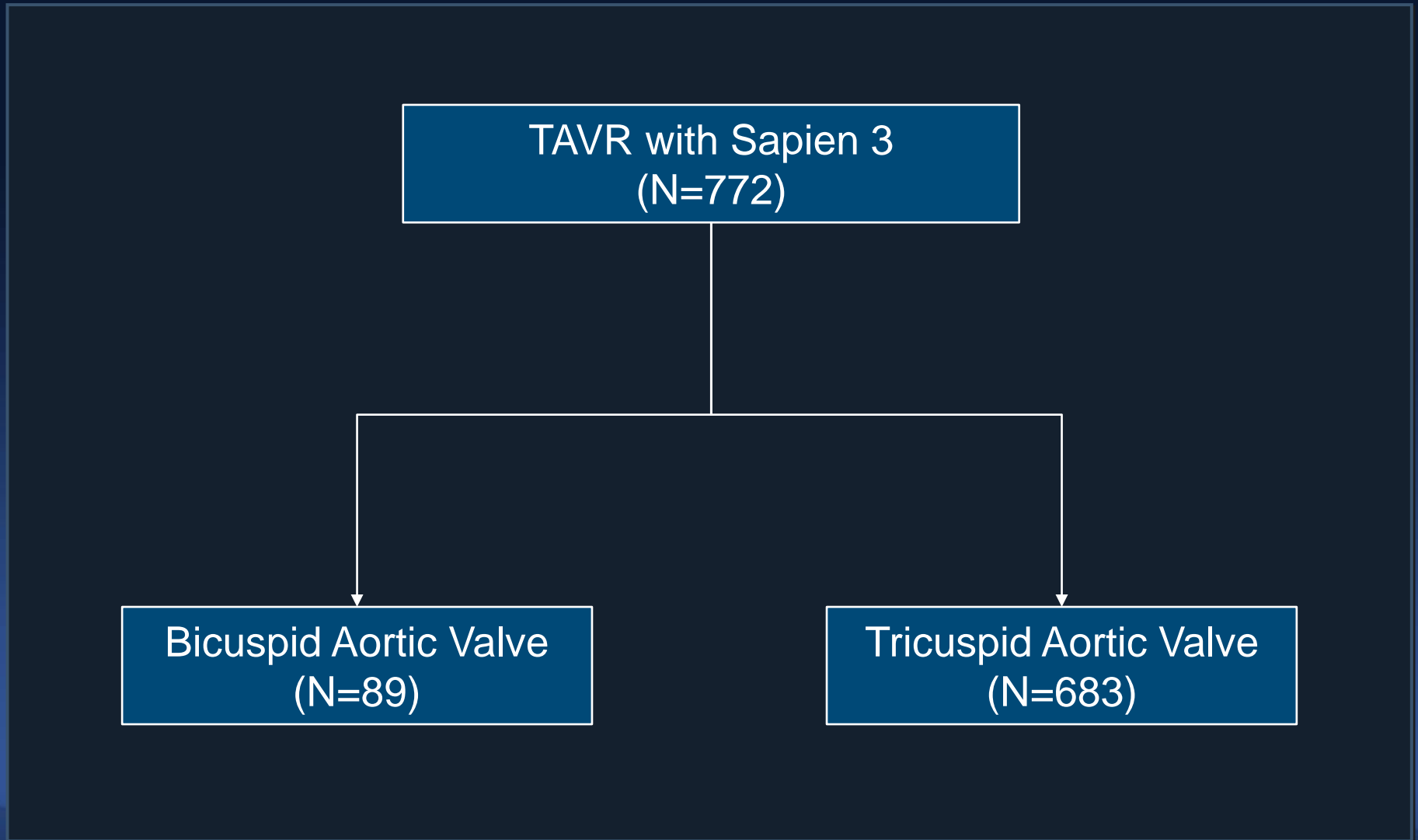
### Goal

- 1) To facilitate device delivery
- 2) To confirm the device size
- 3) To assess the risk of coronary obstruction

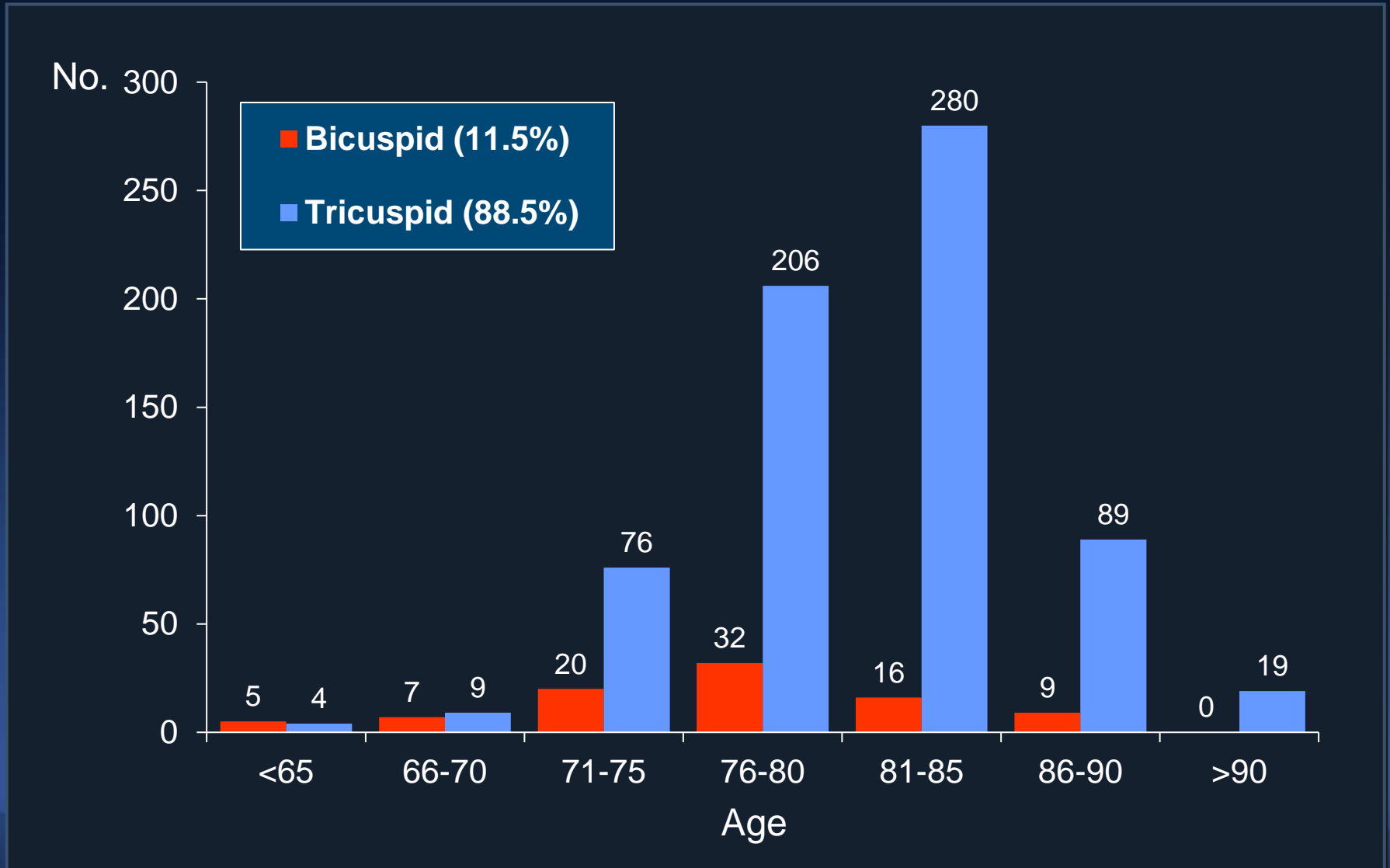
To avoid the risk of aortic complex injury, relatively small balloon should be selected based on the CT measurement of aortic valve complex.

**Balloon Size:** Smaller Than Minimal Diameter

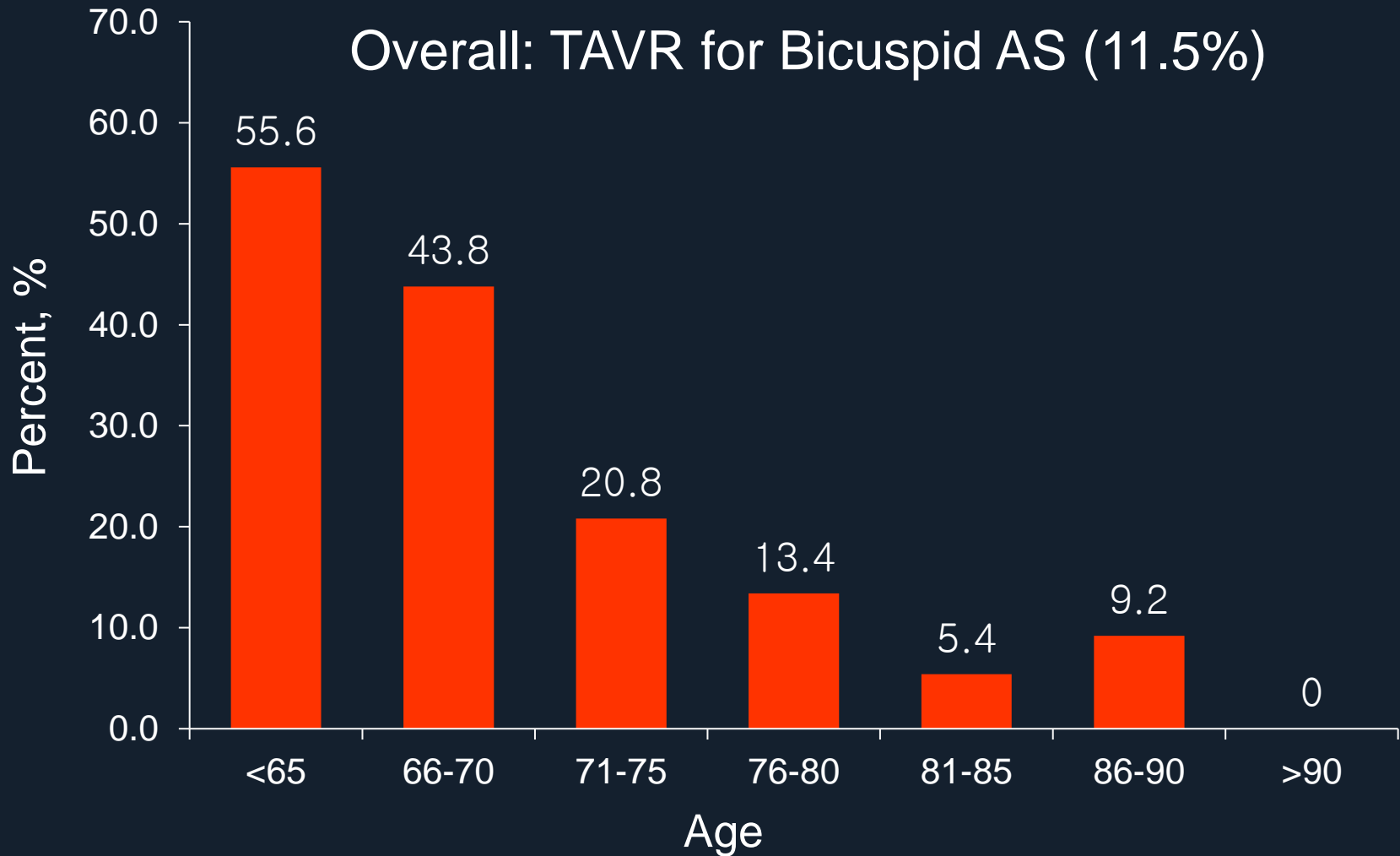
# ASAN TAVR S3 Registry (2016-2021)



# Age Proportion of TAVR for Bicuspid AS

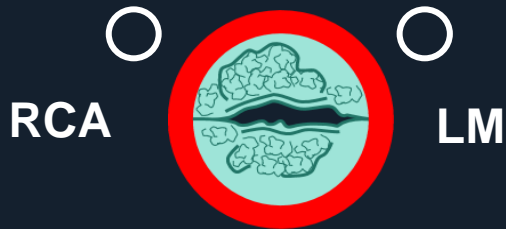


# Proportion of TAVR for Bicuspid AS



# Type of Bicuspid AV\*

**Type 0 24%**



AP type=6



LR type=11

**Type 1 76%**  
1 Raphe



LR fusion=46



RN fusion=6



NL fusion=1

**Type 2**  
2 Rapses



Type 2=0



# Type of Bicuspid AV\*

**Tubular Type**

**Flare Type**

**Tapered Type**

ICD  
↑  
4 mm  
↓  
Annulus  
Diameter

32%

60%

8%

Tubular type: perimeter derived annulus diameter/ICD ratio 0.99-1.1

Tapered type: perimeter derived annulus diameter/ICD ratio >1.1

Flared type: perimeter derived annulus diameter/ICD ratio <0.99

# Baseline Characteristics

	<b>Bicuspid AS (N = 89)</b>	<b>Tricuspid AS (N = 683)</b>	<b>P value</b>
Age	76.9 ± 6.6	80.9 ± 5.0	0.001
Gender (Male)	69.7%	44.9%	<0.001
NYHA Class III/IV	20.3%	30.2%	0.24
BMI	23.7 ± 3.2	24.1 ± 3.8	<0.001
STS score	2.88 ± 1.6	4.1 ± 2.6	<0.001
Diabetes Mellitus	23.6%	35.9%	0.022
Hypertension	57.3%	79.9%	<0.001
Previous Stroke	14.6%	12.0%	0.48
Peripheral Vascular Disease	2.2%	4.2%	0.37
Previous PCI	10.1%	24.9%	0.002
Previous CABG	0%	3.5%	0.10
LVEF, %	58.3 ± 9.4	59.3 ± 10.3	0.38

# CT Measurement

	Bicuspid AS (N = 89)	Tricuspid AS (N = 683)	P value
Annulus Dimensions			
Area, mm <sup>2</sup>	518±100	428±76	<0.001
Perimeter, mm	81.7±8.1	74.3±7.2	<0.001
Mean diameter, mm			
Maximum	28.7±3.3	26.6±2.6	<0.001
Minimum	22.8±2.5	20.6±2.1	<0.001
STJ area, mm <sup>2</sup>	856±235	640±140	<0.001
LVOT Area, mm <sup>2</sup>	505±121	403±99	<0.001
LM Height, mm	16.2±3.9	13.2±2.6	<0.001
RCA Height, mm	18.5±3.4	17.2±2.8	0.001

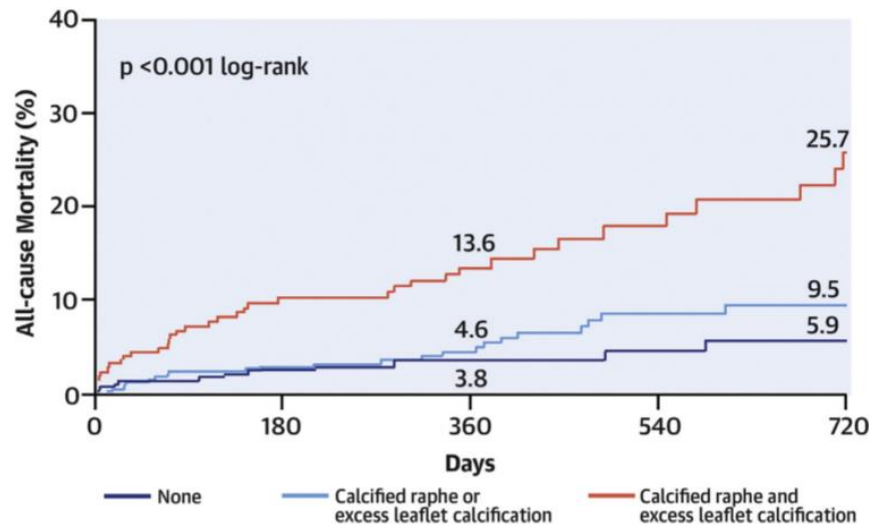
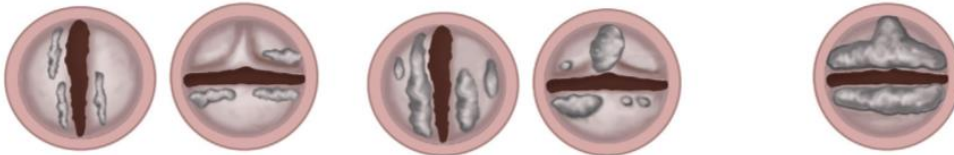
# Calcification Morphology and Outcomes

## Death From Any Cause, According to Morphological Features

No Calcified Raphe or  
Excess Leaflet  
Calcification  
(31.3%)

Calcified Raphe or  
Excess Leaflet  
Calcification  
(42.6 %)

Calcified Raphe Plus  
Excess Leaflet  
Calcification  
(26.0 %)



Severe AV  
calcification



**Higher Aortic Root Injury**  
Higher PVL

J Am Coll Cardiol. 2020;76(9):1018–30

# Mount and Morphology of Calcification

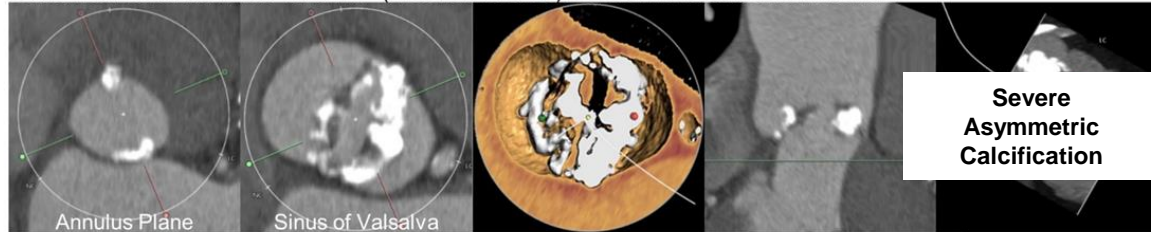
## Case 1

Total amount of calcium was  $65 \text{ mm}^3$  (threshold: 850HU). There was only small amount of calcium.



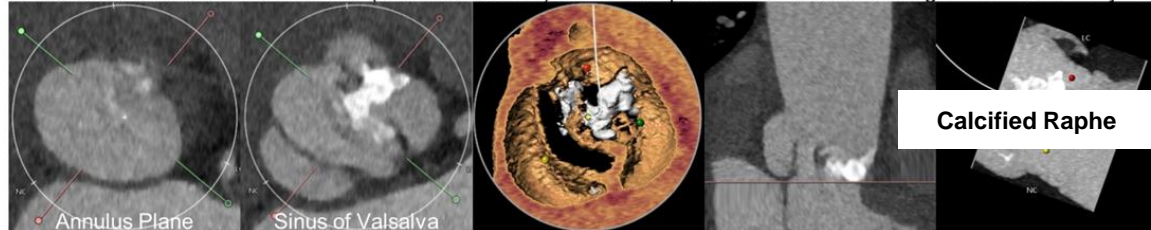
## Case 2

Total amount of calcium was  $1625 \text{ mm}^3$  (threshold: 850HU). Calcium is located at both leaflets.



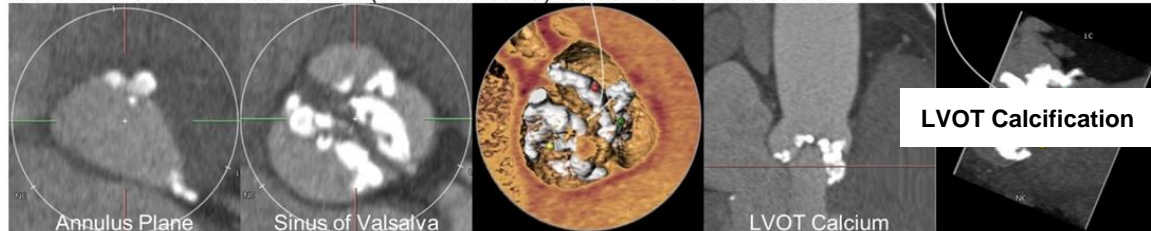
## Case 3

Total amount of calcium was  $380 \text{ mm}^3$  (threshold: 850HU). Calcified raphe is observed between right and left coronary cusp.



## Case 4

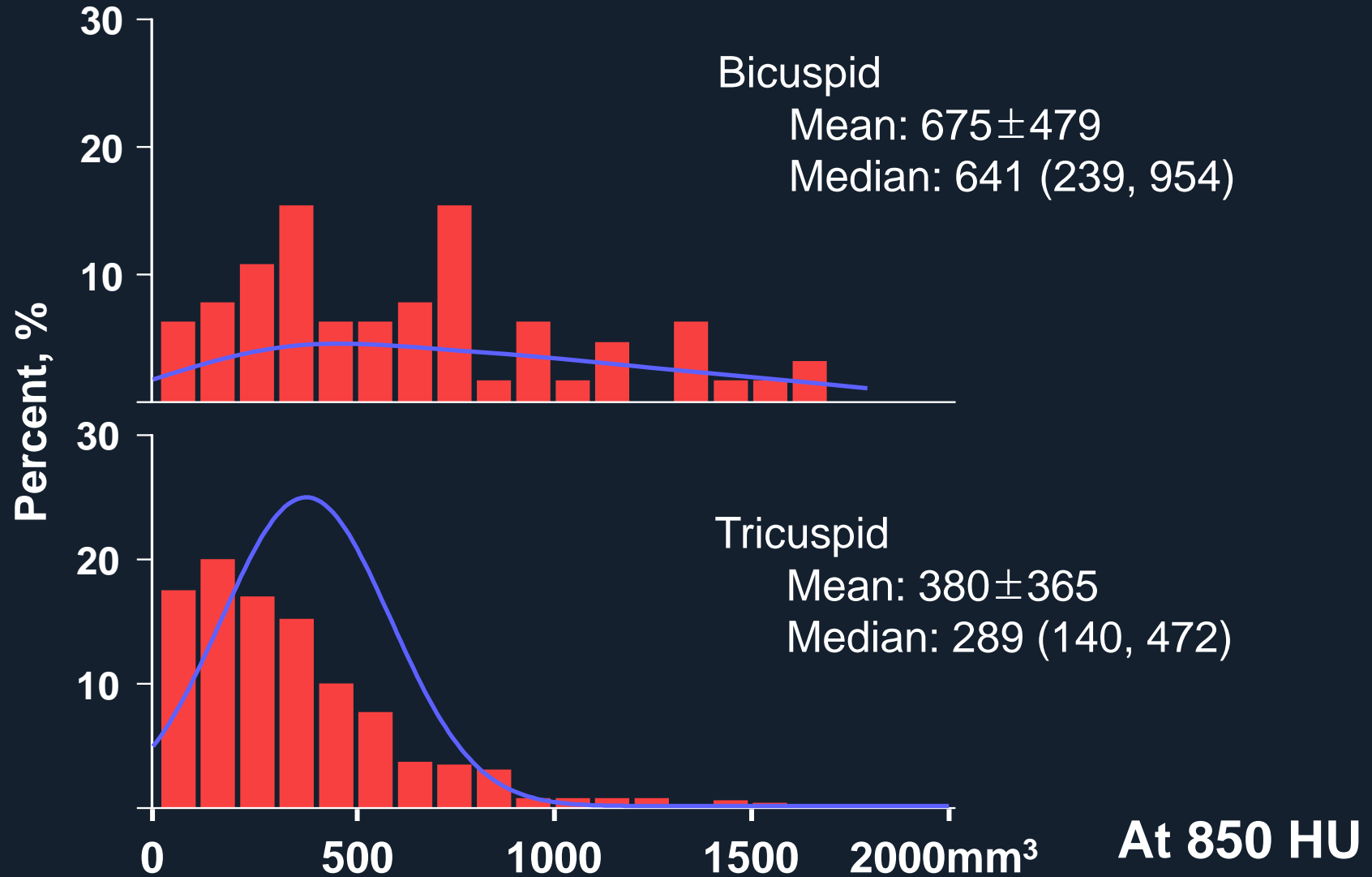
Total amount of calcium was  $958 \text{ mm}^3$  (threshold: 850HU). Calcium is extended to LVOT.



**Lower Risk**

**Higher Risk**

# Valve Calcification Volume



# S3 Area Oversizing Based on the CT

**10-15%, Cutoff**

***Mild Calcification***  
***(Ca volume < 400 mm<sup>3</sup>)***

**10~15%**

***Moderate Calcification***  
***(Ca volume 400-1000 mm<sup>3</sup>)***

**5~10%**

***Severe Calcification***  
***(Ca volume > 1000 mm<sup>3</sup>)***

**0~5%**

***Bicuspid AS and  
Heavy Calcification***

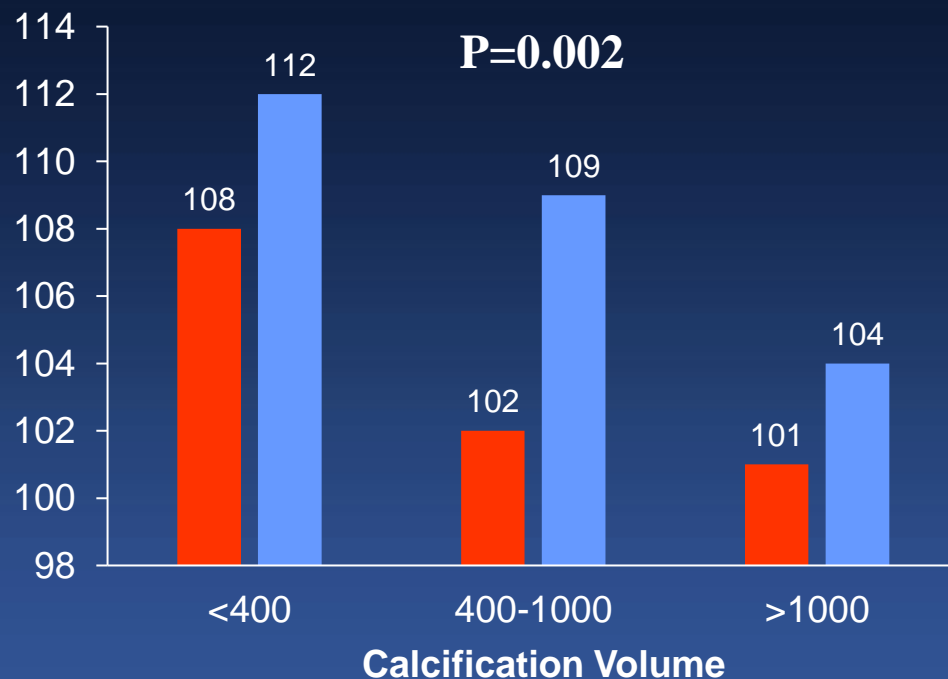
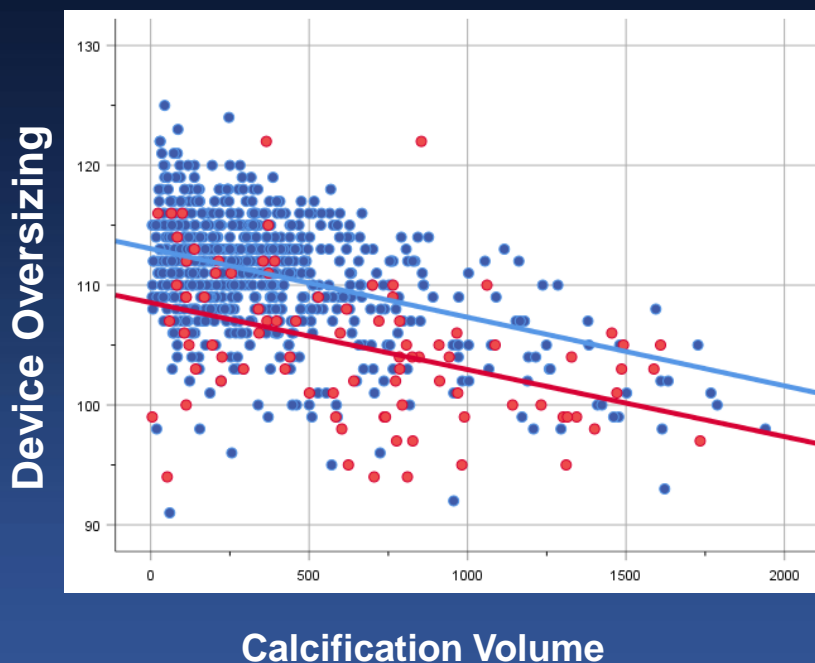
**0%**



# Volume Adjusted Device Under-Over Sizing

**Bicuspid: 104.8%**

**Tricuspid: 110.9%**



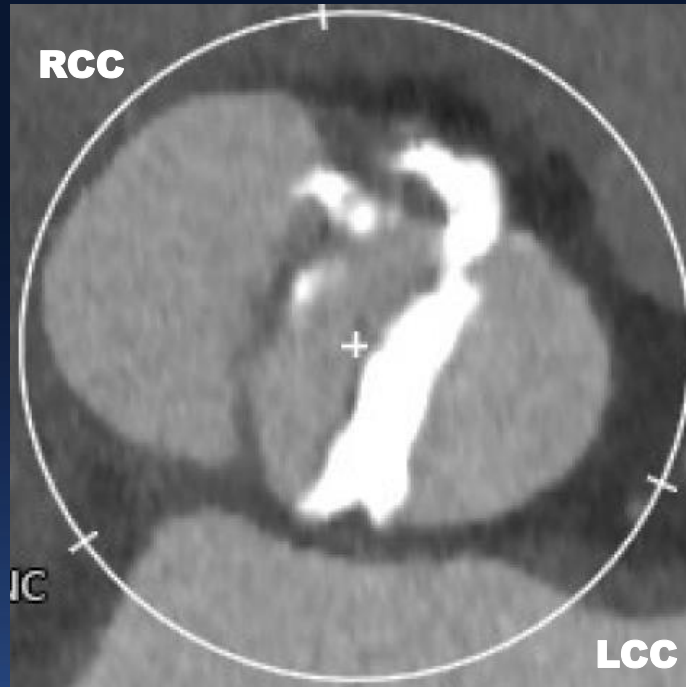
# M/79 with Bicuspid AS



Annulus plane

Aortic Annulus parameters	
Annulus short diameter	26.0 mm
Annulus long diameter	28.6 mm
Annulus mean diameter	27.3 mm
Annulus area	589 mm <sup>2</sup>
Annulus area-driven diameter	27.4 mm
Annulus perimeter	86.5 mm
Annulus perimeter-driven diameter	27.5 mm

# Calcium Amount

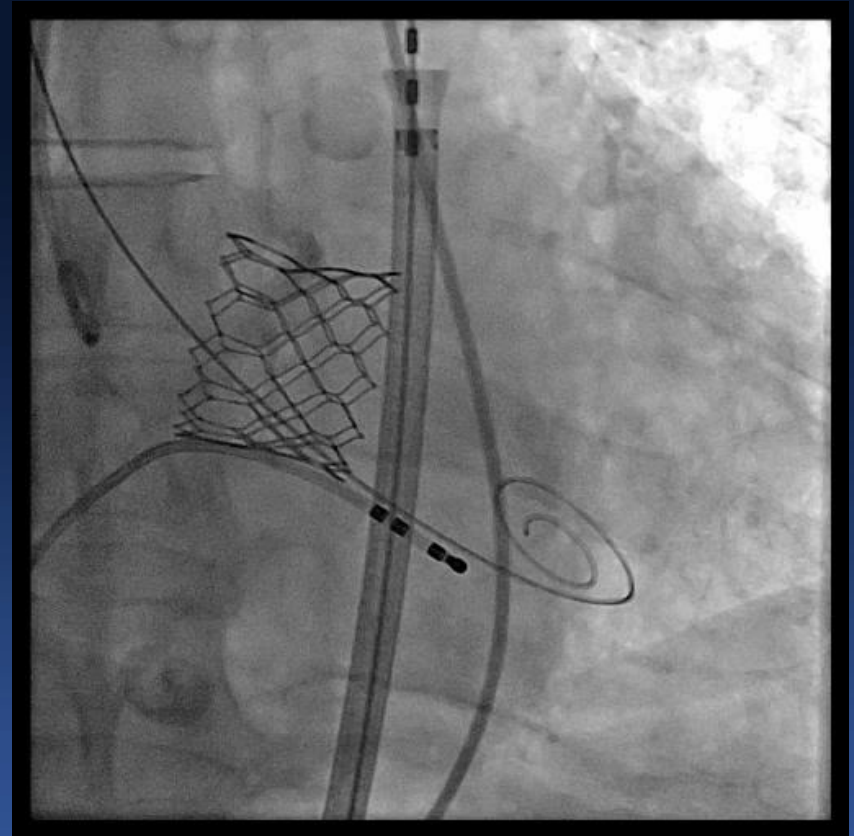
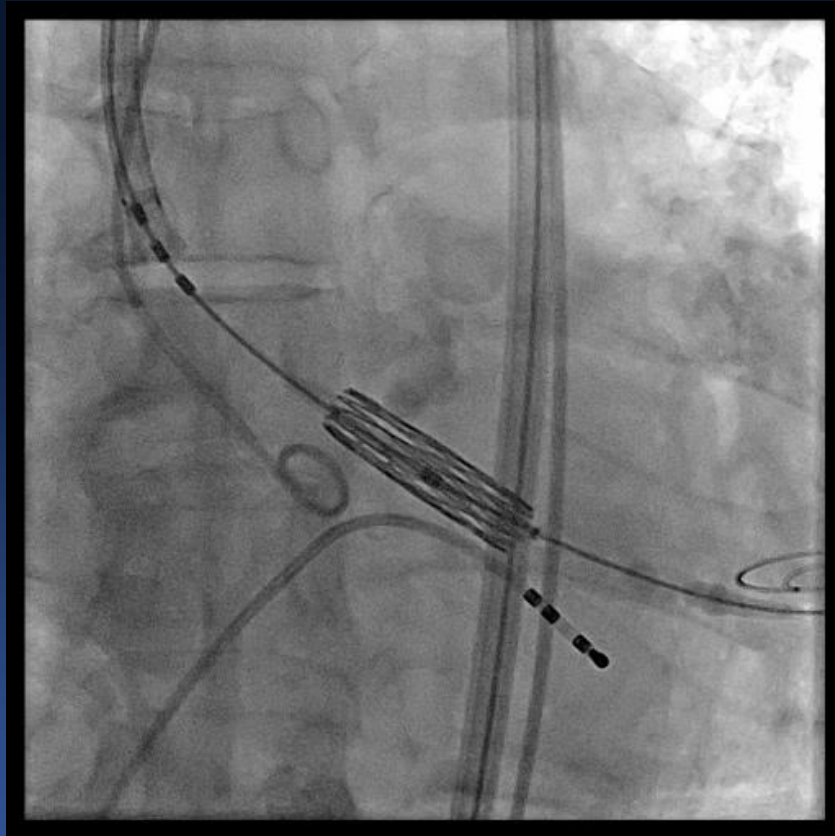


Calcium volume	
RCC	616 mm <sup>3</sup>
LCC	48 mm <sup>3</sup>
Total	664 mm <sup>3</sup>

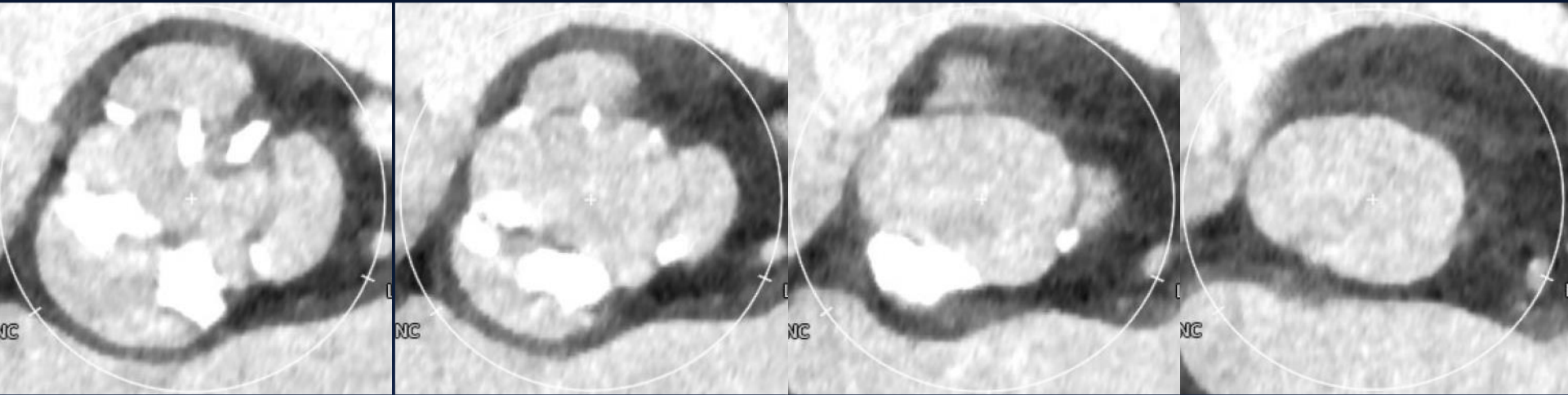
# S3 29mm with -3cc Underfill (2% Oversizing)

Size	Area_oversize (%)	Perimeter_oversize (%)
24	75.6	86.2
25	82.0	89.8
26	88.1	93.3
27	95.0	96.9
28	102.2	100.5
29	110.2	104.4
30	117.9	108.0

# S3 29mm with -3cc Underfill (2% Oversizing)



# M/79 with Bicuspid AS

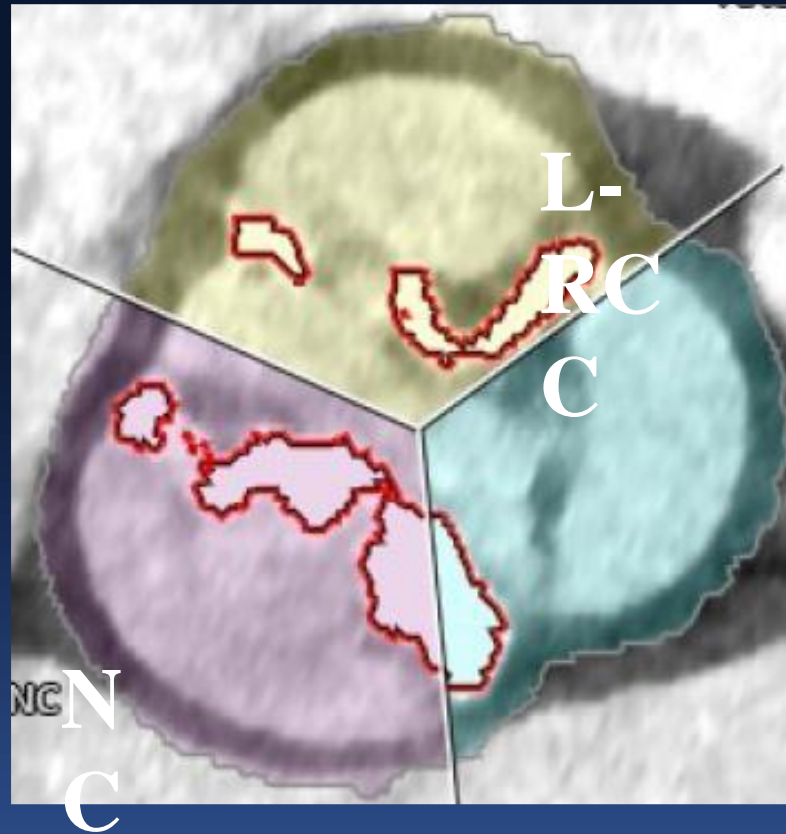


Annulus plane\_20%

Aortic Annulus parameters	
Annulus short diameter	21.0 mm
Annulus long diameter	28.8 mm
Annulus mean diameter	24.9 mm
Annulus area	500 mm <sup>2</sup>
Annulus area-driven diameter	25.2 mm
Annulus perimeter	81.1 mm
Annulus perimeter-driven diameter	25.8 mm



# CT findings – Aortic Valve Complex



Calcium volume	
NCC	875 mm <sup>3</sup>
L-RCC	436 mm <sup>3</sup>
Total	1316 mm <sup>3</sup>

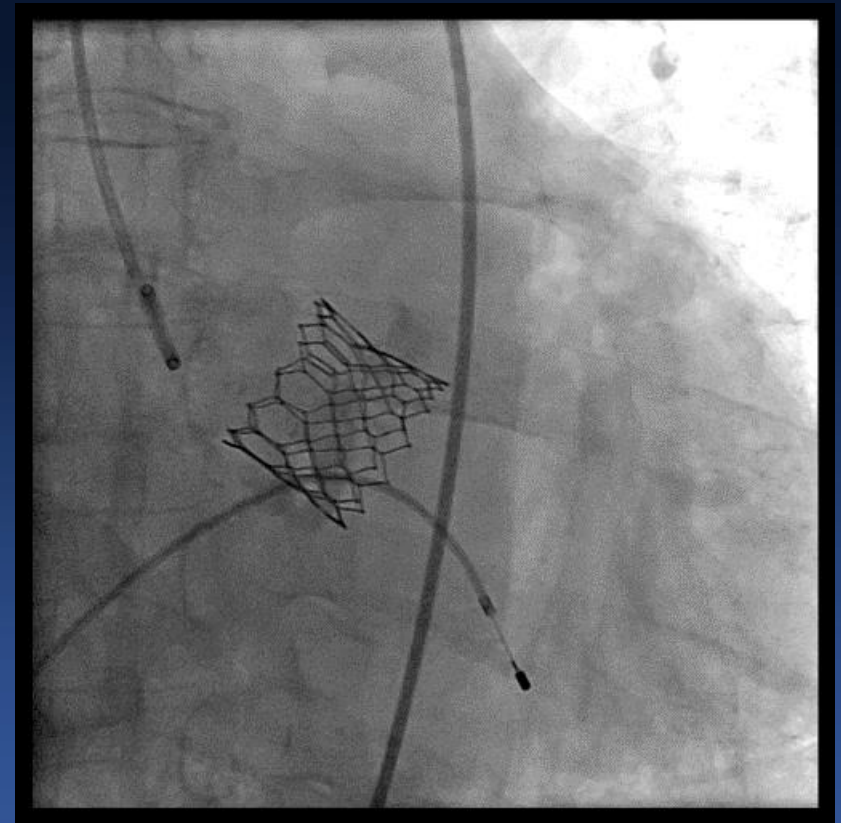
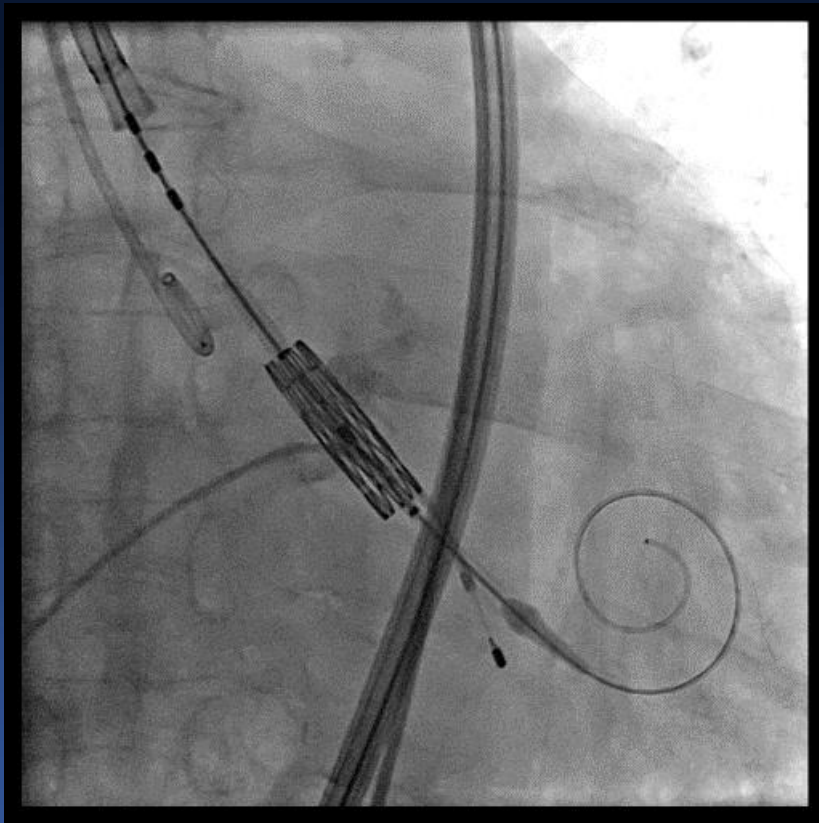
Mean Amount of total Calcium:  $618.5 \pm 446.9$



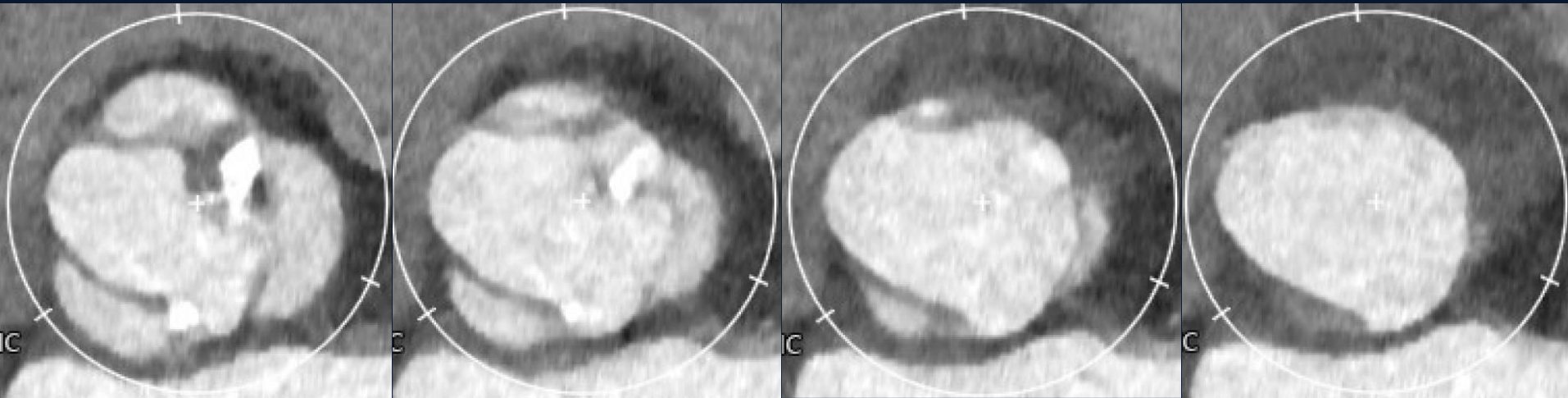
# S3 26mm with 2 cc underfilling (4% Undersizing)

Size	Area Oversize (%)	Perimeter Oversize (%)
23	81.8	88.1
24	89.1	91.9
25	96.6	95.8
26	103.8	99.5
27	111.9	103.3
28	120.4	107.2
29	129.8	111.3

# S3 26mm with 2 cc underfilling (4% Undersizing)



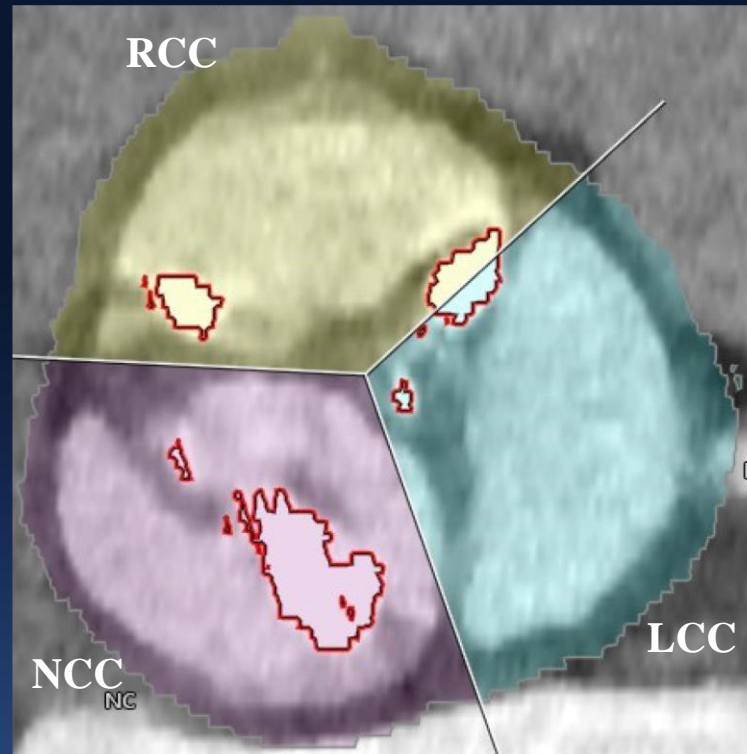
# M/83 with Bicuspid AS



Annulus plane

Aortic Annulus parameters	
Annulus short diameter	25.3 mm
Annulus long diameter	34.1 mm
Annulus mean diameter	29.7 mm
Annulus area	710 mm <sup>2</sup>
Annulus area-driven diameter	30.1 mm
Annulus perimeter	97.0 mm
Annulus perimeter-driven diameter	30.9 mm

# CT findings – Aortic Valve Complex



Calcium volume	
NCC	366 mm <sup>3</sup>
RCC	295 mm <sup>3</sup>
LCC	166 mm <sup>3</sup>
Total	828 mm <sup>3</sup>

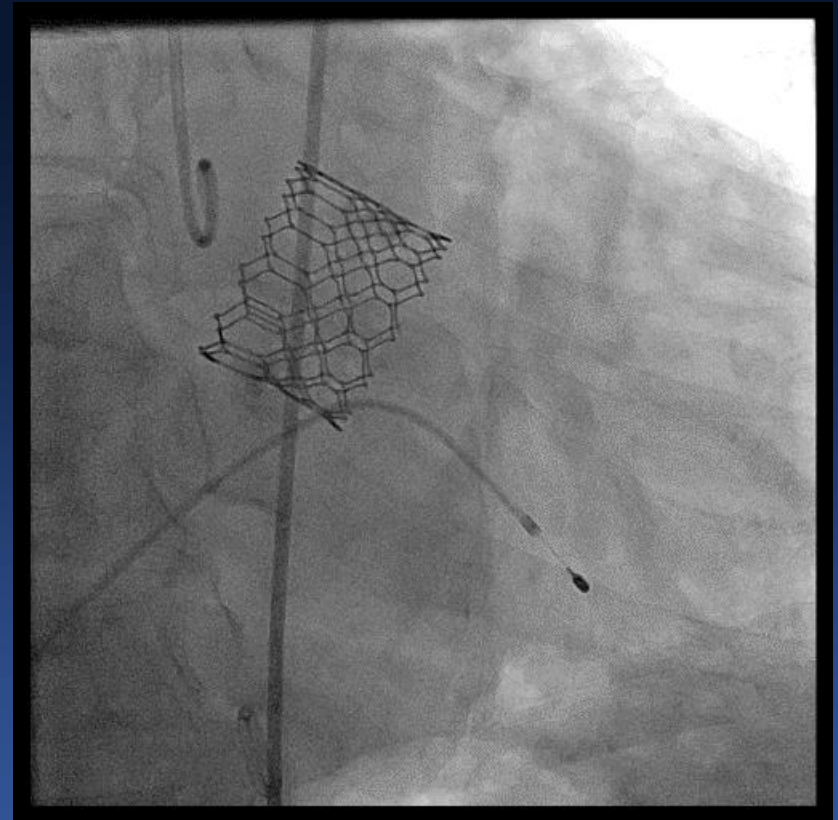
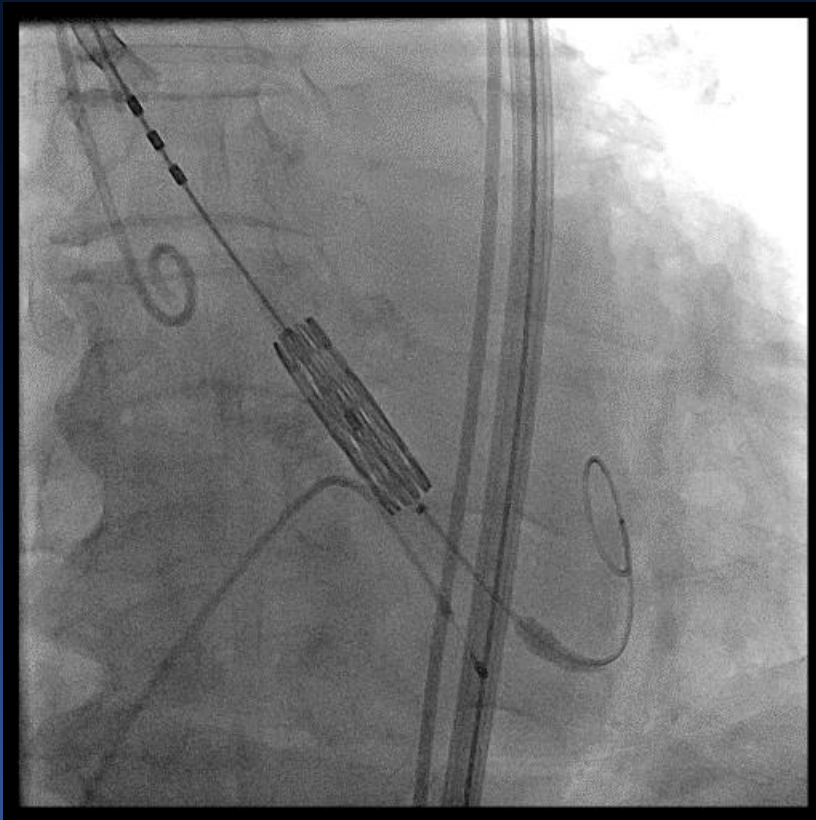
Mean Amount of total Calcium:  $356.7 \pm 303.8$

# S3 29mm (-9% Undersizing)

Size	Area Oversize (%)	Perimeter Oversize (%)
26	73.1	83.2
27	78.8	86.4
28	84.8	89.6
29	91.4	93.1
30	97.8	96.3
31	104.4	99.5

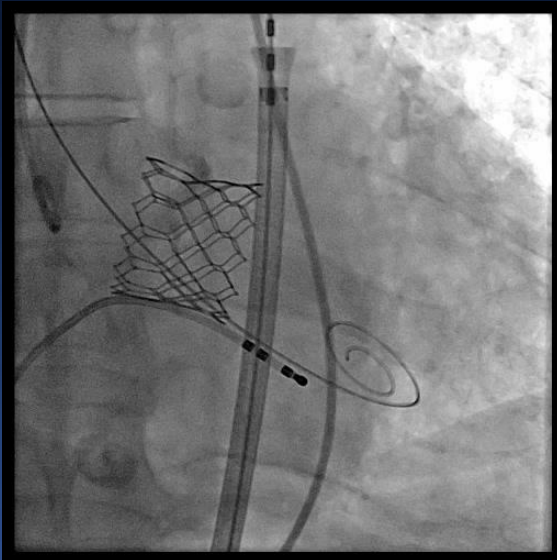


# S3 29mm (9% Undersizing)



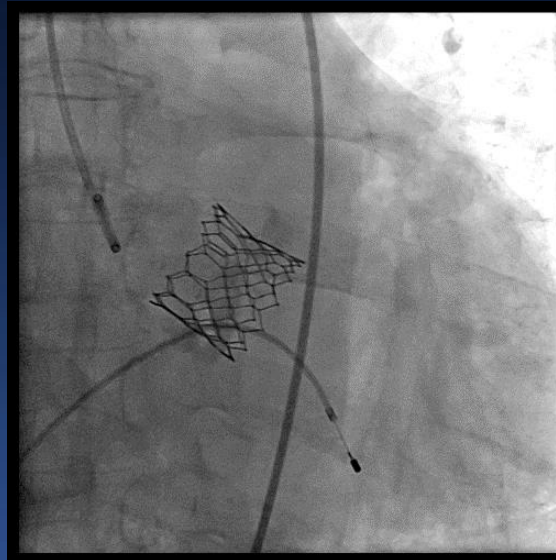
# Undersizing is Effective and Safe

**S3 29mm  
with -3cc Underfill  
(2% Oversizing)**



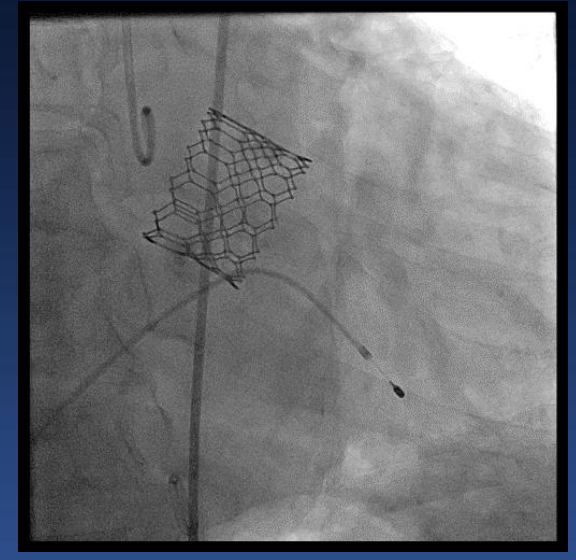
**Calcium 664**

**S3 26mm  
with 2 cc underfilling  
(4% Undersizing)**



**Calcium 1316**

**S3 29mm  
(9% Undersizing)**



**Calcium 828**

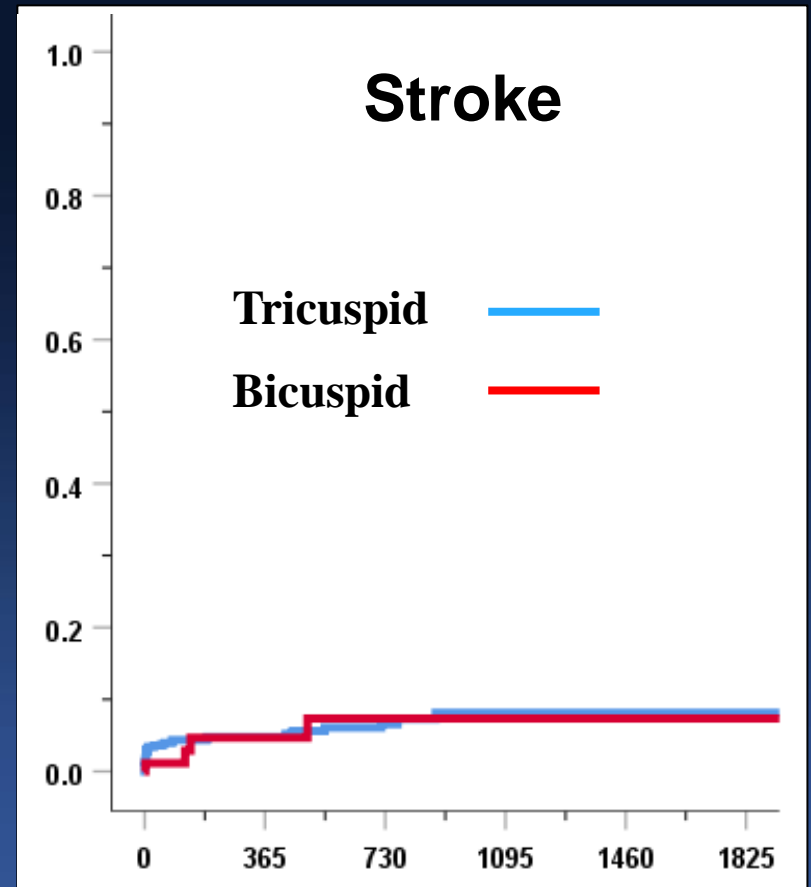
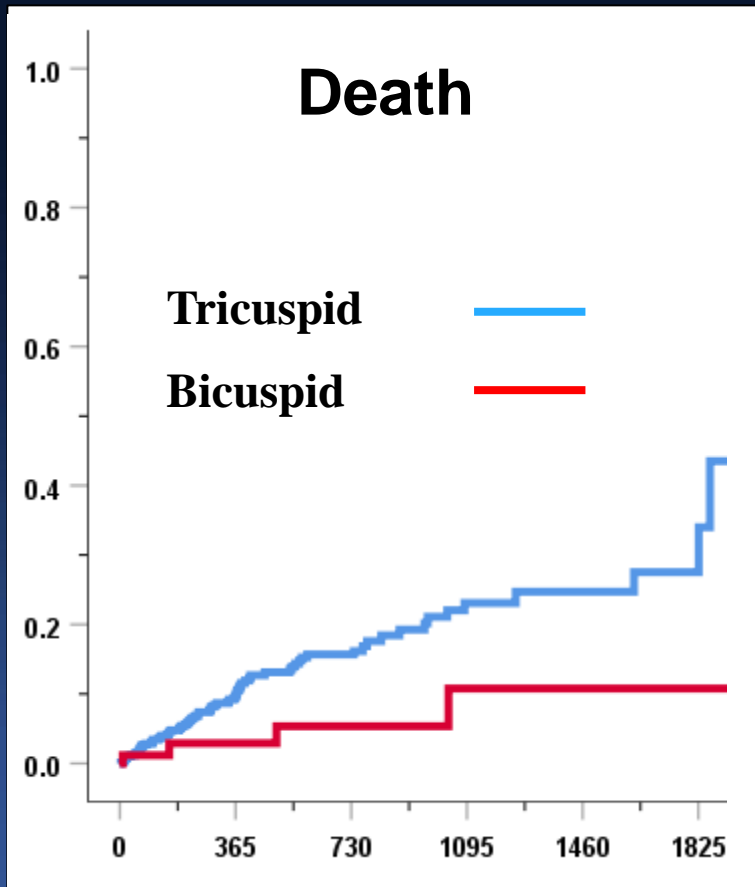
**Don't Do Oversizing in S3**



# Procedural Outcomes

	<b>Bicuspid AS (N = 89)</b>	<b>Tricuspid AS (N = 493)</b>	<b>P value</b>
Pre-Balloon Valvuloplasty	66 (74.2%)	288 (42.2%)	<0.001
Post-Balloon Valvuloplasty	14 (15.7%)	89 (13.0%)	0.48
Annular Root Injury	0	1 (0.1%)	0.24
New Permanent Pacemaker	4 (4.5%)	50 (7.3%)	0.33
PVL ≥ Moderate	4 (4.5%)	8 (1.2%)	0.017

# Death and Stroke



# Optimal TAVR by BEV for Bicuspid AV

- We need more experiences.
- Case selection is important
- The incidence of paravalvular leakage is increased compared to tricuspid aortic valve cohorts undergoing TAVR.
- Aortic injury should be cautious.
- TAVR for bicuspid AS is not associated with excess risk of mortality and stroke.
- S3 implantation on bicuspid AV is not generally different from S3 implantation on tricuspid AV.
- **Don't Do Oversizing, Undersizing is Safe and Effective in Bicuspid AS**