CT Algorithm for Optimal TAVR With Sapien 3

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Conflict of Interest Statement

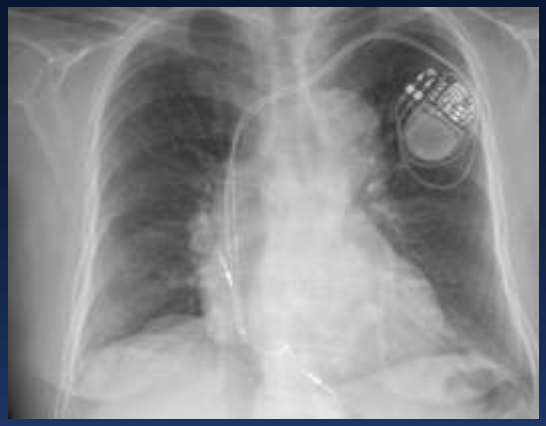
I have nothing to disclose.

Comprehensive Pre-TAVR CT Evaluation

1. Suitable Aortic Root Anatomy
2. Device and Size Selection
3. Coronary Disease Status
   - Avoid Routine Pre-TAVR Angiogram
4. Access Site Assessment
5. Optimal Fluoroscopic Projection Angulation

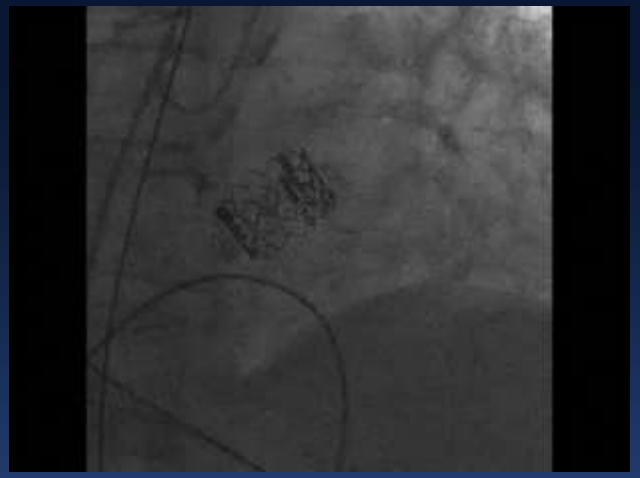
Valve Sizing Matters

Oversize ⟷ **Undersize**



Permanent Pacemaker

PVL



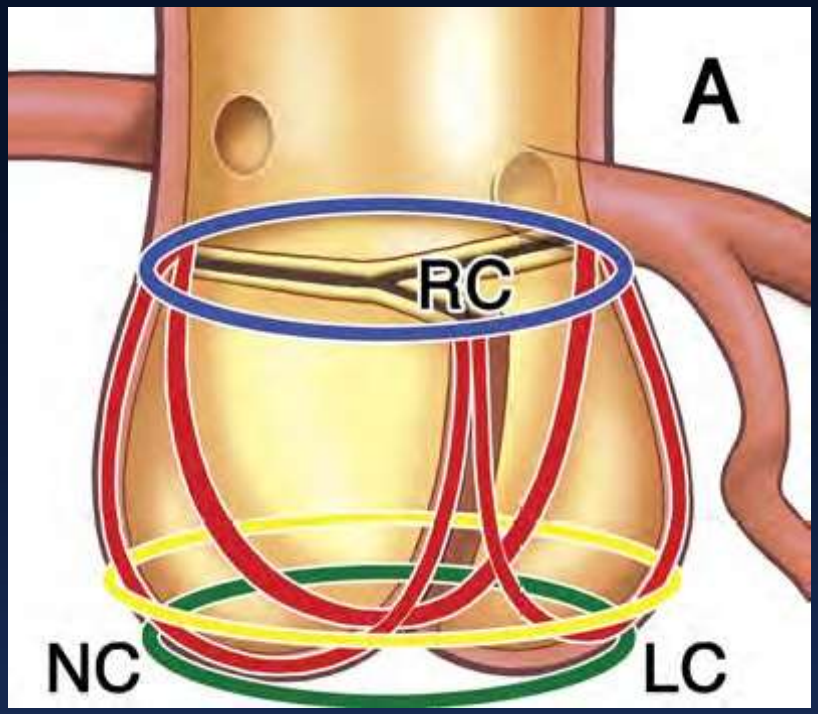
VS.

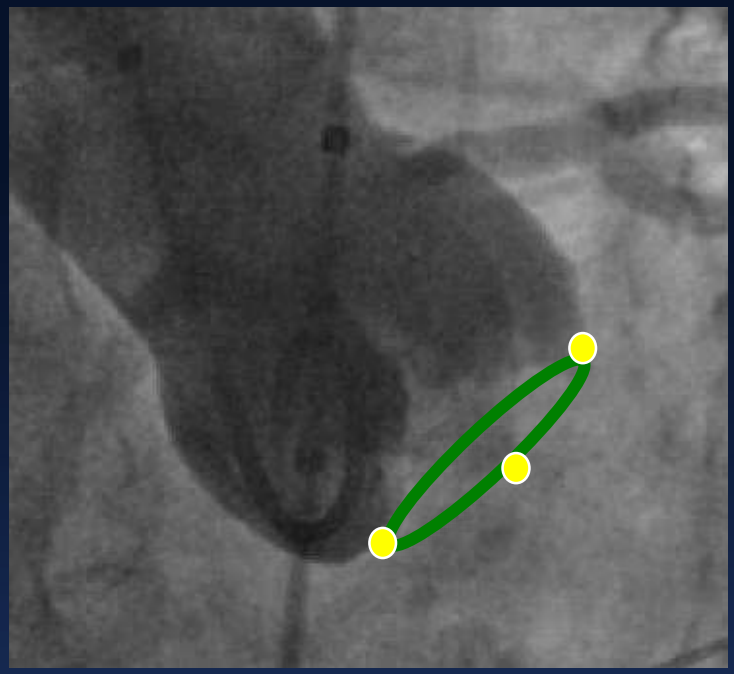
Annular Rupture

Embolization

Virtual Basal Ring

Correct Assessment of Annulus Size





Sinotubular junction

Aortic leaflets

Aortoventricular junction

Aortic Annulus
: virtual ring formed by base of AV leaflets

RC = Right coronary cusp; NC = Non-coronary cusp; LC = Left coronary cusp

Leipsic et al JACC Imaging 2011

Optimal CT Acquisition

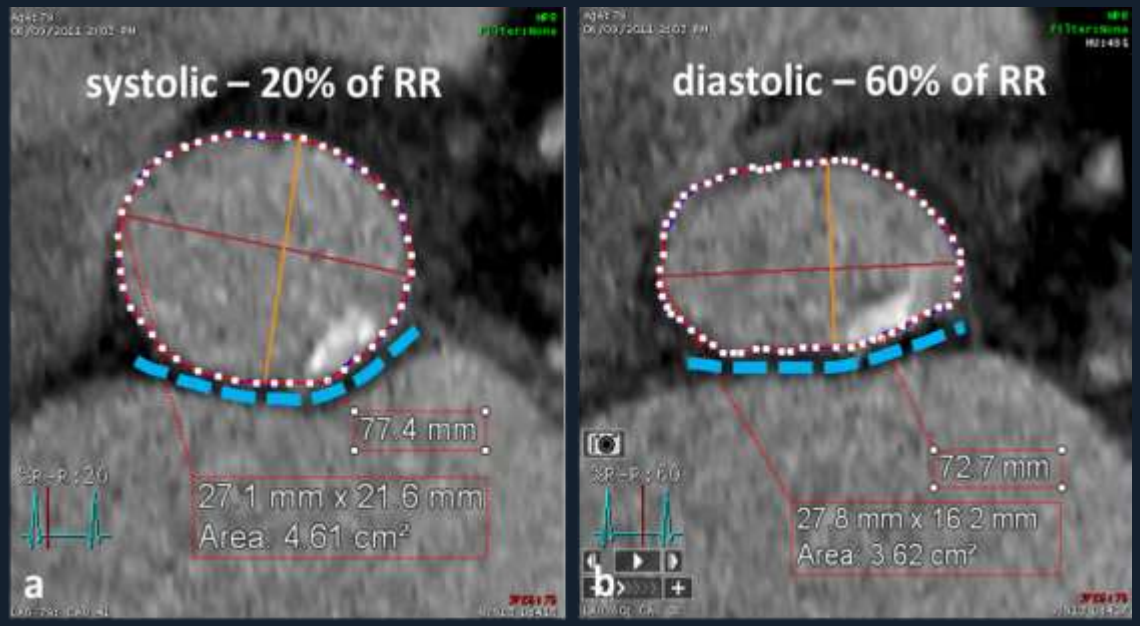
- ECG gated Chest CTA
  - Prospective or retrospective gating
  - ≤ 0.8 mm slice thickness
  - 30 or 40% end-systolic phase
- Abdominal/Pelvic CTA
  - Gating not required
  - Slice thickness ≤ 1.0 mm

Annular dynamism

- Annular size changes throughout cardiac cycle

  → Measurement at end-systolic phase

- Check the diastolic phase in case of septal hypertrophy



Blanke P et al. JACC Cardiovasc Interv. 2012;5(9):984-94

Balloon-Expandable SAPIEN 3 Valve

$$\textbf{Area Oversizing \%} = \frac{nominal\ Sapien\ 3\ area}{Systolic\ annular\ area} \times 100$$

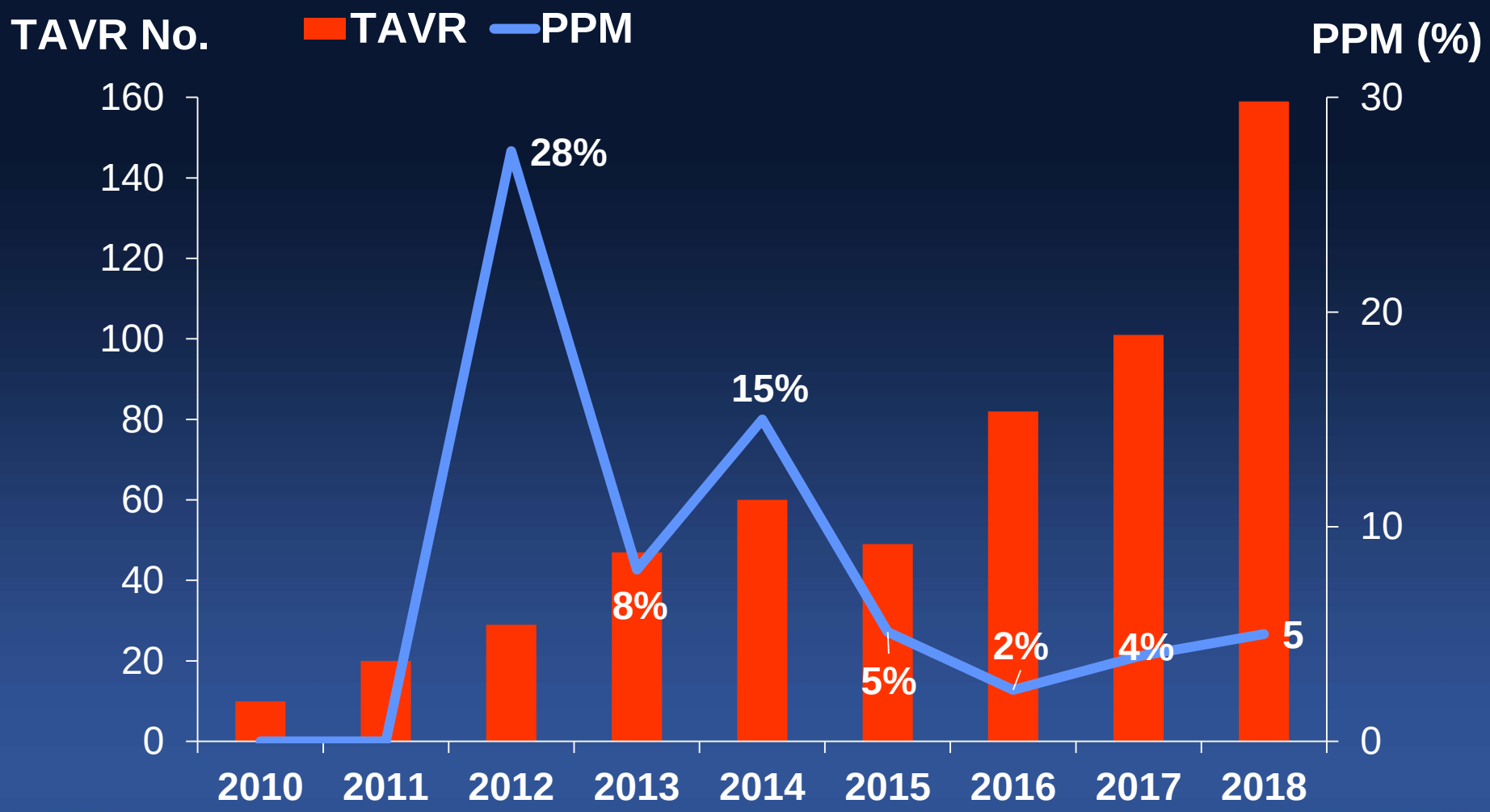
Adjusting S3 Sizing By Balloon Volume (Over or Under filled)

22 mm	- 1cc
23 mm	
24 mm	+ 1cc
25 mm	- 2cc
26 mm	
27mm	+ 2cc
28mm	- 3cc
29 mm	
30 mm	+ 3cc

Predictors of PPM implantation

	Odds Ratio [95% CI]	p-value
Age (per 10 years)	2.65 [1.24 – 5.64]	0.011
RBBB	4.38 [1.70 – 11.32]	0.002
Older-generation valves	3.47 [1.26 – 9.57]	0.016
Annulus area oversizing by CT (per 1%)	1.02 [1.003 - 1.04]	0.024

PPM After TAVR in AMC

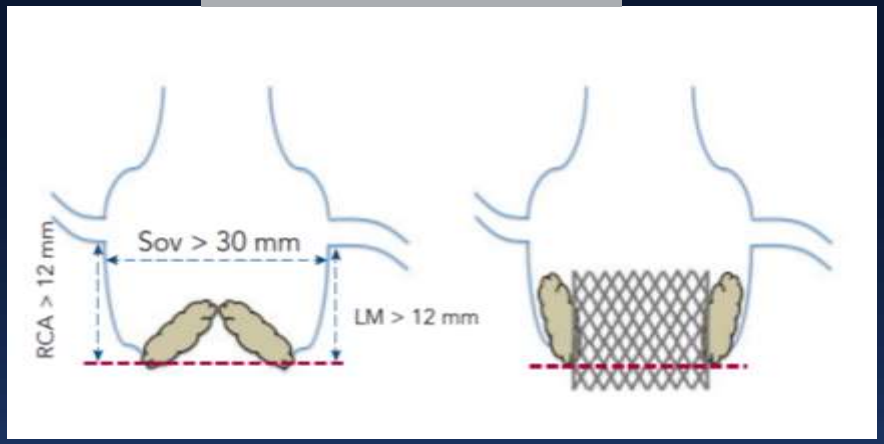


Predictors of PVL ≥ moderate

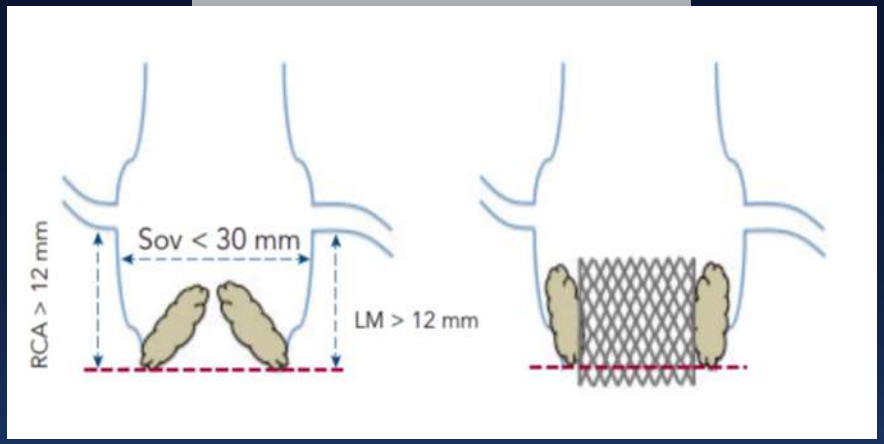
	Odds Ratio [95% CI]	p-value
Total amount of annulus calcium by CT (per 100 mm^3)	1.26 (1.10 – 1.45)	0.001

Risk of Coronary Obstruction

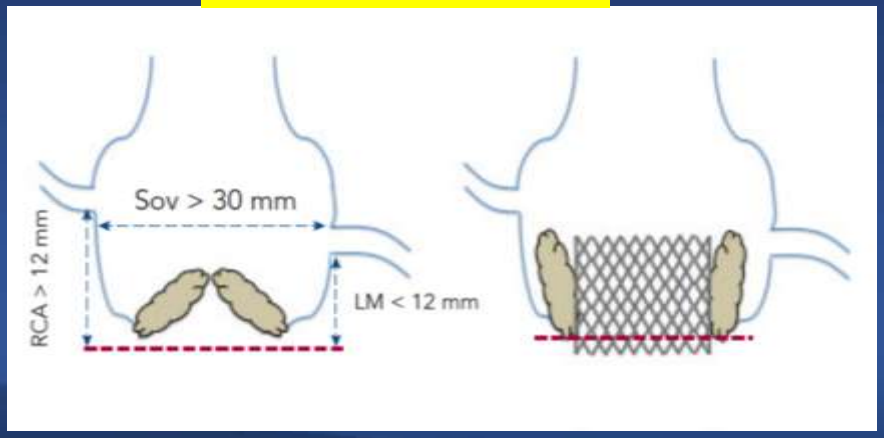
Wide and High



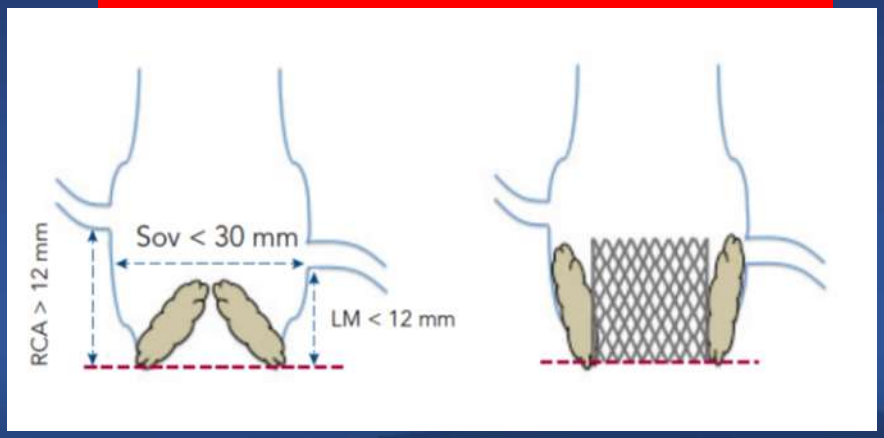
Shallow and High



Wide and Low



Shallow and Low (<12mm)

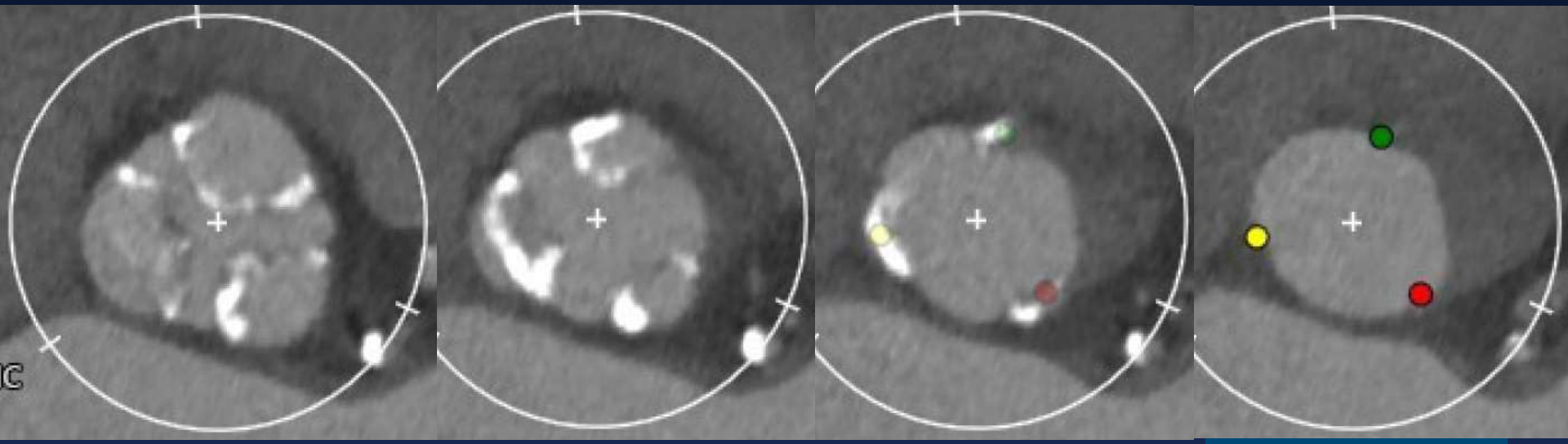


S3 Area Oversizing Based on the CT

15%, Cutoff

Low Calcification (Ca volume < 400 mm^3)	*15%, then Overfill*
Heavy Calcification (Ca volume > 400 mm^3)	*10%, then Overfill*
Small Sinus Valsalva with Low coronary height	*10%, then Overfill*
Bicuspid AS and Heavy Calcification	*0%, then Overfill*

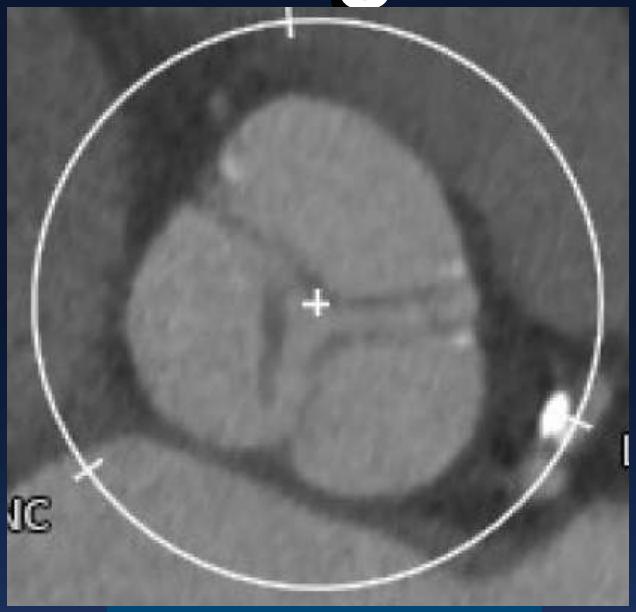
Case #1, 85/M with Severe AS



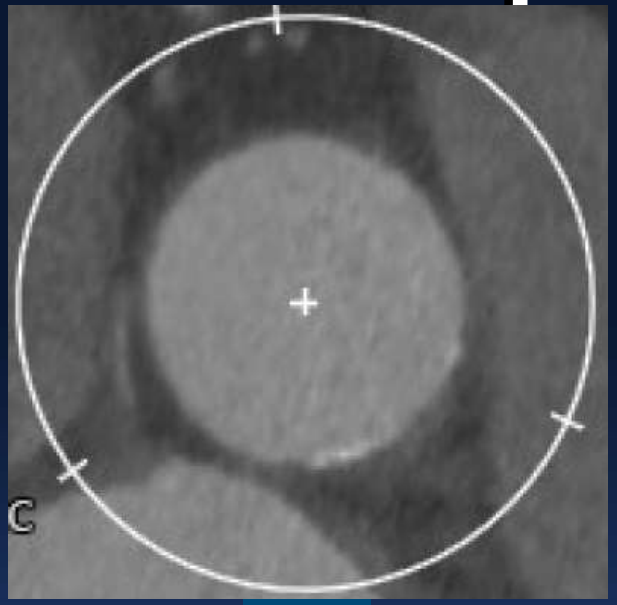
Annulus plane

Aortic Annulus parameters	
Annulus short diameter	21.8 mm
Annulus long diameter	25.6 mm
Annululs mean diameter	23.7 mm
Annulus area	435 mm^2
Annulus area-driven diameter	23.5 mm
Annulus perimeter	74.5 mm
Annulus perimeter-driven diameter	23.7 mm

CT findings – Aortic Valve Complex



Sinus of Valsalva

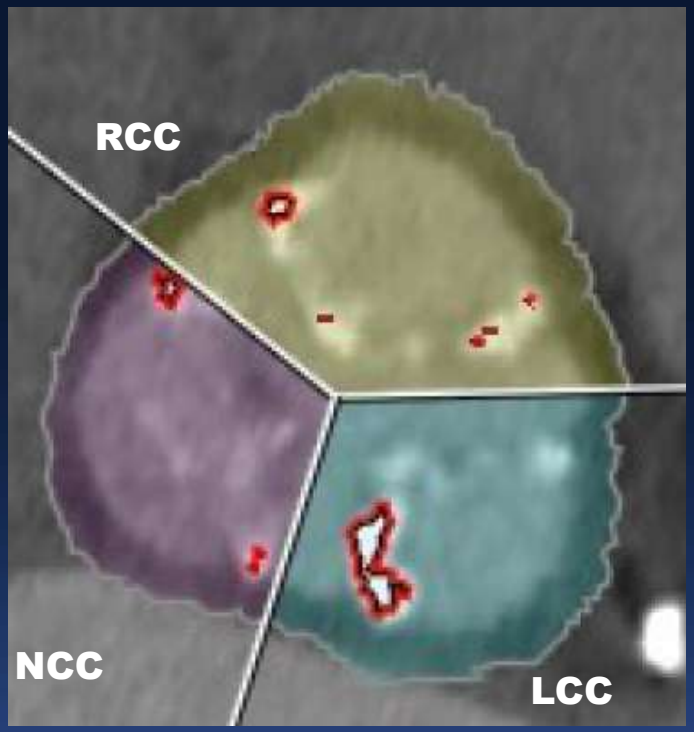


STJ

Sinus of Valsalva		STJ	
Area	830 mm^2	Area	630 mm^2
Sinus / Annulus Area Ratio	1.91	STJ/ Annulus Area Ratio	1.45
NCC diameter	30.6 mm	Mean diameter	28.2 mm
LCC diameter	33.5 mm		
RCC diameter	31.0 mm		

Mean Sinus / Annulus Area Ratio 1.83 ± 0.27 **Mean STJ / Annulus Area Ratio** 1.49 ± 0.29

Calcium Amount



Calcium volume	
NCC	84 mm^3
RCC	62 mm^3
LCC	48 mm^3
Total	194 mm^3

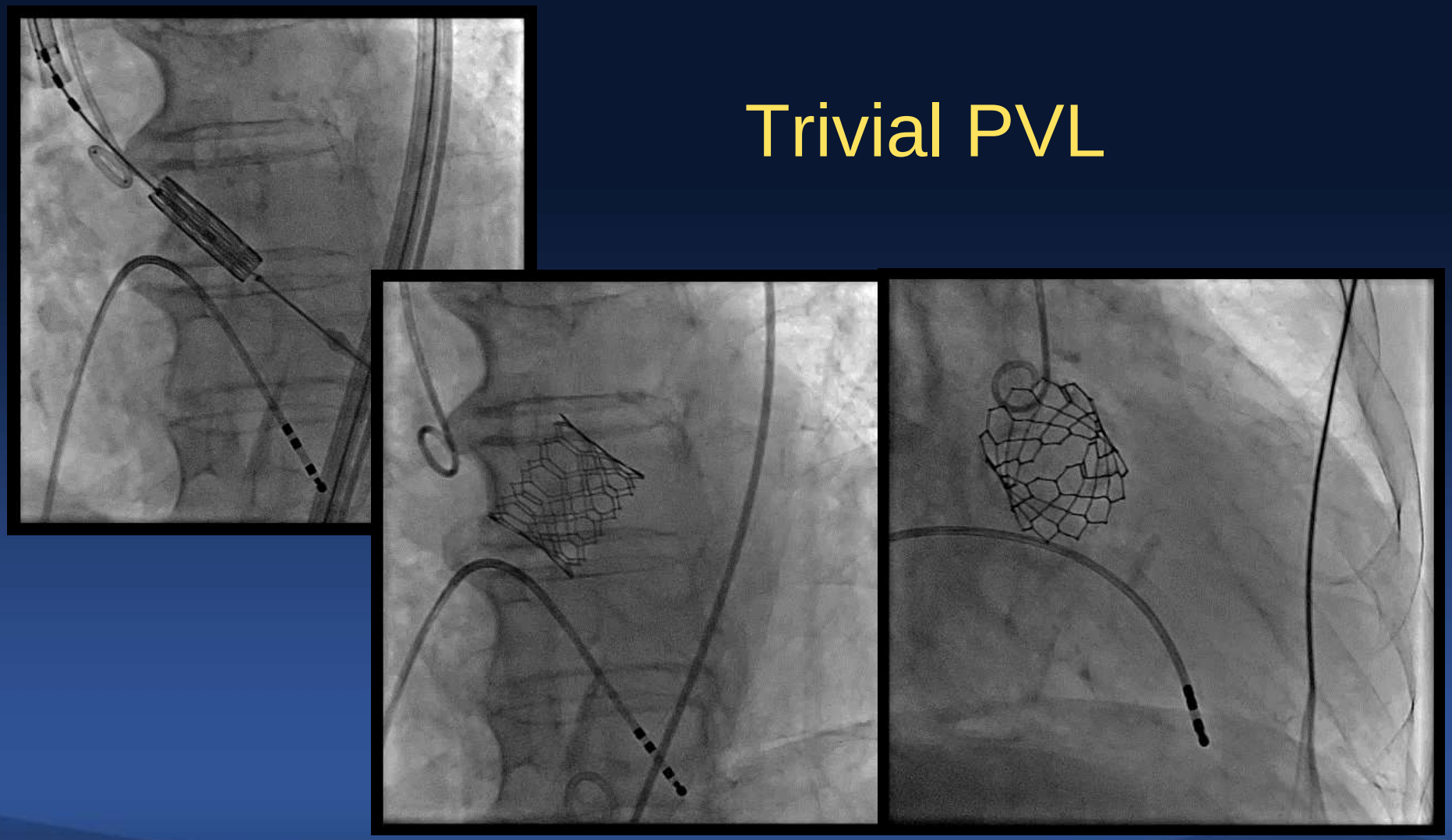
S3 Area Oversizing Based on the CT ***15%, Cutoff***

Low Calcification (Ca volume < 400 mm^3)	*15%, then Overfill*
Heavy Calcification (Ca volume > 400 mm^3)	*10%, then Overfill*
Small Sinus Valsalva with Low coronary height	*10%, then Overfill*
Bicuspid AS and Heavy Calcification	*0%, then Overfill*

I choose
S3 26mm and 1cc Underfill

Size	Area_oversize (%)	Perimeter_oversize (%)
23	94.0	95.9
24	102.4	100.1
25	111.1	104.2
26	119.3	108.4
27	128.7	112.6
28	138.4	116.7
29	149.2	121.2

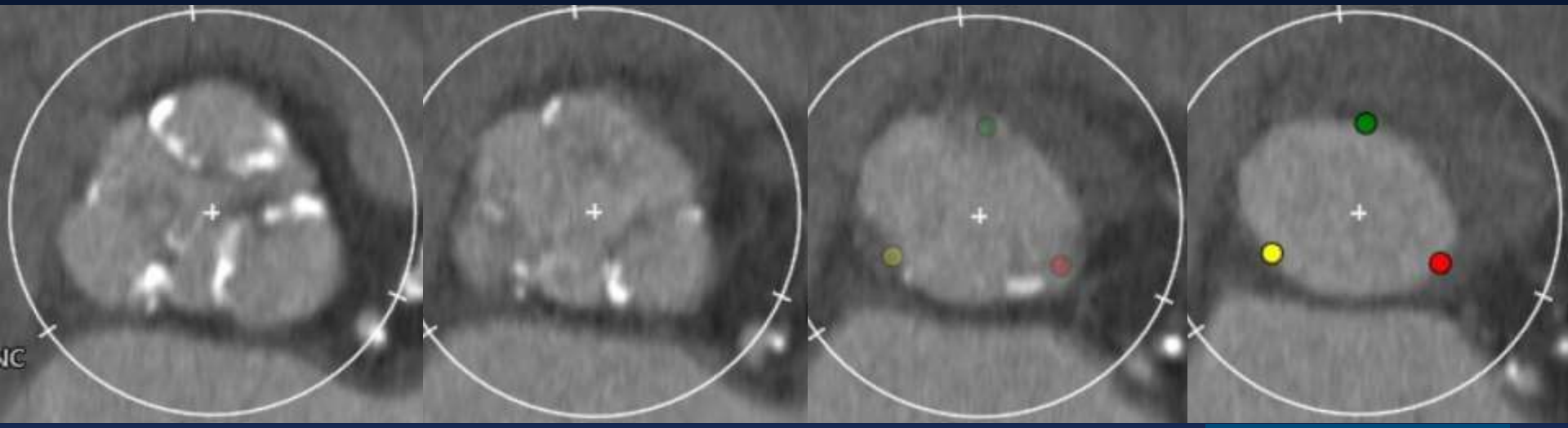
S3 26mm and 1cc Underfill



Trivial PVL

Case #2, 78/M with Severe AS

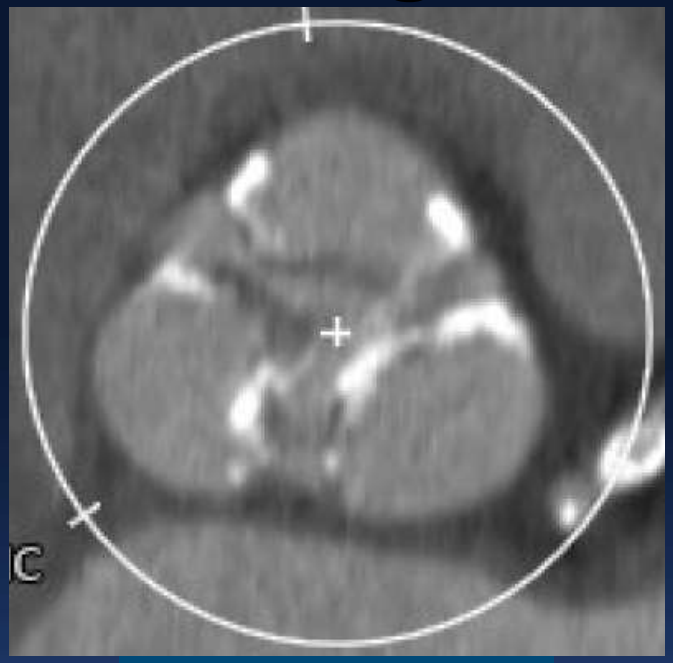
Post-dilation



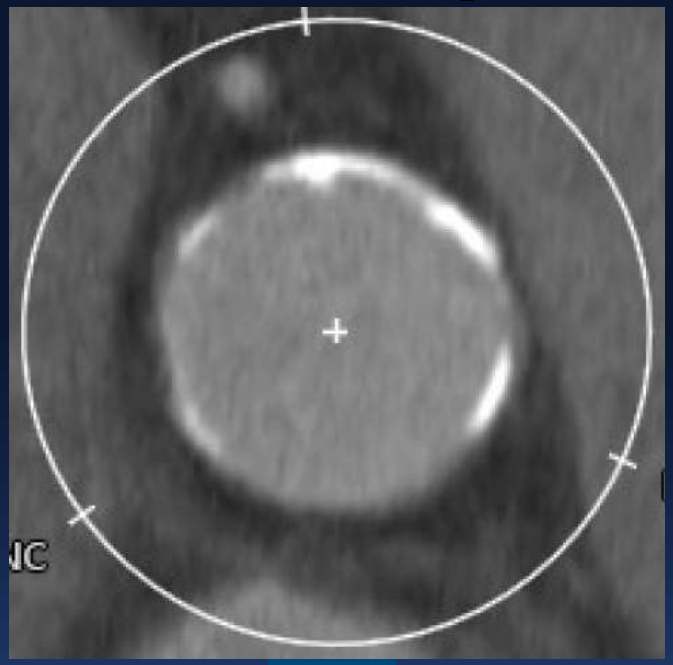
Annulus plane

Aortic Annulus parameters	
Annulus short diameter	22.0 mm
Annulus long diameter	28.2 mm
Annululs mean diameter	24.6 mm
Annulus area	474 mm^2
Annulus area-driven diameter	24.6 mm
Annulus perimeter	78.5 mm
Annulus perimeter-driven diameter	25.0 mm

CT findings – Aortic Valve Complex



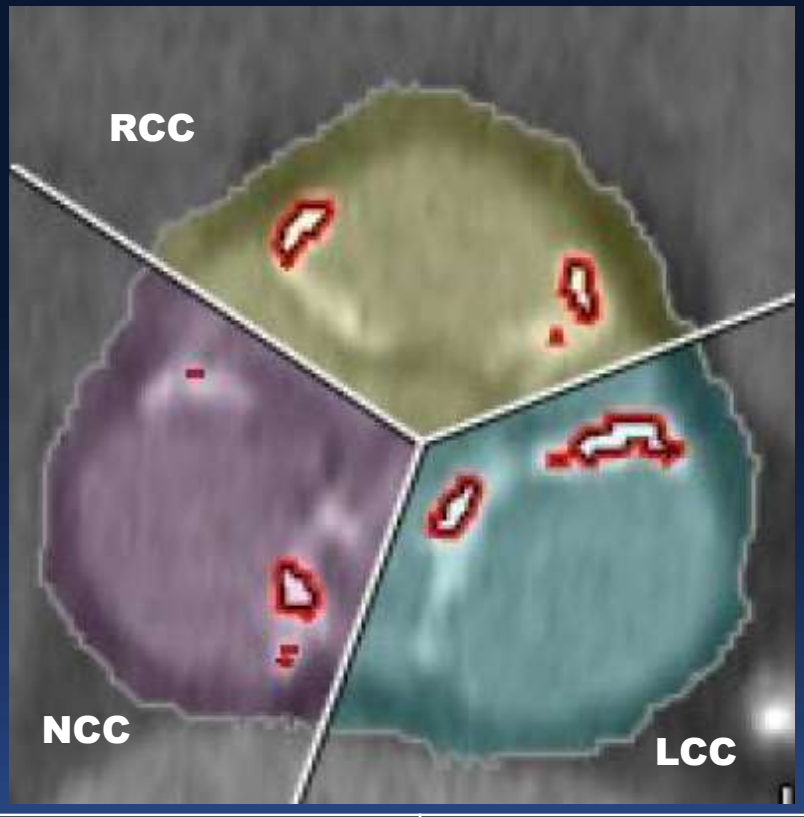
Sinus of Valsalva



STJ

Sinus of Valsalva		STJ	
Area	842 mm^2	Area	626 mm^2
Sinus / Annulus Area Ratio	1.78	STJ/ Annulus Area Ratio	1.32
NCC diameter	33.5 mm	Mean diameter	28.2 mm
LCC diameter	32.7 mm		
RCC diameter	31.2 mm		
Mean Sinus / Annulus Area Ratio	**1.83 ± 0.27**	**Mean STJ / Annulus Area Ratio**	**1.49 ± 0.29**

Calcium Amount

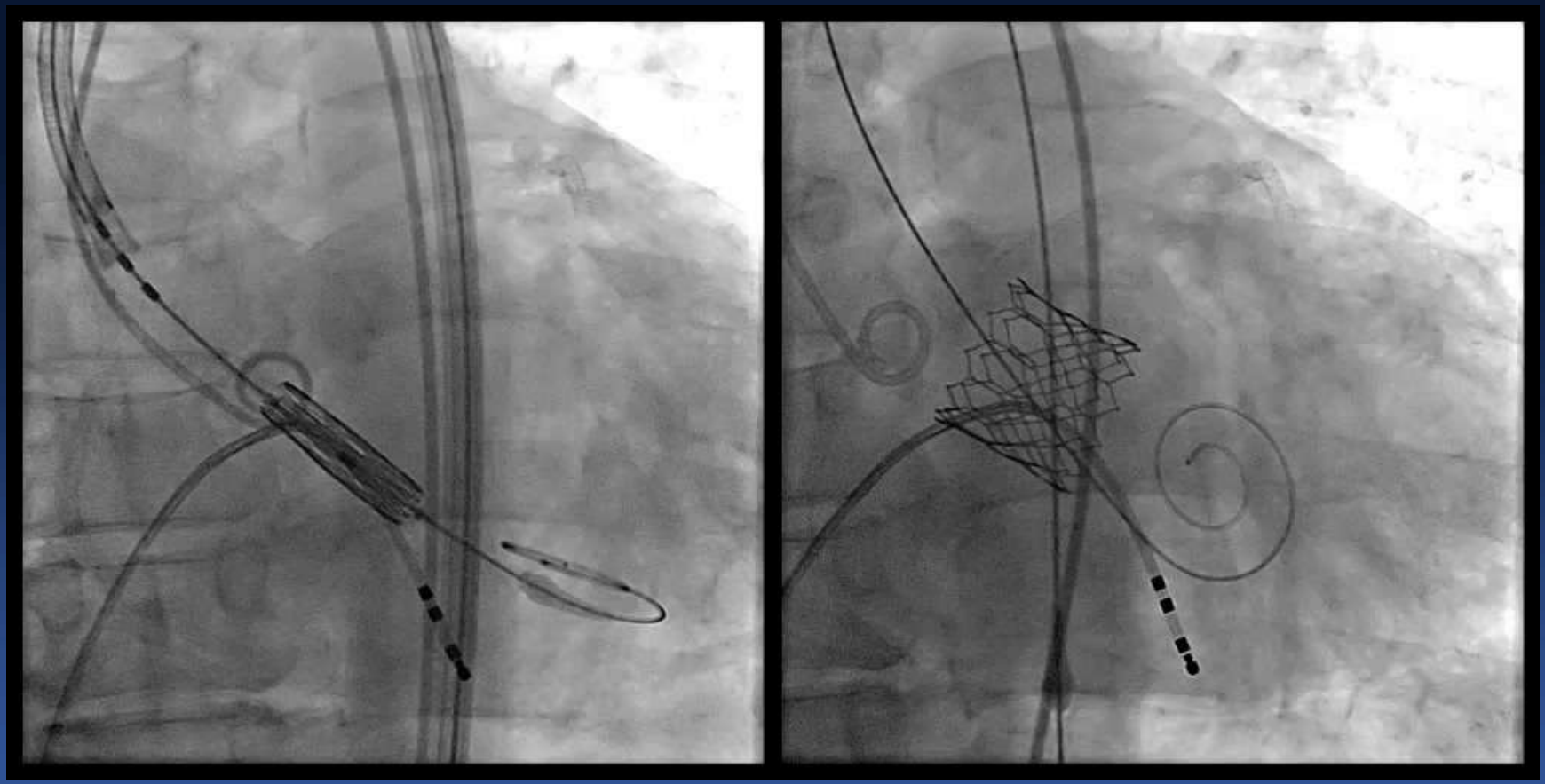


Calcium volume	
NCC	22 mm^3
RCC	48 mm^3
LCC	68 mm^3
Total	138 mm^3

S3 26mm (9.5% Oversizing)

Size	Area_oversize (%)	Perimeter_oversize (%)
23	86.3	91.0
24	94.0	95.0
25	102.0	98.9
26	109.5	102.8
27	118.1	106.8
28	127.0	110.7
29	136.9	115.0

S3 26 mm (9.5% Over sizing)

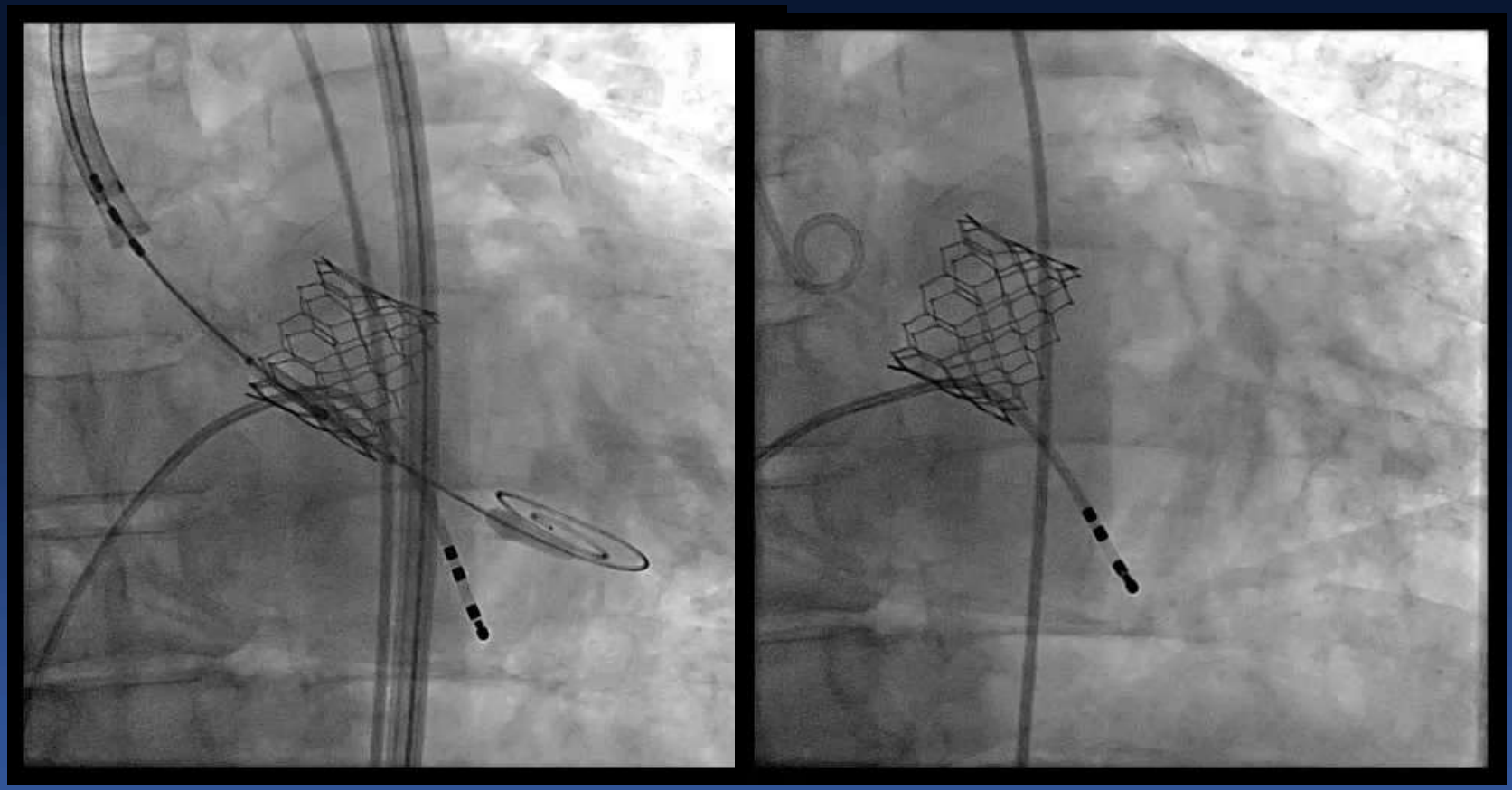


Moderate to Severe PVL

Post-dilation with +2cc Overfill (18% Oversizing)

Size	Area_oversize (%)	Perimeter_oversize (%)
23	86.3	91.0
24	94.0	95.0
25	102.0	98.9
26	109.5	102.8
27	118.1	106.8
28	127.0	110.7
29	136.9	115.0

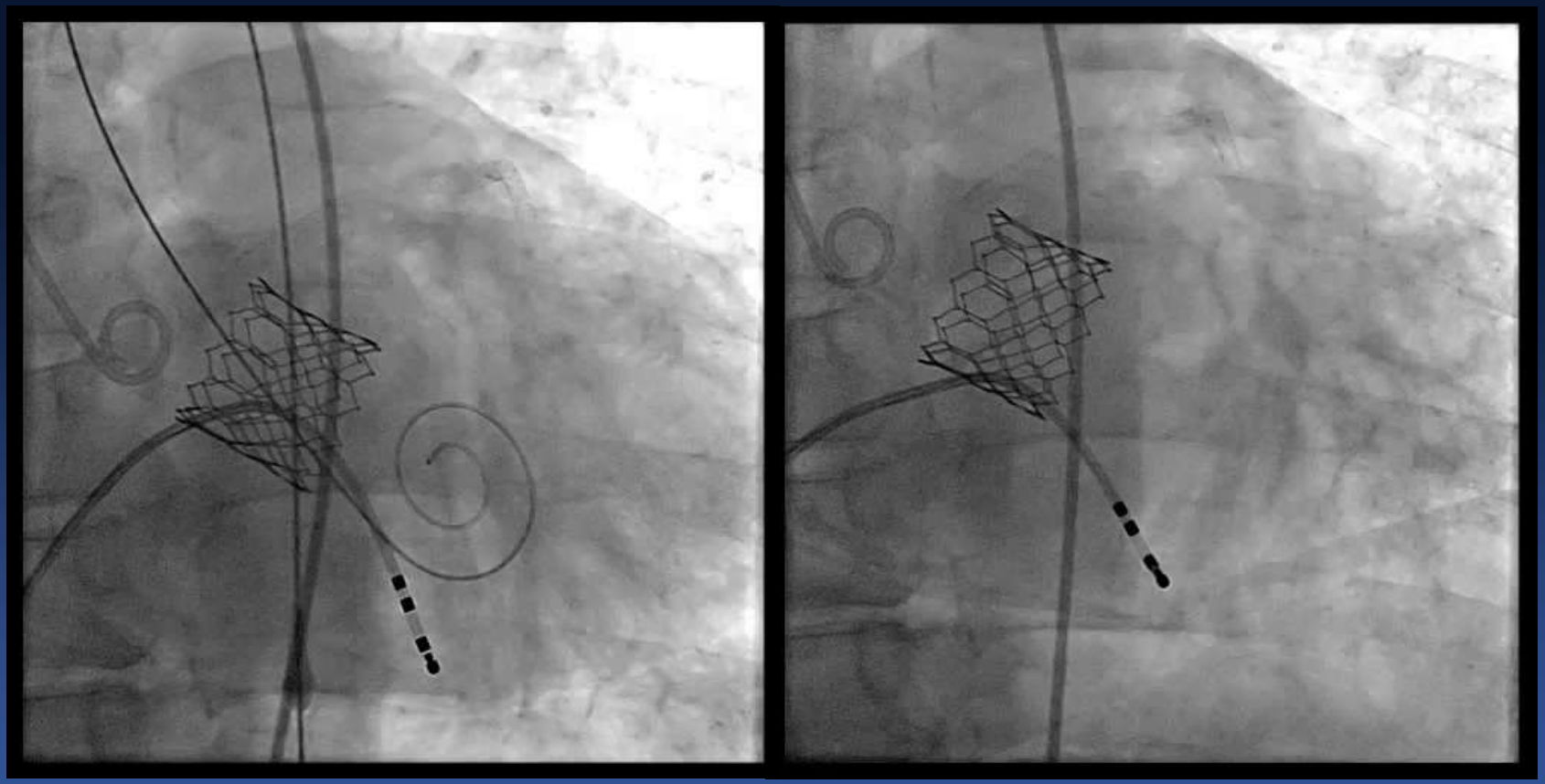
Post-dilation with +2cc Overfill (18% Oversizing)



Trivial PVL

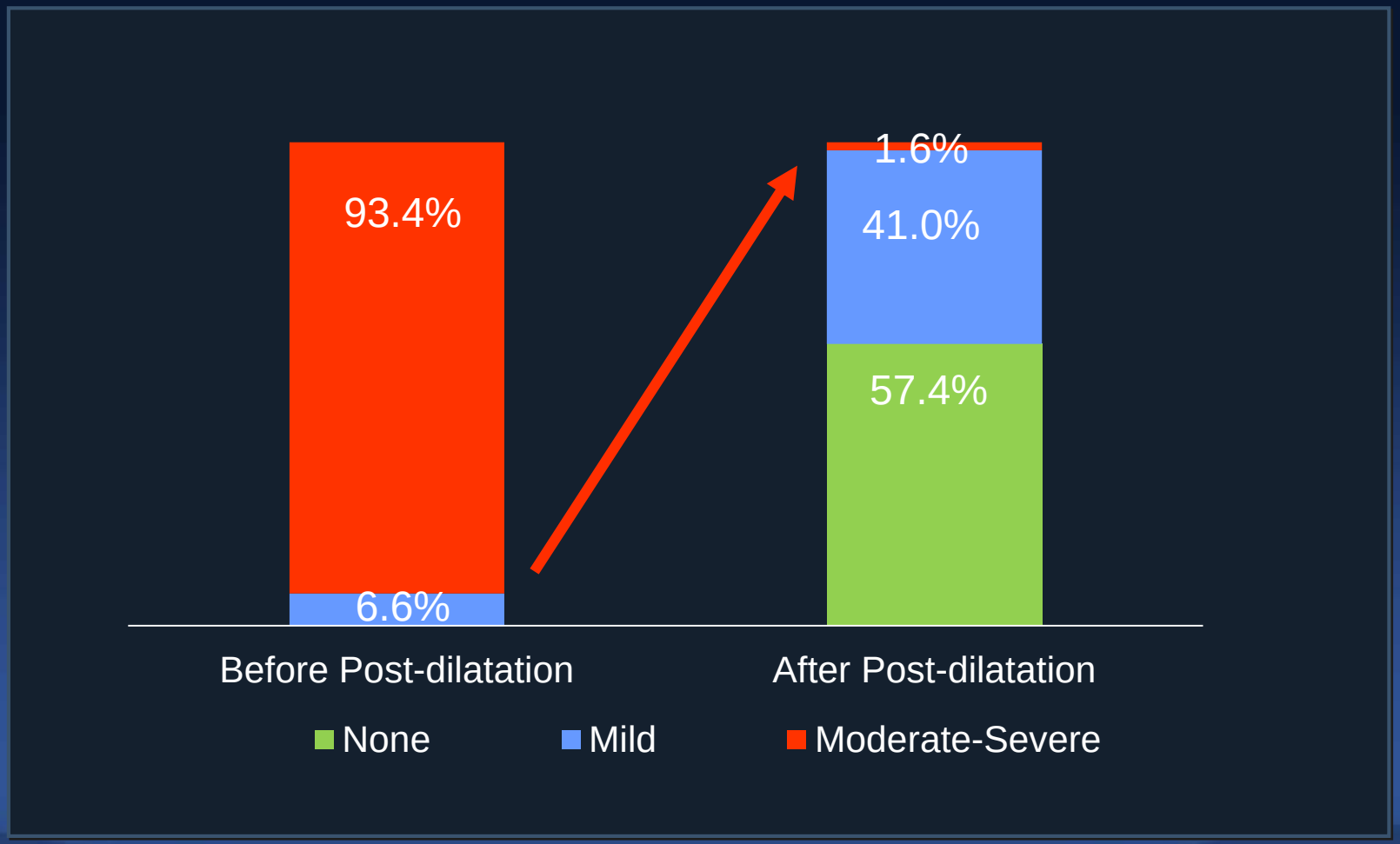
S3 26 mm
(9.5% Oversizing)

+2cc Overfill Post-Dilation
(18% Oversizing)



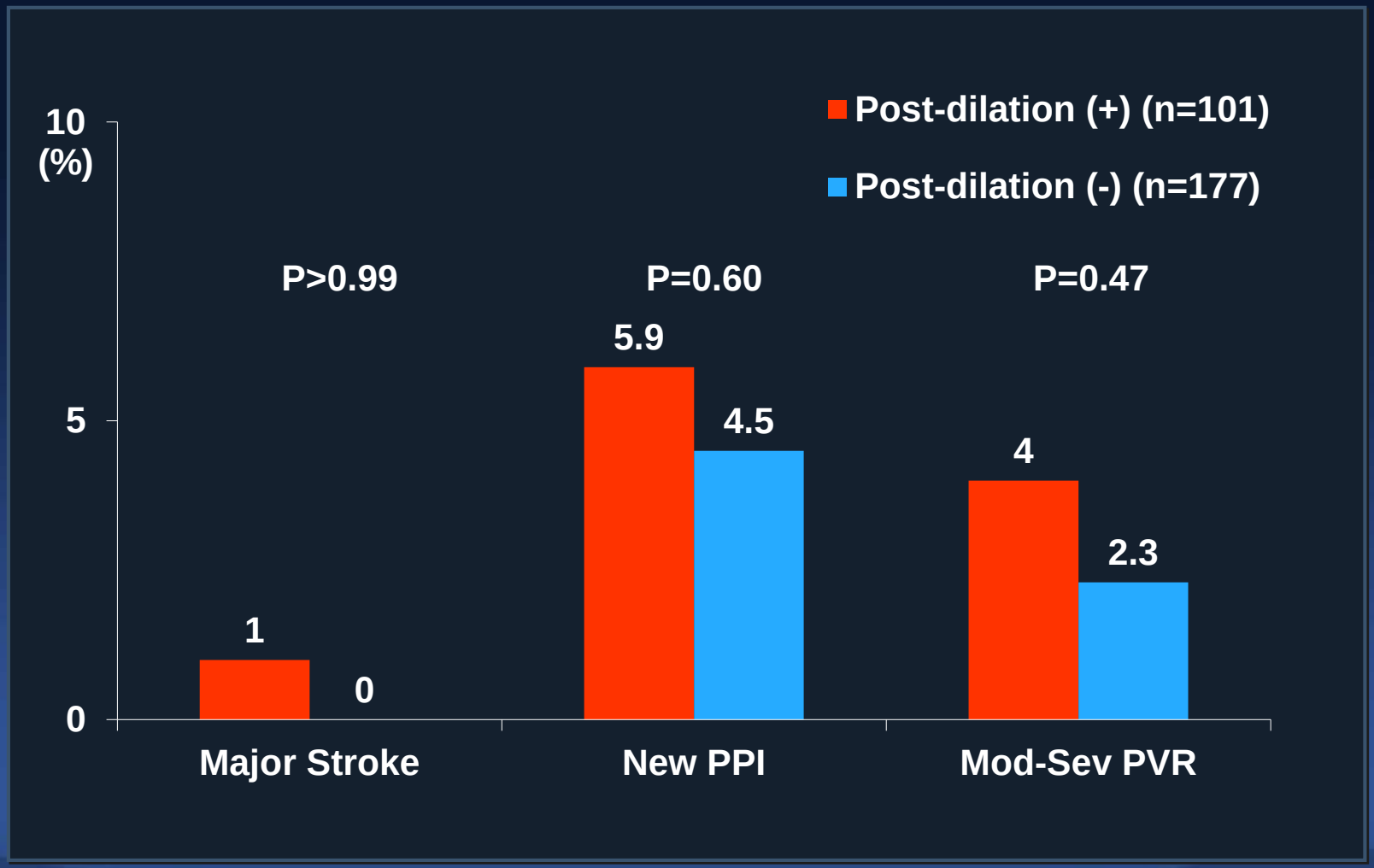
We make a difference!

The impact of Post-Dilatation (n=101)



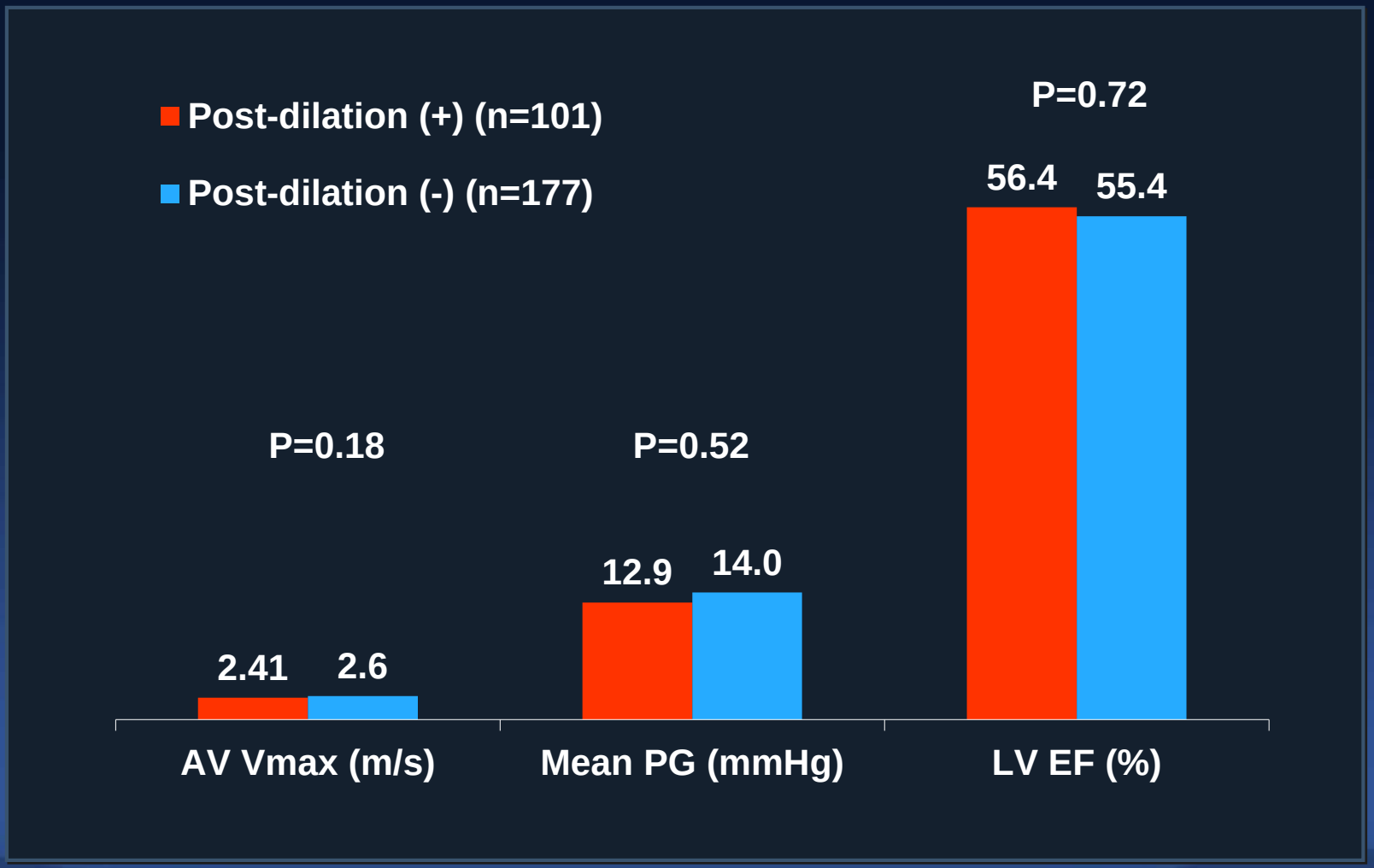
Post-dilation was safe and effective

Clinical Outcomes at 1 month after TAVR



Post-dilation was safe and effective

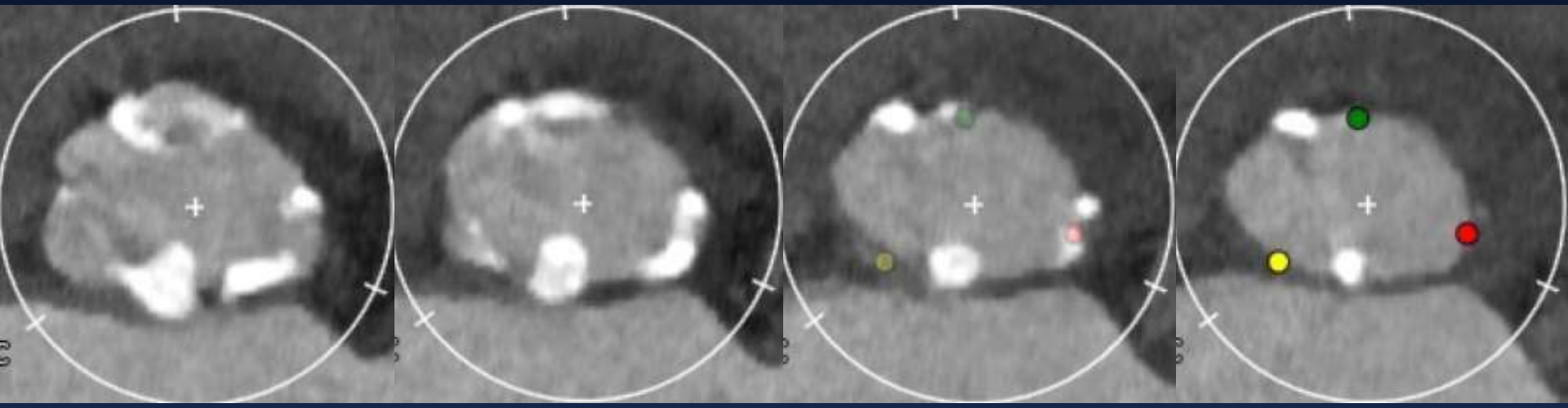
EchoCG at 1 month after TAVR



Outcomes after TAVR

Standard Performance (VARC-2*) for High-Risk AS patients (@ 30 days)		***AMC Total*** (n=533)	***S3 Tricuspid*** (n=232)
• All-cause mortality	< 3%	2.6%	1.3%
• Major (disabling) strokes	< 2%	1.5%	0.4%
• Major vascular complications	< 5%	4.5%	1.7%
• New permanent pacemakers	< 10%	8.4%	3.9%
• Mod-severe PVR	< 5%	8.6%	1.7%

Case #3, 90/M with Severe AS, PCI Hx, AF

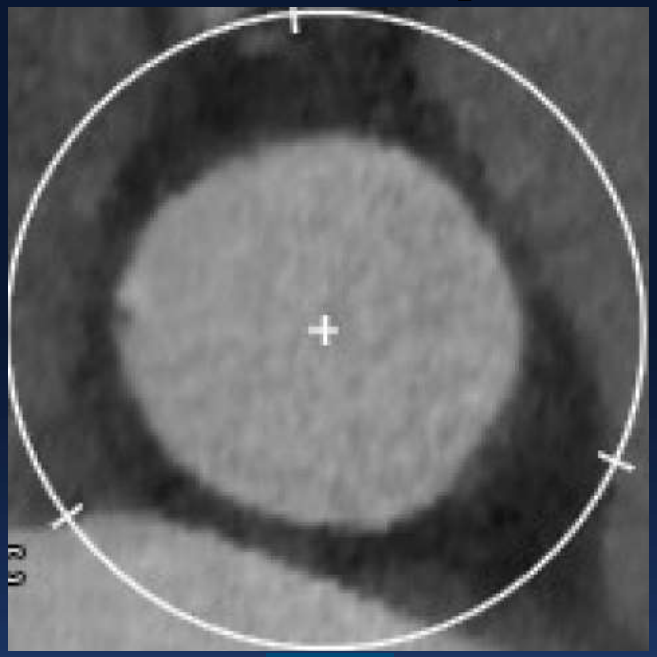


Annulus plane

Aortic Annulus parameters	
Annulus short diameter	20.8 mm
Annulus long diameter	30.8 mm
Annululs mean diameter	25.8 mm
Annulus area	507 mm^2
Annulus area-driven diameter	25.4 mm
Annulus perimeter	82.8 mm
Annulus perimeter-driven diameter	26.3 mm

CT findings – Aortic Valve Complex

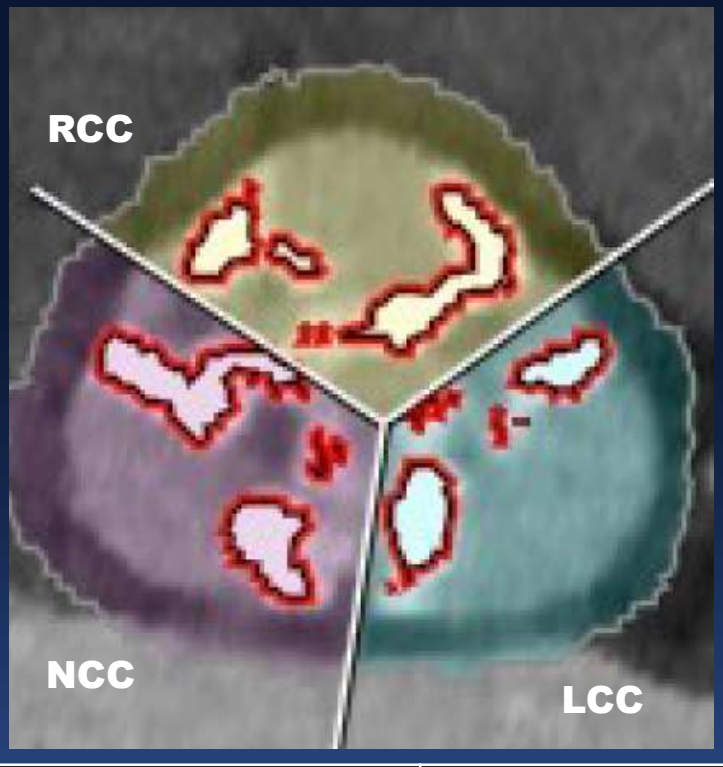
Sinus of Valsalva



STJ

Sinus of Valsalva		STJ	
Area	927 mm^2	Area	750 mm^2
Sinus / Annulus Area Ratio	1.83	STJ/ Annulus Area Ratio	1.48
NCC diameter	35.1 mm	Mean diameter	31.0 mm
LCC diameter	36.7 mm	Height of STJ	24.7 mm
RCC diameter	31.8 mm		
Mean Sinus / Annulus Area Ratio	**1.83 ± 0.27**	**Mean STJ / Annulus Area Ratio**	**1.49 ± 0.29**

Calcium Amount

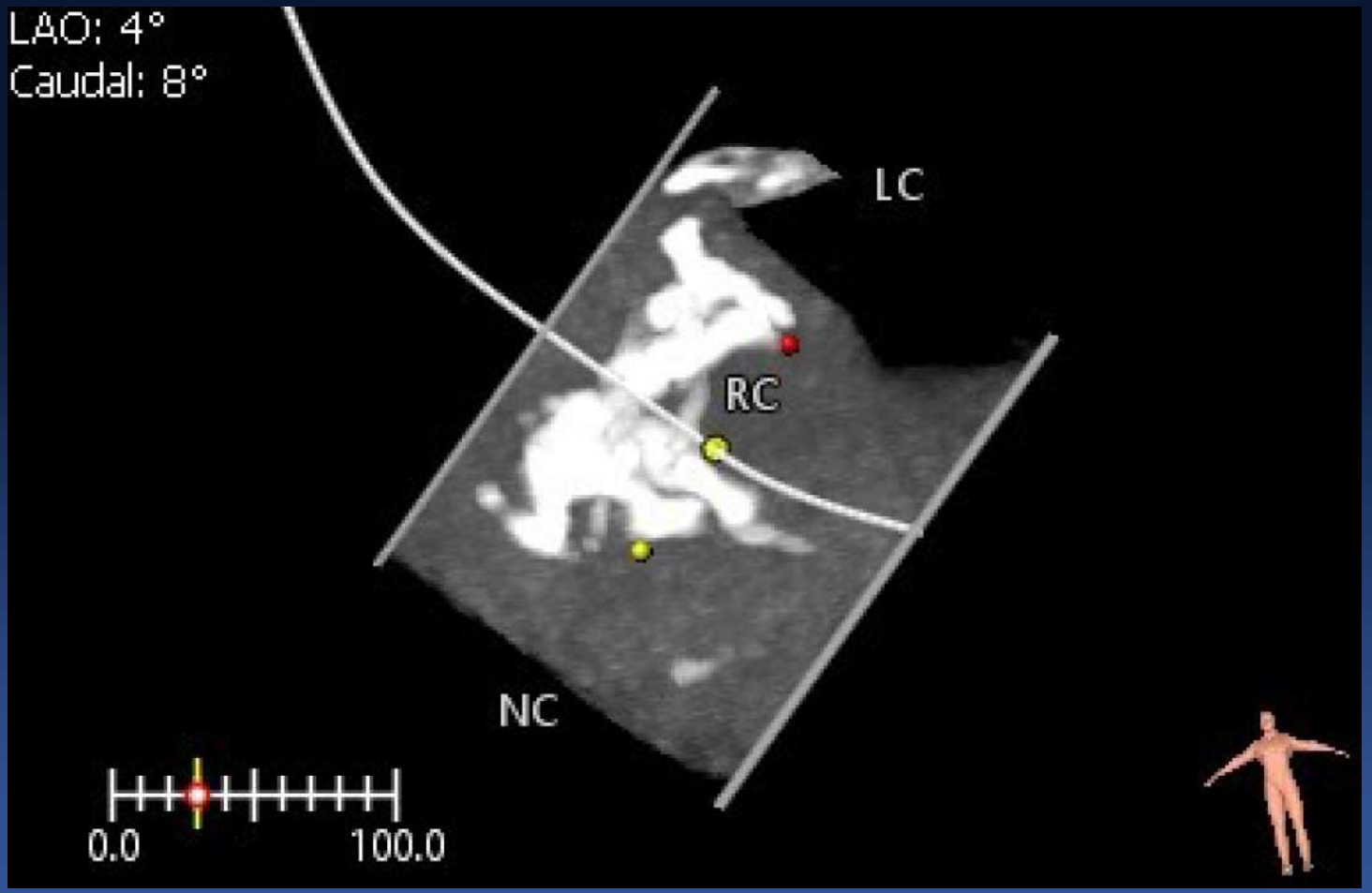


Heavy calcification

Calcium volume	
NCC	723 mm^3
RCC	438 mm^3
LCC	472 mm^3
Total	1633 mm^3

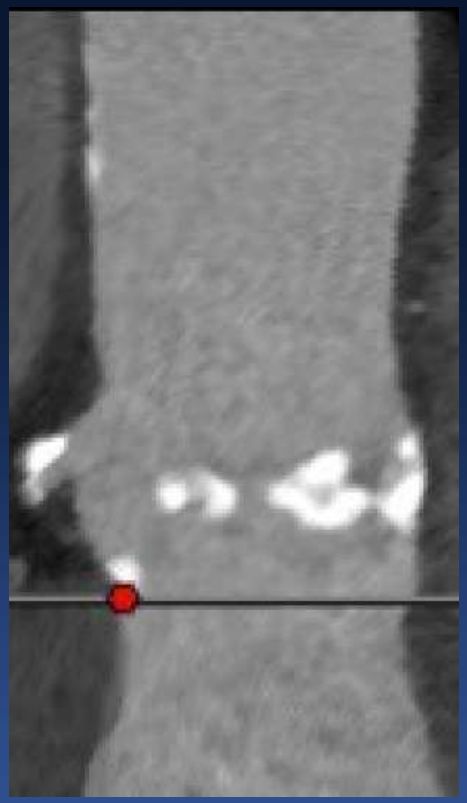
Mean Amount of total Calcium **355.4 ± 289.9**

Calcification of AV complex



CT findings – Coronary Height

LCA



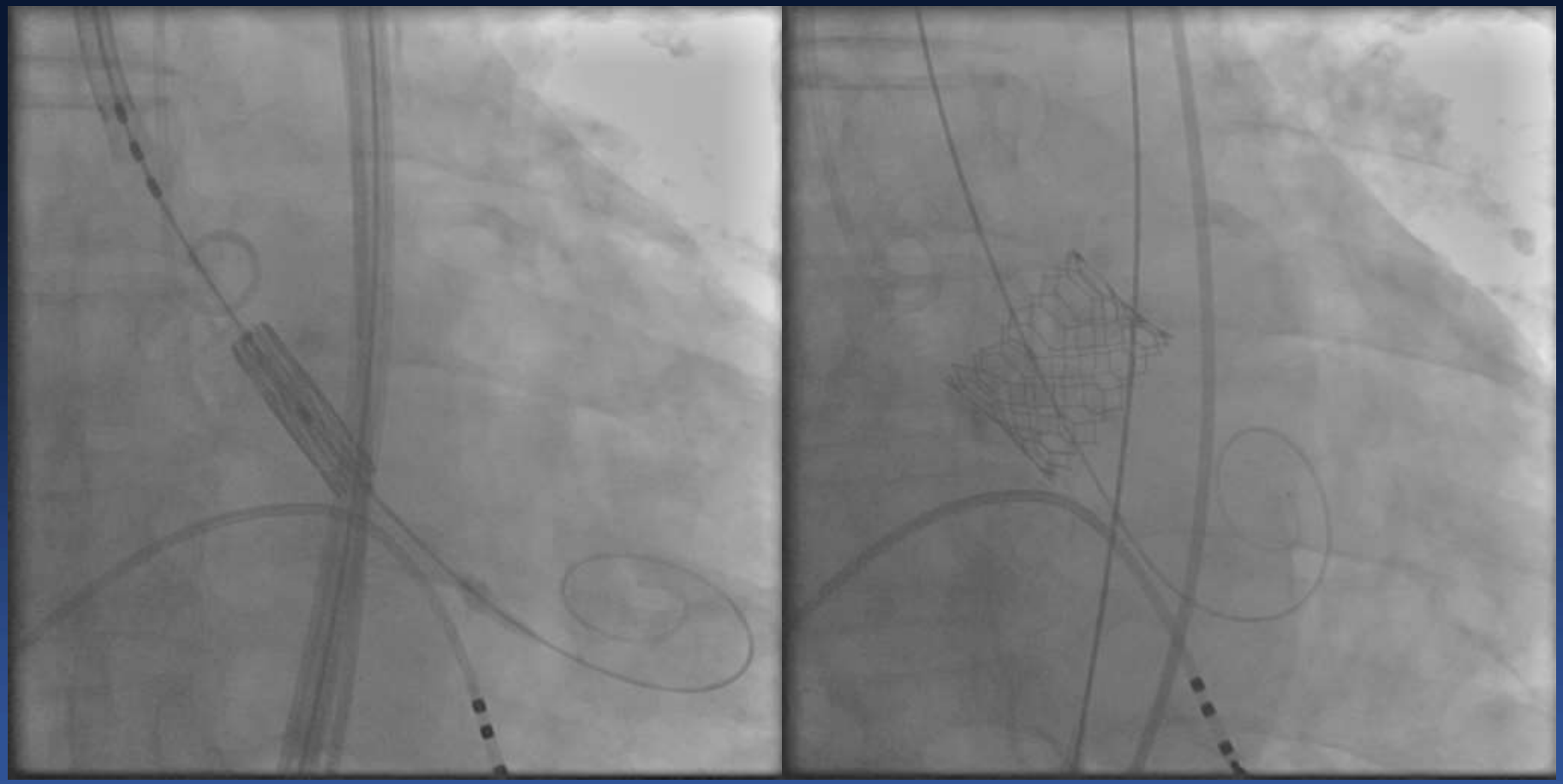
RCA

Coronary Height	
LCA	13.5 mm
RCA	17.7 mm

Begin with Smaller Degree of Oversizing
S3 26mm (2.3% Oversizing)

Size	Area_oversize (%)	Perimeter_oversize (%)
24	87.9	90.1
25	95.3	93.8
26	102.3	97.5
27	110.3	101.3
28	118.6	105.0
29	128.0	109.0
30	137.0	112.8

S3 26mm (2.3% Oversizing)



Moderate PVL

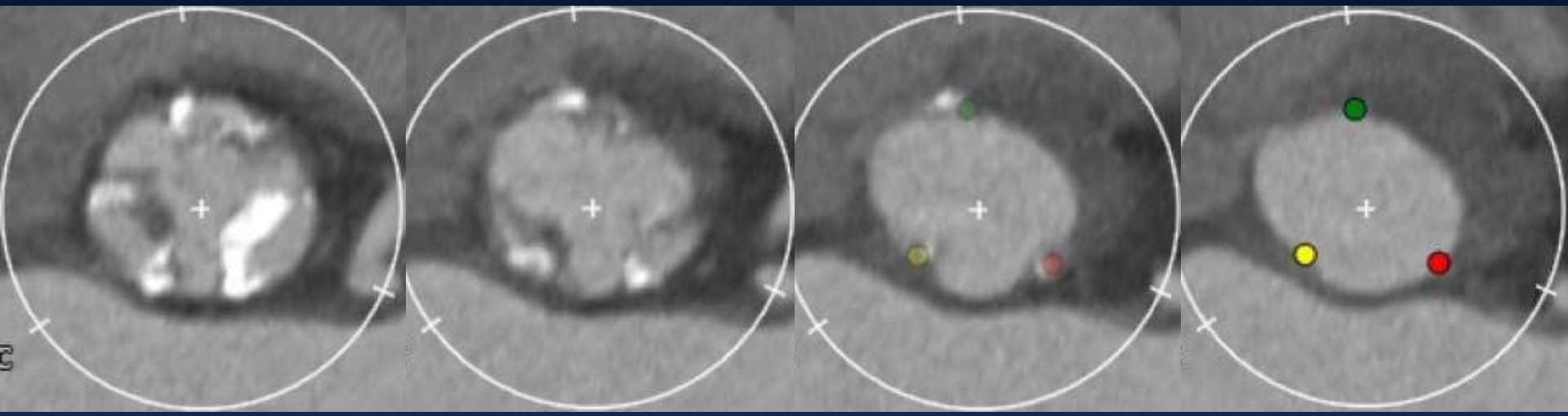
Post-dilation with +2cc Overfill (Up to 27mm, 10% Oversizing)

Size	Area_oversize (%)	Perimeter_oversize (%)
24	87.9	90.1
25	95.3	93.8
26	102.3	97.5
27	110.3	101.3
28	118.6	105.0
29	128.0	109.0
30	137.0	112.8

Post-dilation with +2cc Overfill (10% Oversizing)

Mild PVL

Case #4, 81/F with Severe AS

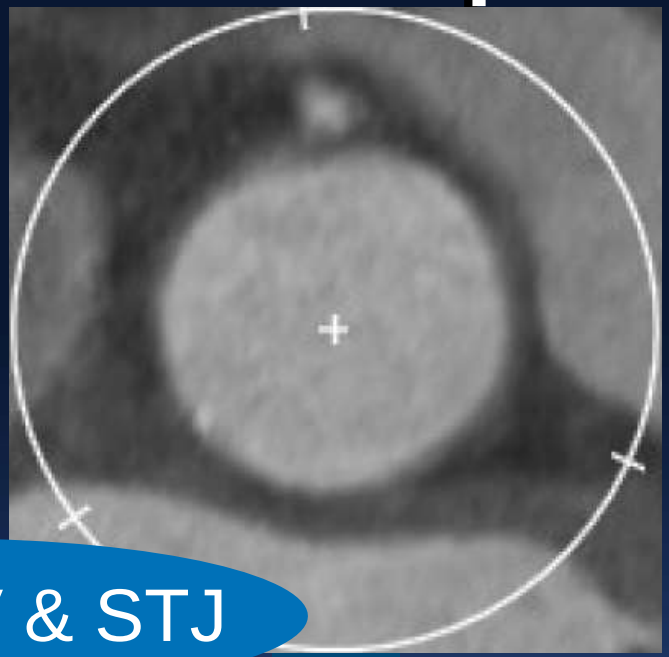


Annulus plane

Aortic Annulus parameters	
Annulus short diameter	21.2 mm
Annulus long diameter	27.8 mm
Annululs mean diameter	24.5 mm
Annulus area	458 mm^2
Annulus area-driven diameter	24.2 mm
Annulus perimeter	77.1 mm
Annulus perimeter-driven diameter	24.6 mm

CT findings – Aortic Valve Complex

Sinus of Valsalva

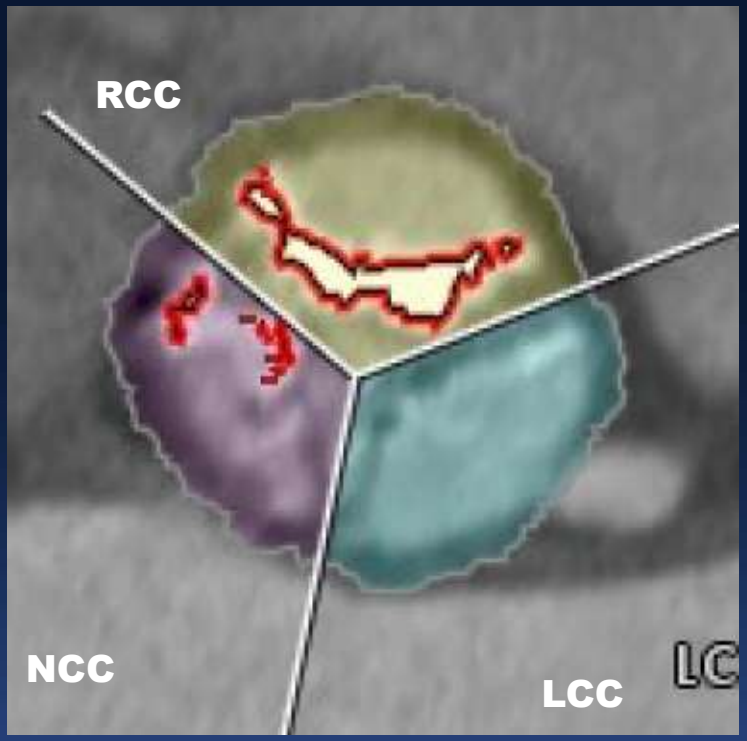


STJ

Small SoV & STJ

Sinus of Valsalva		STJ	
Area	582 mm^2	Area	552 mm^2
Sinus / Annulus Area Ratio	1.27	STJ/ Annulus Area Ratio	1.21
NCC diameter	26.9 mm	Mean diameter	26.2 mm
LCC diameter	27.9 mm		
RCC diameter	26.6 mm		
Mean Sinus / Annulus Area Ratio	**1.83 ± 0.27**	**Mean STJ / Annulus Area Ratio**	**1.49 ± 0.29**

Calcium Amount

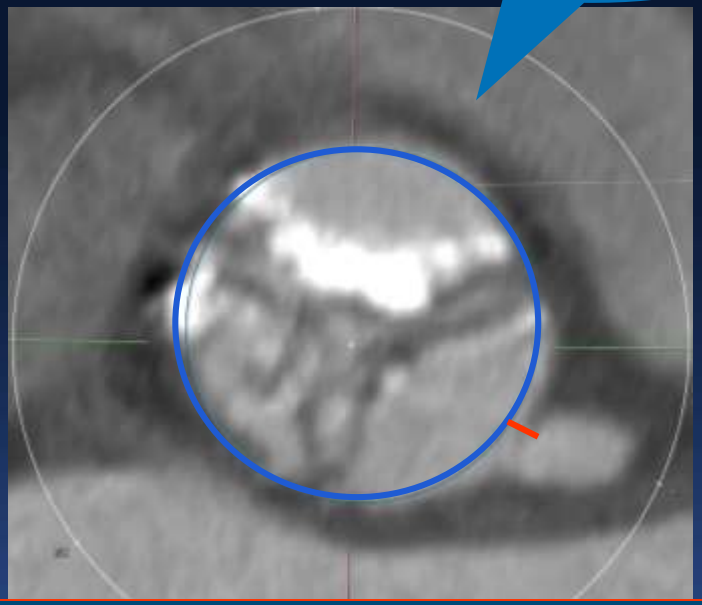


Calcium volume	
NCC	112 mm^3
RCC	201 mm^3
LCC	163 mm^3
Total	476 mm^3

Mean Amount of total Calcium **355.4 ± 289.9**

High Risk Features of Coronary Obstruction

Small SoV



Virtual valve: 110% area oversizing
Virtual valve to LMT: 1.6 mm

LCA

LCC Length: 18.0 mm

RCA

Low coronary height with long LCC leaflet

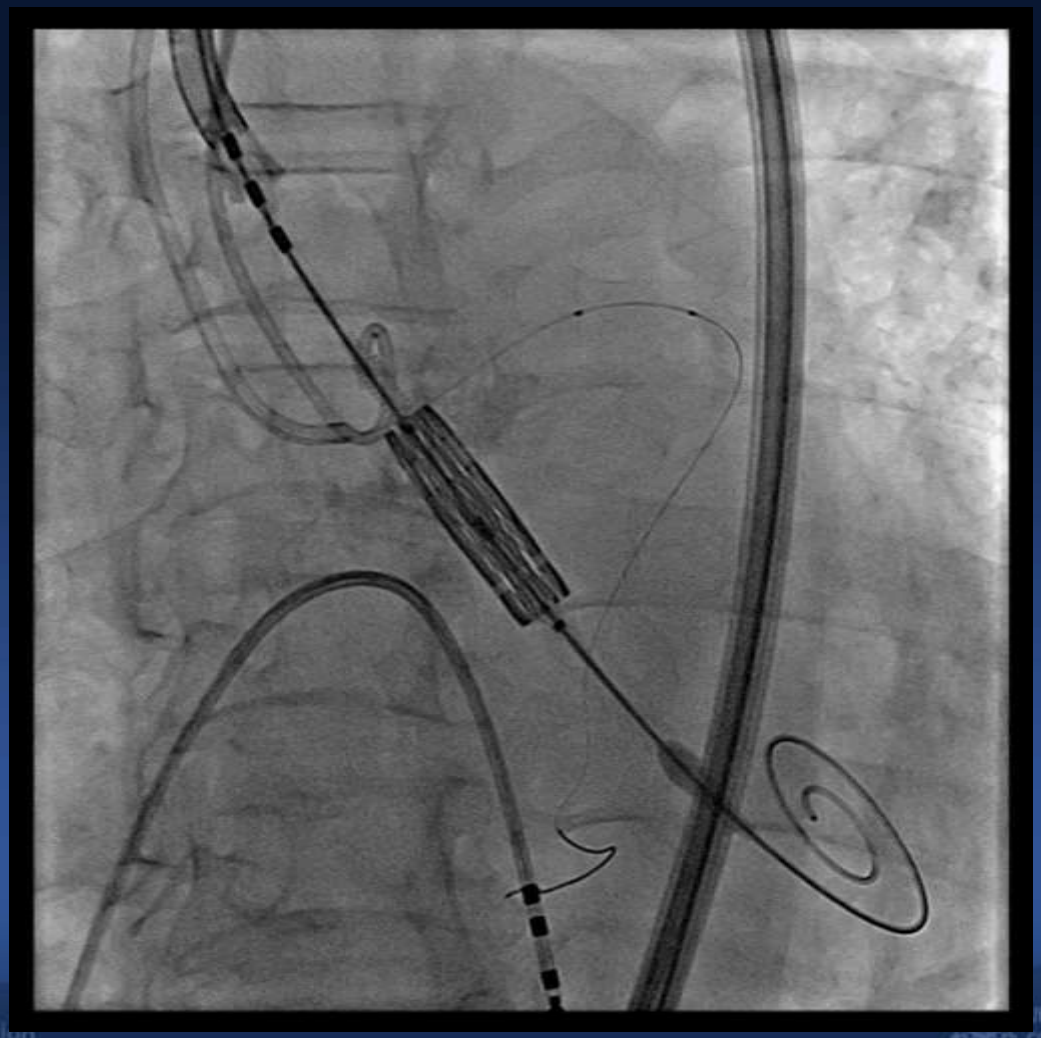
Coronary Height	
LCA	10.8 mm
RCA	16.1 mm

S3 26mm (13.3% Oversizing)

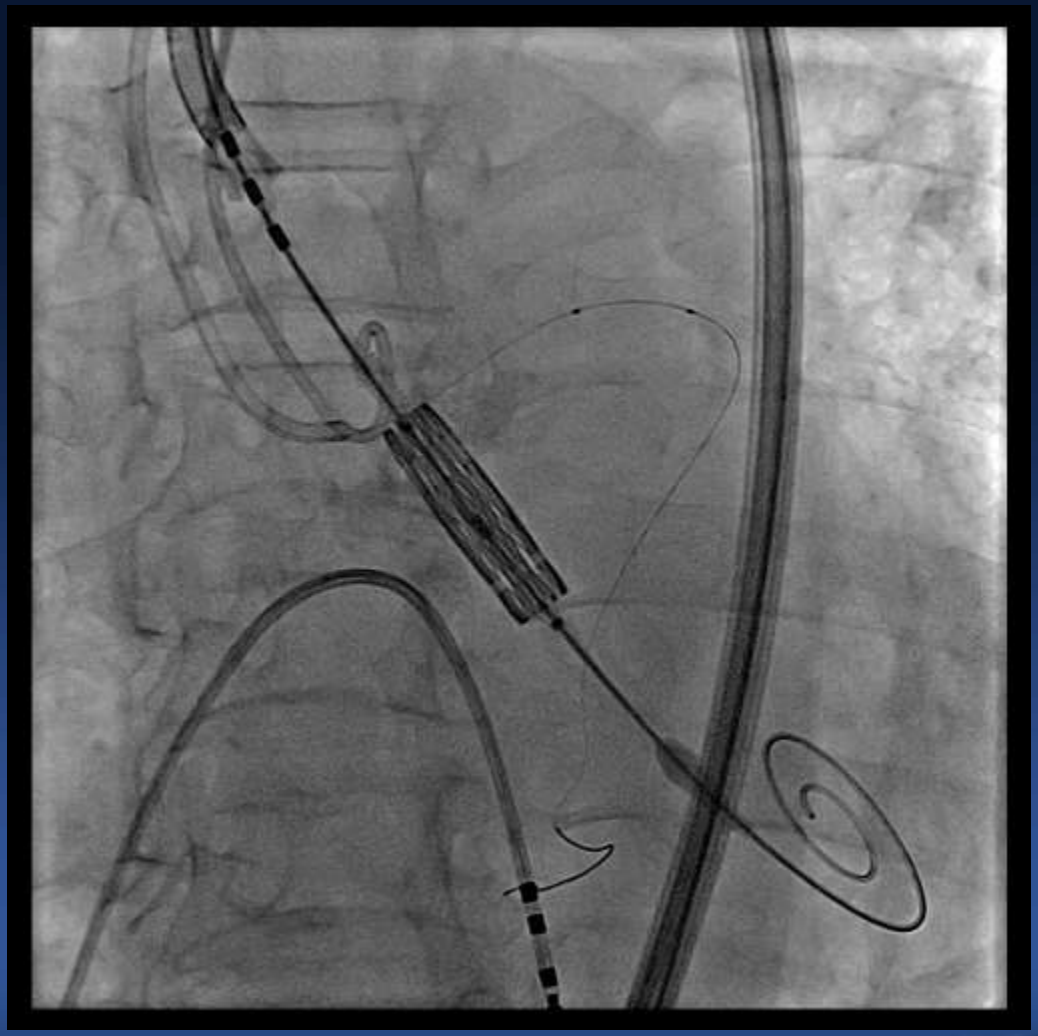
Size	Area_oversize (%)	Perimeter_oversize (%)
23	89.3	92.7
24	97.2	96.7
25	105.5	100.8
26	113.3	104.7
27	122.2	108.7
28	131.4	112.8
29	141.7	117.1

High Risk of Coronary Obstruction

→ Coronary Protection with 3.5 x 20 NC balloon through 6Fr JL4 Guiding catheter

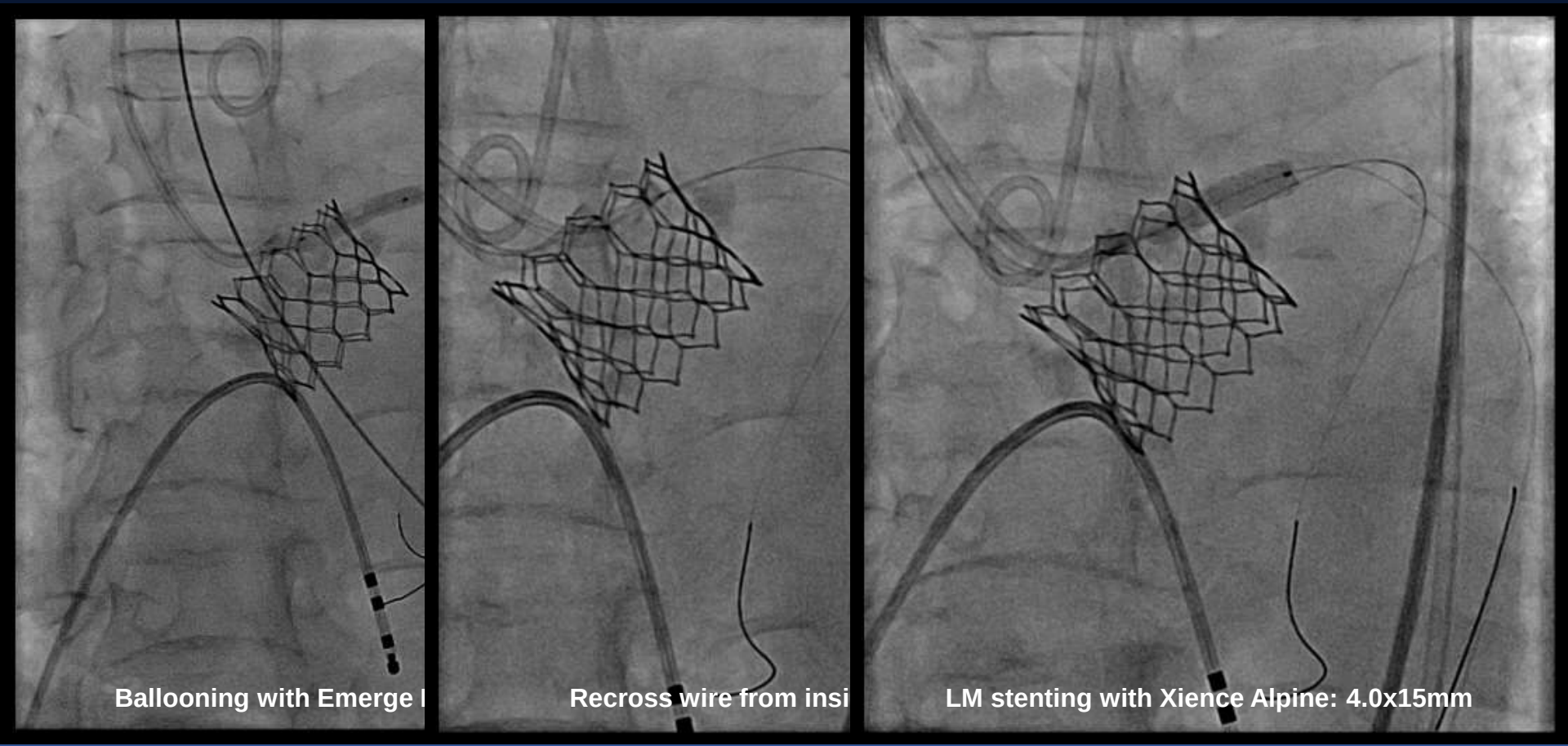


S3 26mm (13% Oversizing) implantation with coronary protection

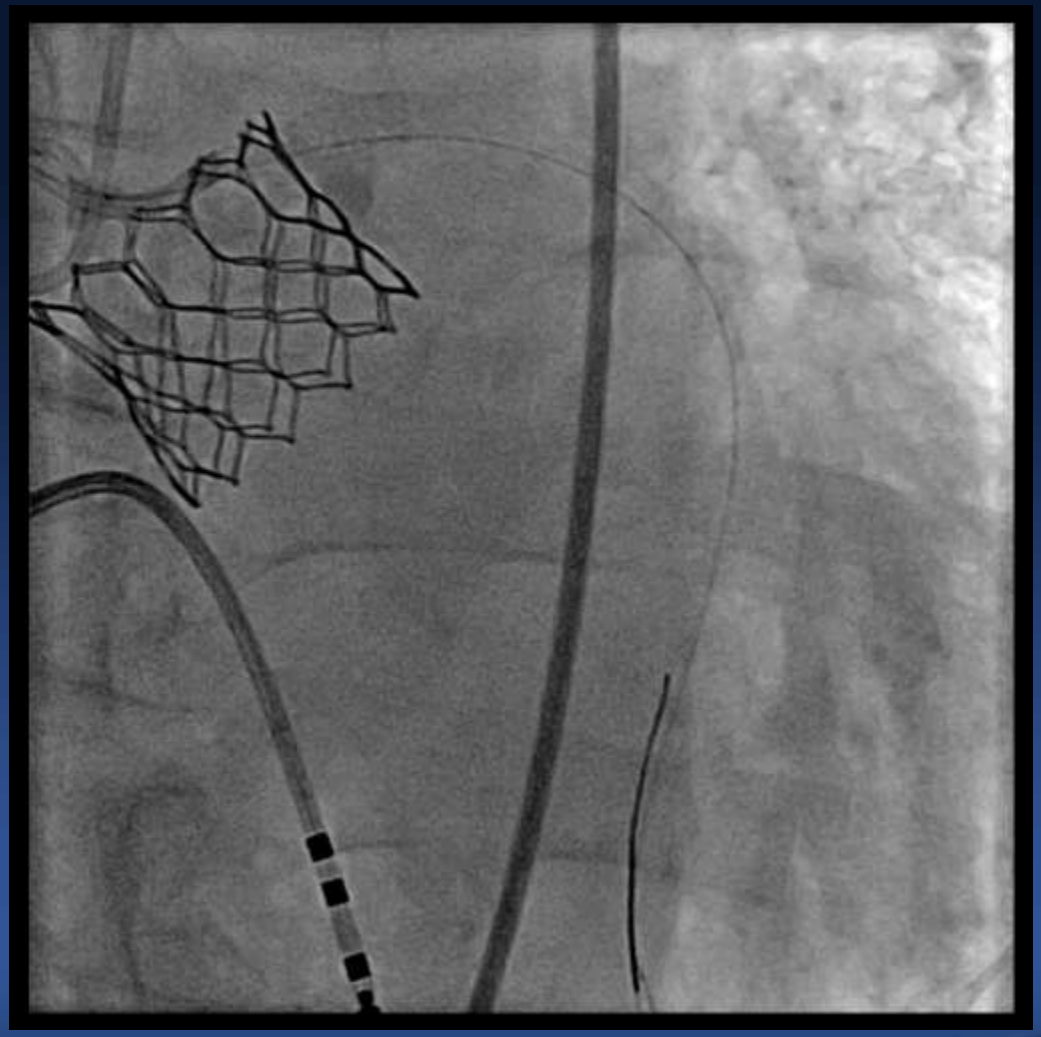


Slow Flow with ST depression after Valve Implantation

PCI at obstructed LM ostium

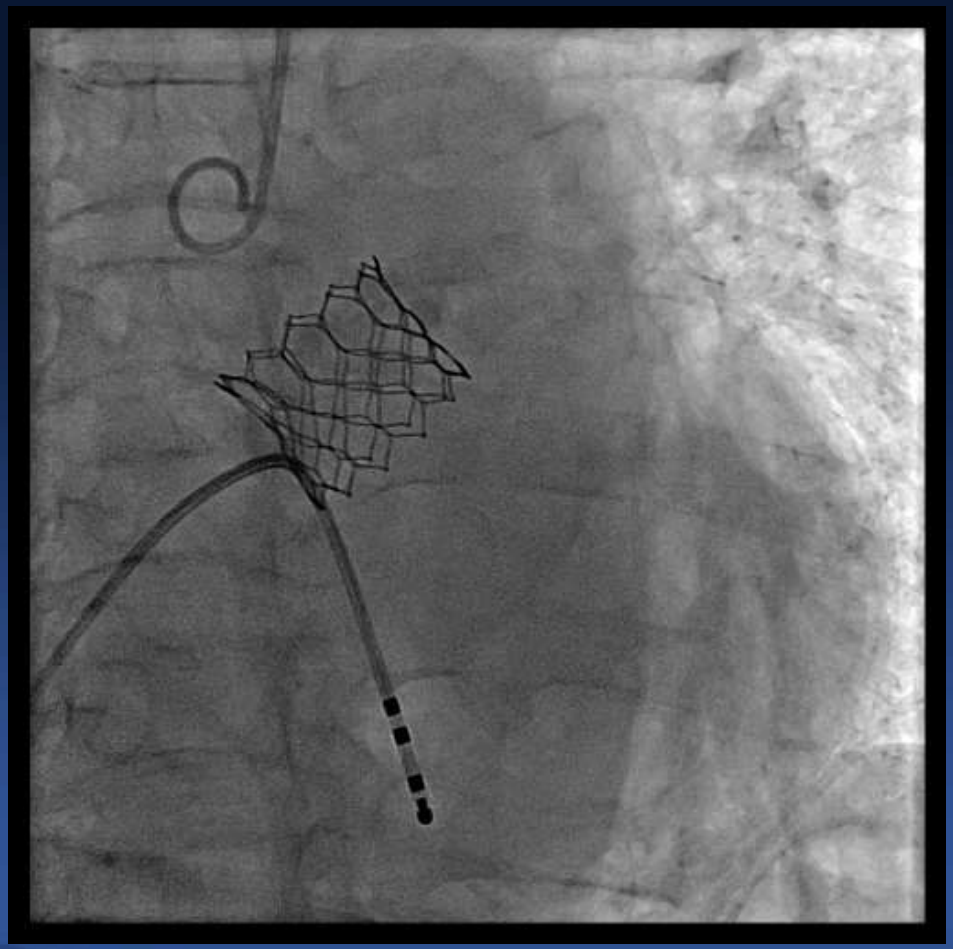


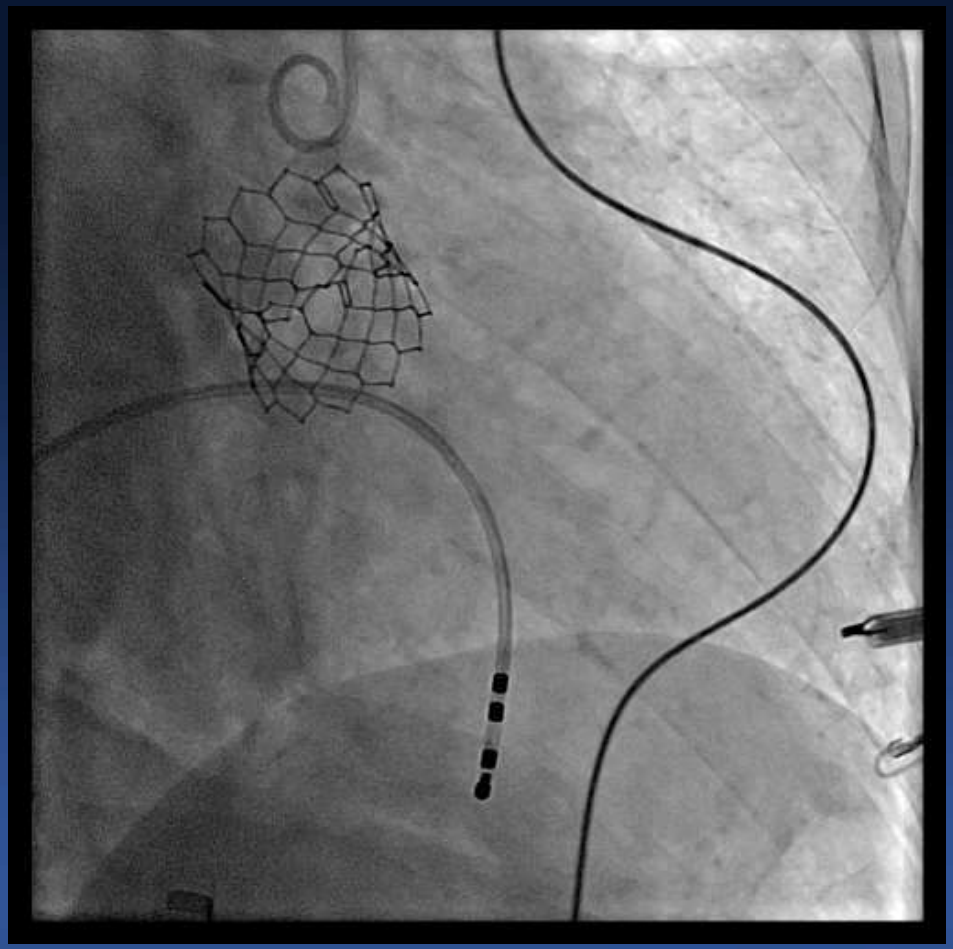
TIMI 3 flow after PCI at LM (Xience 4x15mm)



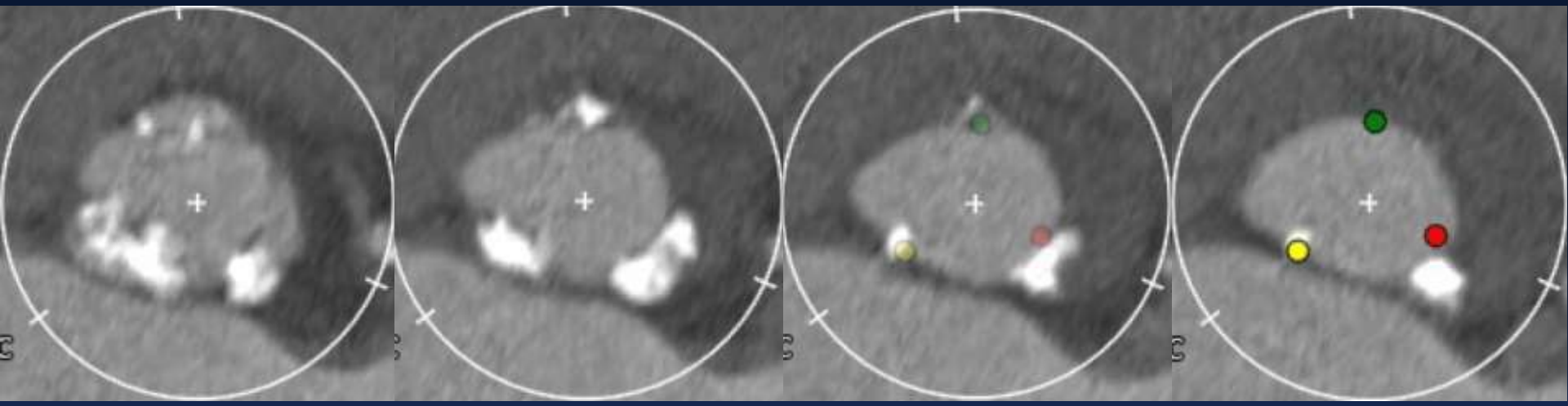
S3 26mm TAVR with Successful Rescue PCI

Sinus Rhythm, Mild PVL





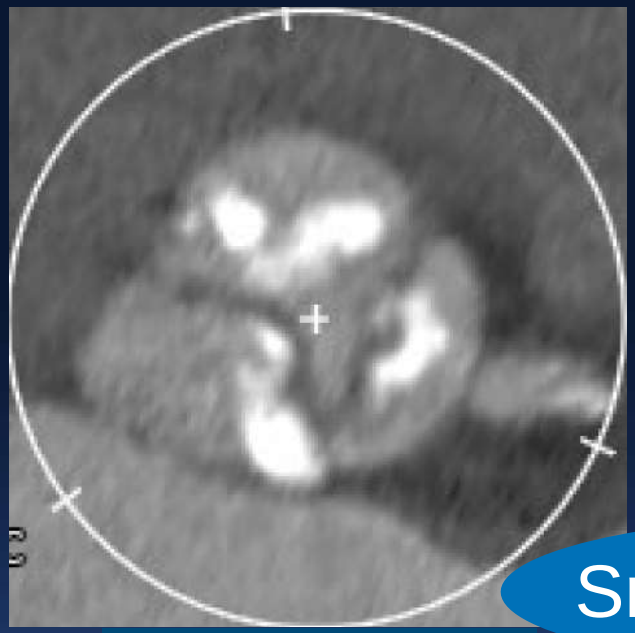
Case #5, 86/F with Severe AS, LV dysfunction



Annulus plane

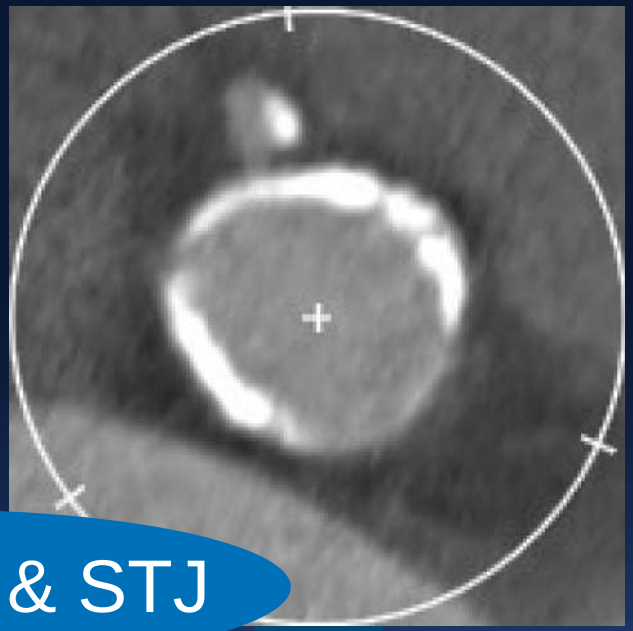
Aortic Annulus parameters	
Annulus short diameter	20.0 mm
Annulus long diameter	27.1 mm
Annululs mean diameter	23.6 mm
Annulus area	427 mm^2
Annulus area-driven diameter	23.3 mm
Annulus perimeter	75.3 mm
Annulus perimeter-driven diameter	24.0 mm

CT findings – Aortic Valve Complex



Sinus of Valsalva

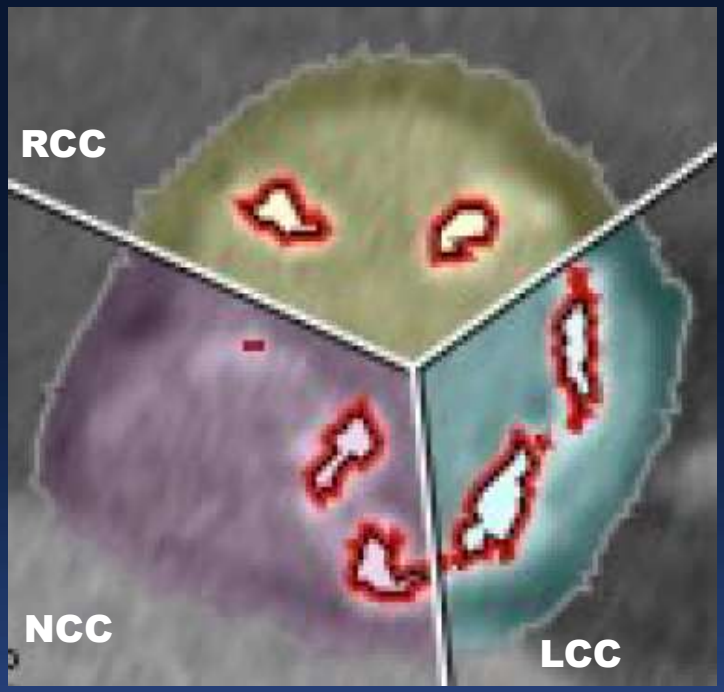
Small SoV & STJ



STJ

Sinus of Valsalva		STJ	
Area	691 mm^2	Area	399 mm^2
Sinus / Annulus Area Ratio	1.62	STJ/ Annulus Area Ratio	0.93
NCC diameter	31.2 mm	Mean diameter	22.7 mm
LCC diameter	28.7 mm	Height of STJ	20.8 mm
RCC diameter	27.8 mm		
Mean Sinus / Annulus Area Ratio	**1.83 ± 0.27**	**Mean STJ / Annulus Area Ratio**	**1.49 ± 0.29**

Calcium Amount

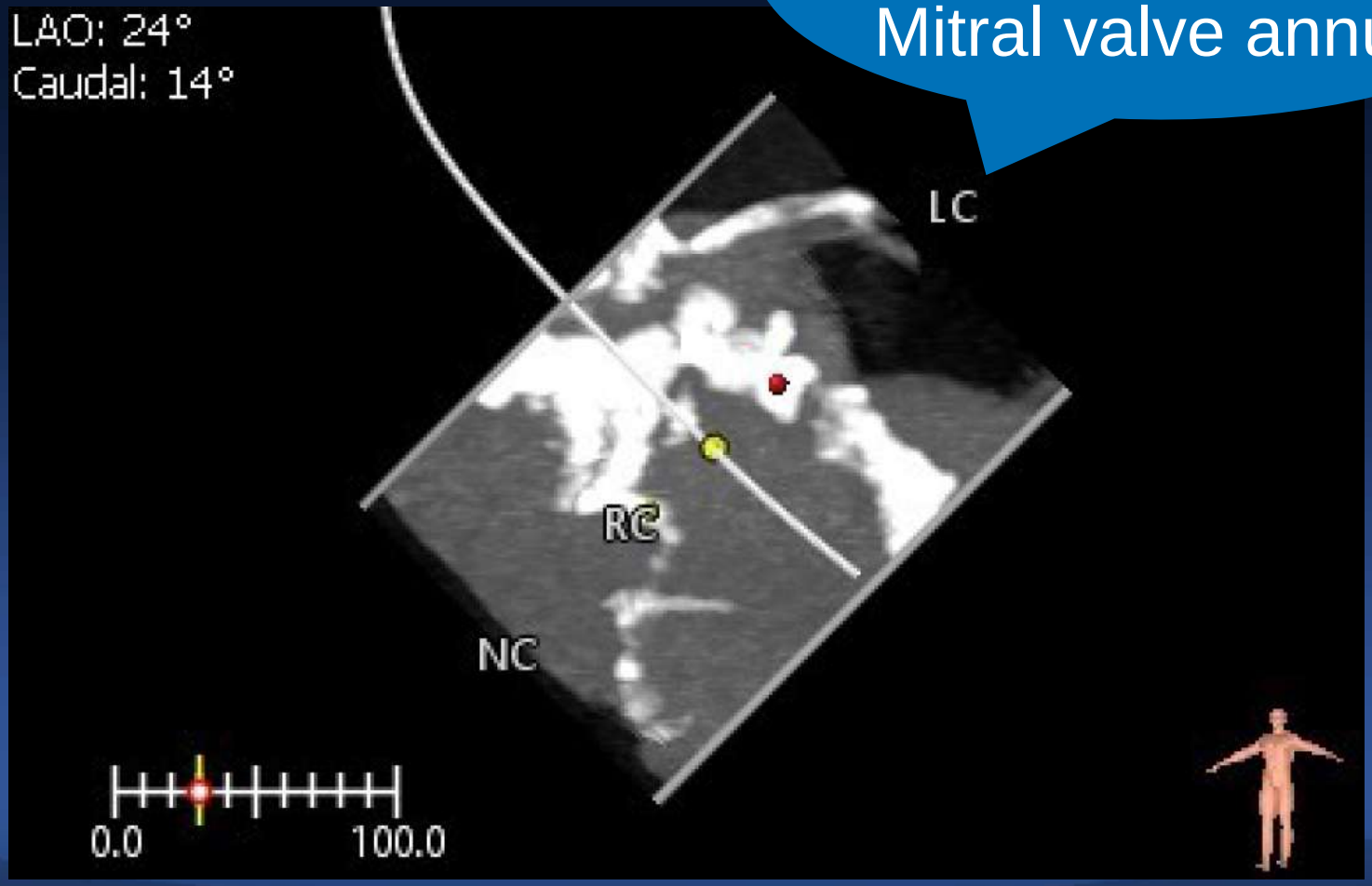


Calcium volume	
NCC	420 mm^3
RCC	234 mm^3
LCC	322 mm^3
Total	976 mm^3

Mean Amount of total Calcium **355.4 ± 289.9**

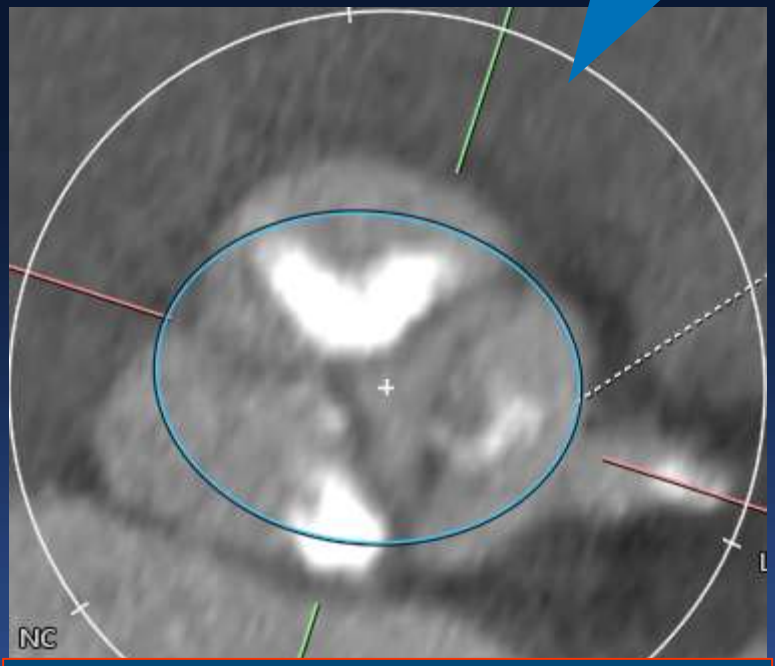
CT findings – AV complex Calcification

Heavy Calcification extended to LVOT & Mitral valve annulus



High Risk of Coronary Obstruction

Small SoV



Virtual Valve: 110% area oversizing
Valve to LMT: 1.0 mm

LCA

Length of LCC: 16.4 mm

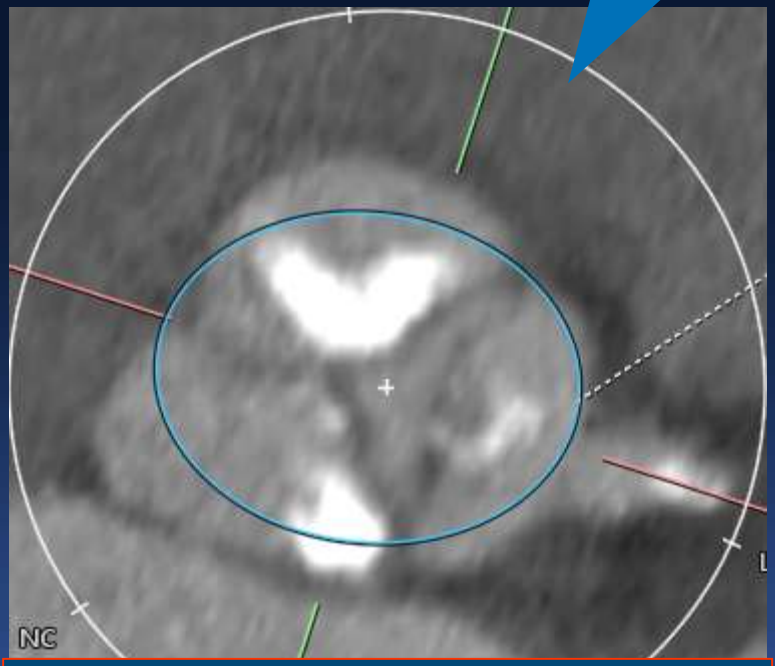
RCA

Low coronary height with long LCC leaflet

Coronary Height	
LCA	10.0 mm
RCA	17.5 mm

Good Candidate for Surgical AVR !!!

Small SoV



Virtual Valve: 110% area oversizing
Valve to LMT: 1.0 mm

LCA

Length of LCC: 16.4 mm

RCA

Low coronary height with long LCC leaflet

Coronary Height	
LCA	10.0 mm
RCA	17.5 mm

86/F,
Severe AS, LV dysfunction (EF 38%),
Parkinsonism
STS score 4.5%

CT Anatomy can Guide to Select Optimal Candidate for TAVR vs. SAVR !!!

→ Successful Sutureless AVR was done.

Case #6, M/79 with Bicuspid AS

Annulus plane

Aortic Annulus parameters	
Annulus short diameter	26.0 mm
Annulus long diameter	28.6 mm
Annululs mean diameter	27.3 mm
Annulus area	589 mm^2
Annulus area-driven diameter	27.4 mm
Annulus perimeter	86.5 mm
Annulus perimeter-driven diameter	27.5 mm

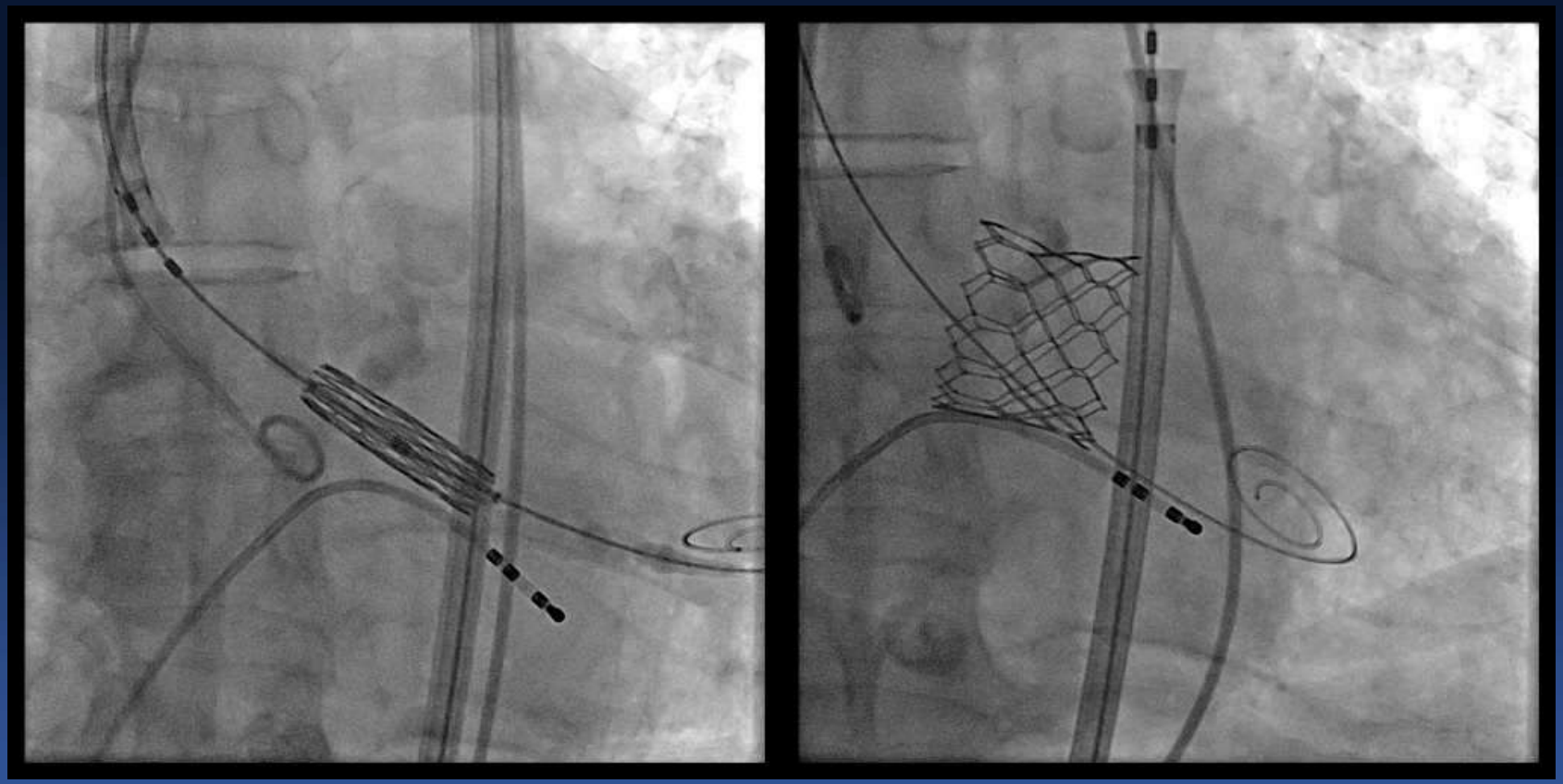
Calcium Amount

Calcium volume	
LCC	616 mm^3
RCC	48 mm^3
Total	664 mm^3

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)

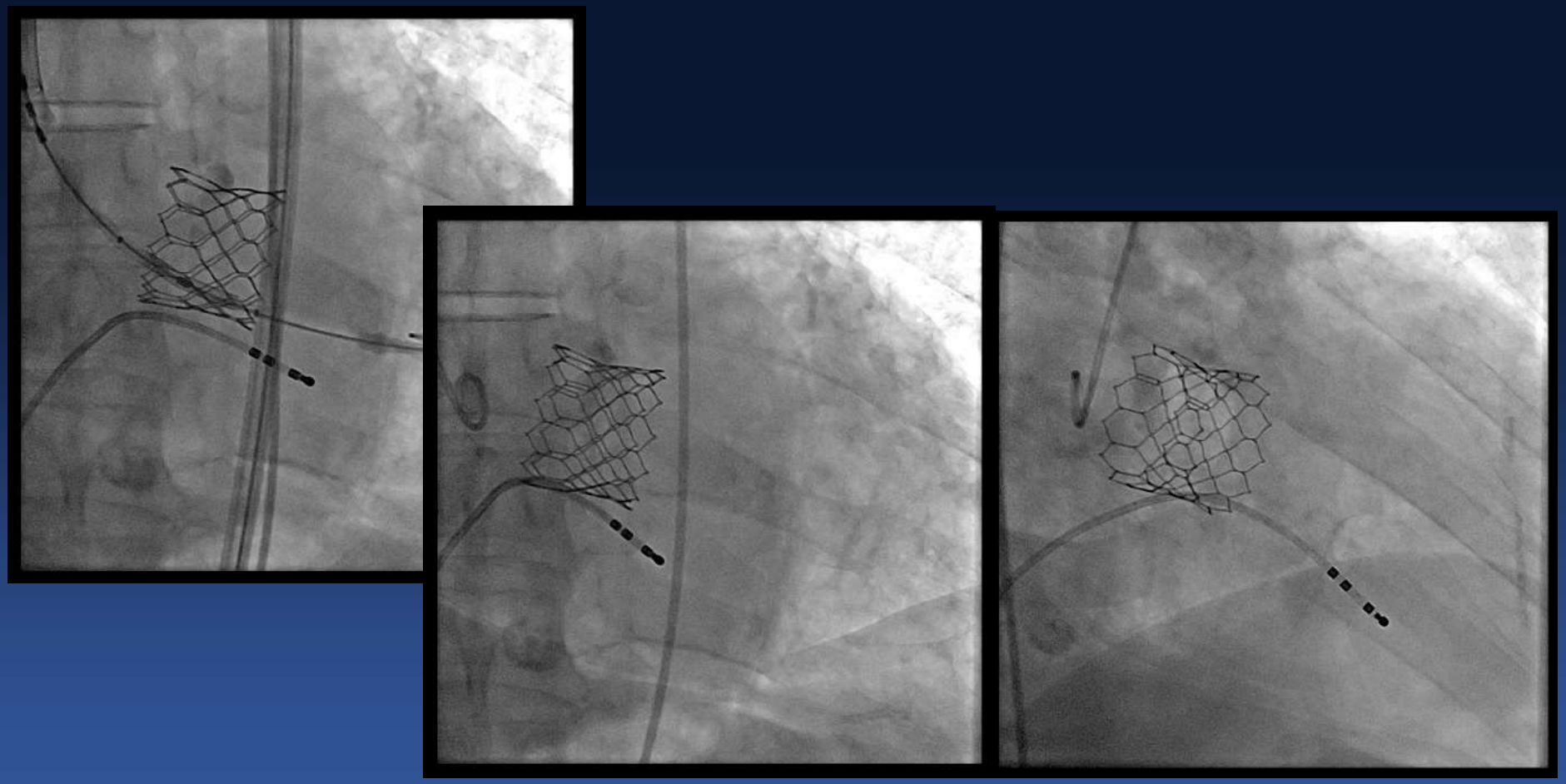


Moderate PVL

Post-dilation with +3cc (nominal volume) (10% 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

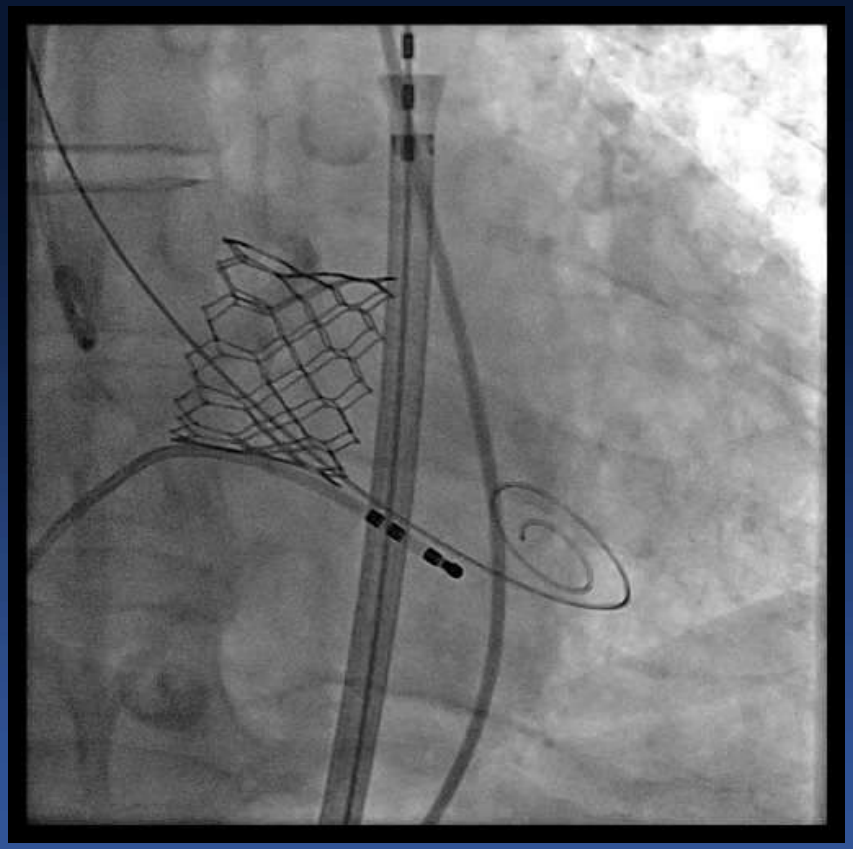
Post-dilation with +3cc (nominal volume)
(10% Oversizing)

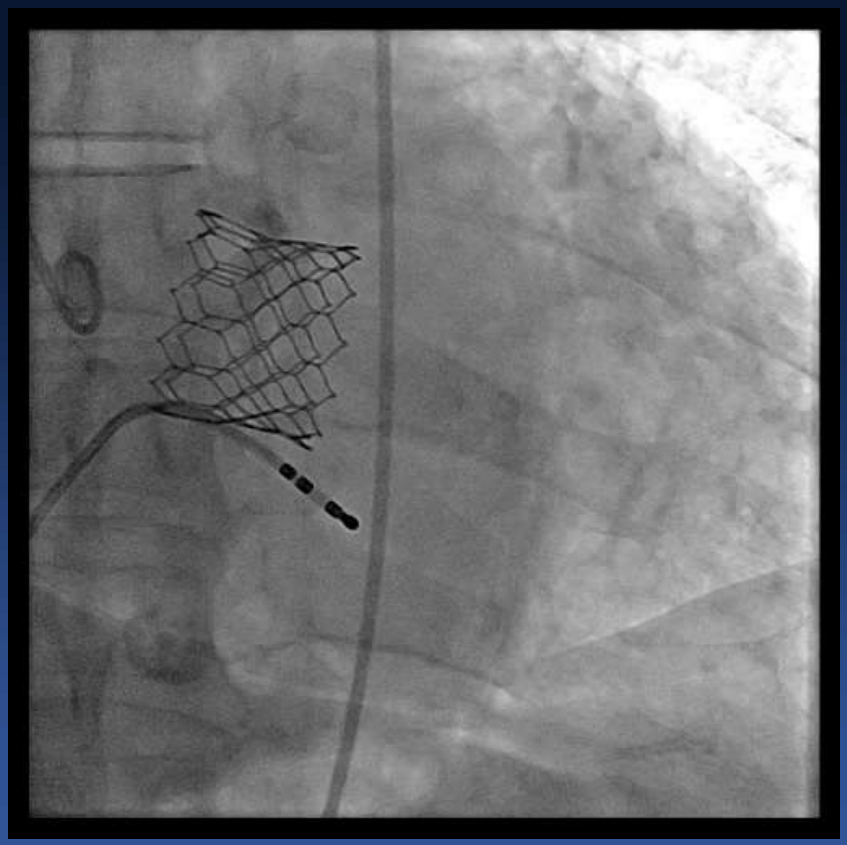


Mild PVL

S3 29 mm -3cc underfill (2% Oversizing)

+3cc Post-dilation, 29 mm nominal (10% Oversizing)

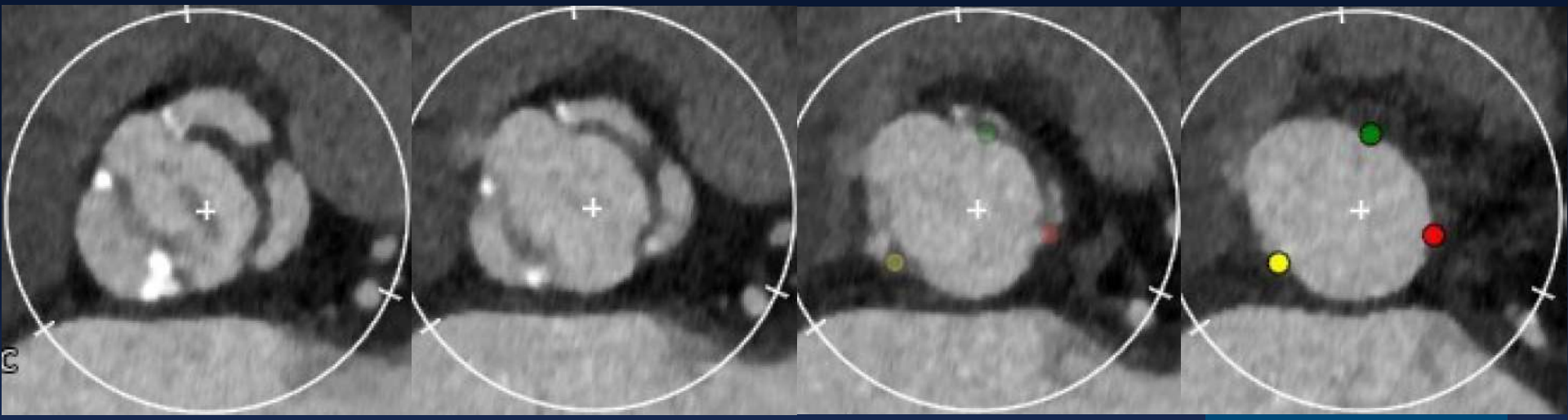




Mild PVL

Case #7, 81/F with Bicuspid AS

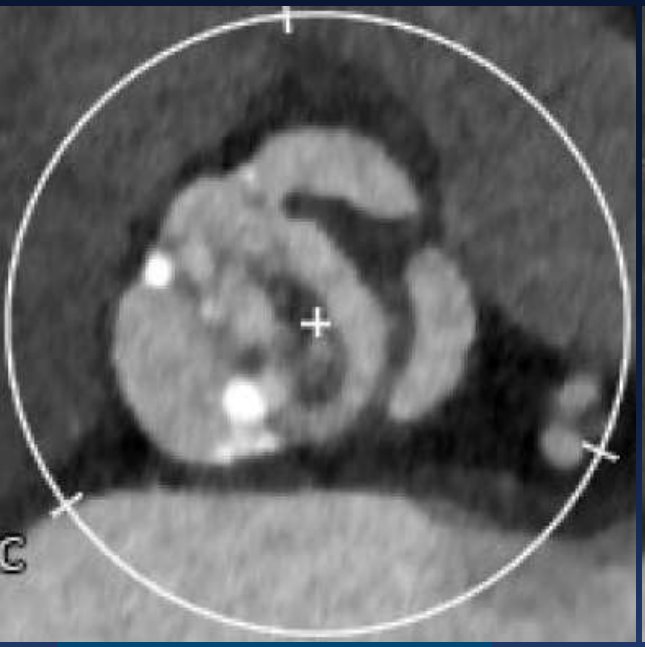
Bicuspid, Coronary



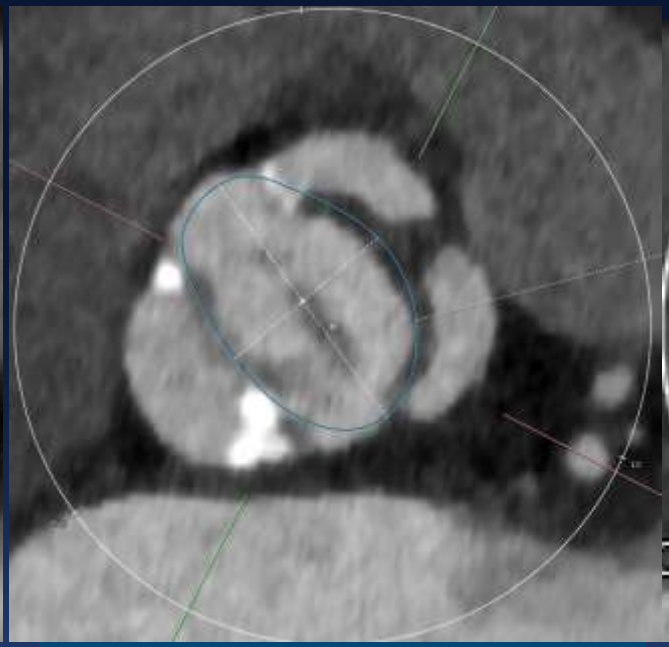
Annulus plane

Aortic Annulus parameters	
Annulus short diameter	20.1 mm
Annulus long diameter	26.0 mm
Annululs mean diameter	23.1 mm
Annulus area	413 mm^2
Annulus area-driven diameter	22.9 mm
Annulus perimeter	73.1 mm
Annulus perimeter-driven diameter	23.3 mm

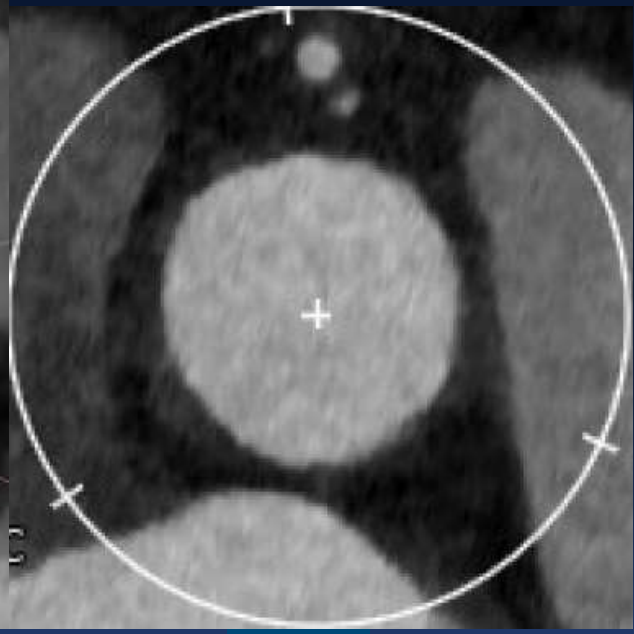
CT findings – Aortic Valve Complex



Sinus of Valsalva



Supra-annulus: 260 mm^2

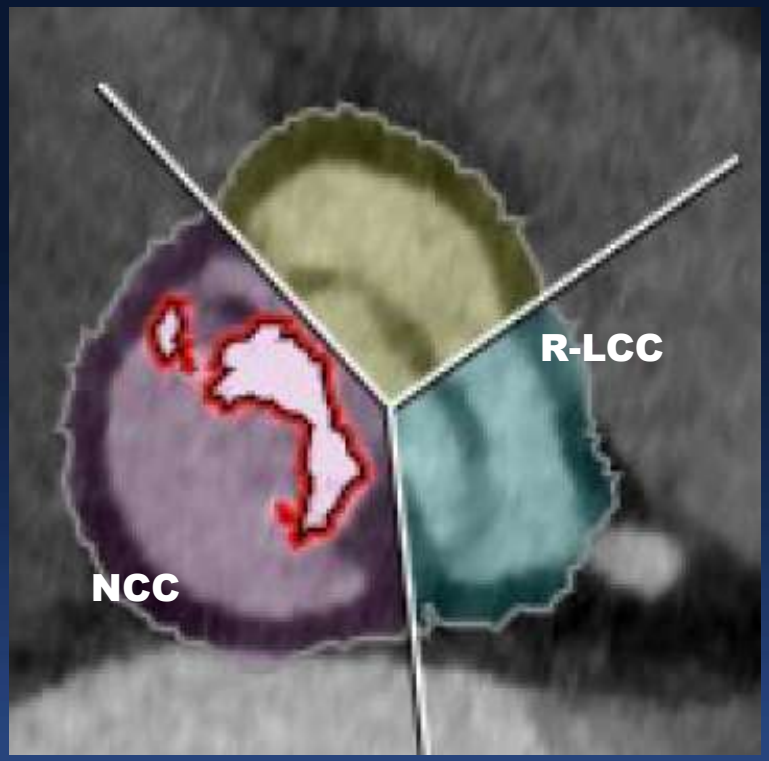


STJ

Sinus of Valsalva		STJ	
Area	598 mm^2	Area	479 mm^2
Sinus / Annulus Area Ratio	1.45	STJ/ Annulus Area Ratio	1.16
Long diameter	24.5 mm	Mean diameter	24.6 mm
Short diameter	30.0 mm		

Mean Sinus / Annulus Area Ratio 1.83 ± 0.27 **Mean STJ / Annulus Area Ratio** 1.49 ± 0.29

Calcium Amount

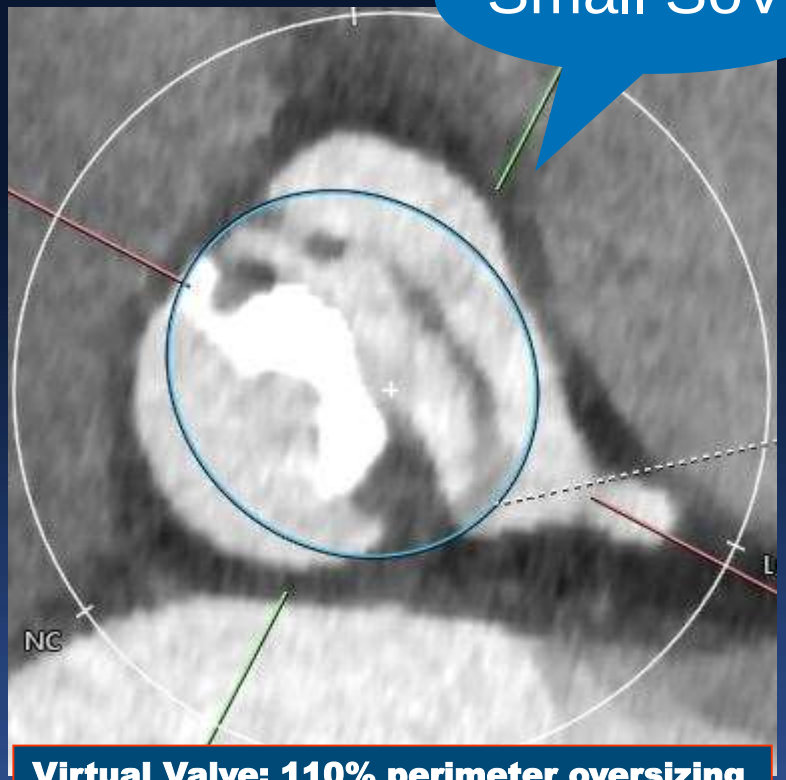


Calcium volume	
R-LCC	4 mm^3
NCC	332 mm^3
Total	336 mm^3

Mean calcium volume 360 mm^3

High Risk of Coronary Obstruction

Small SoV



Virtual Valve: 110% perimeter oversizing
Valve to LMT: 1.0 mm

LCA

Length of LCC: 14.8 mm

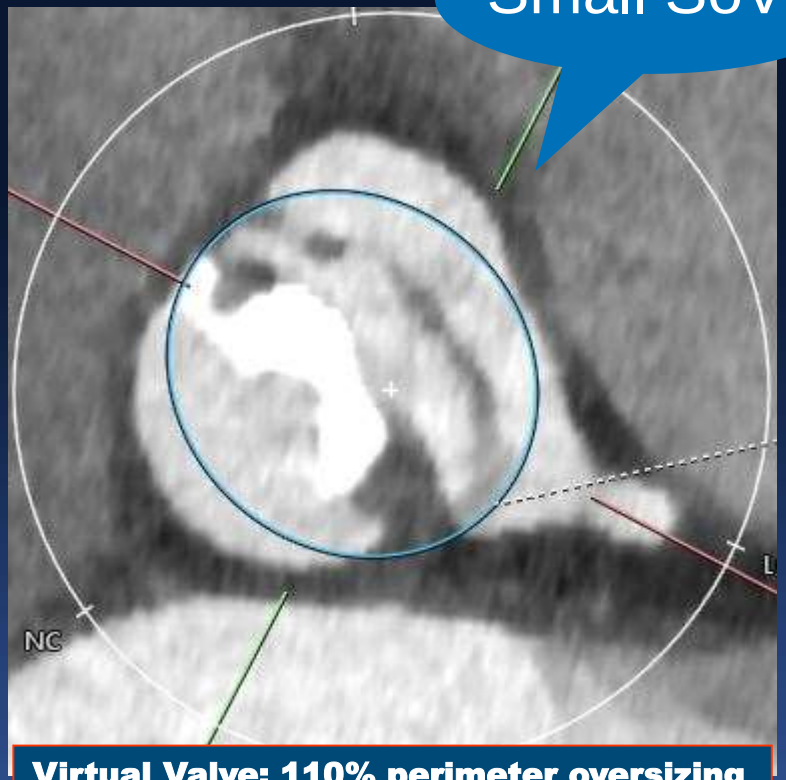
RCA

Low coronary height with long LCC leaflet

Coronary Height	
LCA	10.9 mm
RCA	15.4 mm

Patient was referred for Surgical AVR

Small SoV



Virtual Valve: 110% perimeter oversizing
Valve to LMT: 1.0 mm

LCA

Length of LCC: 14.8 mm

RCA

Low coronary height with long LCC leaflet

Coronary Height	
LCA	10.9 mm
RCA	15.4 mm

Outcomes after TAVR

Standard Performance (VARC-2*) for High-Risk AS patients (@ 30 days)

		AMC Total (n=533)	***S3 Tricuspid*** (n=232)	***S3 Bicuspid*** (n=46)
• All-cause mortality	< 3%	2.6%	1.3%	2.2%
• Major (disabling) strokes	< 2%	1.5%	0.4%	0%
• Major vascular complications	< 5%	4.5%	1.7%	2.2%
• New permanent pacemakers	< 10%	8.4%	3.9%	6.5%
• Mod-severe PVR	< 5%	8.6%	1.7%	8.7%

Conclusion

- Minimizing the rate of permanent pacemaker implantation and significant paravalvular regurgitation is important, especially in the era of TAVR for younger patients with lower risk.
- Appropriate patient and valve selection by comprehensive CT analysis is essential to optimize the procedural outcomes.
- CT sizing algorithm with provisional post-dilation up to intended target area oversizing was safe and effective.