

AMC CT Algorithm to Avoid Permanent Pacemaker after TAVR

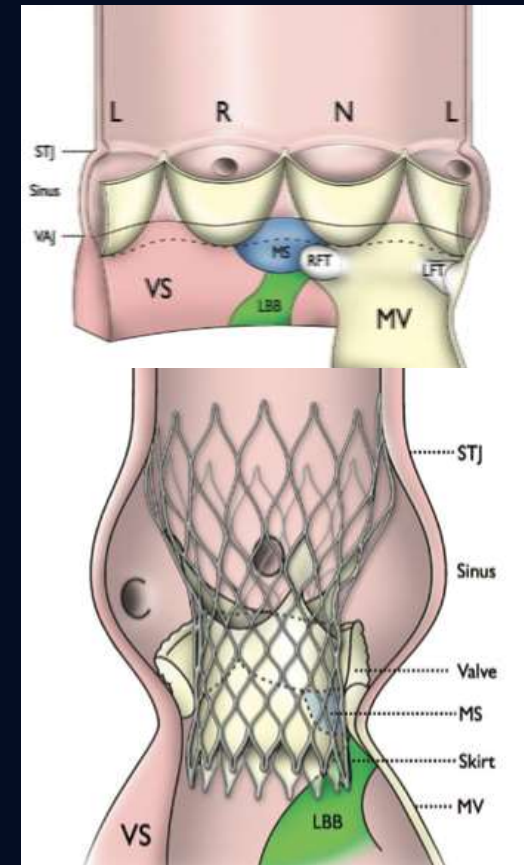
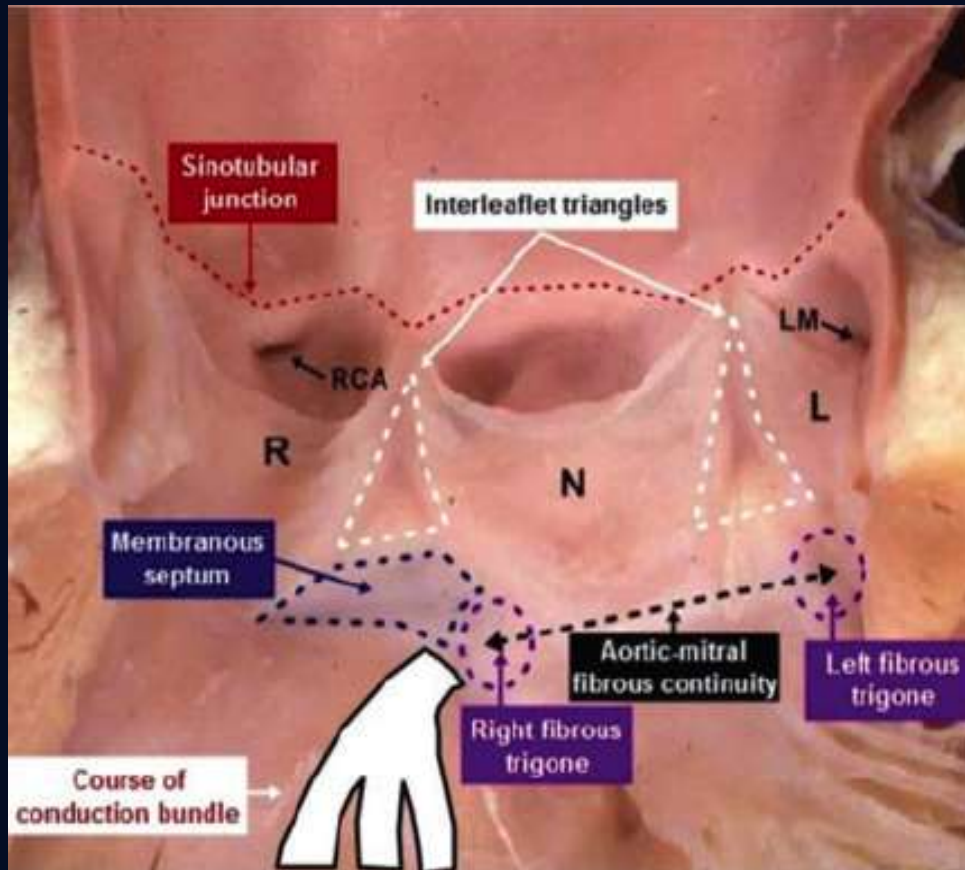
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Conflict of Interest Statement

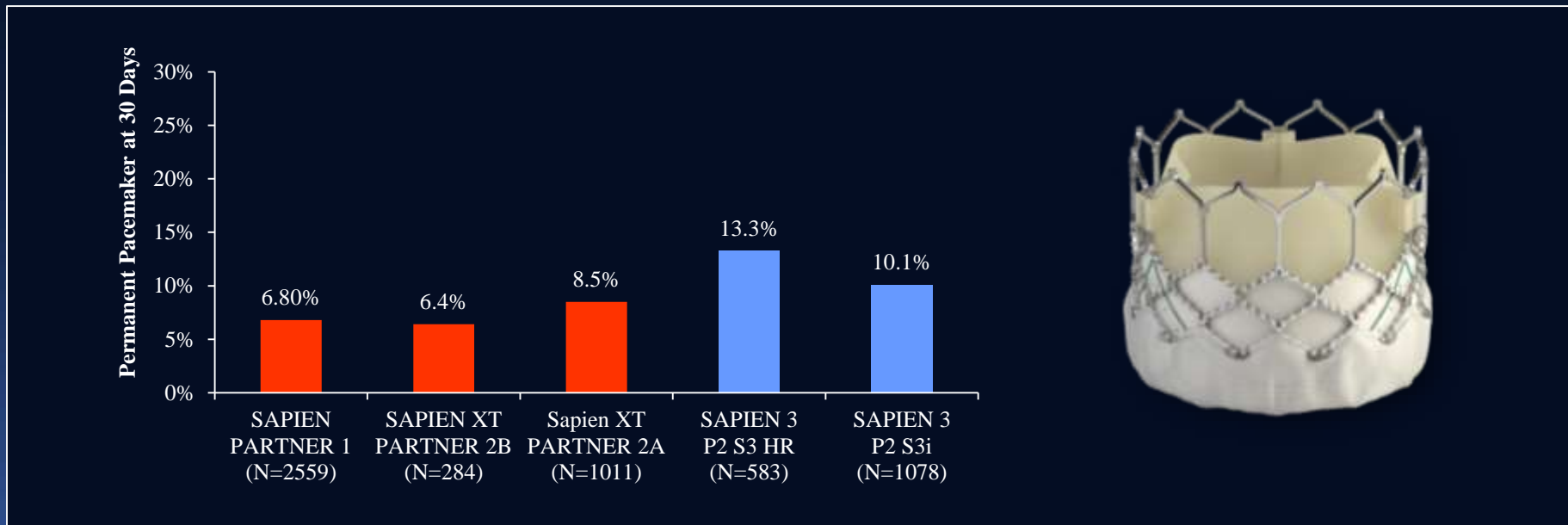
I have nothing to disclose.

TAVR and Cardiac Conduction



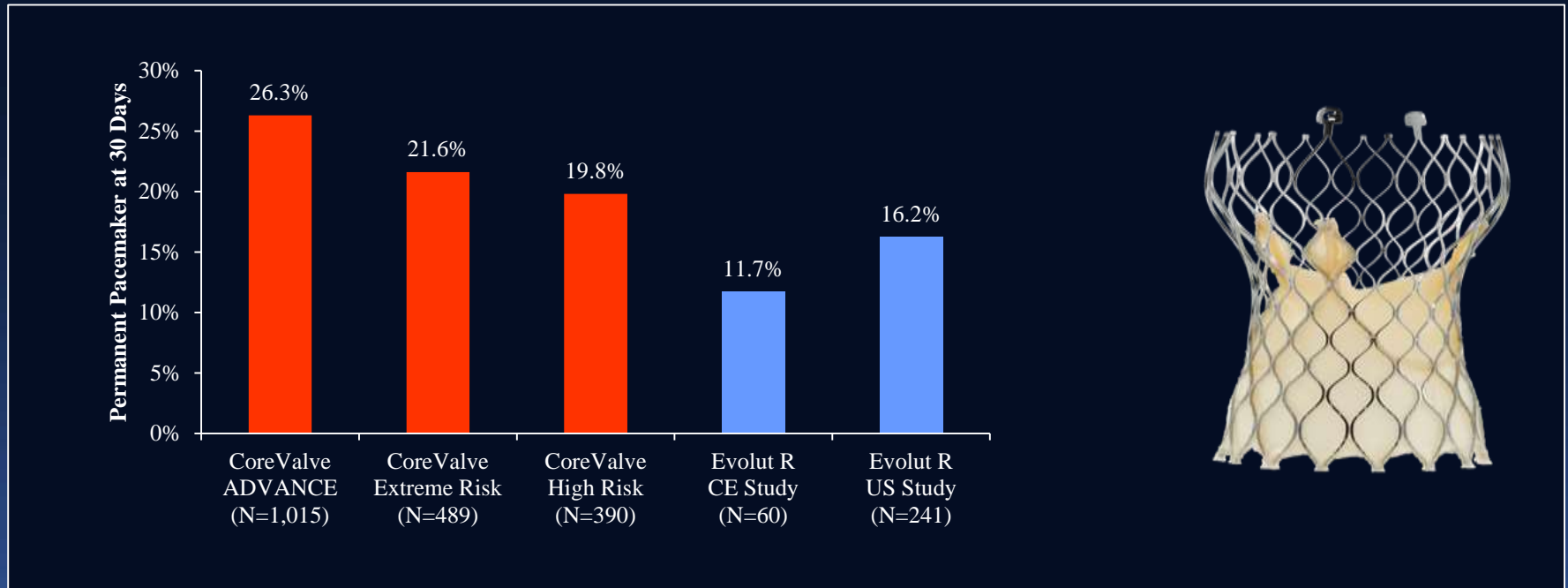
New LBBB and complete heart block (PPM) remain among most frequent complications of TAVR

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

- Male gender
- Age > 75 years
- Previous MI
- **RBBB**
- **Pre-existing conduction disturbance**

Anatomical

- Variation in location of LBBB exit point
- Septum thickness
- Thickness of the non-coronary cusp
- **Elevated left coronary cusp calcium**
- **Membranous septum length**

Procedure

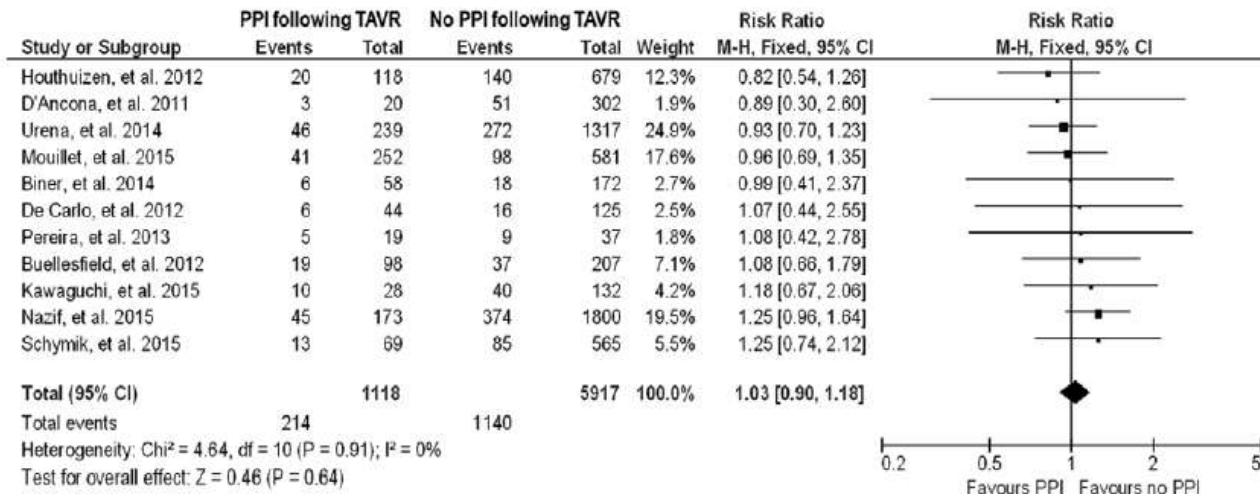
- Radial force of the prosthesis
- **Oversizing**
- **Implant depth**
- Balloon aortic valvuloplasty
- Application of PPI guidelines
- **Learning curve**

Clinical Impact of PPM after TAVR

No Impact of Mortality

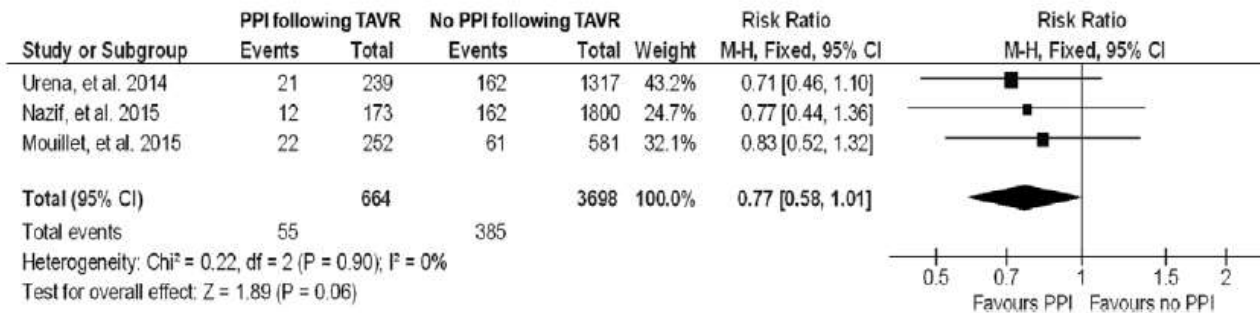
A

1-year RR of all-cause death



B

1-year RR of cardiac death



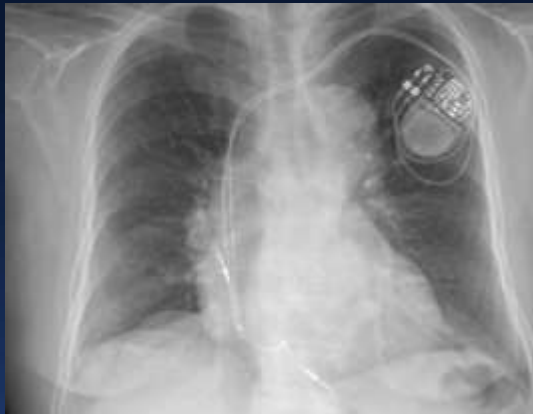
Comprehensive Pre-TAVR CT Evaluation

1. Coronary Disease Status,
- Avoid Routine Pre-TAVR Angiogram
2. Aortic, Iliac and Femoral Anatomy
3. Suitable Aortic Root Anatomy
4. Device Size Selection by CT measurement

Sizing Matters

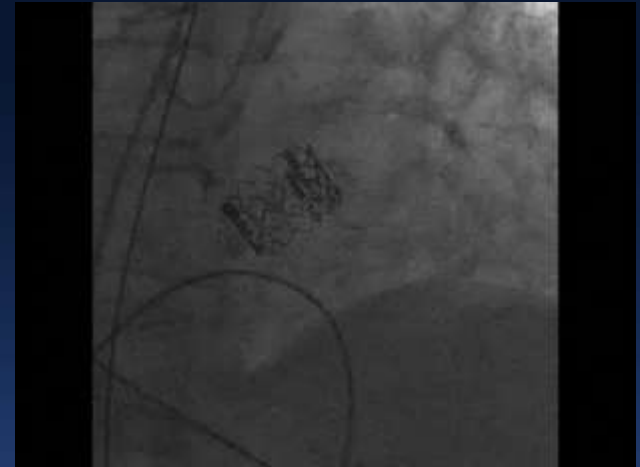
Oversize

Undersize



**Permanent
Pacemaker**

PVL



**Annular
Rupture**

VS.

Embolization

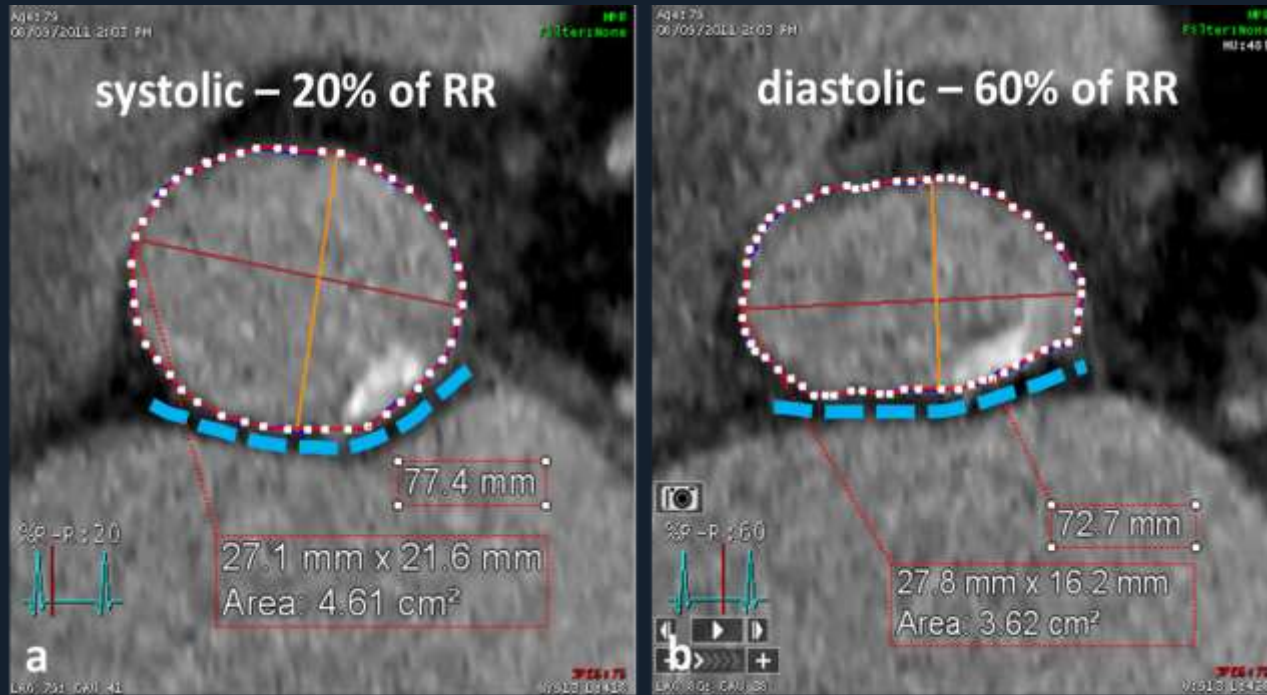


Optimal CT Acquisition

- 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

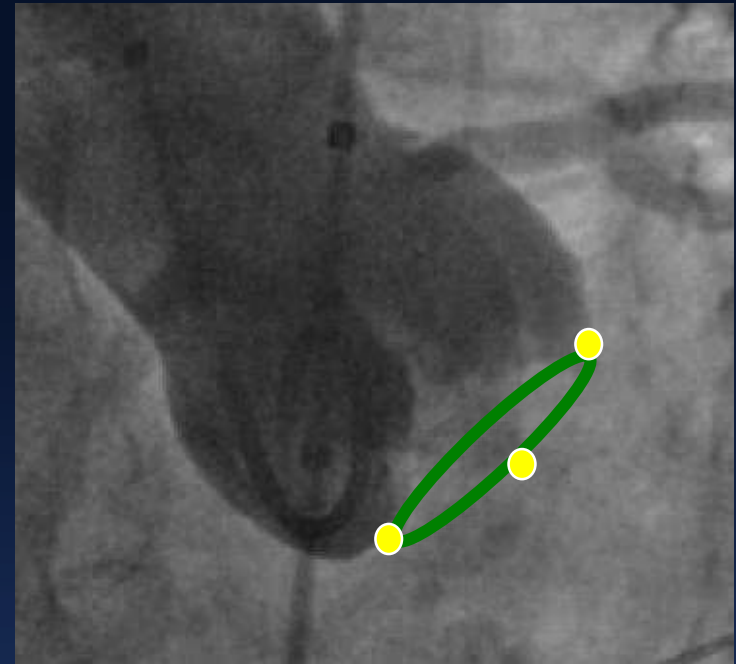
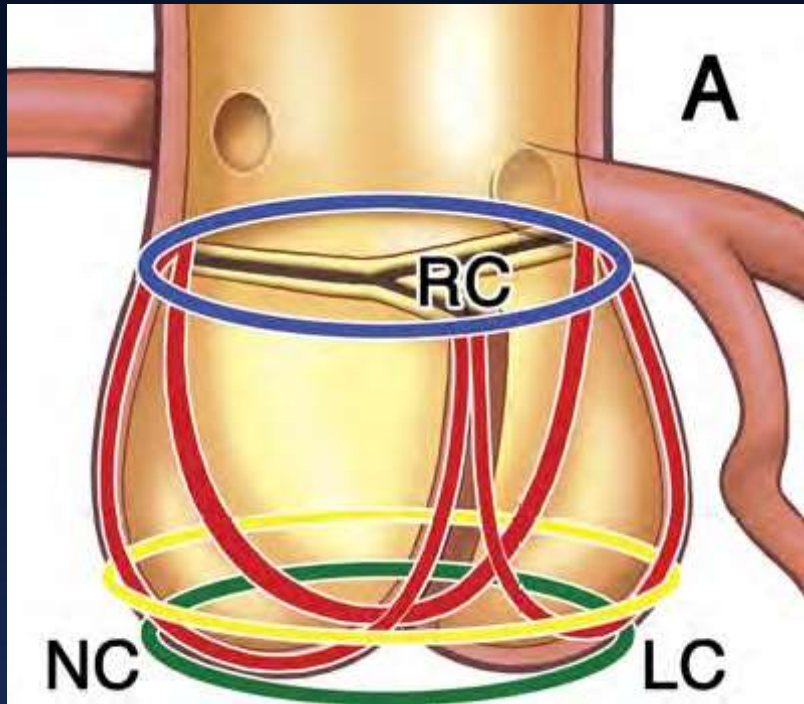
Annular dynamism

- Annular size changes throughout cardiac cycle
→ Measurement at end-systolic phase



Virtual Basal Ring

Correct Assessment of Annulus Size



— Sinotubular junction

— Aortic leaflets

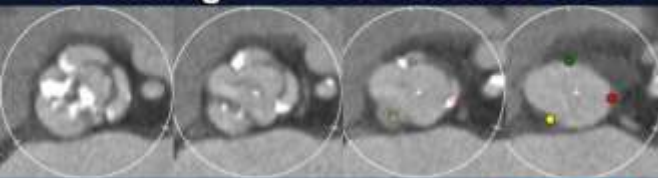
— Aortoventricular junction

— Aortic Annulus
: virtual ring formed by
base of AV leaflets

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

AMC Routine CT Measurement

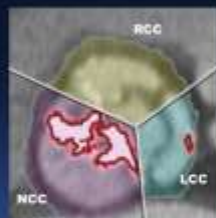
CT findings – Aortic annulus view



Annulus plane

Aortic Annulus parameters	
Annulus short diameter	17.7 mm
Annulus long diameter	28.4 mm
Annulus mean diameter	21.5 mm
Annulus area	353.0 mm ²
Annulus area-driven diameter	21.2 mm
Annulus perimeter	68.8 mm
Annulus perimeter-driven diameter	21.9 mm

CT findings – Aortic Valve Complex



Calcium volume	
NCC	360 mm ³
RCC	37 mm ³
LCC	76 mm ³
Total	473 mm ³

CT findings – Coronary Height



Anomalous origin of RCA from LCC

Coronary Height	
LCA	19.5 mm
RCA	13.5 mm

CT findings – Iliofemoral Angio



Aortic annulus plane for fluoroscopy

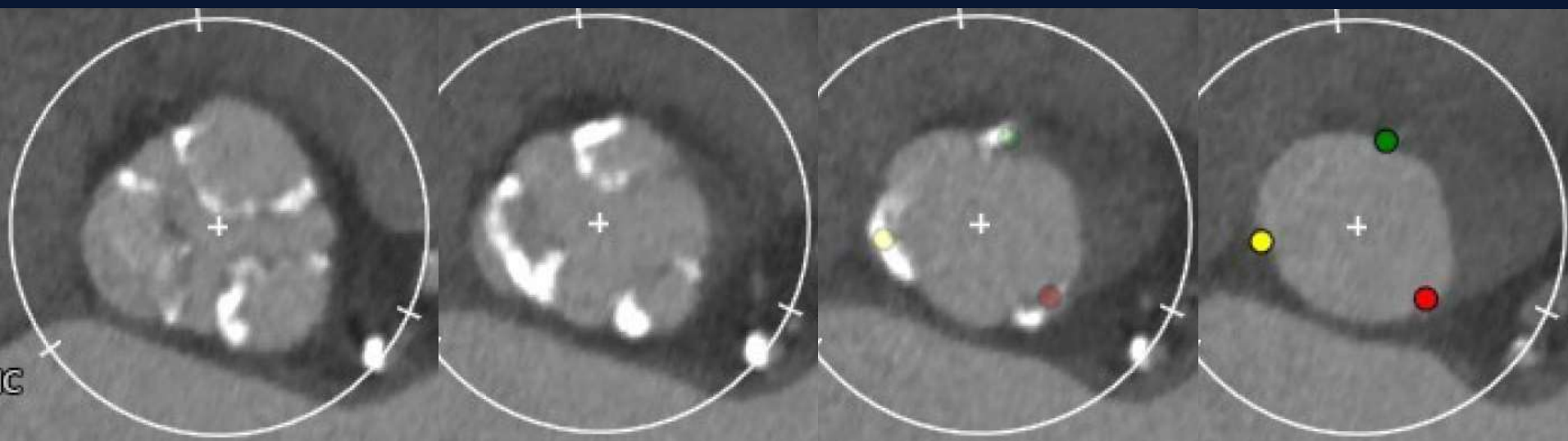


LAO 1
CAUD 16
RR-interval 30%

Sizing for Sapien 3

Size	Area_oversize (%)	Perimeter_oversize (%)
23	115.7	104.1
24	126.0	108.6
25	136.7	113.2
26	146.7	117.7
27	158.2	122.2
28	170.1	126.8
29	183.5	131.6

Aortic Annulus Measurement



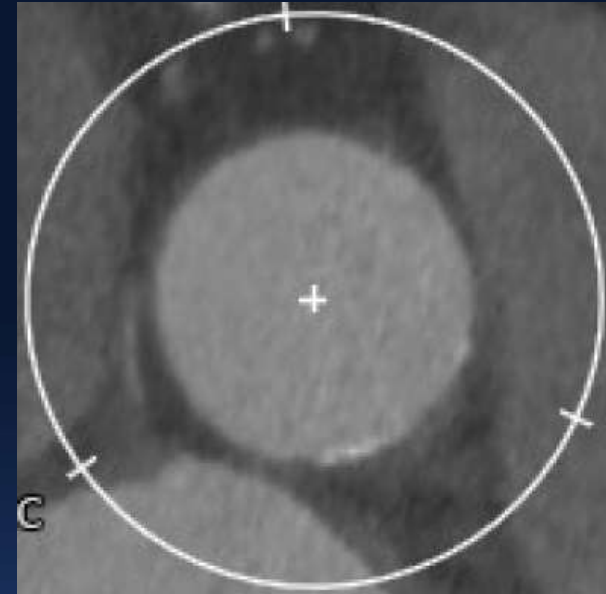
Annulus plane

Aortic Annulus parameters	
Annulus short diameter	21.8 mm
Annulus long diameter	25.6 mm
Annulus 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

Sinus of Valsalva and STJ size



Sinus of Valsalva



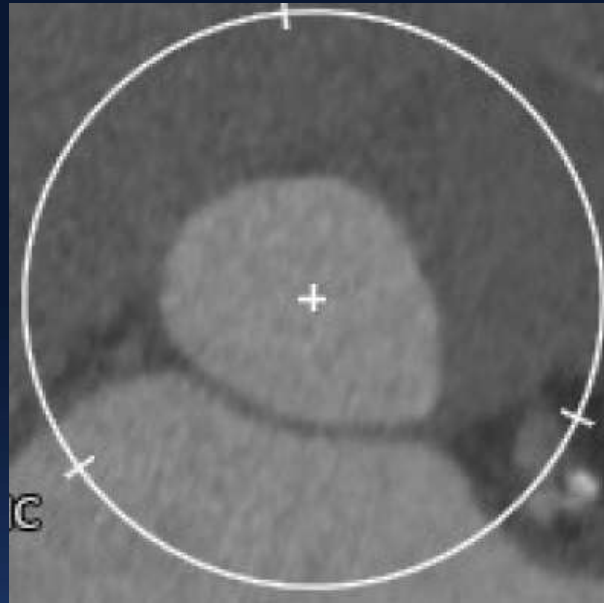
STJ

Sinus of Valsalva		STJ	
Area	830 mm²	Area	630 mm²
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**

LVOT size

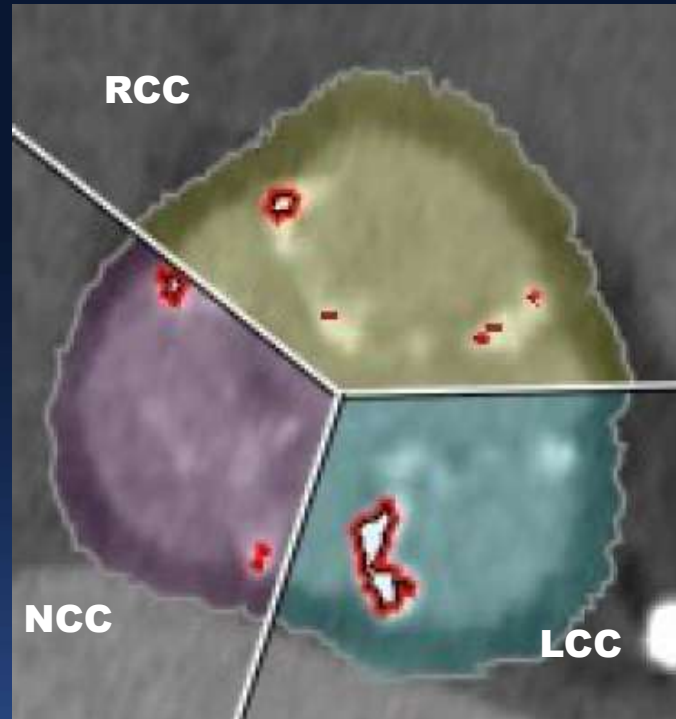


LVOT

LVOT	
Area	417 mm ²
LVOT / Annulus Area Ratio	0.96
Short diameter	20.7 mm
Long diameter	26.4 mm

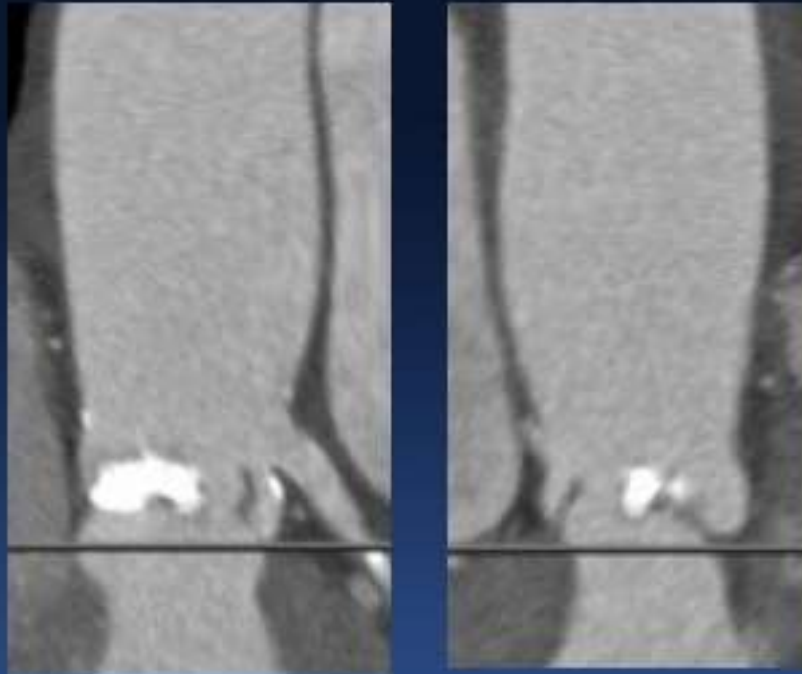
Mean LVOT / Annulus Area Ratio 0.95 ± 0.12

Degree of Calcium



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

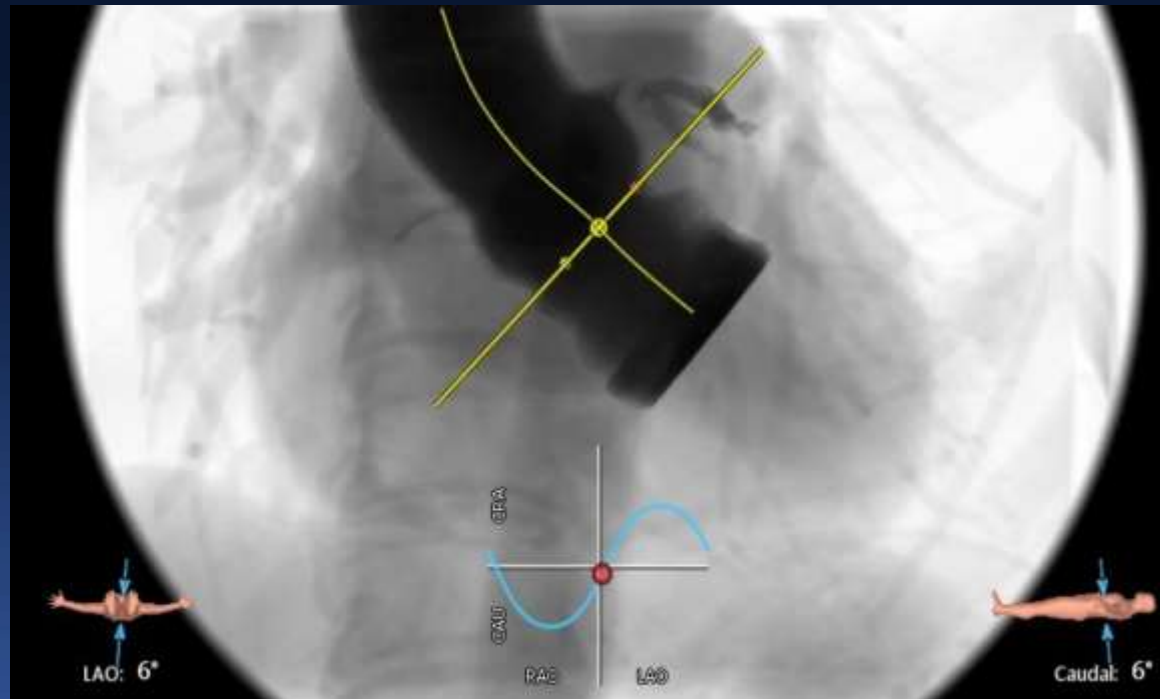
Coronary Height



**Anomalous
origin of RCA
from LCC**

Coronary Height	
LCA	10.5 mm
RCA	13.5 mm

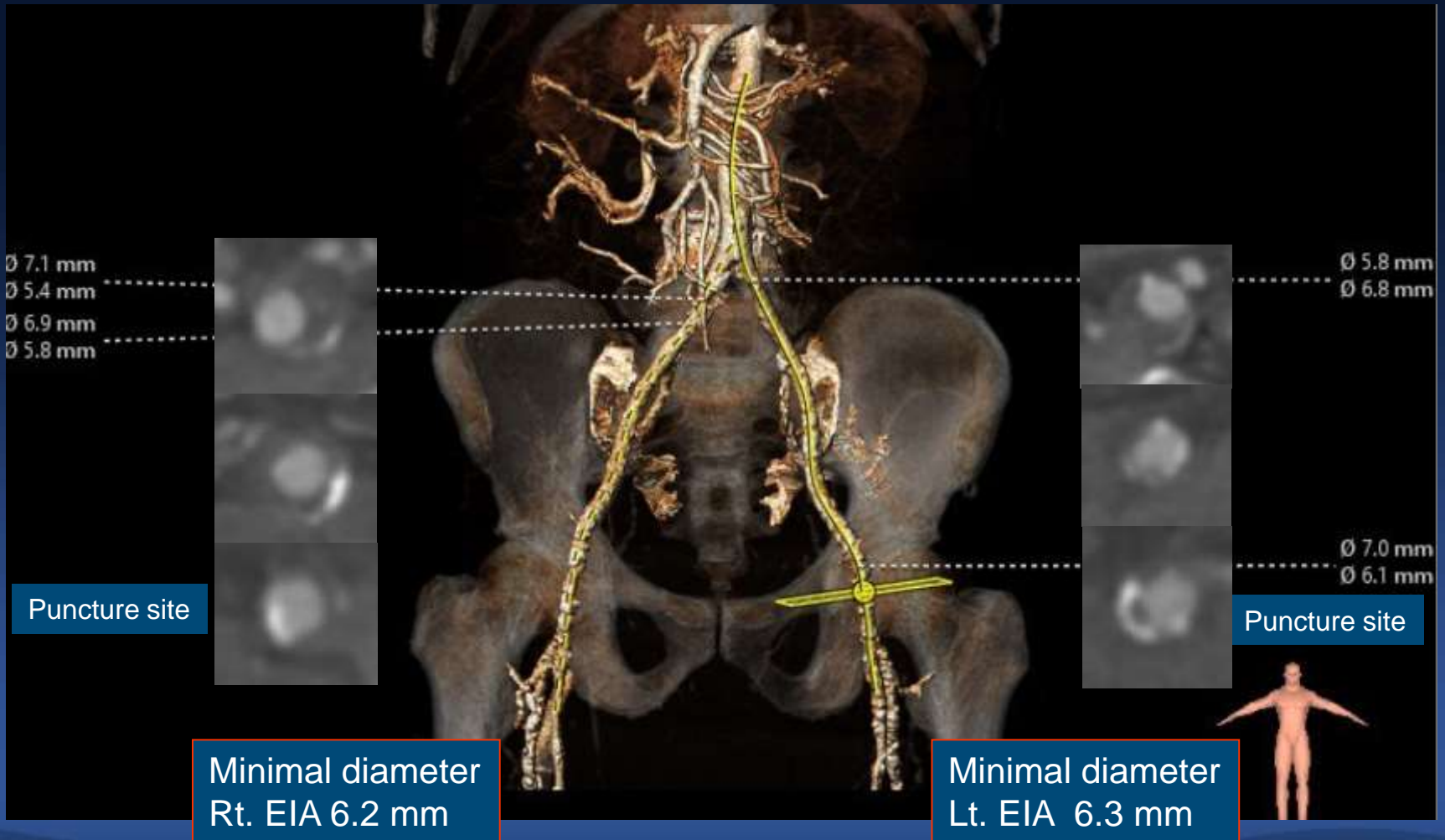
CT Aortography



- Right coronary
- Non-coronary
- Left coronary

LAO 6
CAUD 6
RR-interval 30%

Ileofemoral Angiogram



Valve Type Selection in AMC

- **Size Matters:** Select valve with size in the “Safety Zone”
- **Prefer SAPIEN 3**
 - Less annular/subannular calcification
 - Annulus eccentricity (less eccentric)
- **Prefer EVOLUT R**
 - Severe heart failure (avoid rapid ventricular pacing)
 - Heavy calcification
 - Low coronary height (<10 mm)
 - Smaller peripheral vessel diameter (<5.5 mm)

S3 Device Sizing Algorithm

S3 Area Oversizing Based on the CT

15%, Cutoff

*Low Calcification
(Ca volume < 400 mm³)*

15%~20%, then Overfill

*Heavy Calcification
(Ca volume > 400 mm³)*

10%, then Overfill

*Bicuspid AS and
Heavy Calcification*

0%, then Overfill

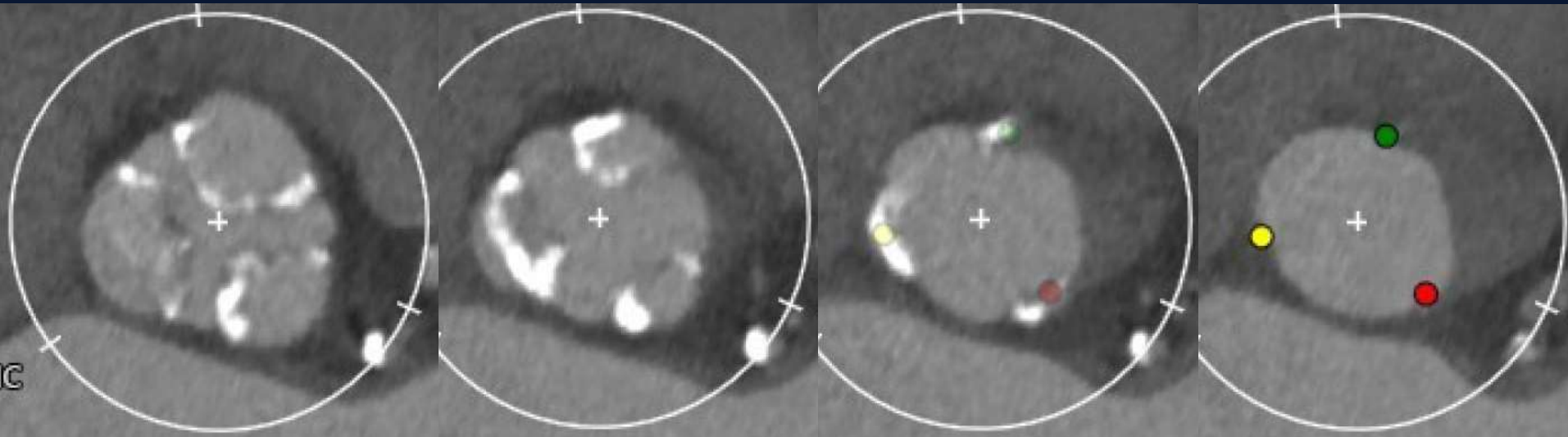
*Small LVOT or
Sinus Valsalva*

10%, then Overfill

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

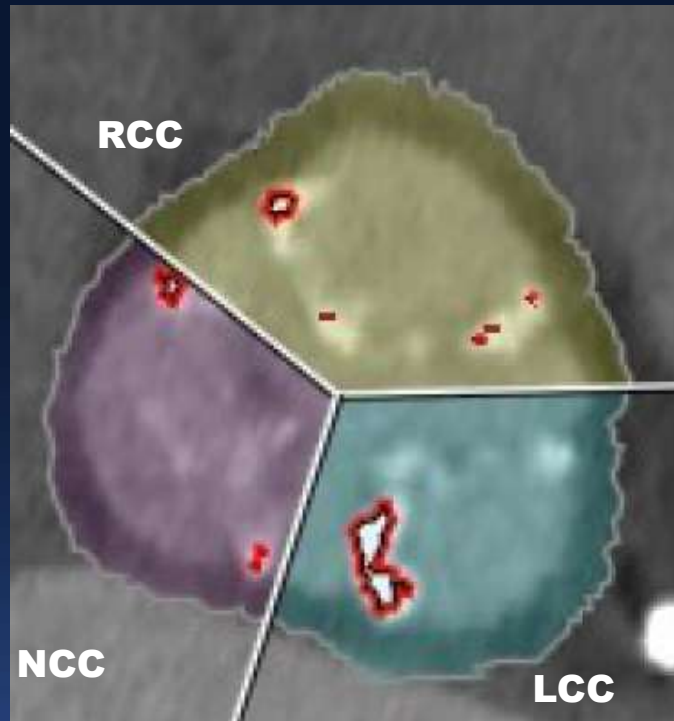
Case 1



Annulus plane

Aortic Annulus parameters	
Annulus short diameter	21.8 mm
Annulus long diameter	25.6 mm
Annulus 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

Calcium Amount



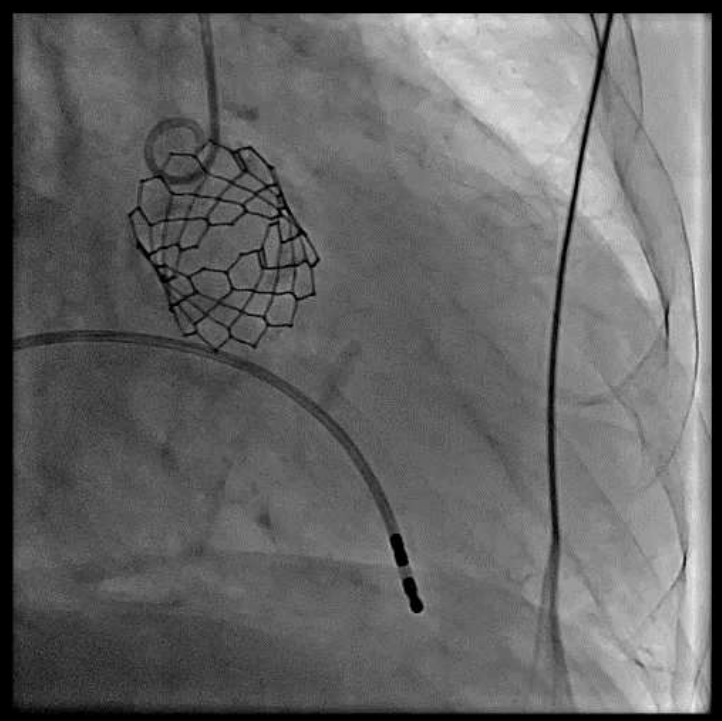
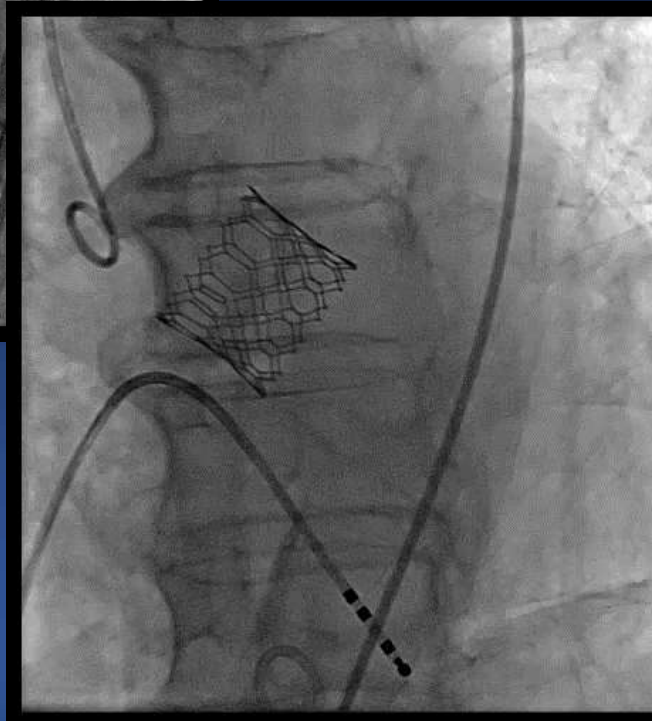
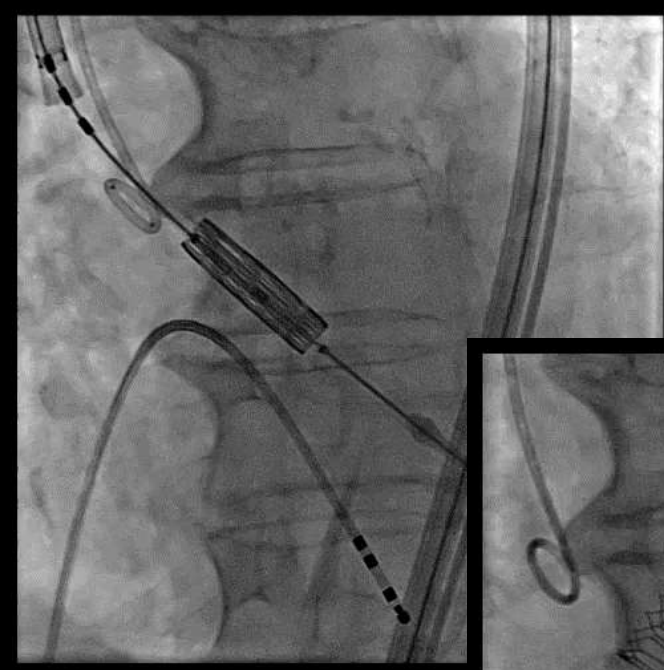
Calcium volume	
NCC	84 mm ³
RCC	62 mm ³
LCC	48 mm ³
Total	194 mm ³

I choose S3 26mm and 1cc Underfill

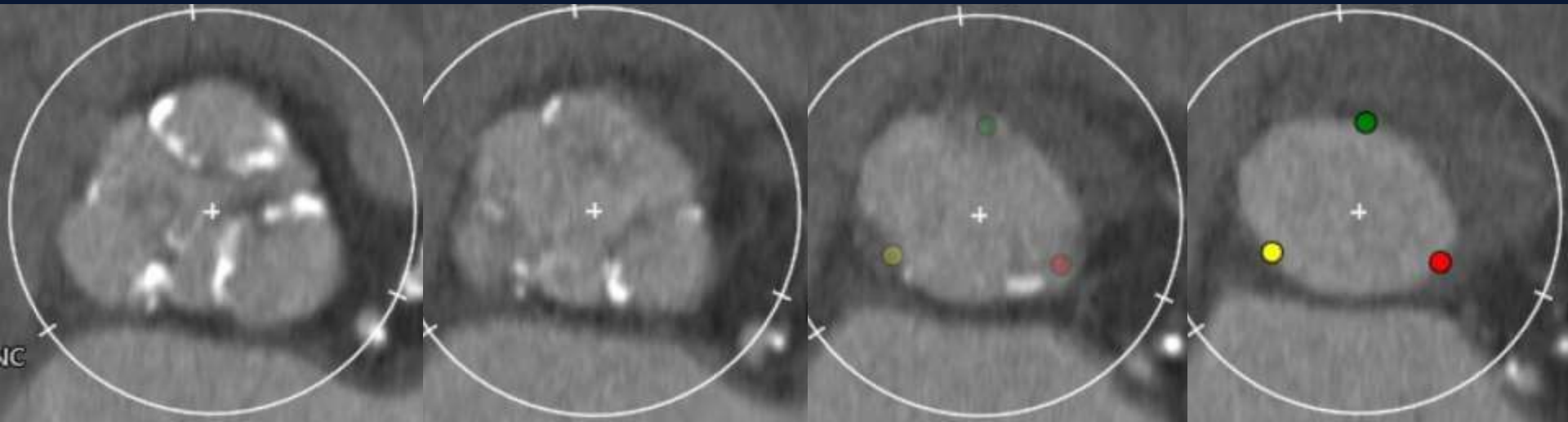
Size	Area_oversize (%)	Perimeter_oversize (%)
23	94.0	95.9
24	102.4	100.1
25	111.1	104.2
26	119.3	108.4
27	128.7	112.6
28	138.4	116.7
29	149.2	121.2

S3 26mm and 1cc Underfill

Trivial PVL



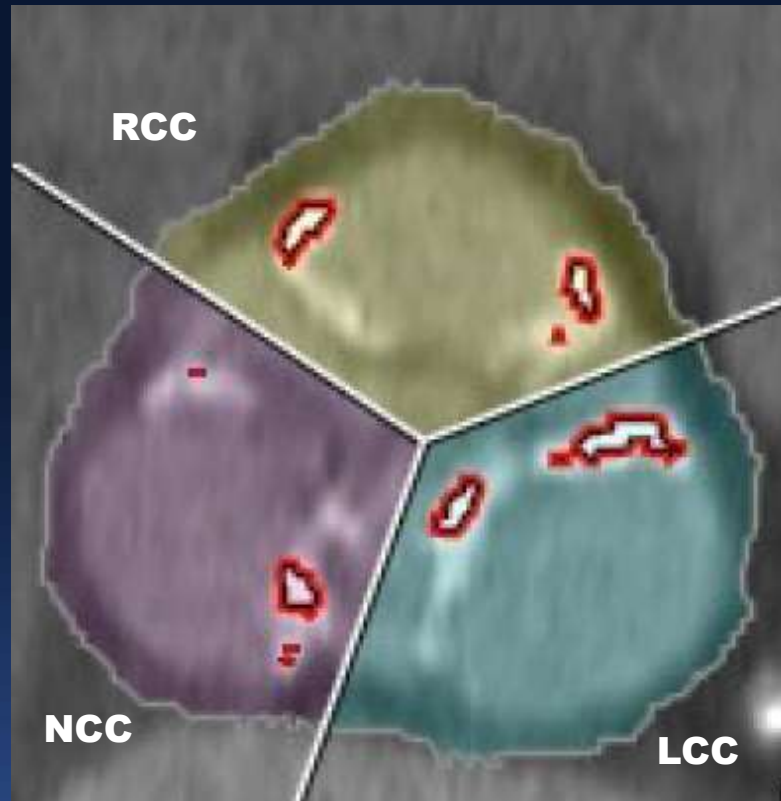
Case 2



Annulus plane

Aortic Annulus parameters	
Annulus short diameter	22.0 mm
Annulus long diameter	28.2 mm
Annulus 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

Calcium Amount

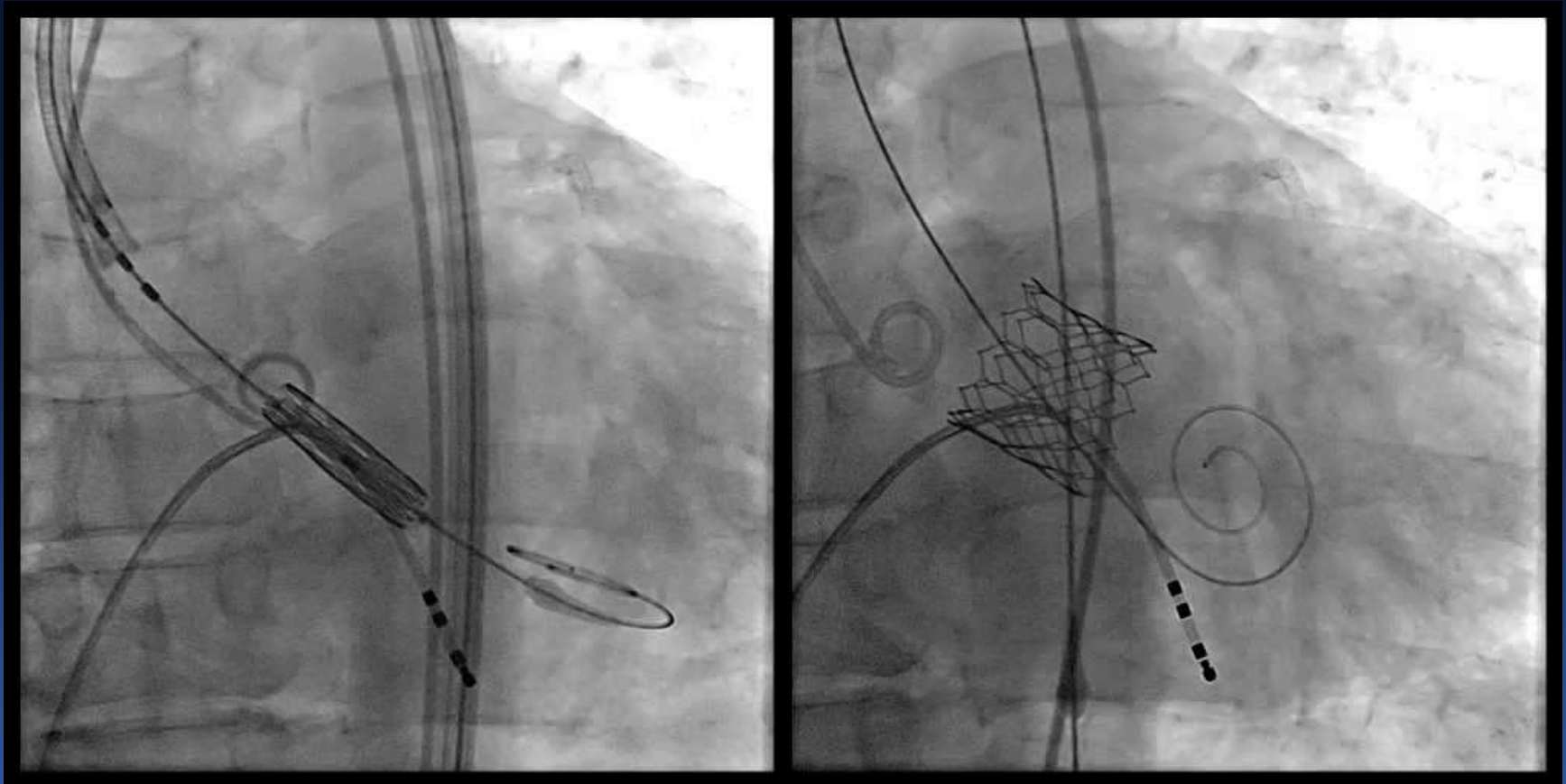


Calcium volume	
NCC	22 mm ³
RCC	48 mm ³
LCC	68 mm ³
Total	138 mm ³

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)

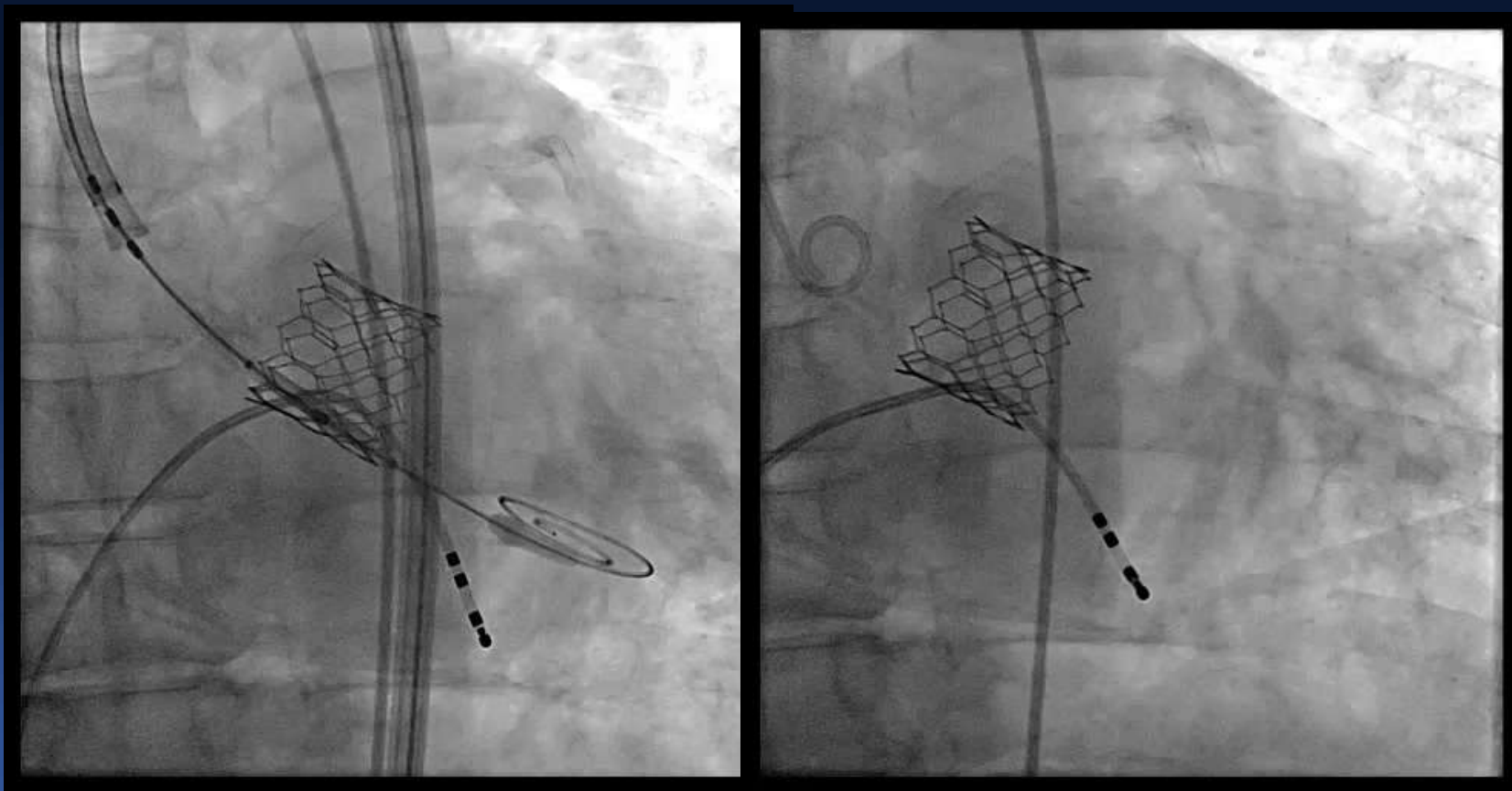


Moderate to Severe PVL

Post-dilatation 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

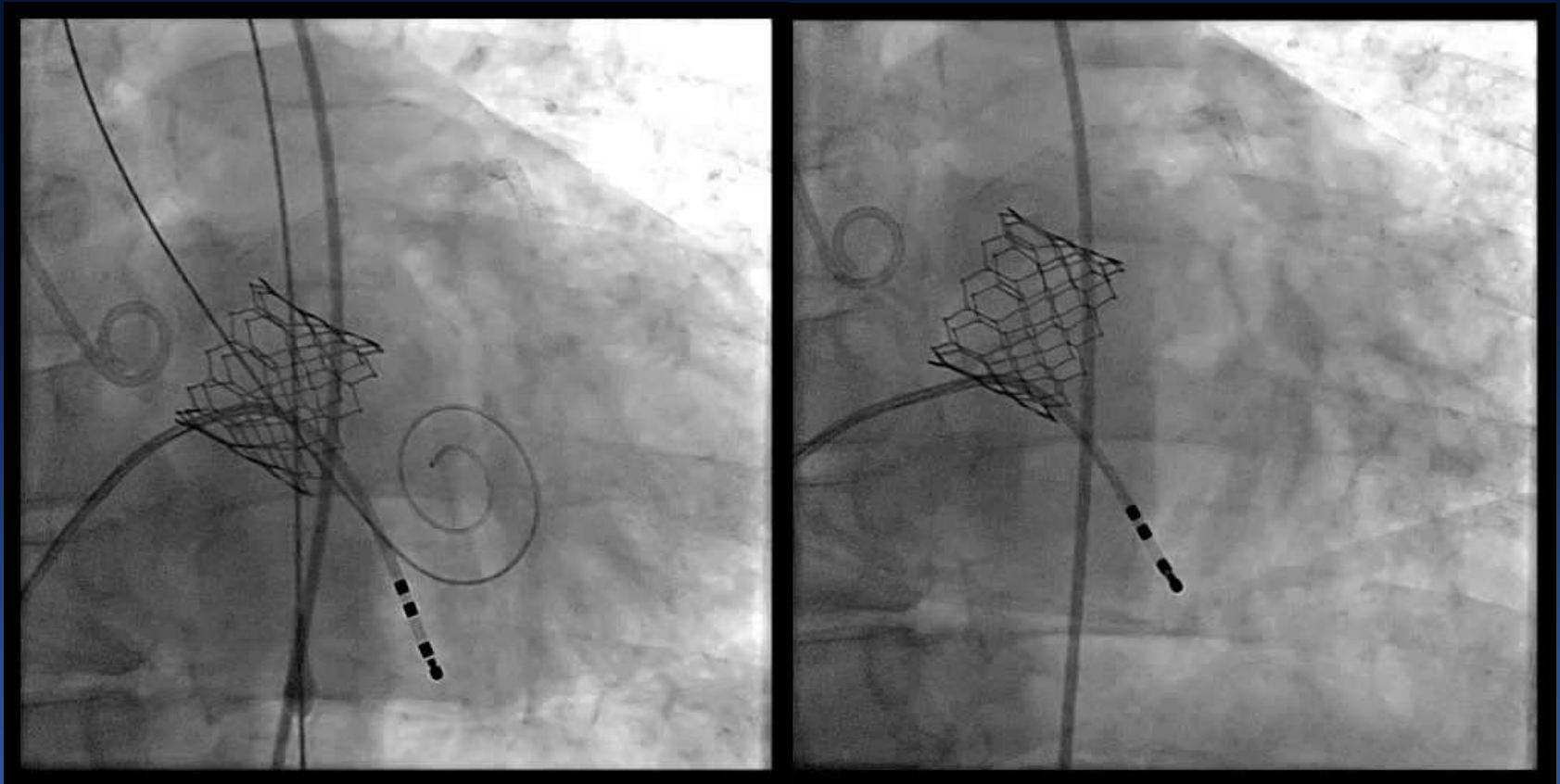
Post-dilation with +2cc Overfill (18% Oversizing)



Trivial PVL

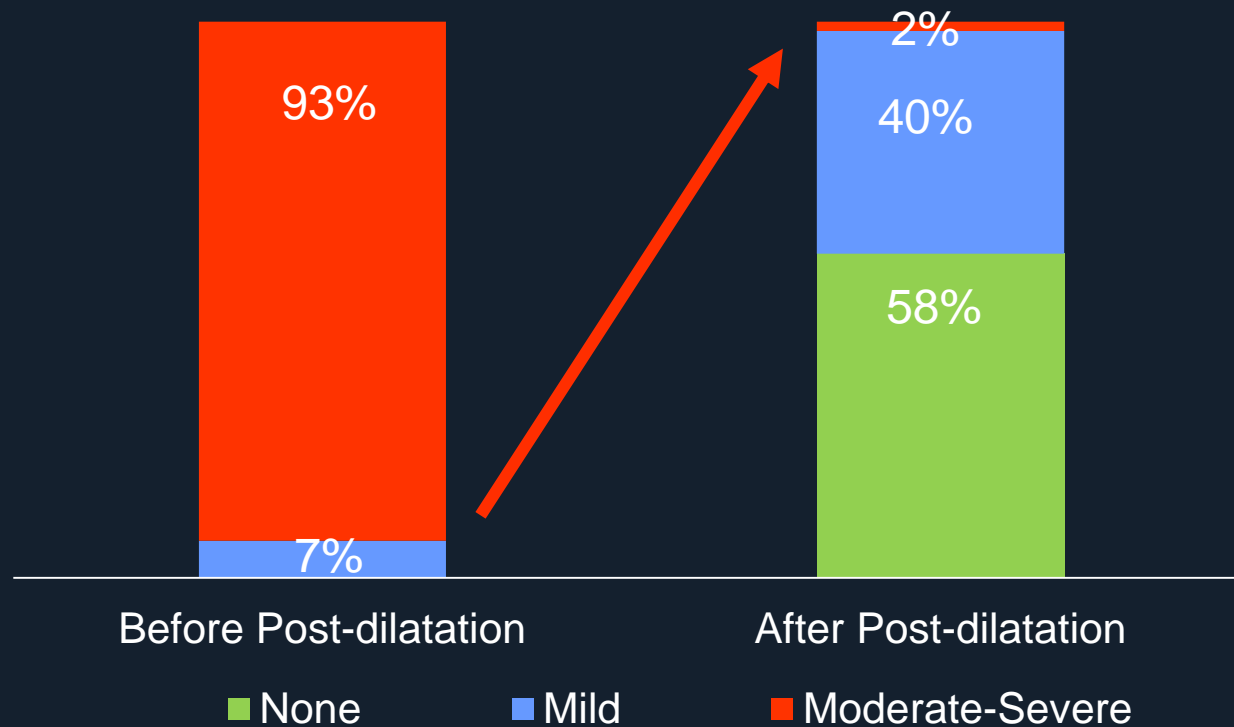
**S3 26 mm
(9.5% Oversizing)**

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



We Can Make A Big Difference !

PVL After Post-Dilatation (Sapien 3, n=60)



Case 3, Bicuspid AV



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 ²
Annulus area-driven diameter	27.4 mm
Annulus perimeter	86.5 mm
Annulus perimeter-driven diameter	27.5 mm

Calcium Amount

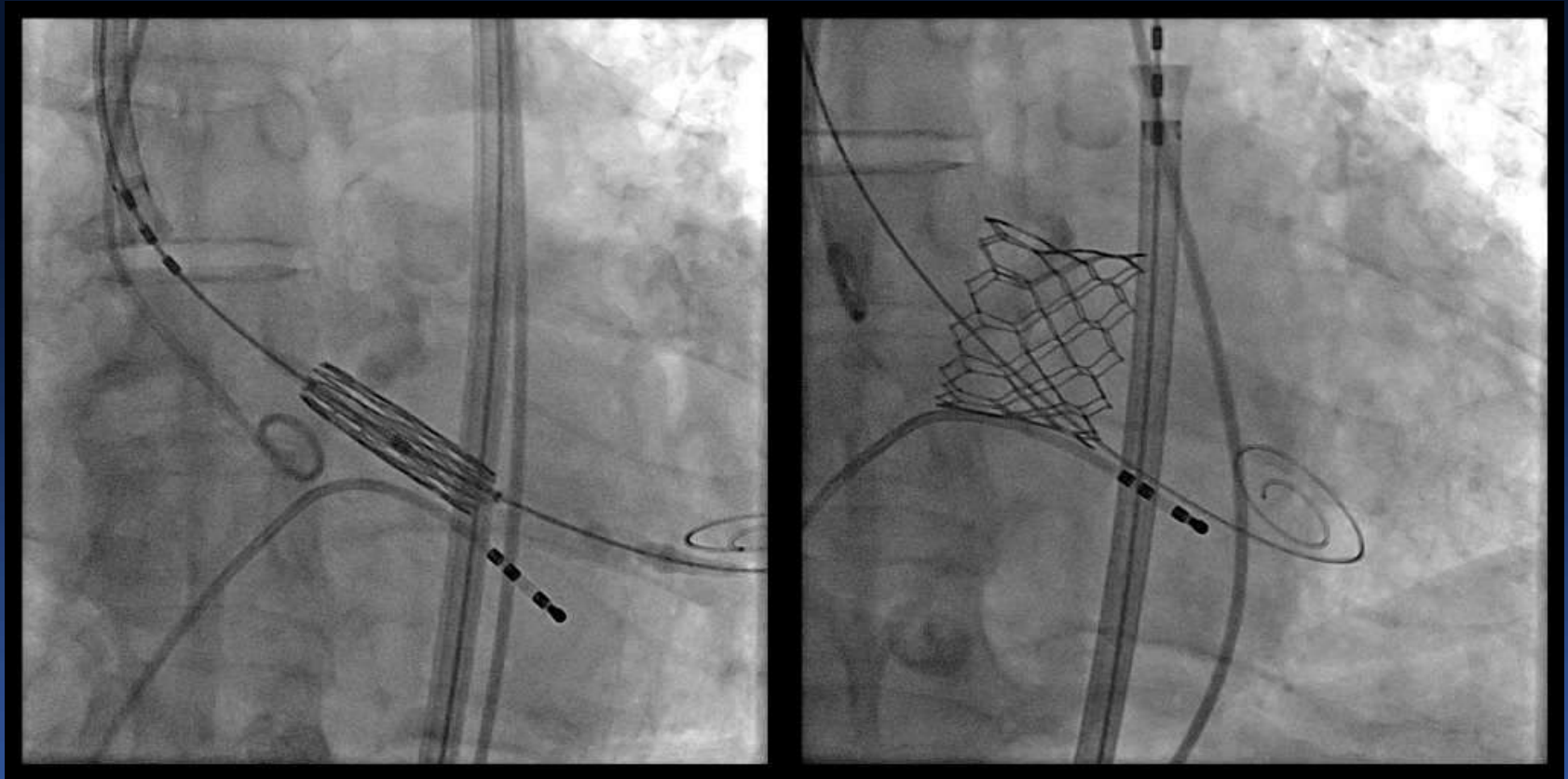


Calcium volume	
RCC	616 mm ³
LCC	48 mm ³
Total	664 mm ³

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)

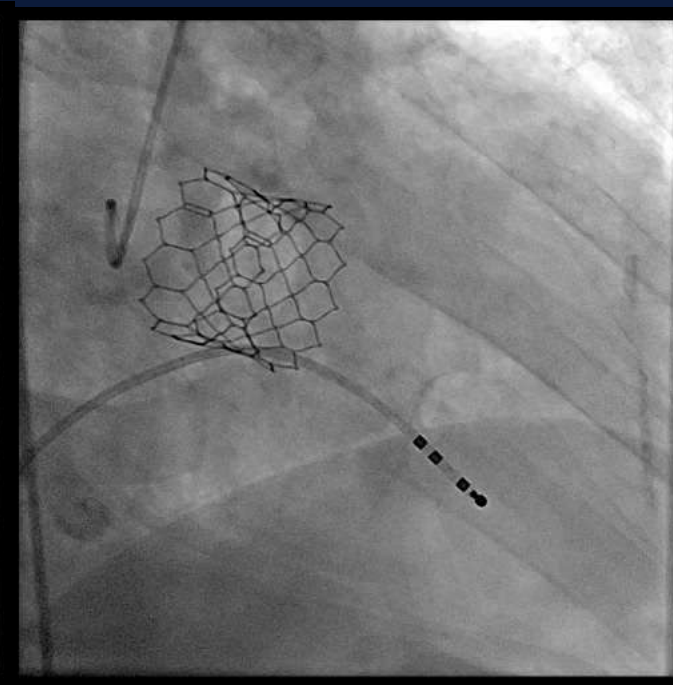
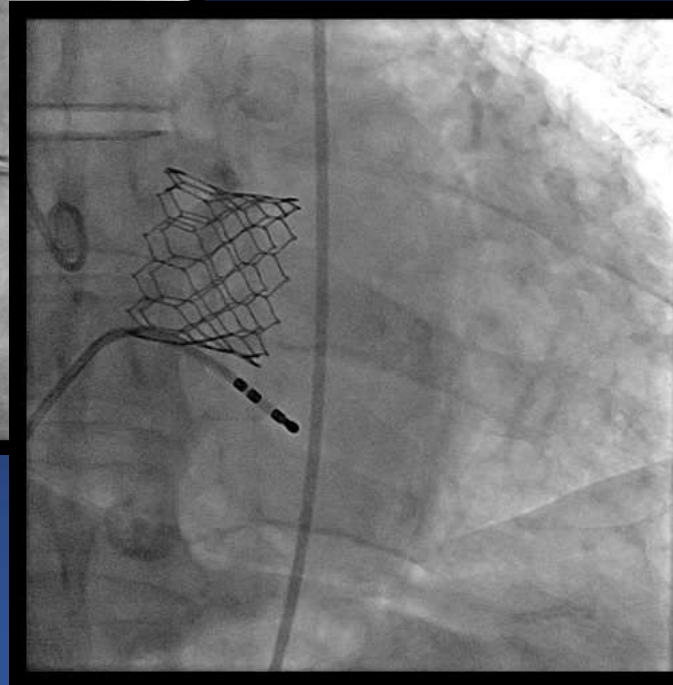
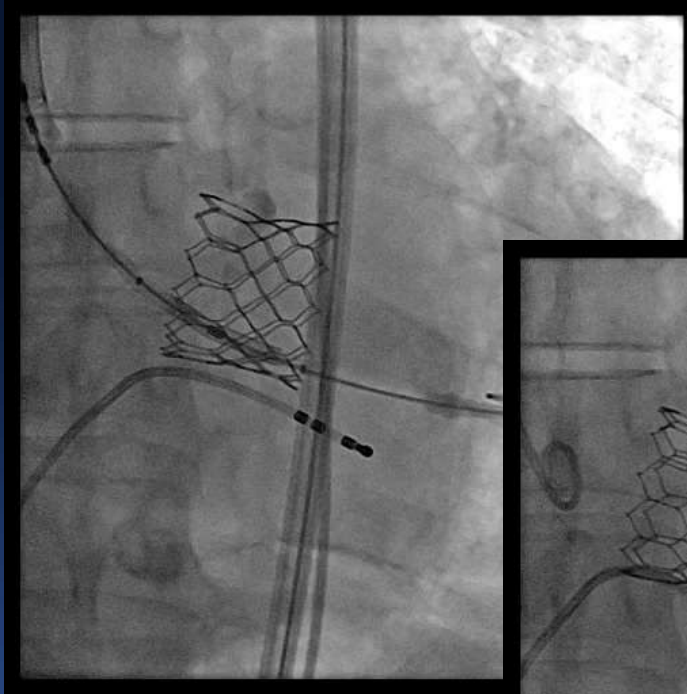


Moderate PVL

Post-dilatation with +3cc Overfill (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

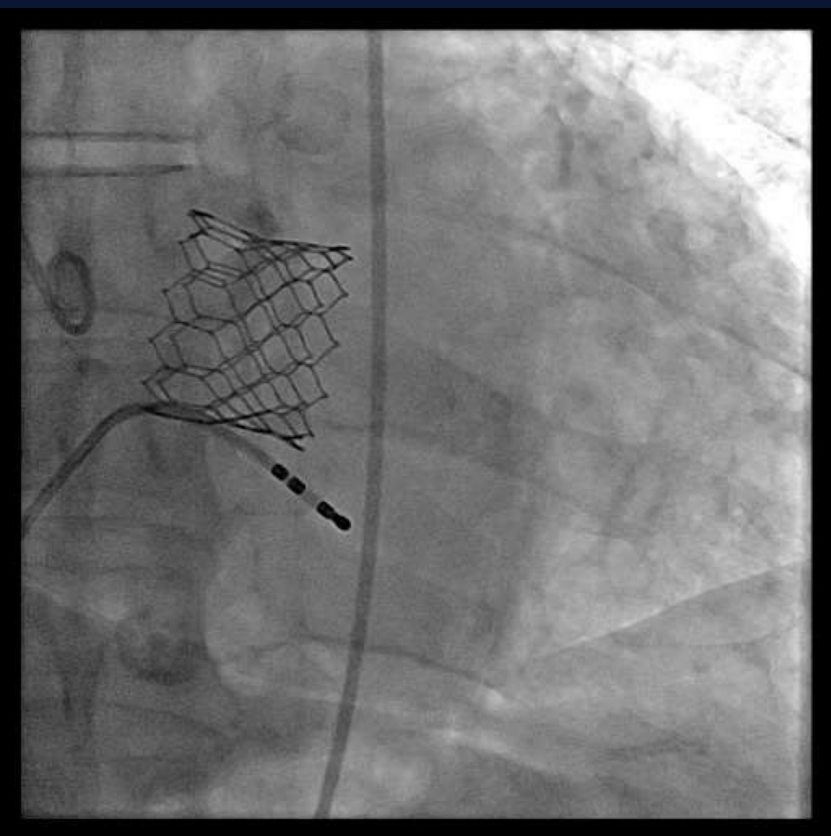
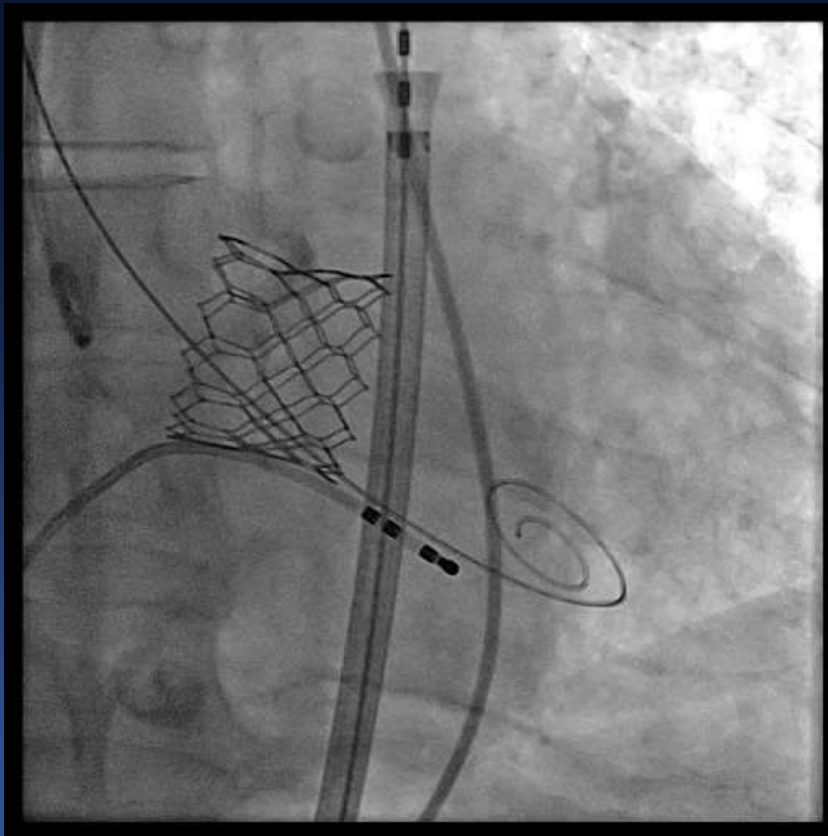
Post-dilation with +3cc Overfill (10% Oversizing)



Mild PVL

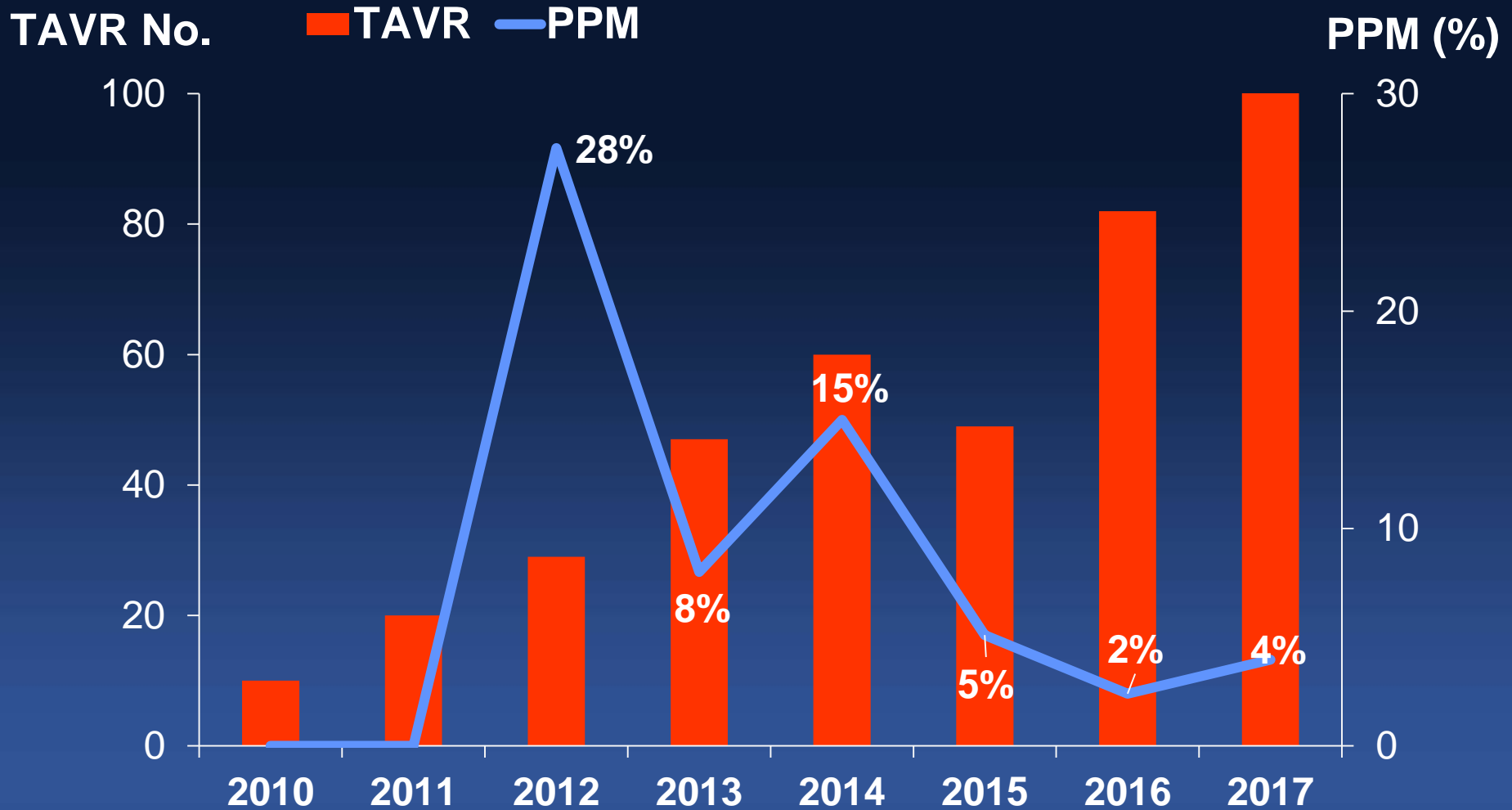
**S3 29 mm -3cc Underfill
(2% Oversizing)**

**+3cc Overfill,
29 mm Norminal
(10% Oversizing)**



We Can Make A Difference !

PPM After TAVR in AMC



Outcomes of TAVR

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

		AMC Total (n=465)	New valves (n=246)	S3 (n=183)
• All-cause mortality	< 3%	2.6%	1.2%	1.6%
• Major (disabling) strokes	< 2%	1.9%	0.4%	0%
• Major vascular complications	< 5%	2.2%	0.4%	0%
• New permanent pacemakers	< 10%	7.7%	4.1%	3.3%
• Mod-severe PVR	< 5%	9.5%	4.1%	2.2%

S3 Area Oversizing Based on the CT

15%, Cutoff

*Low Calcification
(Ca volume < 400 mm³)*

15%~20%, then Overfill

*Heavy Calcification
(Ca volume > 400 mm³)*

10%, then Overfill

*Bicuspid AS and
Heavy Calcification*

0%, then Overfill

*Small LVOT or
Sinus Valsalva*

10%, then Overfill

Conclusion

- **PPM implantation and PVL** is an issue, especially in the era of TAVR for young patients
- Be aware of risk factors (i.e, older age, baseline RBBB, severe calcification, membranous septum length, and procedural factors).
- **Appropriate valve selection and sizing** can minimize the complication rate.
- **Comprehensive CT analysis** is essential to optimize the procedural outcomes.



Thank You !!

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