

Cardiac CT from Diagnosis to treatment planning- from TAVR to PCI

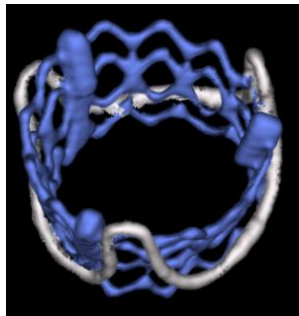
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Canada Research Chair Advanced Cardiac Imaging



Disclosures

Speaker's bureau: GE Healthcare and Philips Healthcare

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Consultant-Heartflow, Circle CVI

Travel support: Arineta

Corelab- NIH, Edwards Lifesciences, Neovasc, Tendyne,
Medtronic, Boston Scientific, Abbott

ACC/AHA Chest Pain Guidelines



Elevating Coronary CTA: CCTA is the only Class 1 noninvasive test with Level A evidence for **diagnosing** CAD and **guiding** treatment decisions

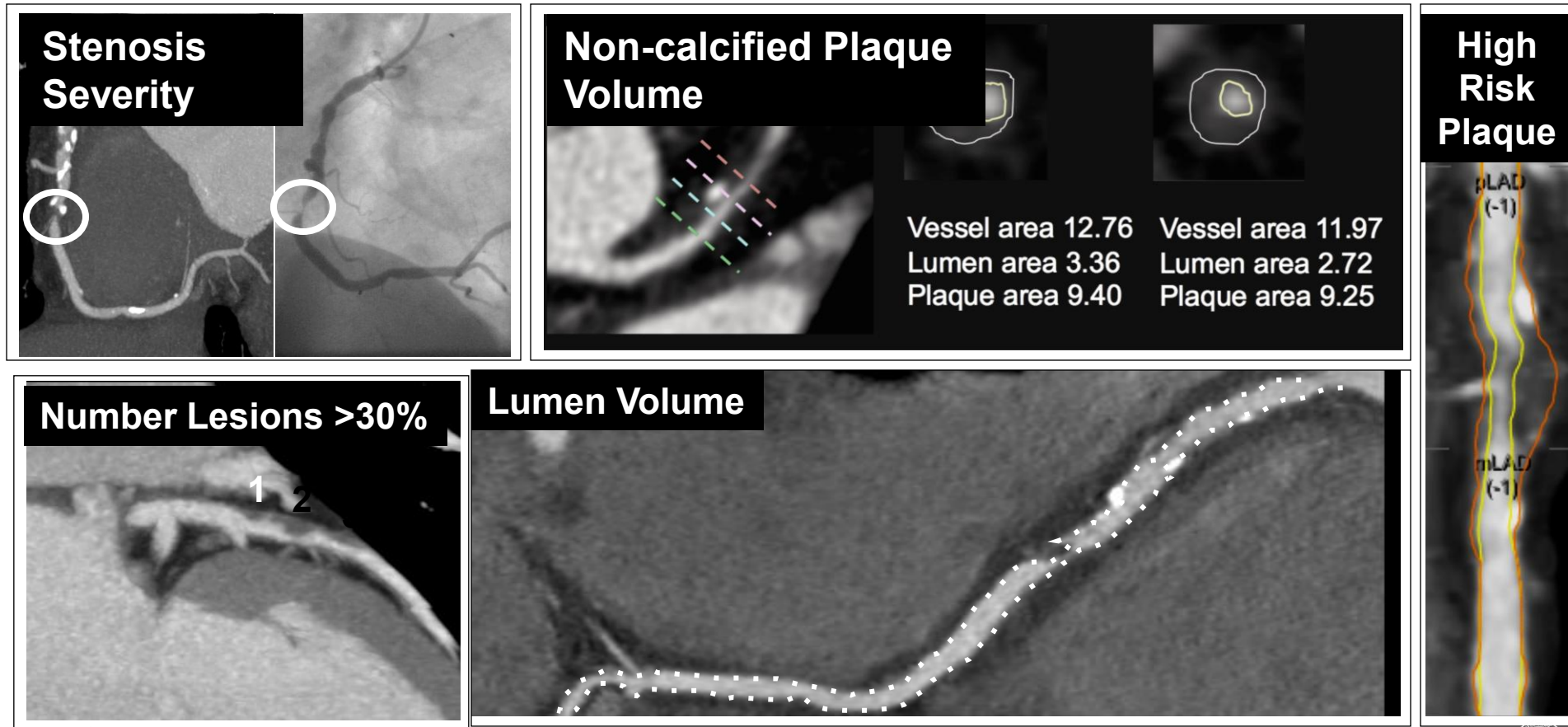
COR	LOE	RECOMMENDATIONS
Index Diagnostic Testing		
Anatomic Testing		
1	A	1. For intermediate-high risk patients with stable chest pain and no known CAD, CCTA is effective for diagnosis of CAD, for risk stratification, and for guiding treatment decisions (1-12).

- **Diagnose** CAD
- **Stratify** patient risk
- **Guide** treatment decisions



Coronary CTA enables clinicians to
Take Informed Action

Quantifying atherosclerosis with CCTA is becoming more robust and reproducible with defined measures

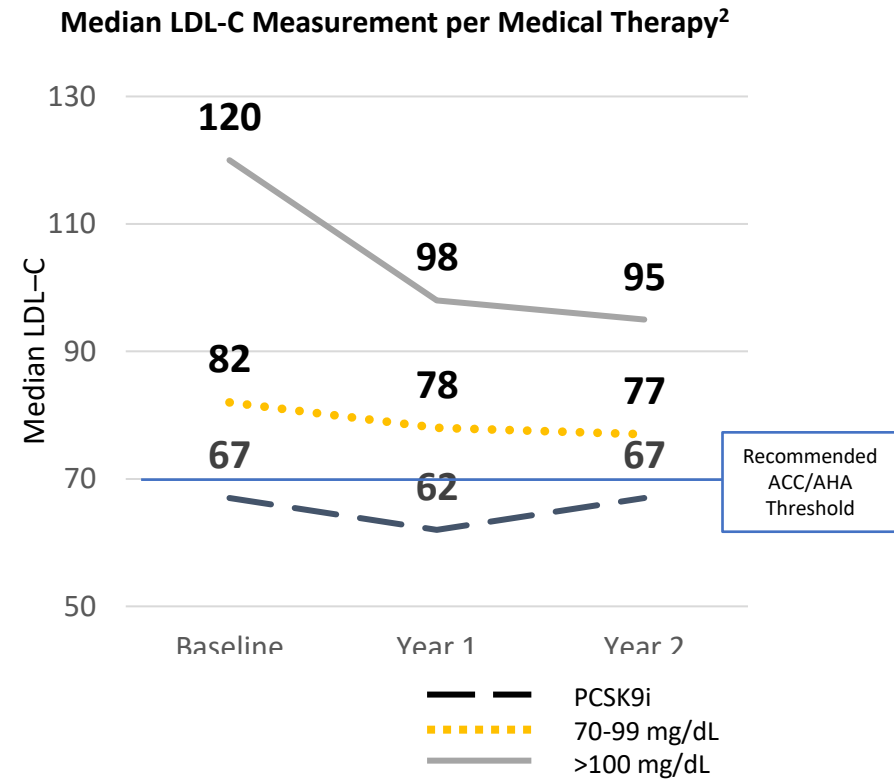


Patients Are Not Reaching LDL Targets

Known LDL-Management Challenges¹

- Inadequate risk classification
- Underutilization of combination therapies
- Lack of patient adherence to Rx

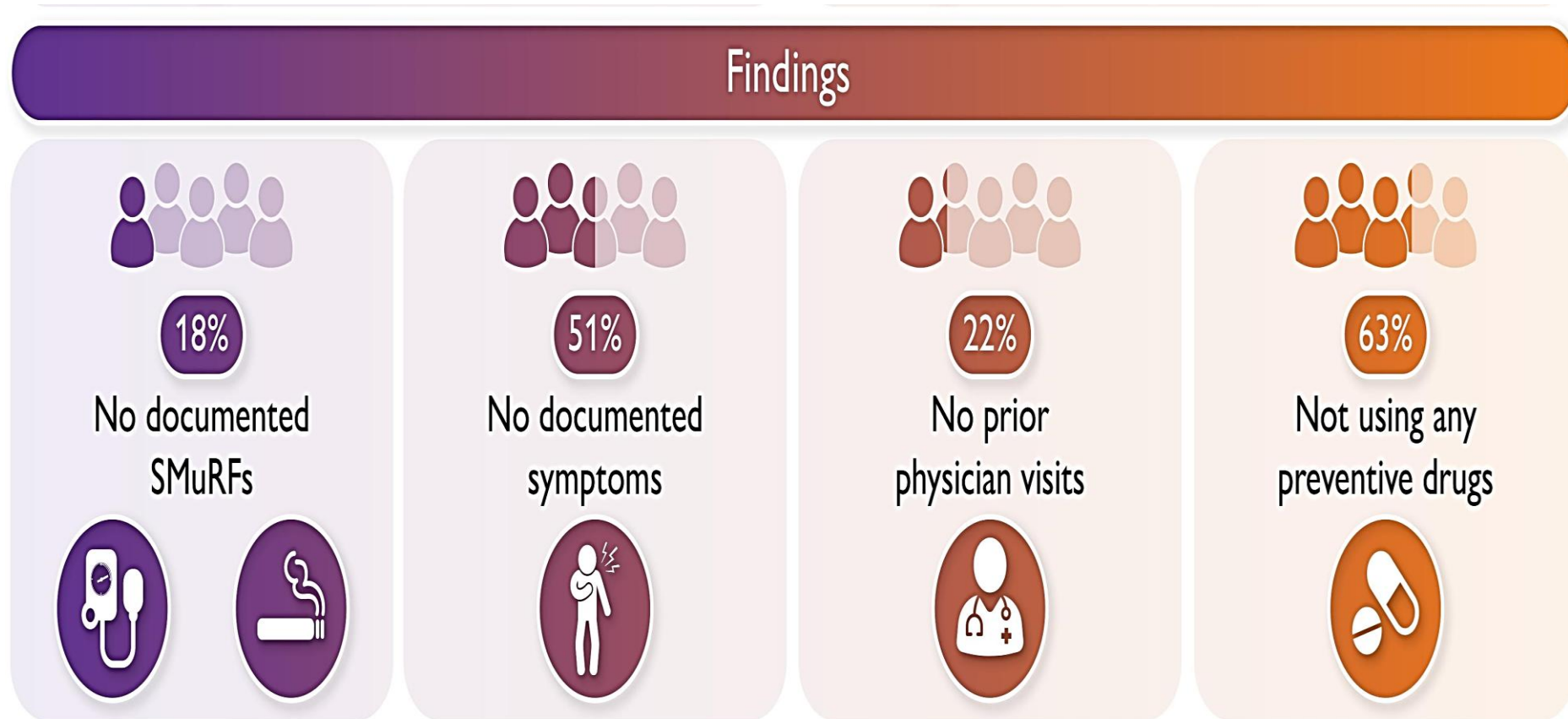
2/3rds of patients remain ≥ 70 mg/dL in this 5,000+ U.S. patient registry.²



1. Ray KK, et al. SANTORINI study. Lancet Reg Health Eur. 2023 Apr 5;29:100624. doi: 10.1016/j.lanepe.2023.100624.

2. Cannon CP, et al. GOULD Registry. JAMA Cardiol. 2021 Sep 1;6(9):1060-1068. doi: 10.1001/jamacardio.2021.1810.

Most patients are low risk prior to MI in the contemporary setting



Visual semiquantitation of plaque should be included in a modern report

CAD-RADS 2.0: Include plaque quantification in every report

	Overall amount of coronary plaque	CAC	SIS*	Visual*
P1	Mild	1–100	≤2	1-2 vessels with mild amount of plaque
P2	Moderate	101–300	3–4	1-2 vessels with moderate amount; 3 vessels with mild amount of plaque
P3	Severe	301–999	5–7	3 vessels with moderate amount; 1 vessel with severe amount of plaque
P4	Extensive	>1000	≥8	2-3 vessels with severe amount of plaque

- ✓ Visual quantification
- ✓ Segment involvement score
- ✓ Calcium score

Management recommendation take into account severity of stenosis and plaque burden



Journal of Cardiovascular Computed Tomography

journal homepage: www.JournalofCardiovascularCT.com



Practice guidelines

CAD-RADS™ 2.0 - 2022 Coronary Artery Disease – Reporting and Data System an expert consensus document of the Society of Cardiovascular Computed Tomography (SCCT), the American College of Cardiology (ACC), the American College of Radiology (ACR) and the North America society of cardiovascular imaging (NASCI)

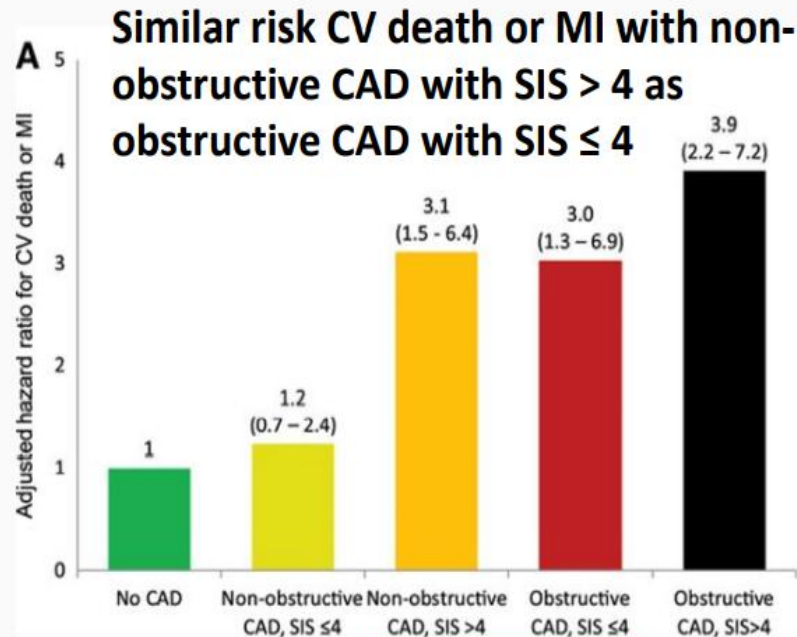
Ricardo C. Cury^{1,*}, Jonathon Leipsic², Suhny Abbata³, Stephan Achenbach⁴, Daniel Berman⁵, Marcio Bittencourt¹, Matthew Budoff⁶, Kavitha Chinnaiyan⁷, Andrew D. Choi¹, Brian Ghoshhajra¹, Jill Jacobs¹, Lynne Kowceck⁸, John Lesser⁹, Christopher Maroules¹⁰, Geoffrey D. Rubin¹¹, Frank J. Rybicki¹², Leslee J. Shaw¹³, Michelle C. Williams¹⁴, Eric Williamson¹⁵, Charles S. White¹⁶, Todd C. Villines¹⁷, Ron Blankstein¹⁸

**ESC CONGRESS 2022
Barcelona & Online**

Plaque is a power predictor of risk

Overall amount of plaque → associated with events

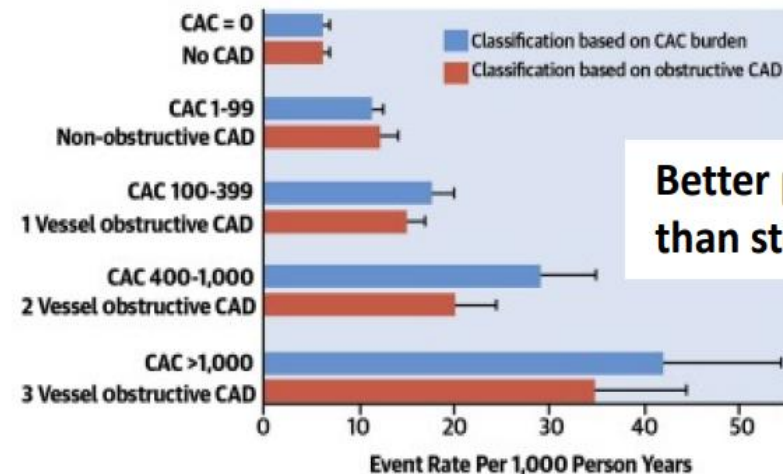
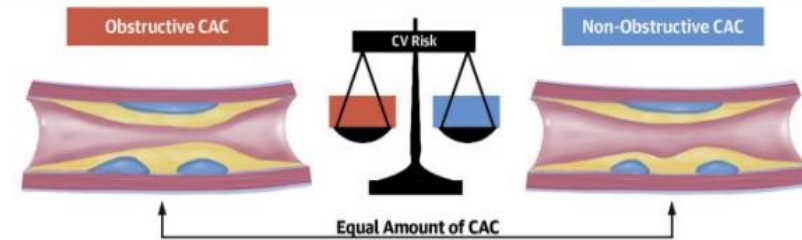
- 3242 patients
- Median 3.6 year follow up



Bittencourt, Blankstein et al, Circulation CV imaging 2014

Western Denmark Heart Registry

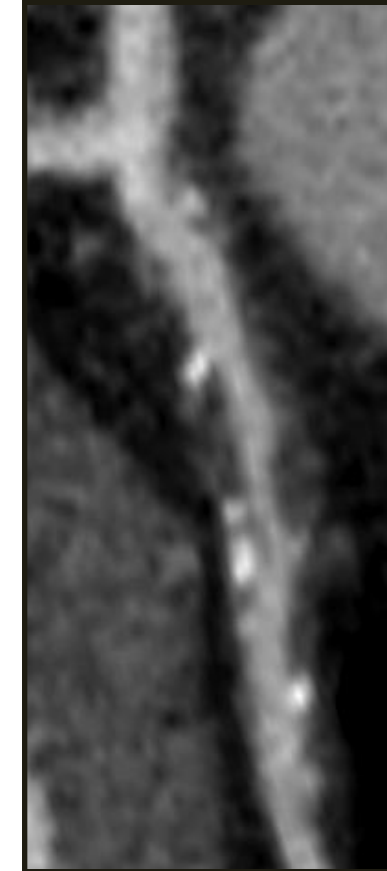
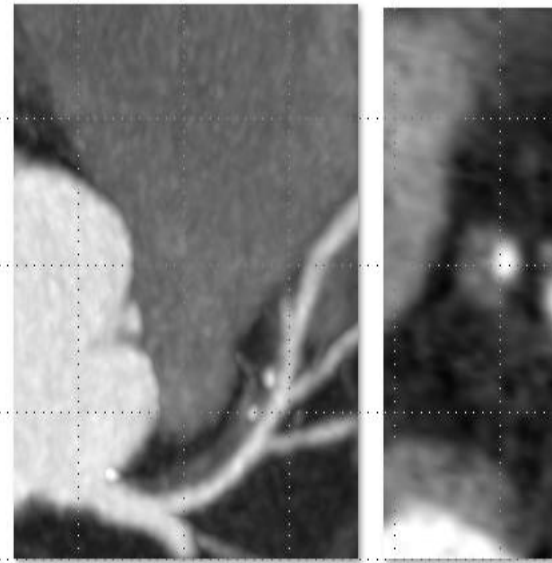
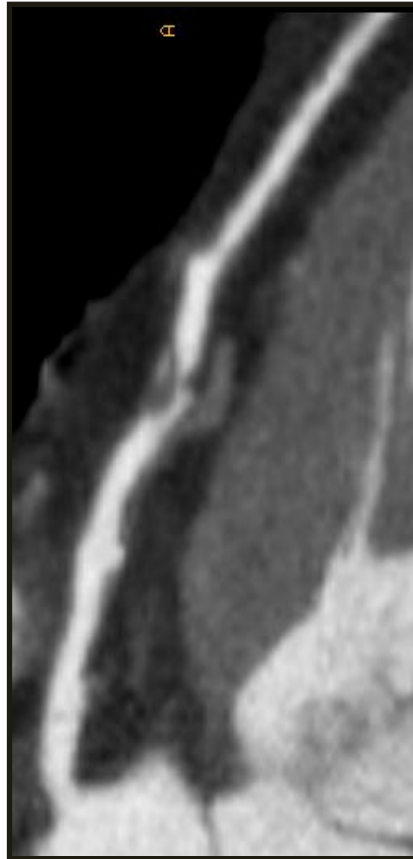
→ 23,759 symptomatic patients



Better predictor than stenosis !

Mortensen et al. JACC 2020

How can SIS be enough??

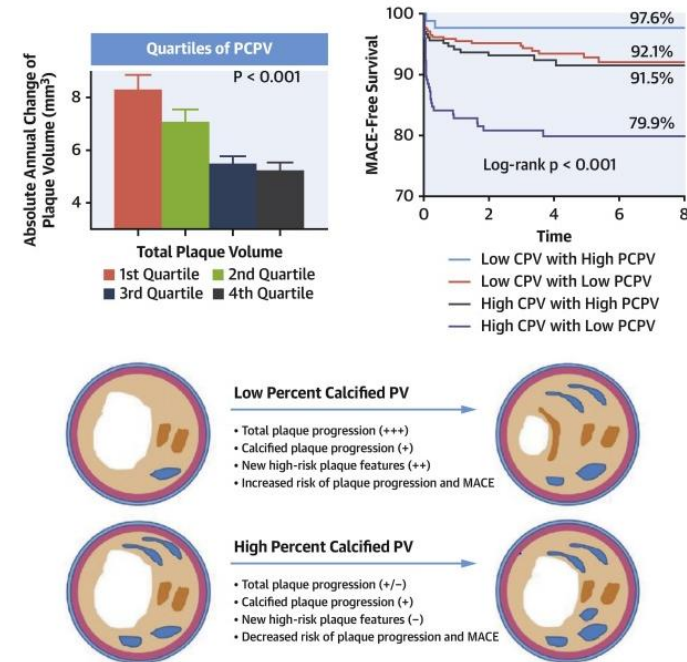
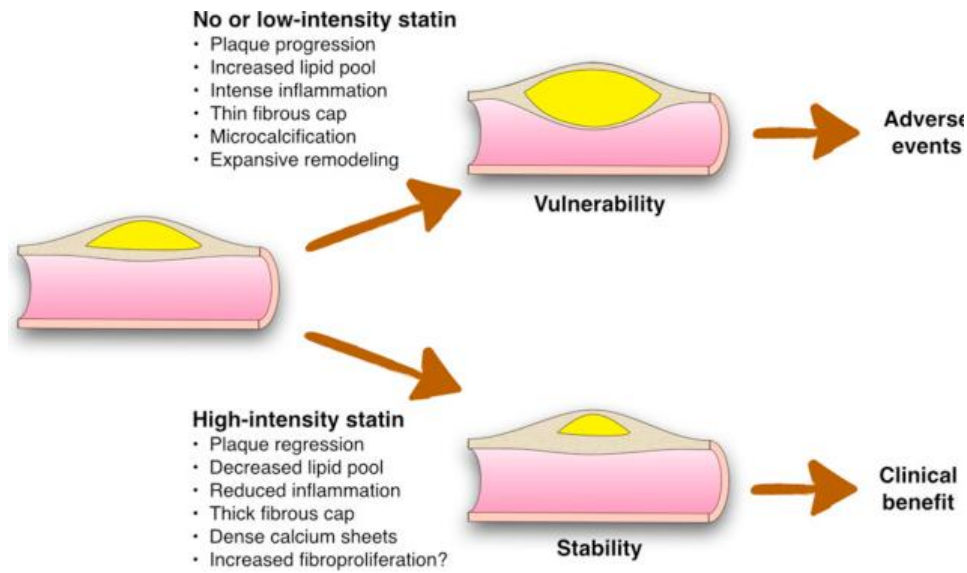


All of the patients have 1 -2 segment of plaque hardly the same disease burden

Plaque progression is a
needed step prior to MI

Unfortunately, CACS is not an effective measure
in younger subjects and cannot be followed to
track treatment response

Tracking CACS alone once present is ineffective



Source: Weir- McCall, Leipsic et al *JACC Imaging* 2020.

Source: Ferencik et al *Athero* 2015.

Support & Acceptance of AI-CPA is Growing

Discussing the What and Why of AI-CPA

THE
LANCET



American
Heart
Association.

- Shift CAD care toward “an emphasis on **early detection of disease**” with “**proactive intervention** at every stage” while “recognising the prognostic importance of the **coronary plaque** itself.”
- “Medical management of non-obstructive CAD plays an essential role in plaque **stabilization and regression**”
- “Phenotyping of non-obstructive CAD with CCTA ... can provide substantial value in the **personalization of preventive therapies**.”

Discussing the When and How of AI-CPA



- “Among patients who have **visual evidence of plaque** on coronary CTA, adding QCPA* may be useful for enhancing risk assessment and guiding the initiation or intensification of preventive therapies.”
- “Ideally, a single report that includes and integrates both coronary CTA (qualitative) and QCPA (**TPV, NCPV and CPV**) data would be preferable.”
- “Serial coronary QCPA may be reasonable if [it] will result in a **meaningful change to patient management**.”

ACC Scientific Statement: AI-CPA in Clinical Practice

Clinical Indication for Plaque Analysis

- Among patients who have **visual evidence of plaque** on coronary CTA, adding AI-CPA may be useful for **enhancing risk assessment** and **guiding the initiation or intensification of preventive therapies**.

ACC SCIENTIFIC STATEMENT

Quantitative Coronary Plaque Analysis in Clinical Practice:

Amount of Plaque	Total Plaque Volume, mm ³
Mild	1-100
Moderate	101-250
Severe	251-750
Extensive	>750



Recommendations:



Validate algorithms against invasive imaging or histology reference data



Visualize plaque on CCTA before ordering AI-CPA (*discard the sub-clinical disease argument*)



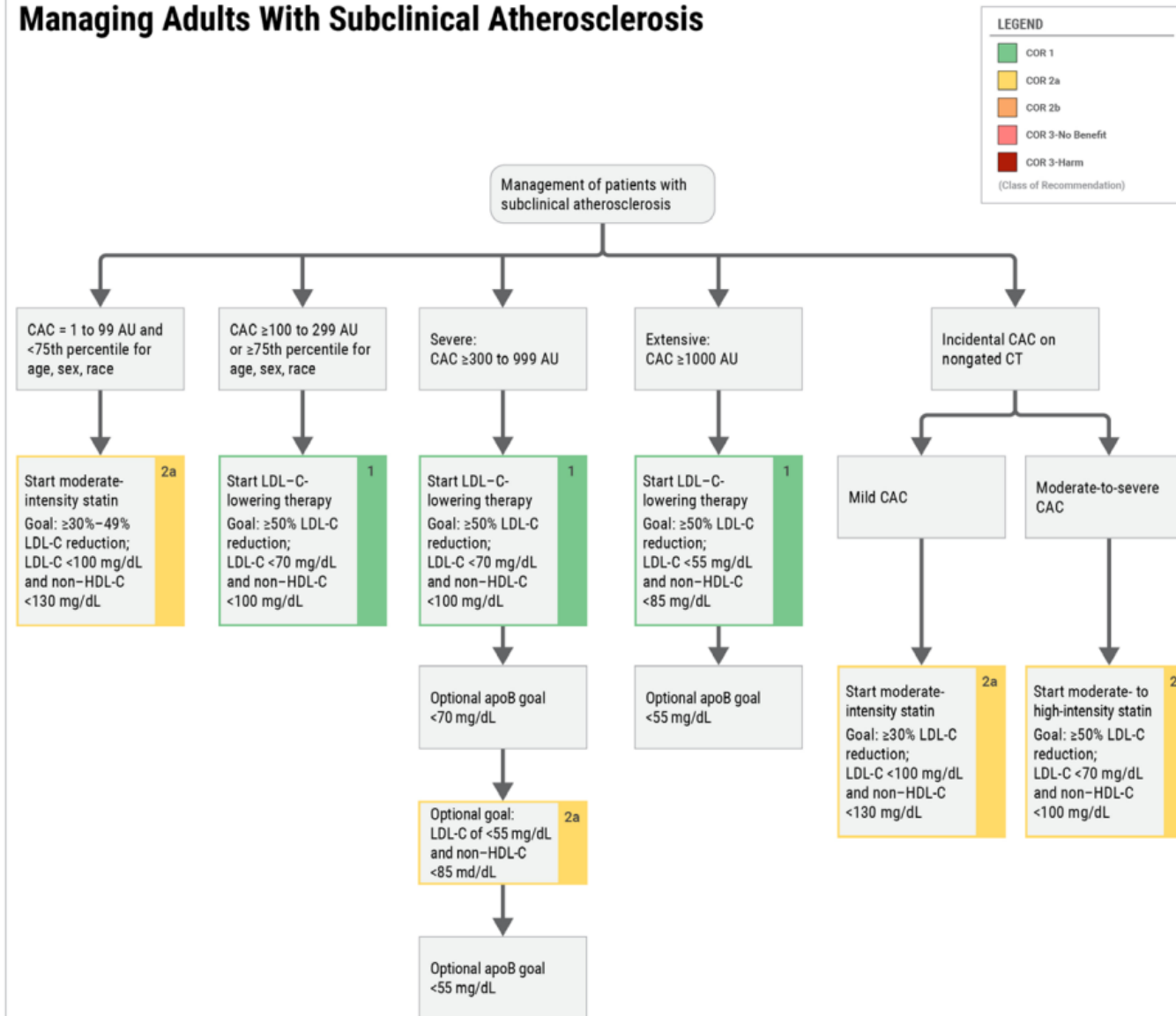
Report total, calcified, and non-calcified plaque volumes (TPV, CPV, NCPV) and excluded segments



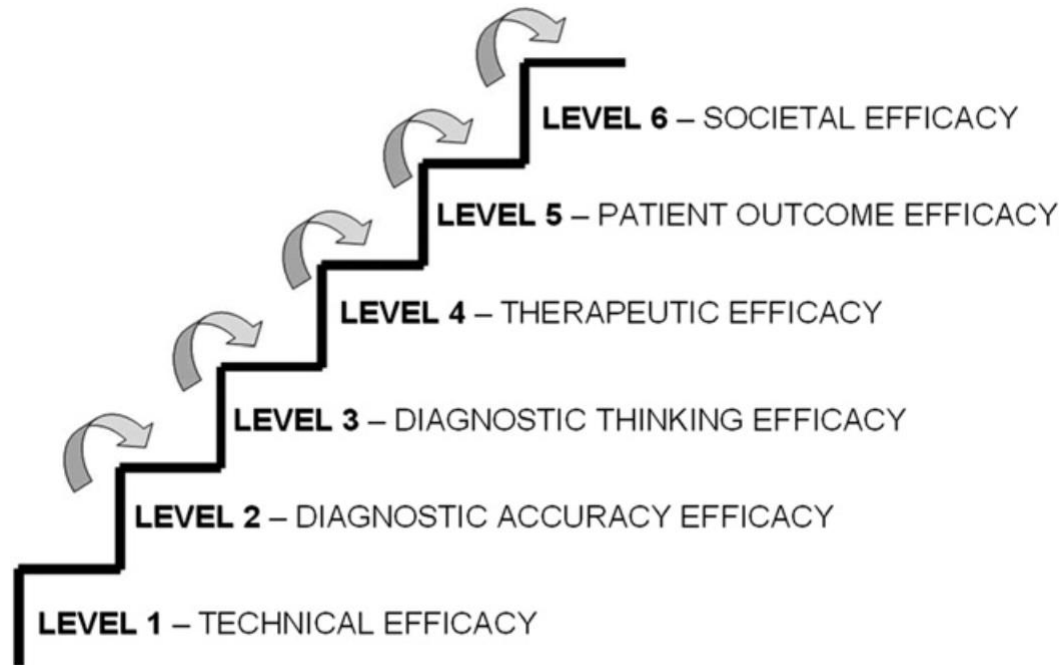
Repeat AI-CPA after 2-5+ years if patient management may change

Atherosclerosis is not considered binary any longer- Lessons from the Dyslipidemia Guidelines

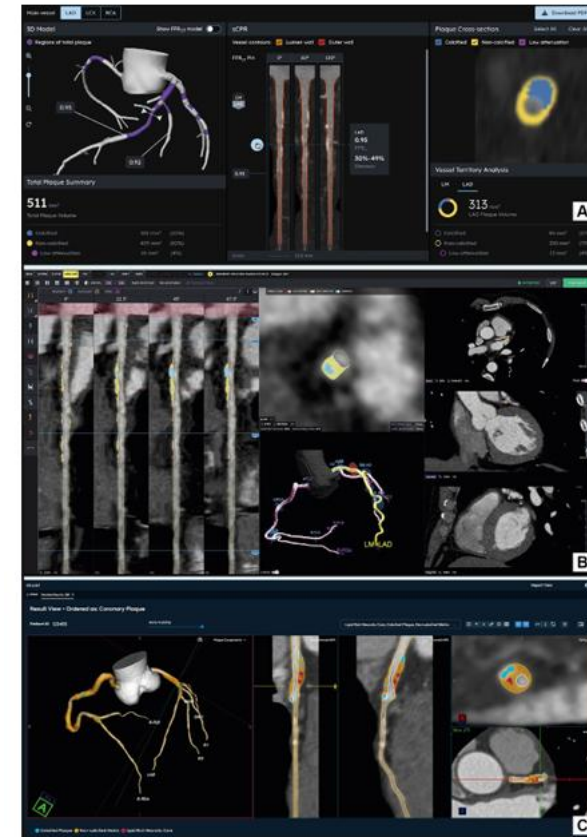
Managing Adults With Subclinical Atherosclerosis



Need Robust and Validated Tools



Fryback and Thornbury's 30 framework of the efficacy of diagnostic imaging.

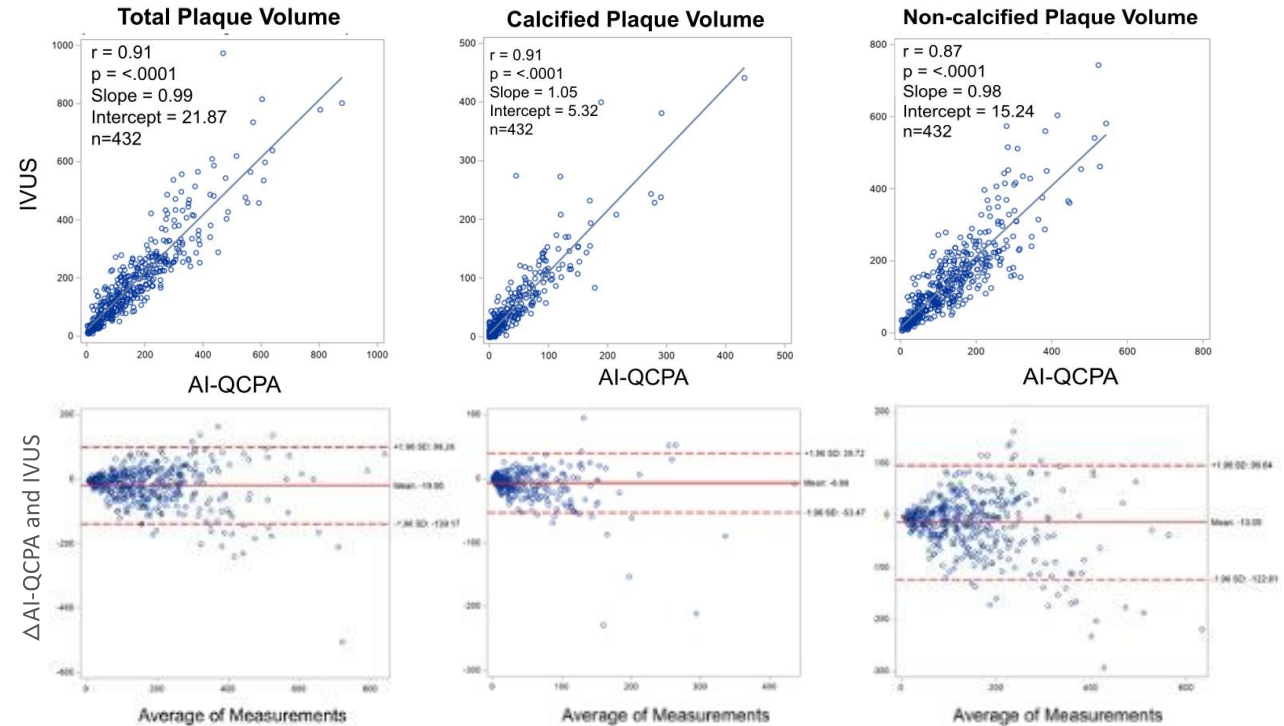


Accuracy: REVEALPLAQUE Study



Study Design

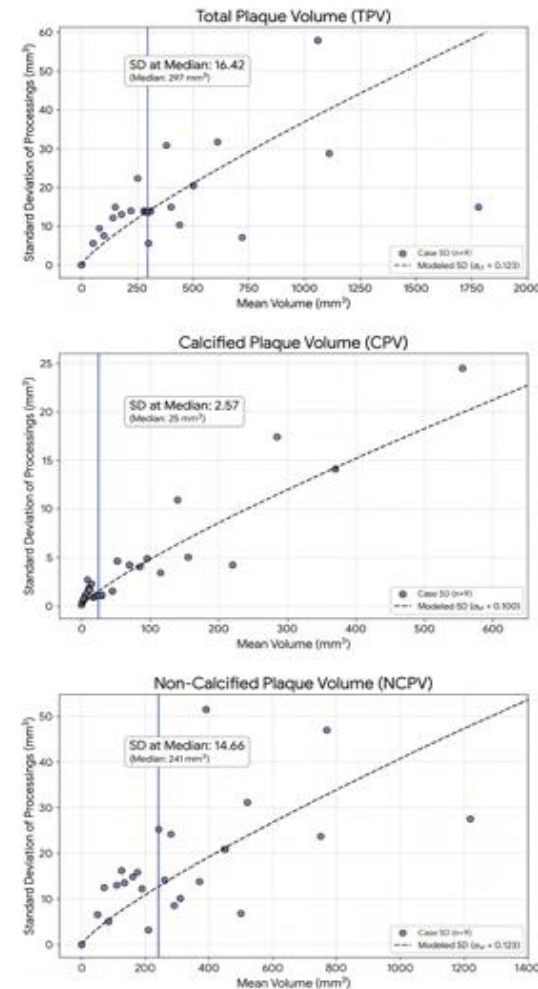
- Blinded, prospective comparison of plaque volume determined by Plaque Analysis vs core lab read IVUS
- 254 patients across 15 sites



Growing validation of the reproducibility of quantitative atherosclerosis

	Inter-observer Variability
TPV	3.1% 12.0 mm ³ [95% CI: 6.3 - 37.4 mm ³]
CPV	5.7% 5.0 mm ³ [95% CI: 3.5 - 13.6 mm ³]
NCPV	3.9% 11.6 mm ³ [95% CI: 7.5 - 26.8 mm ³]
	Intra-Observer Variability
TPV	5.3% 20.4 mm ³ [95% CI: 18.4 - 22.9 mm ³]
CPV	6.4% 5.6 mm ³ [95% CI: 5.1 - 6.3 mm ³]
NCPV	5.9% 17.6 mm ³ [95% CI: 15.8 - 19.7 mm ³]

Figure 2: Plaque volume variability for TPV, CPV, and NCPV.



Population Context: Plaque Nomograms

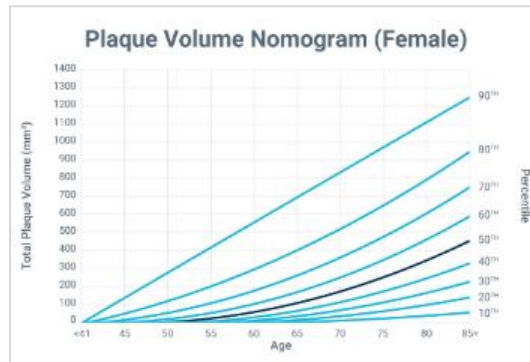
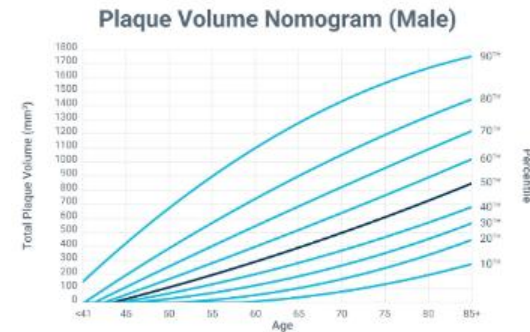


Study Design

- ~12,000 patients from 29 health care systems in US and Canada undergoing clinically-indicated CCTA
- Quantitative plaque assessment using AI QPCA

Results

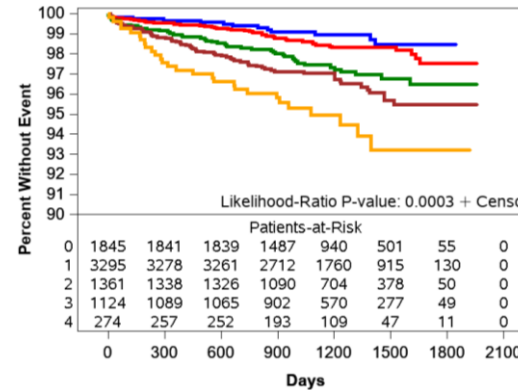
Plaque volume stratification by age and sex now available to help aid in optimizing patient management



Plaque Volumes Inform Risk of MACE

FISH & CHIPS

- Risk of CV Death or MI through 3.3 years by Plaque Stage in 7,899 NHS England patients undergoing clinically indicated CCTA³
- Controlled for age, sex, DM, HTN, dyslipidemia, stenosis, & FFR_{CT}

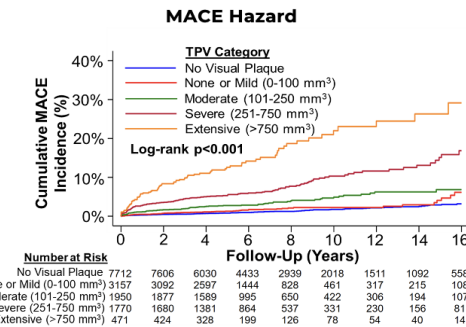
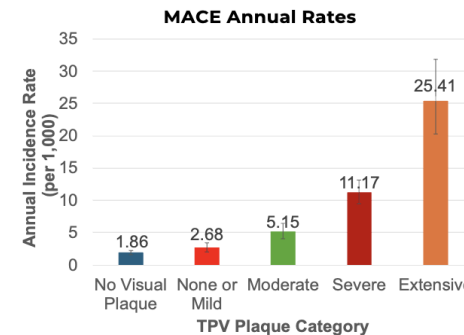


Multiple variable*			
Plaque Stage	TPV (mm ³)	HR (95% CI)	p-value
0	0	Reference	
1	1-100	1.45 [0.77-2.71]	0.2517
2	101-250	2.46 [1.25-4.83]	0.0090
3	251-750	3.18 [1.55-6.53]	0.0017
4	>750	5.10 [2.25-11.52]	<0.0001

Mass General Brigham CCTA Registry

- Long-term CV events through median 6.3 years by DECIDE Plaque Stage in 15,060 MGB patients undergoing clinically indicated CCTA⁴
- AI-QCP volume was associated with adverse cardiovascular events independent of traditional cardiovascular risk factors and stenosis severity

MACE by Total Plaque Volume Category (DECIDE cutoffs)



1. Fairbairn, et al. Presented at AHA Scientific Sessions November 2025.
 2. Presented poster from ACC.26

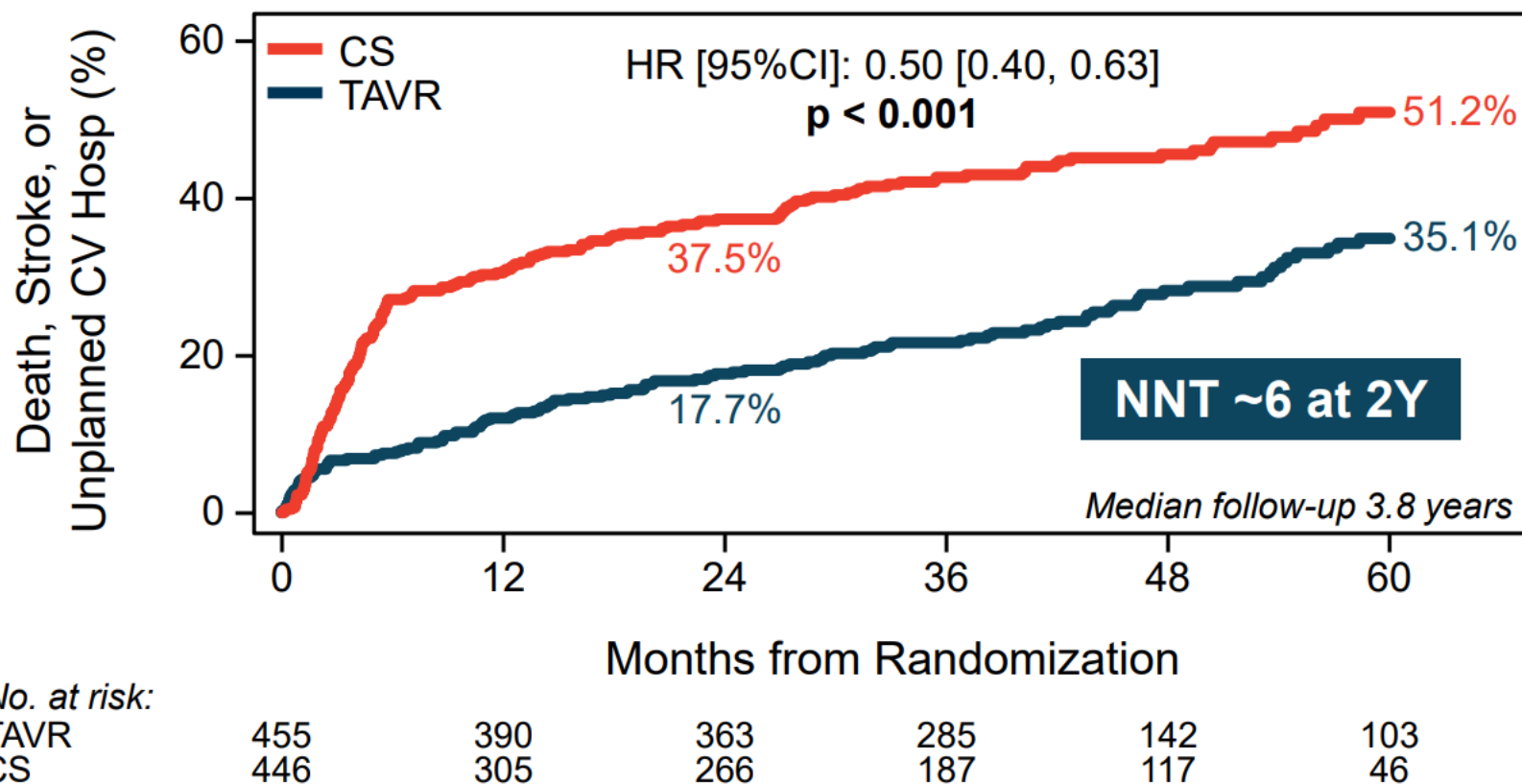
The treatment of valvular heart disease has been disrupted by the advent of transcatheter interventions

Transcatheter Aortic-Valve Replacement for Asymptomatic Severe Aortic Stenosis

P. G  n  reux, A. Schwartz, J.B. Oldemeyer, P. Pibarot, D.J. Cohen, P. Blanke, B.R. Lindman, V. Babaliaros, W.F. Fearon, D.V. Daniels, A.K. Chhatrwalla, C. Kavinsky, H. Gada, P. Shah, M. Szerlip, T. Dahle, K. Goel, W. O'Neill, T. Sheth, C.J. Davidson, R.R. Makkar, H. Prince, Y. Zhao, R.T. Hahn, J. Leipsic, B. Redfors, S.J. Pocock, M. Mack, and M.B. Leon, for the EARLY TAVR Trial Investigators*



Primary Endpoint



CT remains essential in patient selection

Top 5 Reasons for Rejection by Case Review Committee (based on a screening sample of 60 cases)

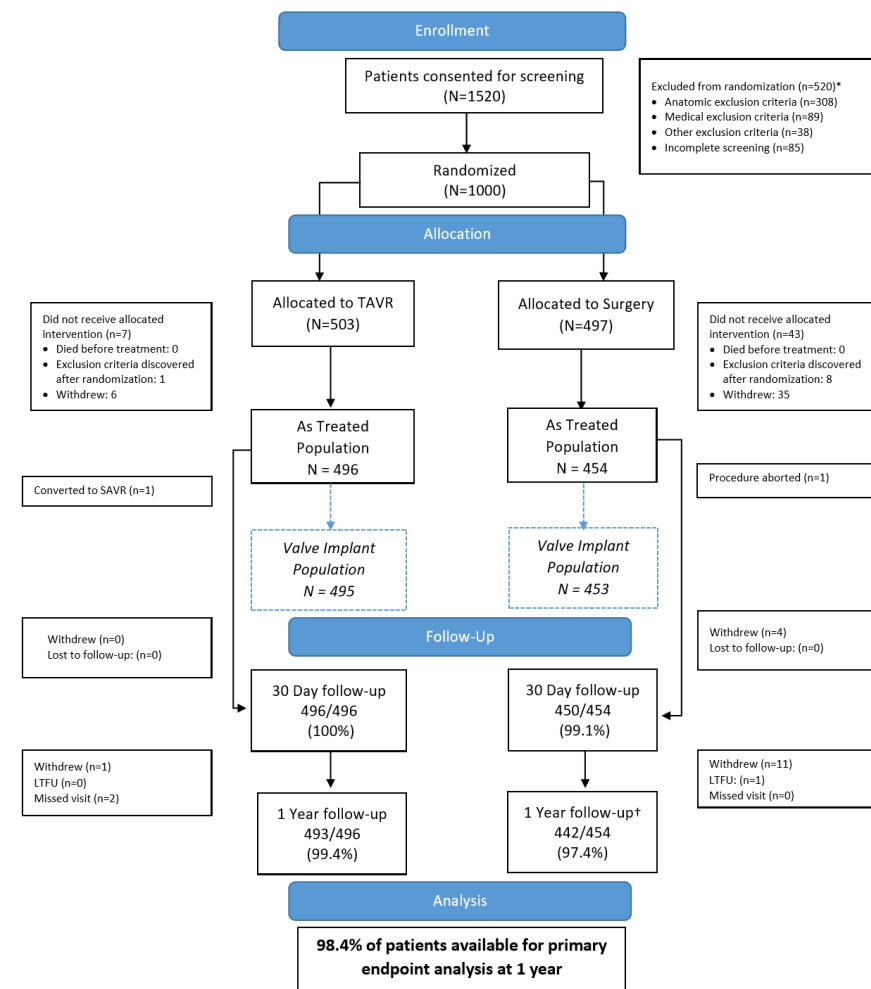
Severe LVOT Calcium – 38%

Adverse Aortic Root (includes small sinus of Valsalva and/or small, calcified sinotubular junction) – 17%

Poor TF Access – 7%

Anomalous Coronary – 5%

High risk of prosthesis patient mismatch – 5%

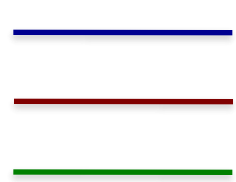
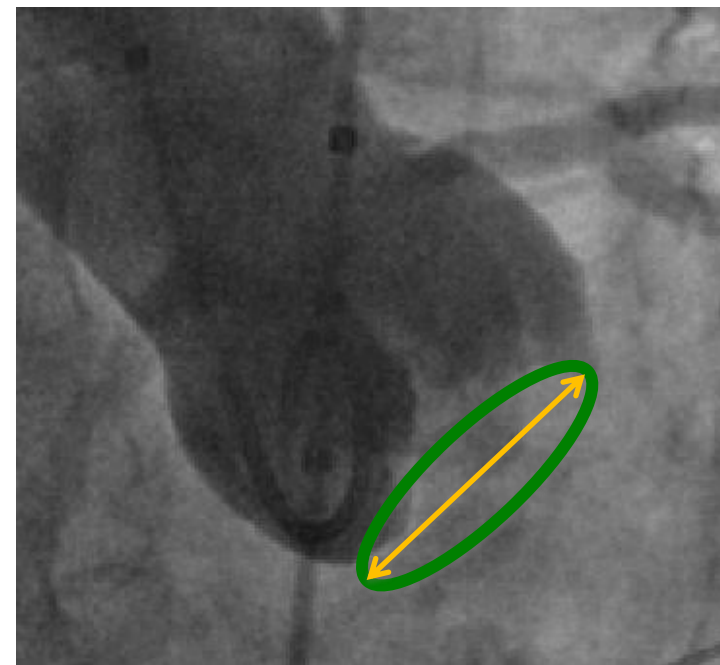
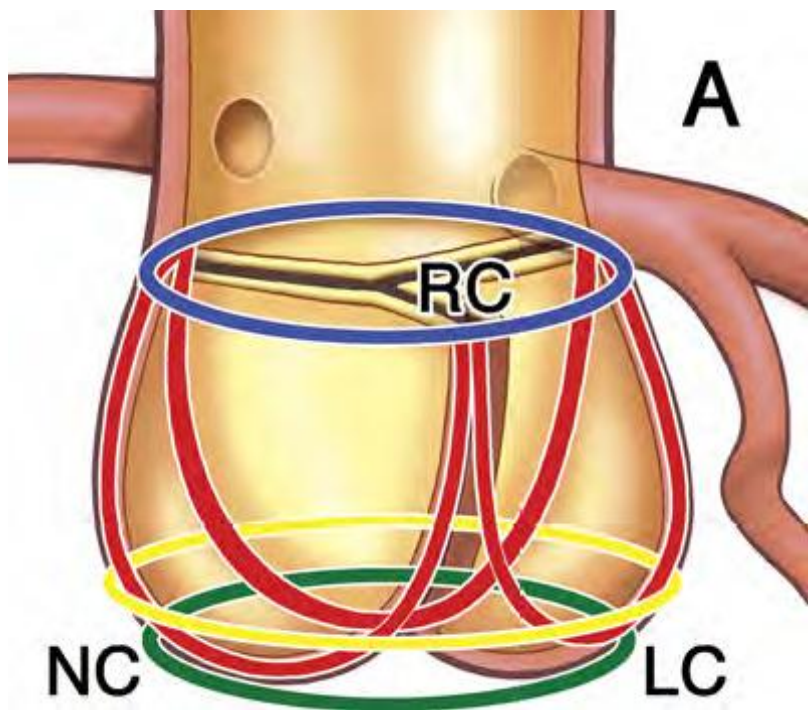


CT plays an essential role in annular
sizing and device selection

Clear and established guidance regarding sizing

TABLE 5 Summary of Recommendations for the Sizing and Reporting of the Aortic Valve, Annulus and Outflow Tract	
Recommendation	Grade of Recommendation*
Annulus assessment and planning	
While facilitated or semi-automated workflows may be used, the interpreter analyzing the imaging must be able to confirm the accuracy of the generated annular plane and perform manual corrections if required.	Strong
Systolic measurements are preferred for measurement and calculation of device sizing	Strong
Area and perimeter measurements are preferred for sizing of the aortic annulus over isolated 2 dimensional measurements and should be provided in the report	Strong
Landing zone calcification	
Annular and subannular calcification should be qualitatively described regarding morphology and extent as well as relation to the aortic valve cusps.	Strong
Valve morphology	
Number of cusps should be stated, and if a bicuspid valve is present, its morphology should be classified.	Strong
The presence of a median raphe and the absence/presence of calcification of this should be mentioned	Strong
The aortic annulus size should be measured and reported in bicuspid aortic valves as for tricuspid aortic valves.	Strong
Aortic root measurement	
Pre-TAVI/TAVR CT assessment should include coronary height, mean SOV diameter, and STJ height and diameter	Strong
Coronary ostial distance from aortic annulus should be measured in a perpendicular fashion from the established annular plane	Strong
*Based on level of consensus. CT = computed tomography; SOV = sinus of valsalva; STJ = sinotubular junction; TAVI = transcatheter aortic valve implantation; TAVR = transcatheter aortic valve replacement.	

The Virtual Basal Ring



Sinotubular junction

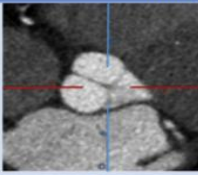
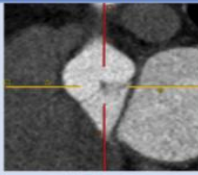
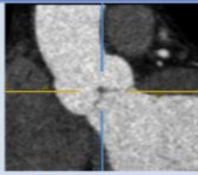
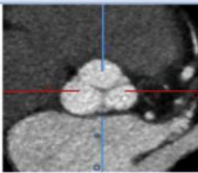
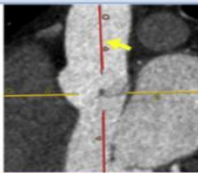
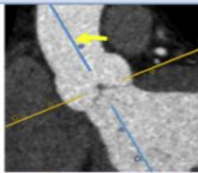
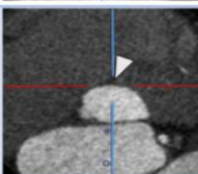
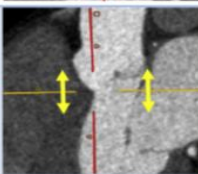
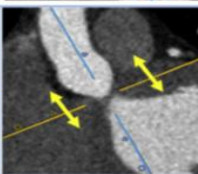
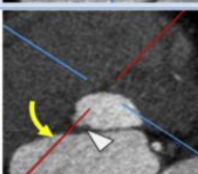
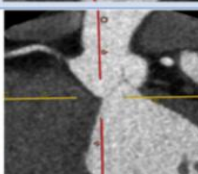
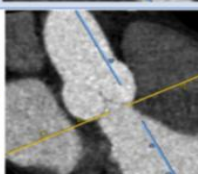
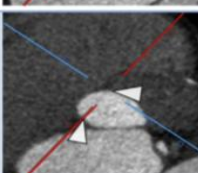
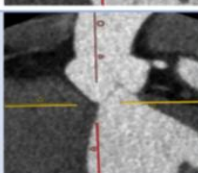
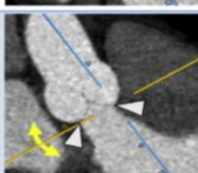
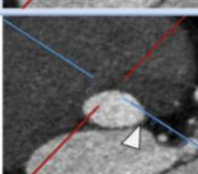
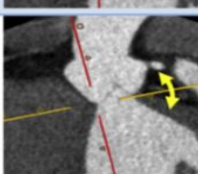
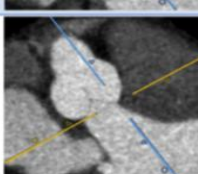
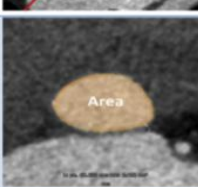
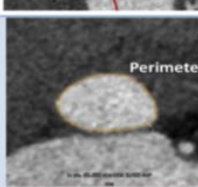
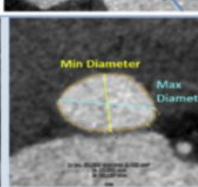
Aortic leaflets

Aortic Annulus

Aortic Annular Diameter

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

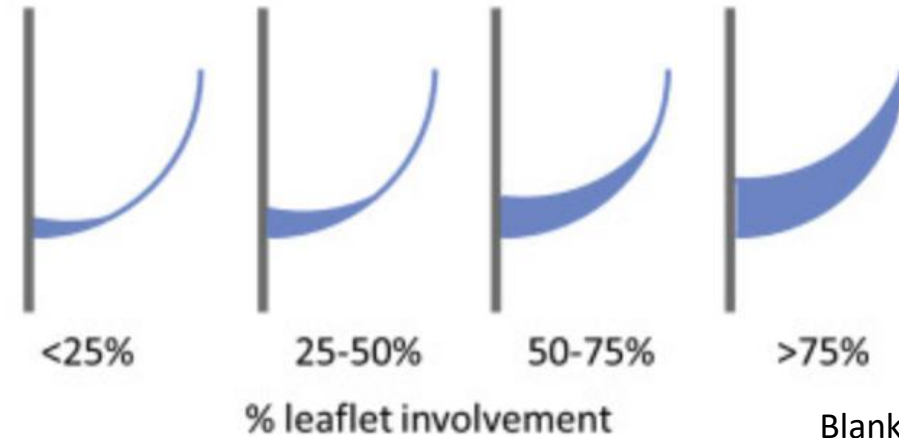
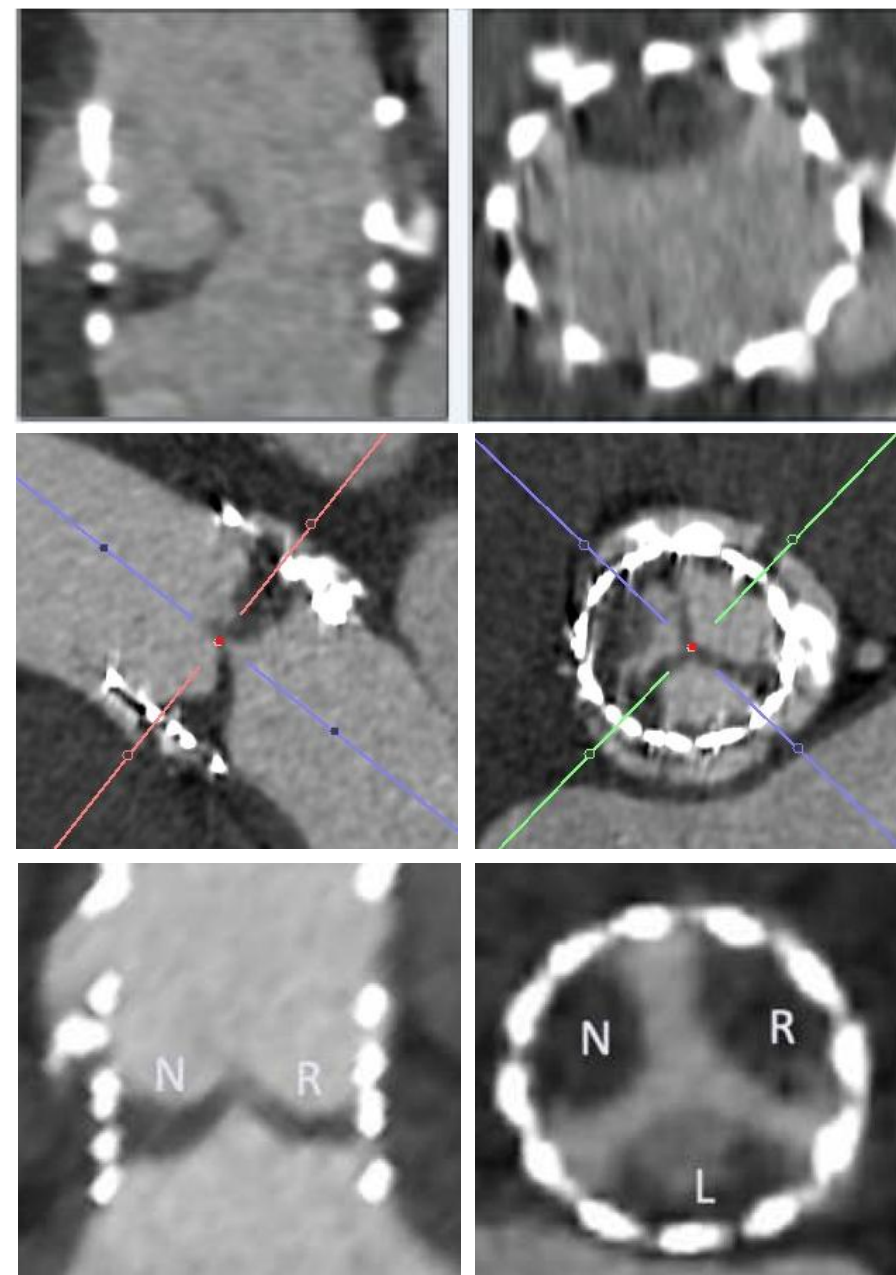
Source: Leipsic et al JACC Img April 2011

Step & Description	Multiplanar reformats		
Step 1: Start out with multi-planar images in default axial, sagittal, and coronal orientation; center cross-hairs onto the aortic valve			
Step 2: Align the cross-hairs in the sagittal and coronal views with the long axis of the aortic root; the resulting double oblique transverse view will depict the aortic valve en face.			
Step 3: Move the double oblique transverse plane up and down to identify the lowest insertion point of the right coronary cusp which is usually located at about 1 o'clock. Position the center of the cross-hairs exactly at the most basal insertion point of the right coronary cusp (white arrow head).			
Step 4: Rotate the cross-hairs counter-clock-wise without moving up and down while maintaining its center position so that the formerly coronal view (here red cross-hair) transects the lowest insertion point of the non-coronary cusp, which is located at approximately 8 o'clock (white arrow head).			
Step 5: The formerly coronal, now double-oblique view will show the lowest insertion point both of the right coronary cusp and the non-coronary cusp (white arrow heads). In this view, rotate the (here orange) cross-hair indicating the double-oblique transverse view to transect exactly through the most basal insertion point of the non-coronary cusps. Once this is achieved, the transverse double oblique plane will contain two of the three lowest cusp insertion points.			
Step 6: In the formerly sagittal view, rotate (without moving it) the cross-hair of the transverse double oblique plane (here orange) until the lowest insertion point of the left coronary cusp just barely appears in the double oblique transverse view (white arrow head). Now, the formerly axial plane is exactly aligned with the lowest cusp insertion points of all three aortic cusps and represents both the orientation as well as the level of the annular plane.			
Step 7: Measurements of aortic annulus dimensions should be performed in the annular plane by means of a contouring tool.			

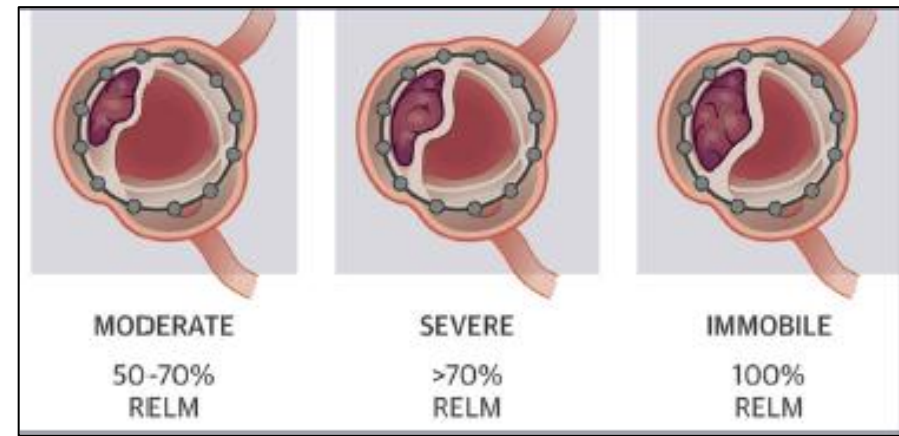


Post TAVR Imaging- Lessons from VARC-3

HALT : H_yp_o-A_ttenuated L_eaflet T_hickening



Blanke et al, JACC IMG 2019

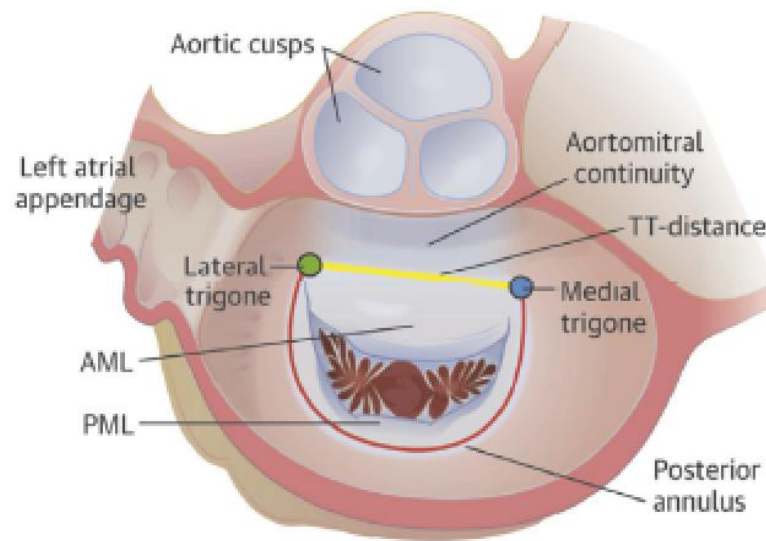


RLM : R_estricted L_eaflet M_otion

The D-shaped annulus

Anatomical Assessment for TMVI Eligibility and Device Sizing

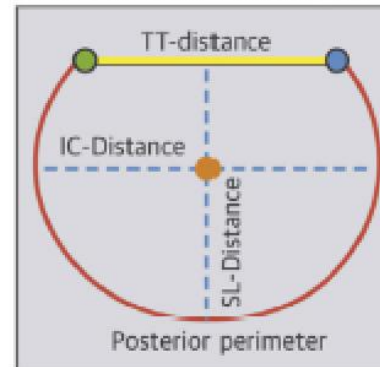
3D ANNULAR SEGMENTATION (CT/3D TEE)



LANDING ZONE CHARACTERISTICS (CT/2D AND 3D TEE)

- Annular calcium
 - MVP/mitral annular disjunction
 - Myocardial shelf
 - Leaflet length
 - Directly inserting papillary muscles
- Adequate Landing Zone: *yes/no*

Pertinent Annular Measurements



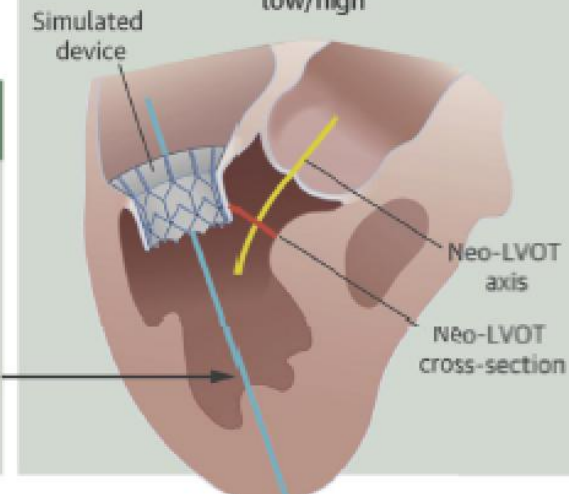
- Annular area
 - Perimeter
 - SL-Distance
 - IC-Distance
- Device Size

DEVICE SIMULATION FOR LVOT OBSTRUCTION PREDICTION (CT)

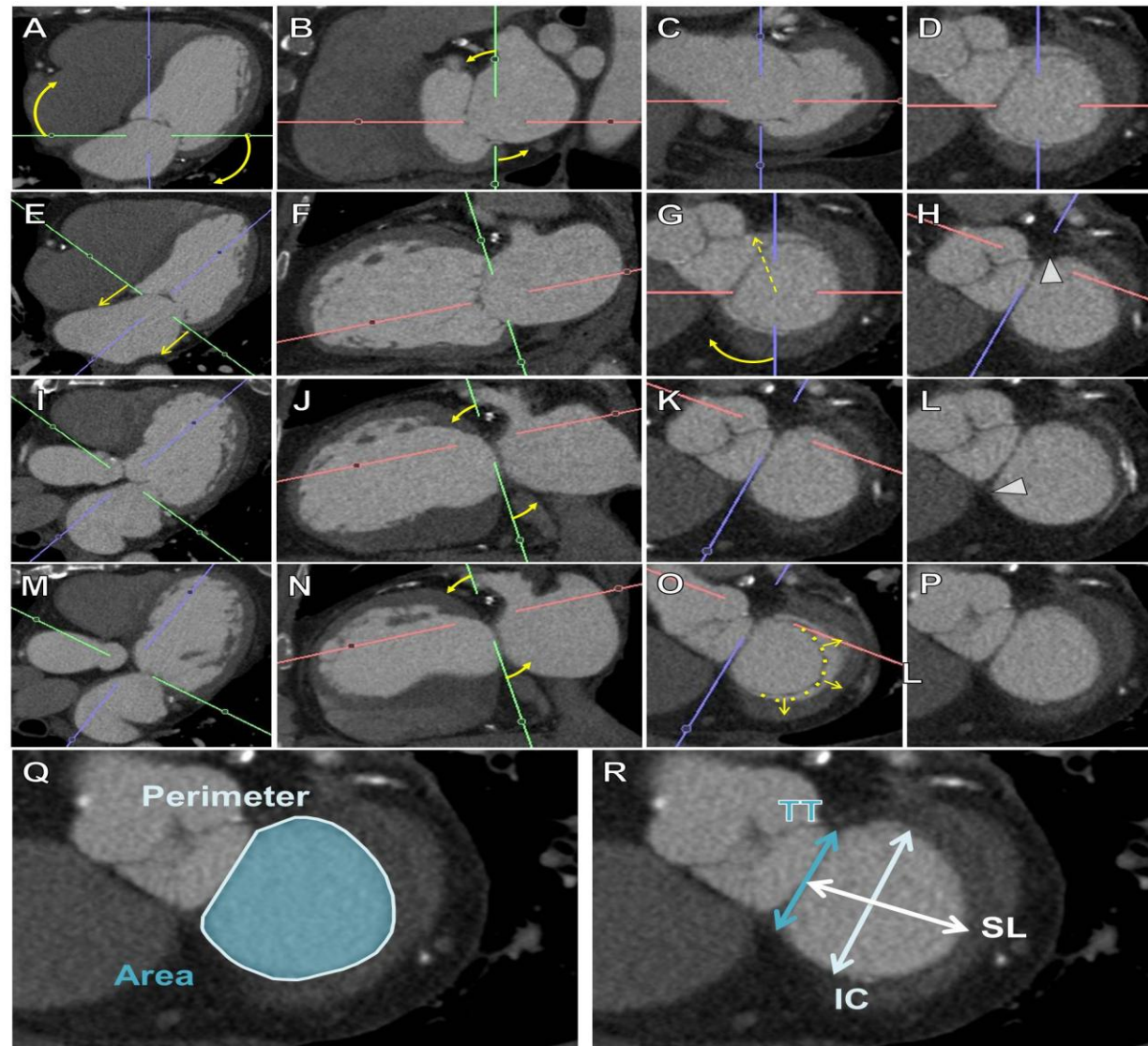
- Embedded geometry in CT data set
- Trajectory determines device orientation
- Quantification of Neo-LVOT area

→ Risk of LVOT Obstruction: low/high

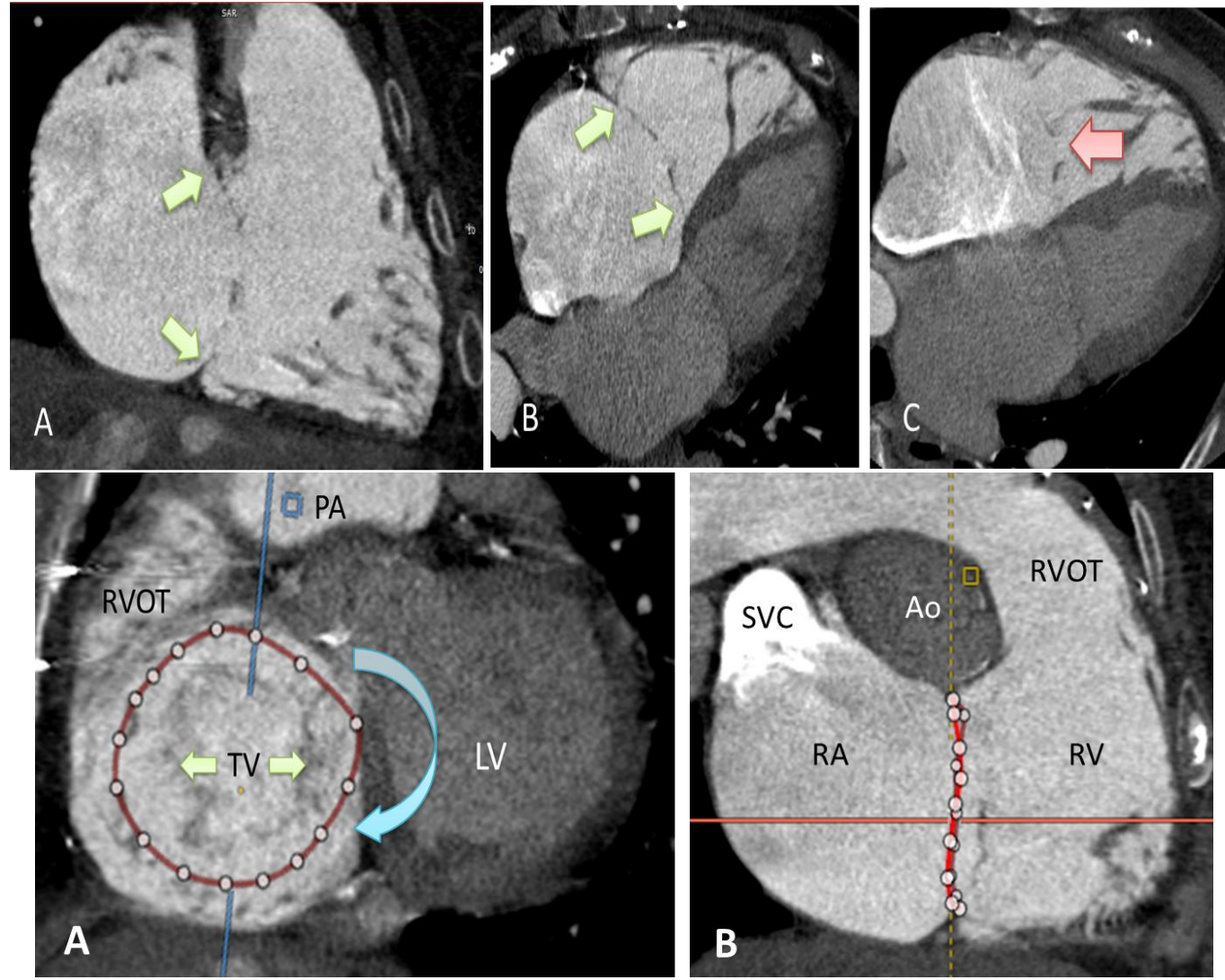
2D MA PLANE + MA TRAJECTORY (CT)



Stepwise approach to annular segmentation

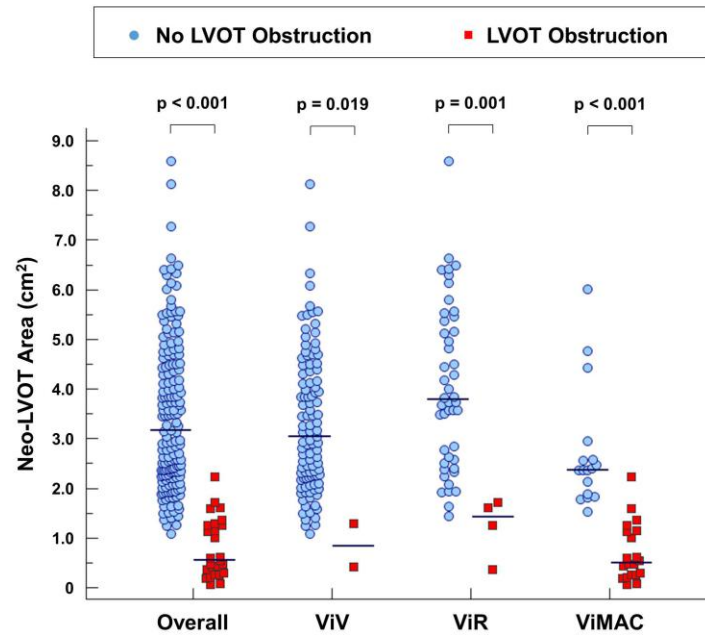


Varied contrast timing allows for Tricuspid Valve/Annular Evaluation

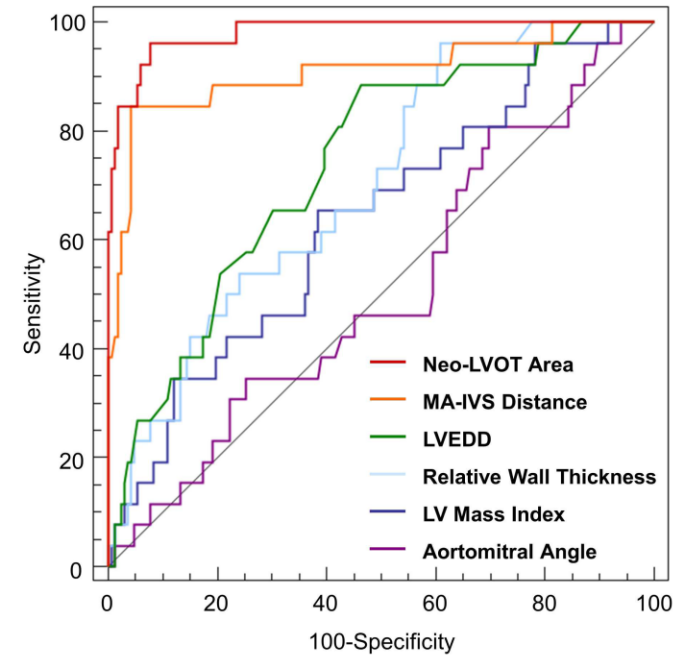


Prediction of LVOT Obstruction

CT Neo LVOT powerful predictor of risk!!!

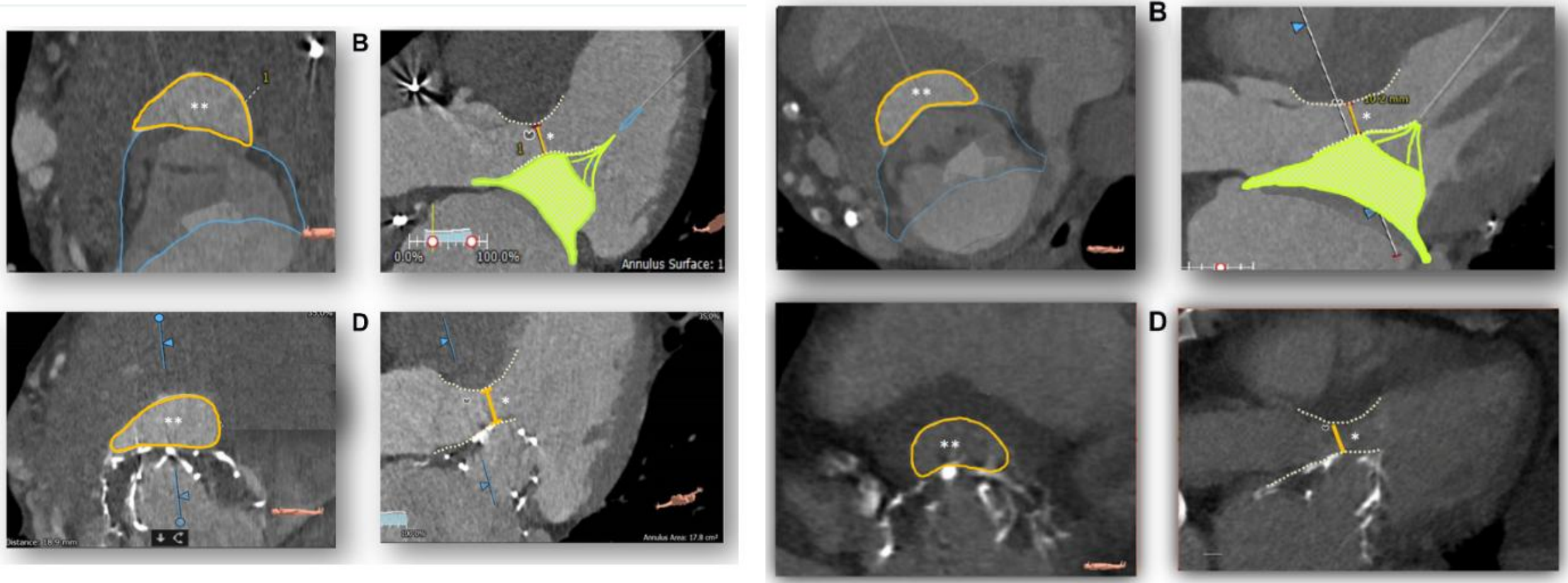


	No LVOT Obstruction	LVOT Obstruction
Overall	3.2 (2.3 – 4.5)	0.6 (0.3 – 1.3)
ViV	3.0 (2.2 – 4.3)	0.8 (0.4 – 1.2)
ViR	3.8 (2.6 – 5.4)	1.4 (0.6 – 1.7)
ViMAC	2.4 (1.9 – 2.8)	0.5 (0.2 – 1.1)

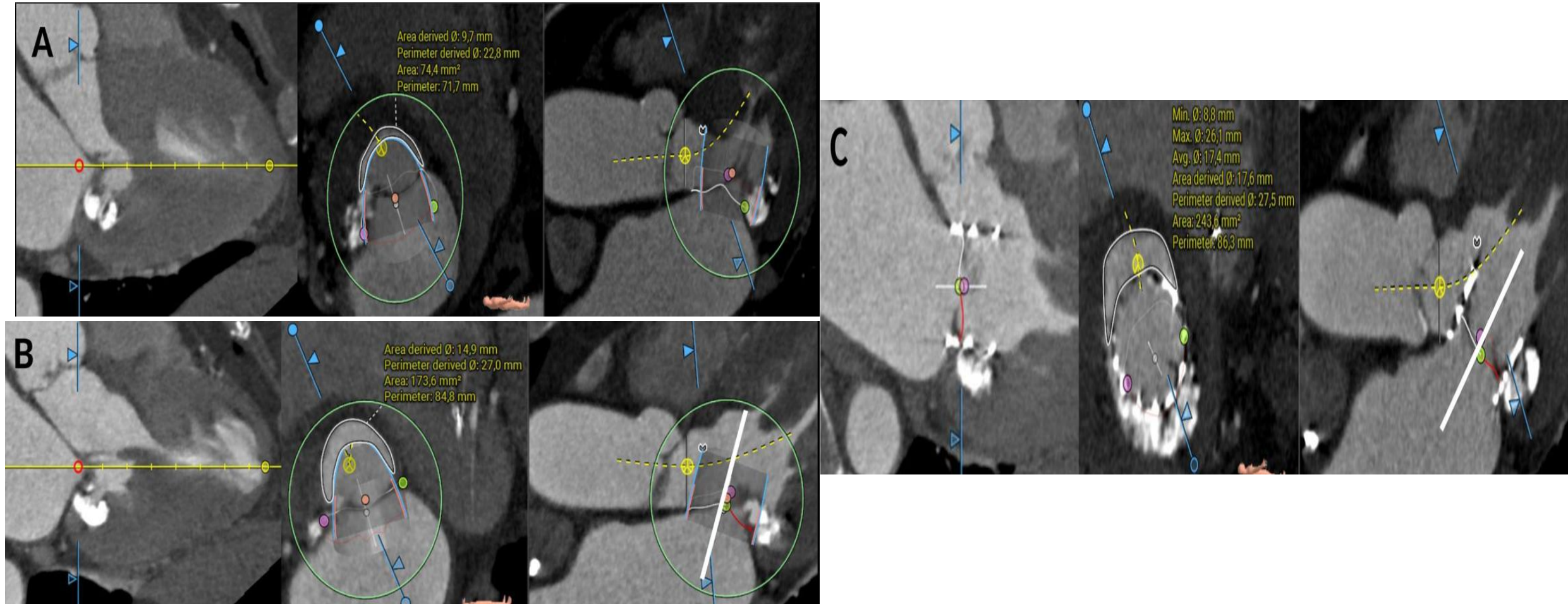


	AUC	Cutoff value	p value	Sensitivity	Specificity
Neo-LVOT Area	0.98	1.7	< 0.001	96.2	92.3
MA-IVS Distance	0.91	17.8	< 0.001	84.6	95.8
LVEDD	0.74	48	< 0.001	88.5	53.3
Relative Wall Thickness	0.70	0.38	0.001	96.2	38.9
LV Mass Index	0.64	105	0.02	65.4	61.1
Aortomitral Angle	0.51	–	0.92	46.2	41.1

Good agreement between Pre and Post Implant NEO LVOT Measurements with certain devices



Efficacy of ASA in mitigating LVOT Obstruction

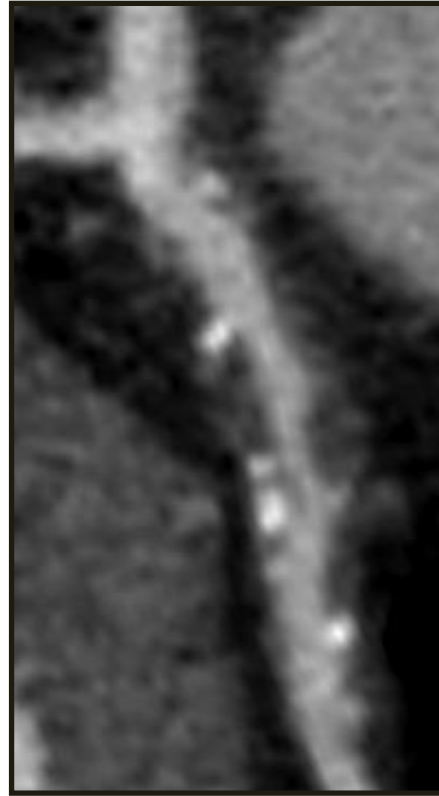
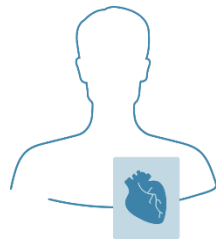


Source: Belfekih et al CCI 2025

CCTA will be used to plan coronary
interventions

You would not do a TAVR without a
non-invasive evaluation of the annulus

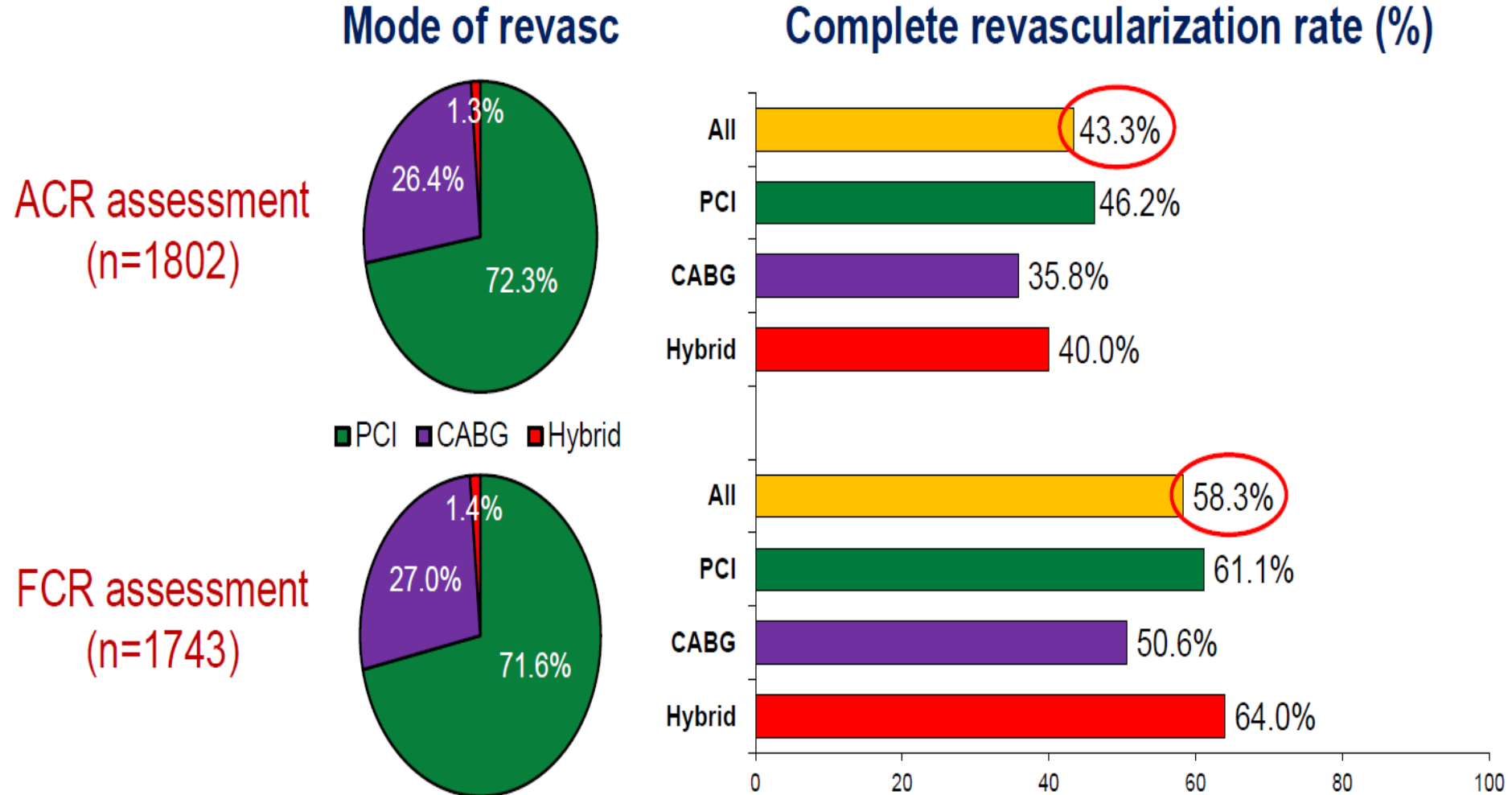
Would you rather make decisions around ICA with this



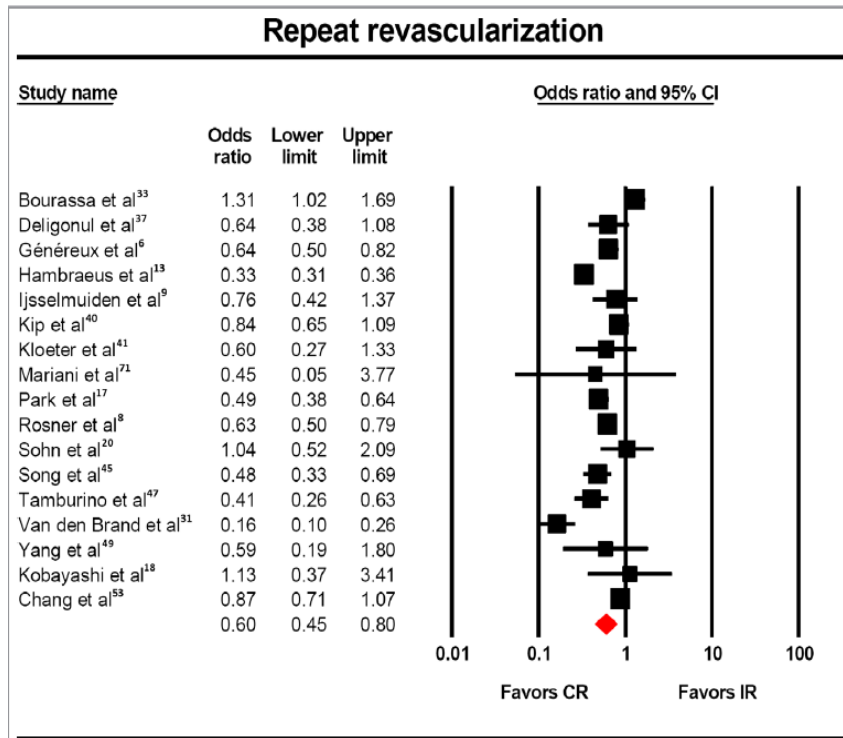
Objective 1: Completeness of Revascularization (INV)



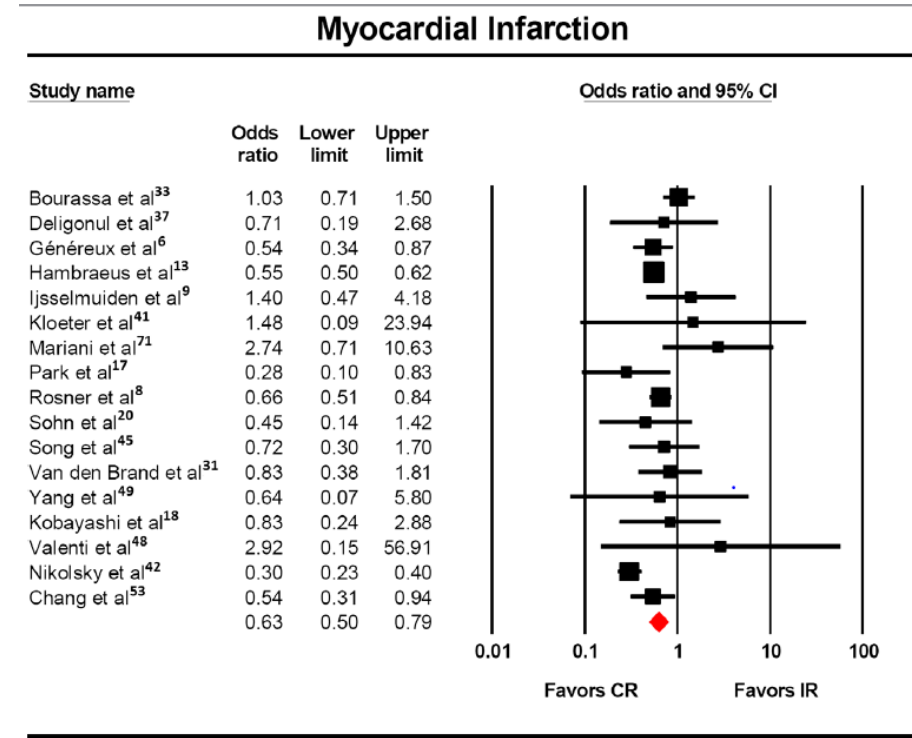
Among 1825 pts randomized to INV in whom a revasc procedure was performed within 6 months, prior to a primary endpoint event



Consistent event reduction with complete revascularization

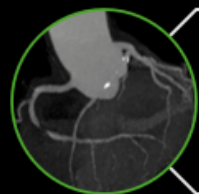


CR- (OR: 0.60, 95%CI: 0.45–0.80)



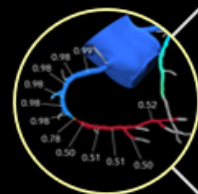
CR- OR: 0.64, 95% CI:0.50–0.81)

Rich pre-procedural data now available prior to PCI



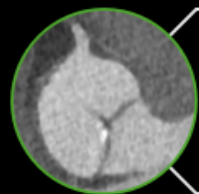
MIP = Maximal Intensity Projection

- Coronary anatomy and case complexity based on calcium burden and lesion type & location
- Vessel course and tortuosity
- Optimal angles for angiography and PCI



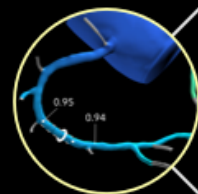
FFR_{CT} = Fractional Flow Reserve derived from CCTA

- Functional significance
- Delta FFR_{CT}
- FFR_{CT} pullback for CAD pattern assessment (focal vs. diffuse)



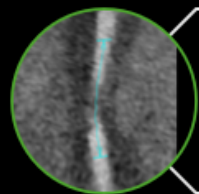
Axial images

- Coronary ostium position and guide selection
- Normal RCA position ~11 o'clock and LCA 4 o'clock
- Aortic dimension for LCA guide catheter curve selection



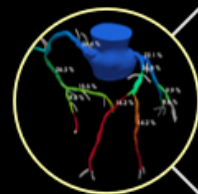
Virtual PCI

- FFR_{CT} based virtual PCI to inform stent length based on predicted post-PCI FFR_{CT}
- Vessel course and tortuosity
- Optimal angles for angiography and PCI



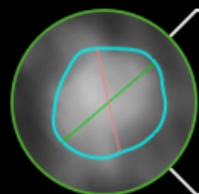
MPR = Multi-Planar Reconstruction

- Lesion location
- Plaque & calcium distribution and composition
- Disease length and estimated stent length



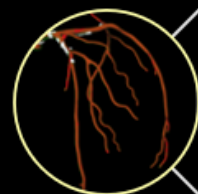
Myocardial mass

- Vessel-specific myocardial mass at risk
- Side-branch protection, 2-stent techniques
- Risk for myocardial injury based on jeopardized mass



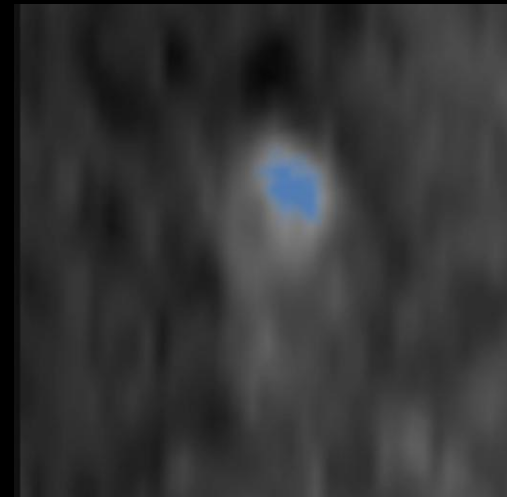
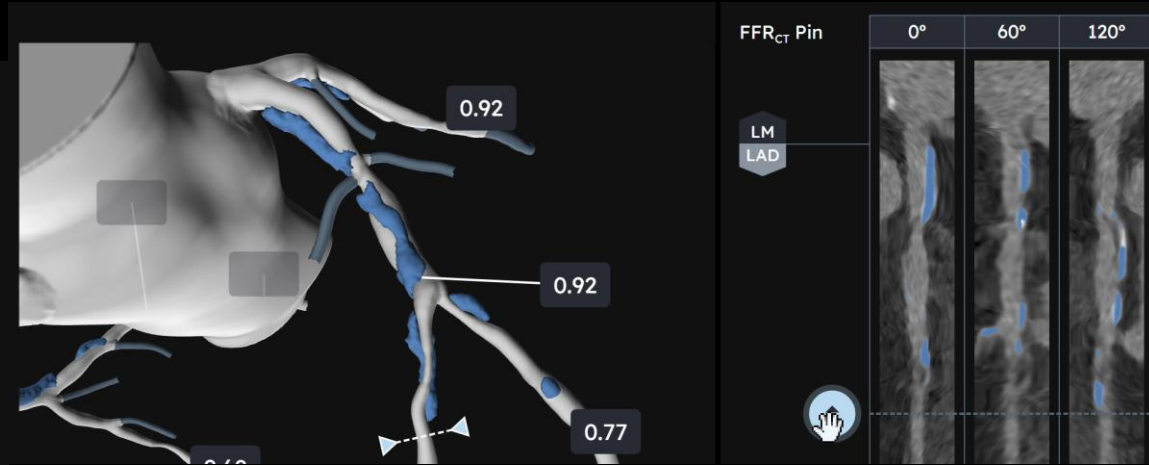
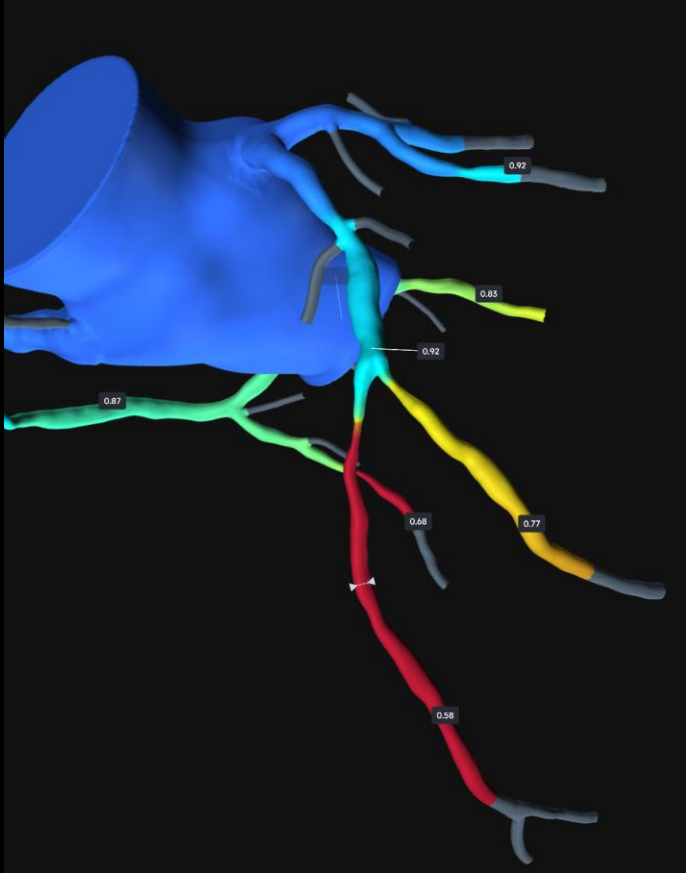
Cross-sections

- Lesion morphology, calcium arc
- Plaque burden
- Proximal and distal reference lumen diameters

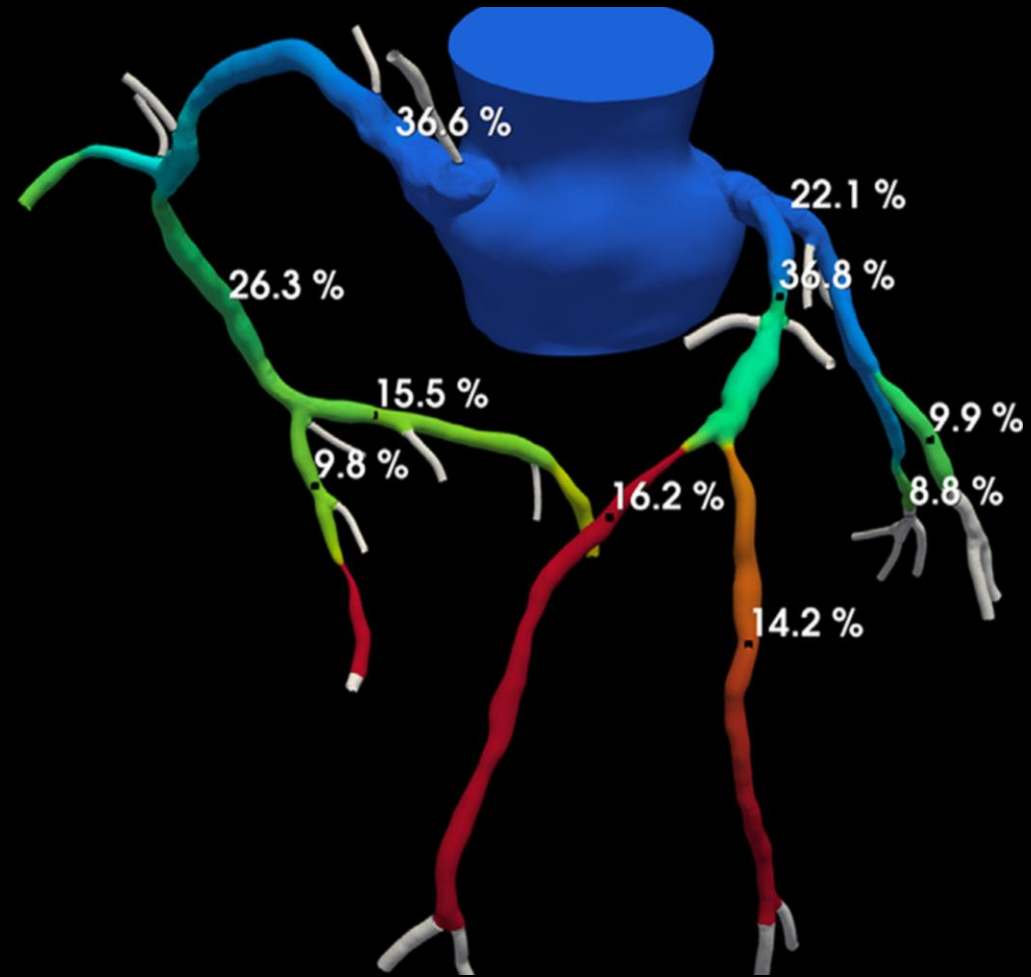


Live guidance from C-arm & CT co-registration

- Optimal angles for angiography and PCI
- Live interaction with CCTA data during case
- Stent length and positioning



Interactive
plaque



Conclusions

- CCTA is an incredibly powerful tool that is useful far beyond diagnostic purposes
- Cardiac CT plays a fundamental role in planning structural heart and valvular interventions
- Lessons gleaned from planning TAVR are now being applied to the integration of CCTA to plan PCI