

CT Scan in planning and performing complex bifurcations PCI

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Never awaken a sleeping lion, their snores
are much more dangerous than your most
powerful barks. .

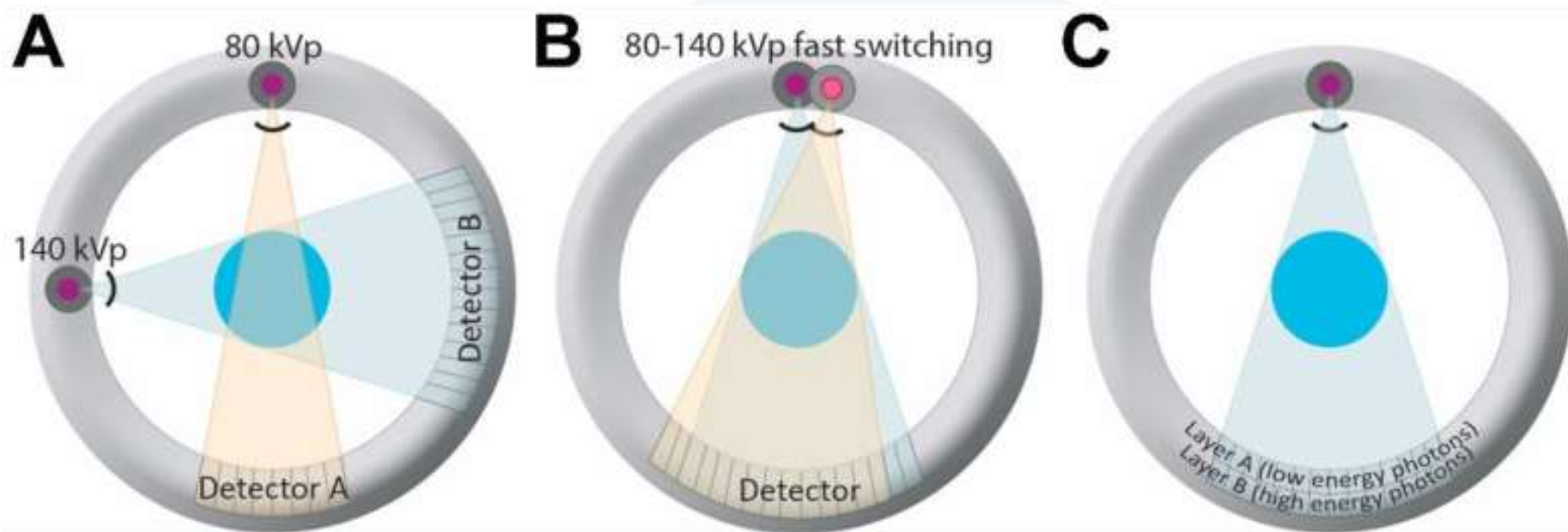
— Amit Raissoni



Antiguas limitantes...

- Calcio ya no es limitante.
- Stents continua siendo una limitante con stents < 3 mm.

DUAL-ENERGY CT





2019 ESC Guidelines for the diagnosis and management of chronic coronary syndromes

The Task Force for the diagnosis and management of chronic coronary syndromes of the European Society of Cardiology (ESC)

“...La TAC coronario se ha convertido en la modalidad no invasiva preferida para evaluar enfermedad de las arterias coronarias en pacientes que se presentan con dolor torácico...”.
(ESC guidelines CCS 2019).

Non-invasive functional imaging for myocardial ischaemia^c or coronary CTA is recommended as the initial test to diagnose CAD in symptomatic patients in whom obstructive CAD cannot be excluded by clinical assessment alone.^{4,5,55,73,78–80}

I

B

Functional imaging for myocardial ischaemia is recommended if coronary CTA has shown CAD of uncertain functional significance or is not diagnostic.^{4,55,73}

I

B

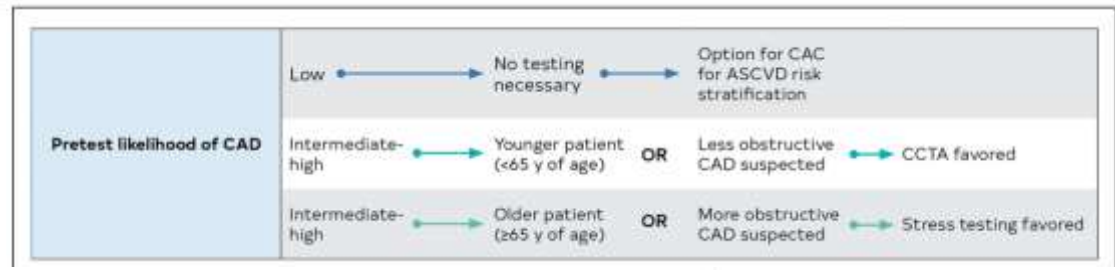
2021 AHA/ACC/ASE/CHEST/SAEM/SCCT/
SCMR Guideline for the Evaluation and Diagnosis
of Chest Pain: A Report of the American College
of Cardiology/American Heart Association Joint
Committee on Clinical Practice Guidelines

...In the most recent chest pain guidelines, CCTA is shown to be more accurate in delineating the presence of coronary disease, with higher positive and negative predictive values in the triage of patients than noninvasive testing....

4.1.2.1. Intermediate-Risk Patients With Acute Chest Pain and No Known CAD

Recommendations for Intermediate-Risk Patients With No Known CAD
Referenced studies that support the recommendations are summarized in Online Data Supplements 14 and 15.

COR	LOE	Recommendations
Index Diagnostic Testing		
Anatomic Testing		
1	A	1. For intermediate-risk patients with acute chest pain and no known CAD eligible for diagnostic testing after a negative or inconclusive evaluation for ACS, CCTA is useful for exclusion of atherosclerotic plaque and obstructive CAD. ¹⁻¹¹
1	C-EO	2. For intermediate-risk patients with acute chest pain, moderate-severe ischemia on current or prior (≤ 1 year) stress testing, and no known CAD established by prior anatomic testing, ICA is recommended.
2a	C-LD	3. For intermediate-risk patients with acute chest pain with evidence of previous mildly abnormal stress test results (≤ 1 year), CCTA is reasonable for diagnosing obstructive CAD. ^{12,13}
Stress Testing		
1	B-NR	4. For intermediate-risk patients with acute chest pain and no known CAD who are eligible for cardiac testing, either exercise ECG, stress echocardiography, stress PET/SPECT MPI, or stress CMR is useful for the diagnosis of myocardial ischemia. ^{1,4,10,14-36}



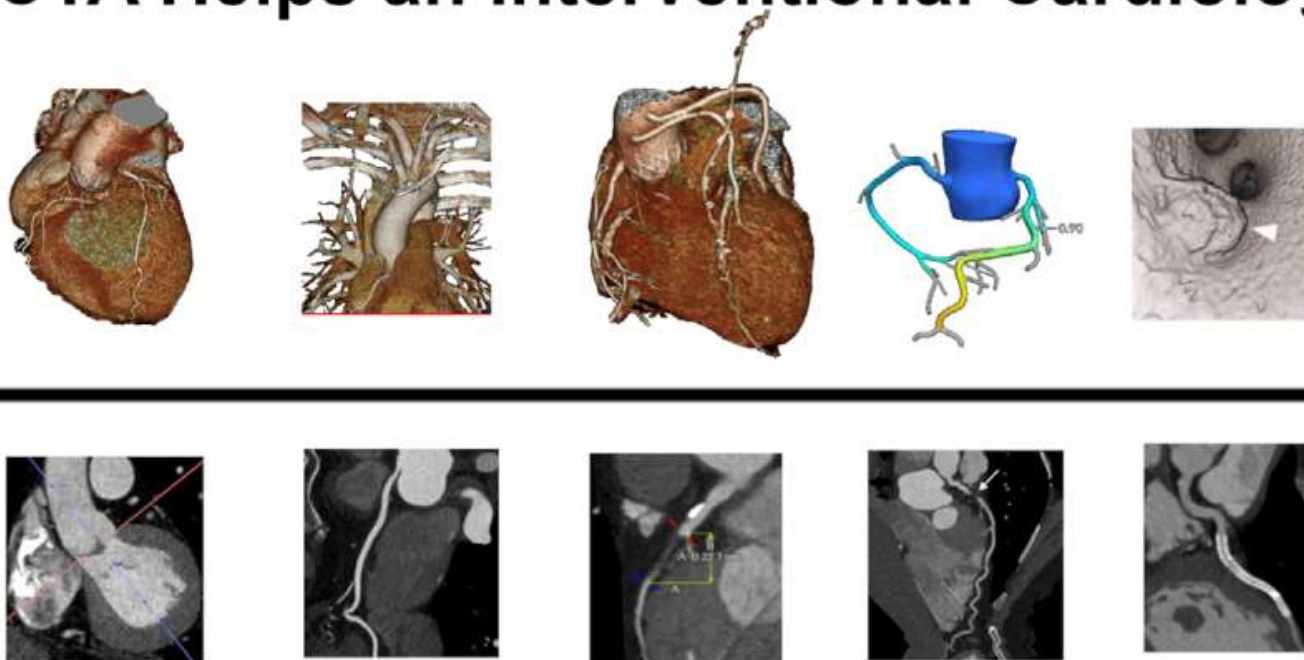
Sequential or Add-on Diagnostic Testing		
2a	B-NR	5. For intermediate-risk patients with acute chest pain and no known CAD, with a coronary artery stenosis of 40% to 90% in a proximal or middle coronary artery on CCTA, FFR-CT can be useful for the diagnosis of vessel-specific ischemia and to guide decision-making regarding the use of coronary revascularization. ³⁷⁻⁴³
2a	C-EO	6. For intermediate-risk patients with acute chest pain and no known CAD, as well as an inconclusive prior stress test, CCTA can be useful for excluding the presence of atherosclerotic plaque and obstructive CAD.
2a	C-EO	7. For intermediate-risk patients with acute chest pain and no known CAD, with an inconclusive CCTA, stress imaging (with echocardiography, PET/SPECT MPI, or CMR) can be useful for the diagnosis of myocardial ischemia.

TAC coronario:

...Liendo mas allá de la evaluación de la gravedad de la estenosis...

TAC coronario:

CCTA Helps an Interventional Cardiologist:



**Reduce Diagnostic Catheterizations / Choose Catheters / Identify Grafts
Clarify Anomalies / Evaluate Coronary Lesions / Prepare for Coronary Intervention**

PUENTES PREVIOS

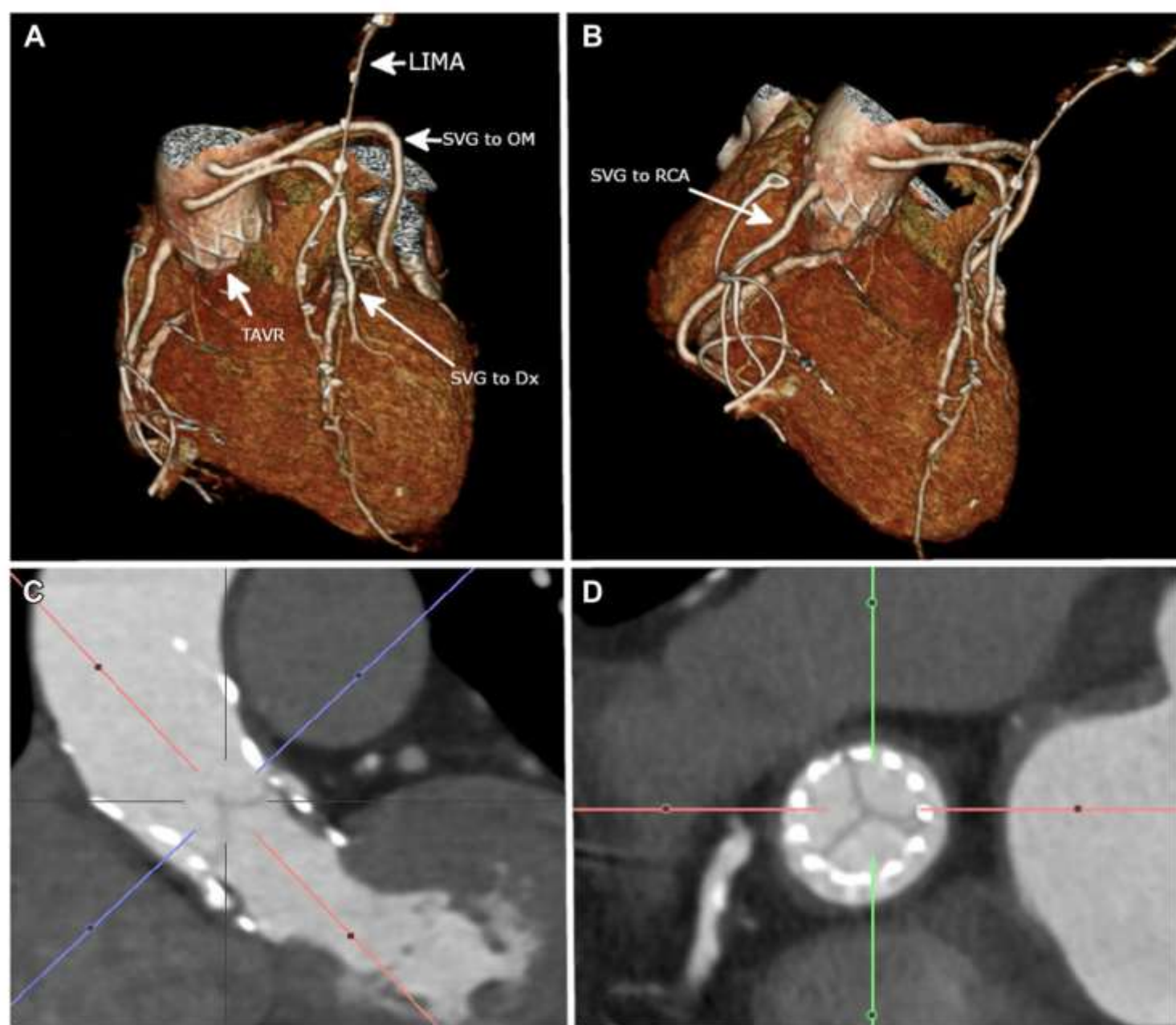


Figure 6. **coronary artery bypass graft (CABG) evaluation of graft patency: Cardiac computed tomography angiography (CCTA) of a patient post transcatheter aortic valve replacement (TAVR) and CABG x 4.** Patency of grafts (LIMA to LAD, SVG to Dx, SVG to OM, SVG to RCA) are all identified. CCTA allows the additional benefit of evaluating the prosthetic valve for thrombosis, which was ruled out on this exam. Dx, diagonal branch (coronary artery); LAD, left anterior descending (coronary artery); LIMA, left internal mammary artery; OM, obtuse marginal (coronary artery); RCA, right coronary artery; SVG, saphenous vein graft.

How early can atherosclerosis be detected by coronary CT angiography? Insights from quantitative CT analysis of serial scans in the PARADIGM trial



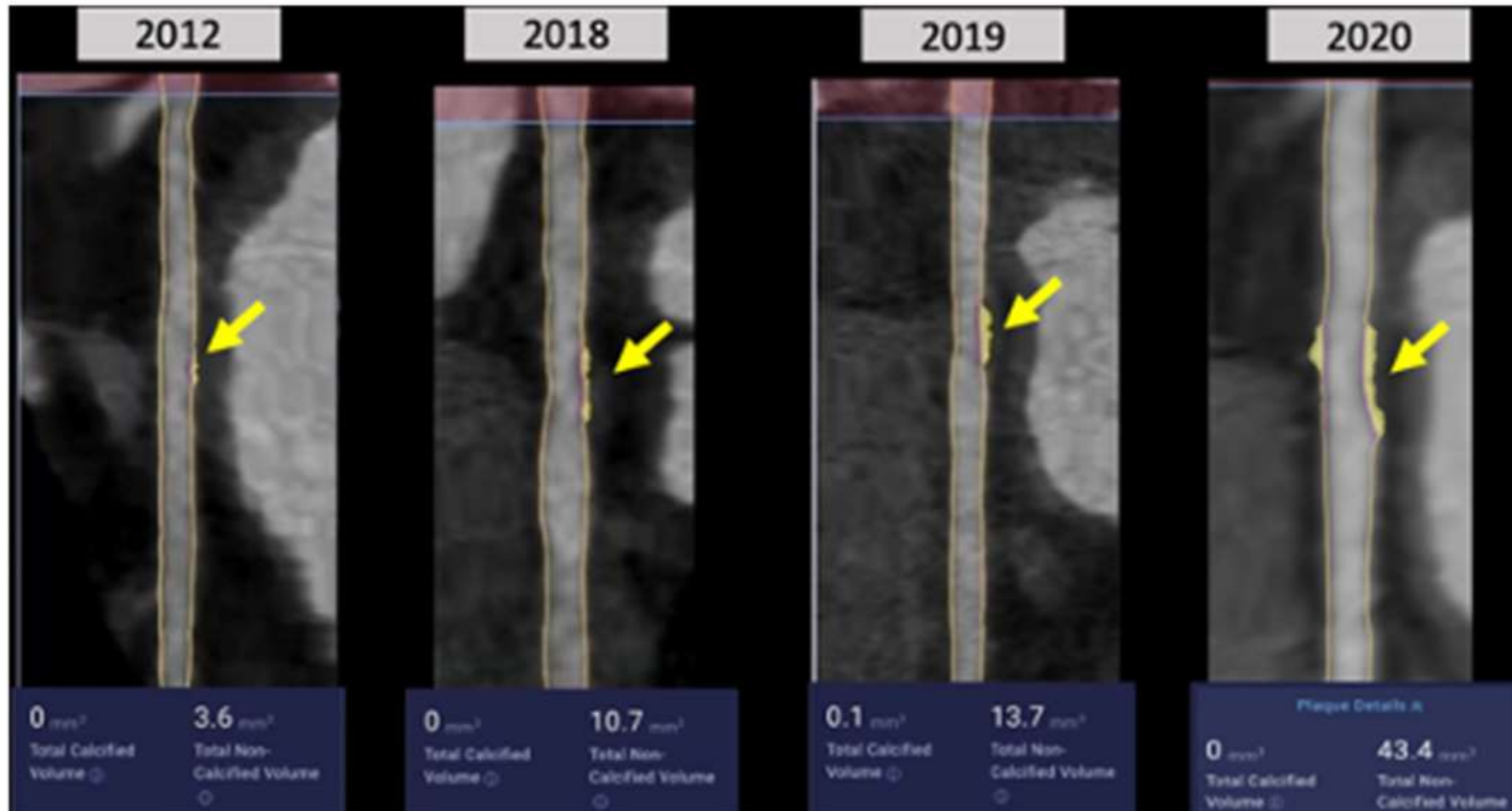
Rhanderson Cardoso^{a, *}, Andrew D. Choi^b, Arthur Shiyovich^a, Stephanie A. Besser^a, James K. Min^c, James Earls^c, PARADIGM Investigators, Ron Blankstein^a

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^b Department of Cardiology, The George Washington University School of Medicine, Washington, DC, USA

^c Cleerly Inc, New York, NY, USA

Progresion de placa: Ai



Percent atheroma volume (PAV), defined as [(plaque volume/vessel volume) x 100] was demonstrated as the best predictor of plaque progression from non obstructive to more than 50% stenosis.

Fig. 2. Progression of a small plaque (3.6 mm³) at the same location in the left circumflex artery over 8 years as detected by AI-based automated plaque quantification. Image courtesy of Ronald Karlsberg, MD.

CT coronarias: No solo informacion anatomica

- Stress CT myocardial perfusion imaging (CT-MPI).
- Fractional flow reserve derived from CCTA (CT-FFR).

In vitro validation of coronary CT angiography for the evaluation of complex lesions



Carlos Collet¹, MD; Yoshinobu Onuma^{2,3}, MD, PhD; Maik J. Grundeken¹, MD, PhD; Yosuke Miyazaki³, MD, PhD; Marcio Bittercourt⁴, MD, PhD; Pieter Kitslaar⁵, MSc; Sadako Motoyama⁶, MD, PhD; Yukio Ozaki⁶, MD, PhD; Taku Asano¹, MD; Jolanda J. Wentzel⁷, MD, PhD; Geert J. Streekstra⁸, PhD; Patrick W. Serruys^{9*}, MD, PhD; Robbert J. de Winter¹, MD, PhD; R. Nils Planken⁸, MD, PhD

Estenosis:

MLD > 1: Sobrestima la severidad de la lesion (0.19 mm)

MLD < 1mm Subestima la severidad de la lesion (-0.48 mm)

as a reference. The accuracy of CTA for the assessment of minimal luminal diameter was -0.07 mm (limits of agreement -0.75 to 0.61), for reference vessel diameter 0.19 mm (limits of agreement -0.25 to 0.63) and diameter stenosis 8.2% (limits of agreement -13.2 to 29.5) with no difference regarding the location within the bifurcation (i.e., proximal and distal main vessel and side branch). In stenosis with minimal luminal diameter ≥ 1 mm, CTA overestimated the lesion severity (bias 0.19 mm, limits of agreement -0.09 to 0.47), whereas in lesions with severe stenosis and minimal luminal diameter ≤ 1 mm, CTA underestimated the lesion severity (bias -0.48 mm, limits of agreement -0.55 to -0.41). CTA was able to identify the contrast-filled lumen in all degrees of lesion severity.

Conclusions: *In vitro*, CTA is accurate for the evaluation of bifurcation lesions. CTA was able to distinguish contrast-filled lumen even in severe obstructive lesions. These findings require further validation in the clinical setting.

Valor de la TAC coronaria en la planificación y guía de de la PCI:

- 1) Evaluación de la extensión, volumen y composición de la placa.
- 2) Predicción del éxito CTO PCI utilizando puntuaciones derivadas de CCTA.
- 3) Identificación de lesiones coronarias que requieran tecnología adicional -> scores de calcio y distribución de placa (Rotablator o IVL).
- 4) Clasificación anatomica en MVD: Scores de SYNTAX

Caracterización de la placa

Table 1. Non-invasive atherosclerosis evaluation by CCTA.

CCTA atherosclerosis evaluation	
Qualitative features	Quantitative analysis
<ul style="list-style-type: none"> – Positive remodeling – Low-attenuation plaque – Napking ring sign – Spotty calcification 	<ul style="list-style-type: none"> – Low-attenuation plaque volume (mm³) – Non-calcified plaque volume (mm³) – Calcified plaque volume (mm³)
Clinical insight for the interventionalist	
<ul style="list-style-type: none"> – All adverse plaque features could be associated with higher rate of peri-procedural MI – Adverse plaque features could be associated with myocardial ischemia, independently from lumen stenosis degree at invasive angiography – Extensive presence of calcified plaque could be associated with the need of dedicated intra-procedural techniques (i.e., rotablator, intravascular lithotripsy) 	

Hallazgos de alto riesgo, placas inestables



CT-FFR y CT-FFR PCI planner (virtual stent).

- CT-FFR: No crosstalk en lesiones en tandem vs FFR invasive
- Virtual PPG score pullback para diagnosticar difusa vs focal

Proximamente:
Myocardium at risk
quantification

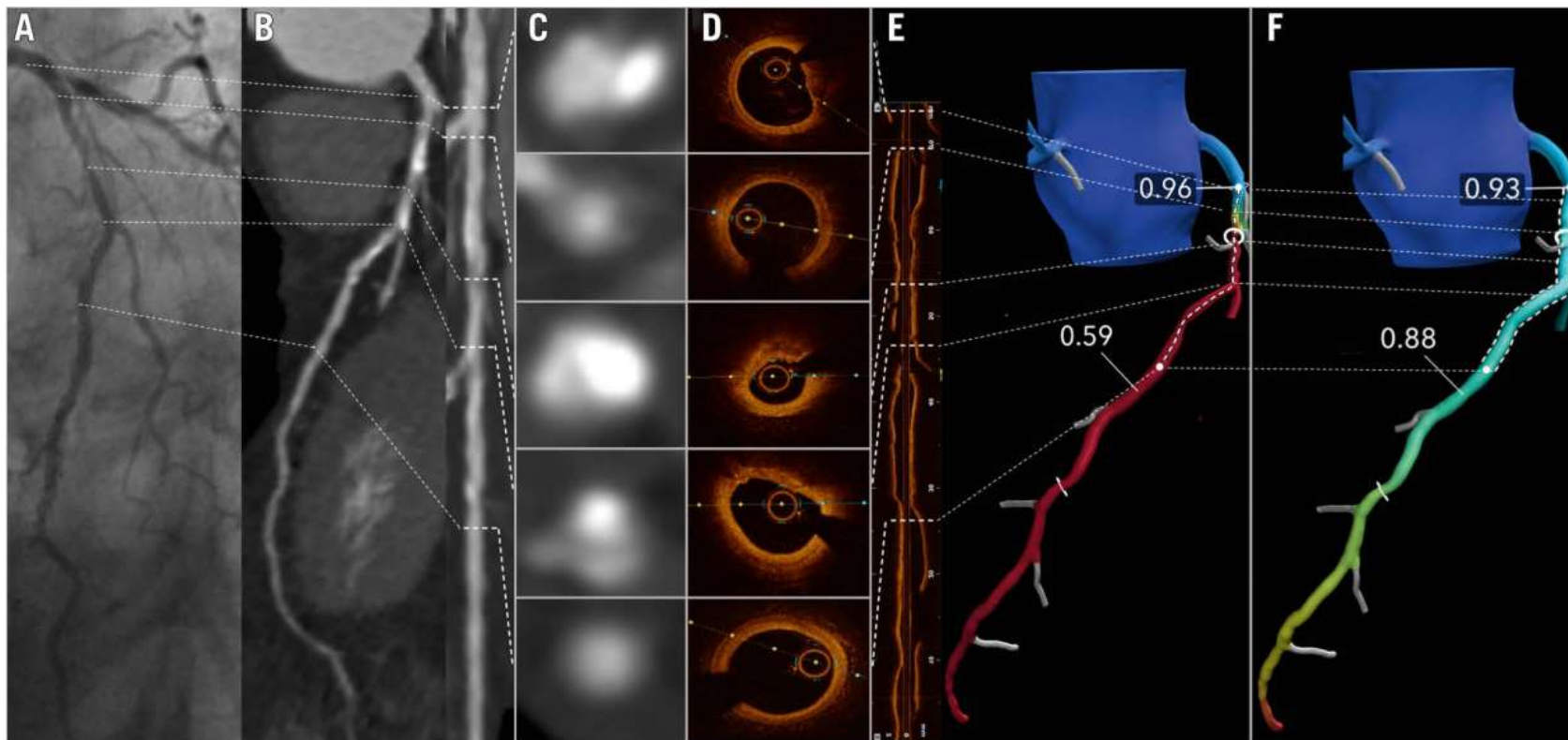
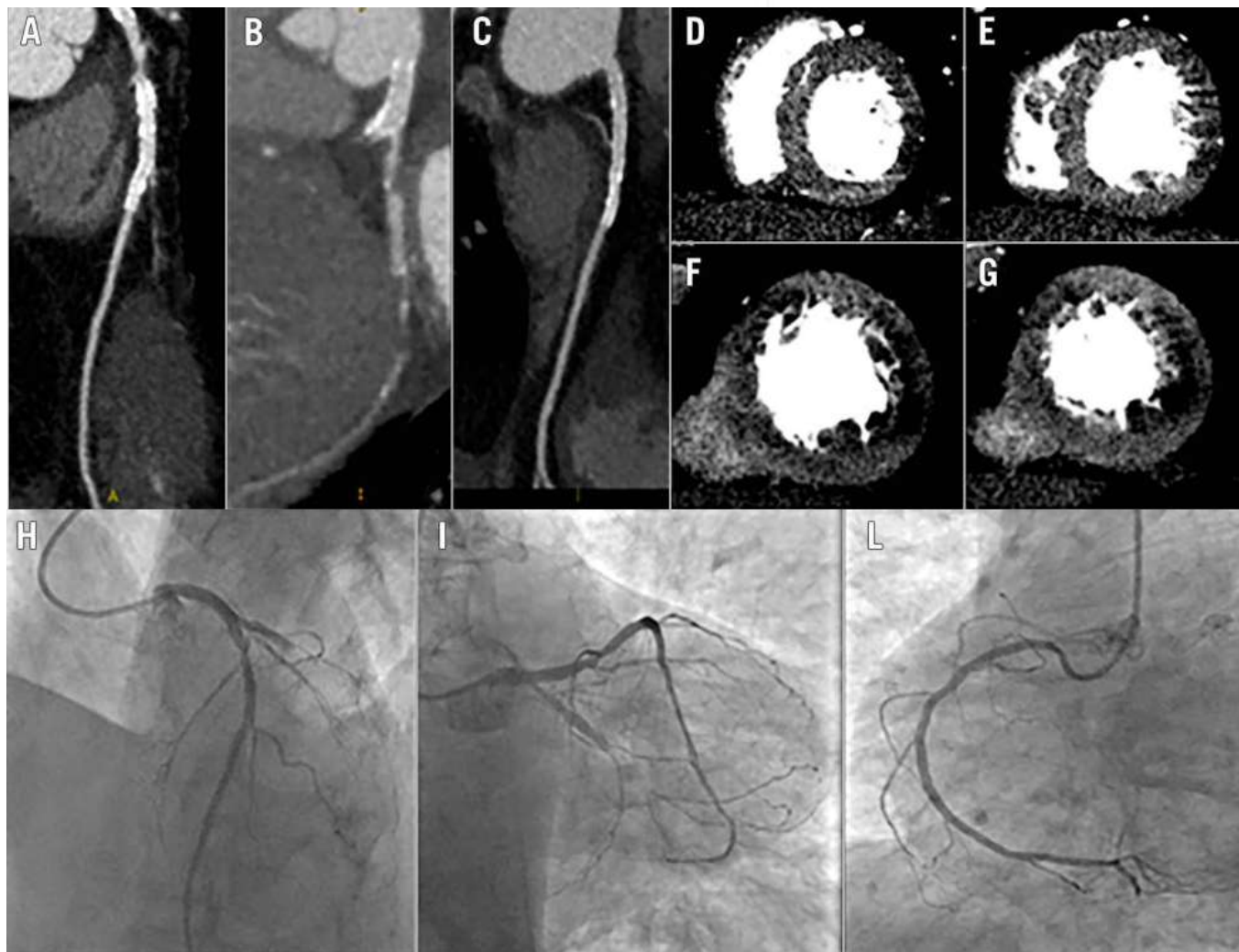


Figure 1. Image showing a co-registration of invasive coronary angiography (A), coronary CTA and straight MPR (panel B and C) with CTA cross sections (panel D), corresponding OCT cross sections and longitudinal OCT view (E). Panel F shows the CT-FFR patient-specific model and panel G the result of the CT-FFR Planner. Invasive coronary angiography (A), coronary CT angiography (B) and straight MPR (C) showing a calcified fibro-atheroma with positive remodeling in the proximal mid LAD. The CT-FFR (panel F) reaches a value of 0.59 with a focal gradient at the level of the MLA (panel D and E mid). The OCT cross sections mirror the CTA images. The most distal CTA cross section exhibits a healthy landing zone for percutaneous stenting also visualized by OCT (E). Based on the CT-FFR model (F), an appropriate stent length and position is selected (dashed lines). In panel G the predicted functional result by the CT-FFR Planner mimicking PCI can be appreciated.

Stents < 3 mm o pacientes con multiples stents ? No problem...

In patients with previous stent implantation the addition of CT-MPI to CCTA might increase the usefulness of CCTA alone as a non-invasive tool for selecting the patient to submit to invasive evaluation.



FAST TRACK CABG TRIAL: ongoing!
 Coronariografia vs CT coronarias para
 decidir CABG en 3 vasos con syntax >33

Heart Team

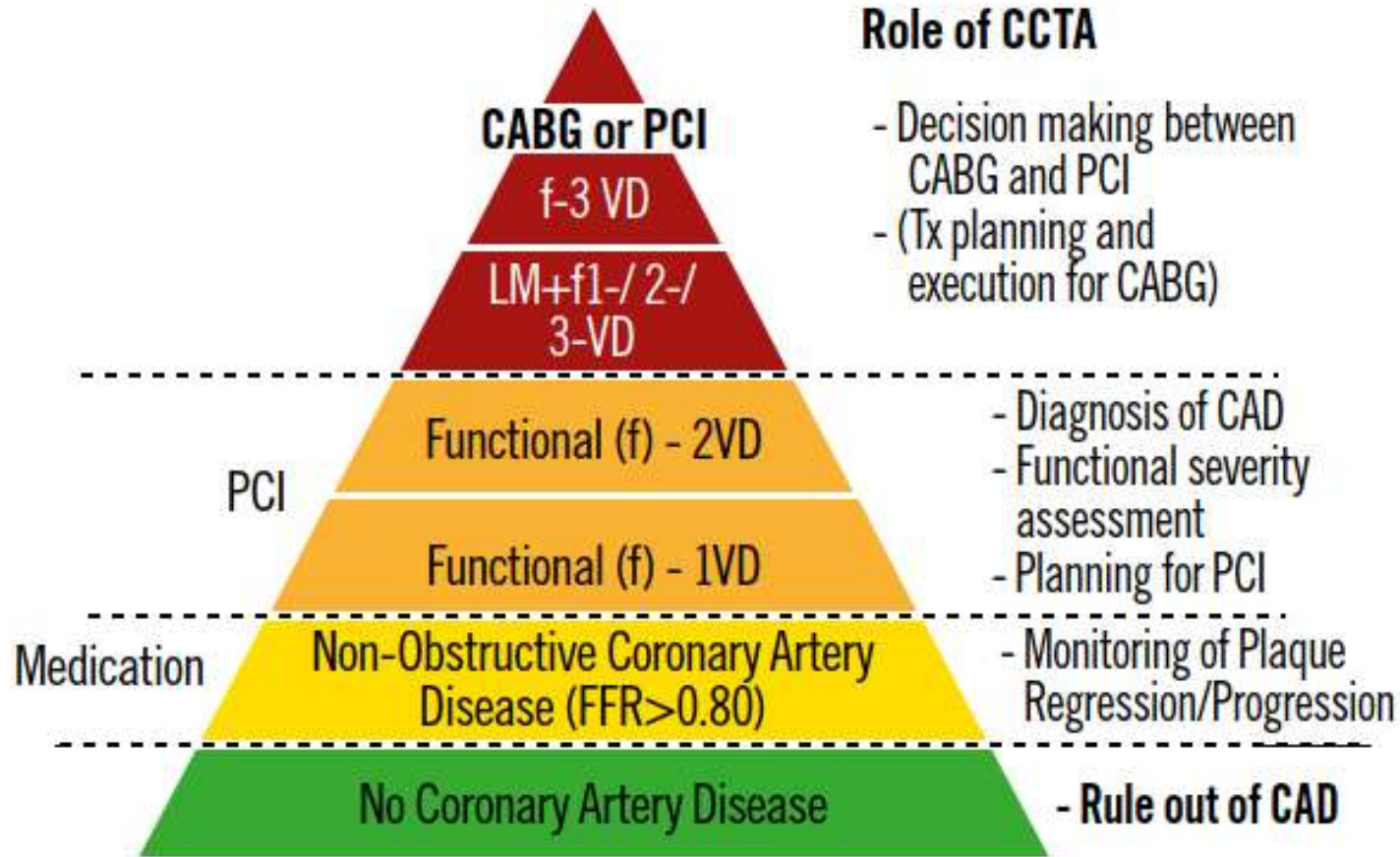
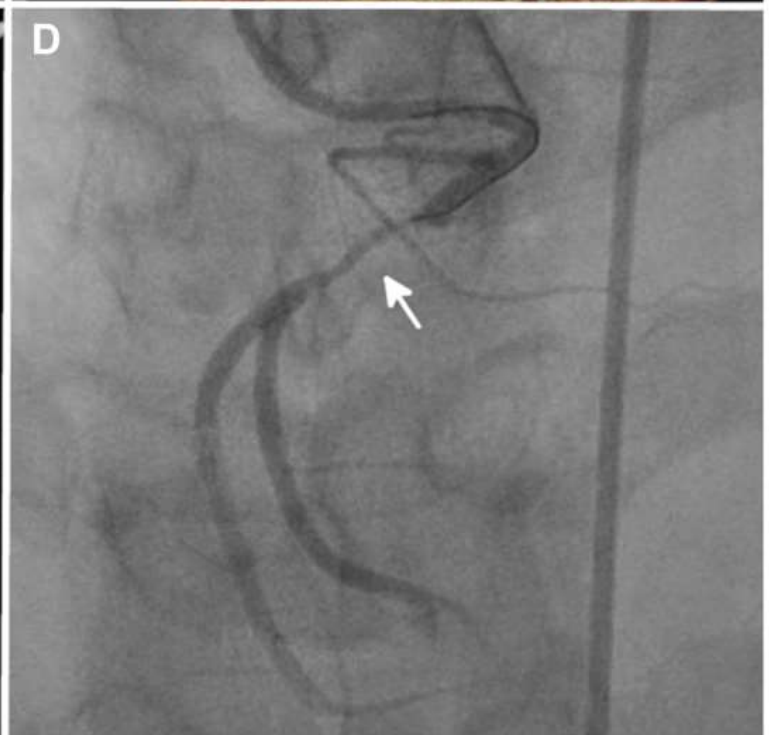
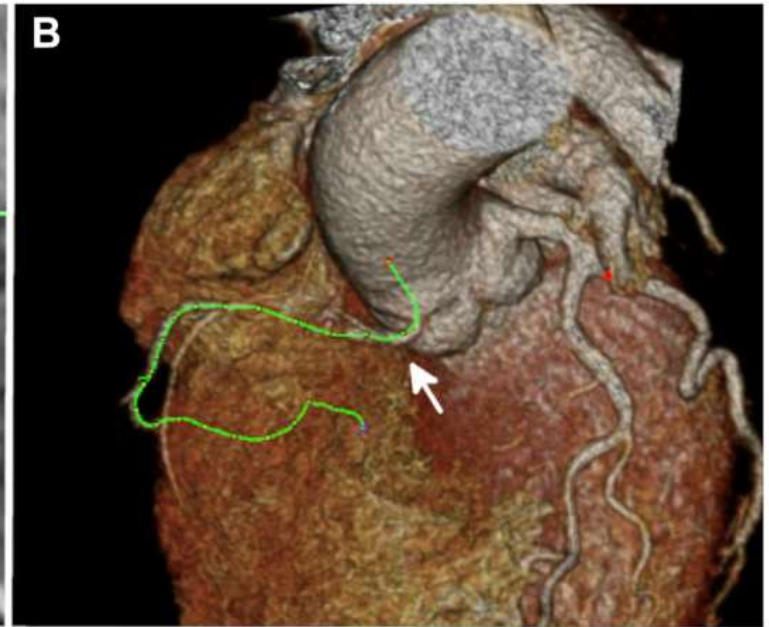
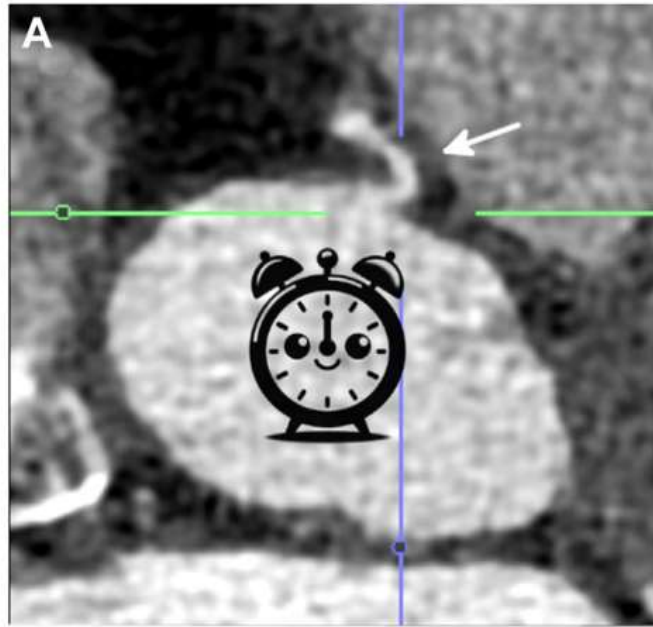


Figure 5. Role of CCTA in different degrees of CAD.

Table 2. SYNTAX score: from anatomy to comorbidity and functional assessment.

1. Anatomic SYNTAX Score (2005): Anatomy (ICA or CTA), population strata outcome, PCI versus CABG <ul style="list-style-type: none"> - Predict MACCE (all-cause mortality, stroke, myocardial infarction, revascularization) prognosis from 1 to 5 years in the SYNTAX trial (PCI vs. CABG in three-vessel disease and left main) and mortality up to 10 years in the SYNTAXES study.
2. SYNTAX Score II (2013): Anatomy (ICA) and comorbidity, PCI versus CABG <ul style="list-style-type: none"> - Predict 4-year all-cause mortality in the SYNTAX trial. - Used as an inclusion criteria for PCI population based on equipoise prediction of all- cause mortality after PCI versus surgery in three-vessel disease and left main (the SYNTAX II trial).
3. Functional SYNTAX Score (2011, 2018): Anatomy (ICA or CTA) and functionality (iFR, FFR, CT-FFR), PCI population <ul style="list-style-type: none"> - Treatment decision making based on anatomy and functionality.
4. Logistic clinical SYNTAX Score (2020): Anatomy (ICA) and comorbidity, individualized outcome for "all-comers" PCI <ul style="list-style-type: none"> - Predict all-cause mortality at 2 years in "all-comers" PCI trials.
5. SYNTAX Score III: Anatomy (CTA), comorbidity, and functionality (CT-FFR), PCI and CABG <ul style="list-style-type: none"> - Treatment decision making between PCI and CABG in three-vessel disease and left main based solely on multi-slice CT scan with CT-FFR in the SYNTAX III REVOLUTION trial.
6. SYNTAX Score III: Anatomy (CTA), comorbidity, and functionality (CT-FFR), CABG population <ul style="list-style-type: none"> - Planning and execution of surgery in three-vessel disease and left main applying SYNTAX Score III derived solely on CTA scan with CT-FFR (the FASTTRACK CABG trial, First in men).
7. SYNTAX Score 2020 (2020): Anatomy (ICA) and comorbidity, PCI versus CABG <ul style="list-style-type: none"> - Predict 5-year MACE and 10-year all-cause mortality based on cross validation in the SYNTAX trial and on external validation in the FREEDOM, BEST, and PRECOMBAT trials.
Evolution of the risk score algorithms derived from the historical SYNTAX I trial. CABG: coronary artery bypass grafting; CTA: computed tomography angiography; FFR: fractional flow reserve; ICA: invasive coronary angiography; iFR: instantaneous wave-free ratio; PCI: percutaneous coronary intervention

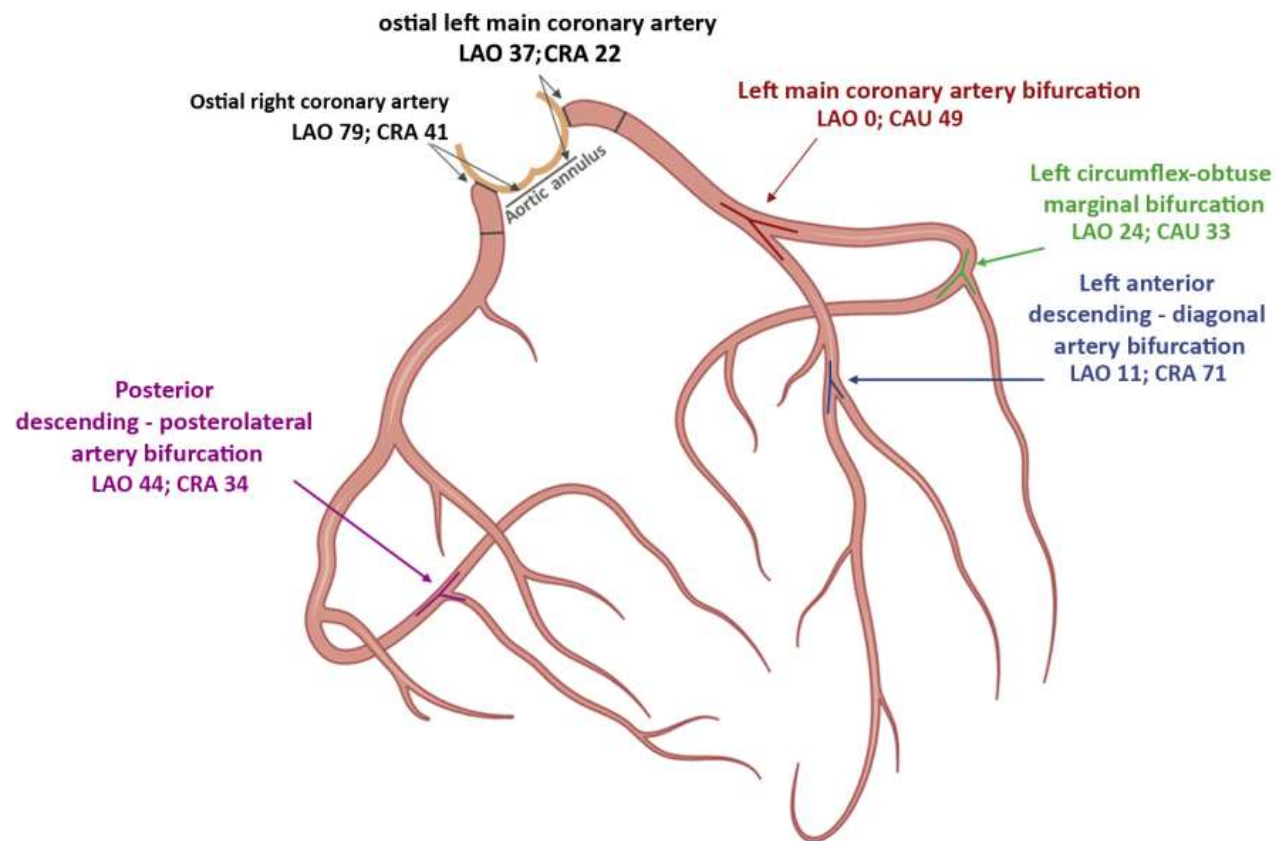
Origen anomalo, arteria con lesion y decision de que cateter usar:
0.75



Bifurcaciones:

1. Reporte de proyecciones optimas para cada paciente
2. Planear la mayor estrategia: Simple vs Compleja
3. Estimar el diametro y tamaño del stent.

CENTRAL ILLUSTRATION Optimal Fluoroscopic Viewing Angles of Coronary Artery Ostia and Bifurcations



Kočka, V. et al. J Am Coll Cardiol Intv. 2020;13(21):2560-70.

CAU = caudal; CRA = cranial; LAO = Left anterior oblique.

Prediction of side branch occlusions in percutaneous coronary interventions by coronary computed tomography: the CT bifurcation score as a novel tool for predicting intraprocedural side branch occlusion



Seung-Hwa Lee¹, MD; Joo Myung Lee¹, MD; Young Bin Song¹, MD, PhD; Taek Kyu Park¹, MD; Jeong Hoon Yang¹, MD, PhD; Joo-Yong Hahn¹, MD, PhD; Seung-Hyuk Choi¹, MD, PhD; Hyeon-Cheol Gwon¹, MD, PhD; Sang-Hoon Lee¹, MD, PhD; Sung Mok Kim², MD, PhD; Yeon Hyeon Choe², MD, PhD; Jin-Ho Choi^{1,3*}, MD, PhD

and a ratio of MV to SB ostium area >4.3 , which constituted a point-based CT bifurcation score. The CT bifurcation score was cross-validated, outperforming any angiographic Medina classification or RESOLVE score (c-statistics=0.749 versus 0.631 to 0.551; $p<0.05$ for all). The sensitivity, specificity, positive predictive value, negative predictive value, and accuracy of the CT bifurcation score ≥ 1 were 90%, 42%, 23%, 96%, and 50%, respectively.

Conclusions: Comprehensive CCTA assessment was able to predict intraprocedural SB occlusion better than the current angiographic classification or scoring system. The CT bifurcation score may thus be a helpful guide for selecting the optimal bifurcation PCI strategy.

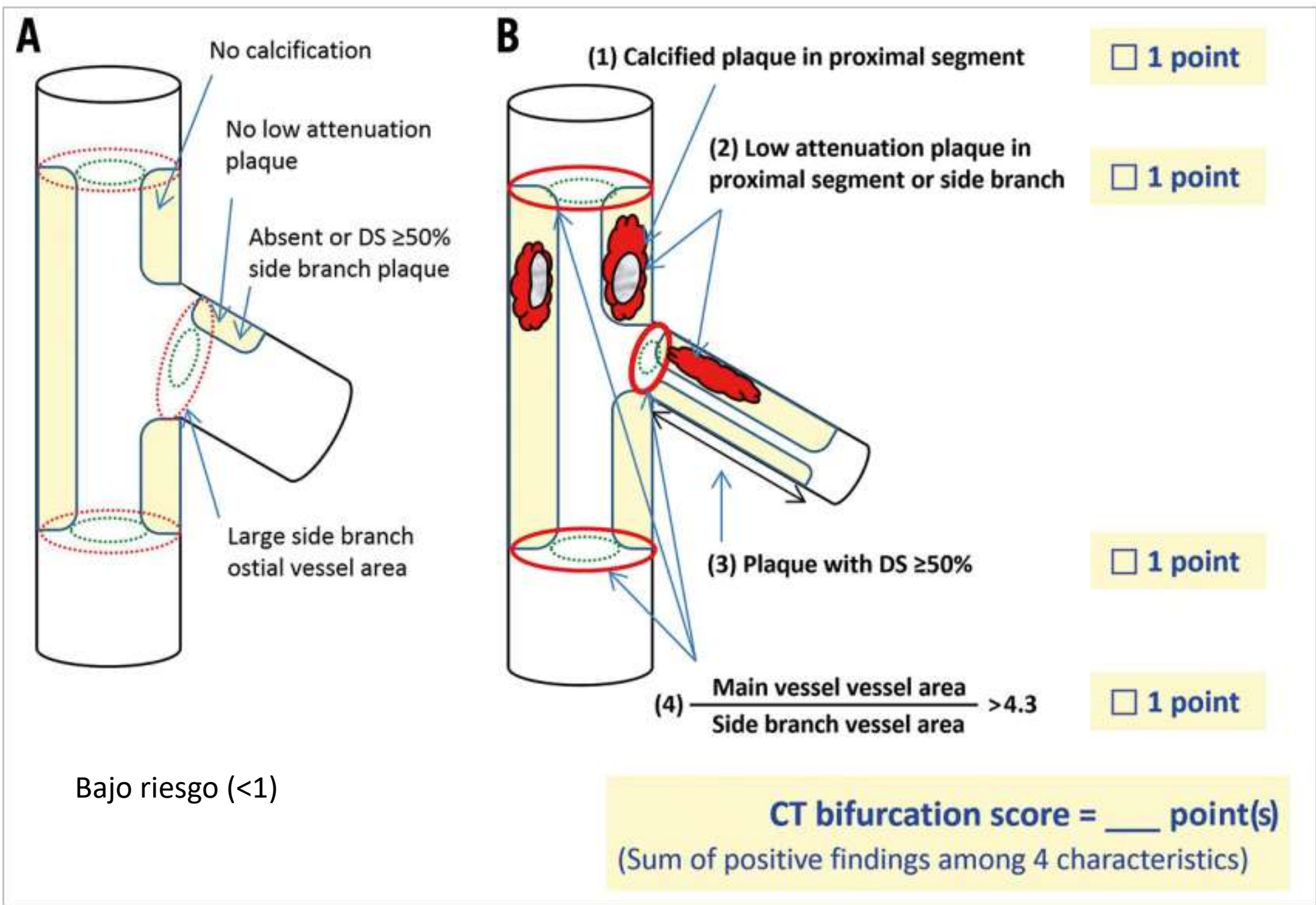
Prediction of side branch coronary intervention in the CT bifurcation score intraprocedural side

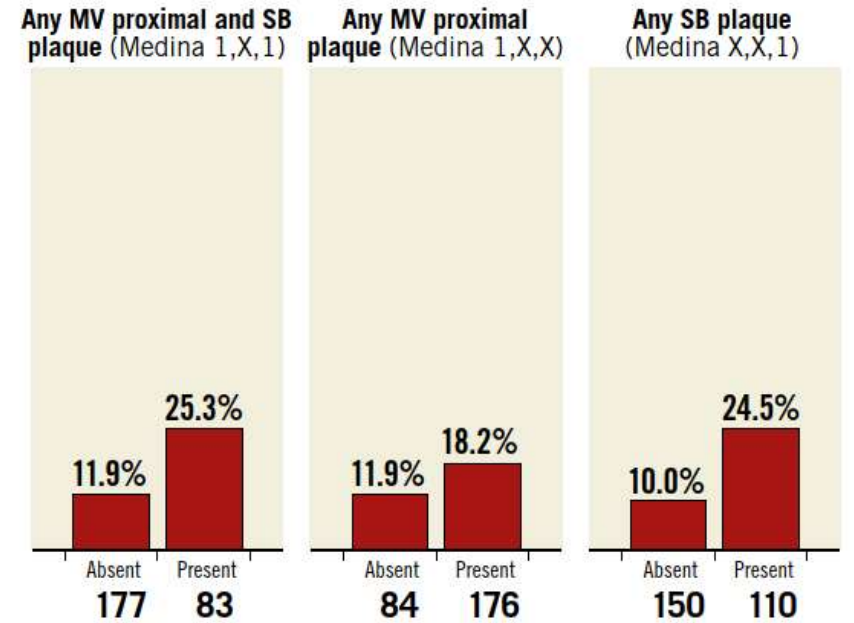
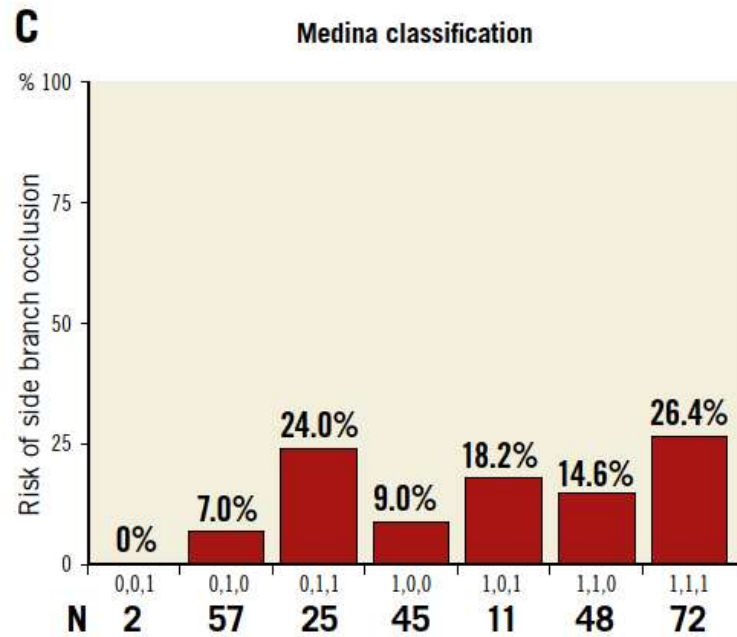
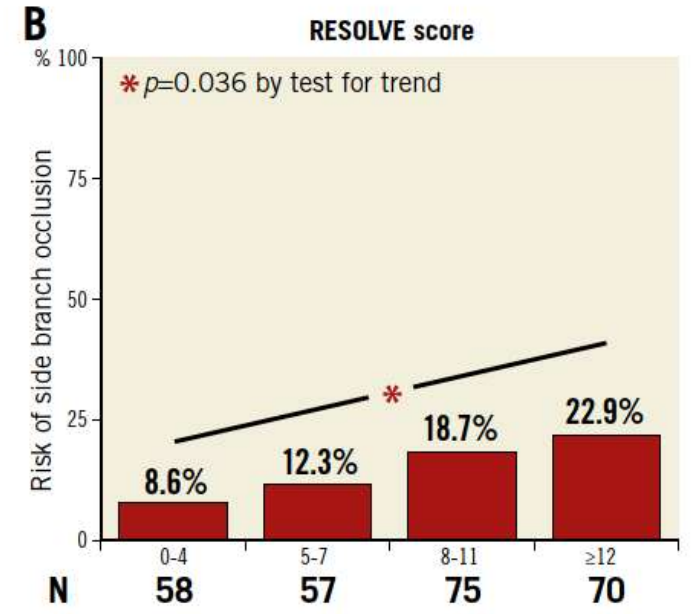
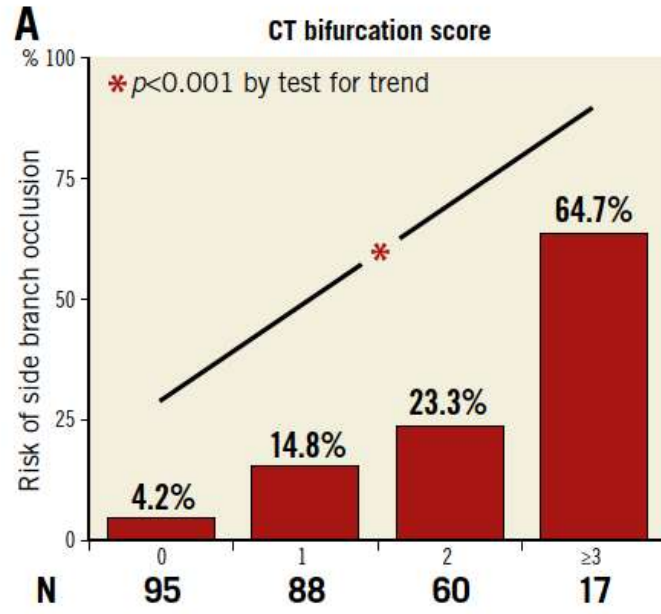
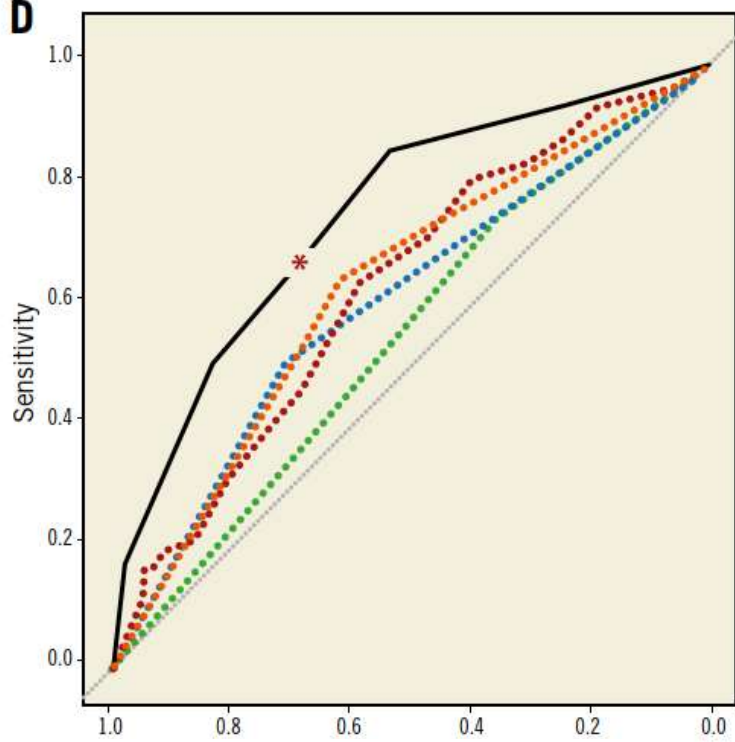


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This paper also includes supplementary data pu





	c-statistics (95% CI)
— CT bifurcation score	0.749 (0.672-0.827)
••••• RESOLVE score	0.627 (0.537-0.717)
••••• Medina classification with any SB plaque (type 1,1,1, 1,0,1, 0,1,1, 0,0,1)	0.631 (0.551-0.711)
••••• Medina classification with MV proximal and SB plaque (type 1,1,1 or 1,0,1)	0.608 (0.526-0.690)
••••• Medina classification with any MV proximal plaque (type 1,1,1, 1,1,0, 1,0,1, or 1,0,0)	0.551 (0.478-0.623)

**CT Guided
PCI**

3D Coronary Tree Overview

Functional Significance

Virtual PCI Plan

Online Procedural Guidance

Myocardial Mass at Risk

Plaque Composition

Ostium Position & Catheter Selection

Conclusiones:

- Estamos presenciando un cambio de paradigma y una revolucion en la Cardiologia. Europa la tiene desde hace 8 años, LATAM esta en ese proceso... En un area dominada por Radiologos, estamos llamados a integrar ese proceso en nuestro hacer...
- El leon dormido de la CT esta mas despierto que nunca, convirtiendose en una de las herramientas mas importantes para el diagnostico de la enfermedad coronaria, por encima de los test funcionales no invasivos (perfusion, ECO stress o dobutamine etc).
- Los programas de cardiologia tienen que cambiar: El entrenamiento en TAC debe ser mandatorio como leer un EKG o hacer una Ecocardiografia.

Conclusiones

- El campo de la CT viene ganando terreno como nunca hemos visto, lo que va a obligar a que los cardiólogos intervencionistas del futuro nos repensemos, y hagamos parte de esta revolución:
 - Preplan para intervencionismo complejo.
 - Entrenarnos para poder manipular el TAC para sacar scores, ver la anatomía en tiempo real mientras hacemos la PCI, ver que placa tiene y saber como actuar... Exactamente como hacen los Estructurales.