10° CONGRESSO NAZIONALE

CAMPUS Cuore

Quello che le Linee Guida Non Dicono

Napoli
Hotel Excelsior
14-15 aprile 2023

CARDIO RADIOLOGIA: UPDATE 2023

- **Le Evidenze Scientifiche**

Cardio TC

Carlo Tedeschi
Cardiologia PSI Napoli Est – Radiologia Ospedale del Mare – ASL NA 1 Centro

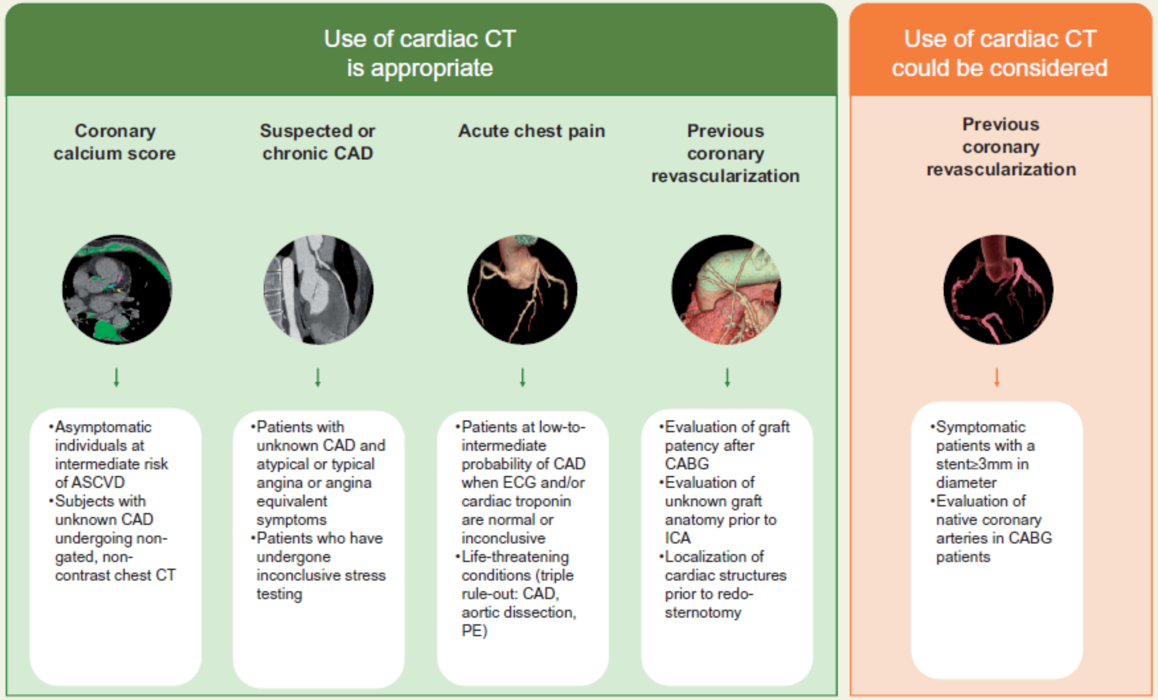
ESC European Society of Cardiology
European Heart Journal - Cardiovascular Imaging (2022) **00**, 1–16
https://doi.org/10.1093/ehjci/jeab293
EACVI DOCUMENT

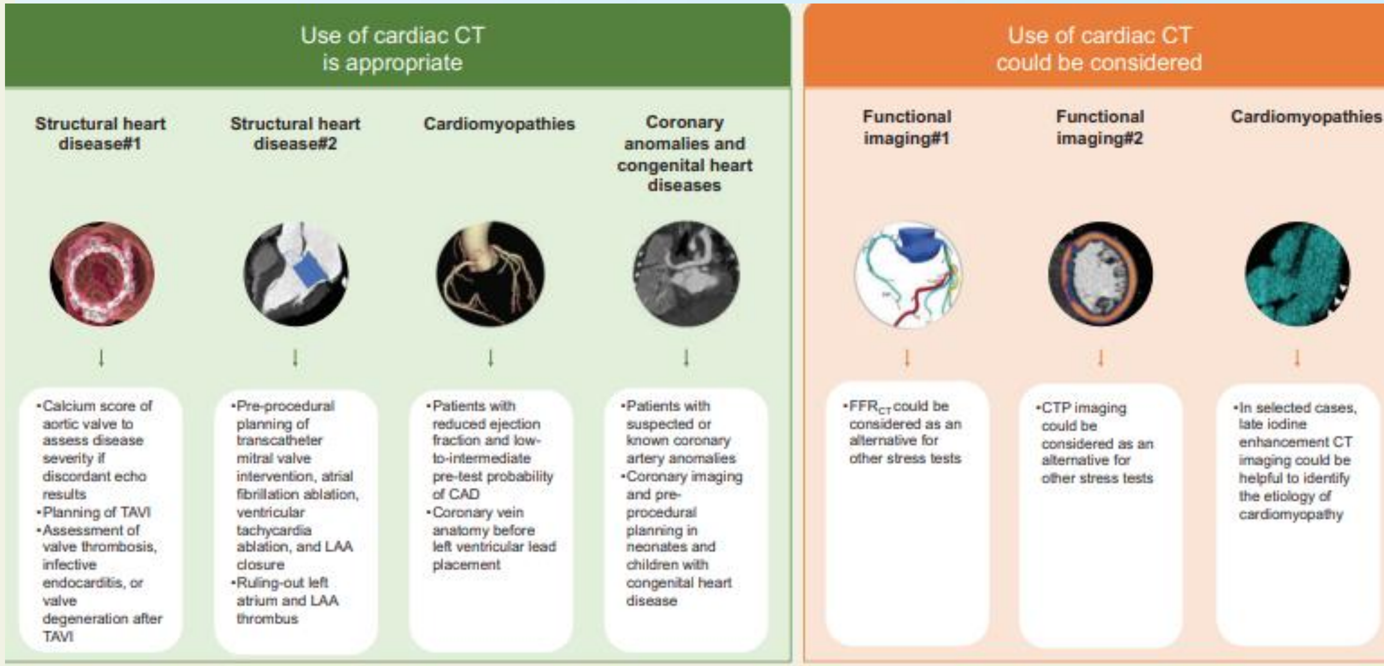
Clinical applications of cardiac computed tomography: a consensus paper of the European Association of Cardiovascular Imaging—part I

ESC European Society of Cardiology
European Heart Journal - Cardiovascular Imaging (2022) **00**, 1–26
https://doi.org/10.1093/ehjci/jeab292
EACVI DOCUMENT

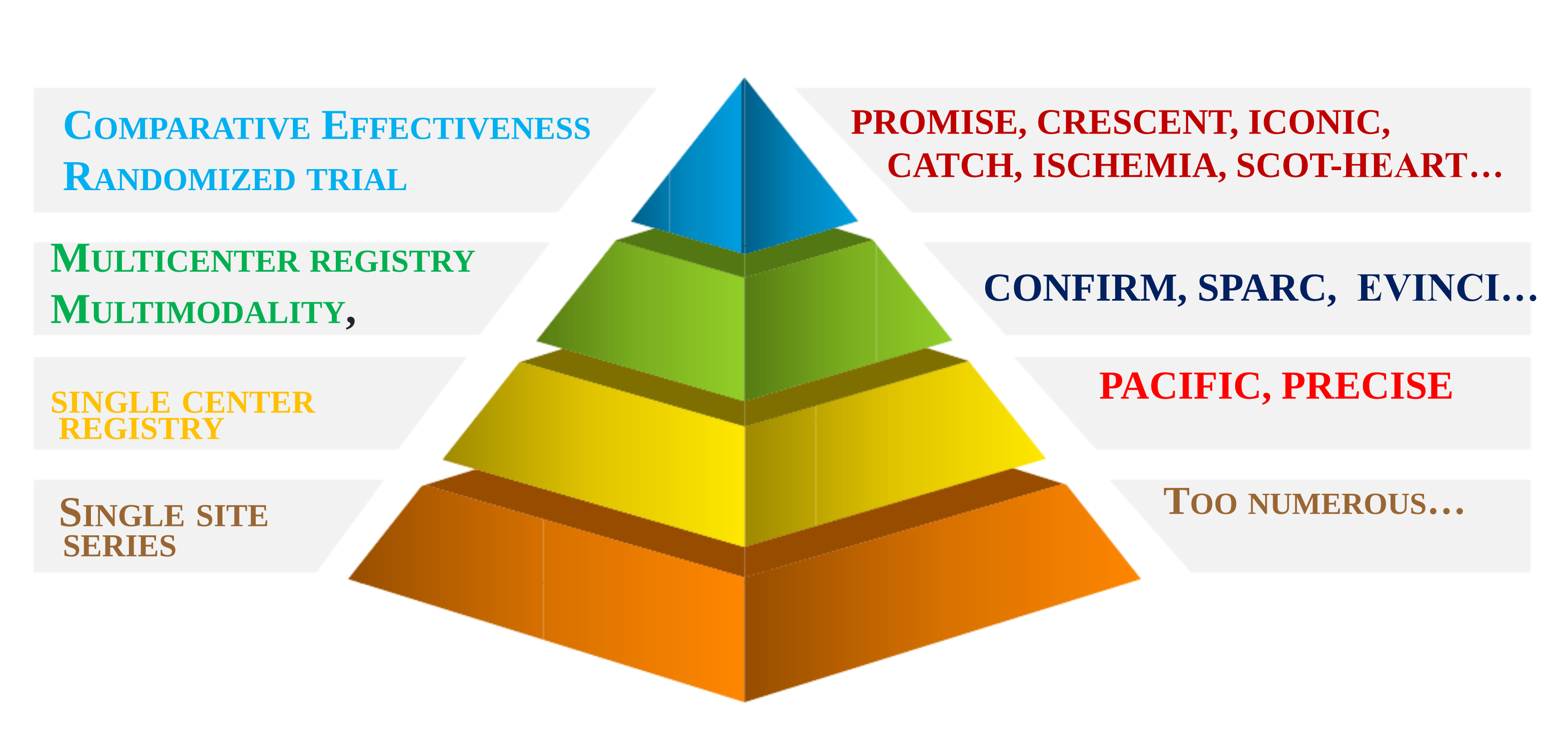
Clinical applications of cardiac computed tomography: a consensus paper of the European Association of Cardiovascular Imaging—part II

Gianluca Pontone [1,*,†], Alexia Rossi[2,3,†], Marco Guglielmo [1], Marc R. Dweck [4], Oliver Gaemperli[5], Koen Nieman [6], Francesca Pugliese [7,8], Pal Maurovich-Horvat [9], Alessia Gimelli [10], Bernard Cosyns [11], and Stephan Achenbach [12]





CTA Evidence - Rapid Advancement with Numerous High Quality Clinical Trials



Source: Shaw Circ Cardiovasc Imaging 2017 Dec;10(12).

Computed Tomography in CCS

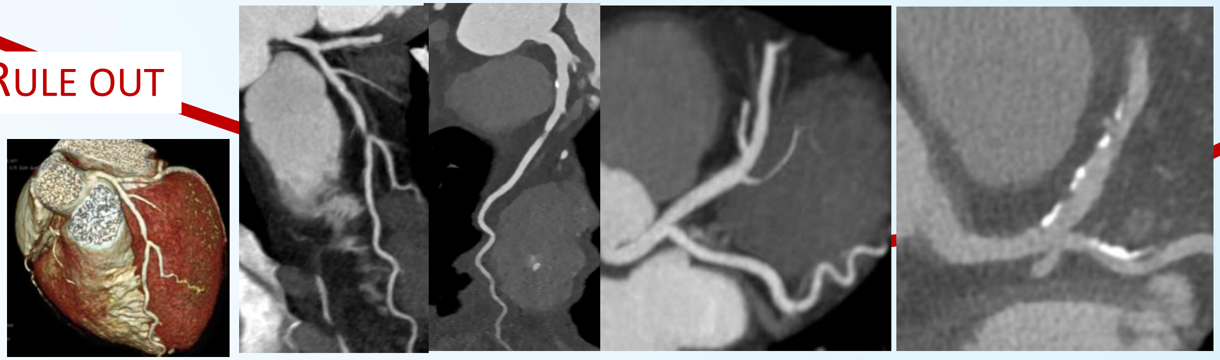
REVASCULARIZATION

Diagnosis of (obstructive) CAD

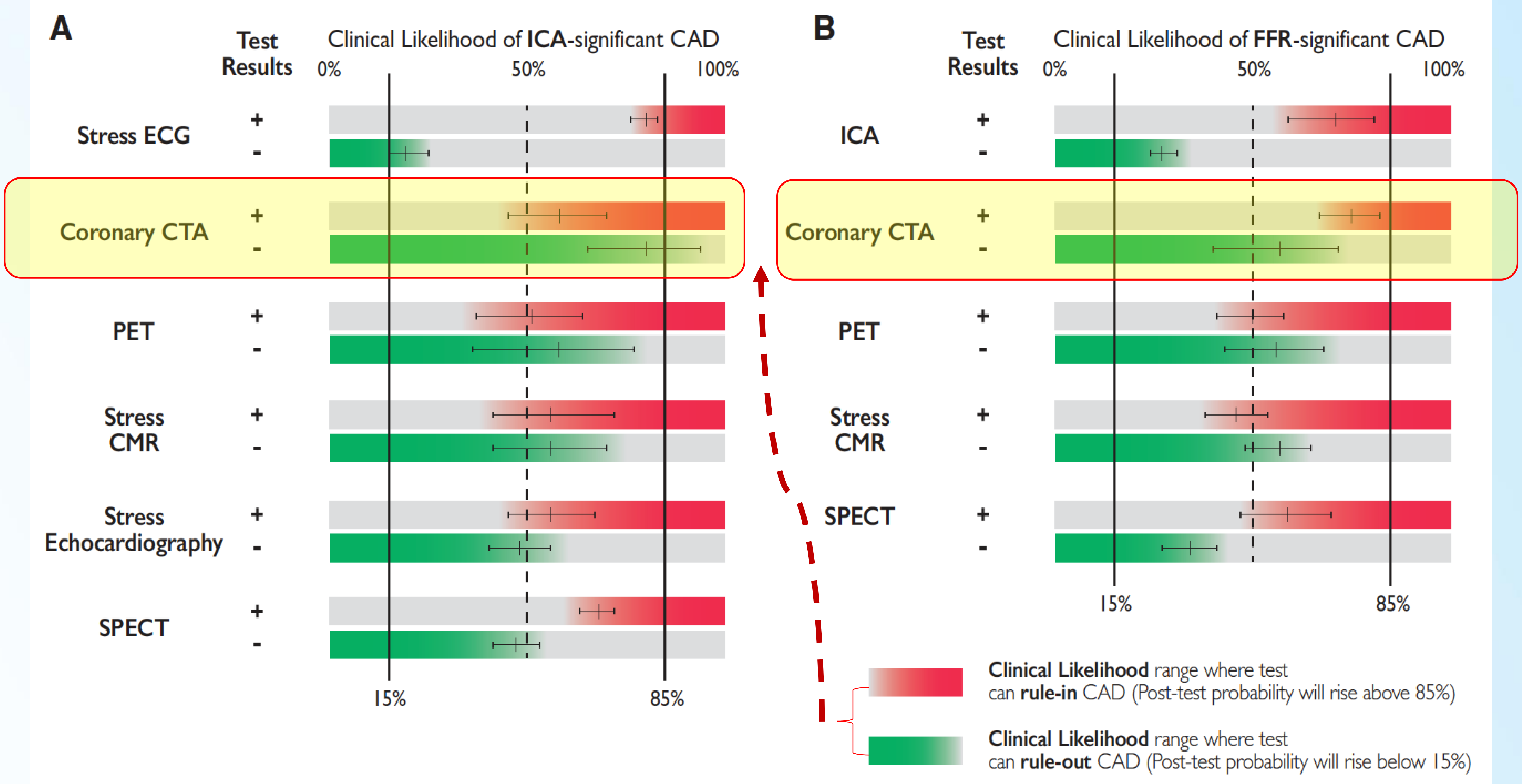
3. TREATMENT

2.Risk stratification regarding future events

1. RULE OUT



Performance dei principali test diagnostici non invasivi



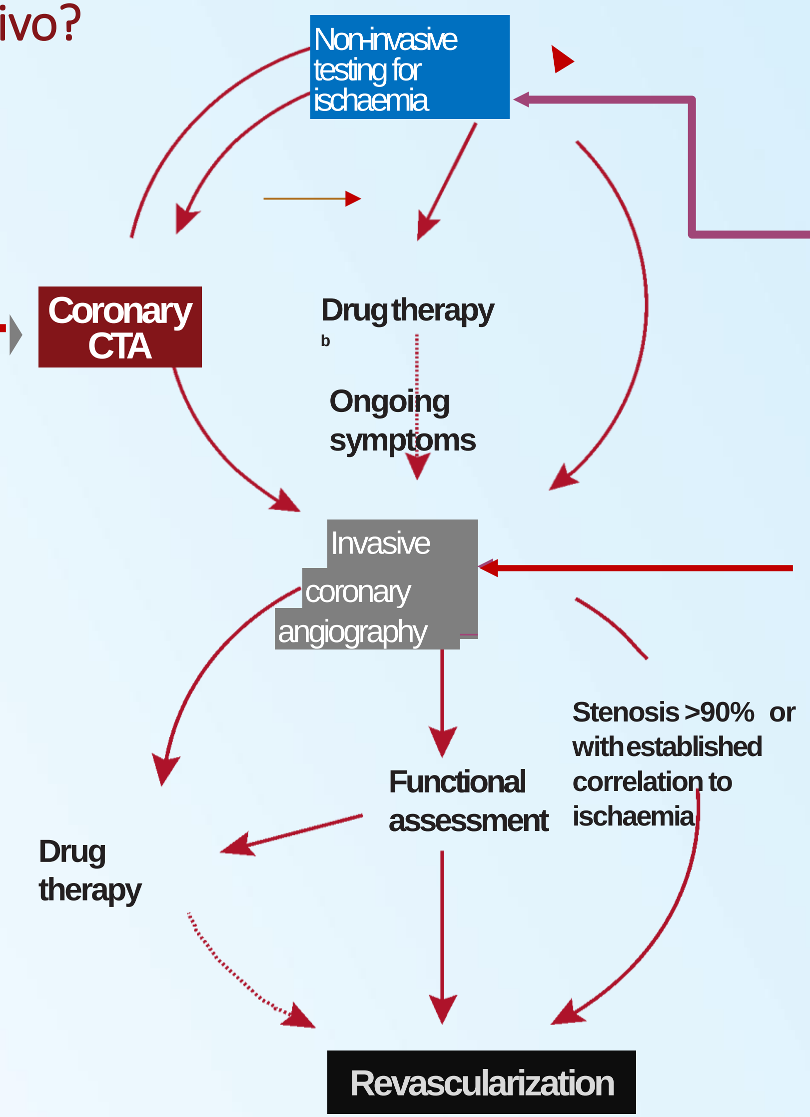
ESC Guidelines for the diagnosis and management of chronic coronary syndromes

Recommendations	Class[a]	Level[b]
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
It is recommended that selection of the initial non-invasive diagnostic test is done based on the clinical likelihood of CAD and other patient characteristics that influence test performance,[d] local expertise, and the availability of tests.	I	C
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
Invasive coronary angiography is recommended as an alternative test to diagnose CAD in patients with a high clinical likelihood, severe symptoms refractory to medical therapy or typical angina at a low level of exercise, and clinical evaluation that indicates high event risk. Invasive functional assessment must be available and used to evaluate stenoses before revascularization, unless very high grade (>90% diameter stenosis).[71,72,74]	I	B
Invasive coronary angiography with the availability of invasive functional evaluation should be considered for confirmation of the diagnosis of CAD in patients with an uncertain diagnosis on non-invasive testing.[71,72]	IIa	B
Coronary CTA should be considered as an alternative to invasive angiography if another non-invasive test is equivocal or non-diagnostic.	IIa	C
Coronary CTA is not recommended when extensive coronary calcification, irregular heart rate, significant obesity, inability to cooperate with breath-hold commands, or any other conditions make obtaining good image quality unlikely.	III	C
Coronary calcium detection by CT is not recommended to identify individuals with obstructive CAD.	III	C

Quale imaging Cardiaco Non-invasivo?
E per quale paziente?

Preferentially considered if:

- Low clinical likelihood
- Patient characteristics suggest high image quality
- Local expertise and availability
- Information on atherosclerosis desired
- No history of CAD

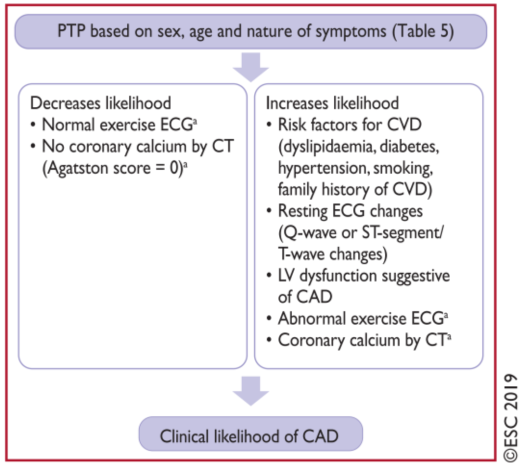


Preferentially considered if:

- High clinical likelihood
- Revascularization likely
- Local expertise and availability
- Viability assessment also required

Preferentially considered if:

- High clinical likelihood and severe symptoms refractory to medical therapy
- Typical angina at low level of exercise and clinical evaluation including exercise ECG indicates high-risk of events
- LV dysfunction suggestive of CAD



Knuuti J, Wijns W, et al. Eur Heart J. 2020;41:407-477

JACC: CARDIOVASCULAR IMAGING
VOL. 10, NO. 3, 2017
ISSN 1936-878X/$36.00
http://dx.doi.org/10.1016/j.jcmg.2016.10.016
PUBLISHED BY ELSEVIER

Comparative Effectiveness Trials of Imaging-Guided Strategies in Stable Ischemic Heart Disease

Leslee J. Shaw, PhD,[a] Lawrence M. Phillips, MD,[b] Eike Nagel, MD,[c] David E. Newby, MD,[d] Jagat Narula, MD, PhD,[e] Pamela S. Douglas, MD[f]

Proportion of Patients With **Obstructive** Coronary Artery Disease Found on Elective Cardiac Catheterization Vs Noninvasive Testing for Suspected CAD Across Multiple Studies

Resa diagnostica CAG dopo CT

PROMISE, N Engl J Med 2015, n = 10 003
CT vs. functional testing

SCOT-Heart, N Engl J Med 2018, n = 4146
CT vs. standard care

Computed Tomography in CCS

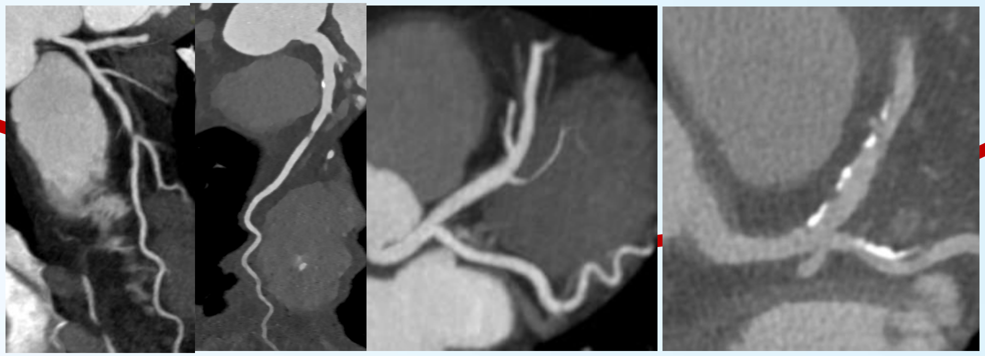
REVASCULARIZATION

Diagnosis of (obstructive) CAD

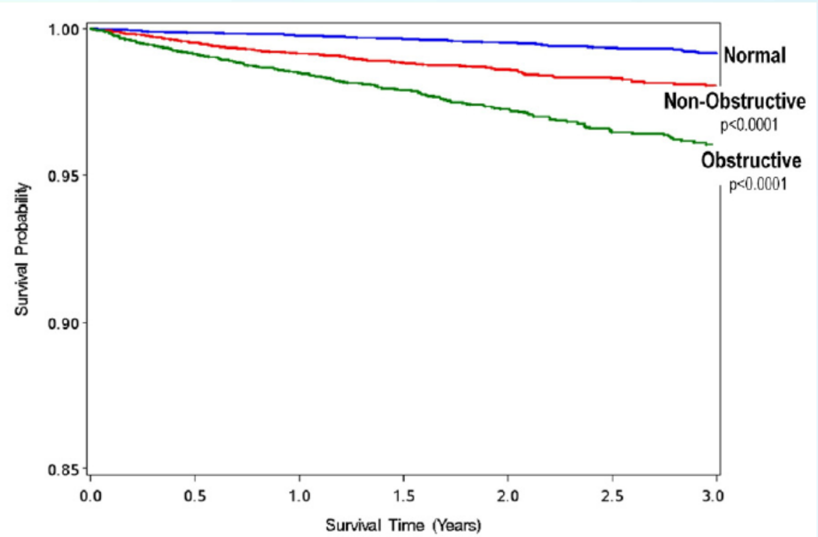
3. TREATMENT

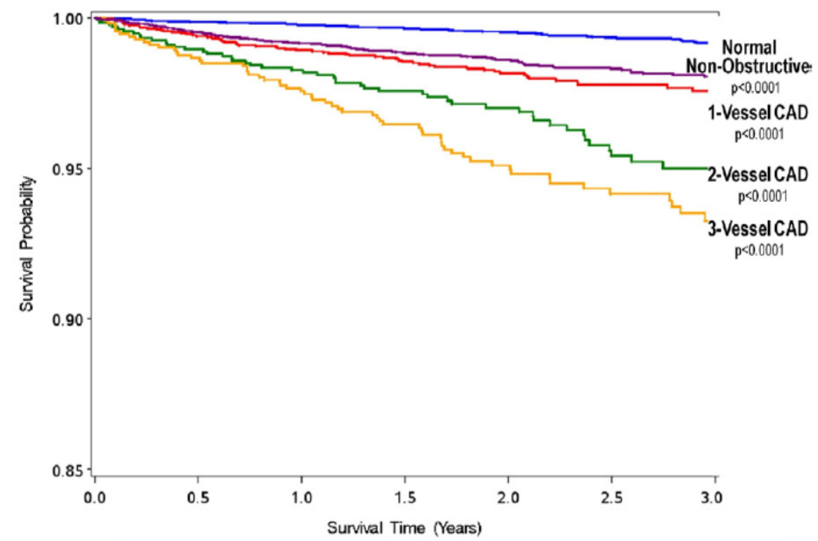
2.Risk stratification regarding future events

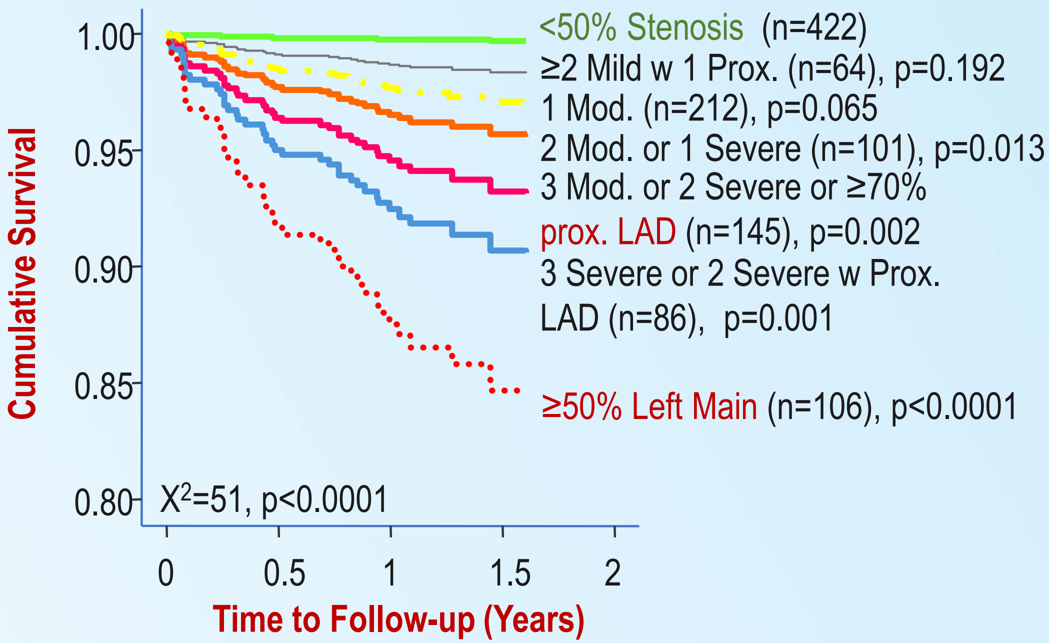
1. RULE OUT



Prognosi







R-A p<0.0001 (adjusting for risk factors, chest pain, + dyspnea), Mild (30%-49%), Mod. (50%-69%), & Severe (≥70%).

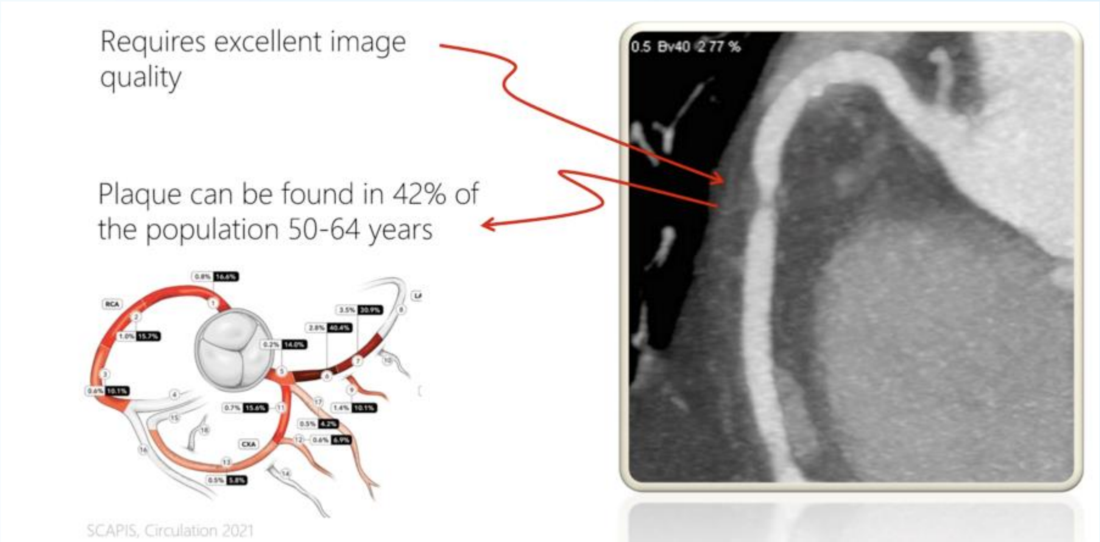
Source: Min et al. J Am Coll Cardiol 2007

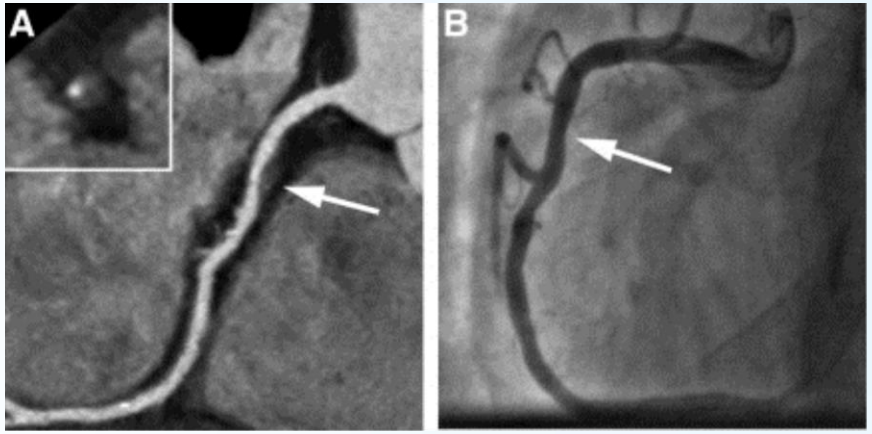
0.3% event rate/ year when coronary CTA is normal

ESC European Society of Cardiology
European Heart Journal - Cardiovascular Imaging (2020) 00, 1–9
doi:10.1093/ehjci/jeaa323

CONFIRM REGISTRY

Non solo rule-out stenosi: CAD non ostruttiva





Tassi di eventi nella CAD non ostruttiva

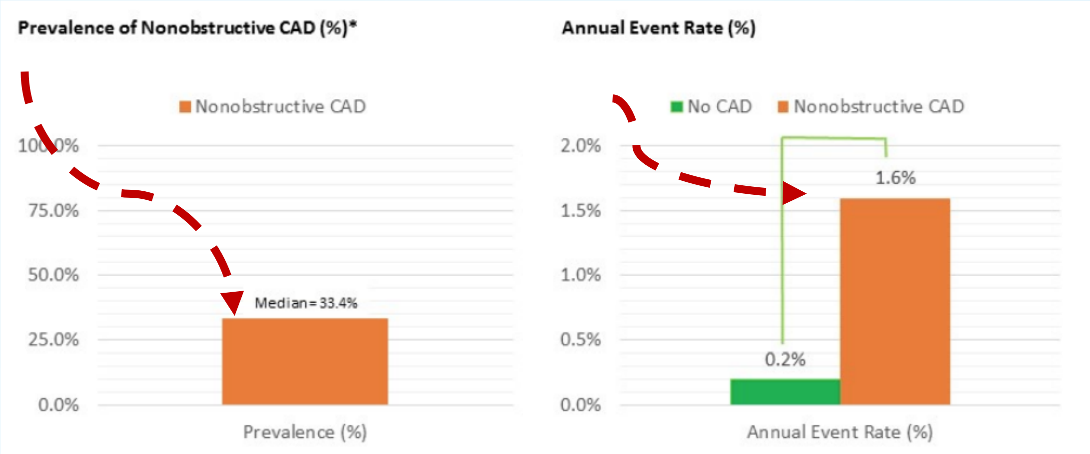


Figure 1. Meta-Analysis of the Prevalence and Clinical Outcomes of Patients Undergoing CCTA with Nonobstructive CAD. Cardiac events were evaluated for nonobstructive CAD (1-49% Stenosis) among patients presenting with suspected disease in 17 published reports (N=49,957) with a median of 2.5 years of follow-up. There is an admixture of event types (all-cause or CAD mortality, ACS, or Revascularization) and length of follow-up (Range: 1.7-10.0 years). There is an 8-fold higher rate of events among patients with nonobstructive CAD as compared to those with No Stenosis or Plaque. Note that the two figures have

Mild non-obstructive Plaques Cause Adverse Events

2,583 patients undergoing CCTA with ≤50% stenosis followed for 3.1 years

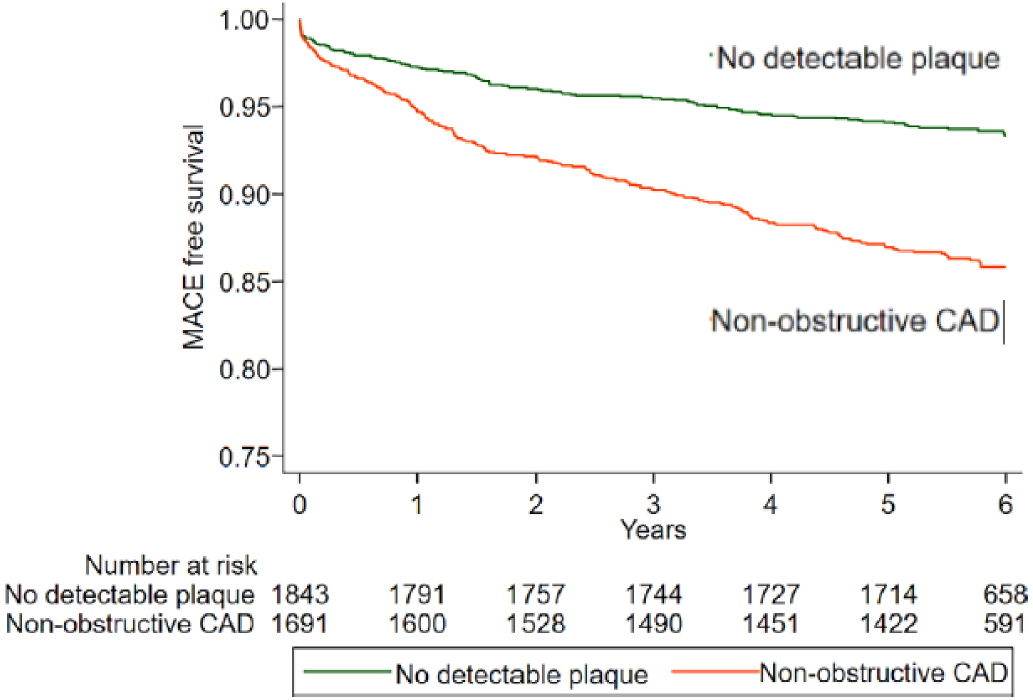


Figure 4: Kaplan-Meier analysis of MACE-free survival for all participants with nonobstructive CAD compared with those who had no detectable plaque. CAD = coronary artery disease, MACE = major adverse cardiovascular event.

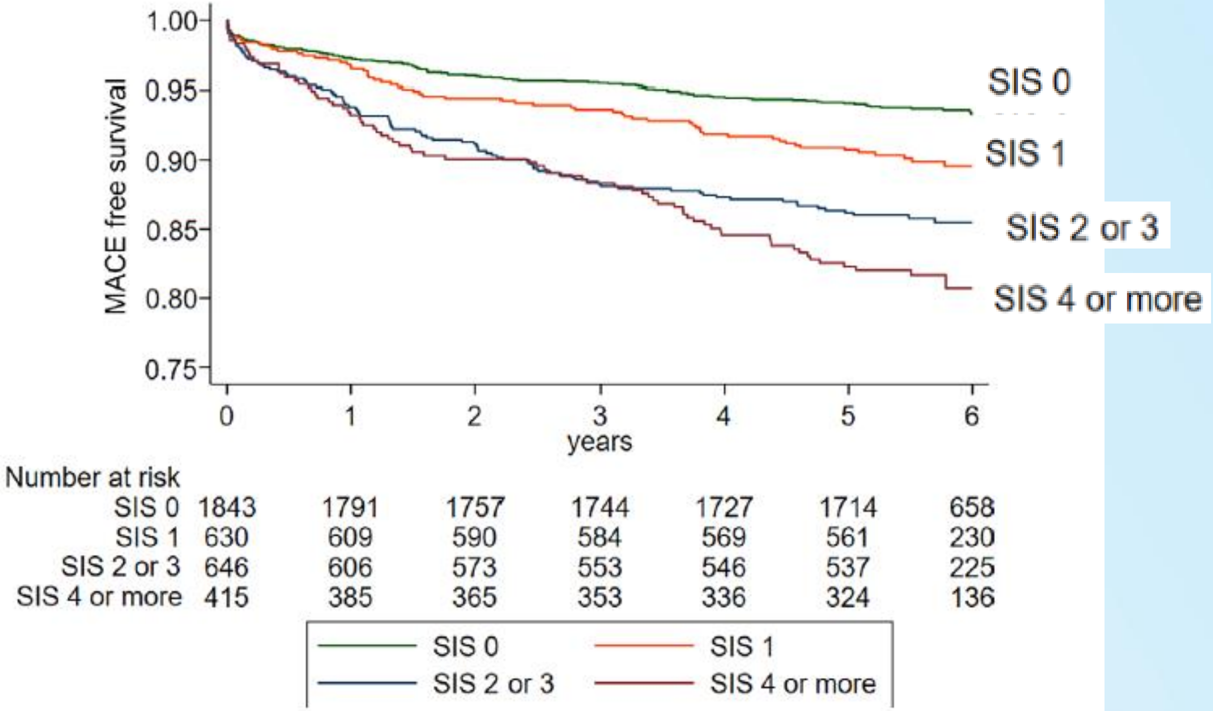


Figure 5: Kaplan-Meier analysis of MACE-free survival for participants as stratified by SIS. MACE = major adverse cardiovascular event, SIS = segment involvement score.

Radiology: Cardiothoracic Imaging 2000 ORIGINAL RESEARCH

CONFIRM REGISTRY

Morfologia e composizione della placca ateromasica

Calcified Plaque

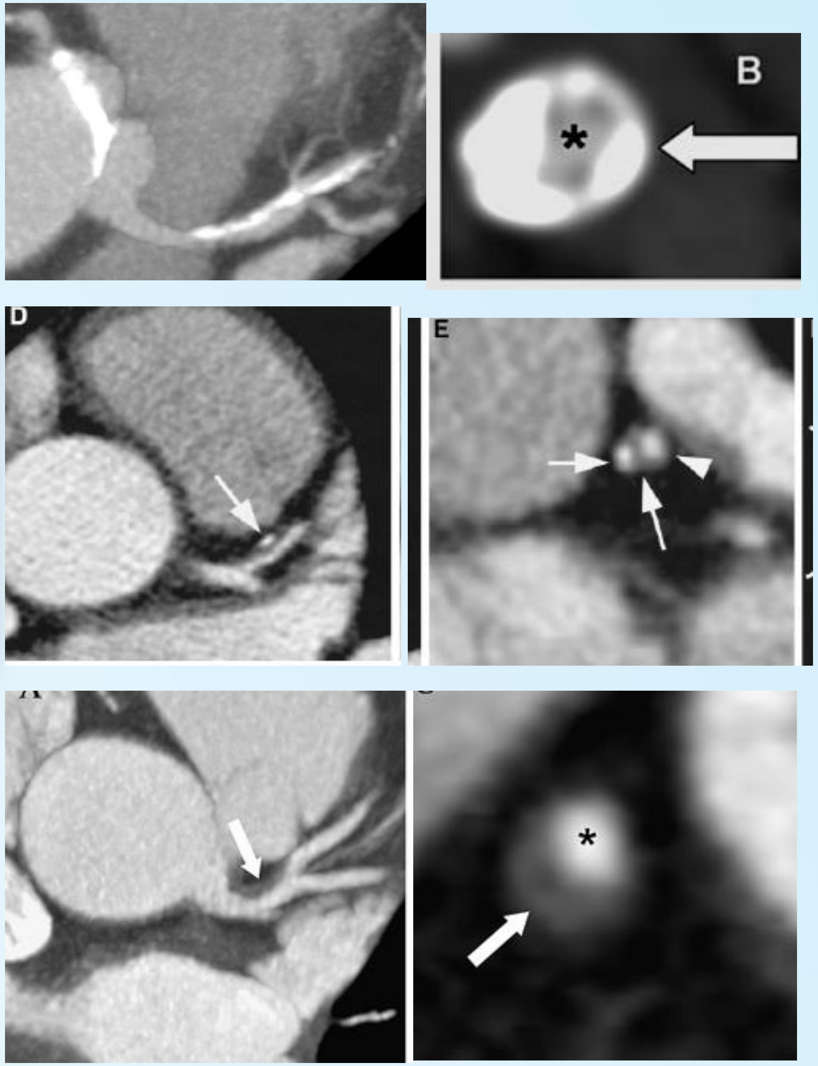
CT attenuation of ≥ 130 HU, separated from the contrast-enhanced lumen > 2 independent planes

Mixed Plaque

Calcified and Non-calcified Plaque per segment

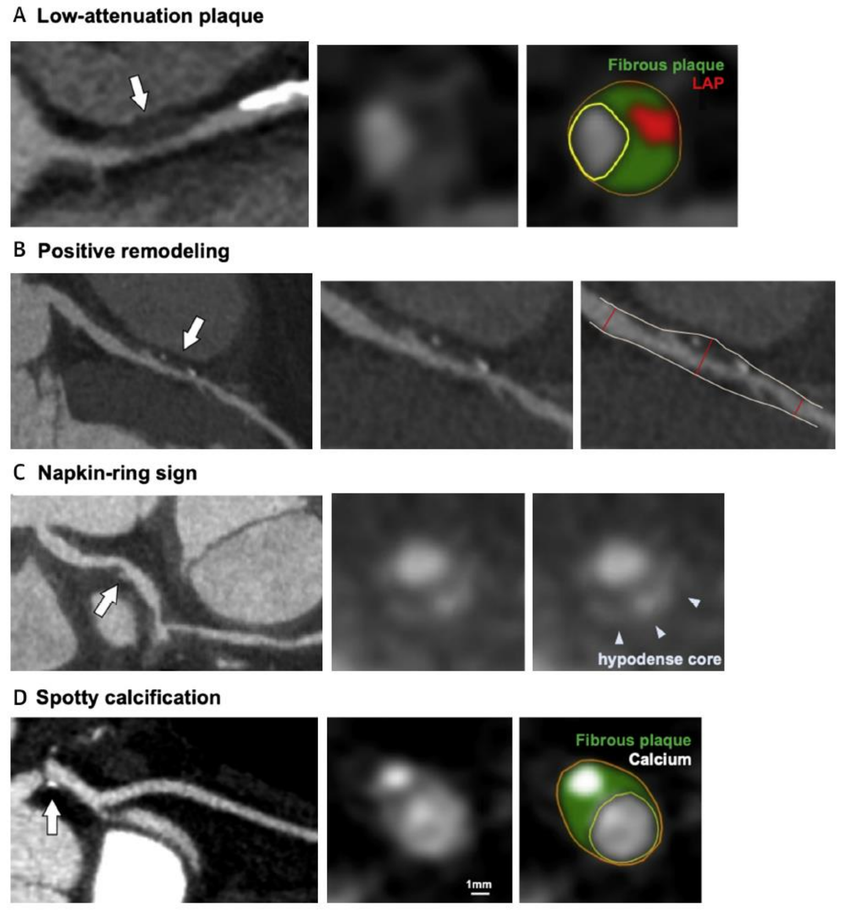
Non-Calcified Plaque

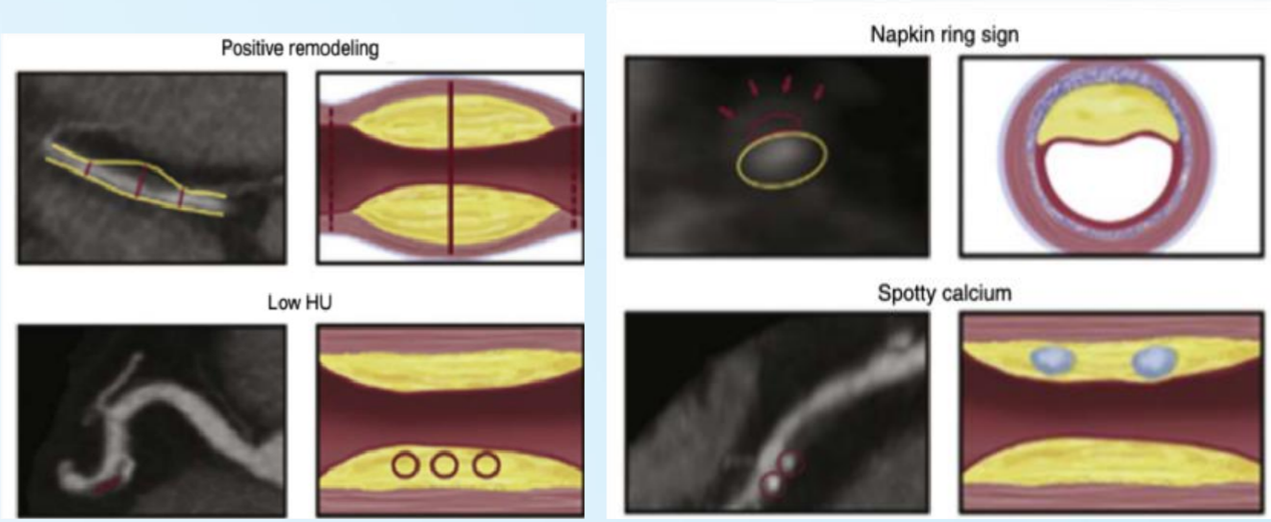
CT attenuation below contrast-enhanced lumen but above the surrounding tissue/ epicardial fat > 2 independent planes

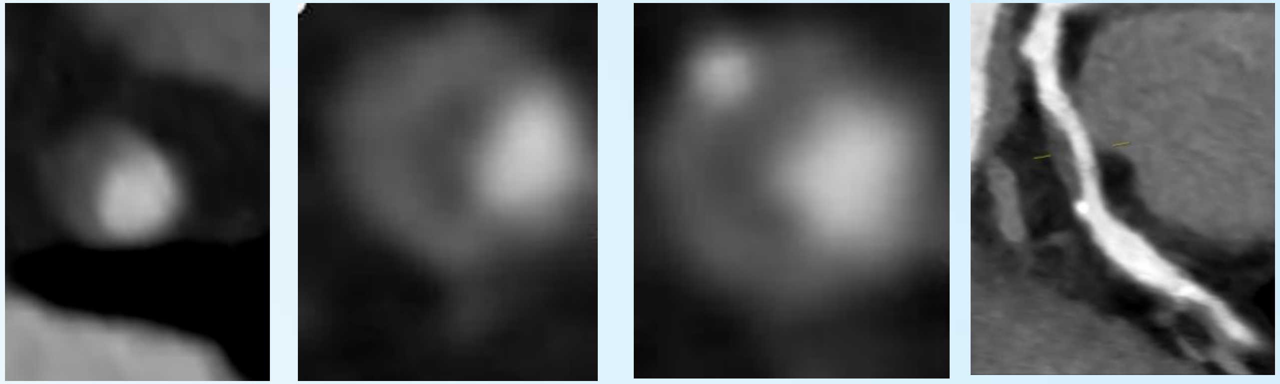


Achenbach et al. Circulation 2004

Type of plaque → High-risk coronary plaque features





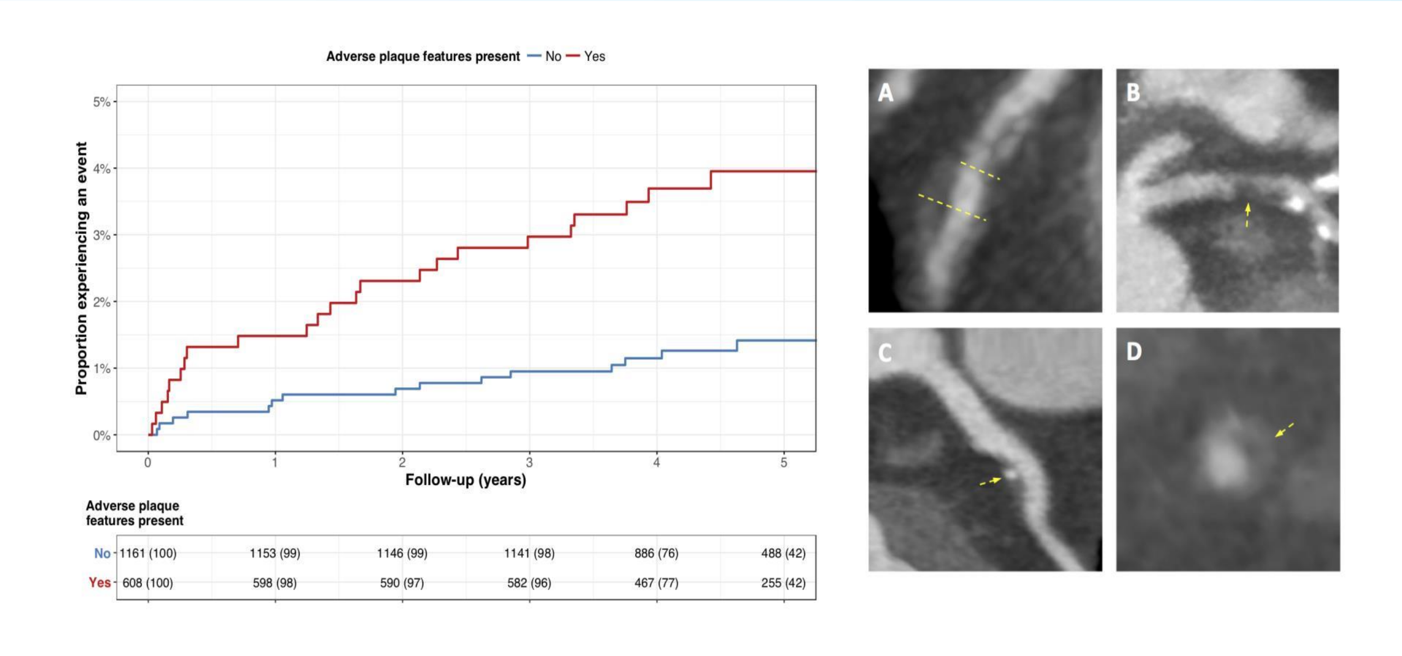


Puchner, et al. JACC 2014

High risk plaque → increased event rates

SCOT-HEART **34% prevalence HRP**

HRP: Positive remodelling, low attenuation

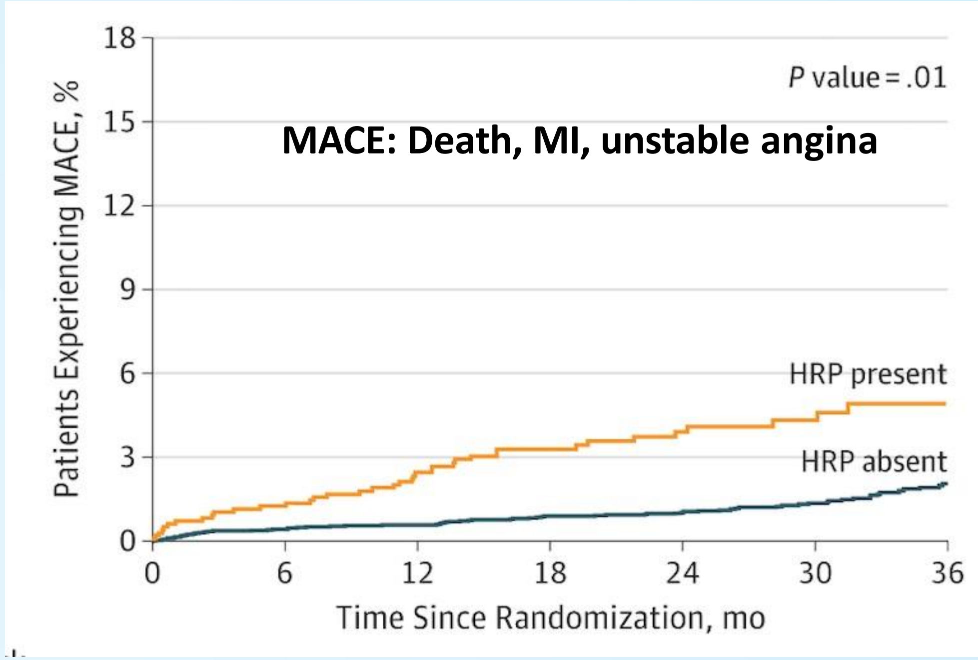


- **3x more likely to have CV death or non-fatal MI with adverse plaque**

Williams et al, JACC 2019

PROMISE **15.3% prevalence HRP**

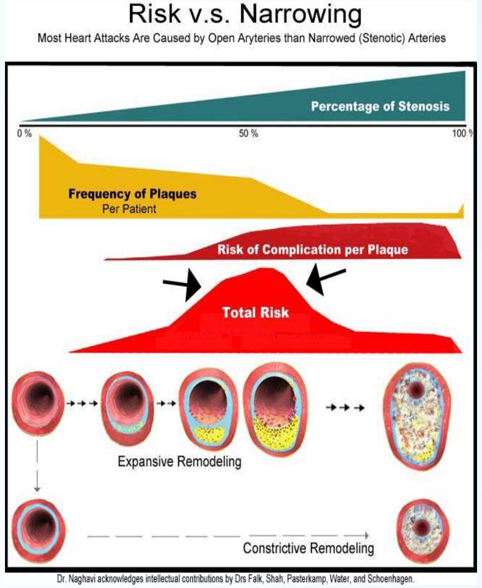
HRP: Positive remodelling, low attenuation plaque, napkin ring sign

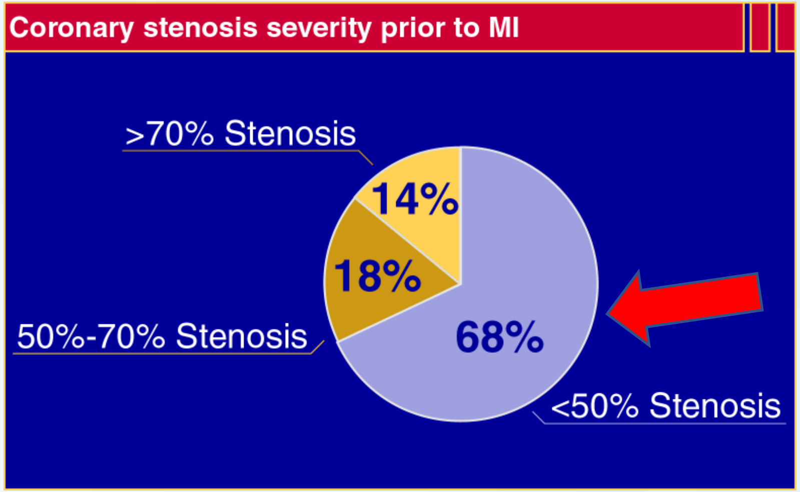


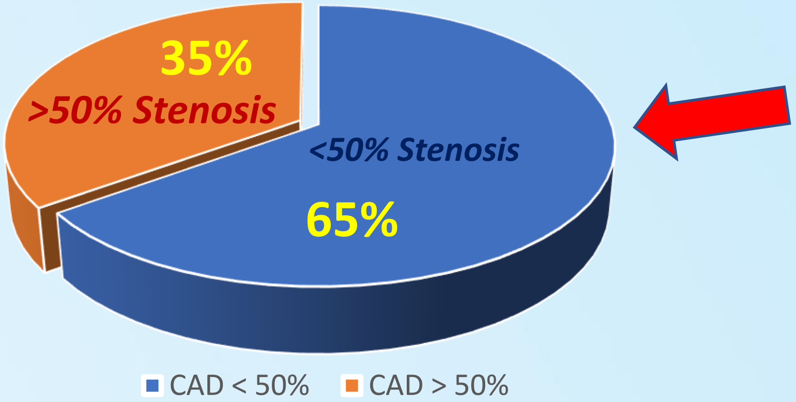
Higher risk of MACE with HRP in patients with non-obstructive disease

Ferencik et al, JAMA Cardiol 2018

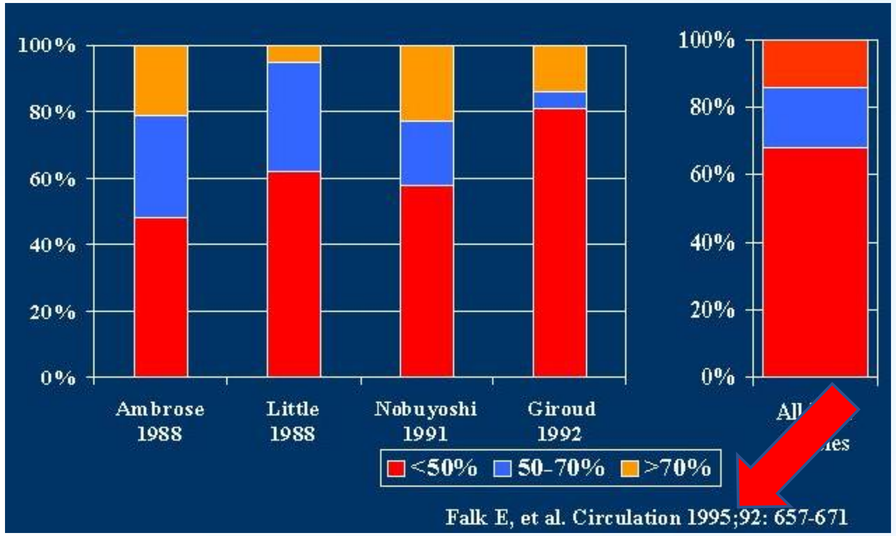
Most Myocardial Infarctions Are Caused by Low-Grade Stenoses







The most of AMI from <50% stenosis



JOURNAL OF THE AMERICAN COLLEGE OF CARDIOLOGY
PUBLISHED BY ELSEVIER ON BEHALF OF THE AMERICAN
COLLEGE OF CARDIOLOGY FOUNDATION
VOL. 71, NO. 22, 2018
SPECIAL FOCUS ISSUE: CARDIOVASCULAR HEALTH PROMOTION

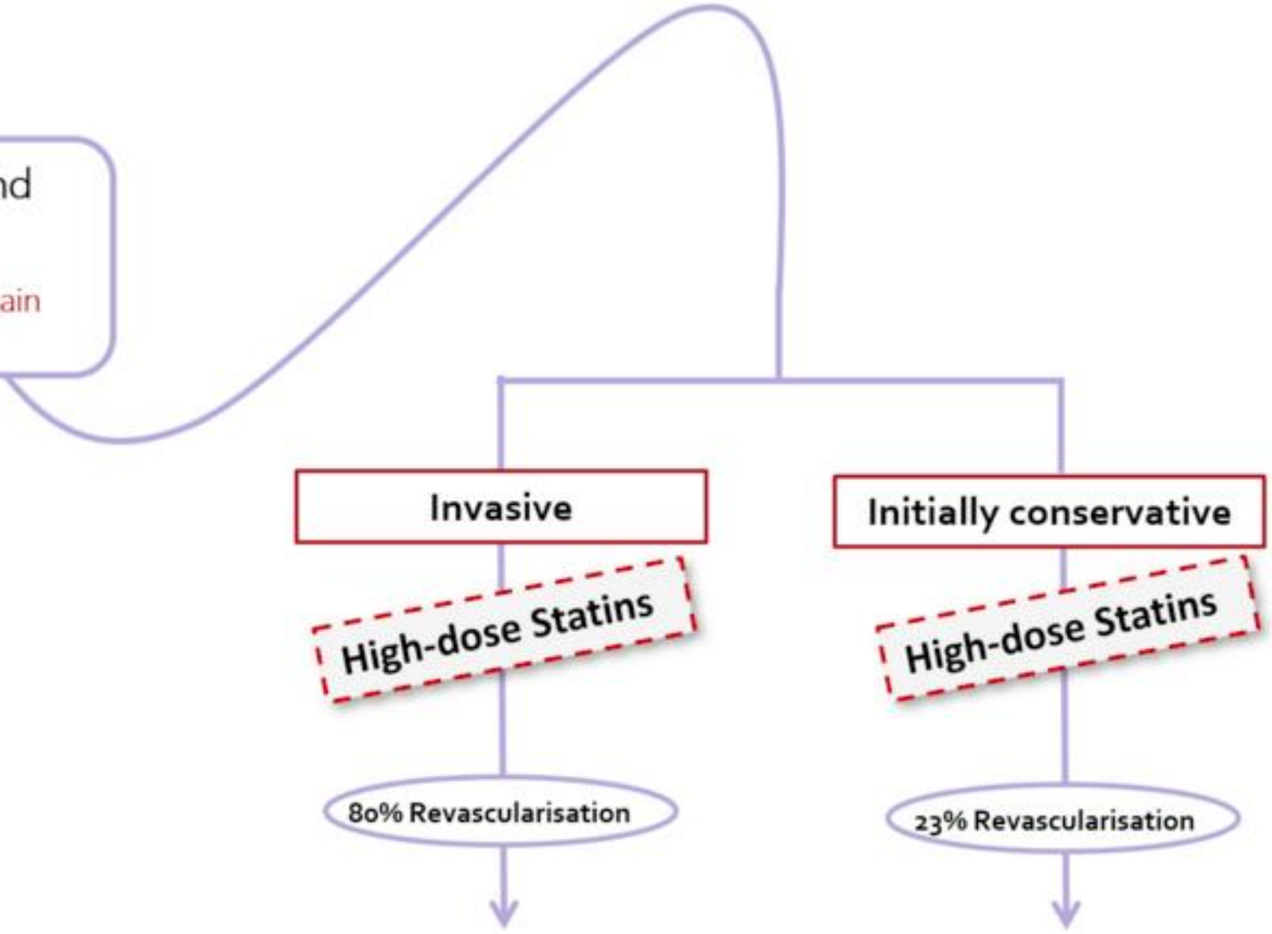
ICONIC Consortium within CONFIRM Registry JACC 2018

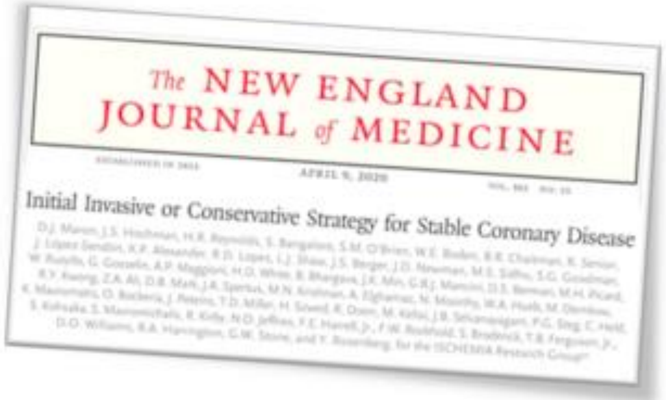
Coronary Atherosclerotic Precursors of Acute Coronary Syndromes

ACS increases with %DS, most precursors of ACS cases and culprit lesions are non-obstructive.
Plaque evaluation, including HRP, PB, and plaque composition, identifies high-risk patients above and beyond stenosis severity.

ISCHEMIA Study

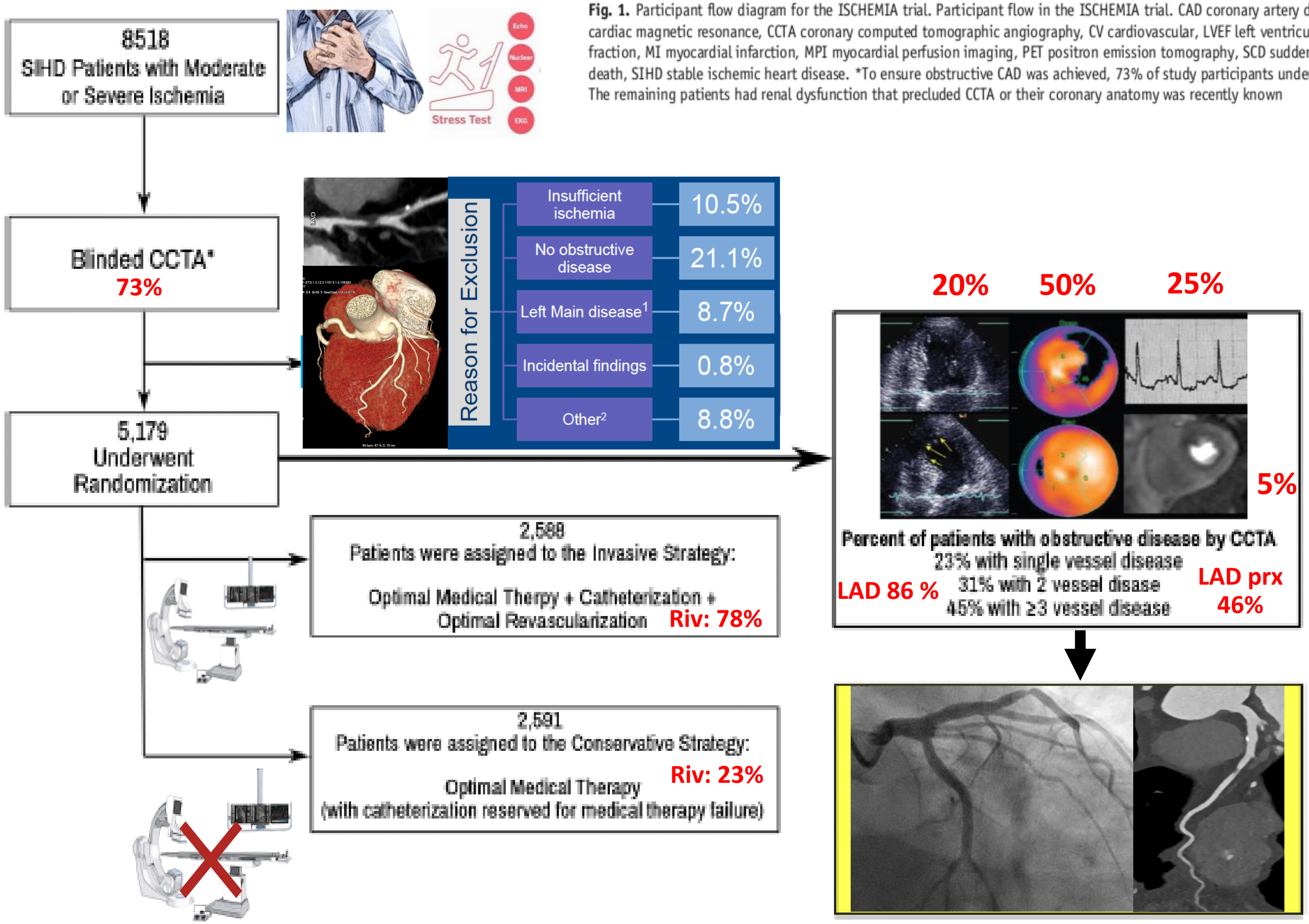
5179 Patients with suspected VAD and positive test for ischemia
(CT: at least one stenosis > 50%, and no left main stenosis)




The NEW ENGLAND JOURNAL of MEDICINE
APRIL 9, 2020
Initial Invasive or Conservative Strategy for Stable Coronary Disease

Ø 3,3 years f/u

Fig. 1. Participant flow diagram for the ISCHEMIA trial. Participant flow in the ISCHEMIA trial. CAD coronary artery disease, CMR cardiac magnetic resonance, CCTA coronary computed tomographic angiography, CV cardiovascular, LVEF left ventricular ejection fraction, MI myocardial infarction, MPI myocardial perfusion imaging, PET positron emission tomography, SCD sudden cardiac death, SIHD stable ischemic heart disease. *To ensure obstructive CAD was achieved, 73% of study participants underwent CCTA. The remaining patients had renal dysfunction that precluded CCTA or their coronary anatomy was recently known



Concordance Vs ICA

97% LM

92% 1V

Participant flow diagram for the ISCHEMIA trial

Computed Tomography in CCS

REVASCULARIZATION

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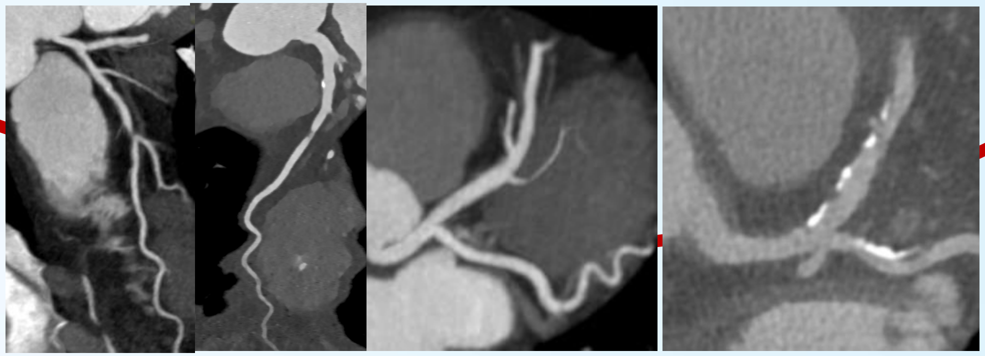


JOURNAL OF THE AMERICAN COLLEGE OF CARDIOLOGY
VOL. 76, NO. 11, 2020

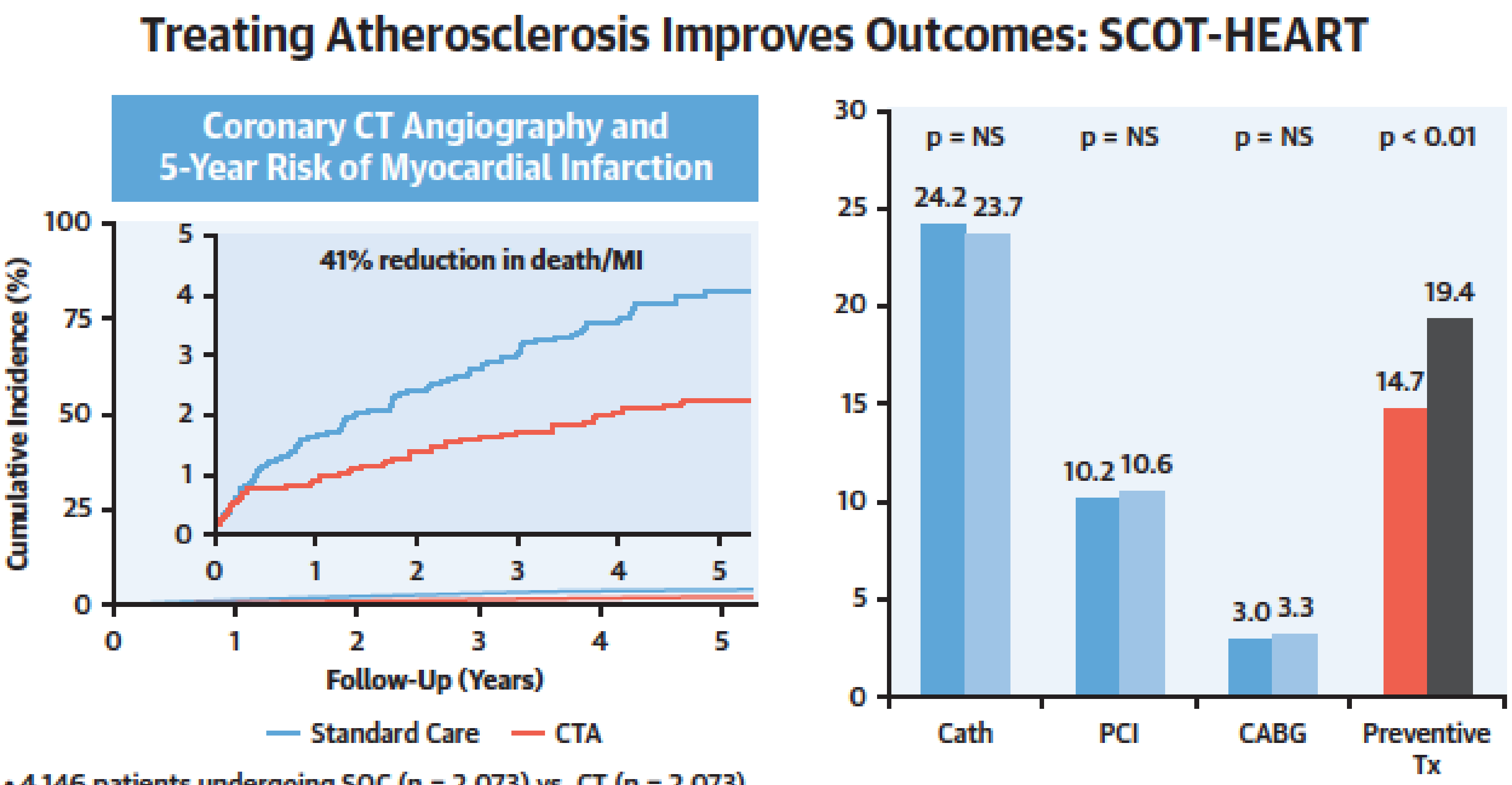
CARDIOVASCULAR MEDICINE AND SOCIETY

Current Evidence and Recommendations for Coronary CTA First in Evaluation of Stable Coronary Artery Disease

Michael Poon, MD,[a] John R. Lesser, MD,[b] Cathleen Biga, MSN, RN,[c] Ron Blankstein, MD,[d,e] Christopher M. Kramer, MD,[f] James K. Min, MD,[g,h] Pamela S. Noack, PhD, MBA,[a] Christina Farrow,[i] Udo Hoffman, MD, MPH,[j] Jaime Murillo, MD,[k] Koen Nieman, MD, PhD,[l,m] Leslee J. Shaw, PhD[n]

Preventive Medication	Started	Stopped
CTA	14%	4%
Standard	4%	0.4%

FIGURE 1 The SCOT-HEART Trial



- 4,146 patients undergoing SOC (n = 2,073) vs. CT (n = 2,073)
- 40% higher preventive therapies in CT arm

A coronary computed tomography (CT) angiography-first approach resulted in a 41% reduction in cardiac death and myocardial infarction (MI) and significantly more early initiation of preventive therapy (Tx). CABG = coronary artery bypass graft; Cath = catheterization; CTA = computed tomography angiography; NS = not significant; PCI = percutaneous coronary intervention; SCOT-HEART = Scottish Computed Tomography of the Heart; SOC = standard of care. Reprinted with permission from Newby et al. (1).

Statins induced phenotypic plaque transformation

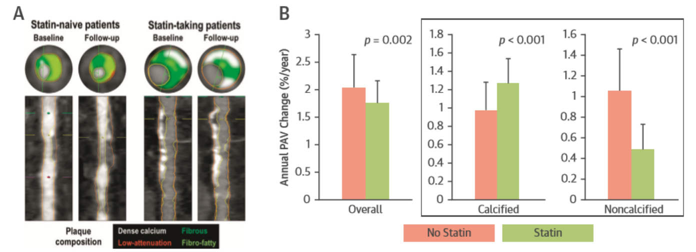
JACC: CARDIOVASCULAR IMAGING
VOL. ■, NO. ■, 2018

Effects of Statins on Coronary Atherosclerotic Plaques

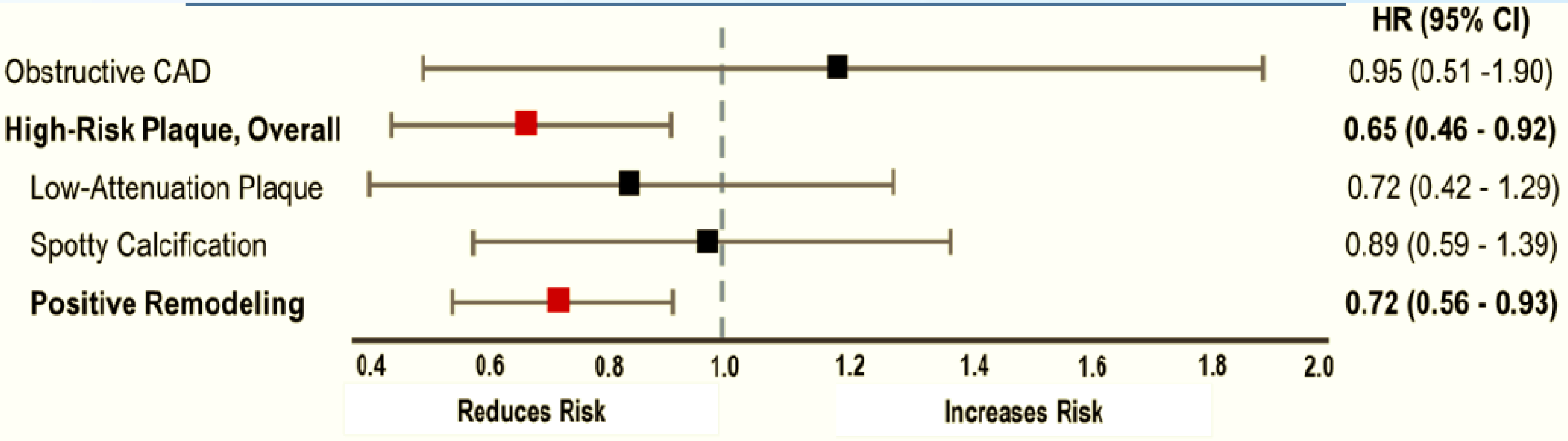
The PARADIGM (Progression of AtheRosclerotic PlAque DetermIned by Computed TomoGraphic Angiography Imaging) Study

Sang-Eun Lee, MD, PhD,[a,b] Hyuk-Jae Chang, MD, PhD,[a,b] Ji Min Sung, PhD,[a,b] Hyung-Bok Park, MD,[b,c] Ran Heo, MD,[b,d] Asim Rizvi, MD,[e] Fay Y. Lin, MD,[e] Amit Kumar, MSc,[e] Martin Hadamitzky, MD,[f] Yong Jin Kim, MD, PhD,[g] Edoardo Conte, MD,[h] Daniele Andreini, MD, PhD,[h] Gianluca Pontone, MD, PhD,[h] Matthew J. Budoff, MD,[i] Ilan Gottlieb, MD, PhD,[j] Byoung Kwon Lee, MD, PhD,[k] Eun Ju Chun, MD, PhD,[l] Filippo Cademartiri, MD, PhD,[m] Erica Maffei, MD,[n] Hugo Marques, MD,[o] Jonathon A. Leipsic, MD,[p] Sanghoon Shin, MD,[q] Jung Hyun Choi, MD, PhD,[r] Kavitha Chinnaiyan, MD,[s] Gilbert Raff, MD,[s] Renu Virmani, MD,[t] Habib Samady, MD,[u] Peter H. Stone, MD,[v] Daniel S. Berman, MD,[w] Jagat Narula, MD, PhD,[x] Leslee J. Shaw, PhD,[u] Jeroen J. Bax, MD, PhD,[y] James K. Min, MD[e]

FIGURE 2 Temporal Changes in Composition of Noncalcified Plaque Volumes According to Statin



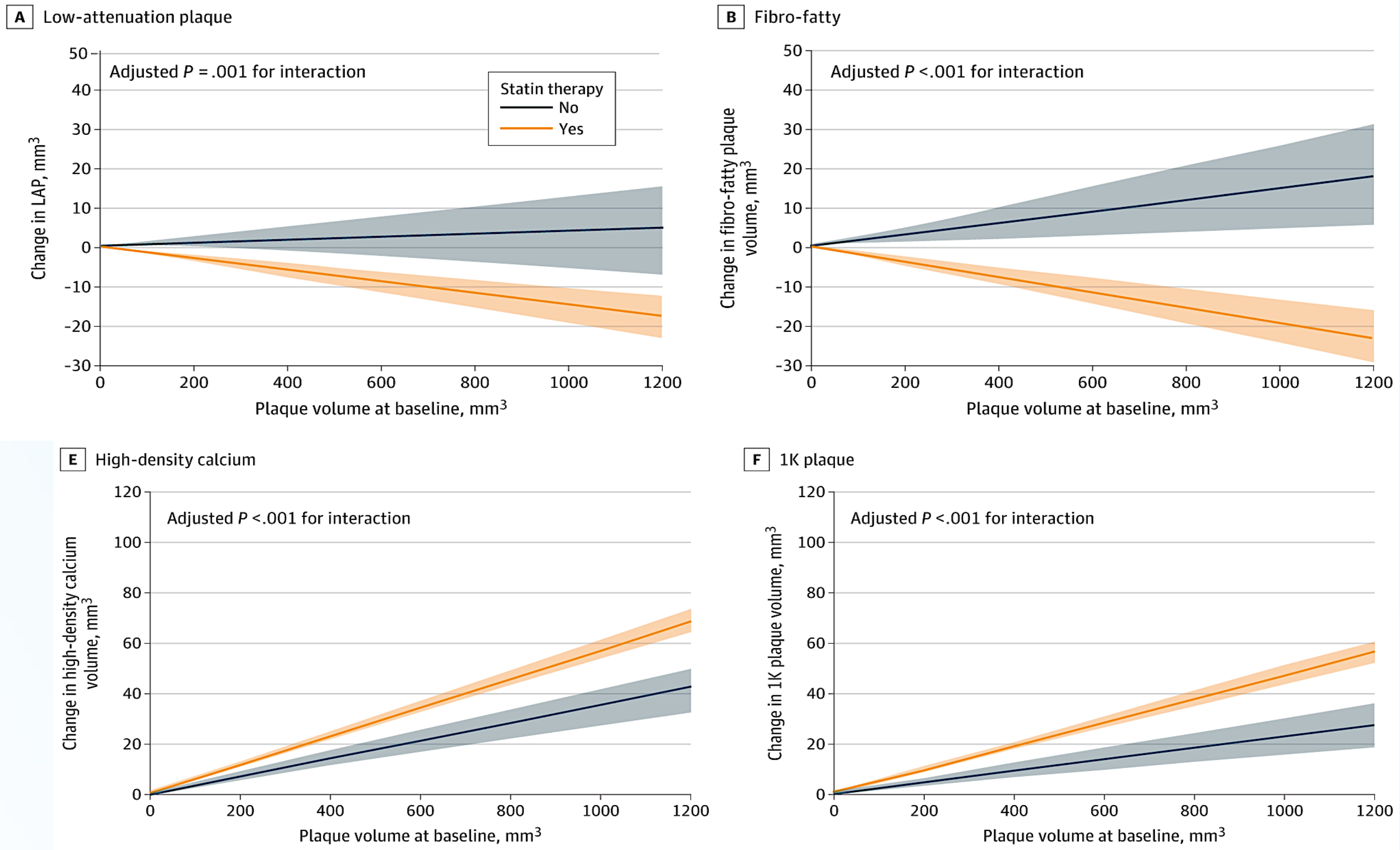
(A) Representative coronary computed tomography angiography images of lesions at baseline and follow-up. **(B)** Annualized change in percent atheroma volume (PAV) and PAV by composition according to statin. Annualized change in PAV per lesion was lower in statin-taking patients **(green bars)** than in statin-naive patients **(pink bars)**, driven from slower progression of noncalcified PAV. Noncalcified PAV is the summation of fibrous, fibro-fatty, and low-attenuation PAV.



* Adjusted: Age, sex, hypertension, diabetes, family history, smoking, baseline PV, and change in LDL level

Reduced the Risk of Overall HRP features and PR

Association of Statin Treatment With Progression of Coronary Atherosclerotic Plaque Composition



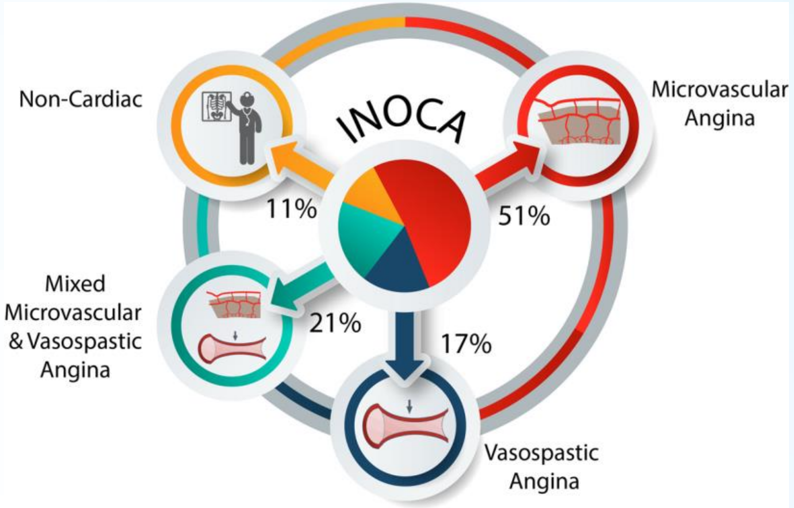
JAMA Cardiol. Published online August 18, 2021. doi:10.1001/jamacardio.2021.3055

Circulation. 2021 September 28; 144(13): 1008–1023. doi:10.1161/CIRCULATIONAHA.120.046791.

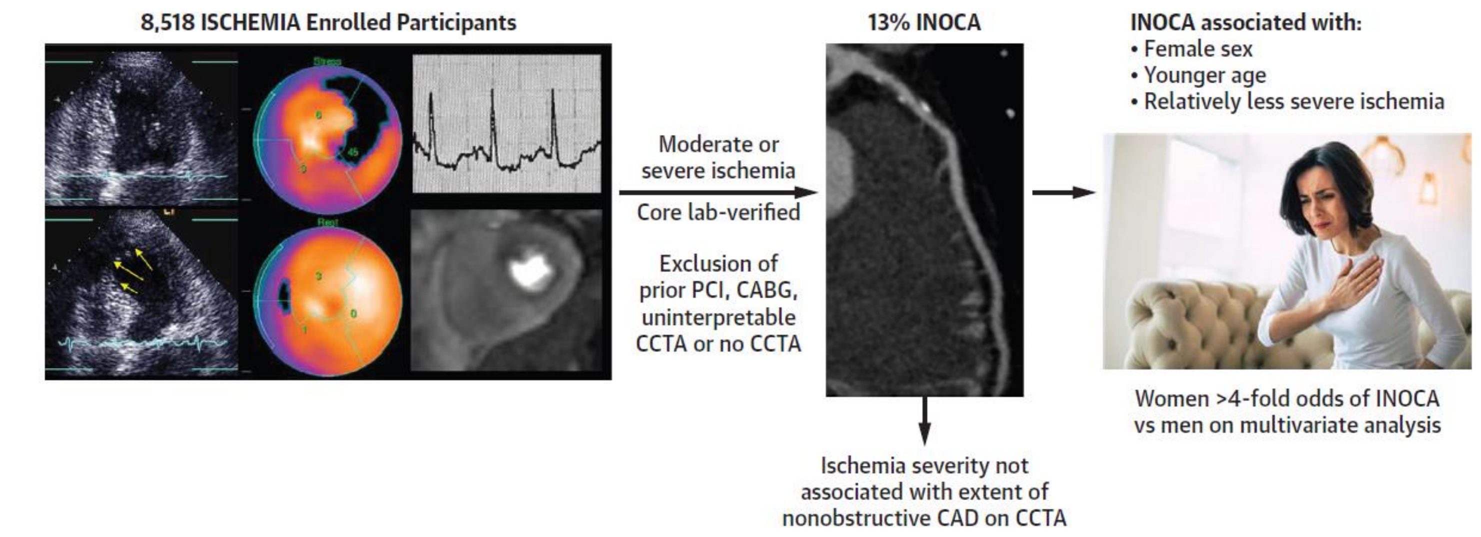
Natural History of Patients with Ischemia and No Obstructive Coronary Artery Disease: the CIAO-ISCHEMIA Study

Harmony R. Reynolds, MD[1], Michael H. Picard, MD[2], John A. Spertus, MD, MPH[3], Jesus Peteiro, MD[4], Jose Luis Lopez Sendon, MD[5], Roxy Senior, MD[6,7], Mohammad C. El-Hajjar, MD[8], Jelena Celutkiene, MD, PhD[9], Michael D. Shapiro, DO, MCR[10], Patricia A. Pellikka, MD[11], Dennis F. Kunichoff, MPH[1], Rebecca Anthopolos, DrPH[1], Khaled Alfakih, MBBS, MD[12], Khaled Abdul-Nour, MD[13], Michel Khouri, MD[14], Leonid Bershtein, MD, PhD[15], Mark De Belder, MD[16], Kian Keong Poh, MD[17,18], John F. Beltrame, BSc, BMBS, PhD[18], James K. Min, MD[19], Jerome L. Fleg, MD[20,22], Yi Li, MS[1], David J. Maron, MD[21], Judith S. Hochman, MD[1]

[1]New York University Grossman School of Medicine, New York, NY, USA

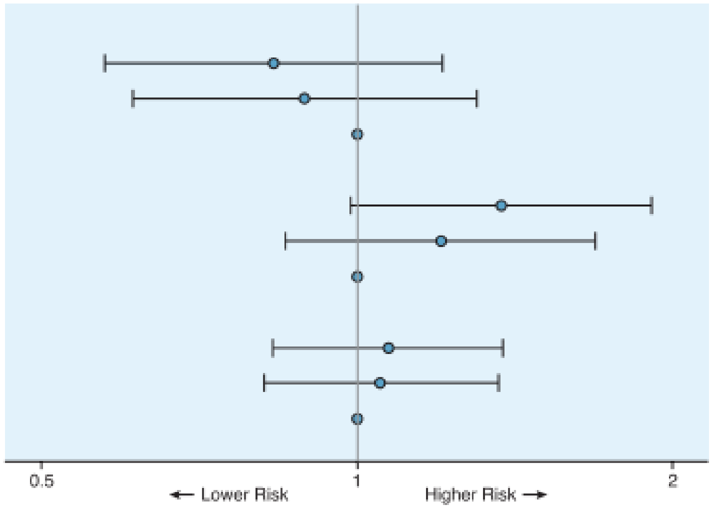


CENTRAL ILLUSTRATION INOCA in the ISCHEMIA Study



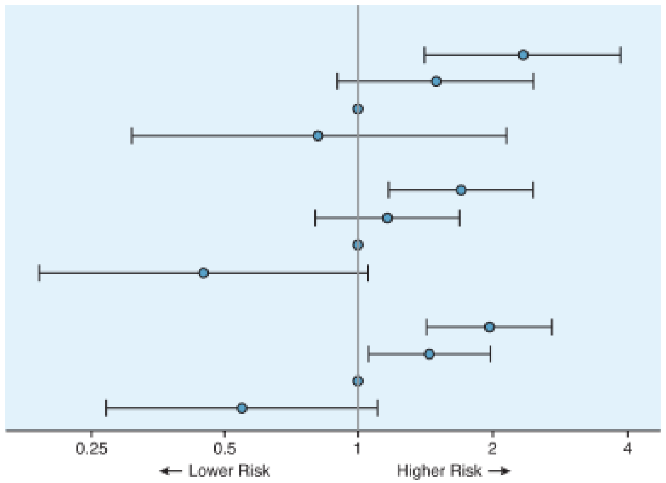
Reynolds HR, et al. J Am Coll Cardiol Img. 2023;16(1):63-74.

We analyzed the prevalence of ischemia with nonobstructive coronary arteries (INOCA), defined as coronary computed tomography angiogram (CCTA) showing <50% diameter stenosis in all coronary arteries, among participants enrolled in ISCHEMIA (International Study of Comparative Health Effectiveness with Medical and Invasive Approaches). Participants with INOCA identified on CCTA were excluded from randomization in the trial. Clinical and stress test variables associated with INOCA are shown. Female sex was strongly associated with INOCA on multivariable analysis. Ischemia severity and extent of nonobstructive coronary artery disease (CAD) on CCTA were not correlated, whether CAD was assessed based on the number of segments with plaque, or incorporated the severity of plaque and the number of segments affected, in the segment stenosis score. CABG = coronary artery bypass grafting; PCI = percutaneous coronary intervention.



	N	4-Year Rate	Hazard Ratio (95% CI)	P-value
All-Cause Mortality				0.332
Severe	2797	5.8%	0.83 (0.57, 1.21)	
Moderate	1702	6.6%	0.89 (0.61, 1.30)	
None/mild	606	9.1%	ref	
Myocardial Infarction				0.044
Severe	2797	9.4%	1.37 (0.98, 1.91)	
Moderate	1702	10.2%	1.20 (0.86, 1.69)	
None/mild	606	8.8%	ref	
Primary Endpoint				0.632
Severe	2797	13.7%	1.07 (0.83, 1.38)	
Moderate	1702	15.1%	1.05 (0.81, 1.36)	
None/mild	606	16.2%	ref	

Figure 1. Association between ischemia severity and outcomes.



	N	4-Year Rate	Hazard Ratio (95% CI)	P-value
All-Cause Mortality				<.001
3V ≥70% or 2V ≥70% w/prox LAD	659	7.8%	2.34 (1.41, 3.89)	
2V ≥70% or 3V ≥50% or 70% prox LAD	894	5.4%	1.49 (0.89, 2.49)	
1V ≥70% or 2V ≥50	743	3.3%	ref	
1V ≥50%	179	3.6%	0.81 (0.31, 2.16)	
Myocardial Infarction				<.001
3V ≥70% or 2V ≥70% w/prox LAD	659	11.2%	1.70 (1.17, 2.47)	
2V ≥70% or 3V ≥50% or 70% prox LAD	894	8.3%	1.16 (0.80, 1.68)	
1V ≥70% or 2V ≥50	743	7.8%	ref	
1V ≥50%	179	5.7%	0.45 (0.19, 1.05)	
Primary Endpoint				<.001
3V ≥70% or 2V ≥70% w/prox LAD	659	16.0%	1.96 (1.41, 2.72)	
2V ≥70% or 3V ≥50% or 70% prox LAD	894	12.4%	1.44 (1.05, 1.98)	
1V ≥70% or 2V ≥50	743	9.8%	ref	
1V ≥50%	179	6.3%	0.55 (0.27, 1.10)	

Figure 2. Association between CAD severity and outcomes.

Quello che le Linee Guida Non Dicono

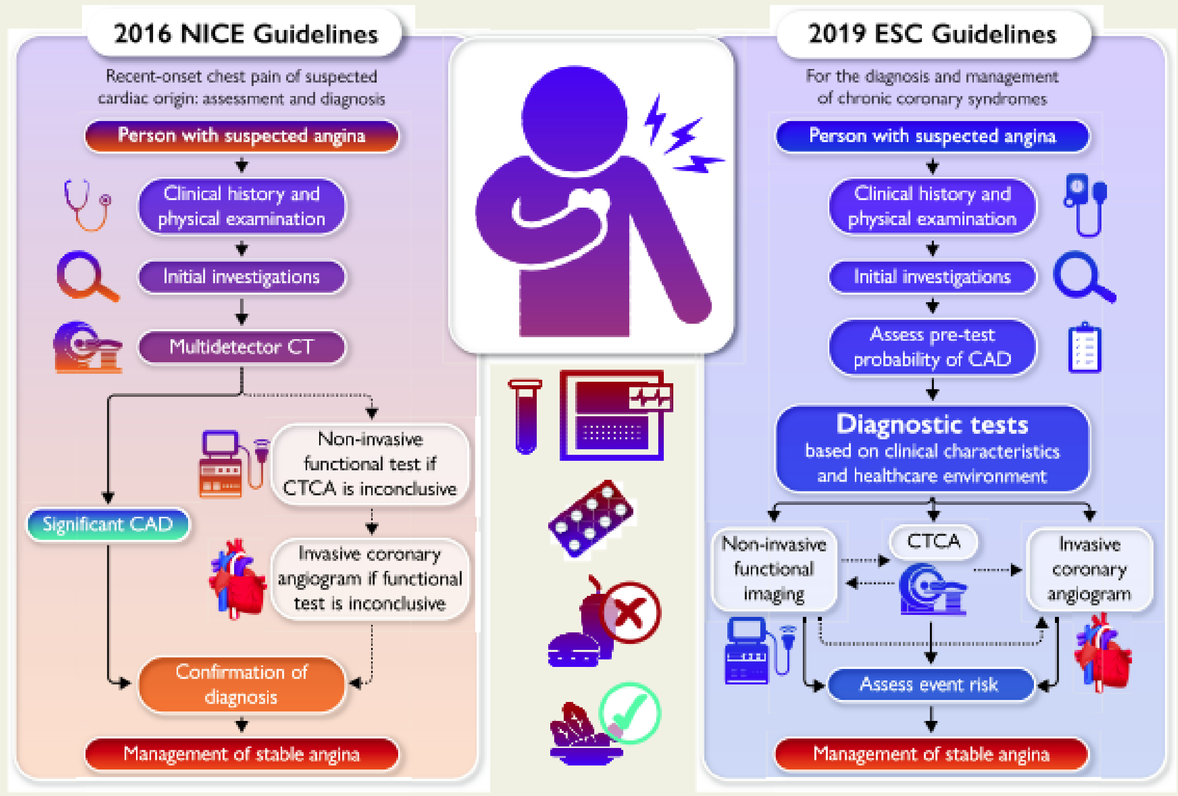
Napoli, Hotel Excelsior - 14-15 aprile 2023

ESC European Society of Cardiology
European Heart Journal (2022) **00**, 1–10
https://doi.org/10.1093/eurheartj/ehac597

GREAT DEBATE
Imaging

Great Debate: Computed tomography coronary angiography should be the initial diagnostic test in suspected angina

Graphical Abstract



Annualized growth rate in imaging usage of 6.6%

JACC: CARDIOVASCULAR IMAGING VOL. ■, NO. ■, 2022

ORIGINAL RESEARCH

National Trends in Coronary Artery Disease Imaging

Associations With Health Care Outcomes and Costs

Jonathan R. Weir-McCall, PhD,[a,b] Michelle C. Williams, PhD,[c] Anoop S.V. Shah, PhD,[d] Giles Roditi, MBChB,[e] James H.F. Rudd, PhD,[a] David E. Newby, PhD,[c] Edward D. Nicol, MD[f,g]

ABSTRACT

BACKGROUND In 2016, the National Institute for Health and Care Excellence Clinical Guideline Number 95 ("Chest pain of recent onset") (CG95) recommended coronary computed tomography angiography (CCTA) as the first-line test for possible angina.

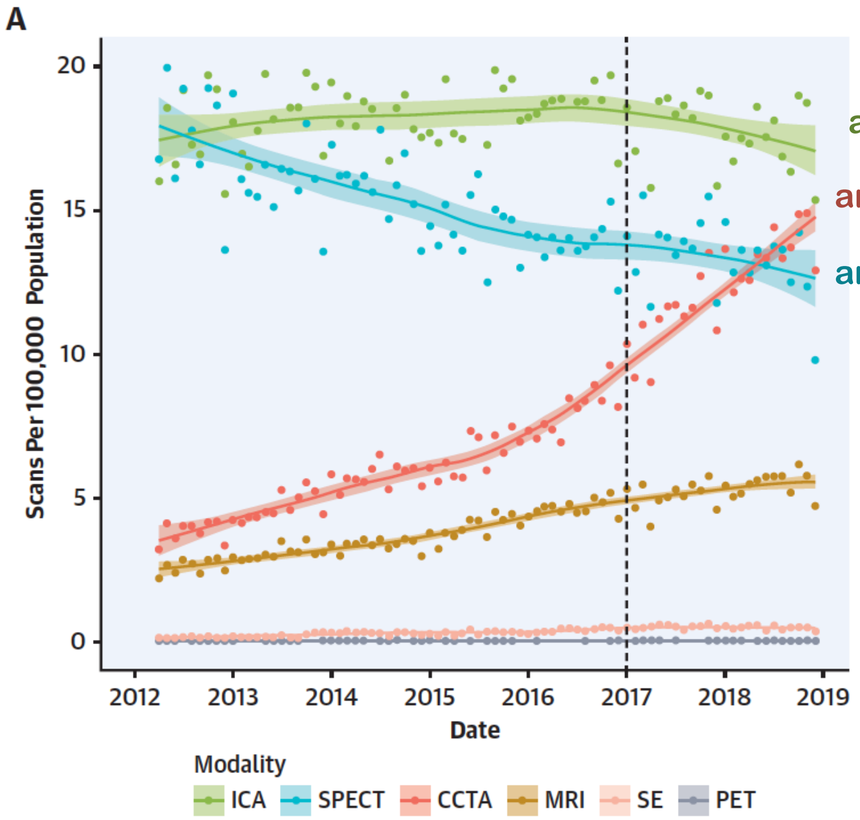
OBJECTIVES The purpose of this study was to determine the impact of temporal trends in imaging use on outcomes for coronary artery disease (CAD) following the CG95 recommendations.

METHODS Investigations from 2012 to 2018 were extracted from a national database and linked-hospital admission and mortality registries. Growth rates were adjusted for population size, with image modality use, cardiovascular hospital admissions, and mortality compared using Kendall's rank correlation. The impact of CG95 was assessed using an interrupted time-series analysis.

RESULTS A total of 1,909,314 investigations for CAD were performed, with an annualized per capita growth of 4.8%. Costs were £0.35 million/100,000 population/year with an increase of 2.8%/year mirroring inflation (2.5%/year). CG95 was associated with a rise in CCTA (exp[β]: 1.10; 95% CI: 1.03-1.18), no change in myocardial perfusion imaging, and a potential modest fall (exp[β]: 0.997; 95% CI: 0.993-1.00]) in invasive coronary angiography. There was an apparent trend between computed tomography angiography growth and invasive catheter angiography reduction across regions (Kendall Tau: −0.19; $P = 0.08$). CCTA growth was associated with a reduction in cardiovascular mortality (Kendall Tau: −0.21; $P = 0.045$), and ischemic heart disease deaths (Kendall Tau: −0.22; $P = 0.042$), with an apparent trend with reduced all-cause mortality (Kendall Tau: −0.19; $P = 0.07$).

CONCLUSIONS Imaging investigations for CAD are increasing. Greater regional increases in CCTA were associated with fewer hospitalizations for myocardial infarction and a more rapid decline in CAD mortality.
(J Am Coll Cardiol Img 2022;■:■-■)

CENTRAL ILLUSTRATION England-wide Examinations Performed Per Month per 100,000 Population for the Investigation of Coronary Artery Disease From 2012 to 2018



annual growth of 2.5%

annual growth of 18.5%%

annual decline of 3.2%

JACC: CARDIOVASCULAR IMAGING VOL. ■, NO. ■, 202

ORIGINAL RESEARCH

National Trends in Coronary Artery Disease Imaging

Associations With Health Care Outcomes and Costs

Jonathan R. Weir-McCall, PhD,[a,b] Michelle C. Williams, PhD,[c] Anoop S.V. Shah, PhD,[d] Giles Roditi, MBChB,[e] James H.F. Rudd, PhD,[a] David E. Newby, PhD,[c] Edward D. Nicol, MD[f,g]

FIGURE 2 Comparison of Changes in Mortality From Cardiovascular Causes With Changes in CCTA Use

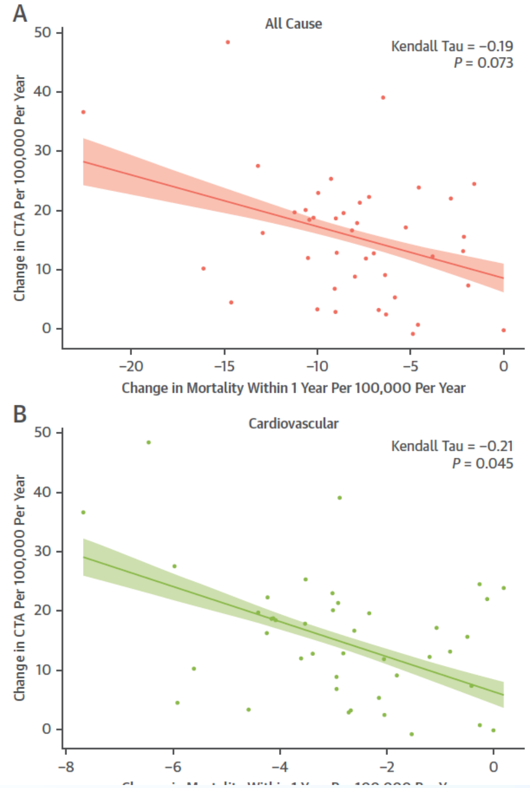
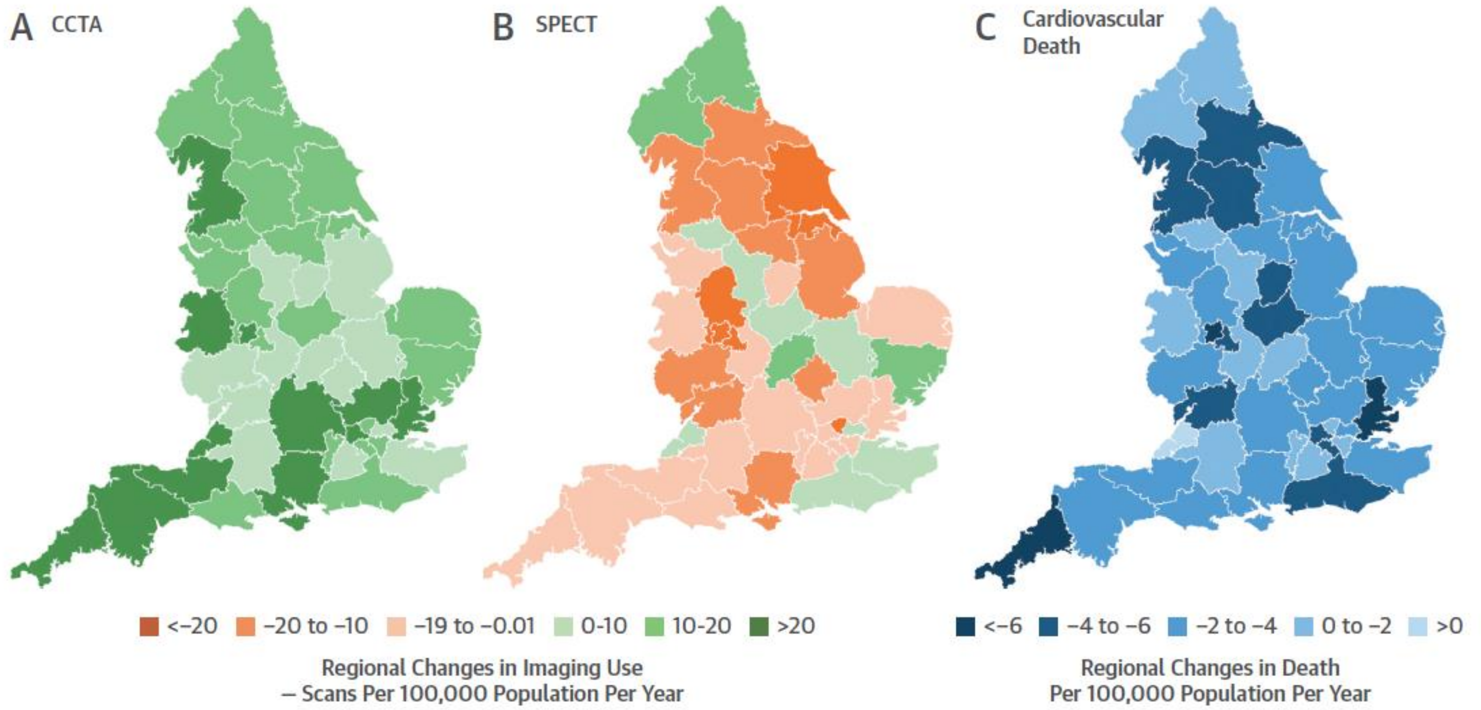


FIGURE 3 Map of the Health Care Regions in England Demonstrating the Regional Changes in usage of CCTA and SPECT and the Regional Changes in Cardiovascular Mortality From 2012 to 2018



Maps represent changes in imaging use for CCTA **(A)** and SPECT **(B)** across the 42 healthcare regions from 2012 to 2018. **(C)** The change in cardiovascular death within a year of imaging in the same health care regions over the same study period. Abbreviations as in Figure 1.

ESC European Society of Cardiology European Journal of Preventive Cardiology (2022) **29**, 608–624
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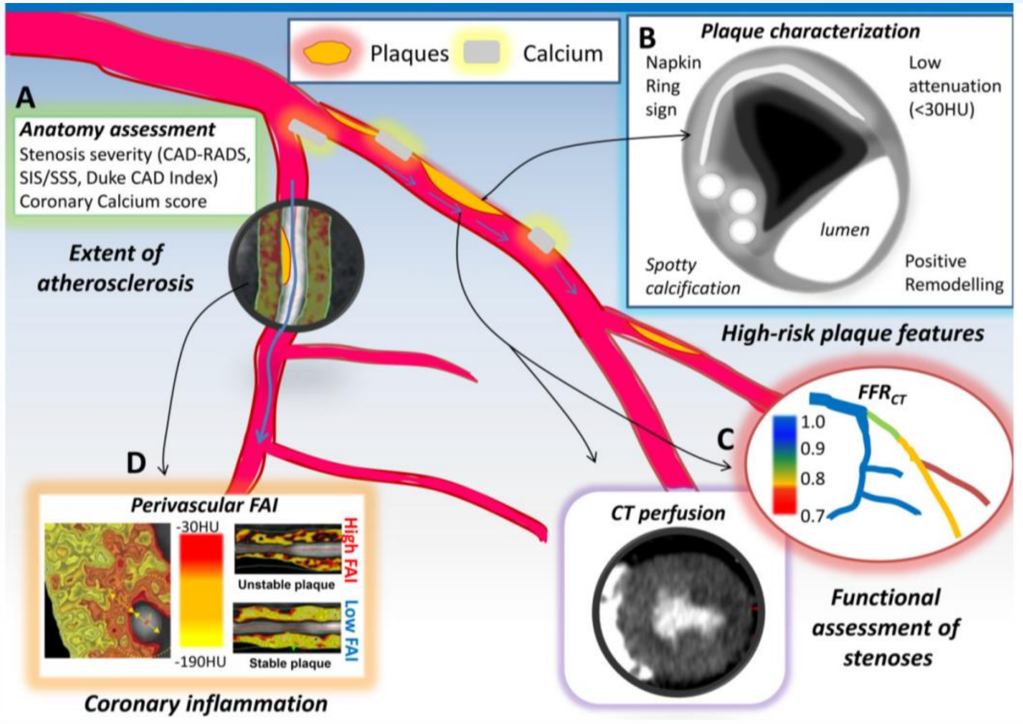
REVIEW
Risk Prediction/Assessment & Stratification

Cardiovascular risk stratification by coronary computed tomography angiography imaging: current state-of-the-art

Alexios S. Antonopoulos [1,2]*, Andreas Angelopoulos [1], Konstantinos Tsioufis [1], Charalambos Antoniades [2], and Dimitris Tousoulis [1]

[1]1st Department of Cardiology, Hippokration Hospital, National and Kapodistrian University of Athens, 114 Vas. Sofias Avenue, 11527, Athens, Greece; and [2]RDM Division of Cardiovascular Medicine, Oxford Academic CT Programme, University of Oxford, John Radcliffe Hospital, Headley Way, OX3 9DU Oxford, UK



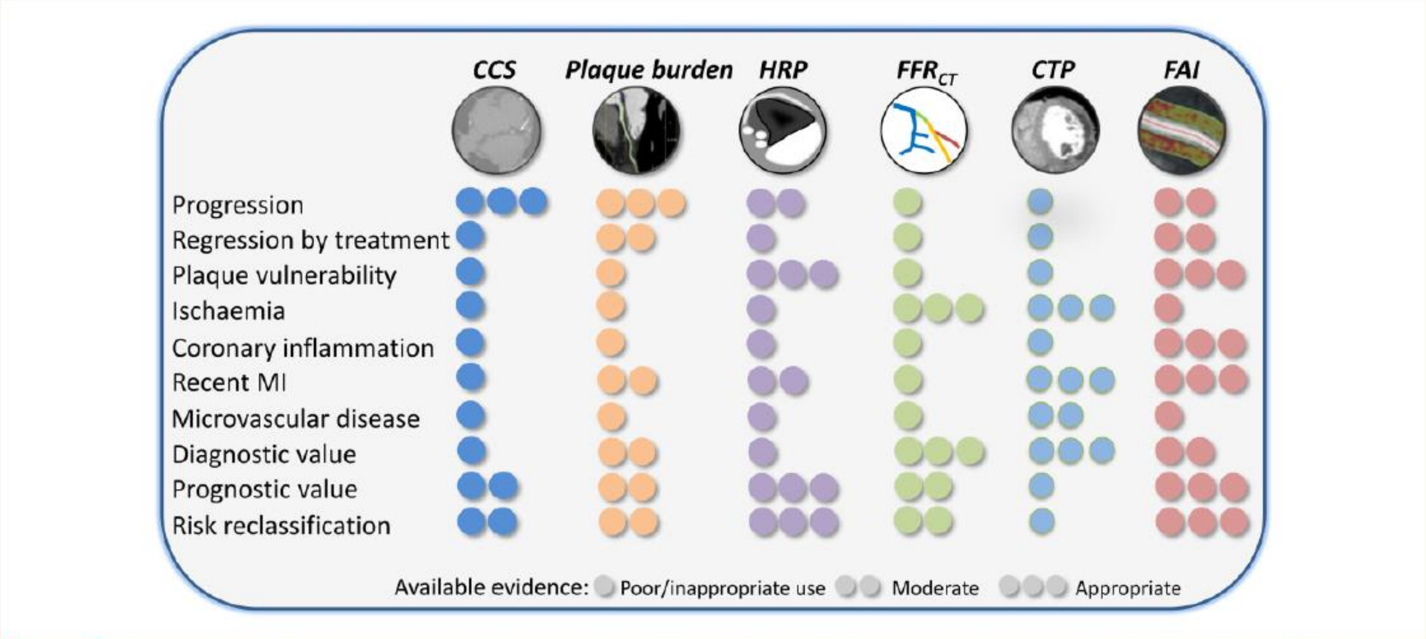


Figure 3 Comparative performance of computed tomography (CT) biomarkers. CCS, coronary calcium score; CTP, CT perfusion; FAI, perivascular Fat Attenuation Index; FFR$_{CT}$, CT-derived fractional flow reserve; HRP, high-risk plaques; MI, myocardial infarction.

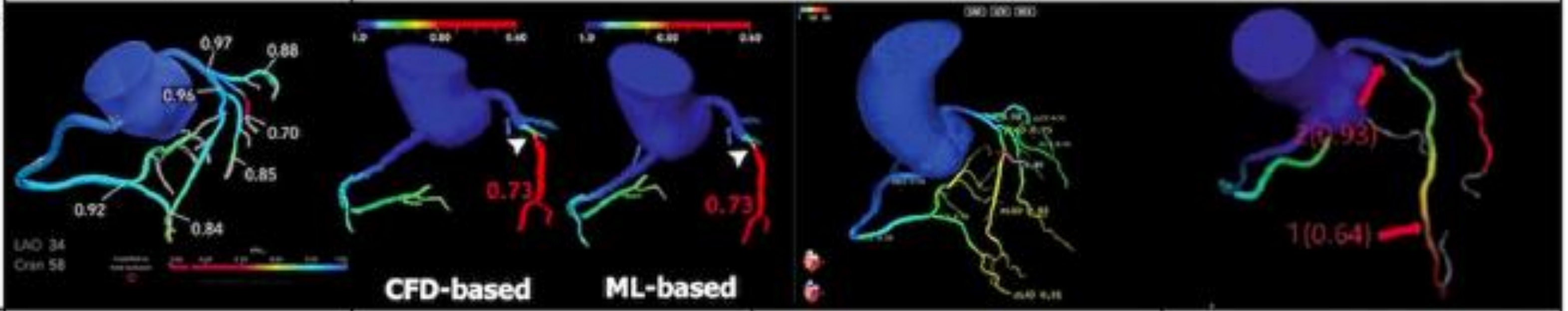
Grazie per la vostra attenzione

carlo.tedeschi@aslnapoli1centro.it

Dr. Carlo Tedeschi

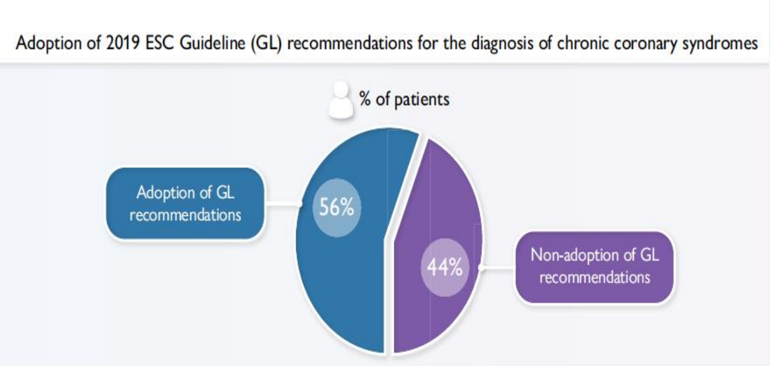
EACVI Level 3 CT
UO Cardiologia PSI Napoli Est
Radiologia Ospedale del Mare

REGIONE CAMPANIA
ASL NAPOLI 1 CENTRO

	HeartFlow FFR_{CT}	Siemens cFFR: Computational fluid dynamics-based	Siemens cFFR: Machine learning-based	Pulse CT-QFR	Canon CT-FFR
3D anatomical model	**≥64** detector CT scanner				**320** detector CT scanner
Analysed vessel diameter in studies	>**1.8** mm	≥**1.5** mm		≥**1.5** mm	≥**1.8** mm
Physiological model Boundary conditions Microvascular resistance	Resting coronary flow (Q) by allometric scaling laws: **Q ∝ myocardial mass** Distribution of coronary flow over 3D model by Murray's law: $\mathbf{Q \propto d^3}$ (d: vessel diameter) Patient-specific microvascular resistance (R): $\mathbf{R \propto d^{-3}}$ Simulation of hyperaemic state by reducing the microvascular resistance			$\mathbf{Q} \sim V^{\frac{3}{4}}$ (V: reference arterial volume) Conversion resting flow to virtual hyperaemic flow (HFV): **HFV=0.10+1.55·RFV -0.93·RFV²** (RFV: resting flow velocity)	Coronary flow: •Δ cross-sectional vessel area using 4 diastole phases Microvascular resistance: •minimised during diastole •constant resistance such that coronary pressure ∝ flow
Computation of flow Computational fluid dynamics (CFD) simulation of coronary flow	Full 3D CFD modelling by parallel supercomputer	Reduced-order CFD modelling by standard desktop computer			
					
Physiological model generation time	Full-order model within **4 hours** of data transfer	**30 to 60 min**		**17 min** (average)	**39.4±8.6 min**
Coronary flow computation time		**10 min**	<**2 sec**	**19 sec** (average)	

CAMPUS Cuore *Quello che le Linee Guida Non Dicono*

Napoli, Hotel Excelsior - 14-15 aprile 2023



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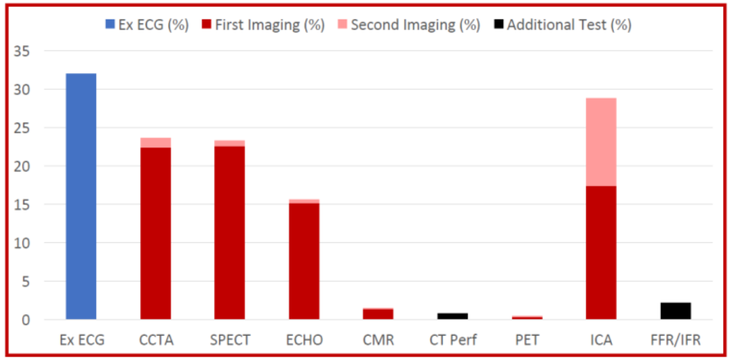
https://doi.org/10.1093/eurheartj/ehac640
CLINICAL RESEARCH
Ischaemic heart disease

Use of cardiac imaging in chronic coronary syndromes: the EURECA Imaging registry

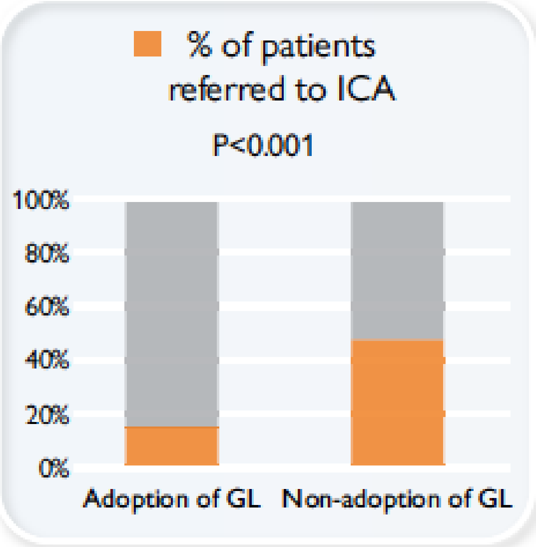
Danilo Neglia [1,2*†], Riccardo Liga [3,4†], Alessia Gimelli [1], Tomaž Podlesnikar [5,6], Marta Cvijić[5,7], Gianluca Pontone [8], Marcelo Haertel Miglioranza [9,10,11], Andrea Igoren Guaricci [12], Sara Seitun [13], Alberto Clemente [1], Alexey Sumin [14], João Vitola [15], Antti Saraste [16], Christian Paunonen[16], Ching-Hui Sia [17], Filipp Paleev [18], Leyla Elif Sade [19], Jose Luis Zamorano [20], Natallia Maroz-Vadalazhskaya [21], Constantinos Anagnostopoulos [22], Filipe Macedo [23], Juhani Knuuti [24], Thor Edvardsen [25,26], Bernard Cosyns [27,28], Steffen E. Petersen [29,30], Julien Magne [31,32,33], Cecile Laroche[34], Clara Berlè[34], Bogdan A. Popescu [35], and Victoria Delgado [36,37*], for the EURECA Investigators[‡]

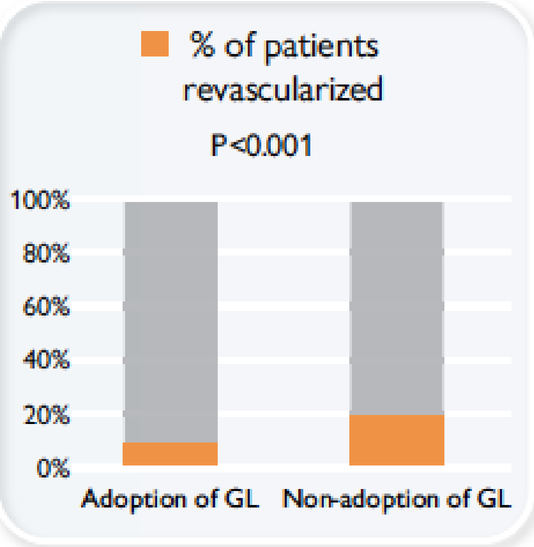
Tests Performed (% of 5156 pts)

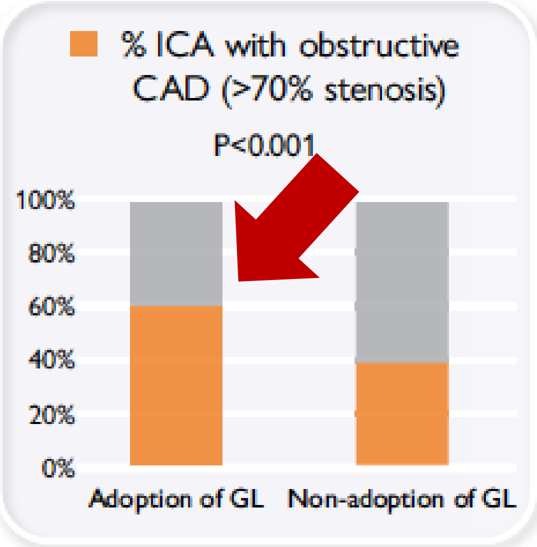


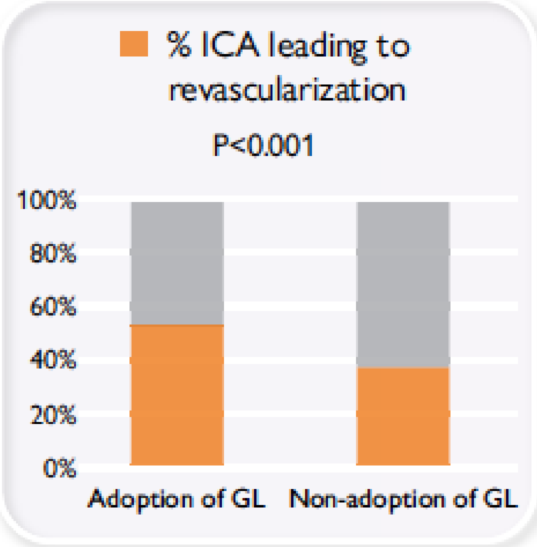
Effects on referral to invasive coronary angiography (ICA) and revascularization (% of patients)

Effects on diagnostic and therapeutic yield of invasive coronary angiography (% of ICA)



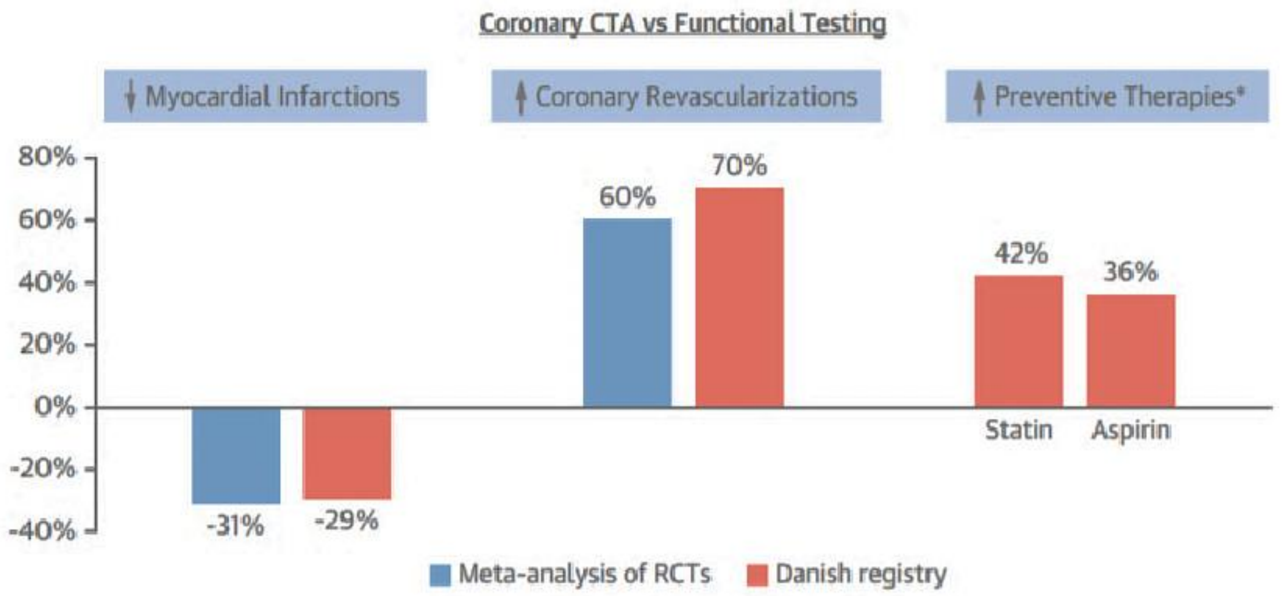






Meta-Analysis of CTA vs. Stress Testing

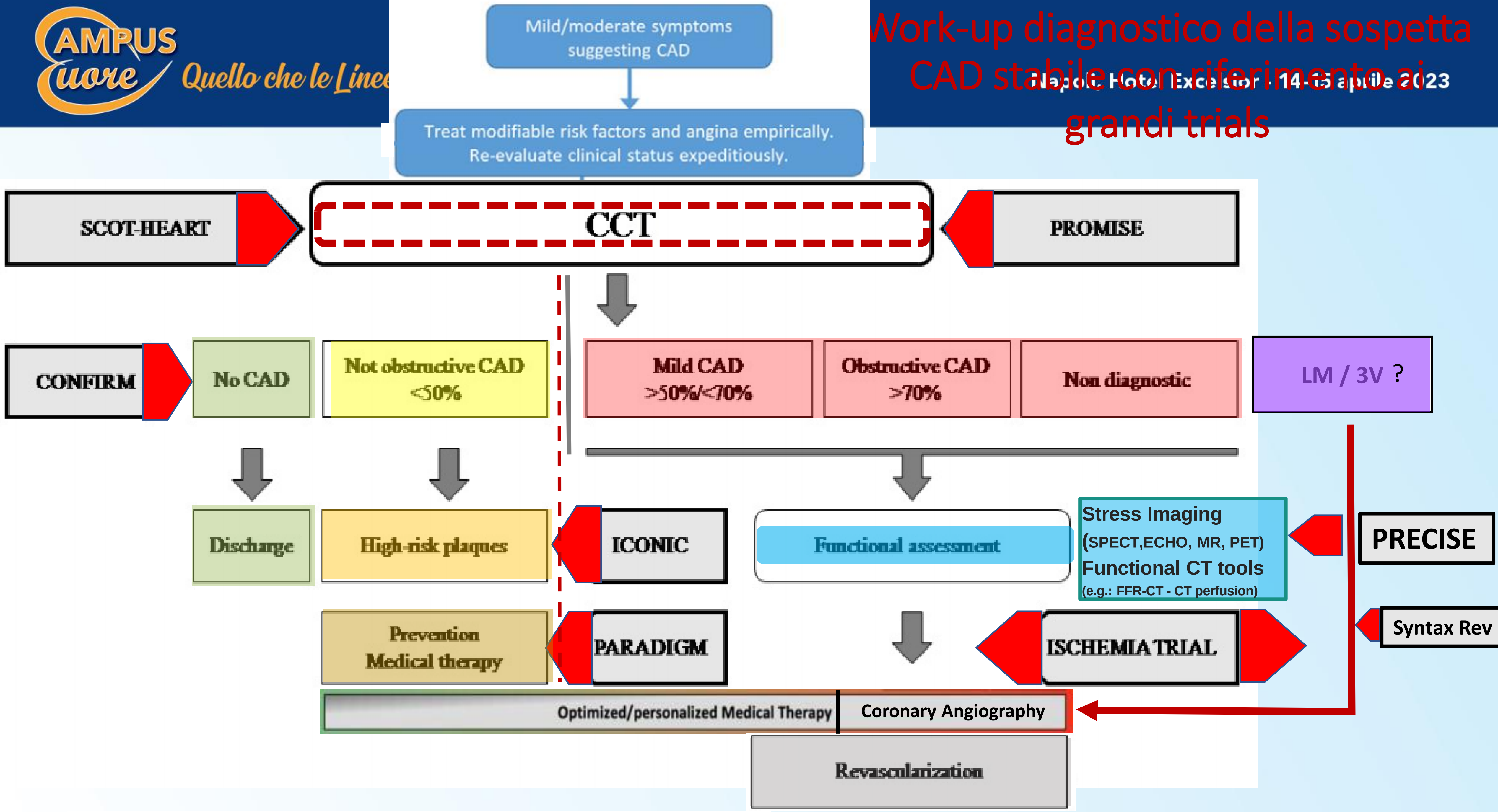
FIGURE 1 Impact of Coronary CTA Versus Functional Testing on Patient Management and Outcomes



Estimates from a recent meta-analysis (14) are displayed in the **blue bars** and those from the Danish registry (15) are displayed in the **orange bars**. *Similar data on medical therapy were not available for the meta-analysis. CTA = computed tomography angiography; RCT = randomized controlled trial.

Source: Blankstein JACC 2017;69:1771-1773., Bittencourt Circulation 2016;133:1963-1968., Bittencourt Circ CV Imag 2016;9:e004419.

Work-up diagnostico della sospetta CAD stabile con riferimento ai grandi trials



Modiif. da: *Cardiovasc Diagn Ther* 2020;10(6):1979-1991 | http://dx.doi.org/10.21037/cdt-20-526

Accuratezza diagnostica ruling-out / in

Supplementary Table 1. Anatomical diagnostic performance of CCTA with ICA as a standard reference.

Study/Author	Reference standard (ICA)	Year	Number of Patients	Sensitivity	Specificity	PPV	NPV	+LR	-LR	Accuracy
ACCURACY (Budoff MJ et al.)	≥50%	2008	230	95	83	64	99	5.56	0.06	NA
Meijboom WB et al.	≥50%	2008	360	99	64	86	97	2.76	0.01	88
MINISCAD (Marano R et al.)	>50%	2009	327	94	88	91	91	7.83	0.07	91
CORE-64 (Arbab-Zadeh A et al.)	≥50%	2012	273	91	87	9	88	7.00	0.10	NA
EVINCI (Neglia D et al.)	>70%, 30-70% with FFR ≤0.80, or LM >50%	2015	475	91	92	83	96	11.38	0.10	91
Budoff MJ et al.	>50%	2017	77	85	90	81	92	8.50	0.17	NA
PICTURE (Budoff MJ et al.)	≥50%	2017	230	92	78	82	90	4.18	0.10	NA
Andreini D et al.: Patients with atrial fibrillation	>50%	2017	83	95	98	95	98	39.00	0.05	96
Andreini D et al.: Patients with heart rate ≥80bpm	>50%	2018	40	100	82	100	82	5.56	0	90
Motoyama S et al.: UHR-CT, Median CACS 171	≥75%	2018	59	100	80	94	100	5.00	0	NA
Takagi H et al.: UHR-CT, Median CACS 250	≥50%	2018	38 Vessels: 113	100 96	67 81	94 80	100 96	3.00 4.96	0 0.05	95 88
VERDICT: NSTEACS (Linde JJ et al.)	≥50%	2020	1,023	97	72	91	88	3.49	0.05	89
Latina J et al. [15]: UHR-CT, Median CACS 1205	≥70%	2021	15 Vessels: 86	100 86	100 88	100 70	100 95	- 7.17	0 0.16	NA NA
CREDENCE: AI-QCT (Griffin WF et al.[19])	≥50% ≥70%	2022	303	94 94	68 82	81 69	90 97	2.94 5.22	0.09 0.07	84 86

AI-QCT: artificial intelligence-enabled quantitative coronary computed tomography angiography; CACS: coronary artery calcium score; CCTA: coronary computed tomographic angiography; ICA: invasive coronary angiography; NPV: negative predictive value; NSTEACS: non-ST-segment-elevation acute coronary syndrome; PPV: positive predictive value; UHR-CT: ultra-high-resolution CT; -LR: negative likelihood ratio; +LR: positive likelihood ratio.

PROGNOSI

Table 2 **Large prospective clinical studies on the prognostic value of coronary computed tomography angiography (beyond calcium scoring)**

Clinical risk models		c-index, mean(range)	
CCS[125–130]		0.76 (0.64–0.82)	
CCTA[4,76,125–131]		0.76 (0.64–0.93)	
CCTA + HRP[14,76,127,128]		0.78 (0.71–0.91)	
CCTA + HRP + FAI[14,106,132]		0.90 (0.84–0.96)	
Author	Sample size	Population type	Main findings
Kwon *et al.* 2011[125]	4338	Low-risk patients underwent CCTA for evaluation of suspected CAD	The predictive value of CCTA was superior to CCS for MACEs.
Chow *et al.* 2011[131]	14 064	CONFRIM registry	CCTA measures of CAD severity presented better prognostic performance for all-cause mortality over routine clinical predictors and LVEF.
Hou *et al.* 2012[126]	5007	Symptomatic patients who underwent CCTA	CCS presented prognostic benefit for MACEs when added to clinical risk factors. Prognostic performance was further improved with CCTA on top of CCS.
Versteylen *et al.* 2013[127]	2054	Stable symptomatic patients who underwent CCTA	CCS added to FRS had better prognostic performance for ACS prediction. Semiautomated plaque quantification added to FRS further improved prognostic performance for ACS.
Hadamitzky *et al.* 2013[128]	1584	Patients with suspected CAD	Total plaque score had an additive predictive value added to Morise score and CCS for cardiac events.
SCOT-HEART investigators[4]	4146	Patients referred for assessment of suspected angina	The addition of CCTA to standard clinical care enhanced diagnostic certainty for angina due to CAD, also reducing the need for further stress testing.
Han *et al.* 2017[129]	3145	Patients that underwent diagnostic CCTA	CCTA improved prognostic performance for MACEs beyond a model included FRS and CCS in asymptomatic older adults.
Budoff *et al.* 2018[130]	10 003	Symptomatic patients with an intermediate pretest probability for CAD randomized to functional or anatomic testing with CCTA	CCS had similar prognostic ability with functional testing for MACEs. CCTA had significantly higher prognostic value compared to functional testing and CCS.
Ferencik *et al.* 2018[76]	4415	Stable symptomatic patients who underwent CCTA	HRP was associated with higher risk for MACE and had better prognostic performance for MACEs when added to a model including ASCVD risk score and luminal stenosis.
Oikonomou *et al.* 2018[14]	3912	Patients with an indication for CCTA	High perivascular FAI values around proximal right coronary artery and left anterior descending coronary artery were predictive of all-cause and cardiac mortality and improved risk discrimination and reclassification on top of risk factors, CCTA and HRP.
Oikonomou *et al.* 2019[106]	5742	167 patients undergoing cardiac surgery, 5487 participants in the CRISP-CT and SCOT HEART, 44 patients with MI and 44 stable CAD controls	A machine learning-derived radiotranscriptomic profile of pericoronary fat (Fat Radiomic Profile) significantly improved prediction for MACEs beyond traditional risk stratification (including risk factors, CCS, coronary stenosis and HRP features).

Definizioni di placche ad "alto rischio" alla Cardio TC

ESC European Society of Cardiology
European Heart Journal - Cardiovascular Imaging (2022) 00, 1–26
https://doi.org/10.1093/ehjci/jeab292
EACVI DOCUMENT

Clinical applications of cardiac computed tomography: a consensus paper of the European Association of Cardiovascular Imaging—part II

Gianluca Pontone [1,*,†], Alexia Rossi[2,3,†], Marco Guglielmo [1], Marc R. Dweck [4], Oliver Gaemperli[5], Koen Nieman [6], Francesca Pugliese [7,8], Pal Maurovich-Horvat [9], Alessia Gimelli [10], Bernard Cosyns [11], and Stephan Achenbach [12]

Table 2 Definitions of adverse plaque characteristics

HRP feature	Definition
Low attenuation plaque	Presence of a central area within the plaque characterized by low CT attenuation <30 HU.[10]
Positive remodelling or remodelling index (RI)	Presence of an outer vessel diameter which is >10% of the diameter of the reference normal segment within the same vessel (RI >1.1).[10]
Spotty calcification	Small focal calcifications <3 mm diameter in any direction.[10]
Napkin-ring sign	Central area of low CT attenuation that is apparently in contact with the lumen and is surrounded by a rim of higher attenuation.[11]

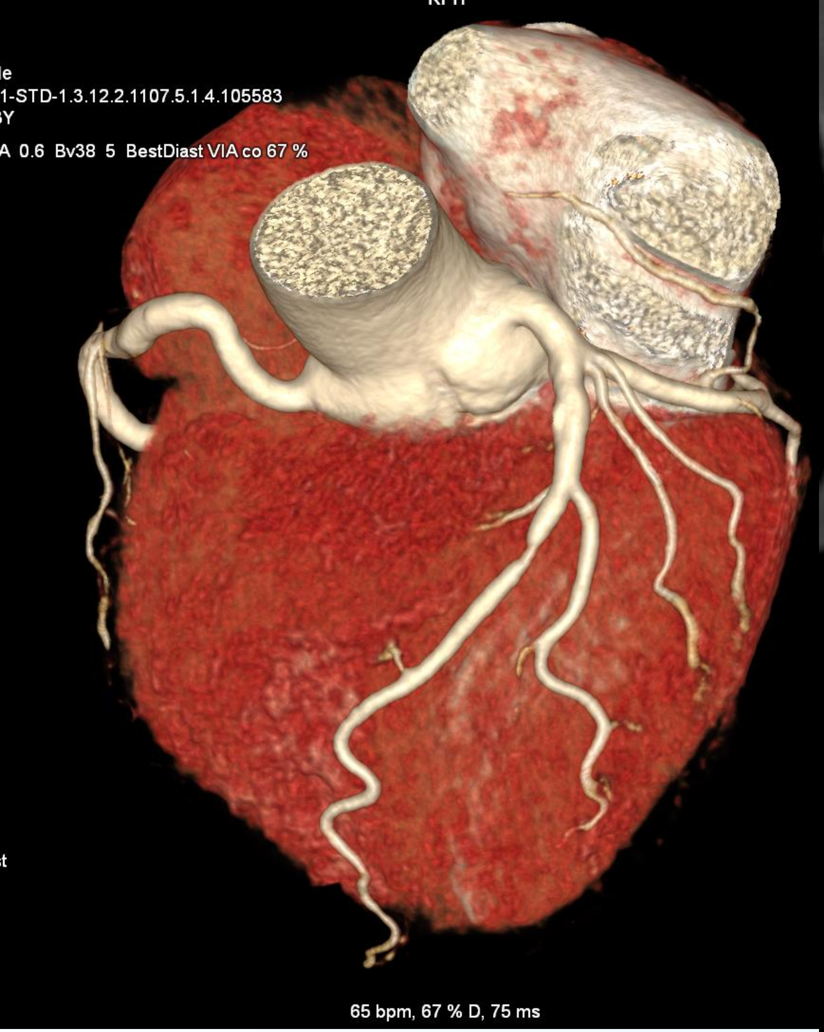
CT, computed tomography; HU, Hounsfield unit; RI, remodelling index.

High Risk Plaque

Table 3 Selection of studies investigating the prognostic value of qualitative adverse plaque characteristic detected by CCTA

Trial	Motoyama et al.[10]	Motoyama et al.[18]	Nadjiri et al.[19]	Feuchtner et al.[16]	Ferencik et al.[12]	Finck et al.[17]	Williams et al.[21]	Senoner et al.[20]	Yamamoto et al.[22]
Study design	Retrospective, observational study	Retrospective, observational study	Retrospective, observational study	Prospective, observational study	RCT	Prospective, observational study	RCT	Prospective, observational study	Prospective, observational study
Sample size	1059	3158	1168	1469	4415	1615	1769	1430	2083
Population	Suspected or known CAD	Suspected or known CAD	Suspected CAD	Suspected CAD, low to intermediate pre-test probability	Suspected CAD	Suspected CAD	Suspected CAD	Suspected CAD, low to intermediate pre-test probability	Suspected CAD
Follow-up (years)	2.3	3.9	5.7	7.8	2.1	10.5	4.7	10.5	2
Primary endpoint	ACS	ACS	Cardiac death, MI, unstable angina, and coronary revascularization	STEMI, NSTEMI, unstable angina	Death from any cause, MI, and hospitalization for unstable angina	Cardiac death or nonfatal MI	Fatal or nonfatal MI	Fatal and nonfatal MACE	Cardiac death, non-fatal acute coronary syndrome, and coronary revascularization >3 months after indexed CCTA
Rate of primary endpoint (%)	1.4	2.8	3.9	2.8	3.0	3.1	2.3	3.9	3.5
Plaque feature	LAP, PR	LAP, PR	PR, NRS, SC	LAP, NRS, SC	LAP, PR, NRS	LAP, NRS, SC	LAP	LAP, PR, NRS, SC	LAP, PR, NRS, SC
Adjusted hazard ratio (95% CI)	LAP and/or PR: 22.79 (6.91–75.17)	LAP and/or PR: 13.13 (3.80–82.66)	PR: 1.04 (0.95–1.1) NRS: 1.4 (0.6–2.9) SC: 1.07 (0.5–2.2)	LAP: 4.5 (1.4–14.8) NRS: 7.0 (2.0–13.6) SC: 2.6 (1.1–6.5)	At least one high risk feature present: 1.72 (1.13–2.62)	LAP: 1.29 (0.40–4.15) NRS: 2.25 (1.09–4.65) SC: 2.35 (0.94–5.90)	LAP: 1.60 (1.10–2.34)	LAP: 4.00 (1.52–10.52) PR: 0.56 (0.18–1.75) NRS: 4.11 (1.77–9.52) SC: 1.40 (0.65–2.98)	≥2 adverse characteristics: 1.95 (1.13–3.34)

ACS, acute coronary syndrome; CAD, coronary artery disease; CCTA, coronary computed tomography angiography; CI, confidence interval; LAP, low-attenuation plaque; MACE, major adverse cardiovascular events; MI, myocardial infarction; NRS, napkin-ring sign; NSTEMI, non-ST elevation myocardial infarction; PR, positive remodelling; RCT, randomized clinical trial; SC, spotty calcification; STEMI, ST elevation myocardial infarction.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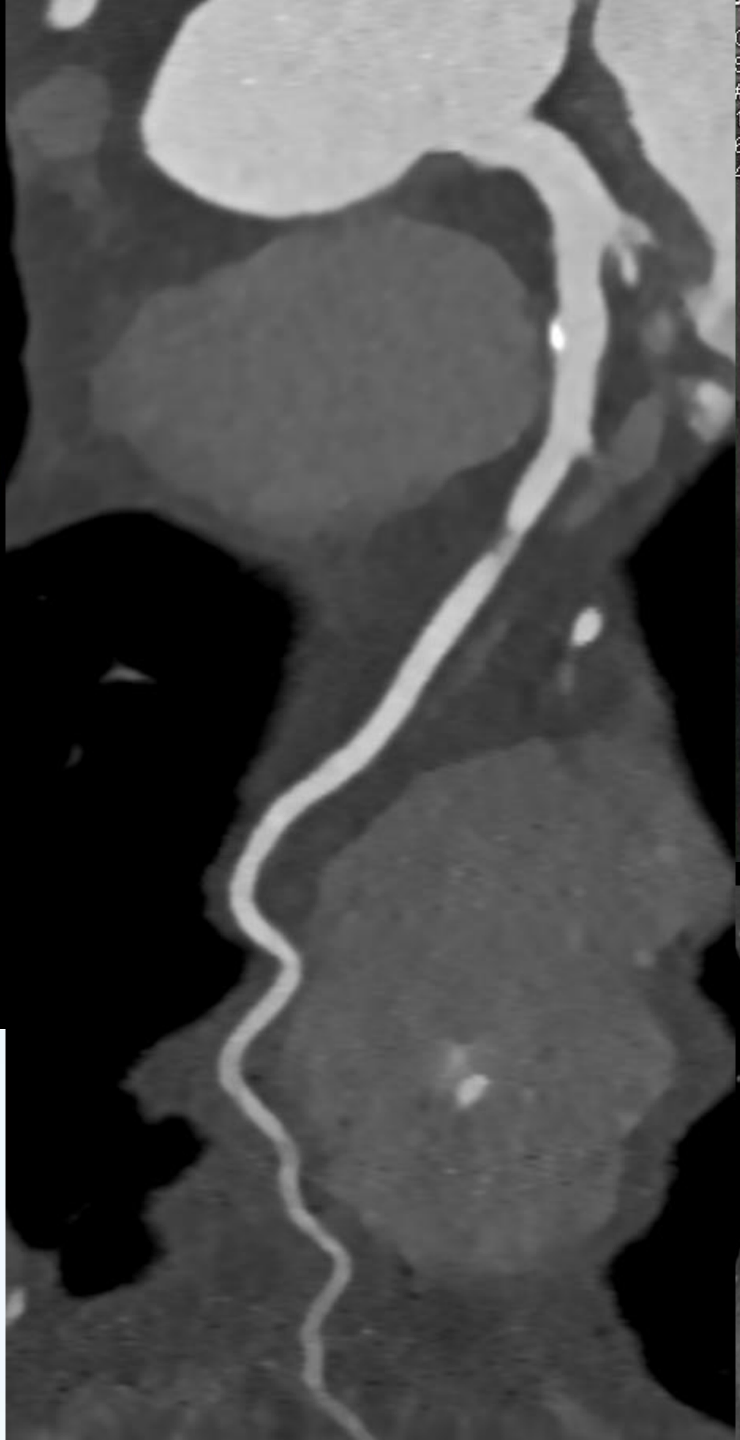

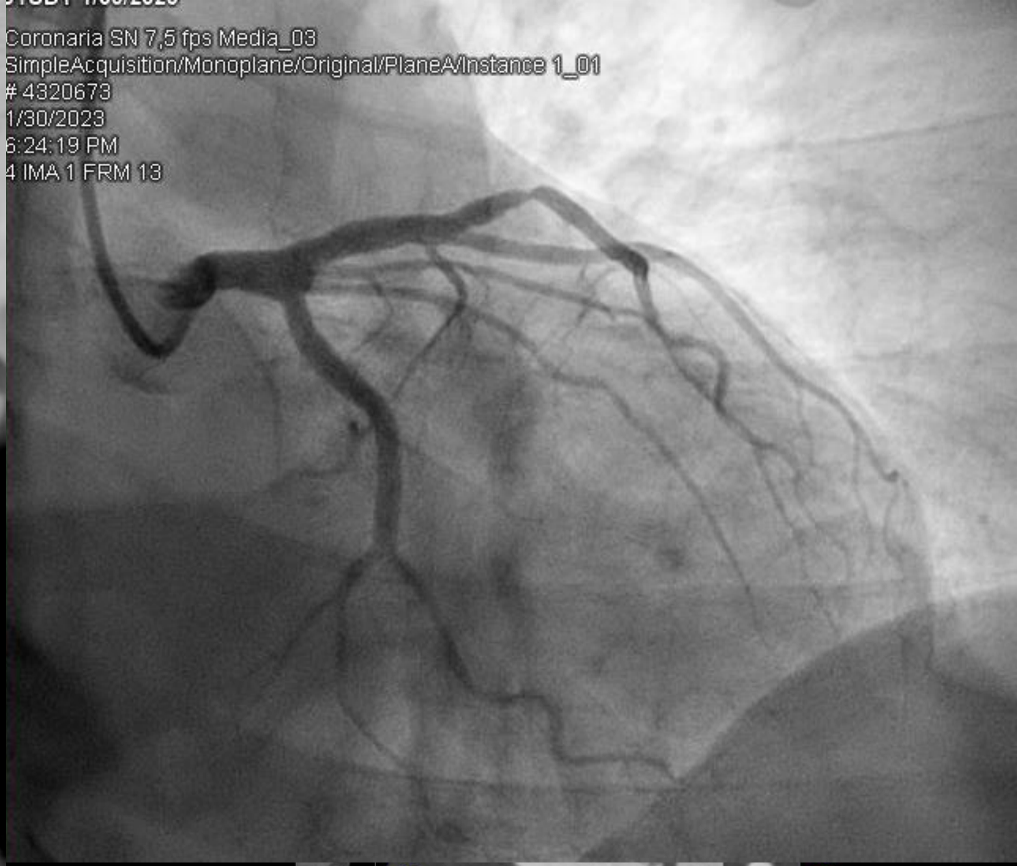
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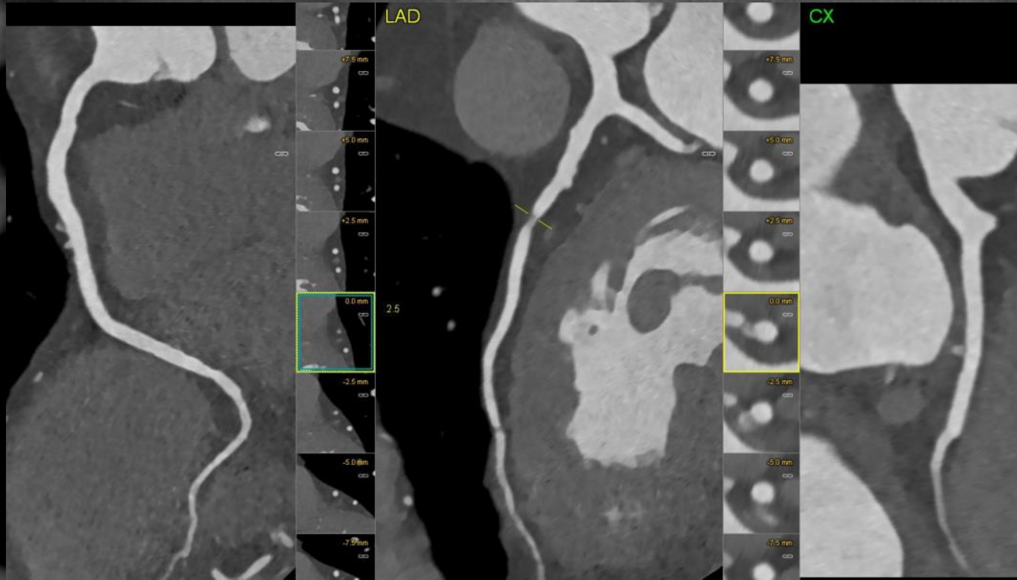
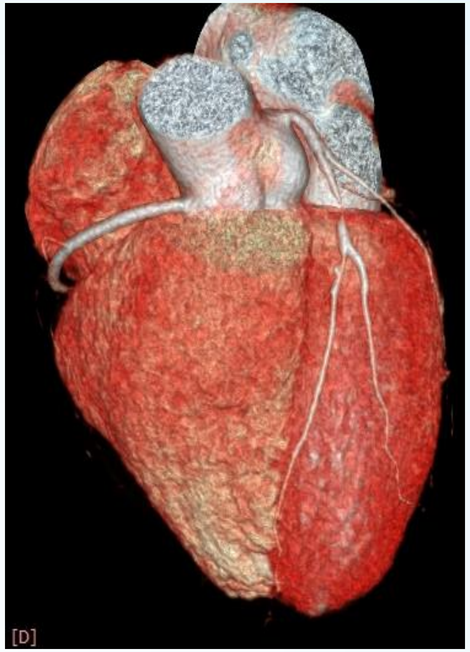
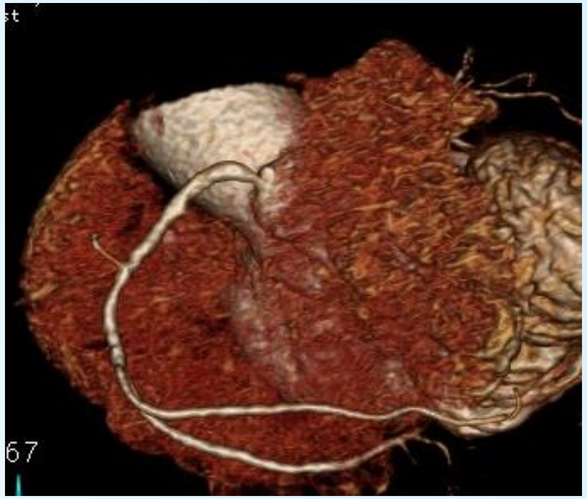

LAD
CX
2.5


RCA
1
Do not measure on left side of the image!


[D]


LAD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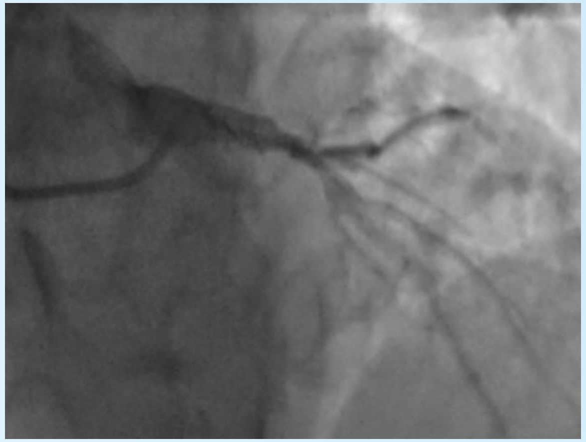


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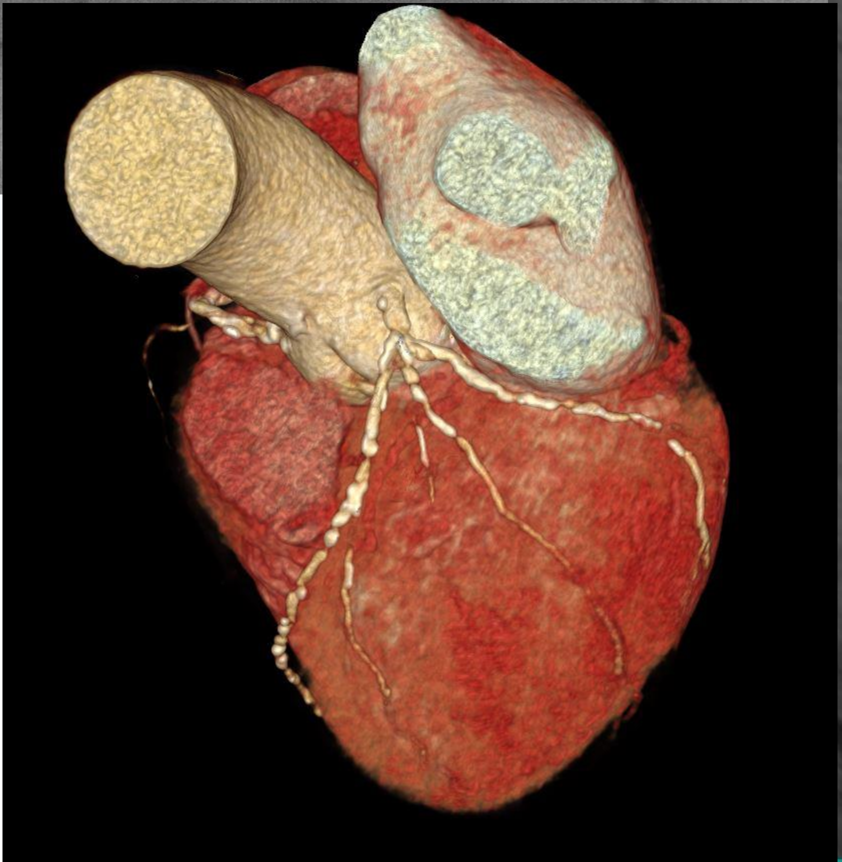
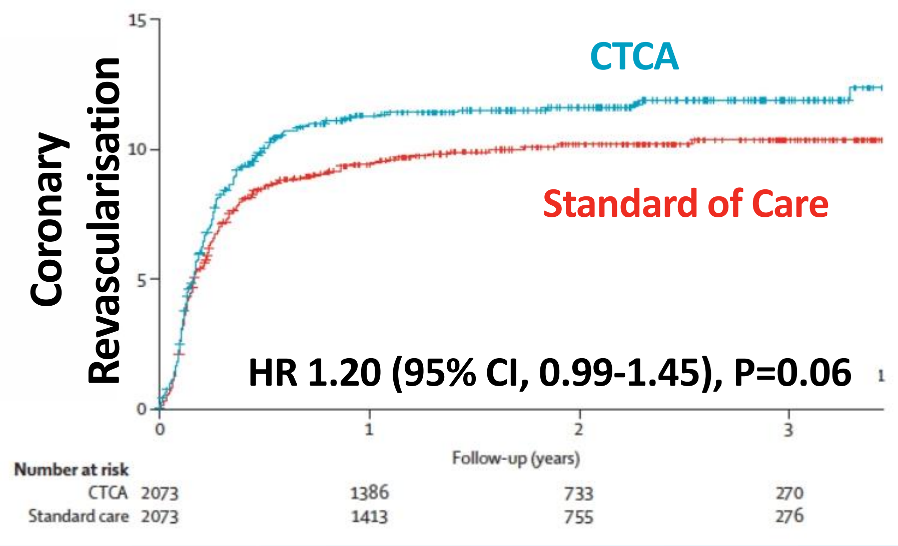


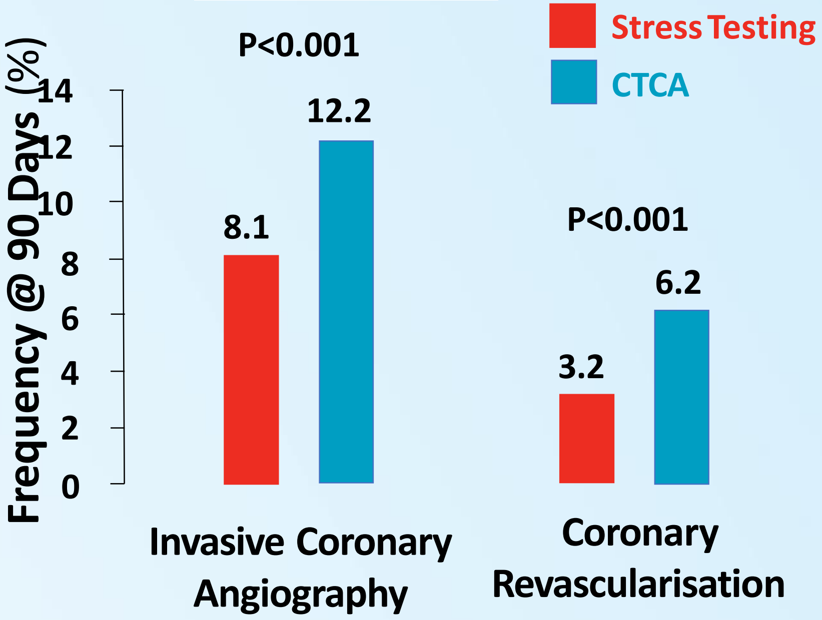
Early Rates of Invasive Angiography and Revascularisation

The SCOT-HEART Trial



Lancet 2015;385:2383-2391

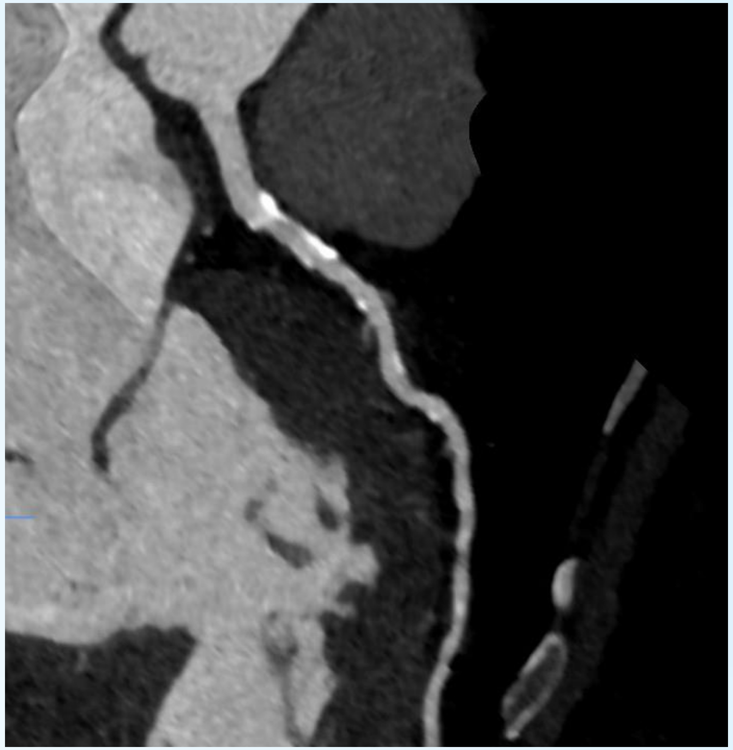
The promise Trial



N Engl J Med 2015;372:1291-1300

Ruolo della cardio TC nel rule-out sopsetta CAD

- ✓ Identify very low risk patients
- ✓ Improved patient risk stratification
- ✓ Identify those at highest risk patients



Anti-inflammatory therapy

PCSK9i

Lp(a) lowering treatment

Icosapent Ethyl

Oral anticoagulants

Bempedoic acid

Ezetimibe

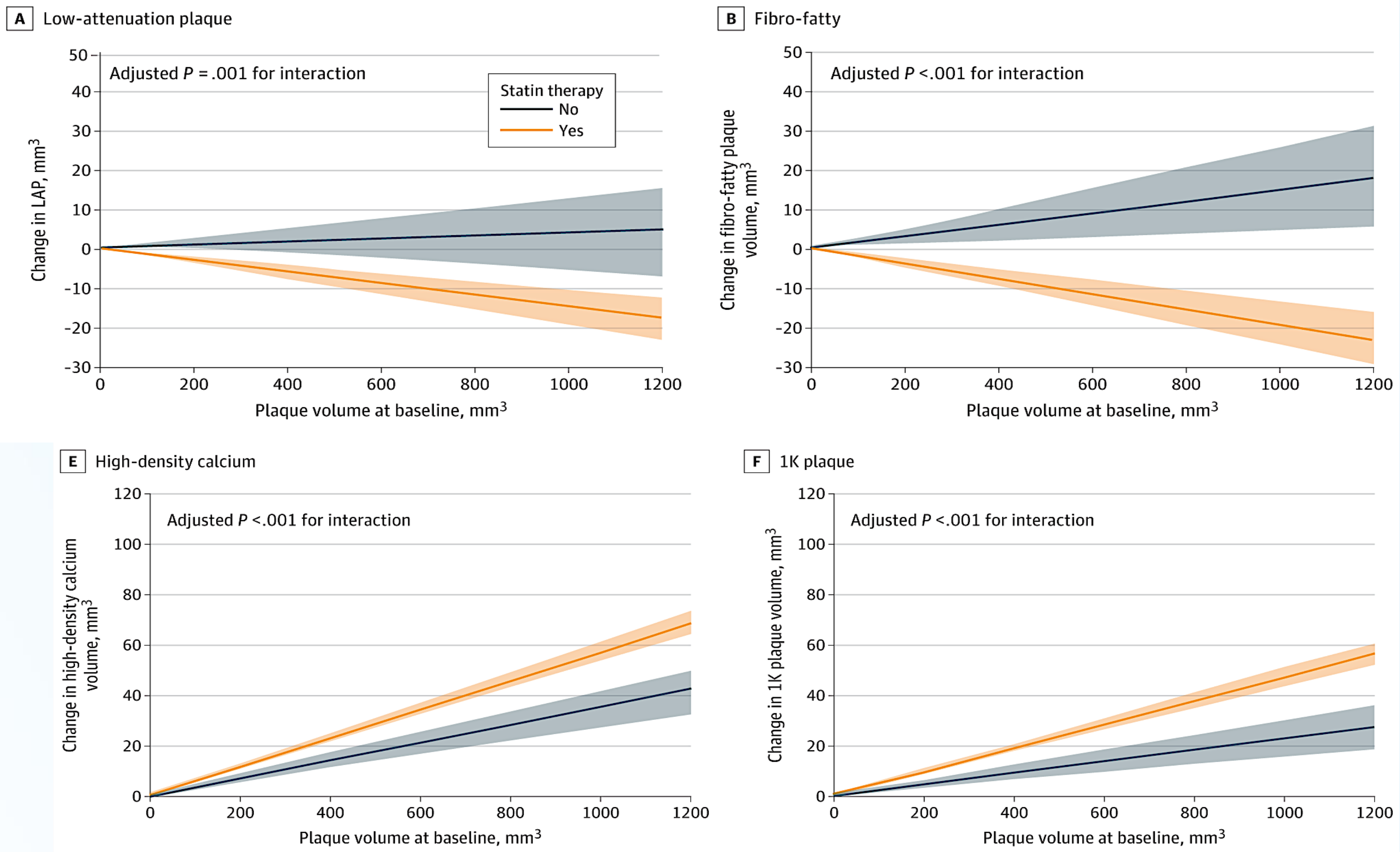
SGLT2i/GLP1-RA

Antiplatelet Rx

BP control

Aggressive Lifestyle changes

Association of Statin Treatment With Progression of Coronary Atherosclerotic Plaque Composition



JAMA Cardiol. Published online August 18, 2021. doi:10.1001/jamacardio.2021.3055

Original Article

Prognostic and Therapeutic Implications of Statin and Aspirin Therapy in Individuals With Nonobstructive Coronary Artery Disease

Results From the CONFIRM (Coronary CT Angiography Evaluation For Clinical Outcomes: An International Multicenter Registry) Registry

Benjamin J.W. Chow, Gary Small, Yeung Yam, Li Chen, Ruth McPherson, Stephan Achenbach, Mouaz Al-Mallah, Daniel S. Berman, Matthew J. Budoff, Filippo Cademartiri, Tracy Q. Callister, Hyuk-Jae Chang, Victor Y. Cheng, Kavitha Chinnaiyan, Ricardo Cury, Augustin Delago, Allison Dunning, Gundrun Feuchtner, Martin Hadamitzky, Jörg Hausleiter, Ronald P. Karlsberg, Philipp A. Kaufmann, Yong-Jin Kim, Jonathon Leipsic, Troy LaBounty, Fay Lin, Erica Maffei, Gilbert L. Raff, Leslee J. Shaw, Todd C. Villines, James K. Min; on behalf/for the CONFIRM Investigators

10,418 patients
with <50% stenosis
(57 ± 12 years; 53% male)

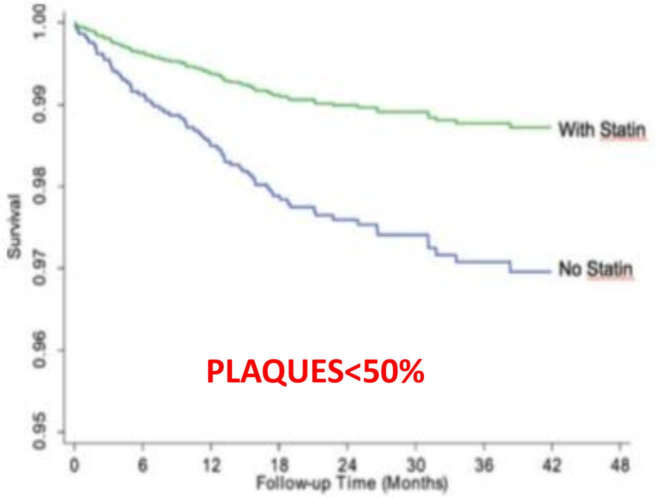


Figure 3.
Kaplan–Meier survival curves as a function of statin use in patients with coronary plaque.

Table 4. Cox Models for All-Cause Mortality in Patients With Nonobstructive CAD

Models	Hazard Ratio* (95% CI)	*P* Value
All patients (n=10 418)		
Statin therapy	0.52 (0.34–0.79)	0.002
ASA therapy	0.77 (0.53–1.12)	0.173
Nonobstructive CAD (n=4706)		
Statin therapy	0.39 (0.23–0.65)	<0.001
ASA therapy	0.66 (0.42–1.04)	0.070
No coronary plaque (n=5712)		
Statin therapy	0.64 (0.30–1.37)	0.252
ASA therapy	0.73 (0.37–1.47)	0.384

CAD indicates coronary artery disease; and CI, confidence interval.
*Adjusted for National Cholesterol Education Program/Adult Treatment Program III risk.

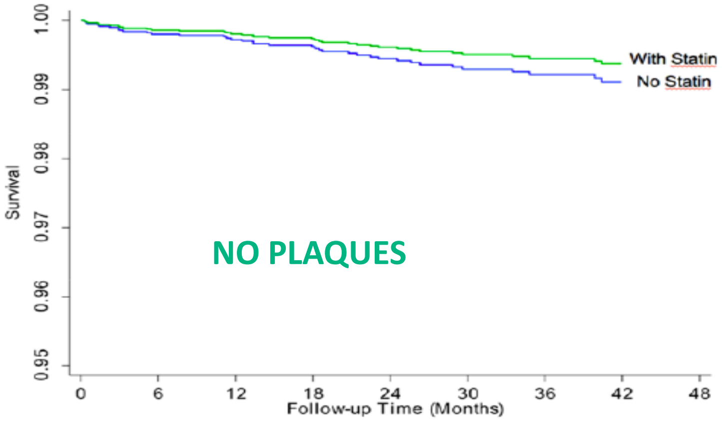


Figure 2. Kaplan–Meier survival curves as a function of statin use in patients without coronary plaque.

Arterioscler Thromb Vasc Biol. 2015 April ; 35(4): 981–989.

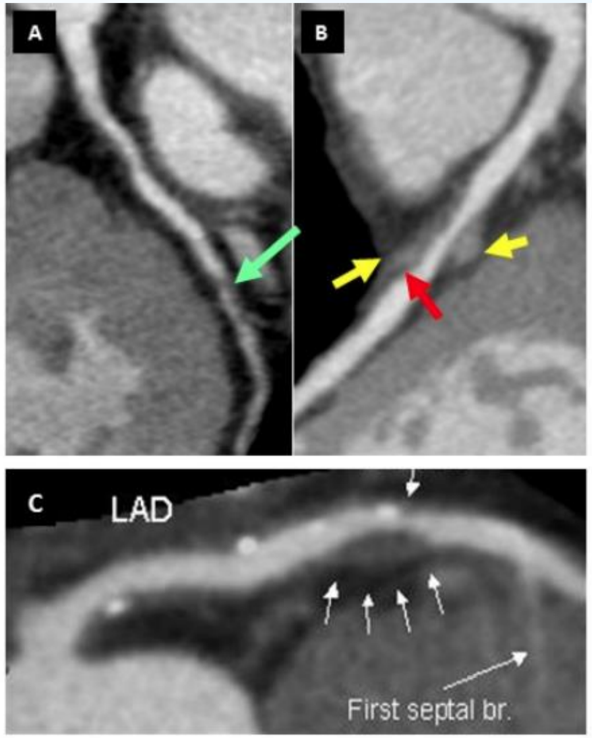
Journal of Cardiovascular Computed Tomography
Volume 15, Issue 2, March–April 2021, Pages 93-109

Guidelines

Society of Cardiovascular Computed Tomography / North American Society of Cardiovascular Imaging – Expert Consensus Document on Coronary CT Imaging of Atherosclerotic Plaque

Leslee J. Shaw [a], Ron Blankstein [b], Jeroen J. Bax [c], Maros Ferencik [d], Marcio Sommer Bittencourt [e], James K. Min [f], Daniel S. Berman [g], Jonathon Leipsic [h], Todd C. Villines [i], Damini Dey [j], Subhi Al'Aref [a], Michelle C Williams [k], Fay Lin [a], Lohendran Baskaran [a], Harold Litt [l], Diana Litmanovich [m], Ricardo Cury [n], Umberto Gianni [a], Inge van den Hoogen [o], Alexander R. van Rosendael [a], Matthew Budoff [p], Hyuk-Jae Chang [q], Harvey E. Hecht [r], Gudrun Feuchtner [s], Amir Ahmadi [r], Brian B. Ghoshajra [t], David Newby [k], Y.S. Chandrashekhar [u], Jagat Narula [r]

Placche ad alto rischio: impatto prognostico



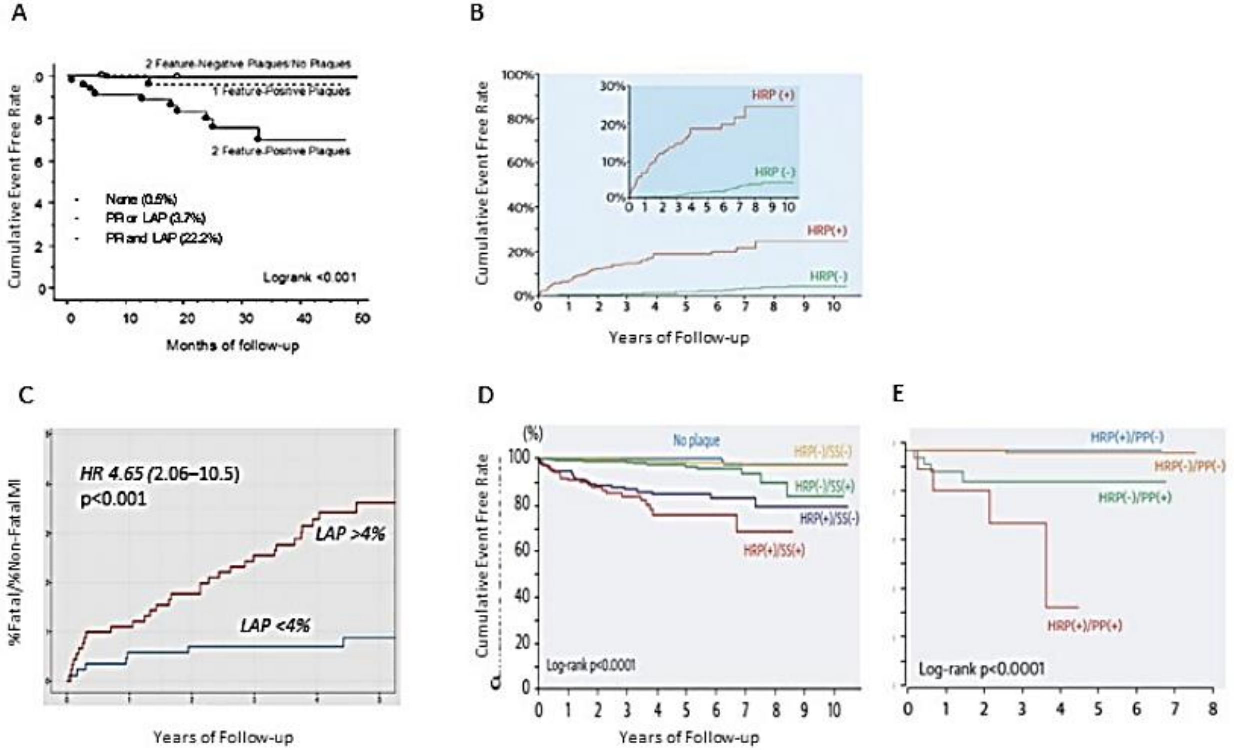
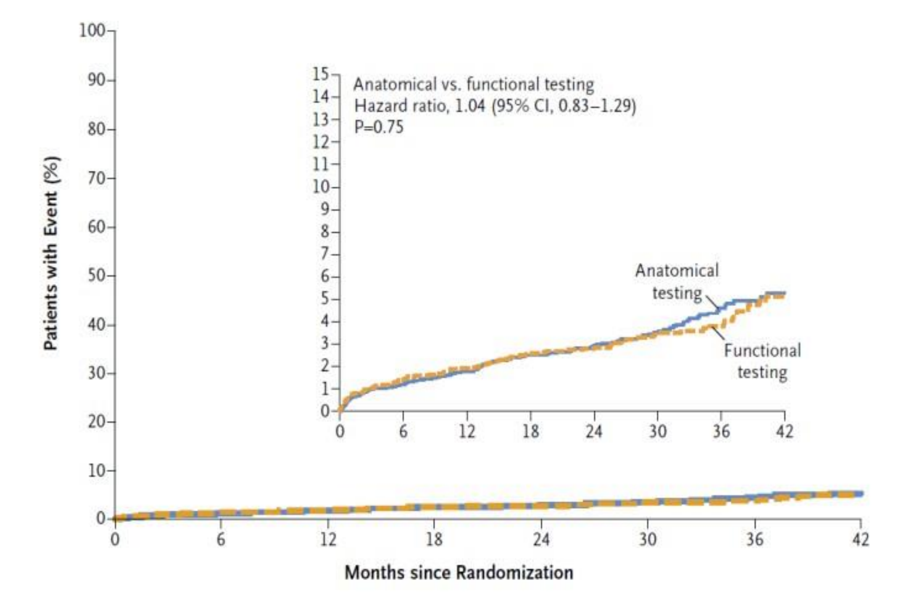


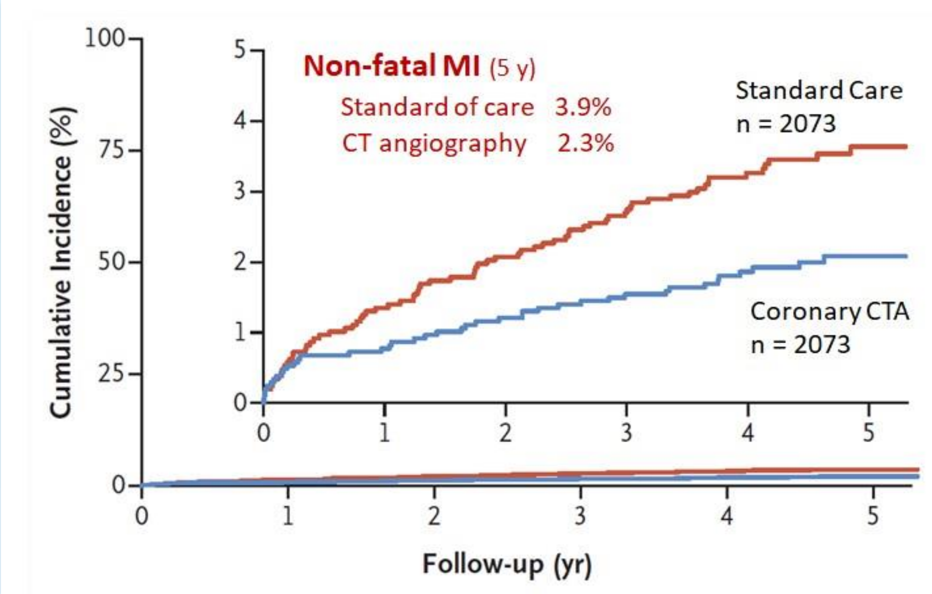
Figure 5: CT angiography-verified plaque composition and clinical outcomes. CT angiography-based 2-feature positive plaques demonstrate a 45-fold higher likelihood of cardiac events as compared to 2-feature negative plaques at 2 years of follow-up (A) and 9-fold higher event rate up to 10 years of follow-up (B). The extent of necrotic core as represented by LAP volume >4% (C), added severity of luminal stenosis (D) and plaque progression in serial CT angiography (E) improve the discriminatory value of CT angiography. Modified from Williams et al. Circulation 2020 and Motoyama et al. JACC 2015.

Coronary CTA in suspected CAD



PROMISE, N Engl J Med 2015, n = 10 003

CT vs. functional testing



Preventive Medication	Started	Stopped
CTA	14%	4%
Standard	4%	0.4%

SCOT-Heart, N Engl J Med 2018, n = 4146

CT vs. „standard care“ (1:1)