CT Coronary Calcium Score: Basics and Beyond

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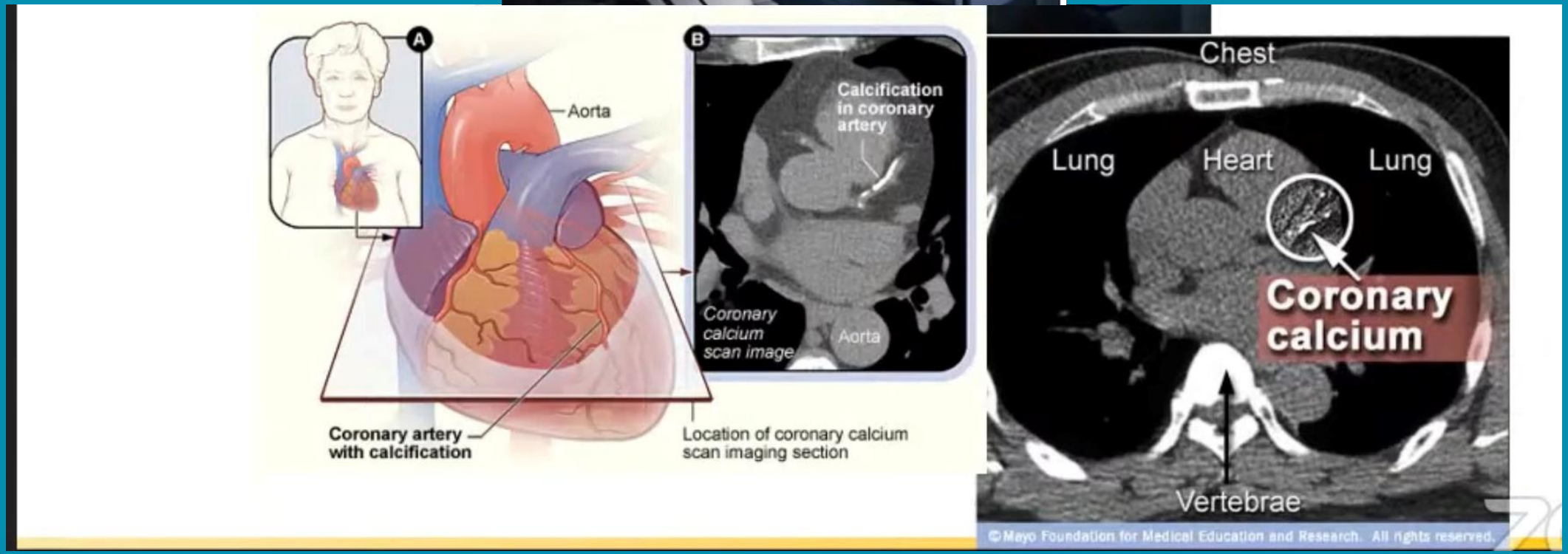
Disclosures

- CSI
- Boston Scientific
- Shockwave Medical
- Abbott
- Philips Medical
- Terumo Medical
- Cordis

Case

- 55 year old male with strong family history of CAD , asymptomatic, non-diabetic, healthy lifestyle exercises regularly
- BP 135/85 , HDL 45, LDL 145
- Pooled Cohort risk ASCVD
  - 6.4% 10 year risk of ASCVD



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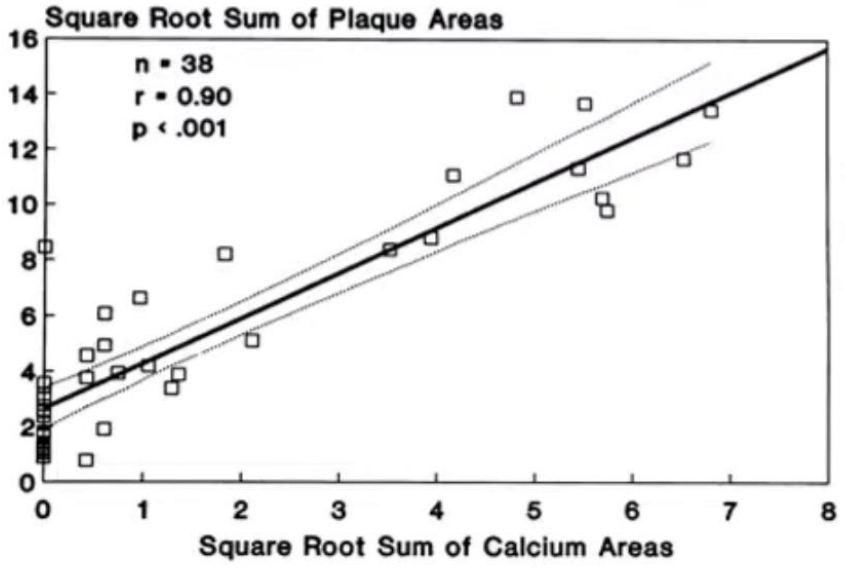
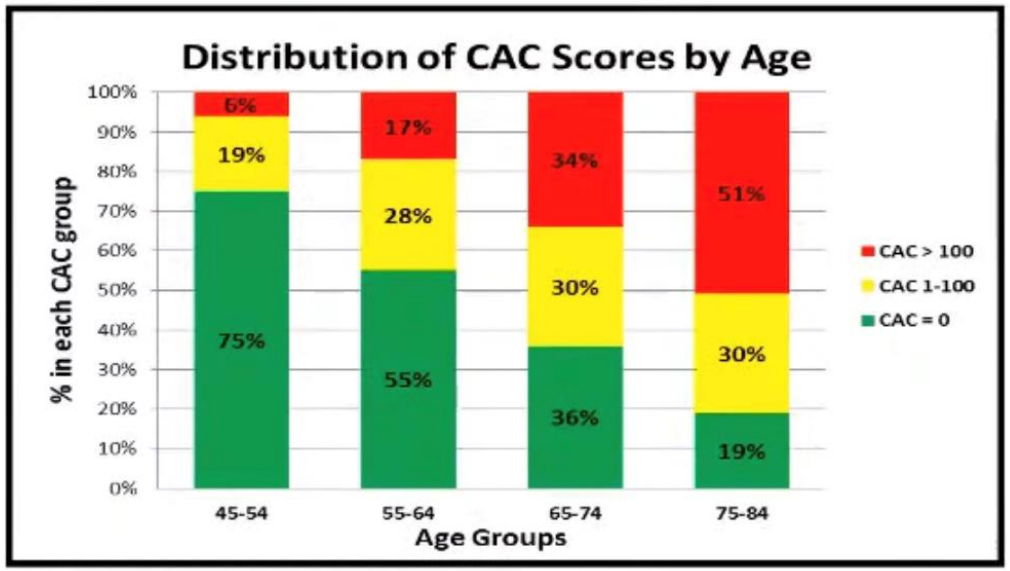
Relationship of CAC to Coronary Atherosclerosis and Age



Rumberger et al. *Circulation*. 1995



Tota-Maharaj et al. *Mayo Clinic Proceedings*. 2014

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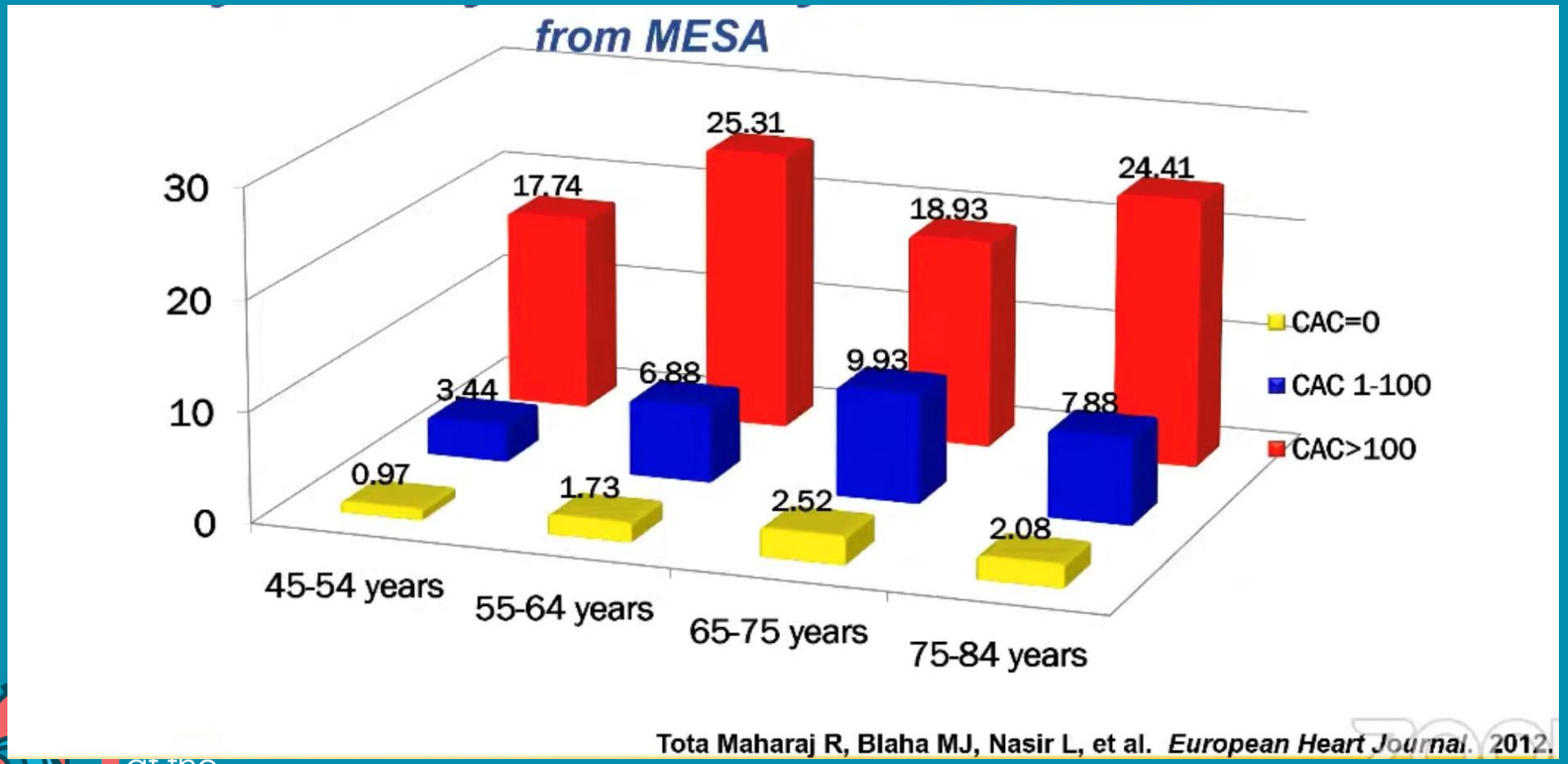
Are you really as old as your arteries

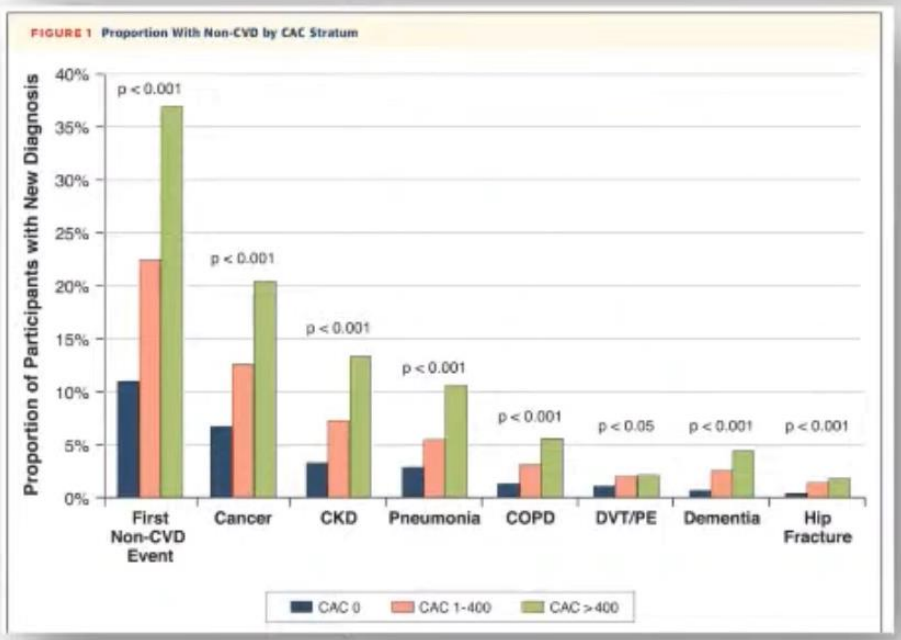


Tota Maharaj R, Blaha MJ, Nasir L, et al. *European Heart Journal*. 2012.

The Association of Coronary Artery Calcium With Noncardiovascular Disease

The Multi-Ethnic Study of Atherosclerosis

Catherine E. Handy, MD, MPH,[1] Chintan S. Desai, MD,[2] Zeina A. Dardari, MS,[3] Mouaz H. Al-Mallah, MD,[3] Michael D. Miedema, MD,[2] Pamela Ouyang, MD,[2] Matthew J. Budoff, MD,[4] Roger S. Blumenthal, MD,[1] Khurram Nasir, MD,[1,2,5,6] Michael J. Blaha, MD, MPH[1]



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Comparing “Negative Risk Markers” in the Multi-Ethnic Study of Atherosclerosis

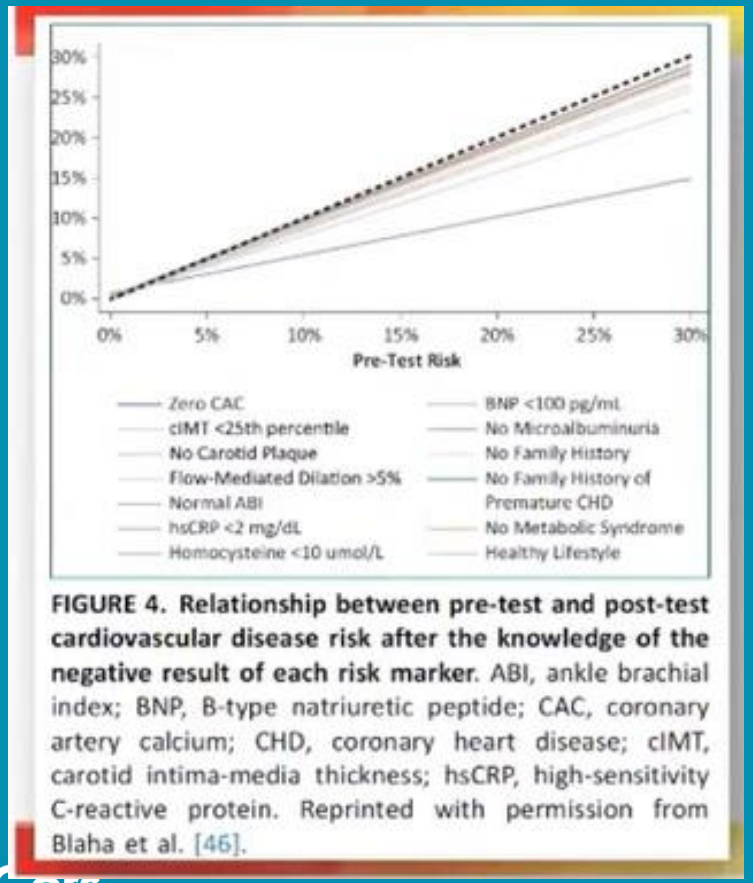

FIGURE 4. Relationship between pre-test and post-test cardiovascular disease risk after the knowledge of the negative result of each risk marker. ABI, ankle brachial index; BNP, B-type natriuretic peptide; CAC, coronary artery calcium; CHD, coronary heart disease; cIMT, carotid intima-media thickness; hsCRP, high-sensitivity C-reactive protein. Reprinted with permission from Blaha et al. [46].

A CAC score of zero is the strongest “negative risk factor” for the development of ASCVD.

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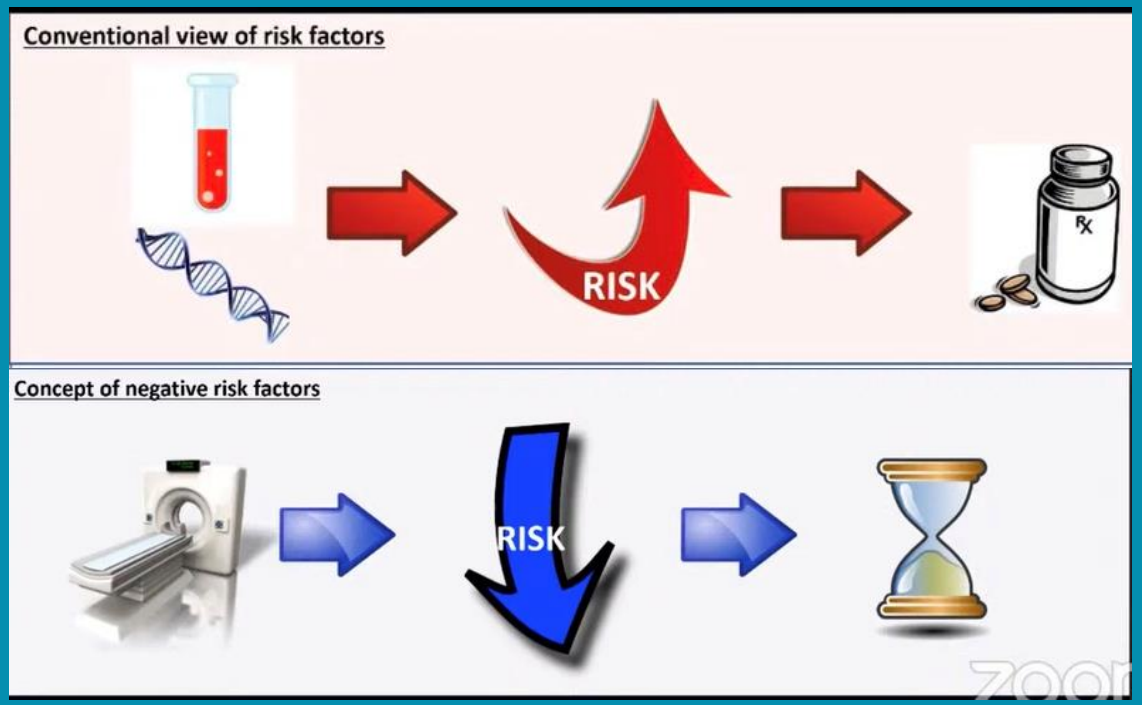

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Associations between C-reactive protein, coronary artery calcium, and cardiovascular events: implications for the JUPITER population from MESA, a population-based cohort study

Michael J Blaha, Matthew J Budoff, Andrew P DeFilippis, Ron Blankstein, Juan J Rivera, Arthur Agatston, Daniel H O'Leary, Joao Lima, Roger S Blumenthal, Khurram Nasir

THE LANCET

Interpretation CAC seems to further stratify risk in patients eligible for JUPITER, and could be used to target subgroups of patients who are expected to derive the most, and the least, absolute benefit from statin treatment. Focusing of treatment on the subset of individuals with measurable atherosclerosis could allow for more appropriate allocation of resources.

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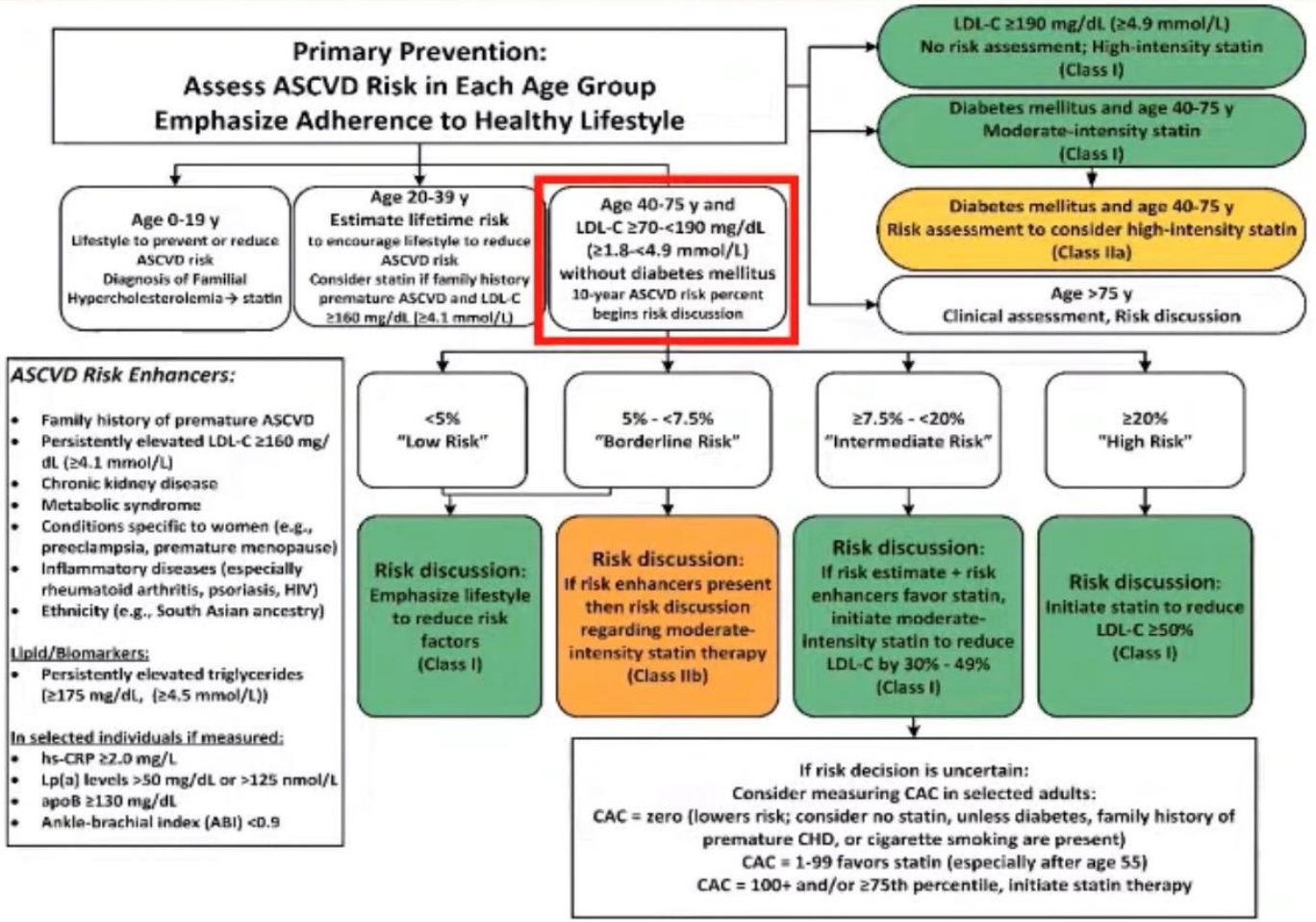
2018 Cholesterol Guidelines



Current Guidelines

IIa	B-NR	In intermediate-risk or selected borderline-risk adults, if the decision about statin use remains uncertain, it is reasonable to use a CAC score in the decision to withhold, postpone or initiate statin therapy.

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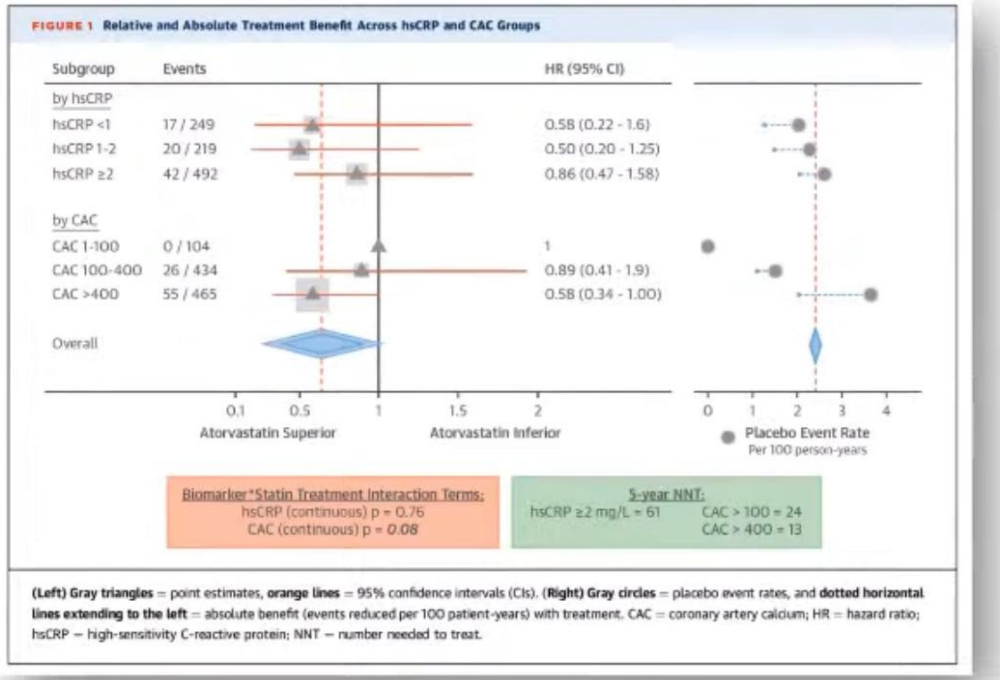
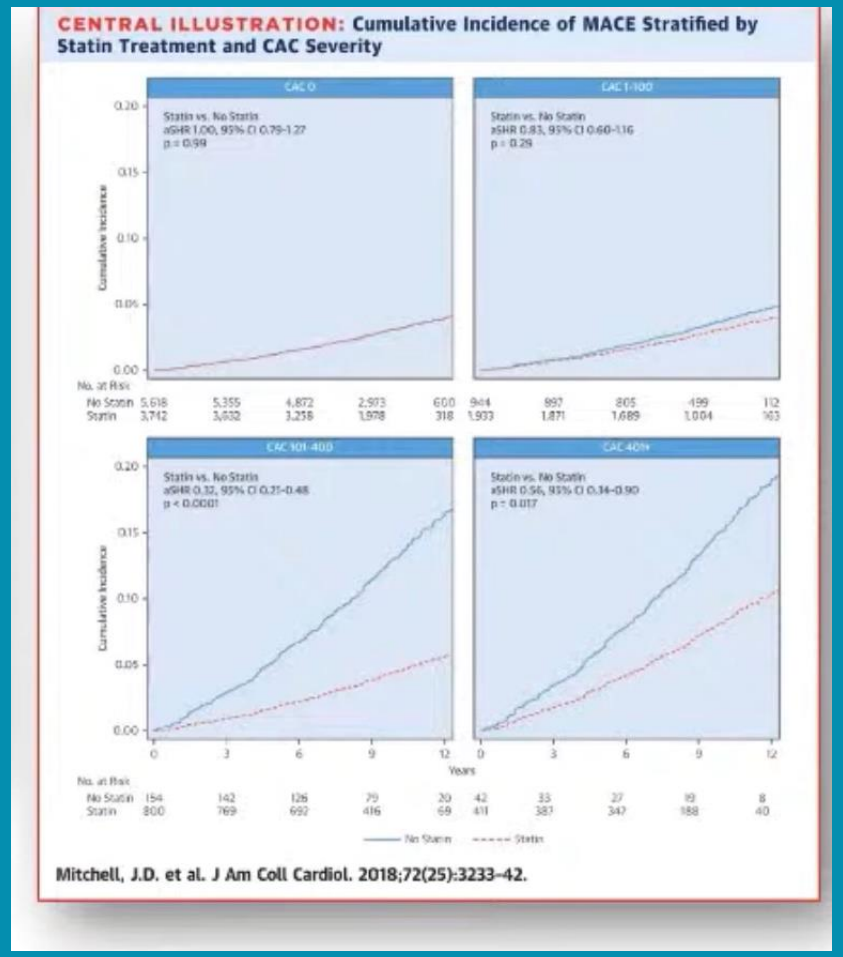
St. Francis Heart Randomized Controlled Trial



Blaha MJ JACC 2018



Mitchell, J.D. et al. J Am Coll Cardiol. 2018;72(25):3233-42.

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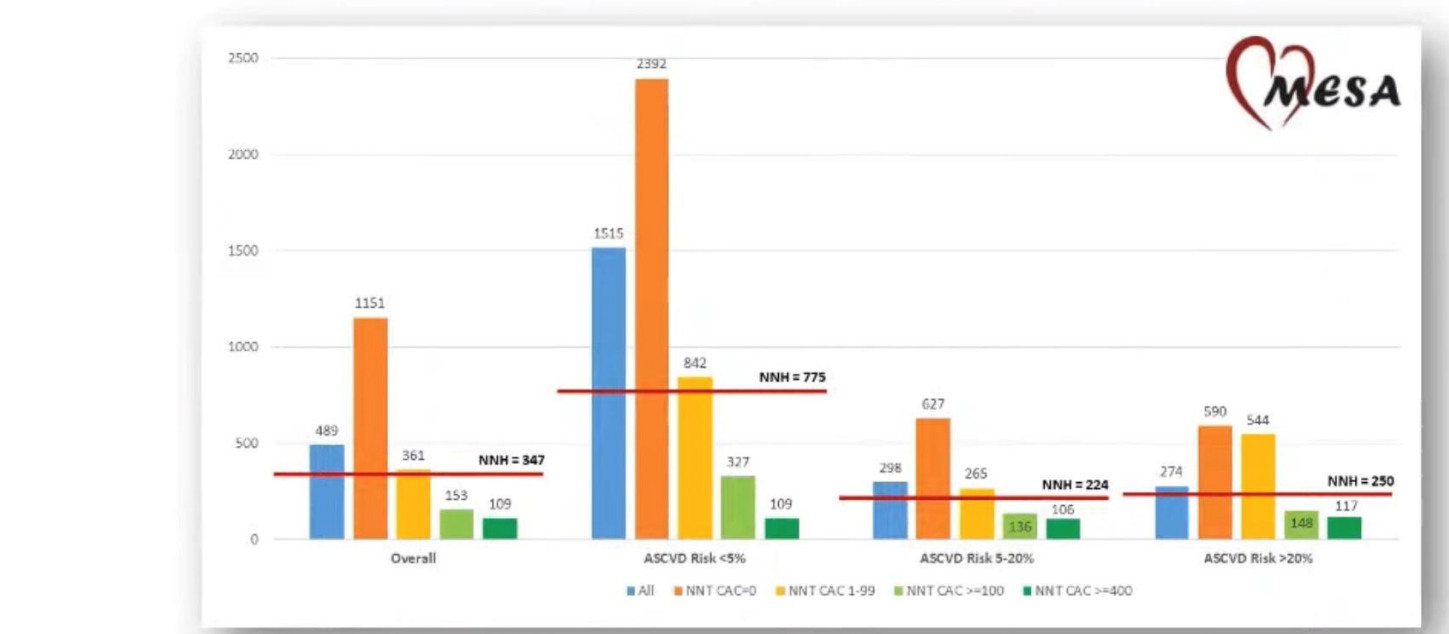
Aspirin Net Benefit According to CAC scores- Updated 2020 Analysis



Cainzos-Achirica, et al.– *Circulation* 2020

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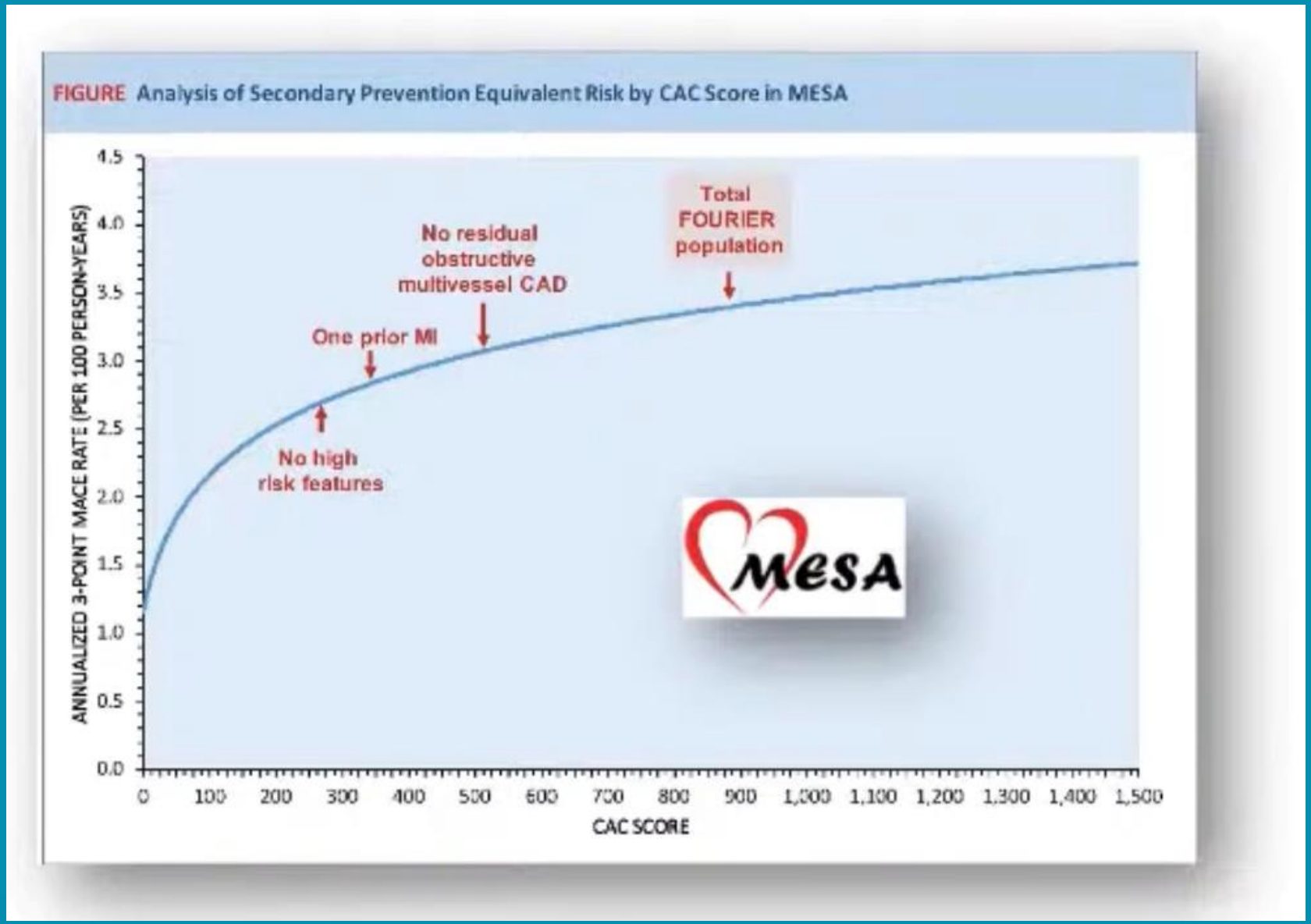

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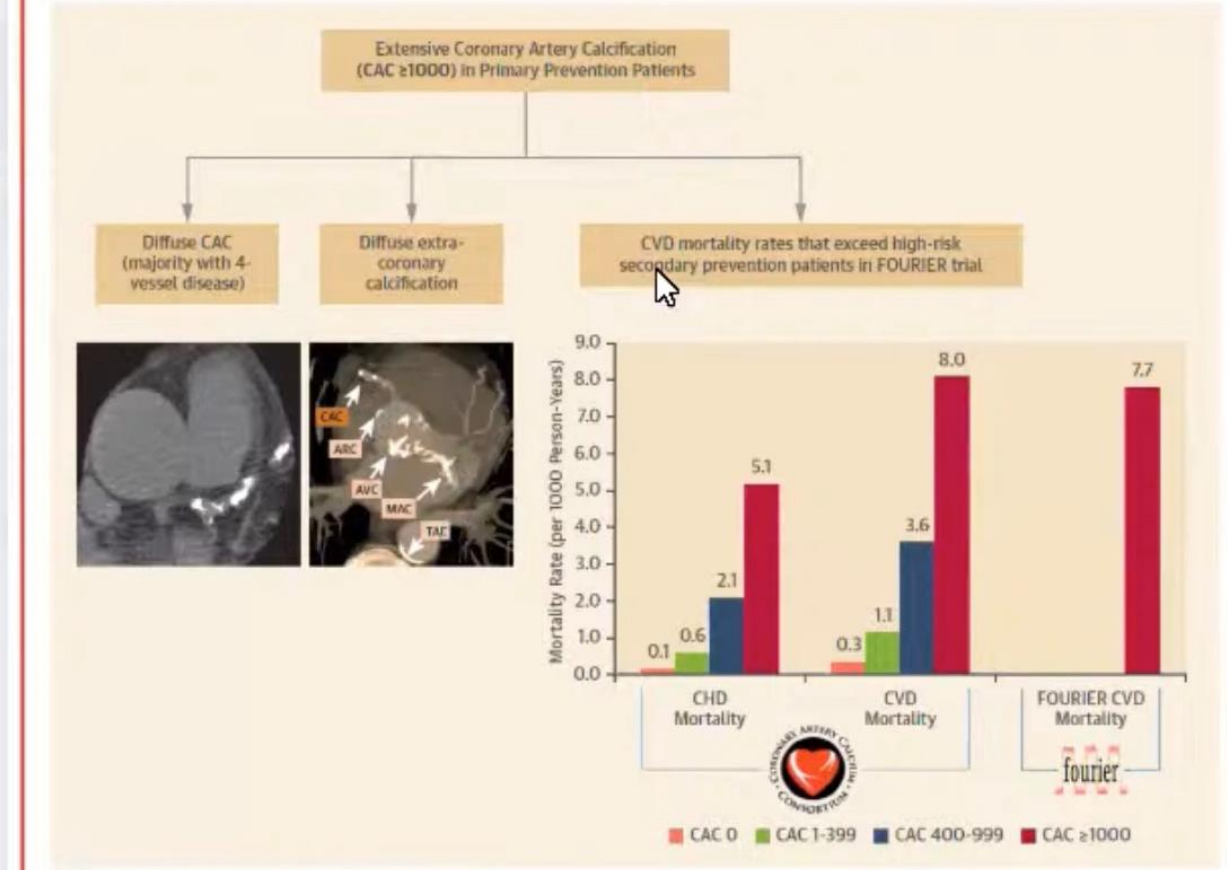
CENTRAL ILLUSTRATION Understanding Extensive CAC (CAC Score ≥1,000) in Primary Prevention Patients



Peng, A.W. et al. J Am Coll Cardiol Img. 2019;■(■):■-■.

Primary prevention patients with extensive CAC (CAC ≥1,000) are unique in their burden of coronary and extra-coronary disease and in their long-term outcomes. Those with CAC ≥1,000 can be found on imaging to have a dispersed pattern of calcification in their coronary artery tree (the majority with 4-vessel disease) and diffuse extra-coronary calcification (TAC, AVC, and MVC). In addition, their annualized CVD mortality rates exceed those of high-risk secondary prevention patients from the FOURIER trial (0.80%/year vs. 0.77%/year). AVC = aortic valve calcium; CAC = coronary artery calcium; CVD = cardiovascular disease; MVC = mitral valve artery; TAC = thoracic artery calcium.

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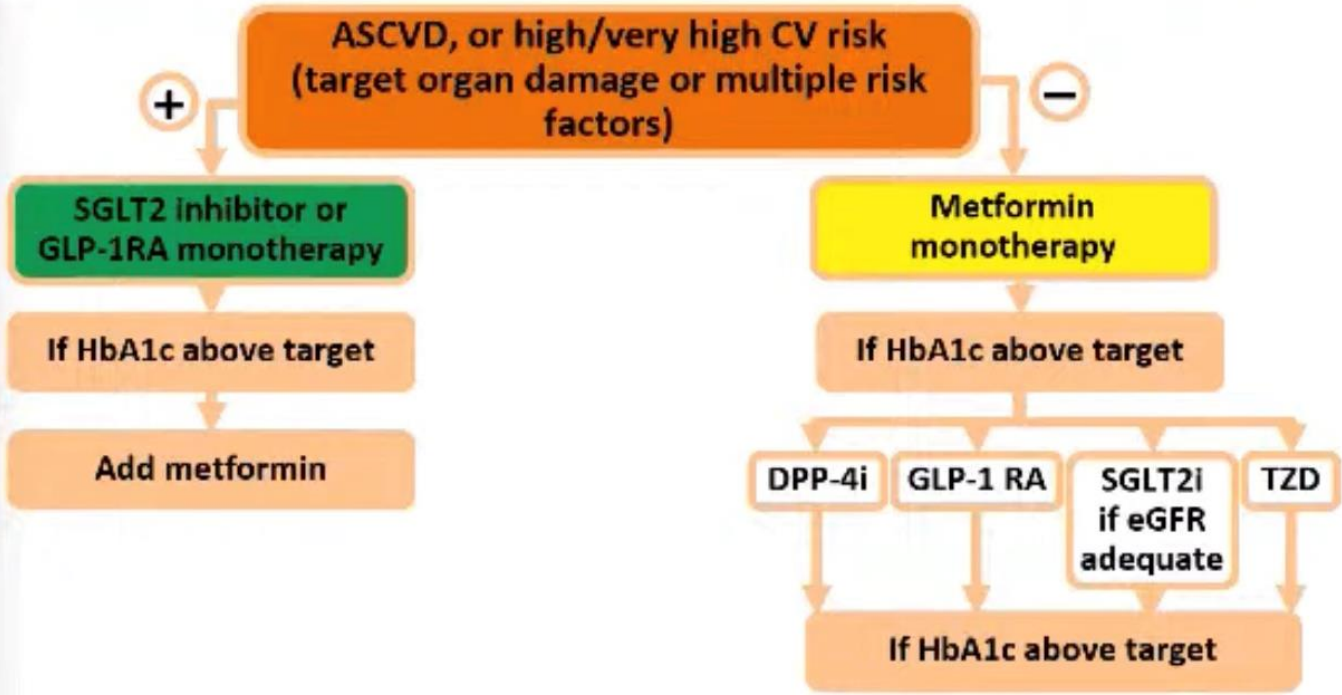
Treatment algorithm in patients with T2DM and ASCVD or high/very high CV risk—drug naïve



Recommendations	Class	Level
CAC score with CT may be considered a risk modifier in CV risk assessment of moderate-risk asymptomatic patients with DM	IIb	B

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How would you treat this patient

- Lifestyle therapy only
- Moderate intensity statin
- High Intensity statin, aspirin,
- Intensive Lifestyle, High Intensity statin, aspirin, consider anti-hypertensive and non-statin add on to achieve LDL < 70 & non HDL < 100

Future CAC-Based Treatment Recommendations

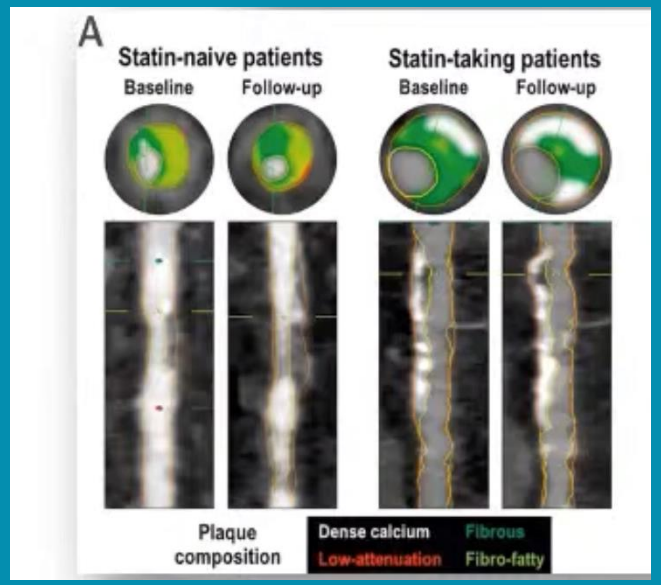
CAC Score	Lifestyle	Statin and Statin Intensity	Non-Statin Add-on*	Aspirin	Blood Pressure Goals	Secondary Prevention Meds**
0	✓					
1-99 < 75th % ≥ 75th %	 ✓ ✓	 *Consider Mod* Moderate			 Routine Routine	
100-299	✓	Moderate to High		✓	Routine	
≥ 90th %	✓✓	High	Consider	✓	Aggressive	Consider
> 300	✓	High	Consider	✓	Aggressive	Consider
>1000	*SECONDARY PREVENTION!!*					

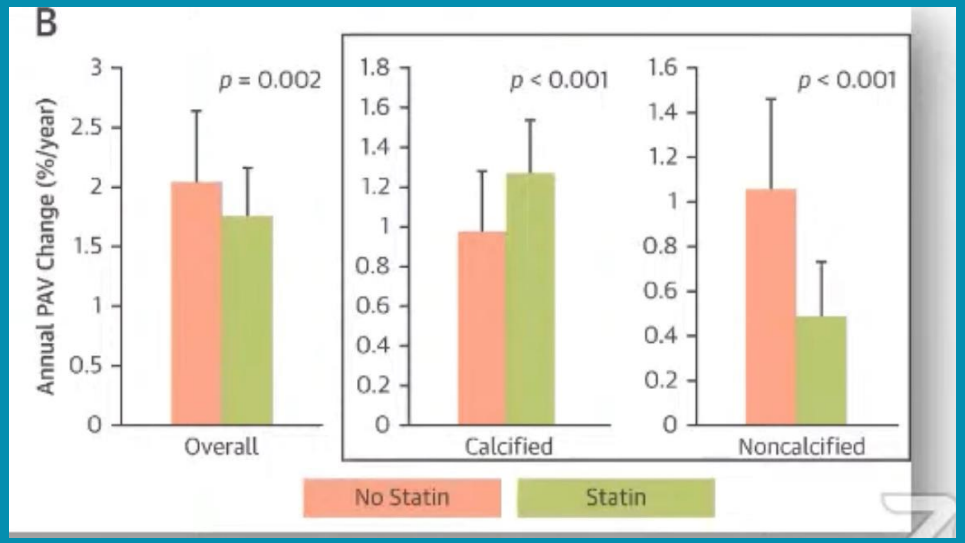
** To achieve an optional LDL-C target of <70 mg/dL.*
*** Vascepa, Low dose Rivaroxaban, GLP1-RA, SGLT2i*

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]





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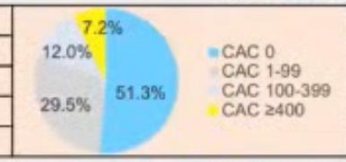
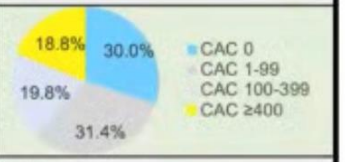
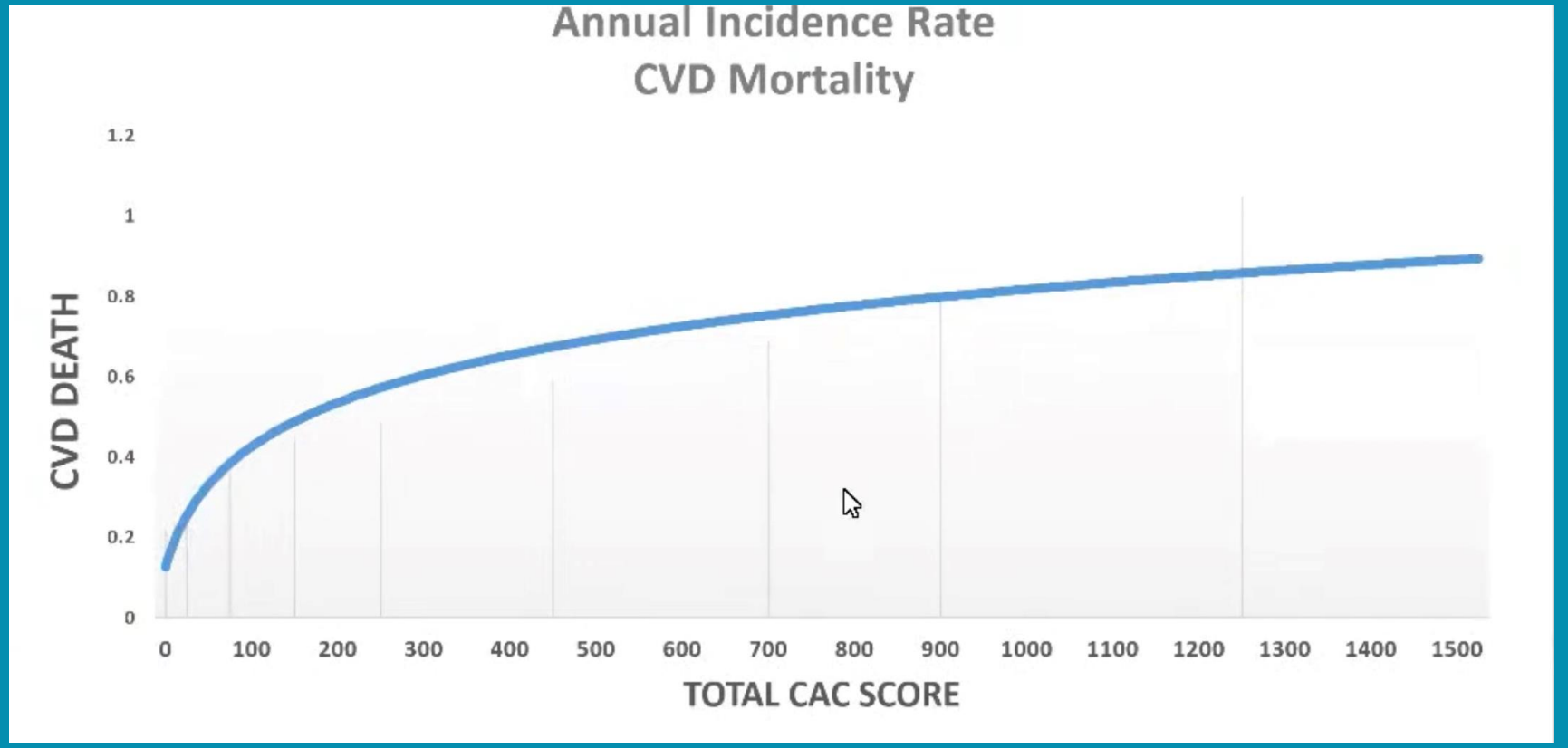
CAC – Predicts risk similarly in statin naïve and statin treated

Prognostic value of CAC score, area and density among individuals not on statin vs. on statin therapy

		NOT ON STATIN THERAPY		ON STATIN THERAPY	
Cohort characteristics					
N		21,874		6,151	
Mean age		54		57	
Women		38%		28%	
White		95%		94%	
Mean CAC score		107 +/- 332		281 +/- 664	
Mortality event rates (per 1000 person-years) and Hazard ratios					
		Mortality event rate	Hazard ratio (95% CI)	Mortality event rate	Hazard ratio (95% CI)
CHD Mortality	CAC 0	0.1	Reference	0.3	Reference
	CAC 1-99	0.3	3.4 (1.5, 7.5)	0.5	0.9 (0.3, 2.7)
	CAC 100-399	0.5	4.5 (1.9, 10.8)	0.8	1.1 (0.4, 3.1)
	CAC ≥400	1.9	13.1 (5.6, 30.3)	2.5	2.2 (0.8, 5.9)
CVD Mortality	CAC 0	0.3	Reference	0.6	Reference
	CAC 1-99	0.8	1.8 (1.2, 2.8)	1.1	1.3 (0.6, 2.7)
	CAC 100-399	1.2	2.0 (1.2, 3.3)	1.7	1.5 (0.7, 3.2)
	CAC ≥400	4.0	5.3 (3.3, 8.6)	3.9	2.4 (1.2, 5.1)
Association of CAC components with CHD and CVD mortality among participants with CAC >0					
		Age and sex + volume **OR** density score adjusted		Age and sex + volume **OR** density score adjusted	
CHD Mortality	Ln (Volume score), per SD	2.3 (1.6, 3.1)		2.5 (1.6, 3.8)	
	Density score, per SD	0.69 (0.49, 0.95)		1.1 (0.7, 2.0)	
CVD Mortality	Ln (Volume score), per SD	1.8 (1.4, 2.2)		1.9 (1.4, 2.6)	
	Density score, per SD	0.78 (0.63, 0.97)		0.9 (0.6, 1.3)	

Osei et al.
Atherosclerosis. 2020



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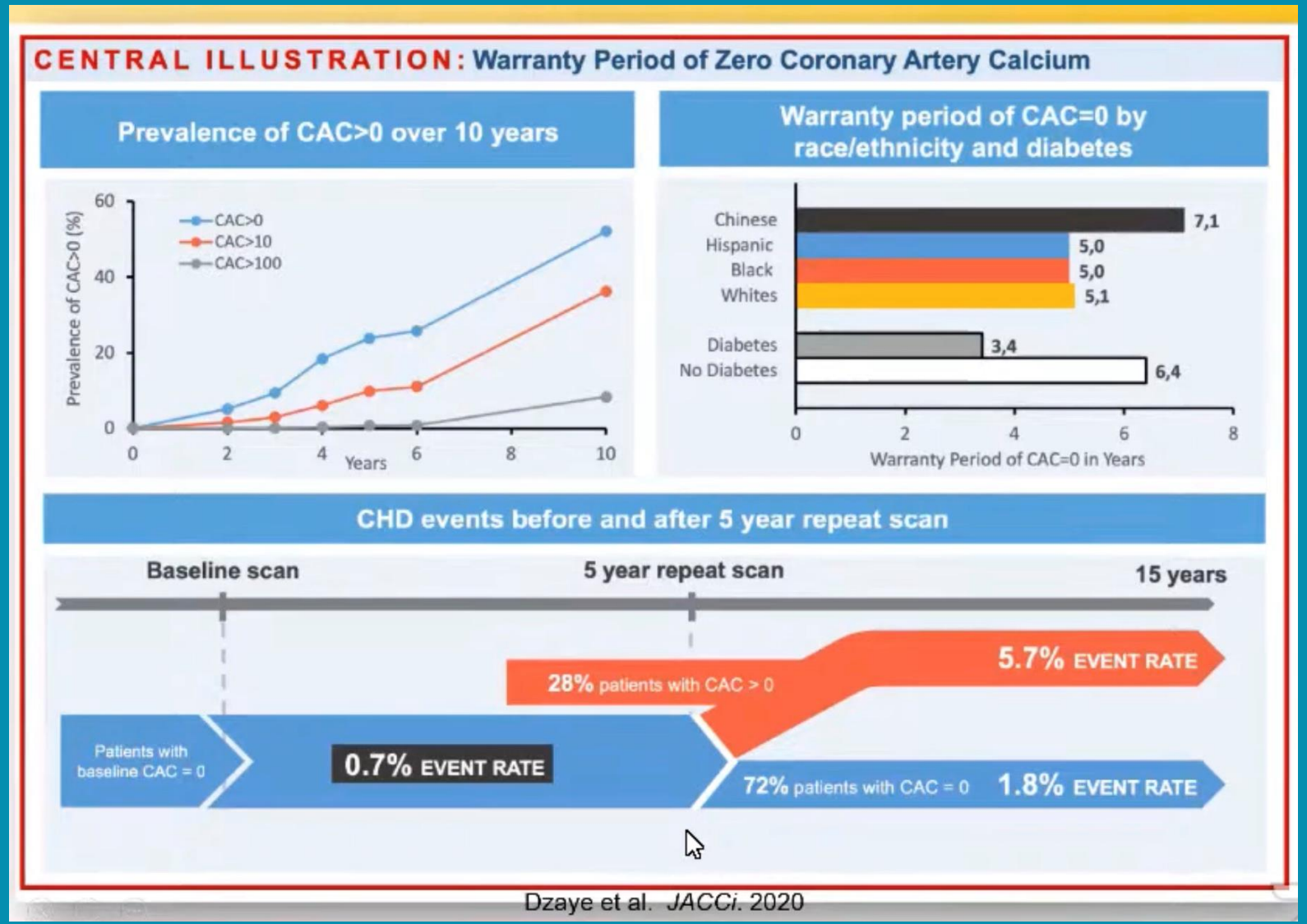

Dzaye et al. *JACCi*. 2020

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The MESA CHD Risk Score

A. MESA 10-Year CHD risk in an individual without CAC but with 3 traditional risk factors

MESA 10-Year CHD Risk with Coronary Artery Calcification

Back to CAC Tools

Gender	Male ●	Female ○
Age (45-85 years)	60	Years
Coronary Artery Calcification	0	Agatston

Race/Ethnicity — **Choose One**

Caucasian	●
Chinese	○
African American	○
Hispanic	○

Diabetes	Yes ●	No ○	
Currently Smoke	Yes ●	No ○	
Family History of Heart Attack	Yes ○	No ●	History in parents, siblings, or children
Total Cholesterol	155	mg/dL	
HDL Cholesterol	55	mg/dL	
Systolic Blood Pressure	140	mmHg	
Lipid Lowering Medication	Yes ○	No ●	
Hypertension Medication	Yes ●	No ○	

Calculate 10-year CHD risk

The estimated 10-year risk of a CHD event for a person with this risk factor profile including coronary calcium is 4.8%. The estimated 10-year risk of a CHD event for a person with this risk factor profile if we did not factor in their coronary calcium score would be 14.6%.

B. MESA 10-Year CHD risk in a individual with CAC=260 but without traditional risk factors

MESA 10-Year CHD Risk with Coronary Artery Calcification

Back to CAC Tools

Gender	Male ●	Female ○
Age (45-85 years)	60	Years
Coronary Artery Calcification	260	Agatston

Race/Ethnicity — **Choose One**

Caucasian	●
Chinese	○
African American	○
Hispanic	○

Diabetes	Yes ○	No ●	
Currently Smoke	Yes ○	No ●	
Family History of Heart Attack	Yes ○	No ●	History in parents, siblings, or children
Total Cholesterol	165	mg/dL	
HDL Cholesterol	60	mg/dL	
Systolic Blood Pressure	130	mmHg	
Lipid Lowering Medication	Yes ○	No ●	
Hypertension Medication	Yes ○	No ●	

Calculate 10-year CHD risk

The estimated 10-year risk of a CHD event for a person with this risk factor profile including coronary calcium is 7.6%. The estimated 10-year risk of a CHD event for a person with this risk factor profile if we did not factor in their coronary calcium score would be 3.7%.

Case Asymptomatic Patient

- 55 year old male with strong family history of CAD , asymptomatic, non-diabetic, healthy lifestyle exercises regularly
- BP 135/85 , HDL 45, LDL 145
- Pooled Cohort risk ASCVD
  - 6.4% 10 year risk of ASCVD
- CAC score is 325 (95th Percentile)
- MESA 10 year risk 12.8% with CAC, 2.8% with CAC = 0

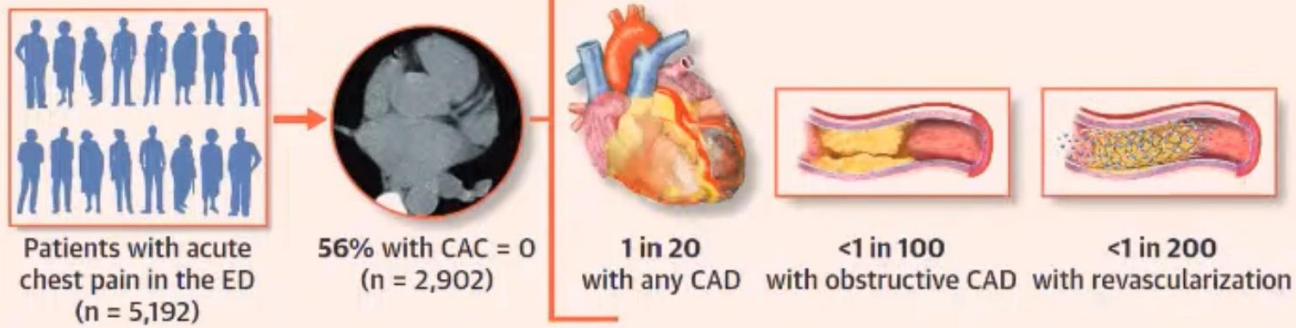
MESA Coronary Age Calculator

55-year old White Man
Total Cholesterol 225 mg/dL
HDL 60 mg/dL
SBP 139 mmHg
Family History of CHD
CAC=300

10-Year Risk Without CAC = 6.7%
10-Year Risk With CAC = 13.8%

Actual Age = 55
Age Without CAC = 61
Age With CAC = 77

CENTRAL ILLUSTRATION CAC = 0 for Diagnosing CAD in Low-to Intermediate-Risk Patients With Chest Pain in the Emergency Department



Diagnostic Accuracy of CAC in Acute Chest Pain	Advantages of CAC Assessment
99.3% Negative Predictive Value	Easy to perform and interpret; Lower costs; No contrast
264 Number Needed to Test	Widely available; Low radiation exposure; Prevents unnecessary testing

Grandhi, G.R. et al. J Am Coll Cardiol Img. 2021;■(■):■-■.

CAC = 0 was common among low- to intermediate-risk patients presenting to emergency department with CP and rules out obstructive CAD (≥50 stenosis) on CCTA with a negative predictive value of 99.3%. The number needed to test with CCTA among those with CAC = 0 to detect 1 patient requiring revascularization was 264. ED = emergency department; other abbreviations as in Figure 1.

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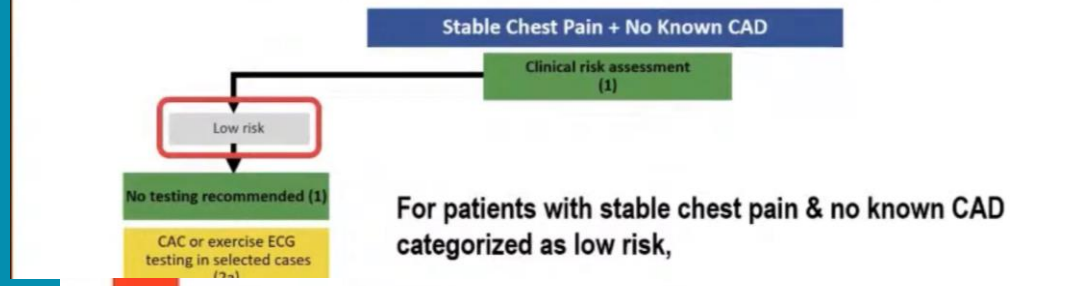
Figure 12. Clinical Decision Pathway for Patients With Stable Chest Pain & No Known CAD



For patients with stable chest pain & no known CAD categorized as low risk,

For patients with stable chest pain & no known CAD categorized as low risk,

2a	B-R	2. CAC testing is reasonable as a first-line test for excluding calcified plaque and identifying patients with a low likelihood of obstructive CAD.
2a	B-NR	3. Exercise testing without imaging is reasonable as a first-line test for excluding myocardial ischemia and determining functional capacity in patients with an interpretable ECG.

Conclusions

- CAC- Guideline endorsed, ready for prime time
- Can guide treatment decisions not just with statins
- Several Ongoing RCTs