The Nuts and Bolts of Coronary Artery Calcium Scoring

Lauren A. Weber, MD, FACC

General Cardiology Wenatchee Valley Medical Group

Co-Founder, Lead of Strategy for All Levels Leadership

Disclosures

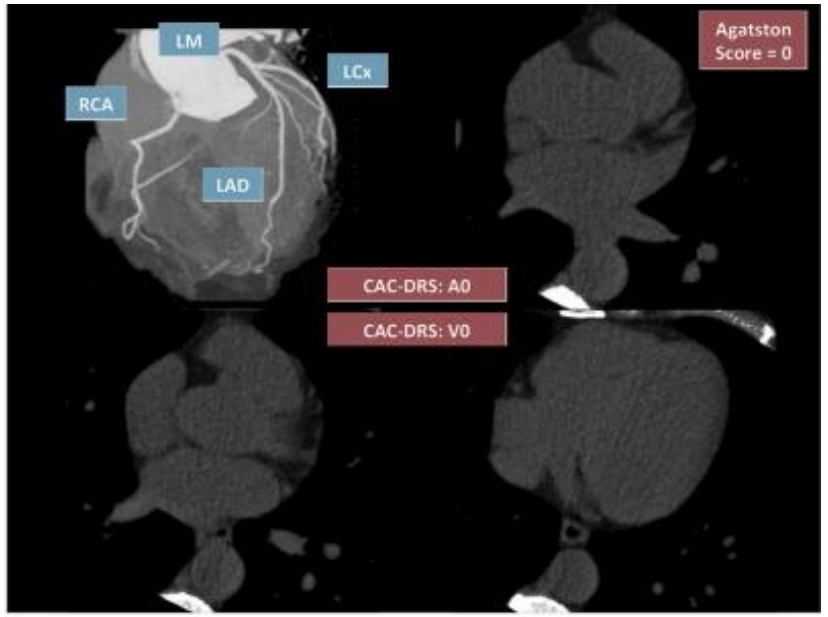
- **None**
- ***Warning*: I'm highly biased to calcium scoring and CCTA ☺**

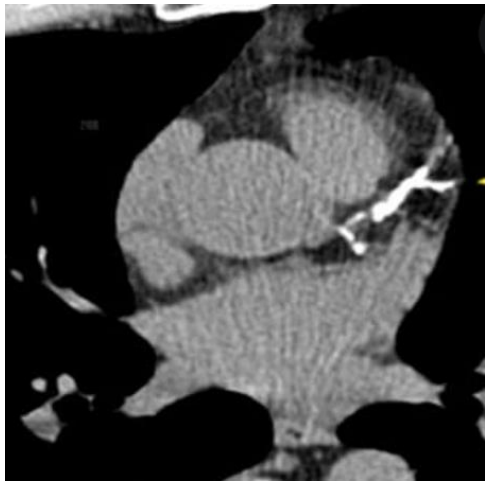
Outline

- What is a coronary artery calcium (CAC) score?
- What's the cost/benefit ratio profile?
- Data review
- Who should be considered for CAC scoring?
- CAC scores in clinical practice
- Non-coronary calcium (the cheat code)
- What about CCTA

What is a CAC Score?

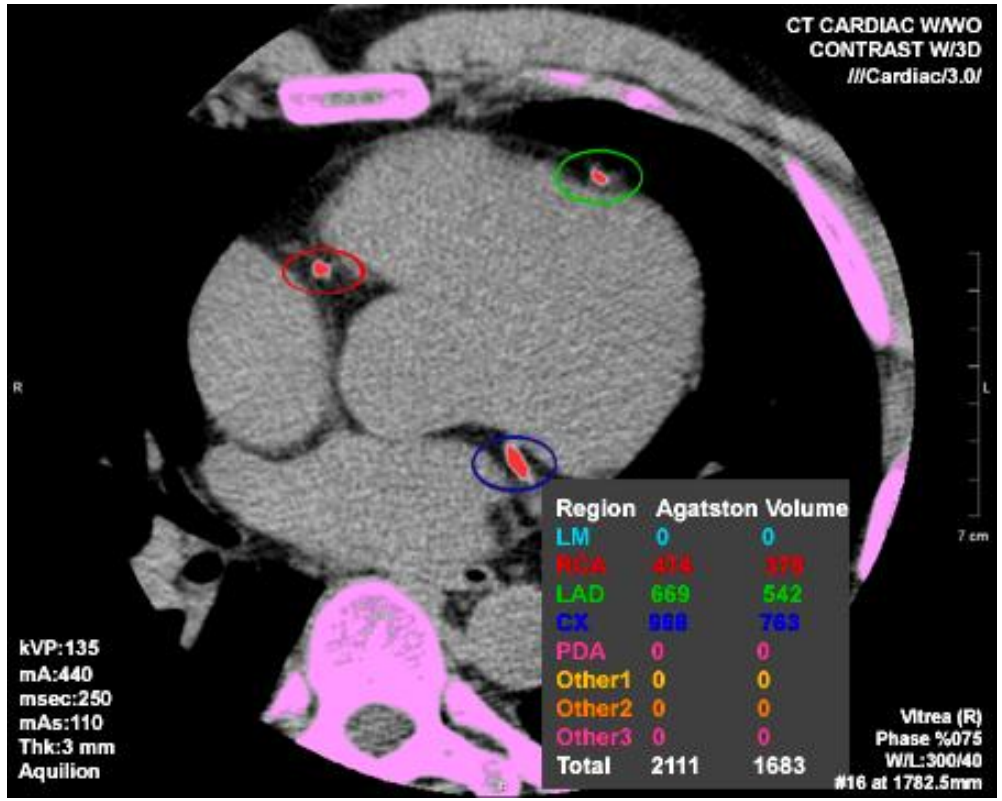
- Obtained from a non-contrast gated or non-gated CT of the chest
- An objective measure of calcified coronary atherosclerosis- confirmed by pathologic studies.
  - Atherosclerosis consists of a lipid core that over time calcifies making it detectable by CT imaging.
- Over 25 years old
  - First guideline for CAC scoring use in clinical care was in 1999
- Reproducible and easy to do
- Radiation doses ~1mSv
- One of the strongest predictors for *individual* long term ASCVD risk
- *"A CAC score of 0 is the strongest negative risk marker in clinical practice"*





How is it done

- CAC scores any pixel above 130 HU with an area of at least 1mm^2
- Summed score for each vessel is calculated
  - AoV, aortic annulus, aorta, MV and MV annulus, and the pericardium are excluded
- ***Agatston*** and volumetric score can both be used and reported
- Total CAC in all coronary lesions as well as a percentile compared with population with the same age and gender.
  - Calcium in other portions of the heart should be noted.



Calcium scoring systems

Agatston calcium score
Total score: 120
Left main: 0
Left anterior descending: 32
Left circumflex: 28.9
Right coronary artery: 59.1

The observed calcium score of 120 is at the 37th percentile for subjects of the same age, gender, and race/ethnicity who are free of clinical cardiovascular disease and treated diabetes.

- **Agatston score= calcified plaque area x maximum calcium lesion density (1-4 based on HU)**
  - **Density factor**
    - **130-199 HU: 1**
    - **200-299 HU: 2**
    - **300-399 HU: 3**
    - **400+ HU: 4**

- **CAC score = 0, very low risk**
- **CAC 1-99 = mildly increased**
- **CAC 100-299 = moderately increased**
- **CAC 300-1000 = moderately to severely increased**
- **CAC > 1000 = severely increased risk**

Calcium density goes up with time!

Cost

- Usually not covered by insurance
- Out of pocket expense of $50-350 across the country, estimated national average around $100.00- 150.00.
- Several cost-effective analysis have been conducted with findings of a CAC guided approach to statin therapy.

CAC Scores and ASCVD Risk

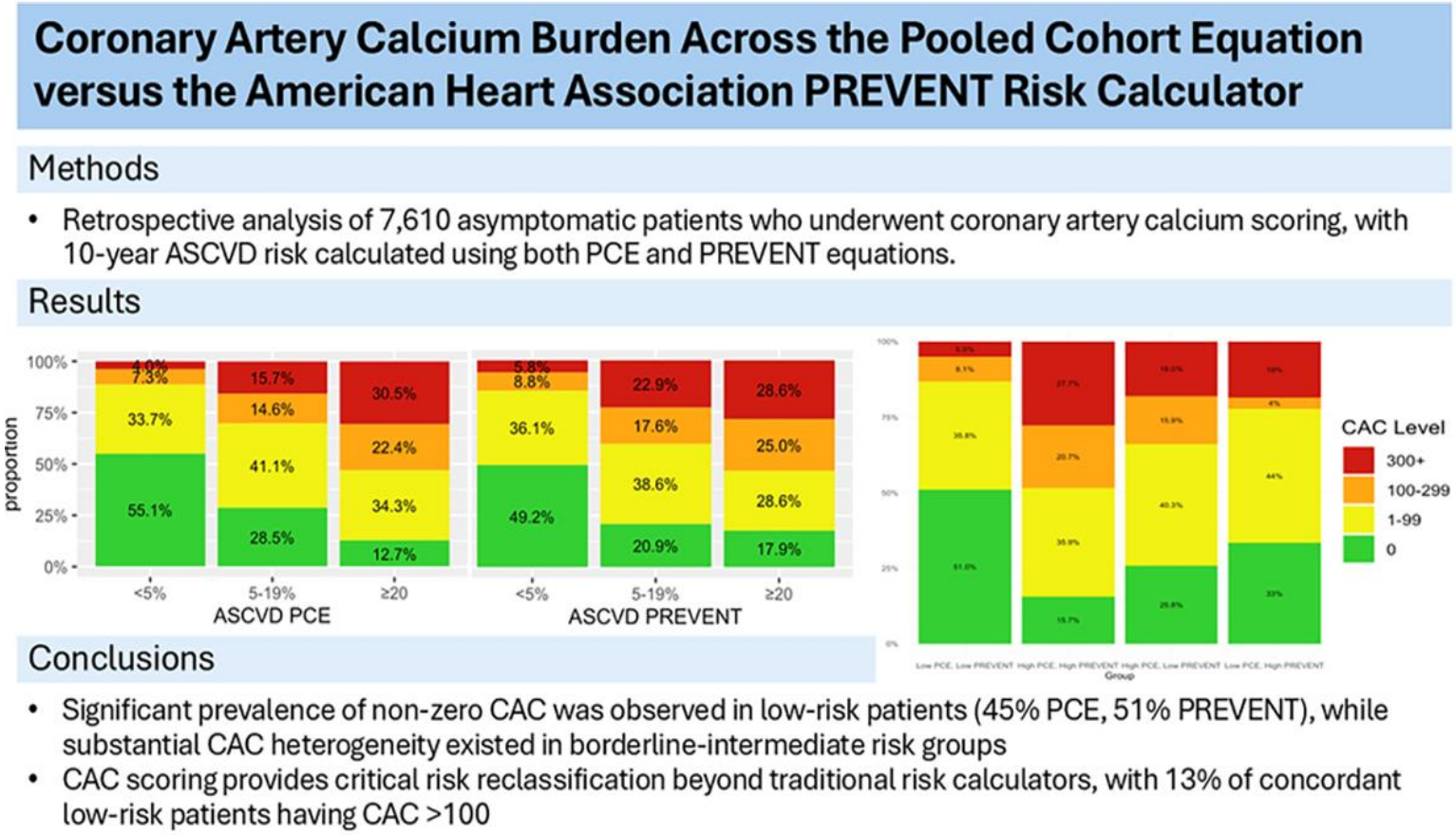
Some Flaws of Population Based Risk

- **Most risk calculators (DF, FRS, CASS, ASCVD, ESC-PTP) have been critiqued for overestimating the prevalence of obstructive coronary disease.**
- **Early critiques of the PREVENT risk calculator is there is possible underestimation of ASCVD risk.**
- **Some patients with unaccounted for risk factors are underestimated.**
- **Yet, these are the scores we use to screen for treatment benefit across a <u>population</u>.**
- **For some patients, an assessment of *individual* risk is warranted.**
- **Calcium scoring provides additional risk assessment to traditional calculators or markers.**

Coronary artery calcium burden across the pooled cohort equation versus the American Heart Association PREVENT risk calculator

Gabrielle S. Gershon [a], Jaret R. Barr [a], Alexander C. Razavi [b], Yan Yang [a], Eshan Momin [a], Omar Dzaye [c], Seamus P. Whelton [c], Michael J. Blaha [c], Roger S. Blumenthal [c], Laurence S. Sperling [b], Carlo N. De Cecco [a], Marly van Assen [a,*]

- Retrospective cohort of 7610 asymptomatic patients (no history of CVD) who underwent clinically indicated CAC scoring between 2010 and 2023.
- 10-year ASCVD and PREVENT scores were calculated and compared across all risk groups.
- Mean age 57 +/- 9 years, 41% women, 11% identified as Black



Gabrielle S. Gershon, Jaret R. Barr, Alexander C. Razavi, Yan Yang, Eshan Momin, Omar Dzaye, Seamus P. Whelton, Michael J. Blaha, Roger S. Blumenthal, Laurence S. Sperling, Carlo N. De Cecco, Marly van Assen, Coronary artery calcium burden across the pooled cohort equation versus the American Heart Association PREVENT risk calculator, American Journal of Preventive Cardiology, Volume 24, 2025, 101301, ISSN 2666-6677, https://doi.org/10.1016/j.ajpc.2025.101301. (https://www.sciencedirect.com/science/article/pii/S2666667725003769)

Does Coronary Calcium Matter?

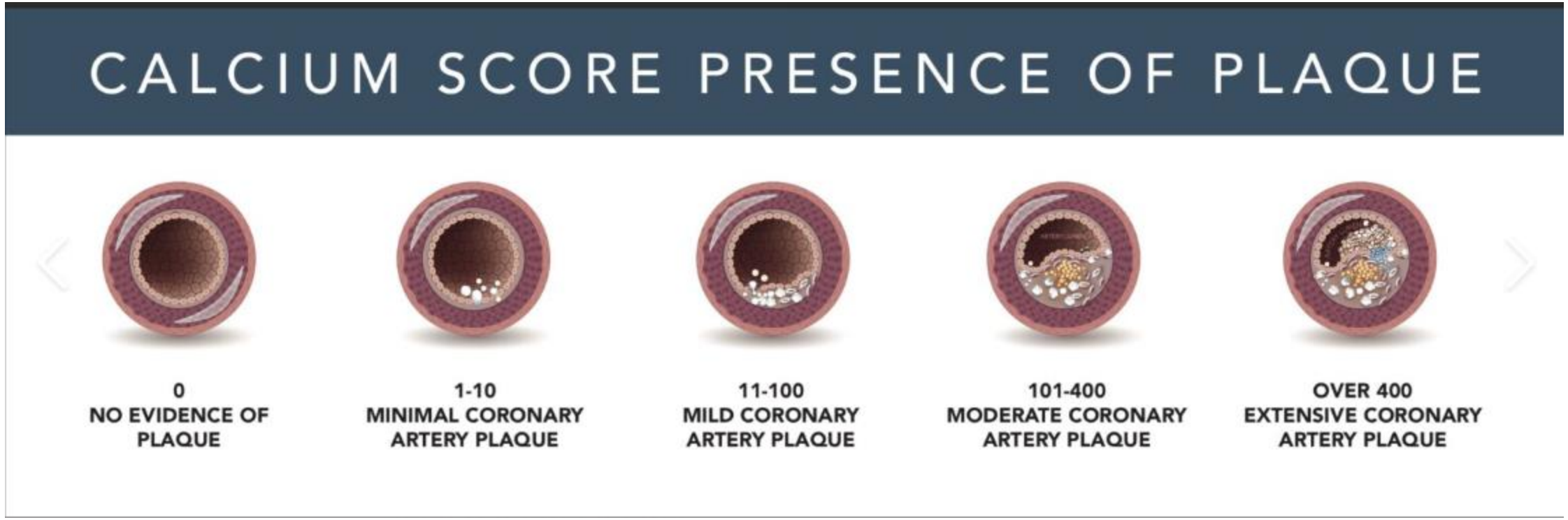


Table 2. *Summary of major prospective CACS studies*

Study name	Prospective army coronary calcium project [15]	Rotterdam coronary calcification study [16]	Multi-ethnic study of atherosclerosis [8]	Heinz Nixdorf recall study [9]	Coronary artery risk development in young adults study [7]
Study type	Prospective, observational	Prospective, observational	Prospective, observational	Prospective, observational	Prospective, observational
Cardiovascular risk factors	Measured	Measured	Measured	Measured	Measured
Main study aim	Assess independent incremental prognostic value of CAC in CAD outcomes in nonreferred patients	Assess prognostic value of CAC for cardiovascular events and mortality in asymptomatic elderly patients	Assess the relationship between CAC and future coronary events in four major racial groups	Evaluate improvement in predicting risk for hard coronary events with the addition of CACS to traditional risk factors	Determine if CAC in adults aged 32–46 years is associated with clinical CAD development
Sample size	1983	1795	6722	4129	3043
M : F (%)	82.0 : 18.0	42.5 : 57.5	47.2 : 52.8	47.0 : 53.0	45.4 : 54.6
Age, years[a]	42.9 ± 2.8	71.1 ± 5.7	62.2 ± 10.2	59.4 ± 7.7	40.3 ± 3.6
Follow-up duration, years[a]	3.0 ± 1.4	3.3 ± 0.8	3.9 (max 5.3)	5.1 ± 0.3	12.5 (SD N/A)
Outcome event definition	CAD: sudden cardiac death, MI, unstable angina	Hard CAD: MI, CAD mortality; CVD: MI, stroke, revascularization, cardiovascular mortality)	Major CAD events: MI, CAD death; coronary events: major CAD events, definite or probable angina	Hard cardiovascular events: nonfatal MI, coronary death	CAD events: MI, acute coronary syndrome, CAD death, revascularization
Analysis method	Agatston	Agatston	Agatston	Agatston	Agatston
Other results	Any CAC was associated with an 11.8-fold increased risk for CAD	Adding CACS to multivariate model of age, sex, and cardiovascular risk factors for CAD events improved AUC from 0.749 to 0.774, $P < 0.02$)	(1) A 7-fold increase in risk for any event amongst those with CACS > 100 vs. 0; (2) For each racial group, doubling of CACS increased the risk for a major event by 15–35% (and for any event by 18–39%)	Adding CACS to FRS scores improved the AUC from 0.681 to 0.749, $P < 0.003$; CACS = 0 has excellent prognosis, event rate of 0.16%/year	Any measurable CAC was associated with a 5-fold increase in fatal and nonfatal CAD events

Cheong B, Wilson J, Spann J, et al. Coronary artery calcium scoring: an evidence-based guide for primary care physicians. J Intern Med 2021; 289:309-324.

ORIGINAL ARTICLE

Coronary Calcium as a Predictor of Coronary Events in Four Racial or Ethnic Groups

Robert Detrano, M.D., Ph.D., Alan D. Guerci, M.D., J. Jeffrey Carr, M.D., M.S.C.E., Diane E. Bild, M.D., M.P.H., Gregory Burke, M.D., Ph.D., Aaron R. Folsom, M.D., Kiang Liu, Ph.D., Steven Shea, M.D., Moyses Szklo, M.D., Dr.P.H., David A. Bluemke, M.D., Ph.D., Daniel H. O'Leary, M.D., Russell Tracy, Ph.D., et al.

- **The MESA investigators examine prevalence, correlation, and progression of subclinical coronary disease among Caucasian, Black, Chinese, and Hispanic populations.**
- **6722 participants between 45-84**
- **No clinical ASCVD at enrollment, followed for a median of 3.9 years**
- **CAC > 0**
  - **70.4% white men 44.7% white women**
  - **52% black men 37% black women**
  - **56.6% Hispanic men 34.8% Hispanic women**
  - **59.2% Chinese men 41.9% Chinese women**

Detran R, Guerci A, Carr J, et al. Coronary Calcium as a Predictor of Coronary Events in Four Racial or Ethnic Groups. N Engl J Med 2008; 358:1336-1345.

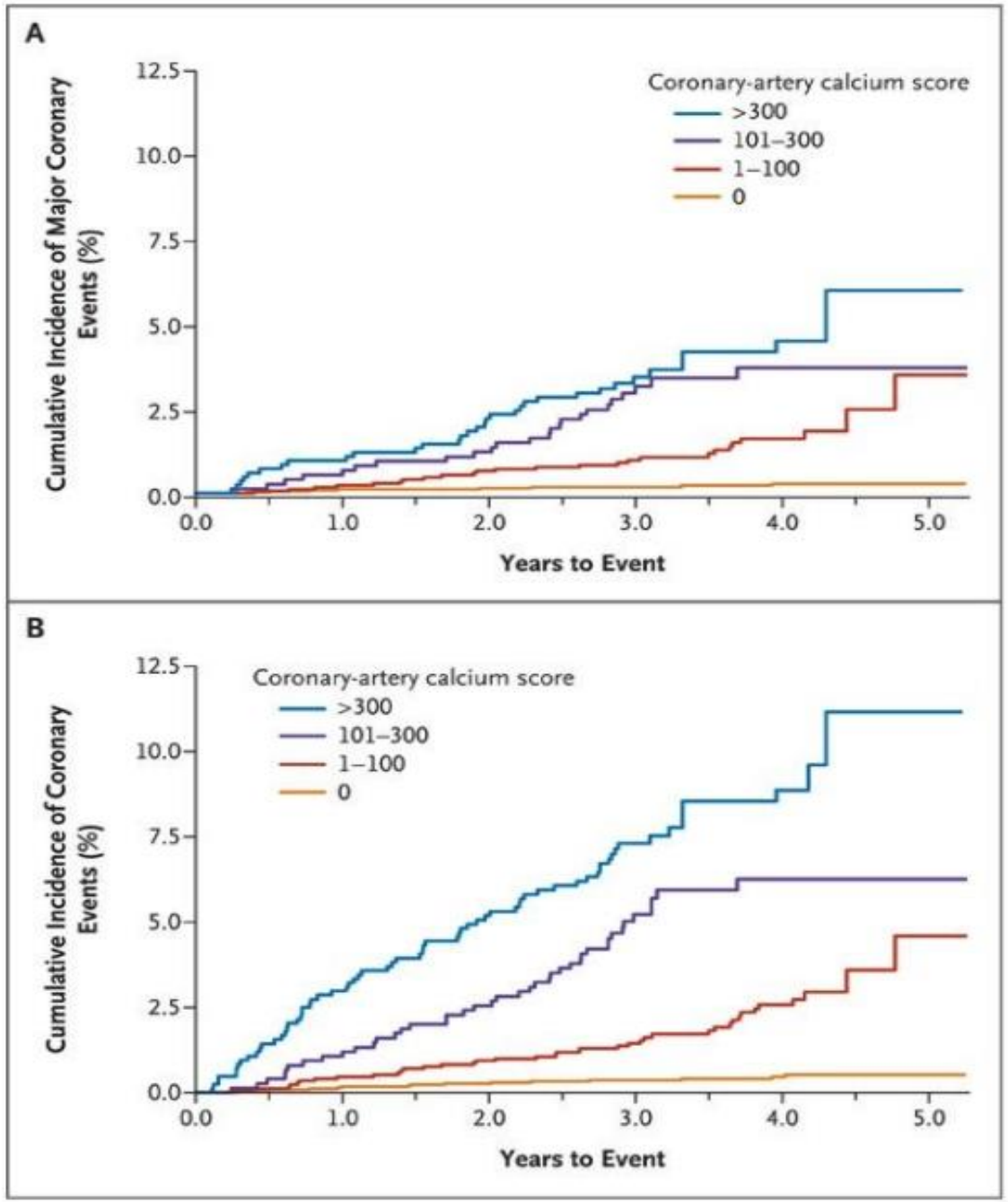


Table 4. Risk of Coronary Heart Disease Associated with Coronary-Artery Calcium Score in Four Racial or Ethnic Groups.*

Racial or Ethnic Group	Major Coronary Event†			Any Coronary Event		
	No.	Hazard Ratio (95% CI)‡	P Value	No.	Hazard Ratio (95% CI)‡	P Value
White	41	1.17 (1.06–1.30)	<0.005	74	1.22 (1.13–1.32)	<0.001
Chinese	6	1.25 (0.95–1.63)	0.11	14	1.36 (1.12–1.66)	<0.005
Black	18	1.35 (1.16–1.57)	<0.001	38	1.39 (1.25–1.56)	<0.001
Hispanic	24	1.15 (1.02–1.29)	<0.025	36	1.18 (1.07–1.30)	<0.001

JAMA Network | Open

Original Investigation | Cardiology

Association of Coronary Artery Calcium With Long-term, Cause-Specific Mortality Among Young Adults

Michael D. Miederma, MD, MPH; Zeina A. Dardari, MS; Khurram Nasir, MD; Ron Blankstein, MD; Thomas Knickelbine, MD; Sandra Oberembt, PA-C; Leslee Shaw, PhD; John Rumberger, MD, PhD; Erin D. Michos, MD, MHS; Alan Rozanski, MD; Daniel S. Berman, MD; Matthew J. Budoff, MD; Michael J. Blaha, MD, MPH

- **Aim to assess CHD risk, CVD risk, and all-cause mortality in individuals aged 30-49 based on CAC score.**
- **Multicenter, retrospective cohort**
- **22,346 participants**
  - **75% men**
  - **CAC prevalence of 34.4%**
  - **7.2% had a CAC > 100**
- **Mean follow up 12.7 years**
- **298 total deaths**
  - **40 CHD**
    - **67.5% of these had a CAC at baseline**
  - **84 CVD**
- **CHD mortality/1000 person years was 10x higher in those with +CAC compared to those with CAC of zero.**

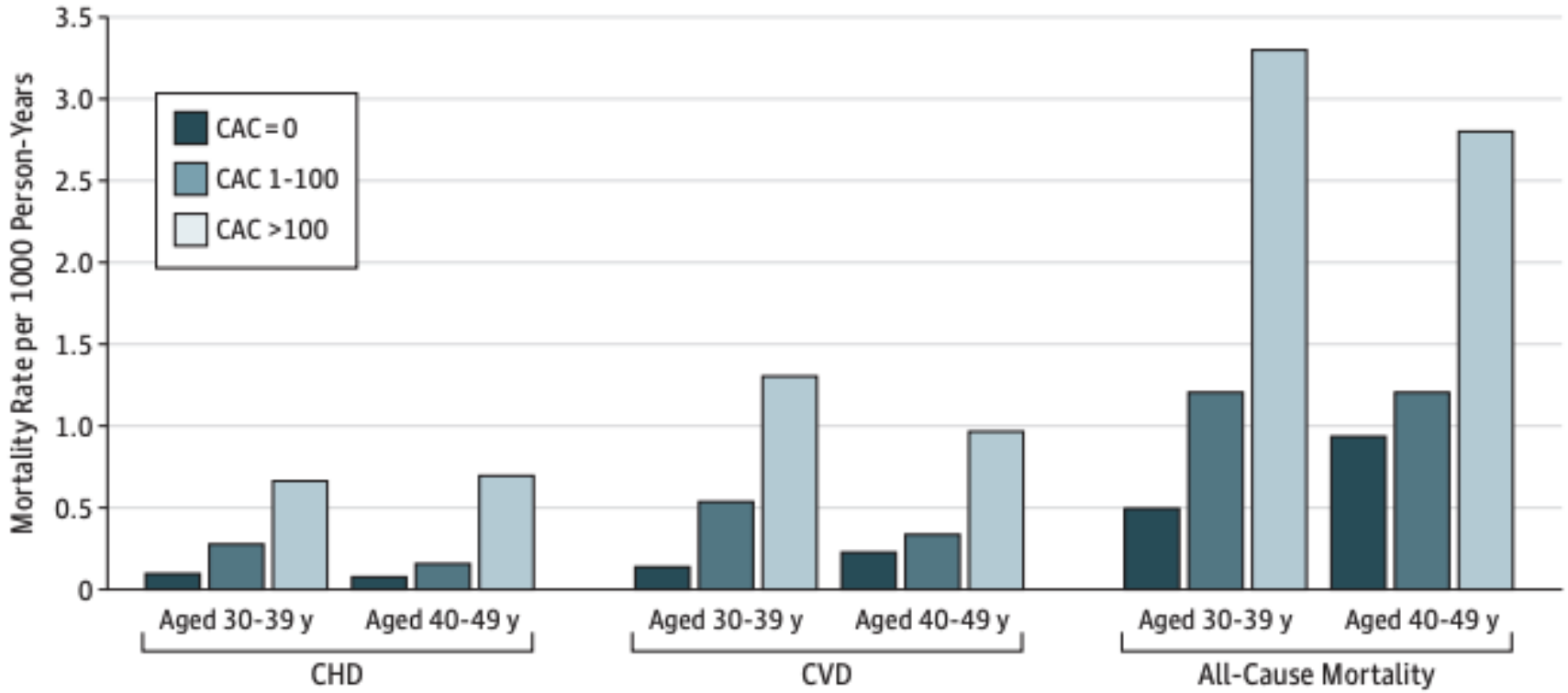
Miederma M, Dardari Z, Nasir K, et al. Association of Coronary artery calcium with long-term, cause-specific mortality among young adults. JAMA Network Open. 2019;2(7):e197440

Table 1. Baseline Characteristics and Estimated 10-Year CVD Risk Among 22 346 Asymptomatic Individuals Aged 30 to 49 Years From the CAC Consortium

Characteristic	Individuals, No. (%)			*P* Value
	All (N = 22 346)	Women (n = 5576)	Men (n = 16 770)	
Age, mean (SD), y	43.5 (4.5)	44.0 (4.4)	43.3 (4.6)	<.001
Race/ethnicity, No./total No. (%)				
White	12 007/13 696 (87.7)	3123/3657 (85.4)	8884/10 039 (88.5)	<.001
Asian	591/13 696 (4.3)	181/3657 (4.9)	410/10 039 (4.1)	
Black	316/13 696 (2.3)	114/3657 (3.1)	202/10 039 (2.0)	
Hispanic	520/13 696 (3.8)	175/3657 (4.8)	345/10 039 (3.4)	
Other	262/13 696 (1.9)	64/3657 (1.8)	198/10 039 (2.0)	
Current smoker	2466 (11.0)	646 (11.6)	1820 (10.9)	.13
Hypertension	4496 (20.1)	1045 (18.7)	3451 (20.6)	.003
Hyperlipidemia	11 082 (49.6)	2346 (42.1)	8736 (52.1)	<.001
Diabetes	882 (3.9)	236 (4.2)	646 (3.9)	.21
Family history of CHD	11 006 (49.3)	3123 (56.0)	7883 (47.0)	<.001
CVD risk, mean (SD)				
Lifetime	42 (9.0)	34 (7.0)	44 (9.0)	<.001
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10-y categories				
<5%	20 709 (92.7)	5454 (97.8)	15 255 (91.0)	<.001
5%-7.5%	1049 (4.7)	90 (1.6)	959 (5.7)	
[illegible]	[illegible]	[illegible]	[illegible]	

Table 3. Prevalence of Traditional CVD Risk Factors and Subsequent Mortality According to Baseline CAC Score Among 22 346 Asymptomatic Individuals Aged 30 to 49 Years From the CAC Consortium

B Rates of CHD, CVD, and all-cause mortality



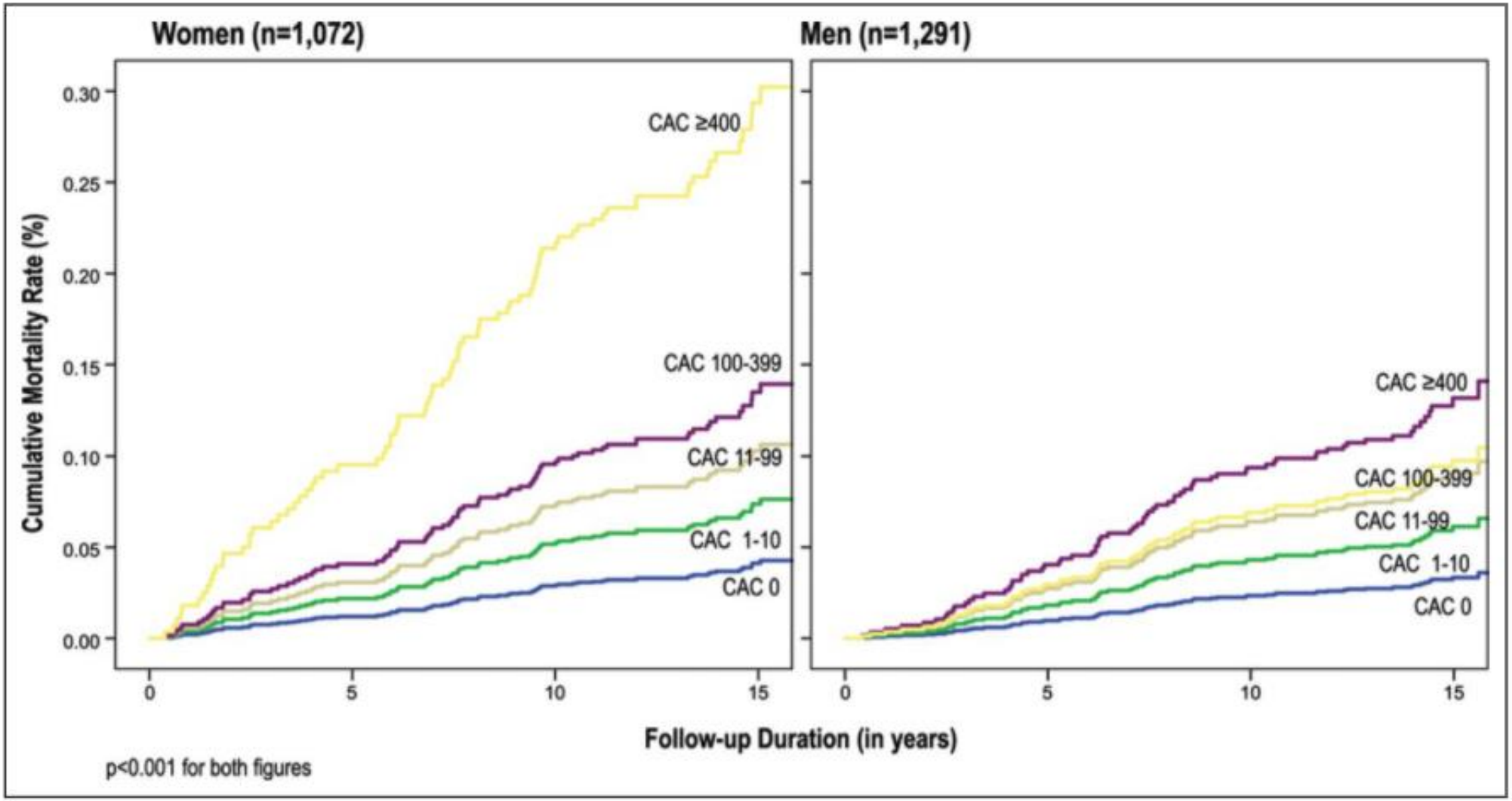
No. (%)	151 (1.0)	90 (1.5)	57 (3.5)	<.001
Rate (95% CI)[b]	0.82 (0.70-0.96)	1.23 (0.94-1.40)	2.81 (2.22-3.63)	

Long-Term Prognosis After CAC scoring among low-intermediate risk women and men

- We know women can have underestimation of their CVD risk by traditional calculators
- 2363 asymptomatic men and women with low-intermediate ASCVD risk (6-9.9% 10 year predicted)
- Followed for a median of 14.6 years

Table 1. Prevalence of Traditional Risk Factors and CAC Score Strata Among Women and Men With a Low-Intermediate Estimated Framingham Risk Score (Table view)

	Women (n=1072)	Men (n=1291)	*P* Value
Age, mean (95% CI)	55.6 (55.0–56.2)	46.7 (46.4–47.1)	<0.001
Age (by deciles), %			
<40 (n=173)	0.2	13.2	<0.001
40–49 (n=1024)	33.0	51.9	
50–59 (n=829)	39.6	31.3	
60–69 (n=187)	13.2	3.6	
≥70 (n=150)	14.0	0.0	
Hypertension (n=648), %	34.0	21.9	<0.001
Dyslipidemia (n=1082)	42.6	48.4	0.005
Diabetes mellitus (n=73)	3.6	2.5	0.141
Current smoker (n=660)	31.1	25.3	0.002
Family history of CAD (n=1586)	68.3	66.2	0.272
CAC scores, %			
0 (n=1333)	54.7	57.9	0.029
1–10 (n=209)	8.6	9.1	
11–99 (n=425)	18.0	18.0	
100–399 (n=264)	12.5	10.1	
≥400 (n=132)	6.3	5.0	


Women (n=1,072)
Men (n=1,291)
Cumulative Mortality Rate (%)
0.30
0.25
0.20
0.15
0.10
0.05
0.00
CAC ≥400
CAC 100-399
CAC 11-99
CAC 1-10
CAC 0
0
5
10
15
Follow-up Duration (in years)
p<0.001 for both figures

Non-traditional & Pregnancy Related Risk Factors

- Women veterans
  - Homelessness
    - 4-fold increased compared to civilian women
  - Sexual trauma
    - 40% of women veterans compared to 17% of civilian women
  - Mental illness
  - PTSD
    - Rates women veterans (17%) > male veterans (12.3%) >> civilian women (5.2%)

1.8 to 4.0- fold increased risk for future CVD

TABLE 1 Complications During Pregnancy That Are Associated With Increased Cardiovascular Disease Risk

Adverse Pregnancy Outcomes	Definition
Hypertensive disorders of pregnancy	This category includes gestational hypertension, chronic hypertension, and pre-eclampsia
Gestational hypertension	New-onset hypertension (SBP ≥140 mm Hg or DBP ≥90 mm Hg) after 20 weeks gestation
Pre-eclampsia	New-onset hypertension (SBP ≥140 mm Hg or DBP ≥90 mm Hg) after 20 weeks gestation with proteinuria or evidence of end-organ dysfunction
Chronic (pre-existing) hypertension	Hypertension present prior to 20 weeks gestation
Gestational diabetes	Glucose intolerance with onset or first recognition during pregnancy
Pre-term birth	Delivery before 37 weeks gestation
Early pre-term birth	Delivery before 34 weeks gestation
Pregnancy loss	Miscarriage or stillbirth
Intrauterine growth restriction	Fetal birthweight less than expected for the gestational age, ≤10th percentile

DBP = diastolic blood pressure; SBP = systolic blood pressure.

Early Onset of CAC in Women with Previous Preeclampsia

- 258 women between 40-63 with prior PE compared to 644 age-ethnicity-equivalent (FRS) women with normotensive pregnancies
- Any CAC was more prevalent with a PE than a normotensive pregnancy for women 45-50.
- CAC advanced faster for women between 45-50 if they had a history of PE
- CAC developed 5 years sooner from age 45+

Table 2. Prevalence of CAC Per Age Category in Women With a History of Preeclampsia and With Normotensive Pregnancies (Table view)

	Age categories			
	40–45 y	45–50 y	50–55 y	55–63 y
Previous preeclampsia	n=83	n=111	n=44	n=12
CAC (AU)	0.0 (0.0–11.4)	0.0 (0.0–85.6)*	0.0 (0.0–113.0)	0.0 (0.0–n/a)
CACS (n–%)†				
No CAC (0 AU)	77 (92.8)	85 (76.6)	31 (70.5)	7 (58.3)
Any CAC (>0 AU)	6 (7.2)	26 (23.4)*	13 (29.5)	5 (41.7)
Minimal CACS (1–10 AU)	1 (1.2)	6 (5.4)	4 (9.1)	0
Mild CACS (11–100 AU)	5 (6.0)	16 (14.4)	7 (15.9)	5 (41.7)
Moderate CACS (101–400 AU)	0	4 (3.6)	2 (4.5)	0
Coronary plaque,‡ n (%)	11 (13.1)	52 (45.2)	19 (43.2)	6 (50.0)
Framingham Risk Score, %	4.10 (1.51–12.51)*	5.17 (2.32–12.15)*	7.25 (3.32–24.44)*	14.00 (3.89–n/a)*
No previous preeclampsia	n=254	n=206	n=123	n=56
CAC (AU)	0.0 (0.0–4.9)	0.0 (0.0–18.9)	0.0 (0.0–87.1)	0.0 (0.0–106.2)
CACS, n (%)				
No CAC (0 AU)	234 (92.1)	186 (90.3)	98 (79.7)	38 (67.9)
Any CAC (>0 AU)	20 (7.9)	20 (9.7)	25 (20.3)	18 (32.1)
Minimal CACS (1–10 AU)	11 (4.3)	9 (4.4)	9 (7.3)	5 (8.9)
Mild CACS (11–100 AU)	7 (2.8)	9 (4.4)	11 (8.9)	10 (17.9)
Moderate CACS (101–400 AU)	2 (0.8)	2 (1.0)	5 (4.1)	3 (5.4)
Coronary plaque,‡ n (%)	n/a	n/a	n/a	n/a
Framingham Risk Score, %	2.07 (0.90–5.61)	3.43 (1.43–8.69)	4.80 (1.83–15.65)	7.41(2.89–15.27)

Benschop L, Brouwers L, Zoet G, et al. Early Onset of Coronary Artery Calcification in Women with Previous Preeclampsia. Circulation: Cardiovascular Imaging. Volume 13, Issue 11, November 2020.

Does Coronary Calcium Matter?

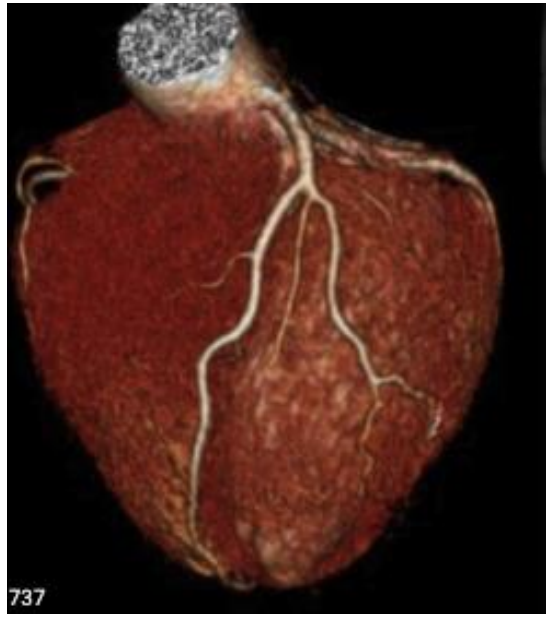
Yes.

The Power of Zero

JACC: CARDIOVASCULAR IMAGING
© 2015 BY THE AMERICAN COLLEGE OF CARDIOLOGY FOUNDATION
PUBLISHED BY ELSEVIER INC.
VOL. 8, NO. 8, 2015
ISSN 1936-878X/$36.00
http://dx.doi.org/10.1016/j.jcmg.2015.01.025

A 15-Year Warranty Period for Asymptomatic Individuals Without Coronary Artery Calcium

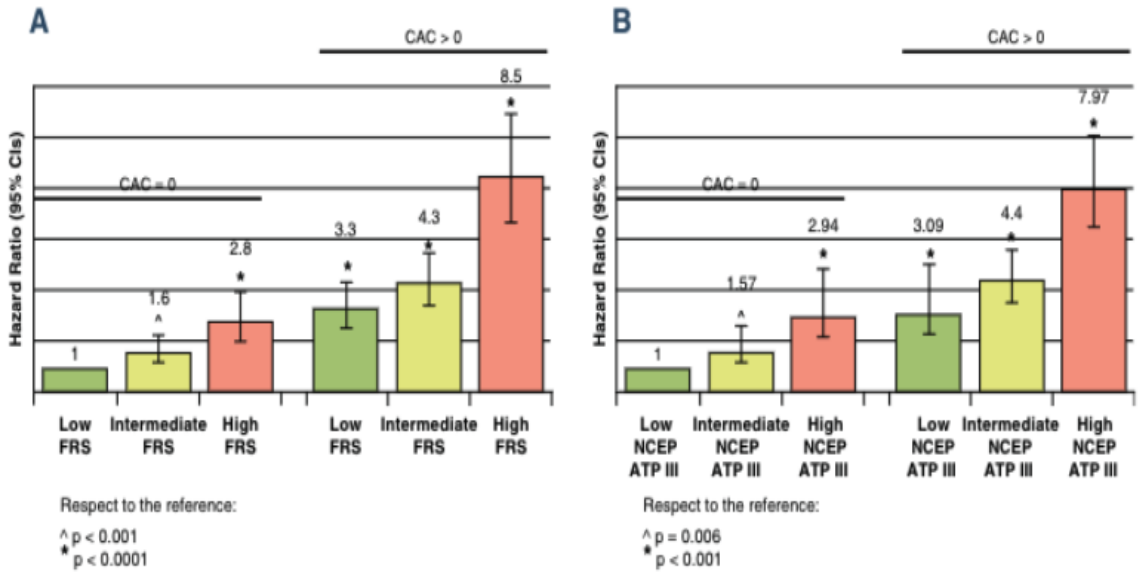
A Prospective Follow-Up of 9,715 Individuals



- **9,715 participants who had CAC scores**
- **4,864 participants with a CAC of zero**
  - **Mean age of 52, 57.9% men**
  - **229 deaths occurred during the mean follow-up period of 14.6 years**
- **A CAC of zero in those with low-intermediate risk had very low rates of death**
- ***Those with high risk who had CAC scores of 0 had better survival than than individuals at low to intermediate risk with any +CAC score*.**
- **Among those with +CAC, CAC score was the strongest predictor of death beyond FRS**

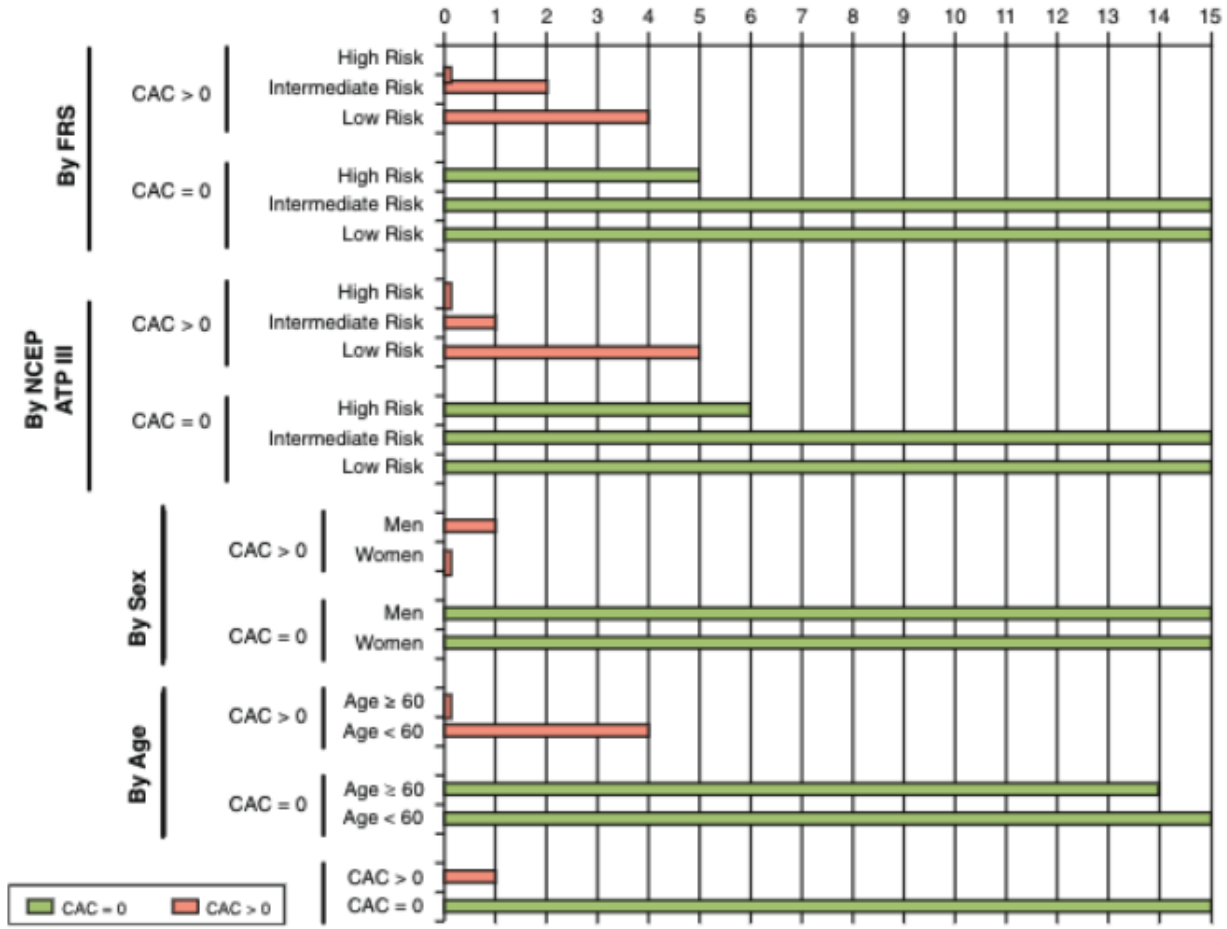
Valenti V, Hartaigh B, Heo R, et al. A 15-Year Warranty Period for Asymptomatic Individuals Without Coronary Artery Calcium: A Prospective Follow-Up of 9,715 Individuals. JACC: Cardiovascular Imaging. Volume 8, Issue 8, Aug 2015, pg 900-909.

FIGURE 2 Hazard Ratios for Risk of All-Cause Mortality



Hazard ratios for risk of all-cause mortality in individuals with and without CAC according to FRS **(A)** and NCEP ATP III **(B)**. CIs = confidence intervals; other abbreviations as in Figure 1.

FIGURE 4 Observed Warranty Period for the Absence of CAC Compared With the Presence of CAC



Observed warranty period (time to exceed 1% risk) for a CAC score of 0 compared with the presence of any CAC during 15 years of follow-up in 9,715 asymptomatic individuals stratified by CAC score, age, sex, FRS, and NCEP ATP III. Abbreviations as in Figure 1.

Valenti V, Hartaigh B, Heo R, et al. A 15-Year Warranty Period for Asymptomatic Individuals Without Coronary Artery Calcium: A Prospective Follow-Up of 9,715 Individuals. JACC: Cardiovascular Imaging. Volume 8, Issue 8, Aug 2015, pg 900-909.

So we're good right?

JACC: CARDIOVASCULAR IMAGING VOL. 14, NO. 5, 2021

PUBLISHED BY ELSEVIER

ORIGINAL RESEARCH

Warranty Period of a Calcium Score of Zero

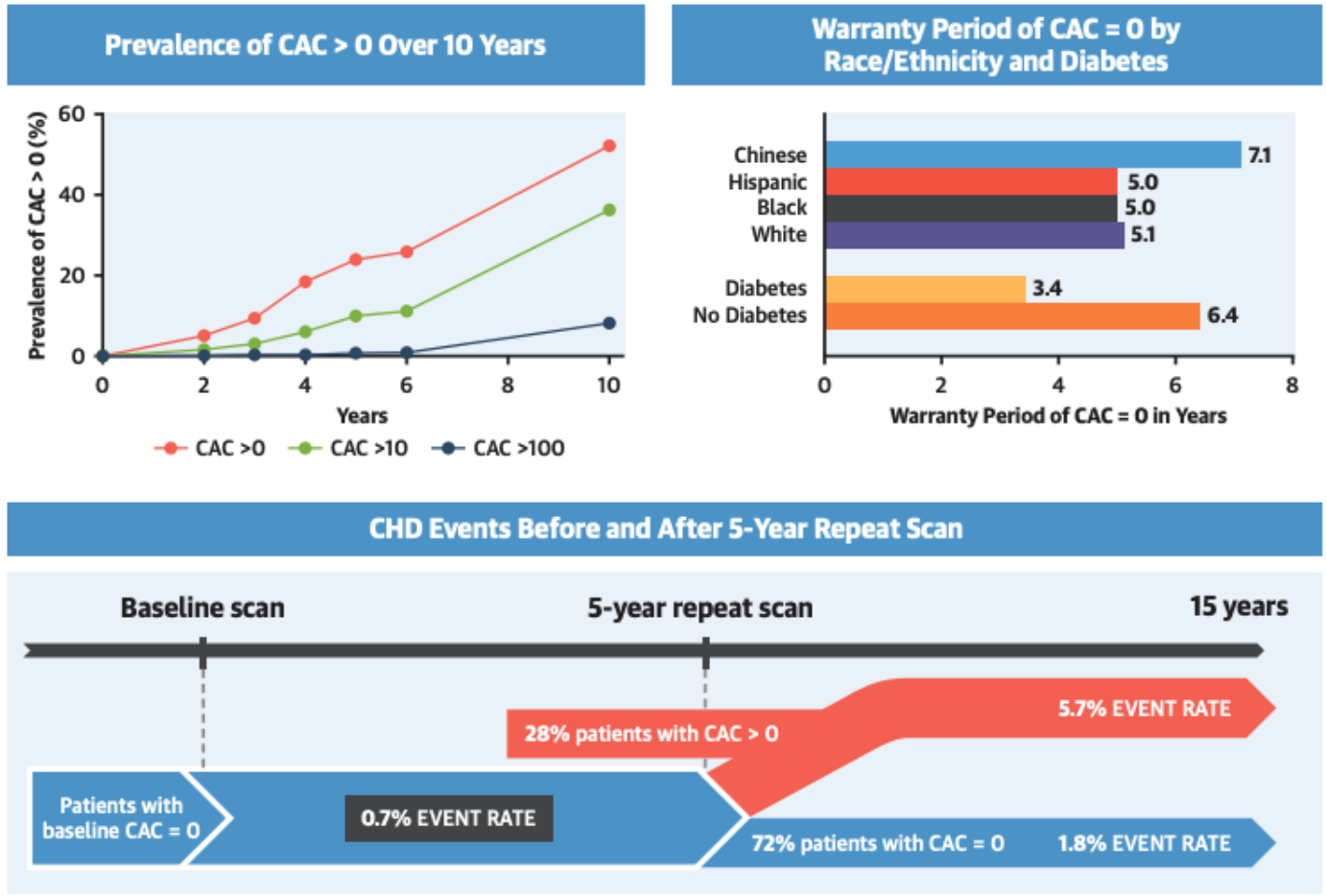
Comprehensive Analysis From MESA

Omar Dzaye, MD, PhD,[a,b,c] Zeina A. Dardari, MS,[a] Miguel Cainzos-Achirica, MD, MPH, PhD,[a] Ron Blankstein, MD,[d] Arthur S. Agatston, MD,[e] Matthias Duebgen, MD,[c] Joseph Yeboah, MD, MSc,[f] Moyses Szklo, MD,[g] Matthew J. Budoff, MD,[h] Joao A.C. Lima, MD, MBA,[i] Roger S. Blumenthal, MD,[a] Khurram Nasir, MD, MPH, MSc,[j] Michael J. Blaha, MD, MPH[a]

- A calcium score of zero is awesome
  - But it's not the whole story
- Before plaque is calcified- it is non-calcified.
- We don't want to ignore important risk factors
- Folks don't stay zero forever
- Be thoughtful about withholding statin therapy

Photo by Fares Hamouche on Unsplash

CENTRAL ILLUSTRATION Warranty Period of CAC = 0



Dzaye, O. et al. J Am Coll Cardiol Img. 2021;14(5):990-1002.

(Top left) Cumulative annual prevalence of CAC >0, CAC >10, and CAC >100 among CAC = 0 MESA participants who were rescanned during follow-up. **(Top right)** Warranty period (in years) of CAC = 0 in the total population by race and diabetes. **(Bottom)** CHD event rate in a subcohort of participants defined by a 4- to 6-year rescan interval. CAC = coronary artery calcium; CHD = coronary heart disease.

TABLE 3 Summary Look-Up Table for Individualized Risk Estimation and Appropriate Timing of CAC Rescans

Risk Group	Recommended Rescan Interval
Low-risk (<5% 10-yr risk)	6-7 yrs
Borderline to Intermediate risk (5-20% 10-yr risk)	3-5 yrs
High risk (>20% 10-yr risk)	3 yrs
Diabetes	3 yrs

Look-up table for individualized risk estimation and appropriate timing of CAC rescans. CAC = coronary artery calcium.

Dzaye, O, Dardari, Z, Cainzos-Achirica, M. et al. Warranty Period of a Calcium Score of Zero: Comprehensive Analysis From MESA. J Am Coll Cardiol Img. 2021 May, 14 (5) 990–1002. https://doi.org/10.1016/j.jcmg.2020.06.048

Practical Application

Who should get one?

Journal of Clinical Lipidology (2021) 15, 33–60

Journal of Clinical Lipidology

NLA Scientific Statement

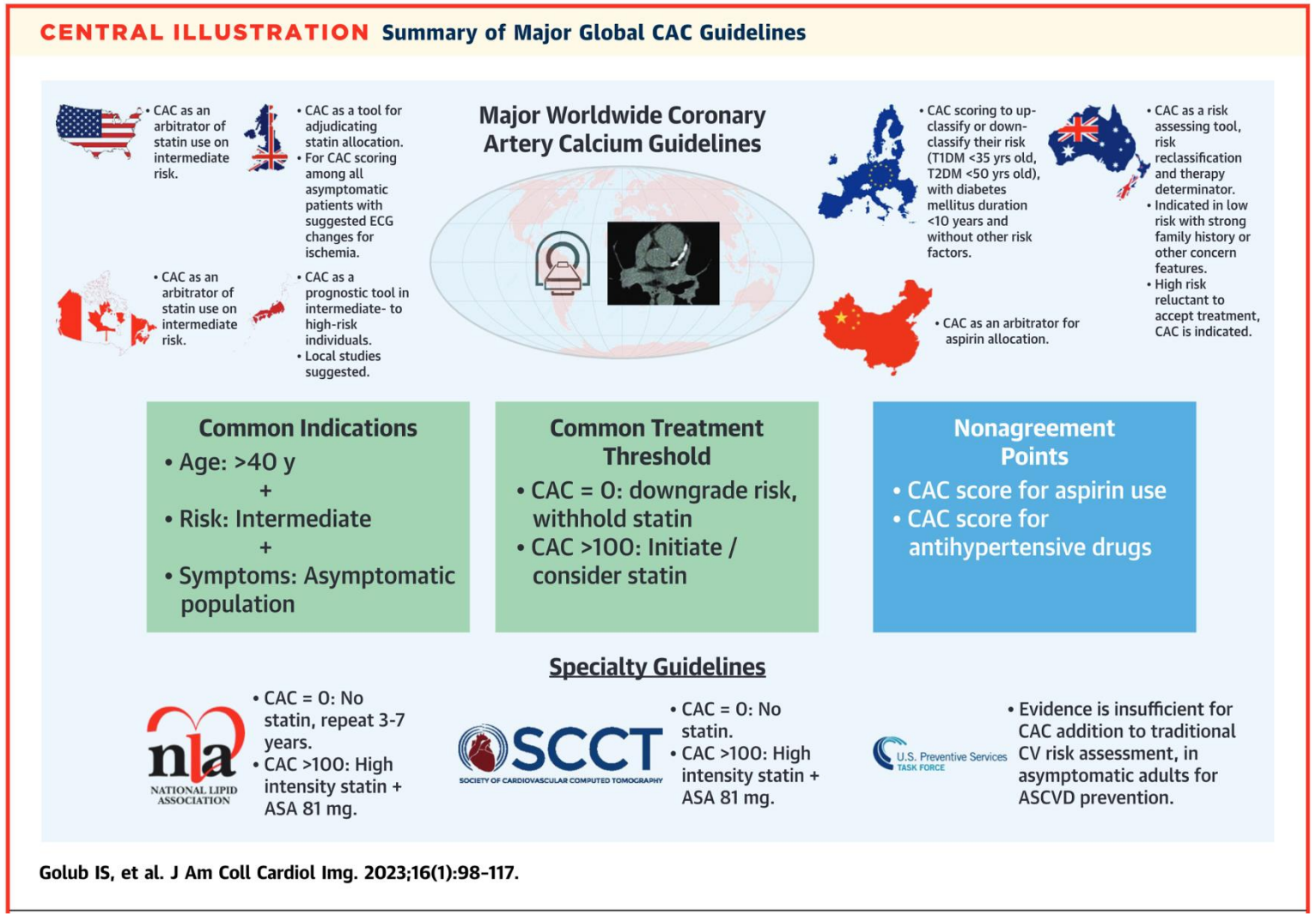
The National Lipid Association scientific statement on coronary artery calcium scoring to guide preventive strategies for ASCVD risk reduction

Carl E. Orringer*, Michael J. Blaha, Ron Blankstein, Matthew J. Budoff, Ronald B. Goldberg, Edward A. Gill, Kevin C. Maki, Laxmi Mehta, Terry A. Jacobson

- 40-75 years old with an LDL of 70-189mg/dL AND at intermediate risk, i.e ≥ 7.5% to < 20%.
- Selected patients with a risk of 5-7.4%
- Selected patients with < 5% risk and other risk factors not included in the risk calculator like FH, social determinants, pregnancy related complications

Orringer C, Blaha M, Blankstein, Budoff M, et. al. The National Lipid Association scientific statement on CAC scoring to guide preventative strategies for ASCVD risk reduction. Journal of Clinical Lipidology (2021) 15, 33-60.

What's happening worldwide?



Golub, I, Termeie, O, Kristo, S. et al. Major Global Coronary Artery Calcium Guidelines. J Am Coll Cardiol Img. 2023 Jan, 16 (1) 98–117. https://doi.org/10.1016/j.jcmg.2022.06.018

Who does not need one

People at high ASCVD risk > 20%

People at very low risk < 5% with no non-traditional risk factors

LDL ≥ 190ng/L

Known CAD or prior intervention

Prior CAC score > 100*

People who have had prior chest imaging that doesn't have visible CAC*

Patient Considerations

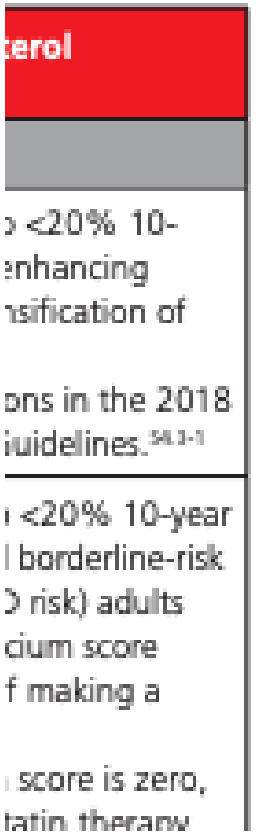


Table 6. Selected Examples of Candidates for Coronary Artery Calcium Measurement Who Might Benefit From Knowing Their Coronary Artery Calcium Score Is Zero

Coronary Artery Calcium Measurement Candidates Who Might Benefit from Knowing Their Coronary Artery Calcium Score Is Zero
Patients reluctant to initiate statin who wish to understand their risk and potential for benefit more precisely
Patients concerned about need to reinstitute statin therapy after discontinuation for statin-associated symptoms
Older patients (men 55–80 y of age; women 60–80 y of age) with low burden of risk factors[54.4-42] who question whether they would benefit from statin therapy
Middle-aged adults (40–55 y of age) with PCE-calculated 10-year risk for ASCVD 5% to <7.5% with factors that increase their ASCVD risk, although they are in a borderline risk group.

Assessing individual risk

MESA 10-Year CHD Risk with Coronary Artery Calcification Back to CAC Tools

1. Gender	Male ○ Female ◉					
2. Age (45-85 years)	45	Years				
3. Coronary Artery Calcification	50	Agatston				
4. Race/Ethnicity	**Choose One**					
	Caucasian ◉					
	Chinese ○					
	African American ○					
	Hispanic ○					
5. Diabetes	Yes ◉	No ○				
6. Currently Smoke	Yes ◉	No ○				
7. Family History of Heart Attack (History in parents, siblings, or children)	Yes ◉	No ○				
8. Total Cholesterol	200	mg/dL	or	5.2	mmol/L	
9. HDL Cholesterol	65	mg/dL	or	1.7	mmol/L	
10. Systolic Blood Pressure	130	mmHg	or	17.3	kPa	
11. Lipid Lowering Medication	Yes ○	No ◉				
12. 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 10.0%. 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 5.8%.

1. Gender	Male ○ Female ◉					
2. Age (45-85 years)	45	Years				
3. Coronary Artery Calcification	50	Agatston				
4. Race/Ethnicity	**Choose One**					
	Caucasian ◉					
	Chinese ○					
	African American ○					
	Hispanic ○					
5. Diabetes	Yes ○	No ◉				
6. Currently Smoke	Yes ◉	No ○				
7. Family History of Heart Attack (History in parents, siblings, or children)	Yes ◉	No ○				
8. Total Cholesterol	200	mg/dL	or	5.2	mmol/L	
9. HDL Cholesterol	65	mg/dL	or	1.7	mmol/L	
10. Systolic Blood Pressure	130	mmHg	or	17.3	kPa	
11. Lipid Lowering Medication	Yes ○	No ◉				
12. 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 6.9%. 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 3.5%.

Real life example

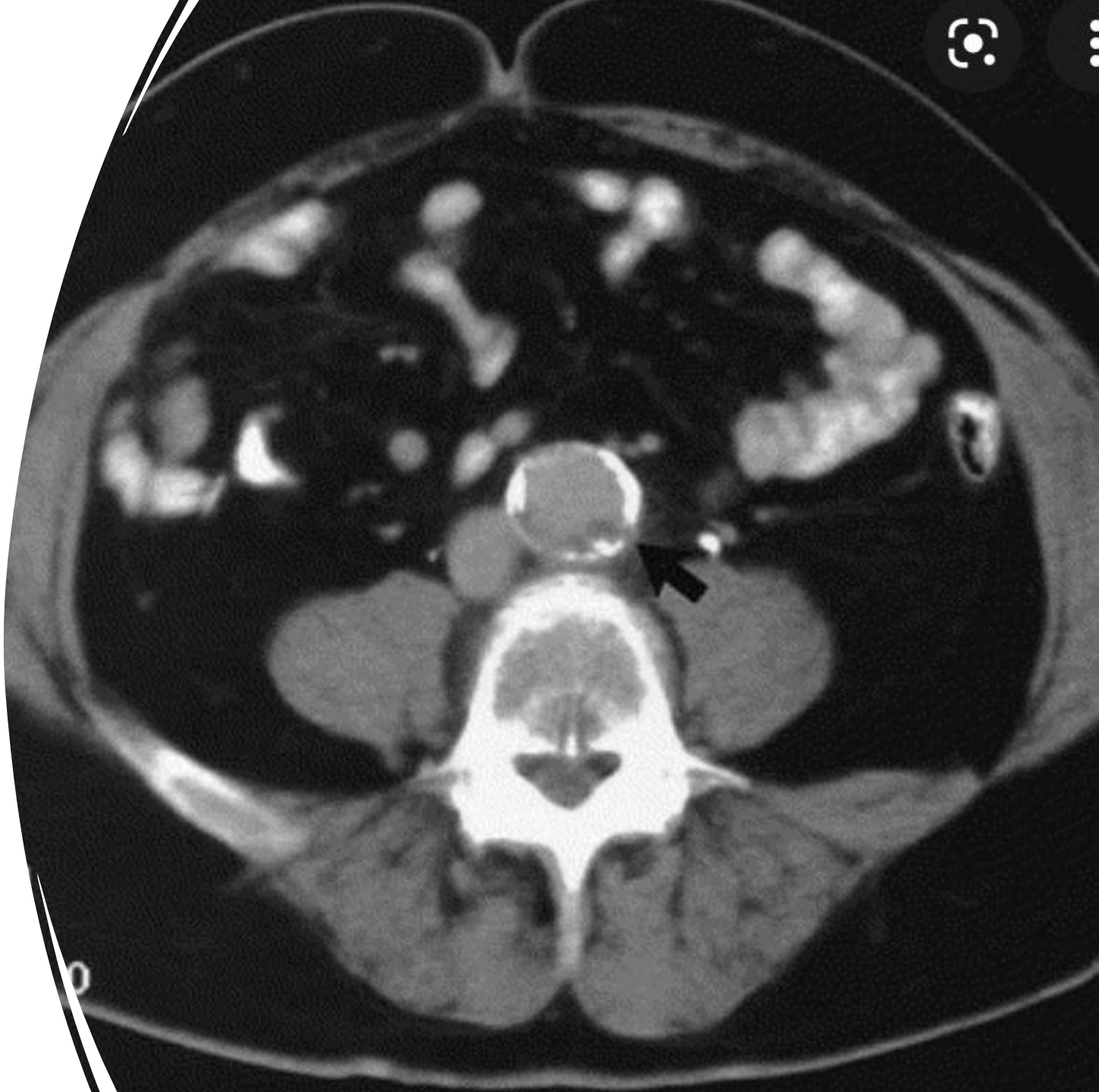
- 44 y/o female
- Traditional risk factors: Overweight
- BP 110/70
- Total Cholesterol 200, TG < 200, HDL 40, LDL 130
- Normal ApoB and Lp(a) 170*
- Non-smoker, non-diabetic, no family history of premature CAD
- ASCVD risk 1.0%
- Non-traditional risk factors: Delivered her first child at 42- who had low birth weight for gestational age, military service

What do you predict her calcium score to be?

CAC = 177

What I do

- Review the reports any CT scan
  - Variability in reporting
- Look at the data yourself- all plaque matters
- If you find CAC up your treatment game!
- Show your patient!
  - Improved physician and patient adherence when patients have a + CAC score
- Beyond that, I follow general global practice



Descending Aortic Plaque

- **Multi-center, community-based, longitudinal cohort study of CVD risk based on CAC and AAC**
- **3011 participants**
- **Followed for 8 years for incident CVD and CHD events**

WHAT IS NEW?

- In young to middle-aged White and Black men and women free of overt cardiovascular disease (CVD), abdominal aorta calcium (AAC) is nearly as strongly related to incident CVD as coronary artery calcium (CAC).
- Higher CVD rates occur at AAC Agatston score values of over 1000, comparable to the CVD rates at CAC Agatston score values of over 300.
- AAC score tends to be as high in Black women as in both Black and White men; the substantially higher AAC in Black women than in White women may help to explain their different CVD event rates.

WHAT ARE THE CLINICAL IMPLICATIONS?

- AAC can be used without any additional costs or harm to the patient and may aid in predicting coronary heart disease and CVD events.
- Because AAC is correlated with CAC, the presence of a high AAC score raises suspicion that CAC may be present.
- Because the incidental AAC finding alerts the clinician to potential CVD risk that should be further investigated, automated AAC scoring in planned abdominal computed tomography scan for a non-CVD medical diagnostic work-up may be used as a quick and low-cost tool to identify patients who are at increased risk of CVD.

Jurgens P, Carr J, Terry J, et al. Association of Abdominal Aorta Calcium and Coronary Artery Calcium with Incident Cardiovascular and Coronary Heart Disease Events in Black and White Middle-Aged People: The Coronary Artery Risk Development in Young Adults Study. JAHA, Vol 10, Issue 24, 12 Dec 2021.

Treating based on CAC scores

**Excluding Familial Hyperlipidemia

IIa	B-NR

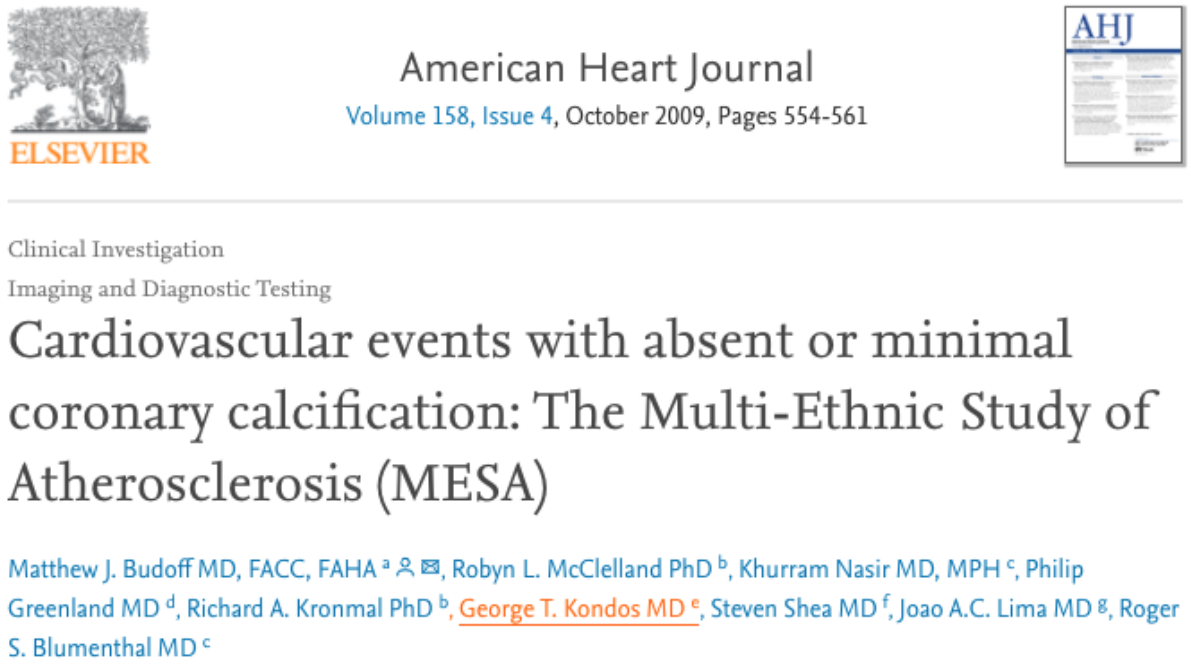
7. In intermediate-risk (≥7.5% to <20% 10-year ASCVD risk) adults or selected borderline-risk (5% to <7.5% 10-year ASCVD risk) adults in whom a coronary artery calcium score is measured for the purpose of making a treatment decision, AND
   - If the coronary artery calcium score is zero, it is reasonable to withhold statin therapy and reassess in 5 to 10 years, as long as higher-risk conditions are absent (e.g., diabetes, family history of premature CHD, cigarette smoking);
   - If coronary artery calcium score is 1 to 99, it is reasonable to initiate statin therapy for patients ≥55 years of age;
   - If coronary artery calcium score is 100 or higher or in the 75th percentile or higher, it is reasonable to initiate statin therapy (S4.3-28, S4.3-34).

Adapted from recommendations in the 2018 Cholesterol Clinical Practice Guidelines (S4.3-1).

Arnett, D, Blumenthal, R, Albert, M. et al. 2019 ACC/AHA Guideline on the Primary Prevention of Cardiovascular Disease: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. JACC. 2019 Sep, 74 (10) e177–e232.
https://doi.org/10.1016/j.jacc.2019.03.010

What about low CAC scores

- 3,923 asymptomatic patients
- Followed for 4.1 years for MI, angina, resuscitated CA, or CHD death.
- Mean age 58 +/- 9, 39% male
- 3415 had NO detectable CAC 0
- 508 had CAC scores from 1-10
- Those with minimally elevated CAC scores had a 3-fold higher event rate than those with a CAC of 0.



ELSEVIER

American Heart Journal
Volume 158, Issue 4, October 2009, Pages 554-561

AHJ

Clinical Investigation
Imaging and Diagnostic Testing

Cardiovascular events with absent or minimal coronary calcification: The Multi-Ethnic Study of Atherosclerosis (MESA)

Matthew J. Budoff MD, FACC, FAHA [a], Robyn L. McClelland PhD [b], Khurram Nasir MD, MPH [c], Philip Greenland MD [d], Richard A. Kronmal PhD [b], George T. Kondos MD [e], Steven Shea MD [f], Joao A.C. Lima MD [g], Roger S. Blumenthal MD [c]

My Practice

CAC = 0	CAC = 1-99 AND < 75th percentile	CAC ≥ 100 or ≥ 75th percentile	CAC ≥ 1000
Can defer statin	Moderate-intensity statin	Moderate to high intensity statin	High intensity statin
Consider repeat CAC in 3-5 years for risk enhancers	Goal LDL < 100mg/dL	Goal LDL <70mg/dL	Goal LDL < 70mg/dL
		Consider ezetimibe if goal not reached	Consider ezetimibe if goal not reached May consider PSCK9mAb if additional lower needed

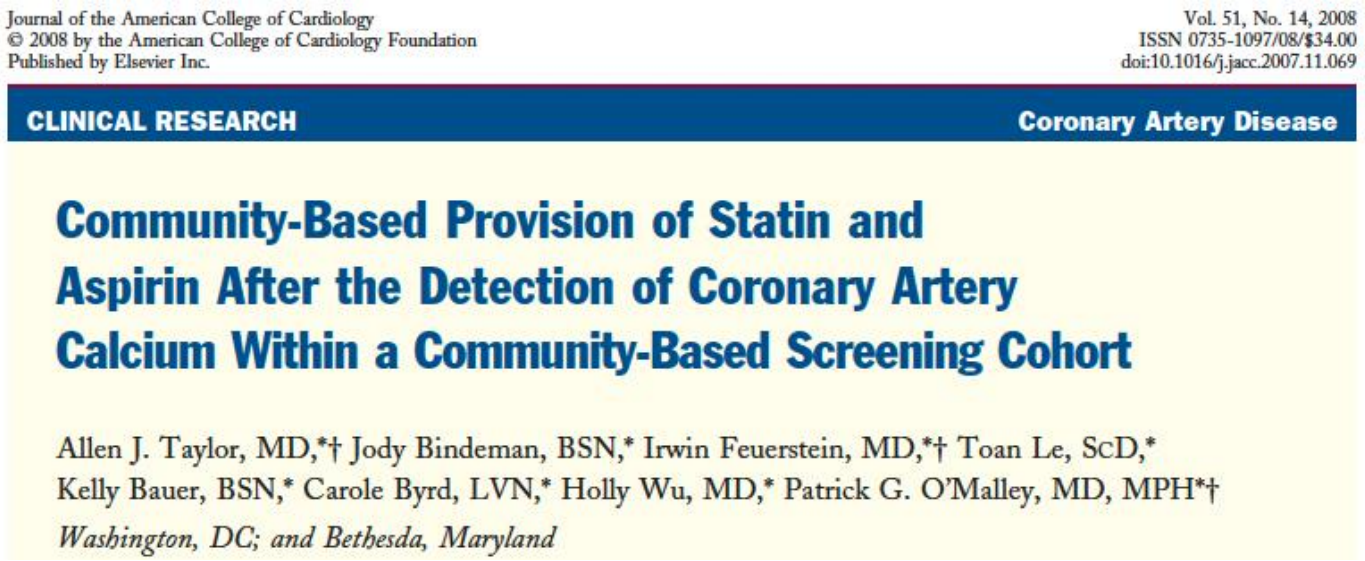
**Also check Lp(a)

Lloyd-Jones, D, Morris, P. et al. 2022 ACC Expert Consensus Decision Pathway on the Role of Nonstatin Therapies for LDL-Cholesterol Lowering in the Management of Atherosclerotic Cardiovascular Disease Risk: A Report of the American College of Cardiology Solution Set Oversight Committee. JACC. 2022 Oct, 80 (14) 1366–1418. https://doi.org/10.1016/j.jacc.2022.07.006

CAC Guided Treatment Outcomes

Provider Certainty

- 1,640 AD Army men between ages 40-50 screened with risk factors and CAC
- Risk assessment and CAC score reported to patients
- No medications prescribed at the time of disclosure
- Followed for 6 years with telephone visits



Journal of the American College of Cardiology
© 2008 by the American College of Cardiology Foundation
Published by Elsevier Inc.

Vol. 51, No. 14, 2008
ISSN 0735-1097/08/$34.00
doi:10.1016/j.jacc.2007.11.069

CLINICAL RESEARCH — Coronary Artery Disease

Community-Based Provision of Statin and Aspirin After the Detection of Coronary Artery Calcium Within a Community-Based Screening Cohort

Allen J. Taylor, MD,*† Jody Bindeman, BSN,* Irwin Feuerstein, MD,*† Toan Le, ScD,*
Kelly Bauer, BSN,* Carole Byrd, LVN,* Holly Wu, MD,* Patrick G. O'Malley, MD, MPH*†
Washington, DC; and Bethesda, Maryland

Taylor A, Bindeman J, Feuerstein I, et al. Community-Based Provision of Statin and Aspirin After the Detection of Coronary Artery Calcium Within a Community-Based Screening Cohort. JACC 2008, Vol 51, No. 14.

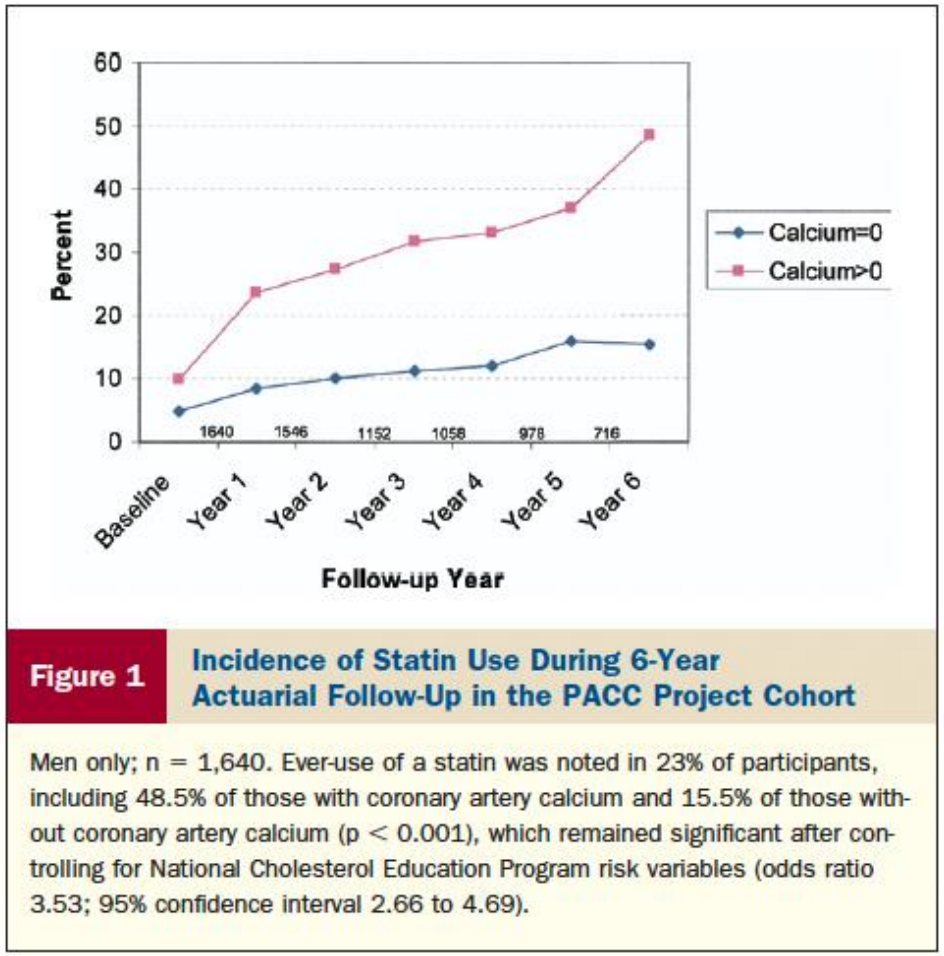


Figure 1 **Incidence of Statin Use During 6-Year Actuarial Follow-Up in the PACC Project Cohort**

Men only; n = 1,640. Ever-use of a statin was noted in 23% of participants, including 48.5% of those with coronary artery calcium and 15.5% of those without coronary artery calcium ($p < 0.001$), which remained significant after controlling for National Cholesterol Education Program risk variables (odds ratio 3.53; 95% confidence interval 2.66 to 4.69).

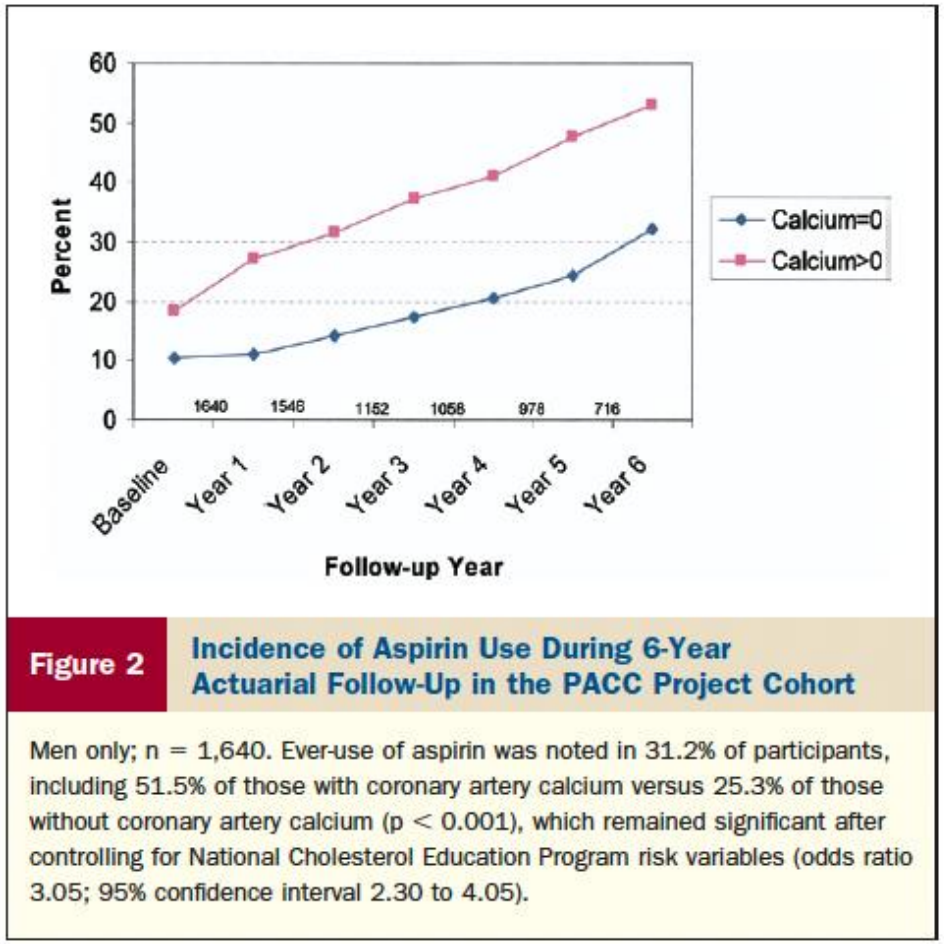


Figure 2 **Incidence of Aspirin Use During 6-Year Actuarial Follow-Up in the PACC Project Cohort**

Men only; n = 1,640. Ever-use of aspirin was noted in 31.2% of participants, including 51.5% of those with coronary artery calcium versus 25.3% of those without coronary artery calcium ($p < 0.001$), which remained significant after controlling for National Cholesterol Education Program risk variables (odds ratio 3.05; 95% confidence interval 2.30 to 4.05).

- **3-Fold increased risk of statin use for those with a positive CAC score (48.5% vs 15.1%, p< 0.001) and aspirin (53.0% vs 32.3%; p< 0.001)**

Taylor A, Bindeman J, Feuerstein I, et al. Community-Based Provision of Statin and Aspirin After the Detection of Coronary Artery Calcium Within a Community-Based Screening Cohort. JACC 2008, Vol 51, No. 14.

Patient Certainty

Motivational effects of coronary artery calcium scores on statin adherence and weight loss

Nove K. Kalia, Lucas Cespedes, George Youssef, Dong Li and Matthew J. Budoff

Table 1 Characteristics of study population

	Participants (%)
Number	2608
Age (years)	58±8
Males	72
Hypertension	51
Tobacco use	14
Diabetes	7
Family history of premature CHD	69

CHD, coronary heart disease.

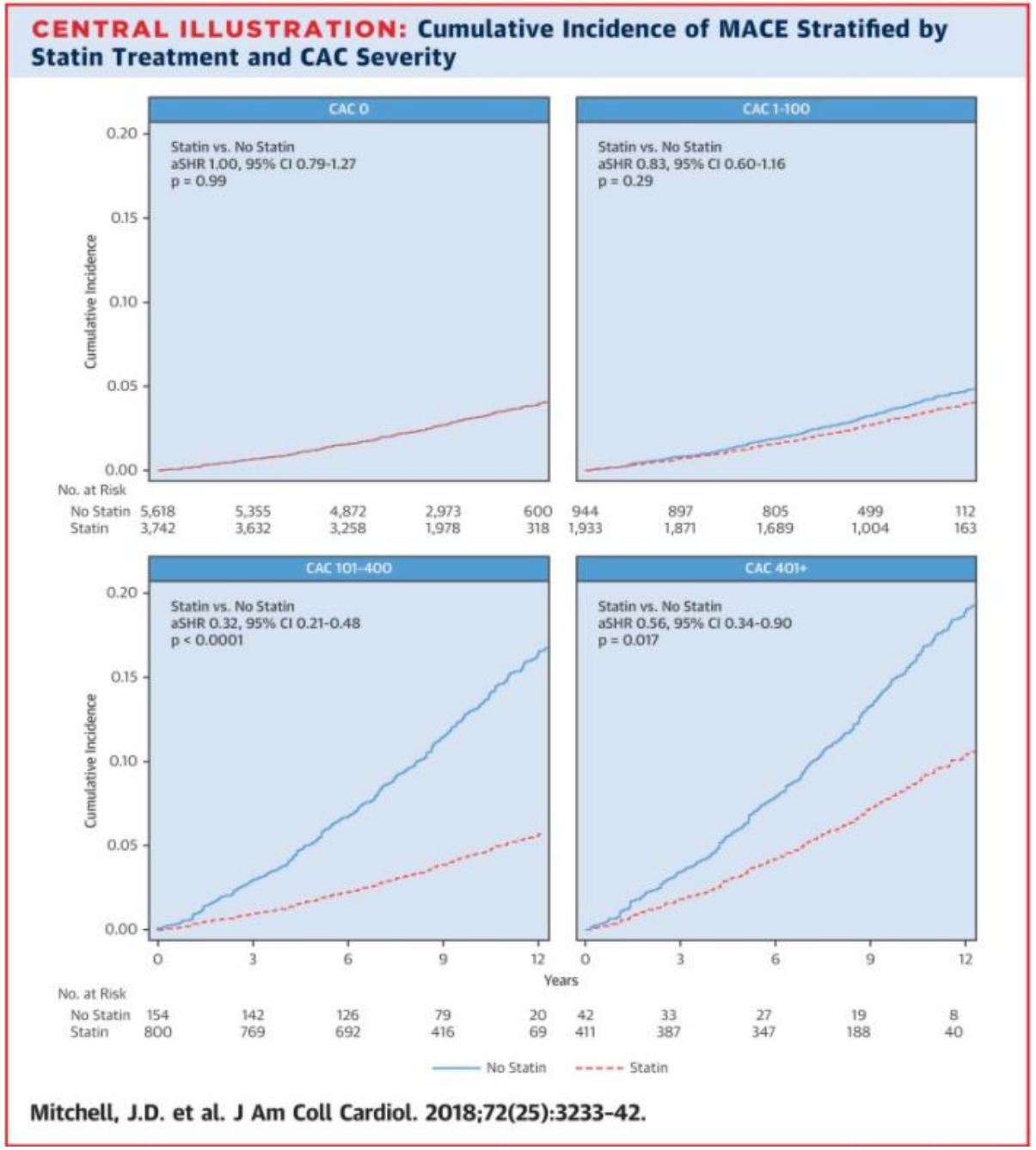
Table 2 Statin compliance for cohort based on baseline calcium score

CAC score	Patients with hyperlipidemia (*n*)	Statin compliance [*n* (%)]
0	514	141 (27.4)
1–100	779	305 (39.2)
100–400	580	311 (53.6)
>400	735	432 (58.8)

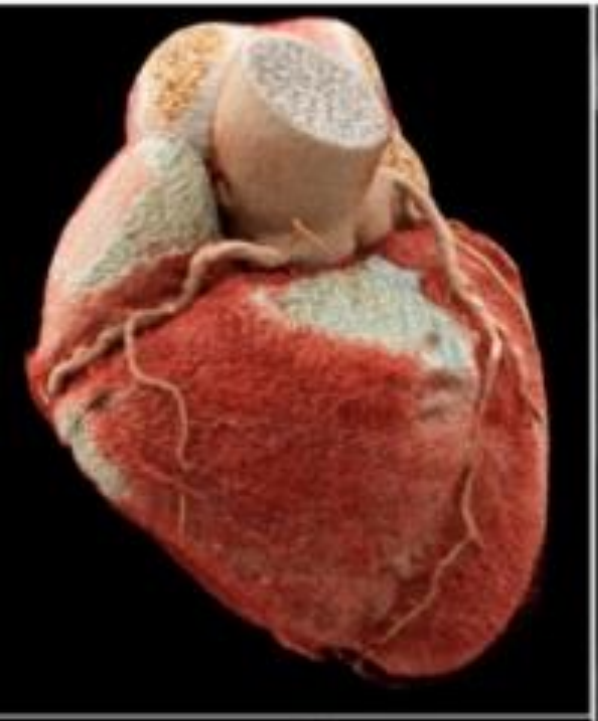
CAC, coronary artery calcium.
$P < 0.001$ for trend of values.

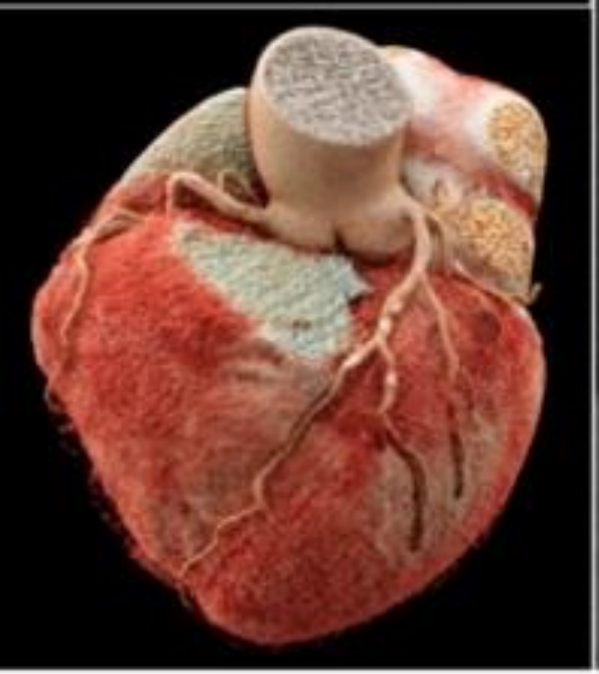
Does it affect outcomes?

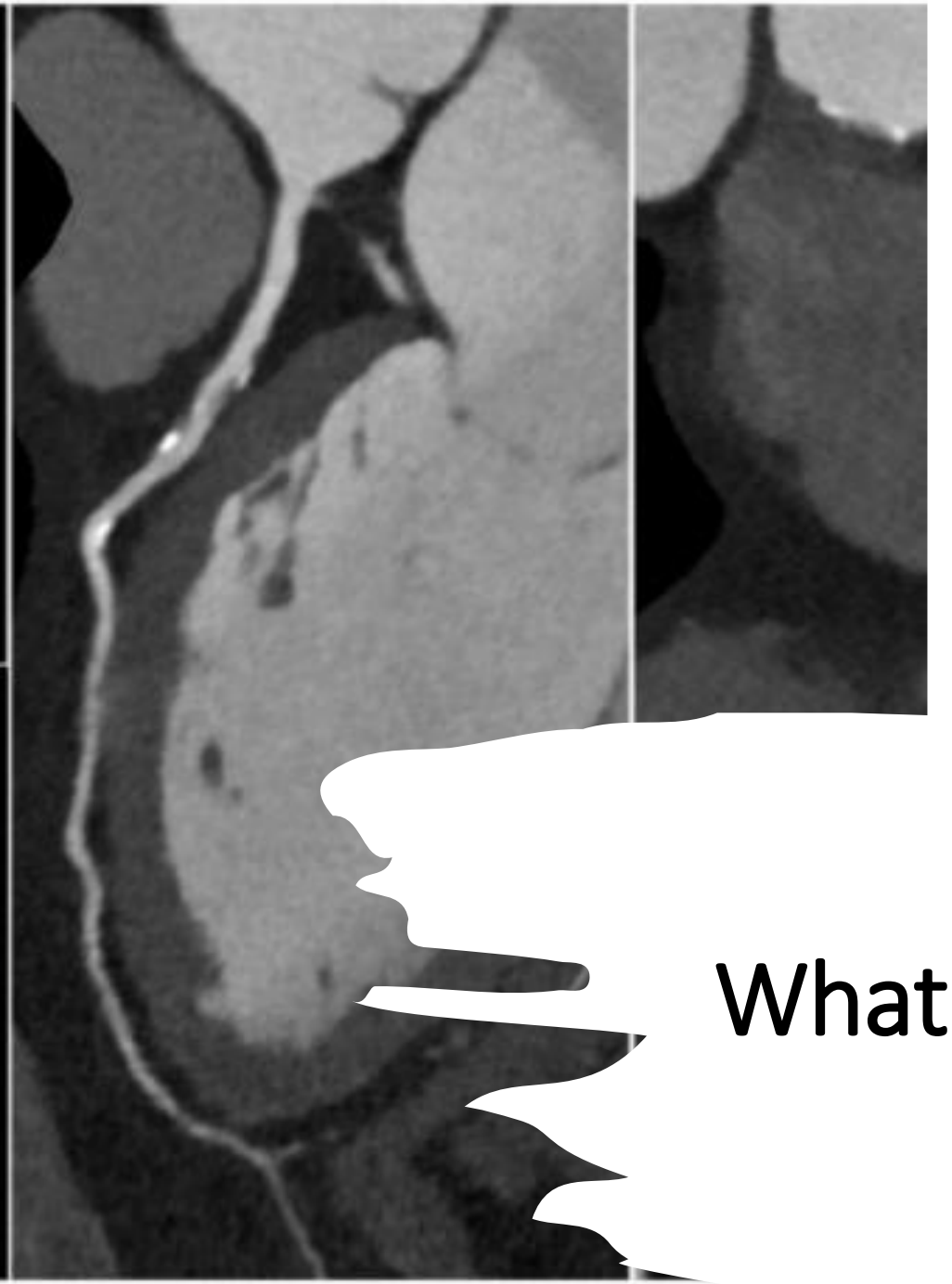
- 13,644 patients
- Mean age 50
- Followed for a median of 9.4 years
- Statin therapy decreased risk of MACE in patients with *any* CAC.
- NNT 12 (CAC > 100)



Mitchell J, Fergestrom N, Gage B, et al. Impact of Statins on Cardiovascular Outcomes Following Coronary Artery Calcium Scoring. Dec 2018. JACC, Vol 72, Issue 25. Pg 3233-3242.







?

What about CCTA?

Controversial & Patient Selection is Key

- It may be appropriate to perform CTA in selected asymptomatic high risk individuals, especially in those who have a higher likelihood of having a large amount of non-calcified plaque
- It is rarely appropriate to perform coronary CTA in very low risk symptomatic patients, e.g., <40 years of age with non-cardiac symptoms (chest wall pain, pleuritic chest pain).
- It is rarely appropriate to perform CTA in low- and intermediate risk asymptomatic patients.

- Patients should be bradycardic or able to tolerate bradycardia by giving beta blockers with a goal heart rate of 50-60 bpm
- Patients must be able to get nitroglycerin
- Patients must be able to get IV contrast
- Irregular heart rhythms like atrial fibrillation or frequent ectopy are limiting
- Known high calcium scores (> 400) limit accuracy
- Obesity decreases image quality
- Know what you're going to do with the data ahead of time

SCCT 2021 Expert Consensus Document on Coronary Computed Tomographic Angiography: A Report of the Society of Cardiovascular Computed Tomography Narula, Jagat et al. Journal of Cardiovascular Computed Tomography, Volume 15, Issue 3, 192 - 217

Summary

Calcium scoring is a safe and effective way to screen individuals for subclinical atherosclerosis

It has significant prognostic power for future events and excellent negative predictive value

Consider in intermediate risk individuals or low risk individuals with risk factors not captured by traditional risk scores

Look at CT scans yourself- a lot of times you can get the answer for free

If you find CAC, intensify the patient's preventative therapies- you've found the substrate for future CV events before they've happened!


Questions?