

What is the Clinical Utility of Coronary CT Angiography?

**Leslee J. Shaw, PhD,
MASNC, FACC, FAHA, MSCCT**



Endowed Chair and Professor
Director, Blavatnik Family Research Institute
Departments of Medicine (Cardiology) and
Population Health Science & Policy

 @lesleejshaw

 leslee.shaw@mountsinai.org



Disclosures

- **Past-President**  
- **Blavatnik Family Foundation**
- **Helen Gurley Brown Foundation**
- **Gilinski Family**
- **NIH-NHLBI**
 - 1U01HL10556 - ISCHEMIA Trial Imaging Coordinating Center
 - 1R01HL159433 - Atherosclerotic Plaque Progression with COVID-19
- **NIH-NIA** 1U54AG062334 - Atherosclerotic Plaque in HIV-Infected Women
- **Dept of Defense** Women's IschemiA Trial to Reduce Events In NonObstRuctive CAD (WARRIOR) Trial
- **JACC CV Imaging** - Executive Editor
- **Invited Speaker** - Knowledge to Practice (K2P), Roche Diagnostics, Amgen, Heartflow, Heart in Diabetes, Mount Sinai Complex Cardiac Cases, SNMMI, University of Virginia, University of British Columbia, Cedars-Sinai Medical Center, Houston Methodist, Optum Health, Covanos, Elucid Imaging, SCCT, ASNC, ACC, AHA, ESC, BSCCT, NASCI, ICNC, TCT, EACVI, UN-IAEA, CardioAlexandria, Egyptian Society of Cardiology, Centro Cardiologico Monzino, Northwell Health, Columbia University, CardioEgypt.

Coronary CT Angiography (CCTA)

- **Basics**

- Risk Stratification – CCTA + FFR-CT

- **2021 ACC / AHA Guideline**

- ED Evidence
- Stable CAD Evidence
- Relevant Messages in the Guideline

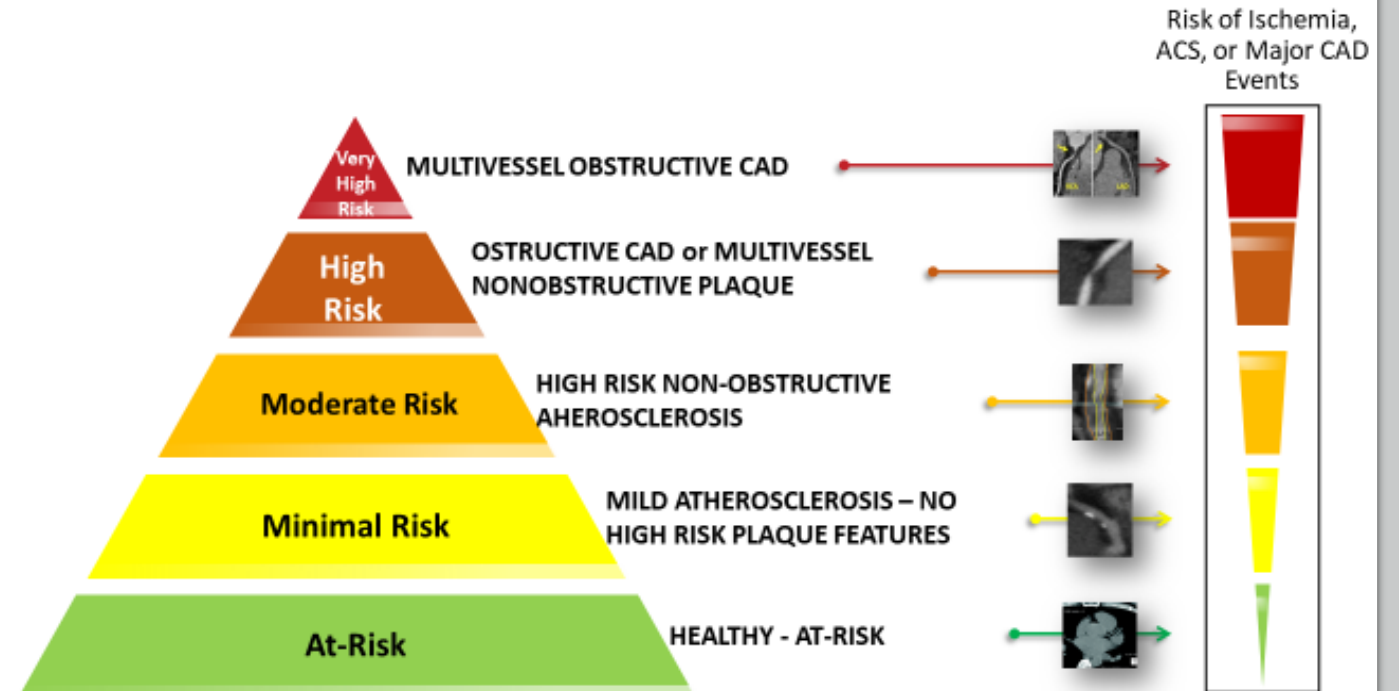
- **Novel Measures**

- Atherosclerotic Plaque
- Perivascular Fat



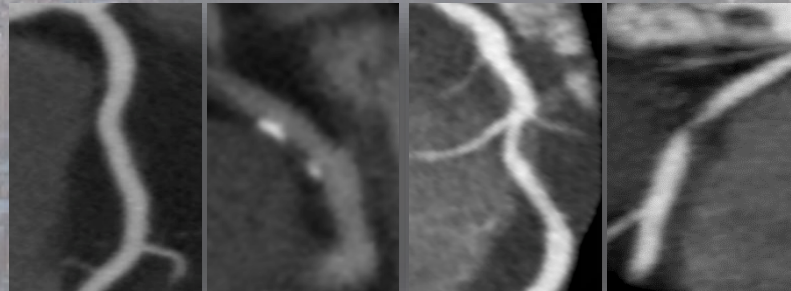
SOCIETY OF
CARDIOVASCULAR
COMPUTED TOMOGRAPHY

Expert Consensus Document on Coronary CT Imaging of Atherosclerotic Plaque




Source: Shaw J Cardiovasc Computed Tomog 2021;15:93-109.

Suspected CAD



Pre-test Probability of Obstructive CAD in Stable Chest Pain Patients

- PTP >15%: Int-High Risk
 - Testing is Beneficial
- PTP ≤15%: Low Risk


Testing Not Routinely Needed in Low-Risk Patients

Risk Guidance also available from a CAC scan or, when available, from a visual estimation of CAC from prior noncardiac chest CT

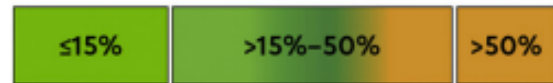
Low Risk – CAC Score = 0

Age, y	Chest Pain		Dyspnea	
	Men	Women	Men	Women
30-39	≤4	≤5	0	3
40-49	≤22	≤10	12	3
50-59	≤32	≤13	20	9
60-69	≤44	≤16	27	14
70+	≤52	≤27	32	12

A Pretest probability based on age, sex, and symptoms



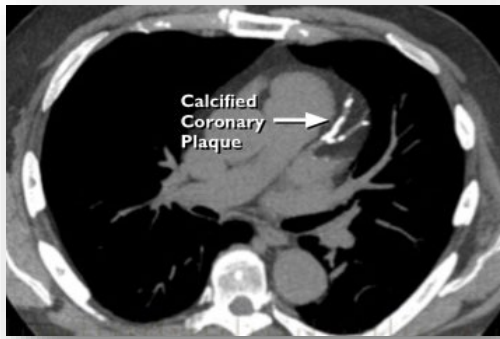
B Pretest probability based on age, sex, symptoms, and CAC score*



CAC
1-99

CAC
≥100-999

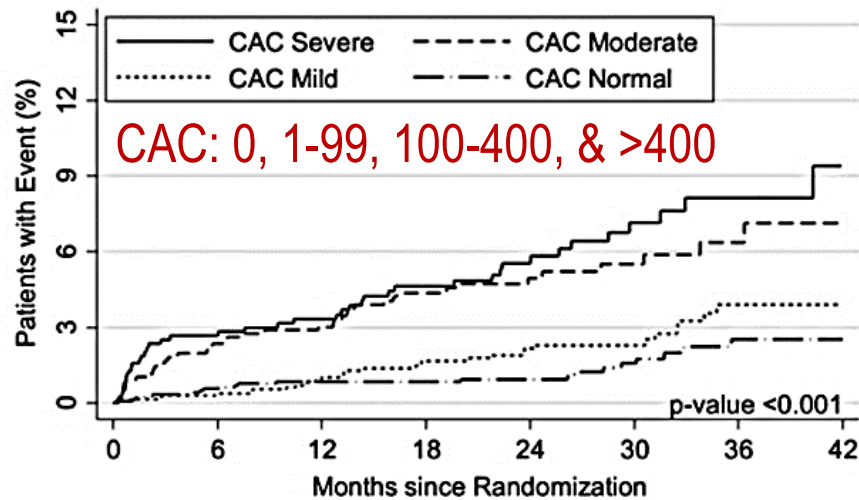
CAC
≥1,000



NIH-NHLBI PROMISE Trial: Prognosis by Coronary Artery Calcium (CAC)



CAC testing (n=4,209)



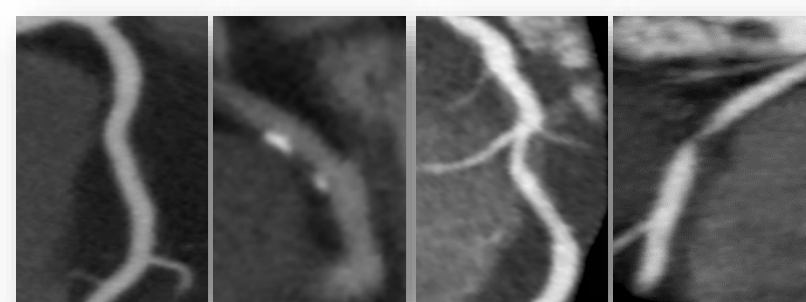
Number at risk	0	6	12	18	24	30	36	42
Normal	1457	1402	1314	1090	813	518	278	82
Mild	1340	1290	1200	955	734	469	246	76
Moderate	772	736	698	554	412	264	133	34
Severe	640	593	560	453	345	226	116	35

- CAC Findings:
 - None: 35%
 - Mild: 32% (HR: 1.9)
 - Moderate-Severe: 33% (HR: 3.9-4.7)

84% of Events Occurred in Patients with Detectable CAC (p<0.001)

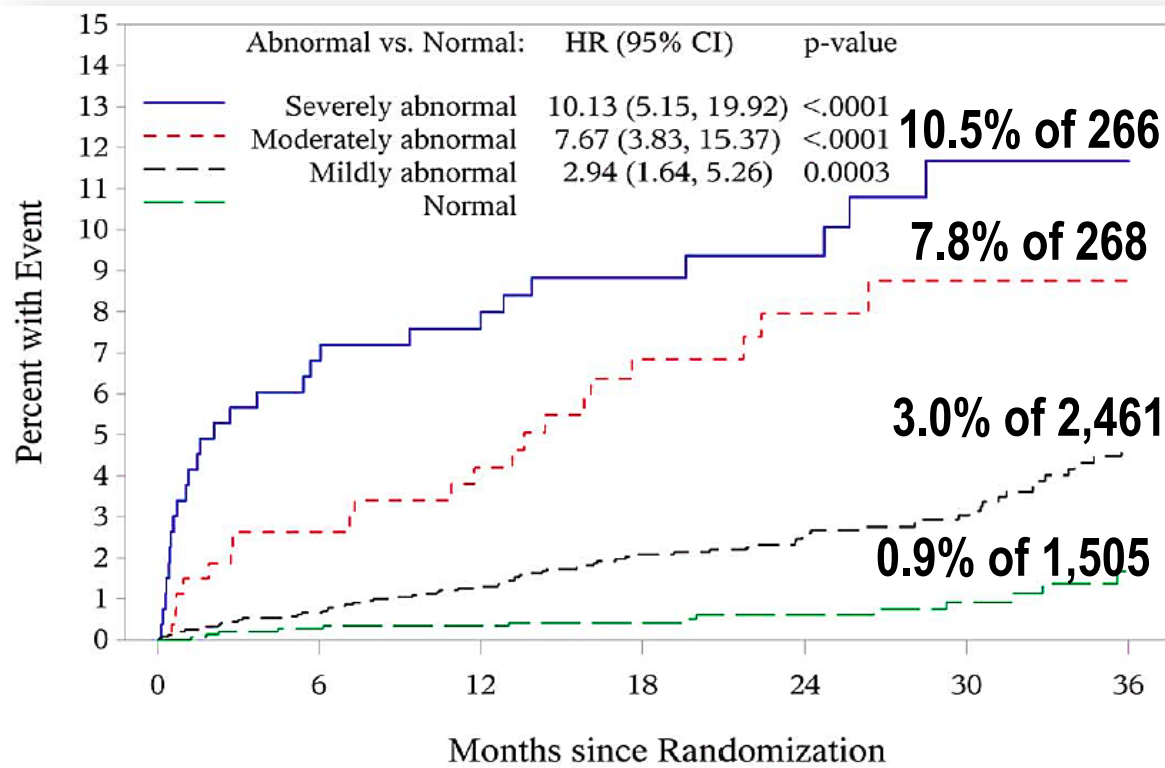
Helps to Guide Risk and Preventing Care

*~2-year mean follow-up.

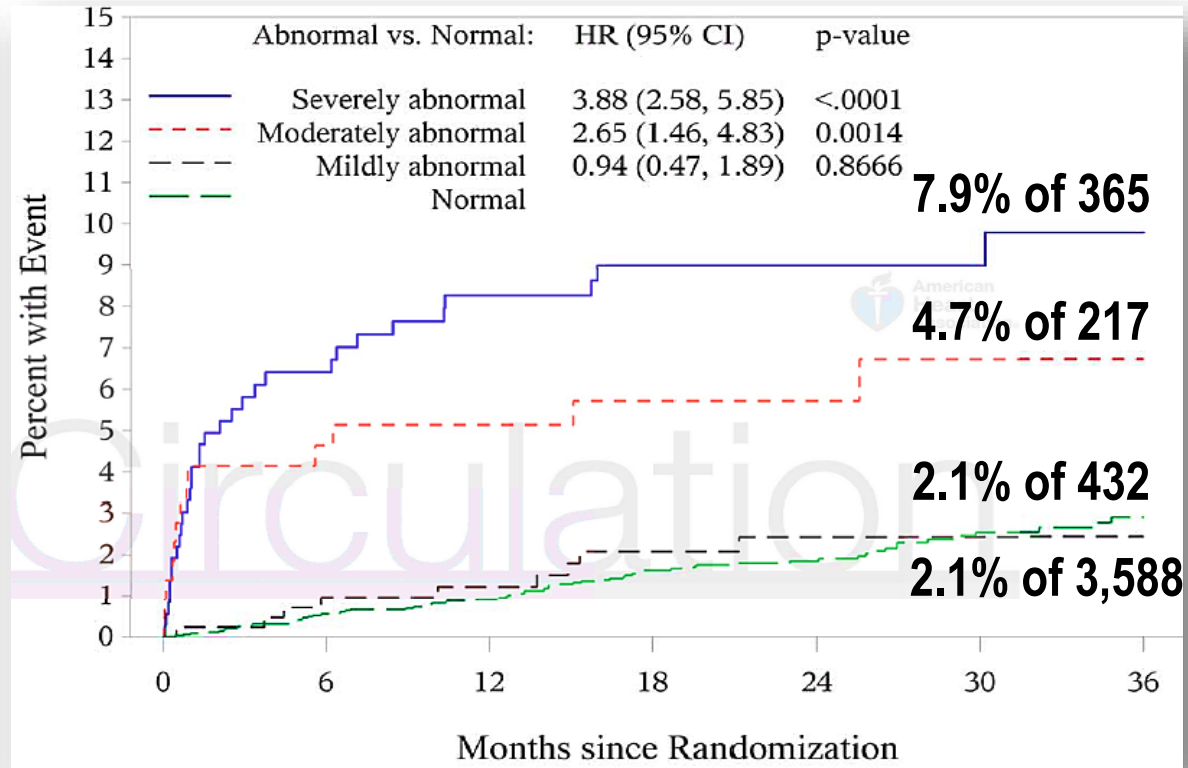


CCTA Has Better Accuracy vs. Stress Testing

CCTA (n=4,500)



Stress Testing (n=4,602)



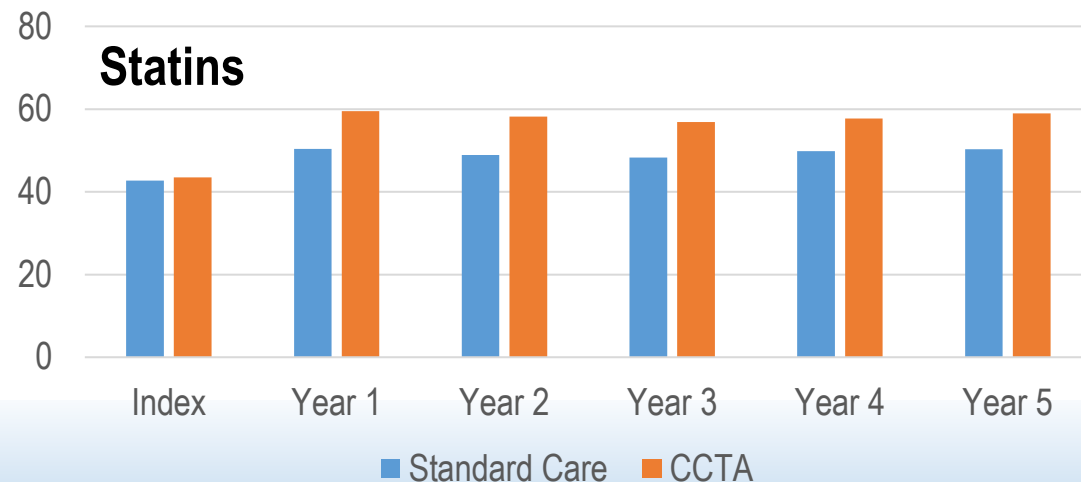
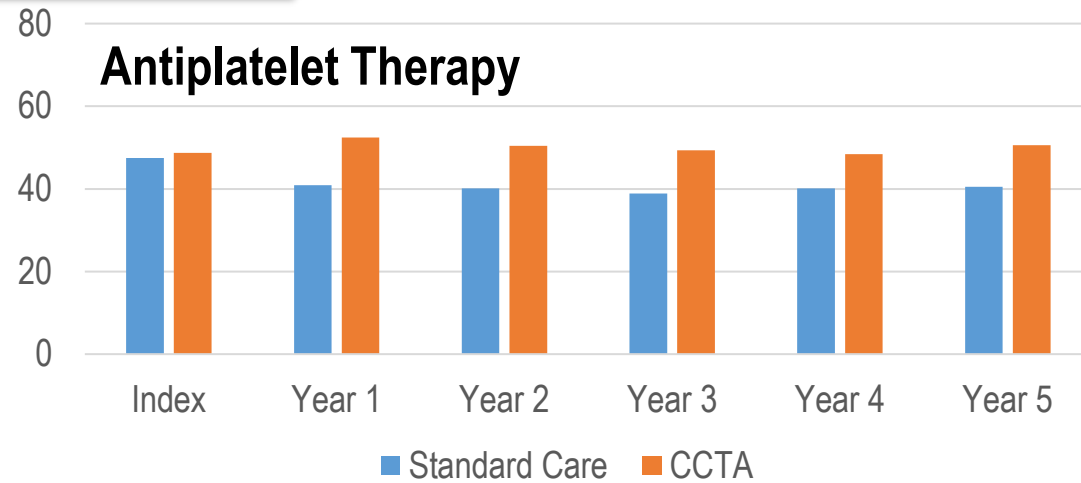
*~2-year Death or ACS.

- *Failure to Provoke Ischemia Does Not Exclude Risk!*

Source: Hoffmann Circulation 2017;135:2320-2332.

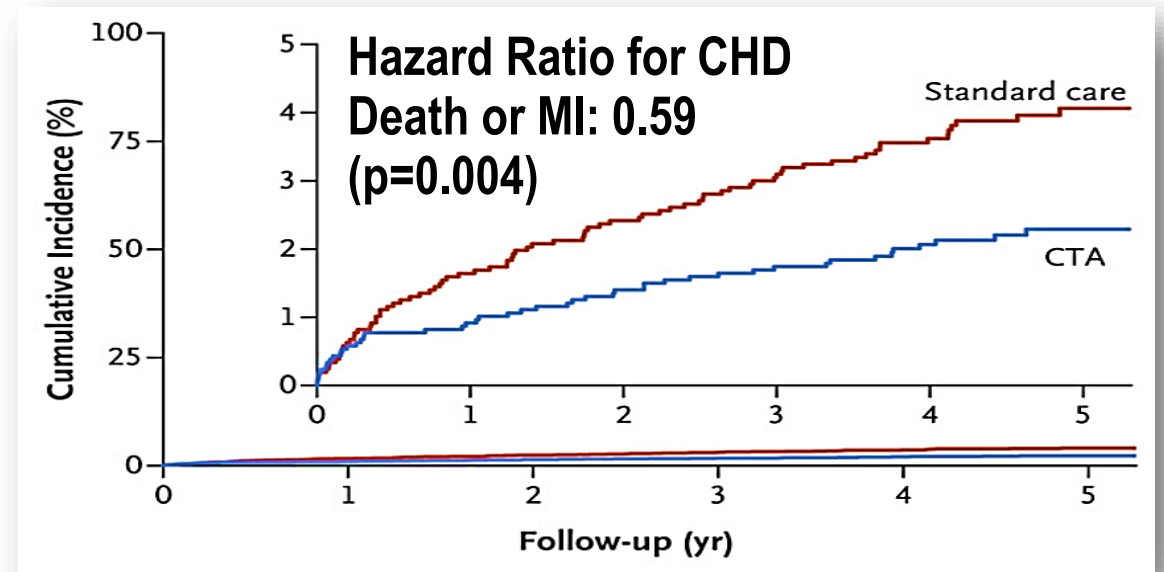


SCOT-HEART Trial – Targeted Treatment to Higher Risk Improves Outcomes



Prompted CT-Guided Preventive Care

- *Higher Use of Antiplatelets + Statins*



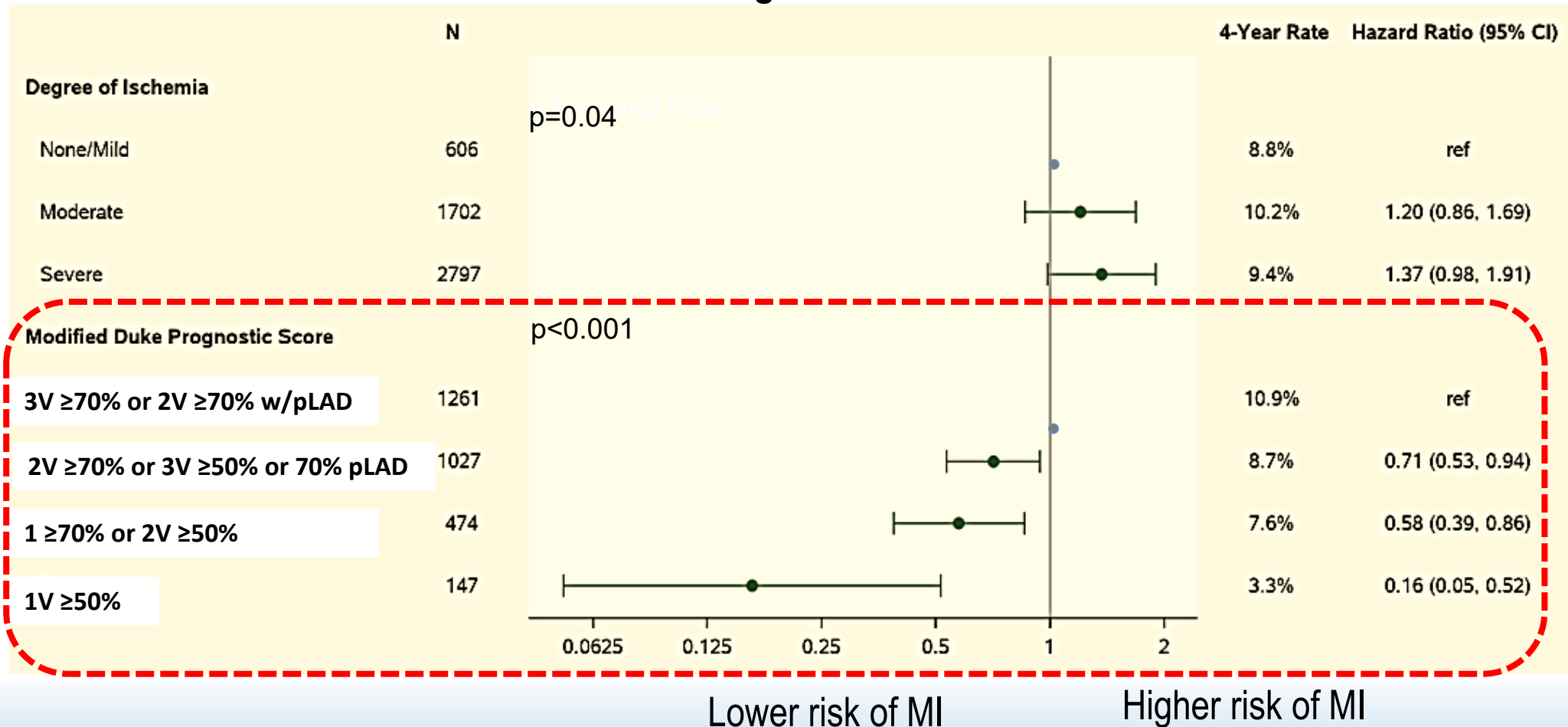
Known CAD





CCTA CAD Extent Is More Predictive of Trial Endpoints

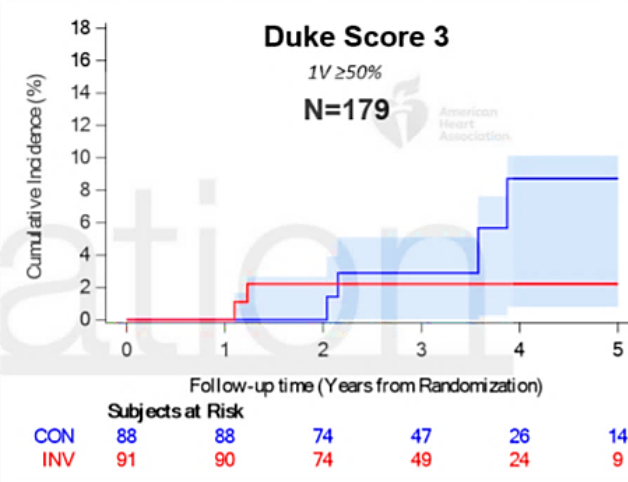
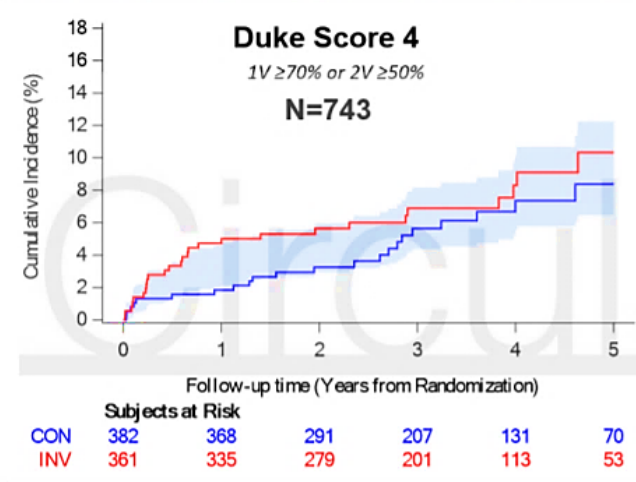
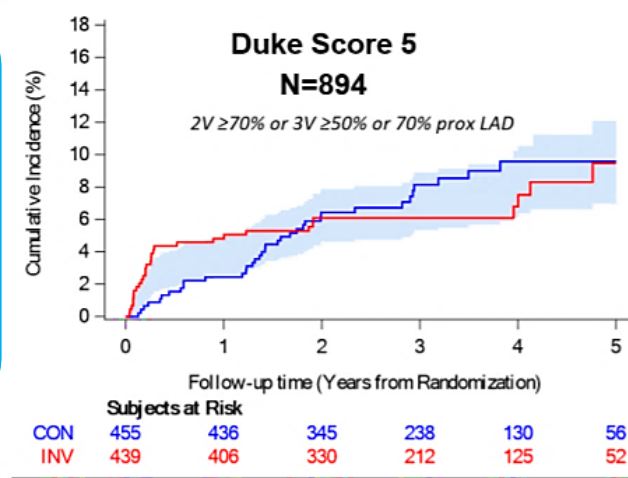
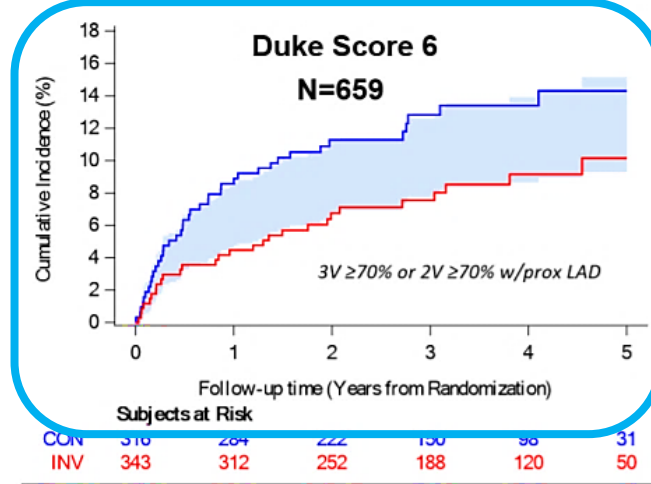
Predicting Incident MI





Can Severe CAD Defined by CCTA Guide Patients who Benefit from Invasive Care?

Myocardial Infarction



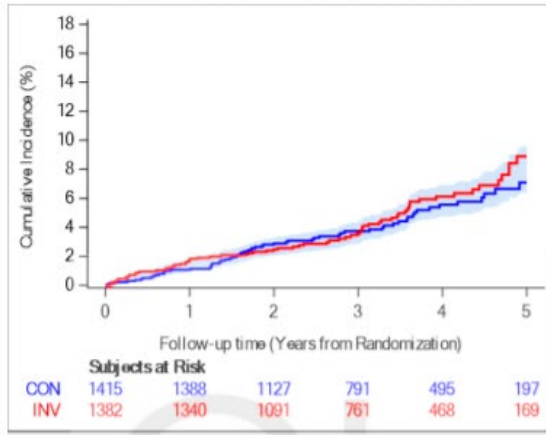
Uninterpretable CCTA : ≥1 uninterpretable key segments (n=1,343 / 2,818 = 48%).



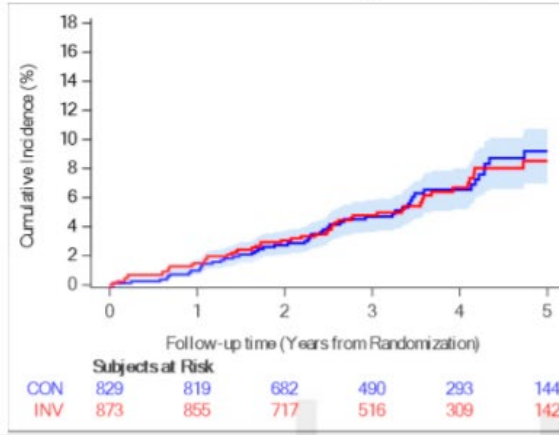
Ischemia Severity & Outcomes by Treatment

All-Cause Mortality

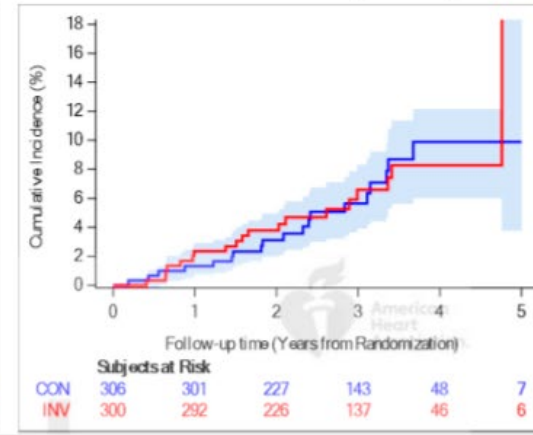
Severe Ischemia (N=2797)



Moderate Ischemia (N=1702)

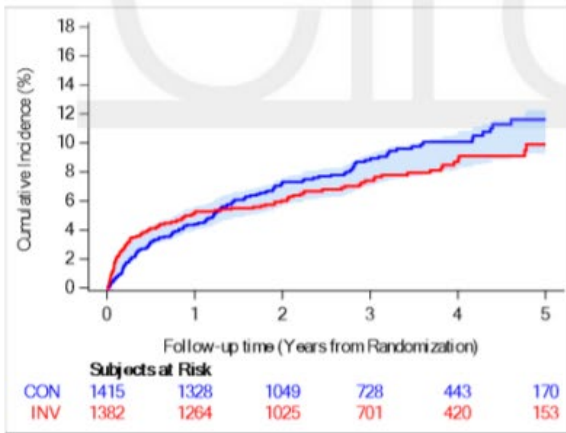


Mild/No Ischemia (N=606)

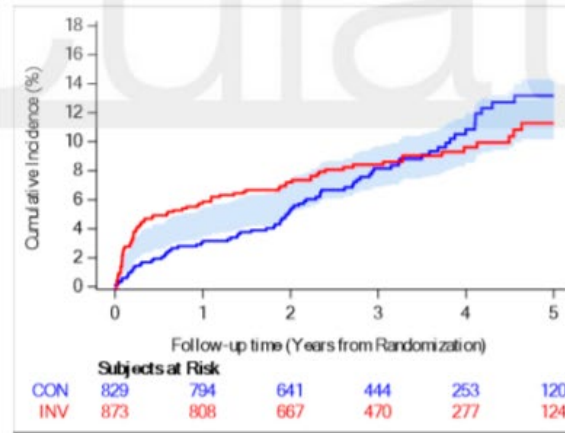


Myocardial Infarction

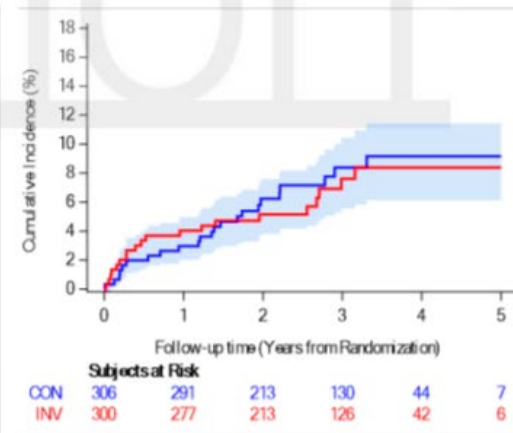
Severe Ischemia (N=2797)



Moderate Ischemia (N=1702)



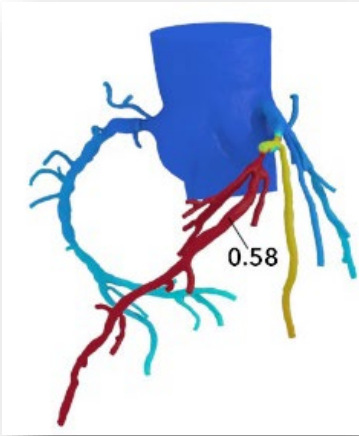
Mild/No Ischemia (N=606)



No statistical differences noted.

International Study of Comparative Health Effectiveness (ISCHEMIA) Trial

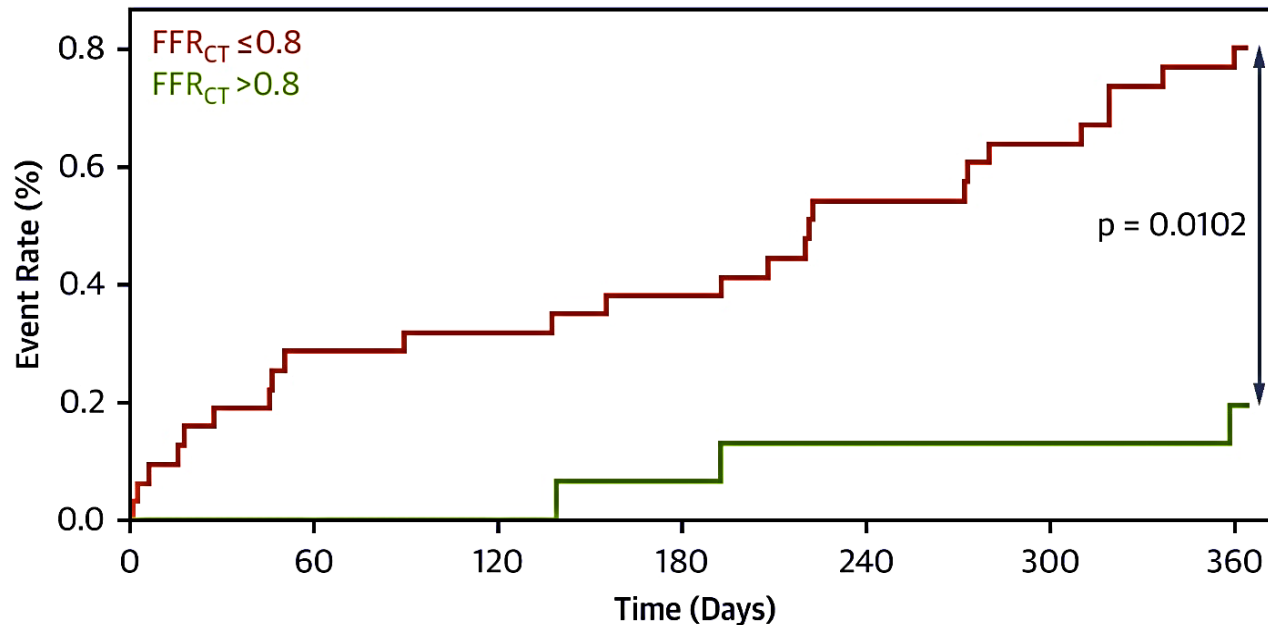
Source: Reynolds Circulation 2021;144:1024-1038.



Fractional Flow Reserve with CCTA (FFR-CT)

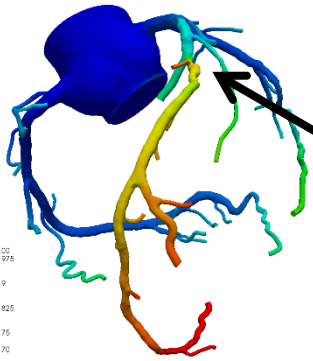
Assessing Diagnostic Value of Noninvasive FFR-CT in Coronary Care (ADVANCE) Registry
(N=4,737)

CV Death and MI Stratified by $FFR_{CT} > 0.80$ vs ≤ 0.80
N = 4737



- Computational Fluid Dynamics Applied to CCTA Data to Estimate FFR-CT

- HR: 4.22 (95% CI: 1.3-13), $p=0.01$
- Other FFR-CT Measures
 - Δ Across the Lesion (≥ 0.06)
 - Δ Across the Vessel (Diffuse)



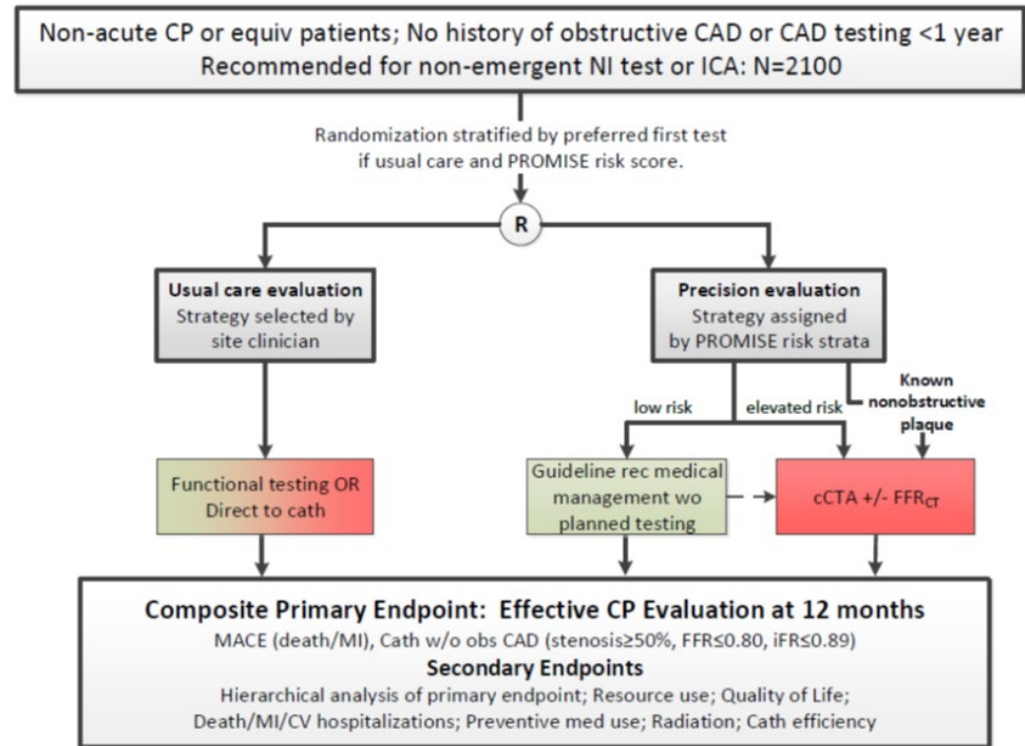
FFR-CT = 0.78

FFR to Guide Treatment Decisions

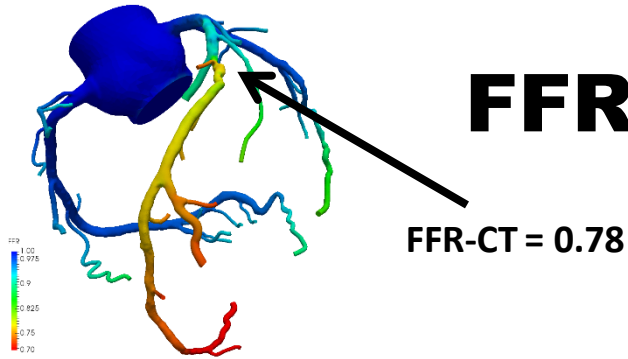
Need Randomized Trials to Show Improved Outcomes with FFR-CT Guided Care!



- **Strengths:**
- High Negative Predictive Value
 - Exclude Ischemia with FFR >0.80
- **One Stop**
 - CT Data is Sent Out with ~Prompt FFR Measurement
 - Consideration of Patient Time / Efficiency of Diagnosis – No Additional Testing with FFR-CT



FFR to Guide Treatment Decisions



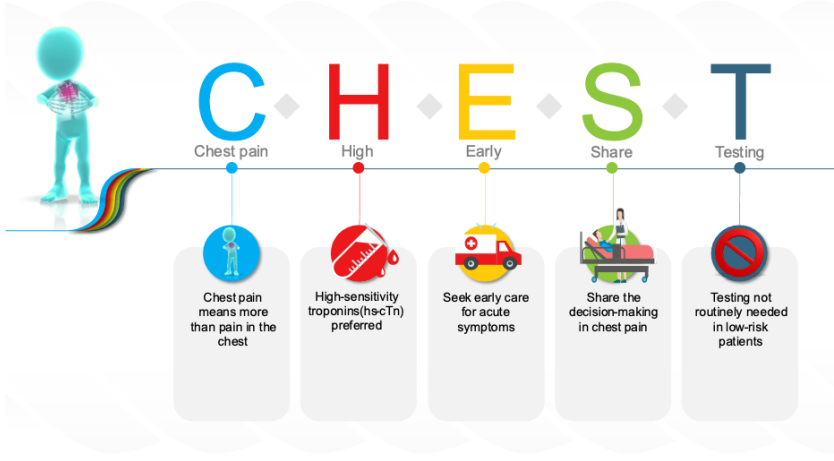
• Strengths:

- High Negative Predictive Value
 - Exclude Ischemia with FFR >0.80
- **One Stop**
 - CT Data is Sent Out with ~Prompt FFR Measurement
 - Consideration of Patient Time / Efficiency of Diagnosis – No Additional Testing with FFR-CT

• Limitations:

- Moderate Correlation w/ Invasive FFR Important for Revascularization Decisions
 - Improved w/ Immediate Post-Stenosis Measurement
- Outpatient Cohorts - Low Prevalence of Obstructive CAD → ~10-20% Eligible for FFR
- Adds Cost (But, Overall Lower Costs Fewer ICA, PCI,...)

Key Messages



Comparative Randomized Trials

ACC / AHA Chest Pain Guideline

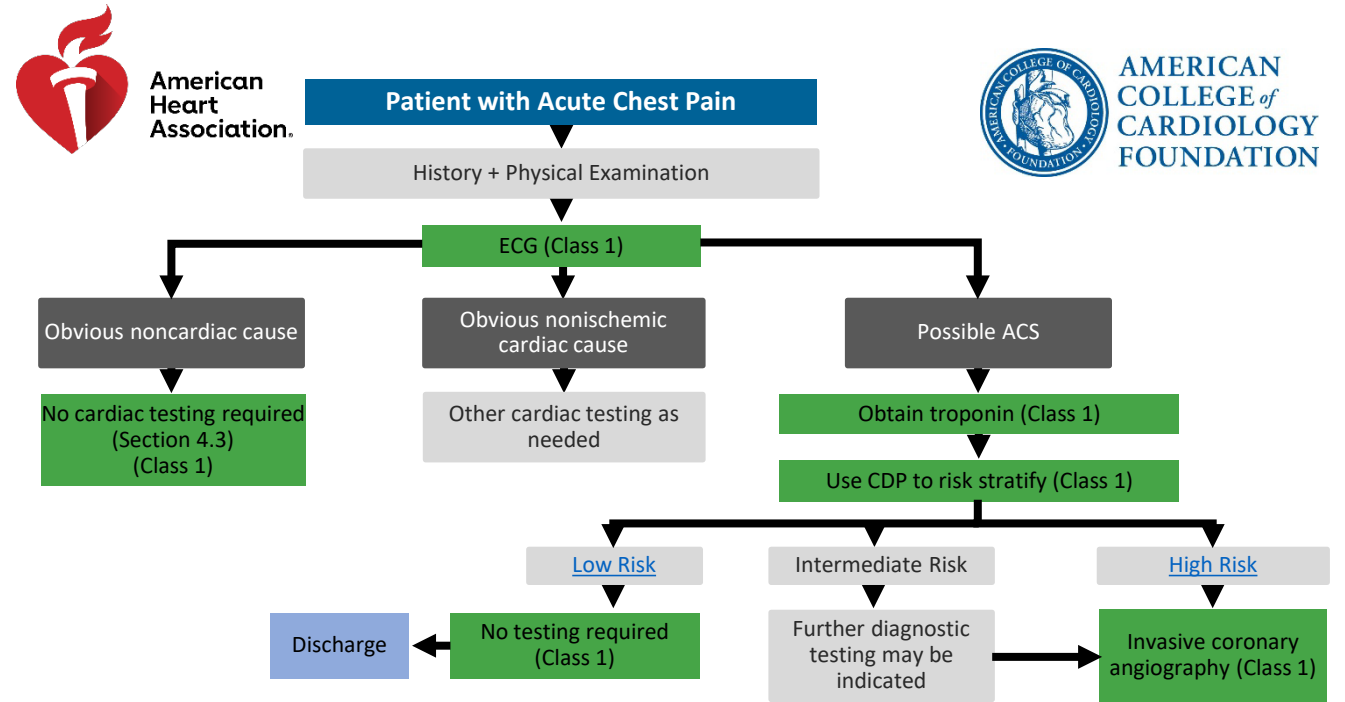
Unique Messages

Clinical Practice Guidelines

Robust Evidence – More So Than Any Other Modality!

Clinical Practice Guidelines with Numerous Class I Indications for CCTA

2021 AHA/ACC Guideline for the Evaluation & Diagnosis of Chest Pain



- Acute Chest Pain: 11 Randomized Trials of CCTA vs. Standard Care (N=6,460)
- Stable Chest Pain: 9 Randomized Trials of CCTA vs. Stress Testing or Invasive Coronary Angiography (N=22,450)

CCTA in the Acute Chest Pain Evaluation

- 11 Randomized Trials in Lower Risk Patients with CCTA vs. Standard Care (N=6,460)

- CCTA ↓ time to diagnosis & early D/C
- No safety issues with CCTA (death, MI, repeat ED or ACS) over ~1-6 months

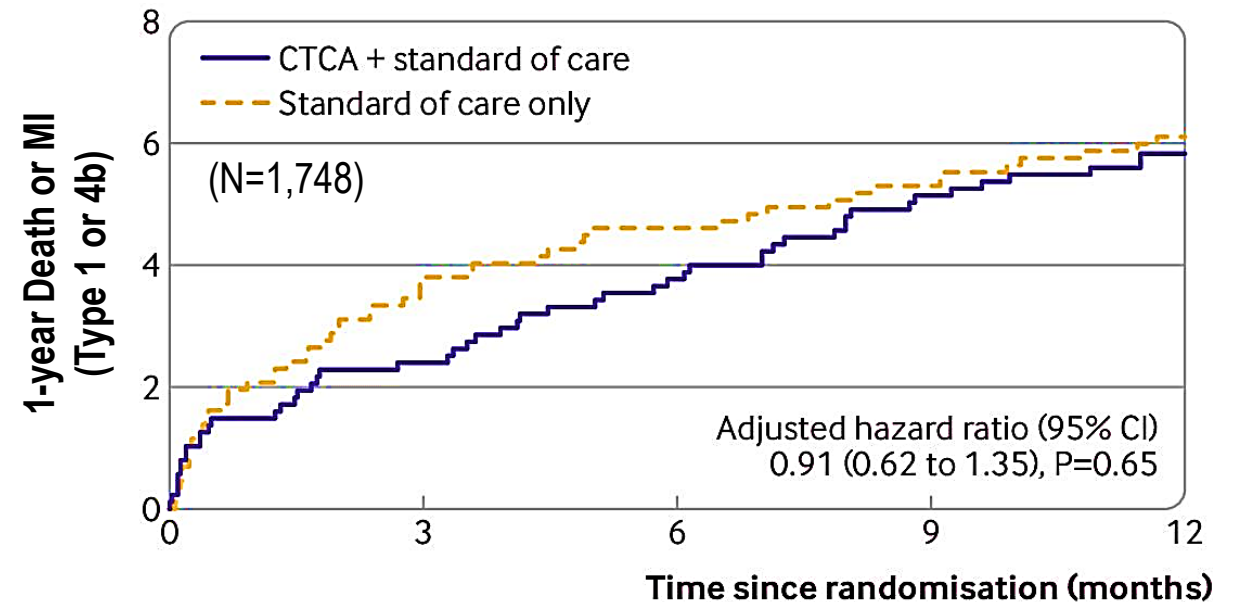
2 New Trials (not in Guideline)

- VERDICT Trial*

- NSTEMACS – AMI, Dynamic ECG Δs, or GRACE >140
- Very Early (≤12 h) CCTA – Accurate & Early D/C
- Neg. Predictive Value: 91% to Rule-Out CAD

Rapid Assessment of Potential Ischemic Heart Disease With CTCA (RAPID-CTCA)

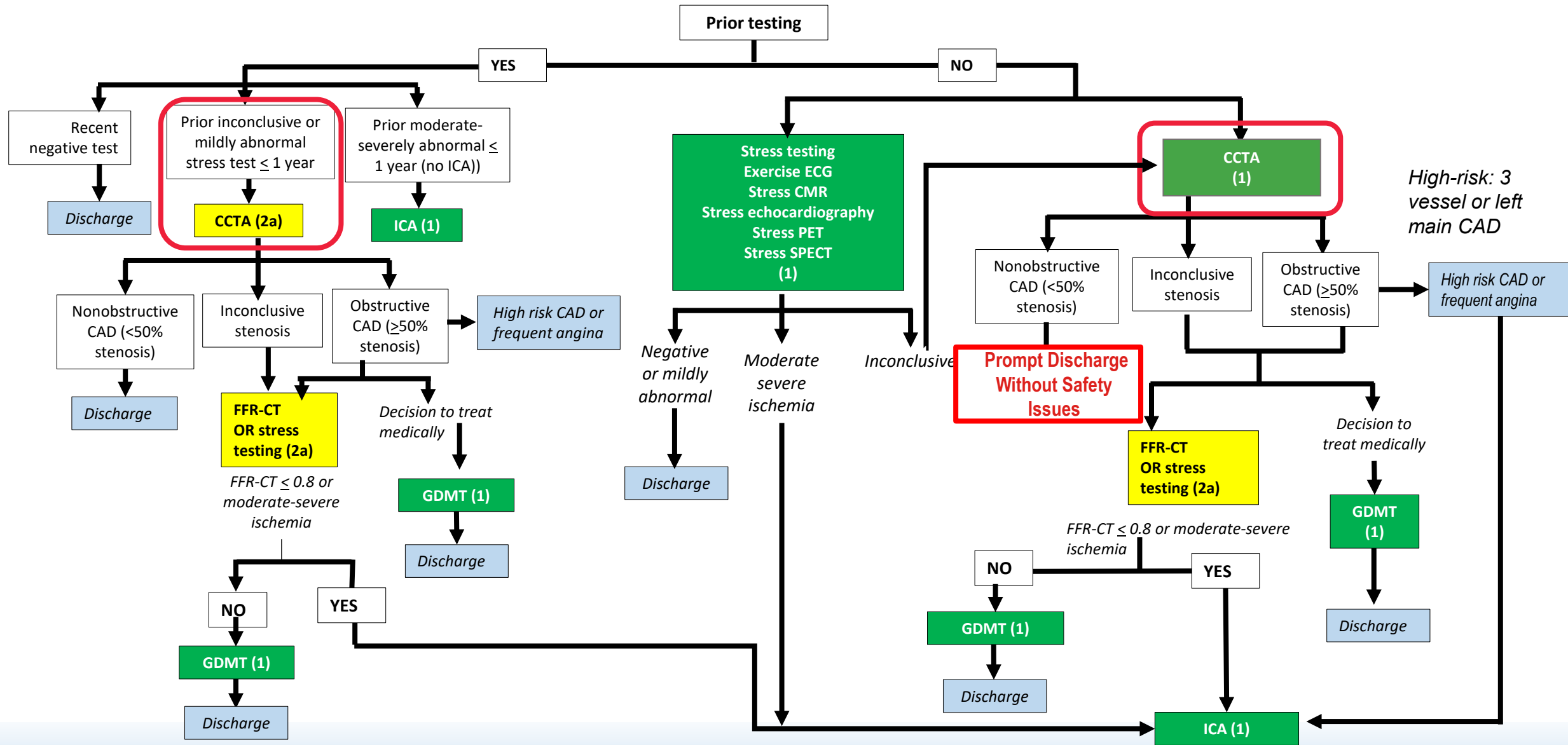
Early CCTA (~4.2 hrs) vs. Standard Care



Suspected/Provisional ACS Diagnosis + ≥1 = Known CHD, ↑ Cardiac troponin, or Abnormal ECG

*VERDICT: Very Early Vs. Deferred Invasive Evaluation Using CCTA in Patients with ACS

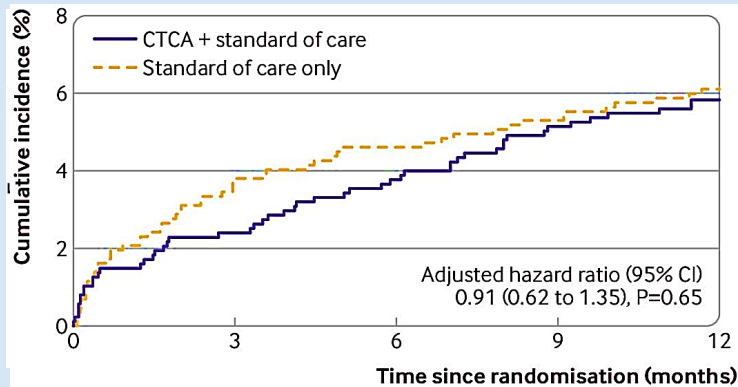
Evaluation Algorithm for Patients With **Suspected ACS** at Intermediate Risk With No Known CAD



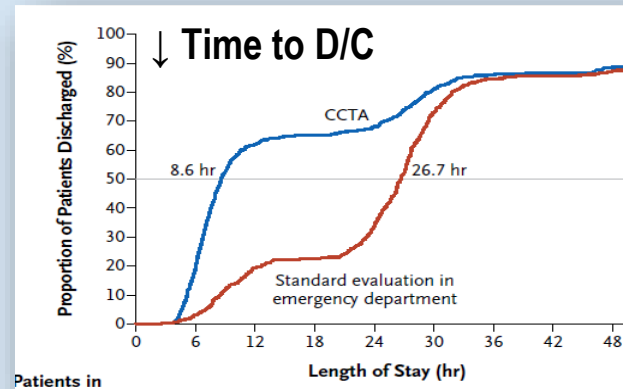
Source: Gulati JACC 2021;78:e187-e285., JACC 2021;78:2218-2261., Circulation 2021;144:e368-e454.

Current Evidence – CCTA in the ED

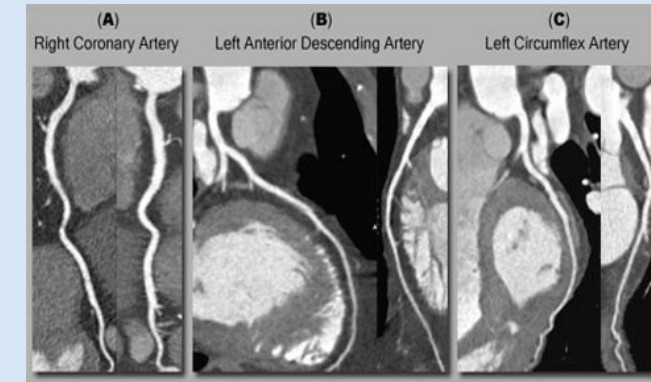
No Definitive Clinical Outcome Benefit



Rule Out MI / Ischemia Using Computer-Assisted Tomography II (N=1,000)



High Negative Predictive Value



Best Candidates

Intermediate Risk, No Known CAD

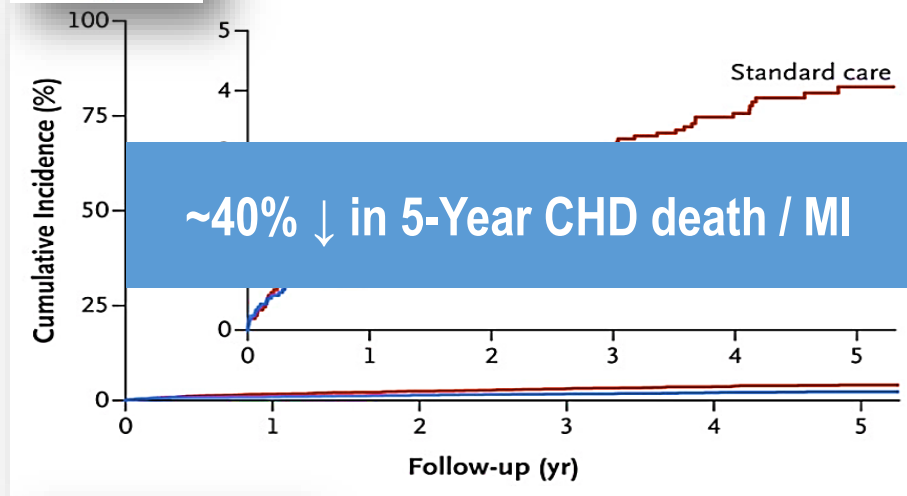
- Accurate & Prompt Diagnosis!
- Prompt D/C, Especially with NO Stenosis or Plaque

CCTA in the Stable Chest Pain Evaluation

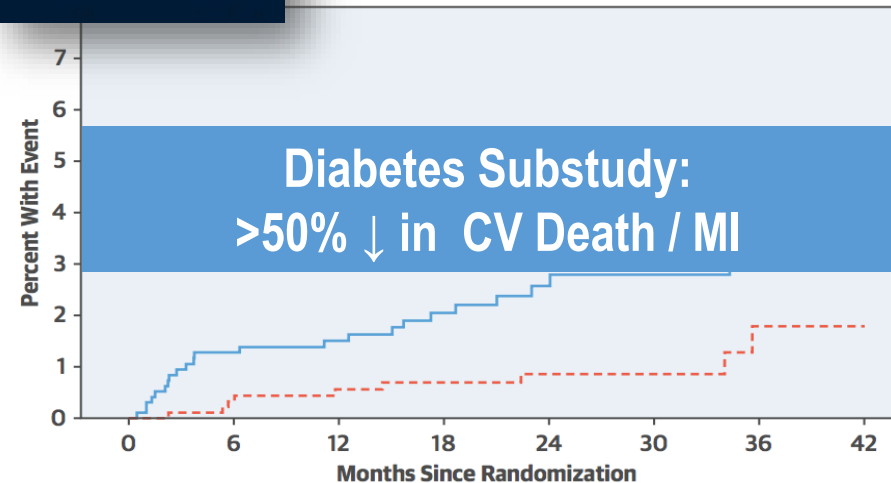
- 8 Randomized Trials:
 - Elective ICA Indicated: CCTA + Selective Invasive Coronary Angiography
 - CCTA vs. Standard Testing (No Difference)
- **SCOT-HEART: CCTA Reduced Longer Term Outcome**
 - *Tied to Greater Use of Statins, Aspirin*
- **PROMISE: CCTA Improved Outcome in Diabetics**



Scottish Computed Tomography of the HEART Trial



PROspective Multicenter Imaging Study for Evaluation of Chest Pain Trial



Source: Gulati JACC 2021;78:e187-e285., JACC 2021;78:2218-2261., Circulation 2021;144:e368-e454., Sharma JACC 2019;73:893-902., SCOT-HEART NEJM 2018;379:924-933.

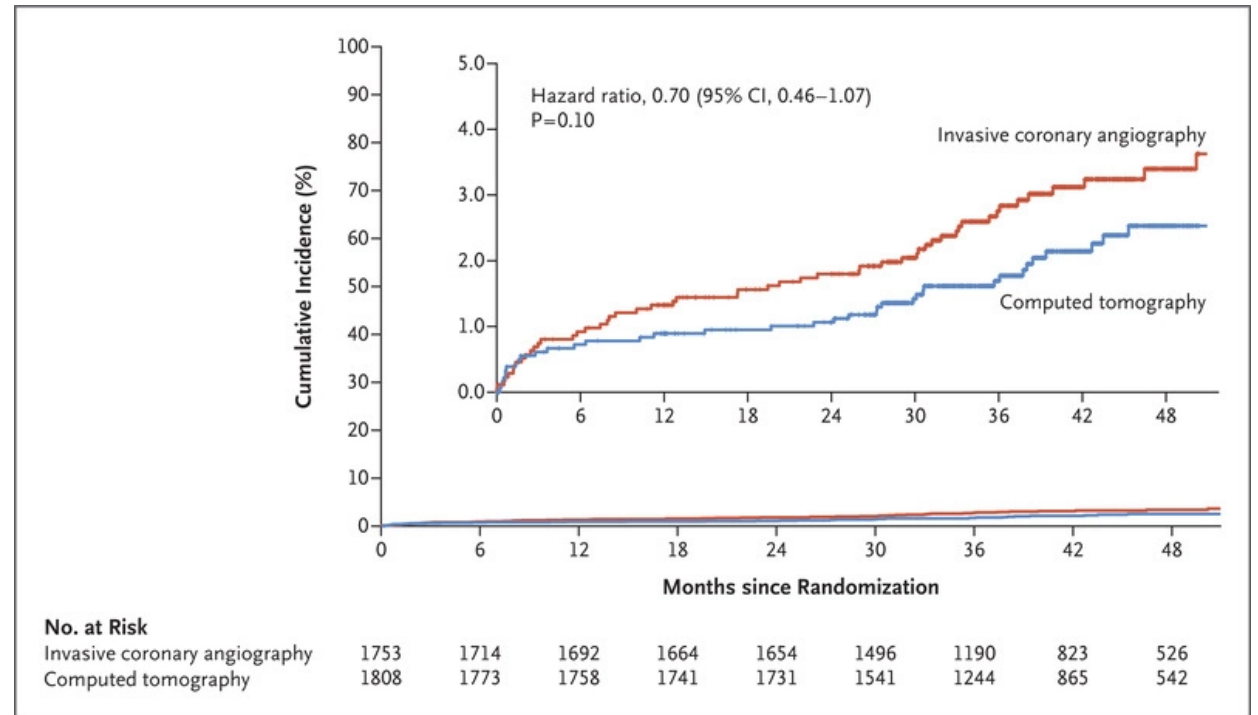
CT or Invasive Coronary Angiography in Stable Chest Pain

The DISCHARGE Trial Group*

- N=3,561 (26 centers, 16 European countries)
Referred for ICA with Stable Chest Pain + Intermediate CAD Probability
- MACE**
 - CT: 2.1% of 1,808 pts | HR: 0.70 (0.46-1.07)
 - ICA: 3.0% of 1,753 pts | p=0.10
- Procedure-related complications
 - CT: 0.5% | HR: 0.26 (0.13-0.55)
 - ICA: 1.9%

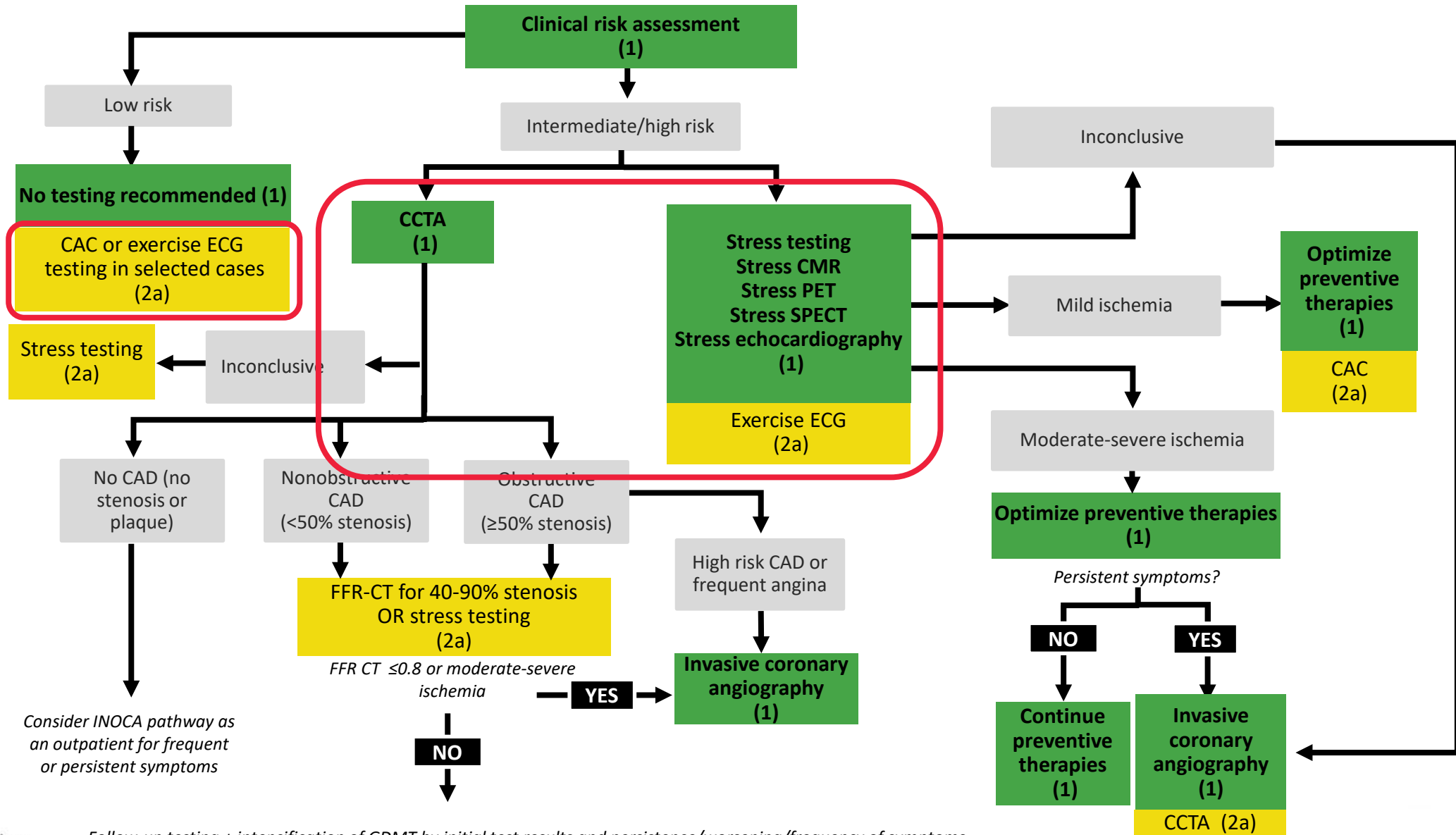
*Diagnostic Imaging Strategies for Patients with Stable Chest Pain and Intermediate Risk of Coronary Artery Disease

Similar MACE Event Rates in CT and ICA Arms



**MACE: CV death, MI, or Stroke over 3.5 years.

Stable Chest Pain + No Known CAD



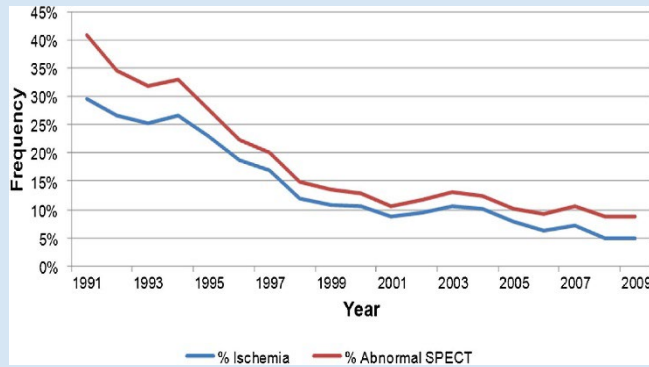
Follow-up testing + intensification of GDMT by initial test results and persistence/worsening/frequency of symptoms



Source: Gulati JACC 2021;78:e187-e285., JACC 2021;78:2218-2261., Circulation 2021;144:e368-e454.

Current State of Diagnostic Testing

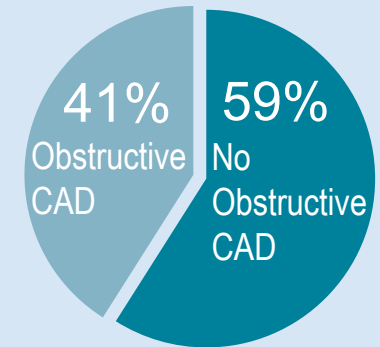
Low Rate of Ischemia (~5%)



PROspective Multicenter Imaging Study
for Evaluation of Chest Pain Trial
(N=10,003)

Chest Pain Atypical	78%
Chest Pain Typical	12%
Obstructive CAD	12%
CHD Death or MI	1% / year

ACC - National CV Data Registry -
Elective Invasive Coronary Angiography
(N=376,430)



Best Candidates

Much More Than
Lower Risk!!!!

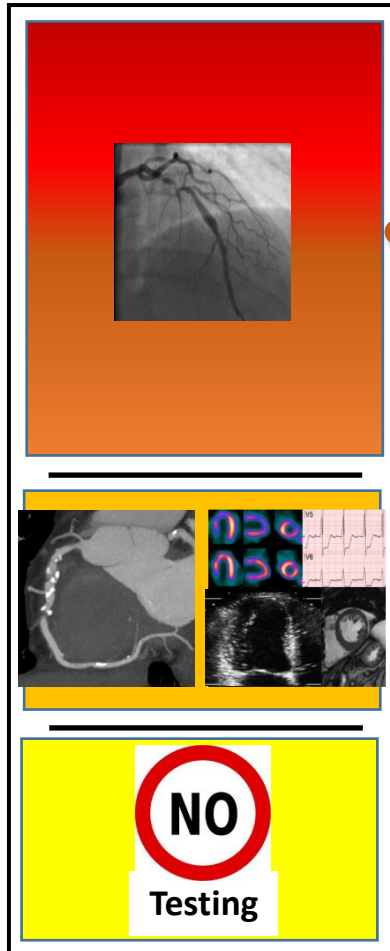
Suspected CAD

- CCTA First Followed By Selective FFR-CT or Stress Testing
 - Higher Diagnostic Accuracy
 - Lower MACE Rate in Normals
- Atherosclerosis Detection - Guide Preventive Care

Acute Chest Pain

Evaluation

ED Evaluation



Risk of Major CAD Events

Per ACC / AHA Guideline

ACS

INVASIVE CORONARY ANGIOGRAPHY

High Risk

ANATOMIC OR FUNCTIONAL TESTING

ANATOMIC OR FUNCTIONAL TESTING

Intermediate Risk

DEFER TESTING - OPTIONAL Ex ECG or CAC SCAN

Low Risk

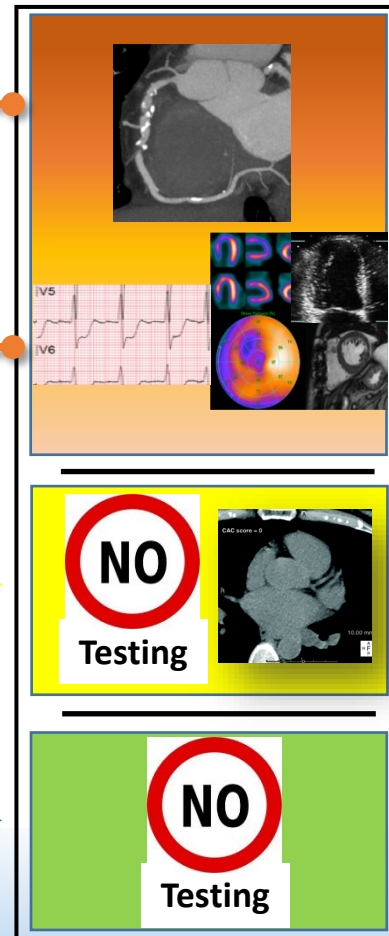
Asymptomatic

NO TESTING

Stable Chest Pain

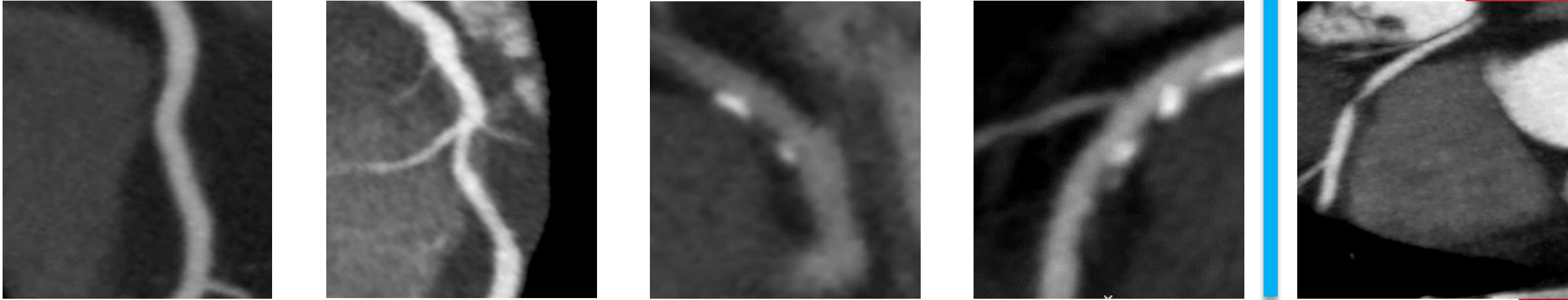
Evaluation

Outpatient Evaluation

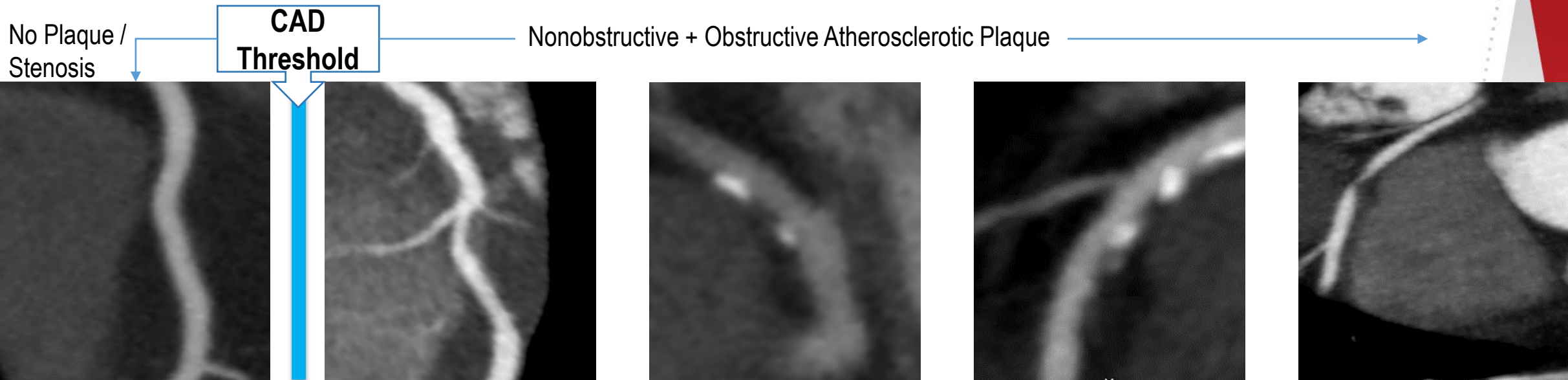


CCTA Redefines “CAD”

- Traditional Goal of Stress Testing = Obstructive Stenosis $\geq 50\%$



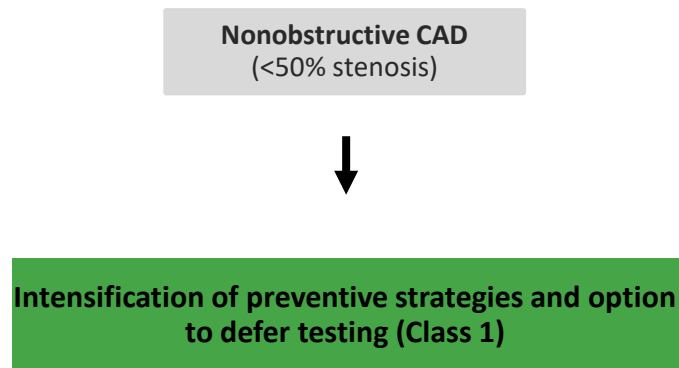
- Updated Definition = Presence of Atherosclerotic Plaque or Any Obstructive Stenosis



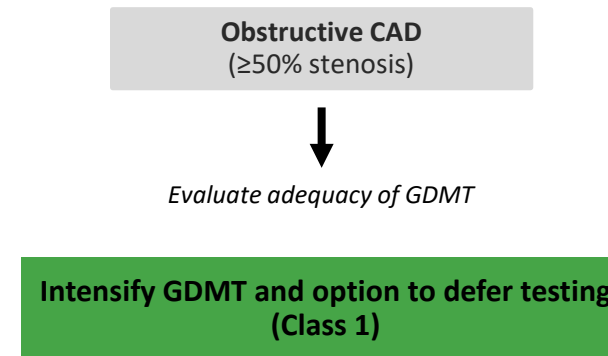
Emphasis on Medical Management



Intensify Preventive Therapy for Nonobstructive CAD



Optimize GDMT in Obstructive CAD

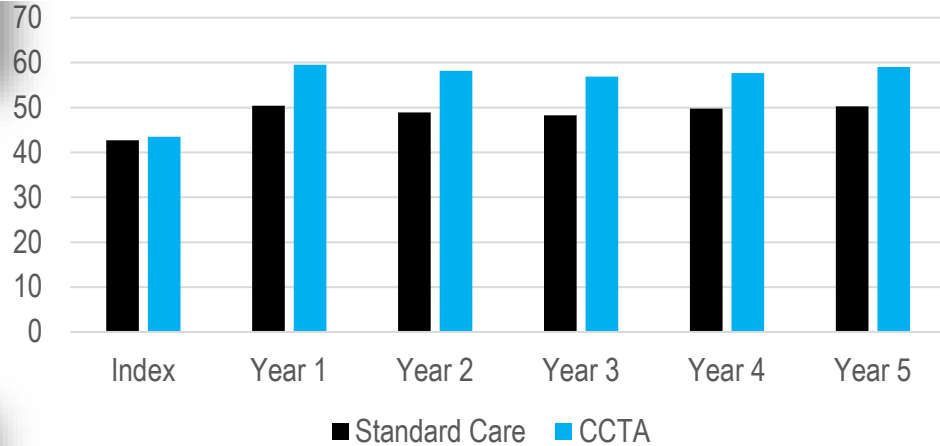


Evolving Evidence on CT-Guided Preventive Care



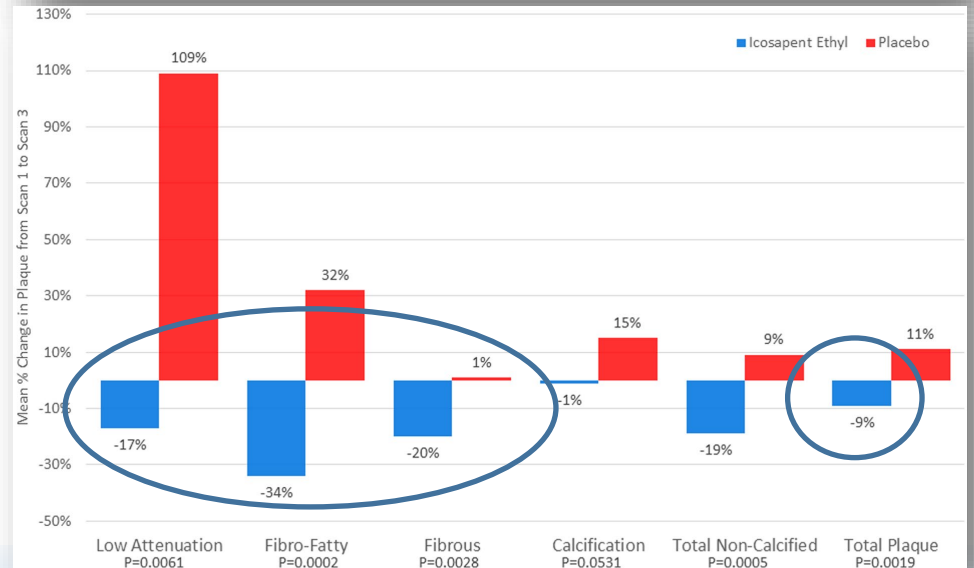
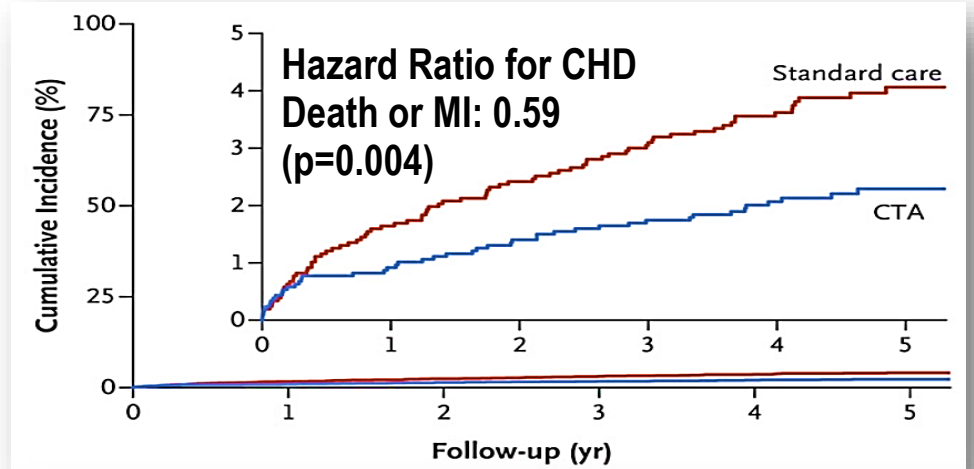
Statin Use

Scottish Computed Tomography of the HEART Trial



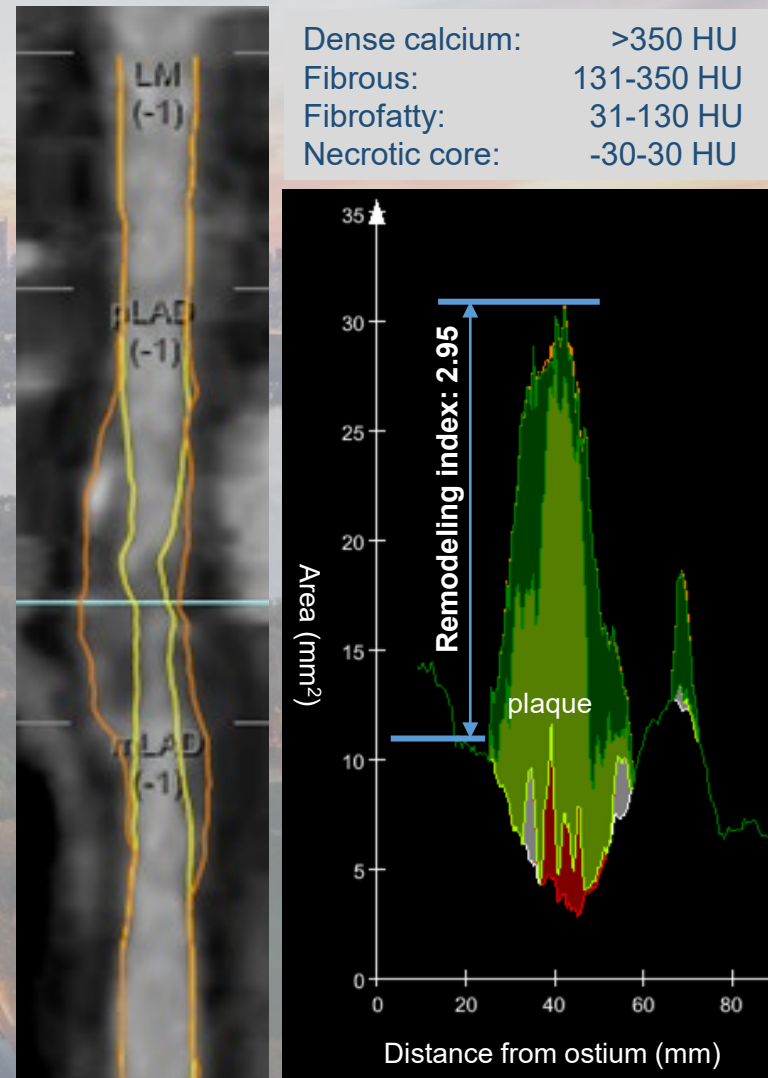
Effect of Vascepa on Improving Coronary Atherosclerosis in People With High Triglycerides Taking Statin Therapy (EVAPORATE) Trial

- n=68 with Atherosclerosis ($\geq 20\%$ stenoses) on Statin w/ elevated Tg & LDL-C ≥ 40 to ≤ 115 mg/dL
- 1^o endpoint - Δ low density plaque volume @ 18 m IPE (4g / day) vs. Placebo



Source: SCOT-HEART NEJM 2018;379:924-933., SCOT-HEART Lancet 2015;385:2383-2391., Williams JACC 2016;67:1759-68., Budoff Eur Heart J 2020;41:3925-3932.

Risk Stratification with Atherosclerotic Plaque

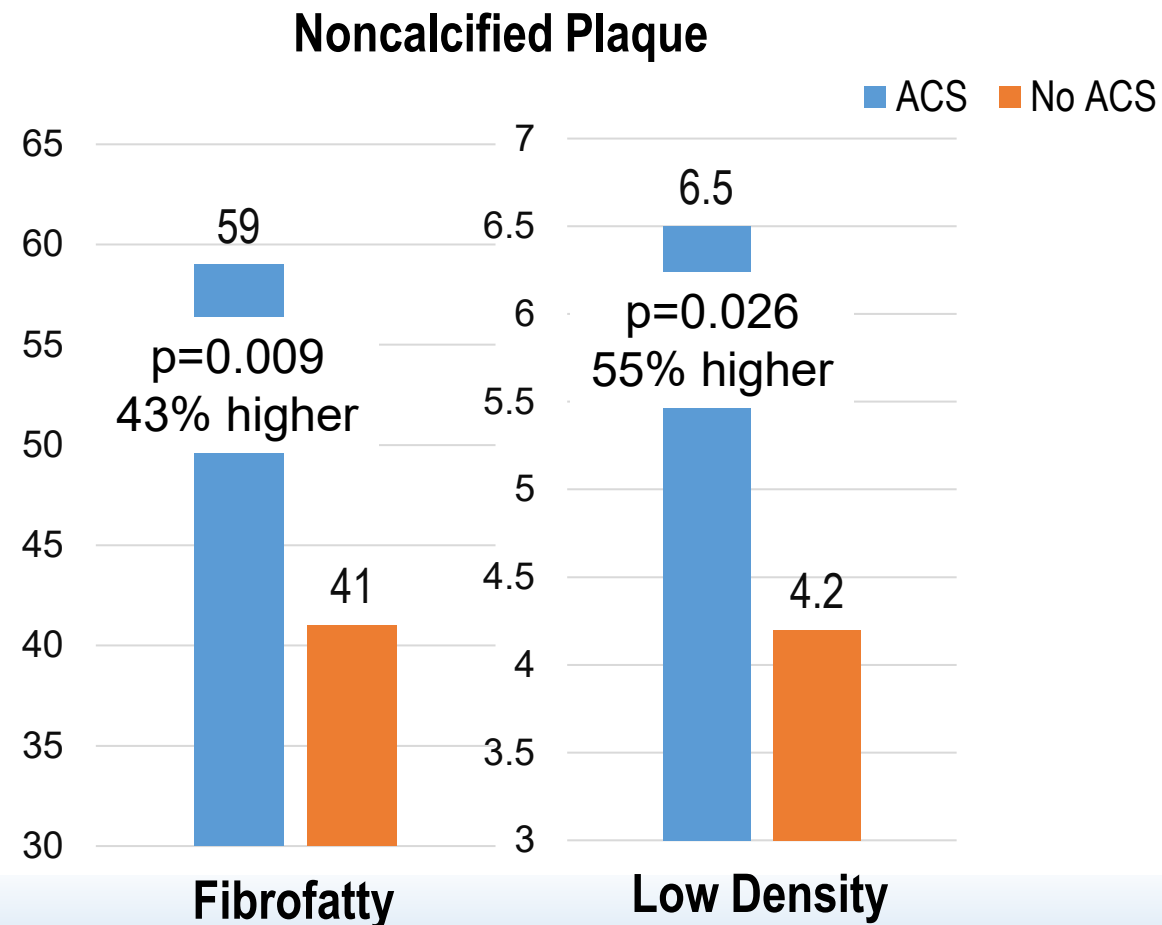


ICONIC

Incident COronary EveNTs Identified by Coronary Tomography

Coronary Atherosclerotic Precursors of Acute Coronary Syndromes

- 65% of ACS = Nonobstructive CAD
- Quantitative Plaque Assessment:
 - ↑ Volume of **“Lipid Rich”** Noncalcified Plaque
 - Low Density (p=0.026) &
 - Fibrofatty Plaque (p=0.009)
 - High Risk Plaque Predicts ACS
 - Low Density Plaque
 - Hazard Ratio: 1.4 (p=0.02)



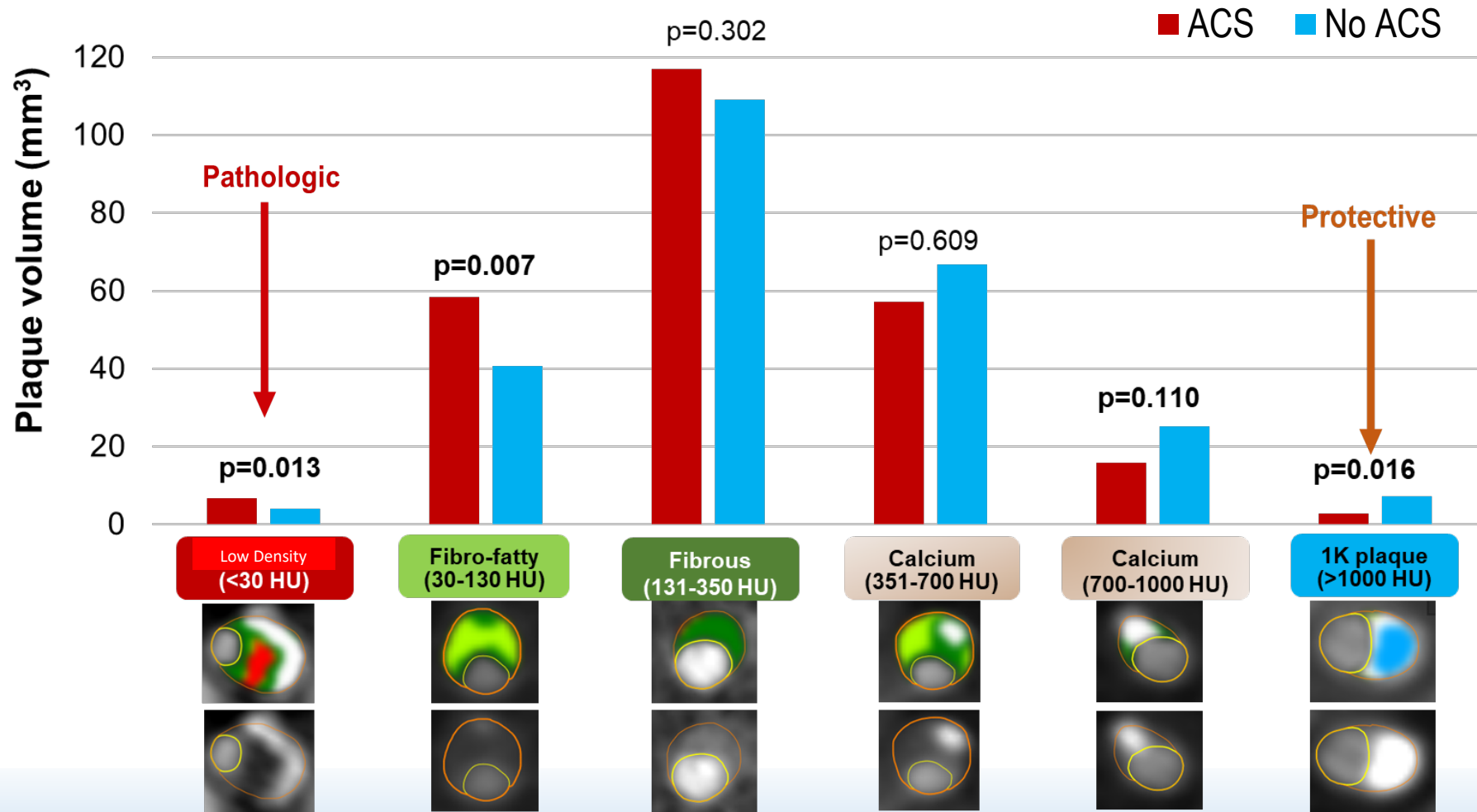
NIH-NHLBI-sponsored

Source: Chang J Am Coll Cardiol 2018;71:2511-2522.

ICONIC

Incident COronary EveNts Identified by Coronary Tomography

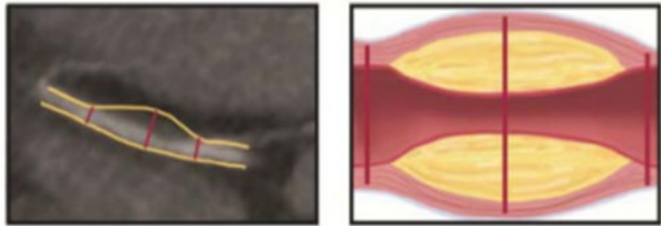
Coronary Atherosclerotic Precursors of Acute Coronary Syndromes



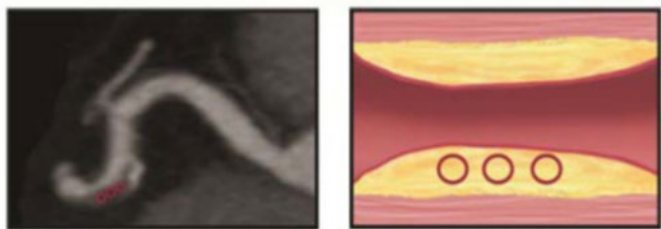


NIH-NHLBI PROMISE Trial: High Risk Plaque Features

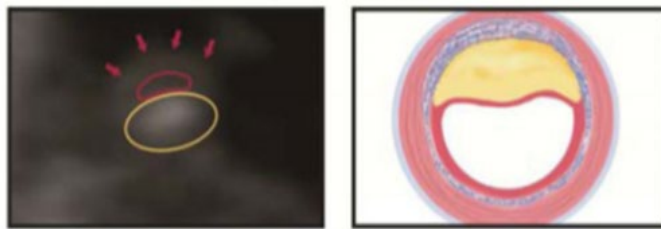
Positive Remodeling



Low Attenuation



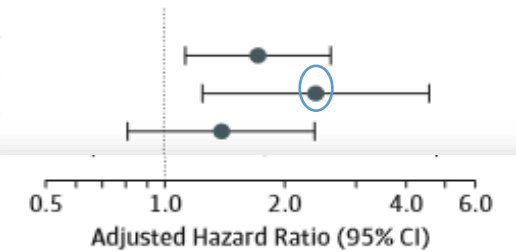
Napkin Ring Sign



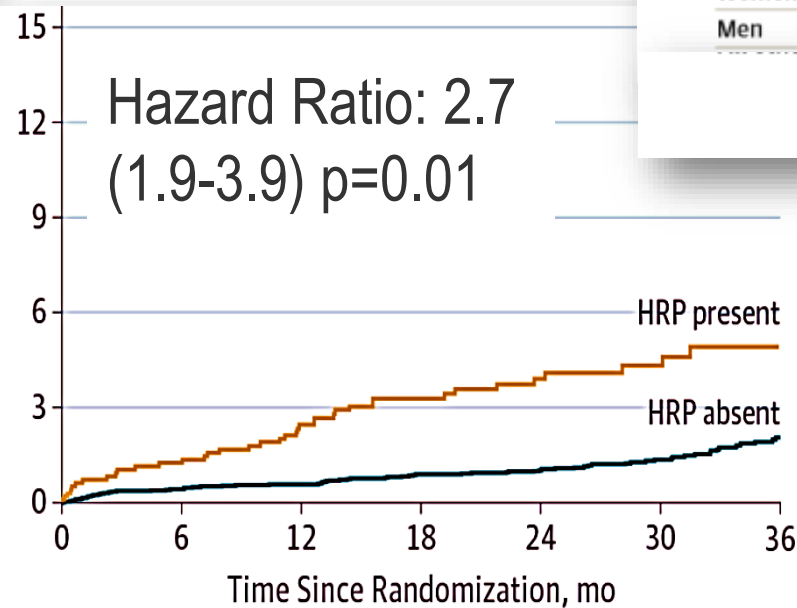
High-Risk Plaque More Predictive in Women, Younger, & Nonobstructive CAD

Subgroup

- Overall
- Women
- Men



Hazard Ratio: 2.7
(1.9-3.9) p=0.01

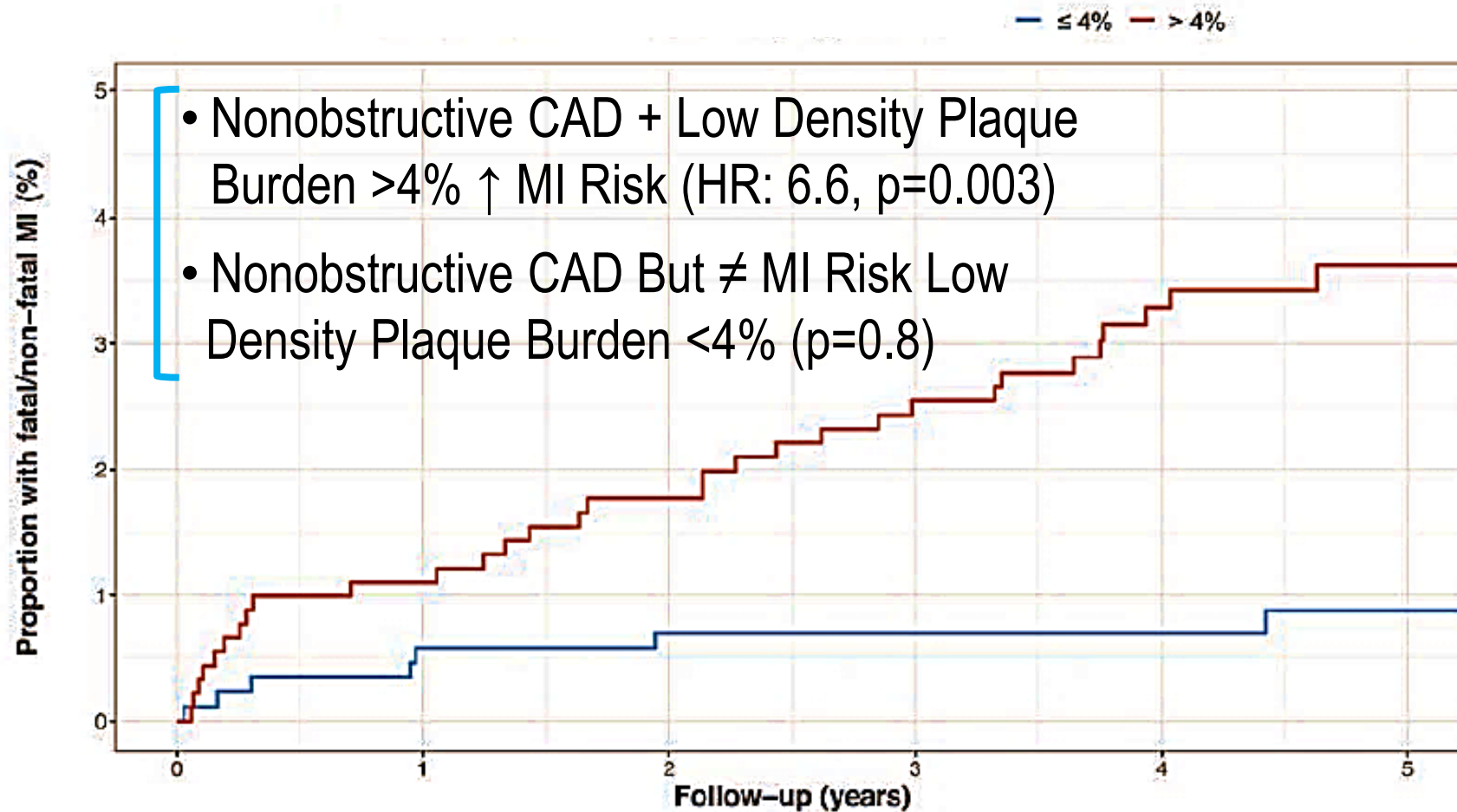


Napkin Ring: Central area of low density abuts lumen & ring higher density.

*Analysis did not include spotty calcification

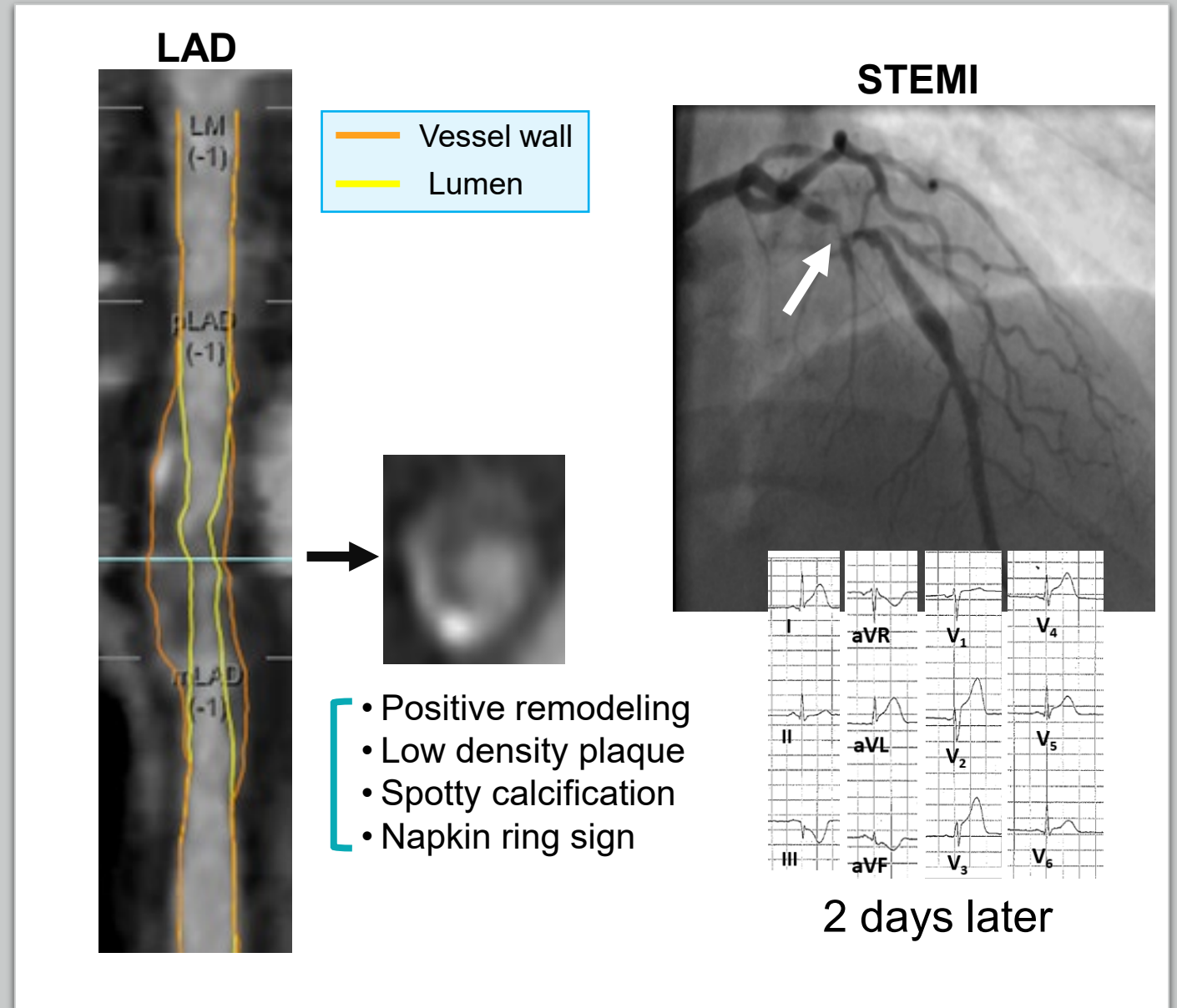


SCOT-HEART Trial: Incident MI by Low Density Plaque Burden



Concluding Remarks

- Rapid Evolution in CT Evidence
- Evolving Understanding of the Role of Atherosclerotic Plaque Assessment
- Lots to Learn About Risk Prediction!



Thank You



Optum Health Education™

USMD Cardiac CT Program

Stephen B. Johnston MD, FACC
Medical Director of Specialty Medicine
USMD – Part of Optum Care

November 2, 2022



DISCLOSURE STATEMENT

Dr. Stephen Johnston has no financial relationships to disclose.

April 2020

United Healthcare will reimburse for Coronary CT Angiograms when ordered to evaluate stable chest pain in members with low and intermediate risk for coronary artery disease (CAD) as first-line testing.

Computed tomographic angiography (CTA) is expected to replace the need for other functional stress testing in this population.

The following tests are considered functional stress tests:

1

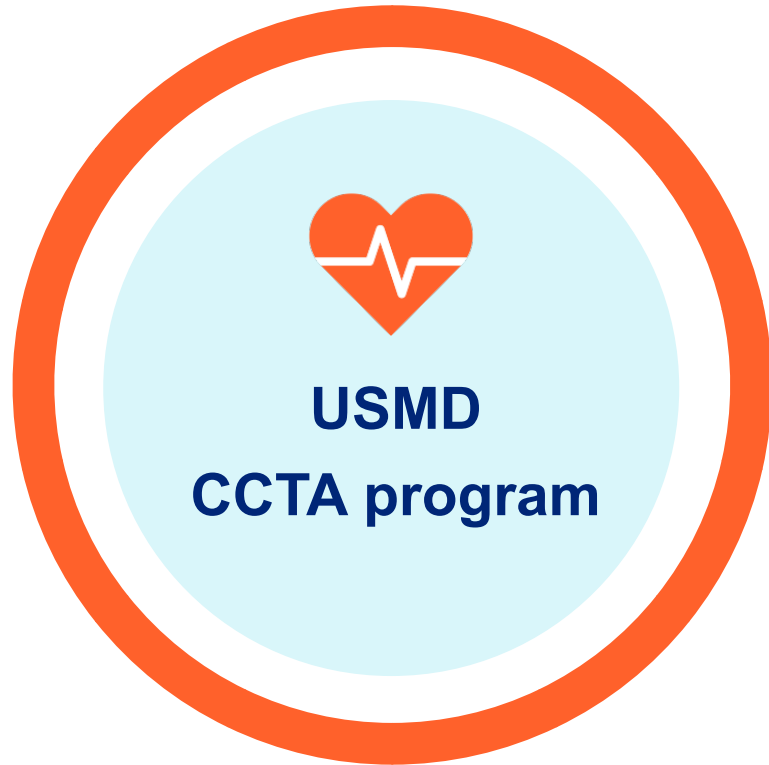
Nuclear Stress

2

Stress Echocardiogram

3

PET Stress



Return on investment

Cost savings generated by coronary CTA 1st strategy.

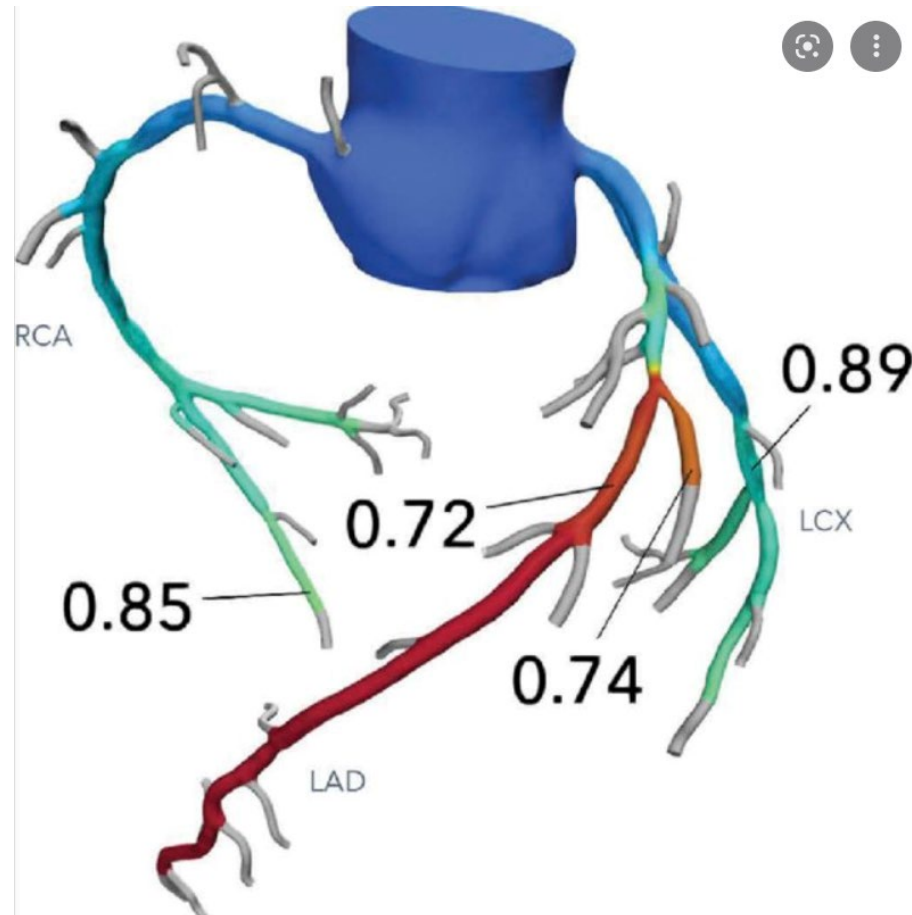
Direct referrals

Primary care providers are encouraged to make direct referrals for coronary CTA.

Send for FFRct

Having the ability to send for FFRct would be a fundamental component of the program. Improves gatekeeper function of cardiac CTA along with reduced downstream testing.

FFRCT



Cardiac CT imaging center workflow

PCP can help!

How?



The data supporting a CCTA 1st strategy in the evaluation of stable chest pain is undeniable.

The technology will continue to improve/ Cardiac CT is dominating industry product development.

With the power of being part of Optum, we can be leaders in the field.

Try it!

“

“Functional stress testing does a poor job of identifying obstructive CAD, ruling out significant LM disease, prognosticate outcomes, guide decision making, correlate well to angina or correlate to CAD extent and severity.”



Matthew Budoff, MD

Investigator, The Lundquist Institute

Professor of Medicine, David Geffen School of Medicine at UCLA

Program Director and Director of Cardiac CT, Division of Cardiology, Harbor-UCLA Medical Center

If you have additional questions, please contact:

- Optimal Care: OptimalCare@optum.com
- Optum Health Education: moreinfo@optumhealtheducation.com
- Leslee J. Shaw, PhD, MASNC, FACC, FAHA, FSCCT:
leslee.shaw@mountsinai.org
- Stephen B. Johnston, MD, FACC: stephen.johnston@usmd.com