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Coronary CTA for Calcium Scoring and Plaque Analysis

Wm. Guy Weigold, MD, FACC, FSCCT

Director, Cardiac CT

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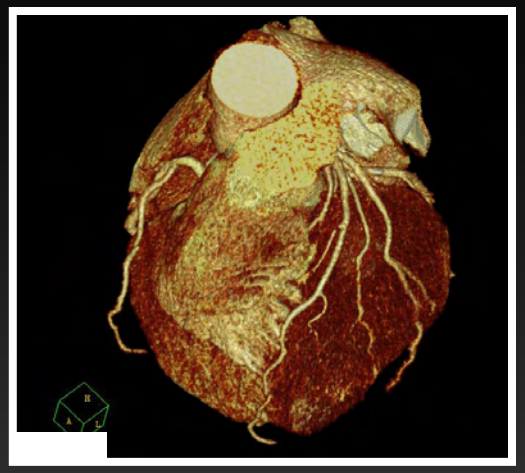
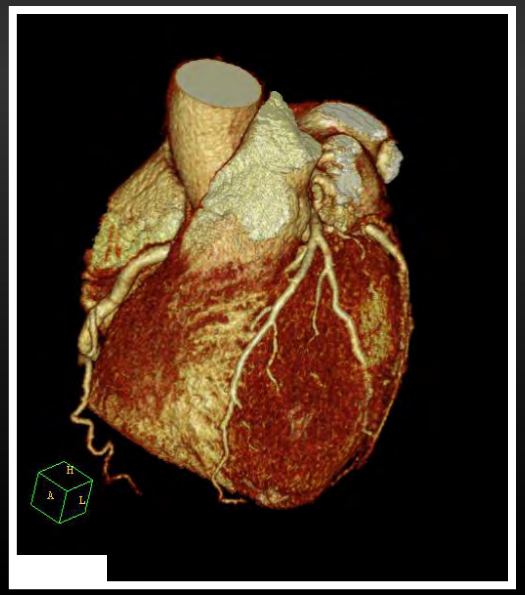
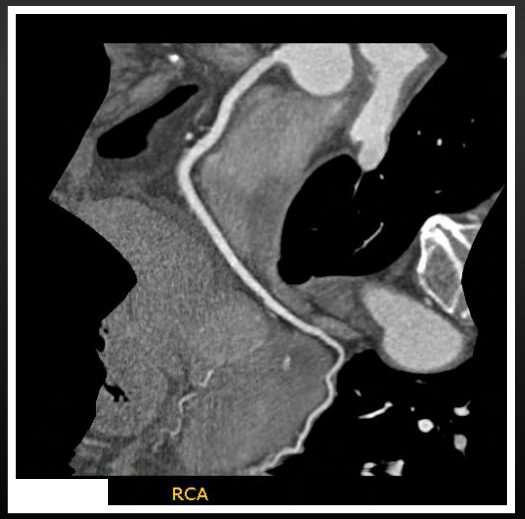
Cardiac CT = Coronary CT Angiography







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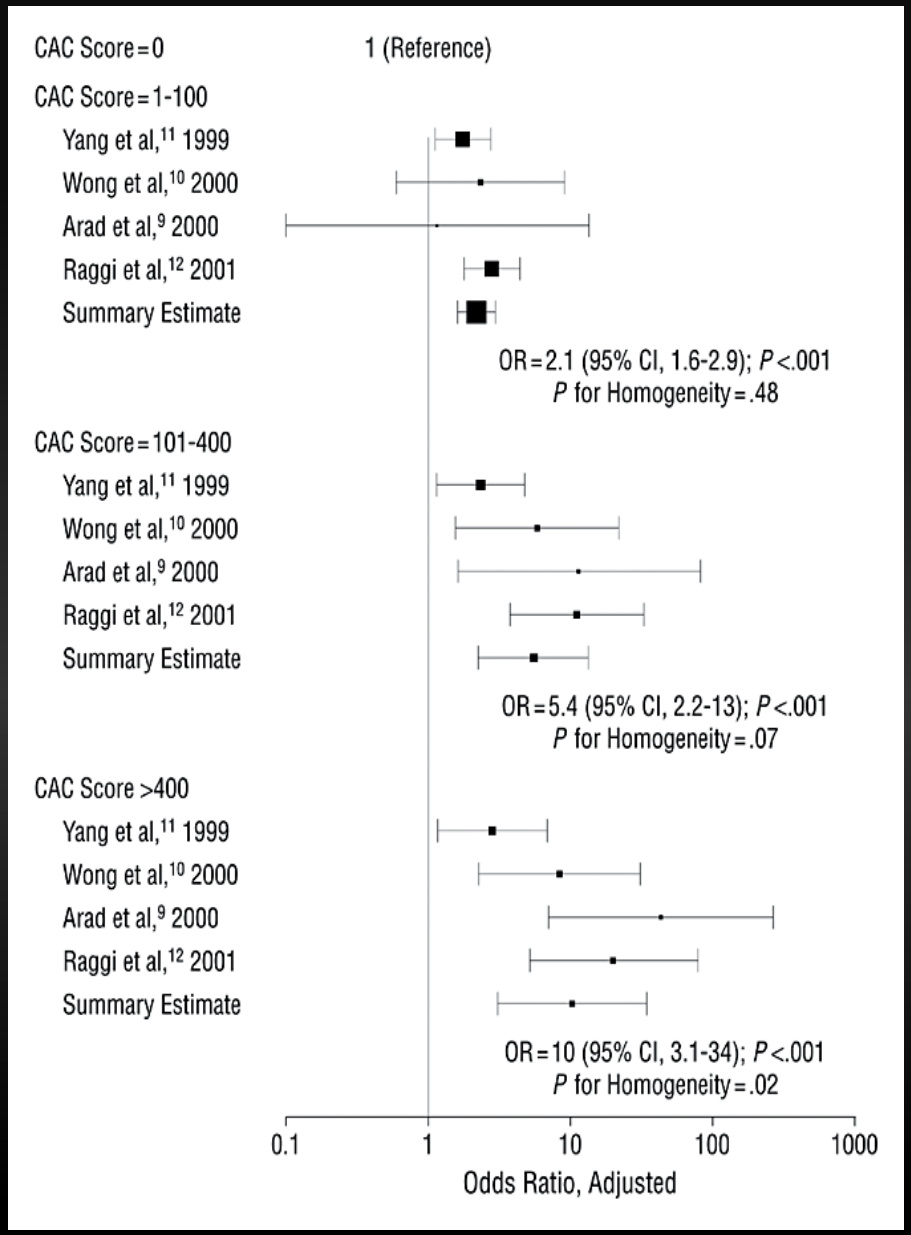
Cardiac CT also = Coronary Calcium Scan

Preceded coronary CTA by 10 years (1990)

- Calcium scoring method
  - **Agatston, Janowitz**, Hildner, Zusmer, Viamonte, **Detrano**

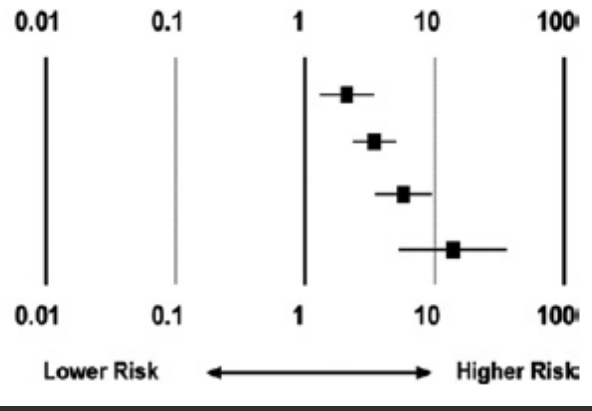
Incremental predictive value of CACS



Arch Intern Med. 2004;164(12):1285-92

From JACC 2007 consensus: CHD death or MI

Summary RR Ratio	CACS	RR	(95% CI)	Events / N: Higher Risk	Events / N: Low Risk*	p
Average Risk	1-112	1.9	(1.3-2.8)	67 / 9,514	45 / 12,163	0.001
Moderate Risk	100-400	4.3	(3.1-6.1)	110 / 5,209	49 / 11,817	<0.0001
High Risk	400-999	7.2	(5.2-9.9)	182 / 3,940	49 / 8,649	<0.0001
Very High Risk	1,000	10.8	(4.2-27.7)	14 / 196	6 / 905	<0.0001

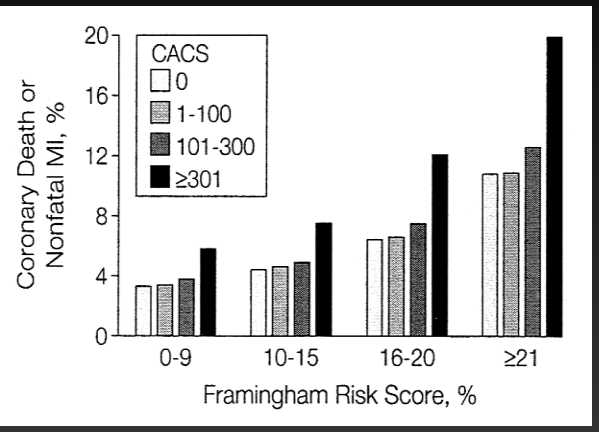


- Higher CAC scores associated with higher event (CHD death or MI) rates and higher RR ratios
  - High risk rate: 4.6%
  - Very high risk rate: 7.1%
  - (rates at 3-5 years)

Greenland P, Bonow RO, Brundage BH, et al. JACC 2007;49:378-402

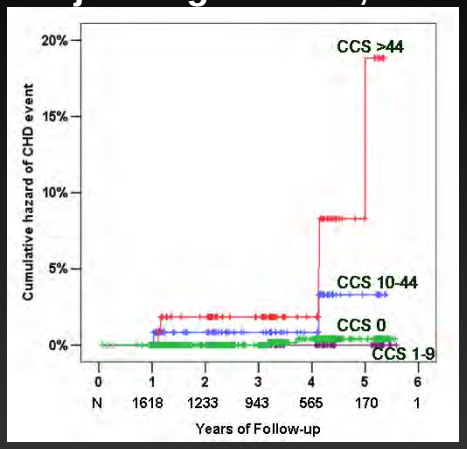
Following this meta-analysis, 4 more prospective studies

South Bay Heart Watch: Middle aged, higher risk



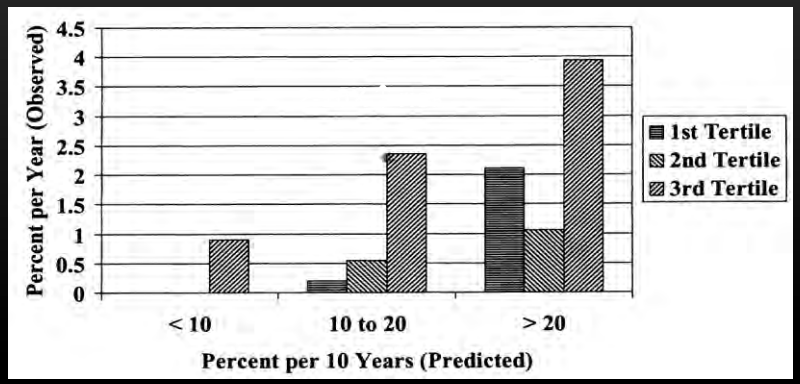
Greenland. JAMA 2004;291:210-215.

PACC Project: Aged 40-50, low risk



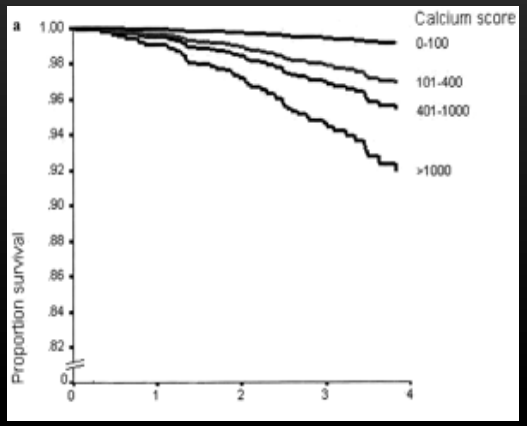
Taylor et al, JACC 2005;46:807-814

St. Francis: Middle aged



Guerci et al. JACC 2005;46:158

Rotterdam: Elderly



Vliegenthart. Circulation 2005;112:572

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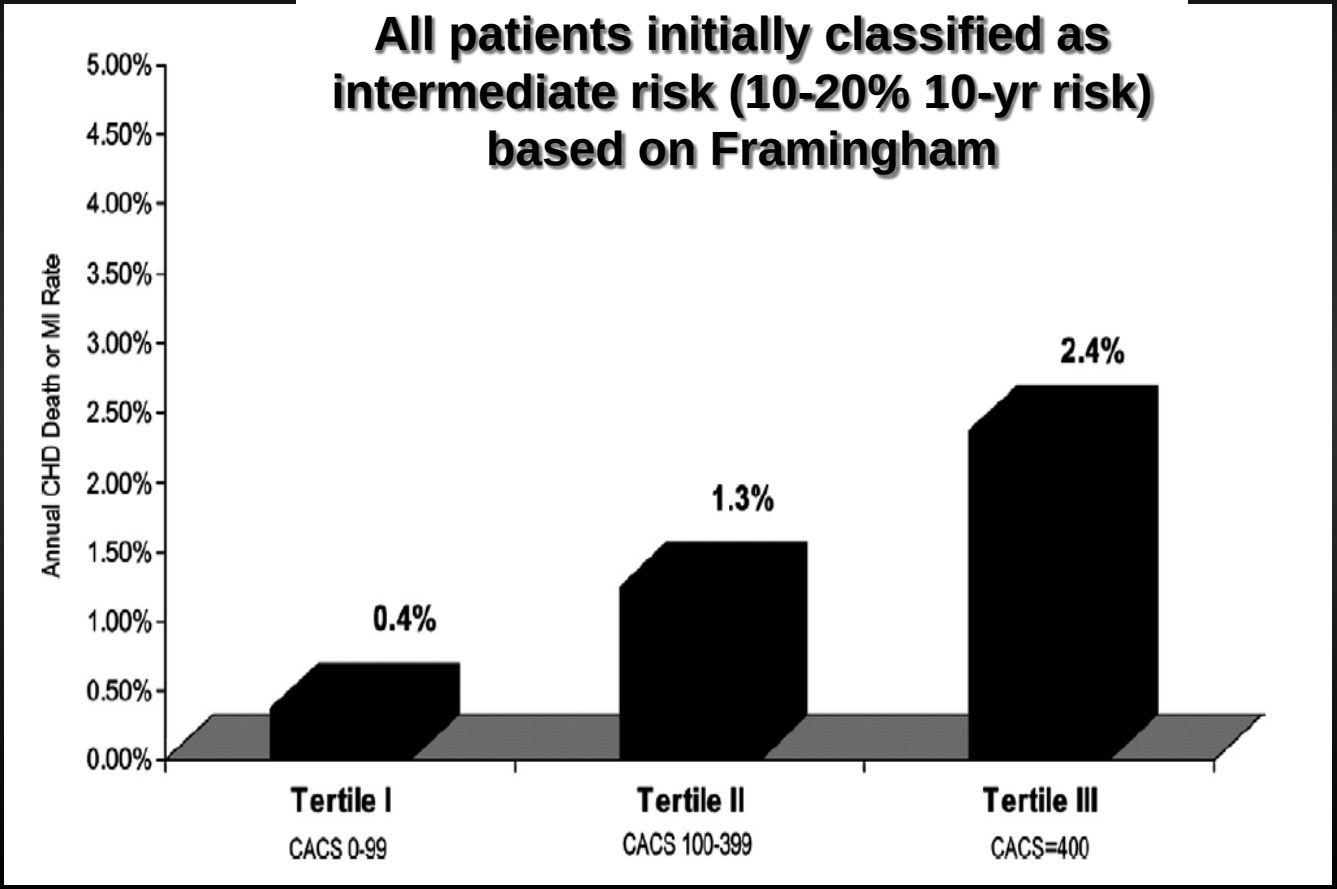
Pooled data from 4 studies:

Intermediate Framingham risk patients only (10-20% 10-yr risk)



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Cardiac Imaging

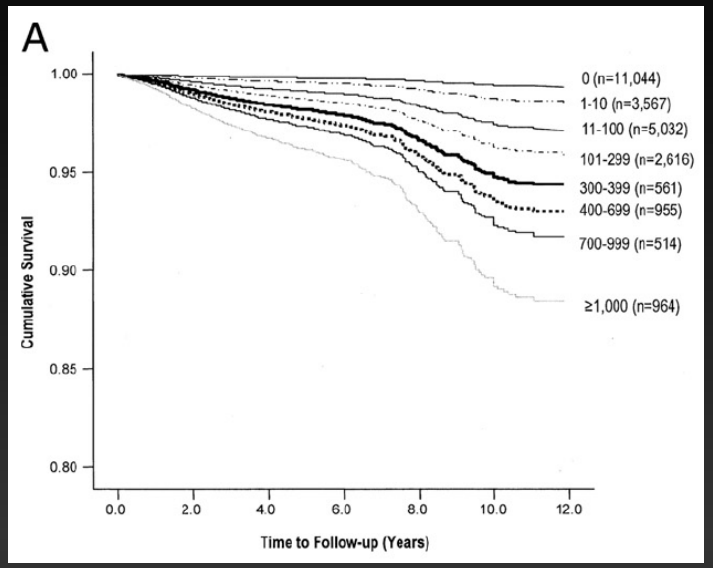
Long-Term Prognosis Associated With Coronary Calcification

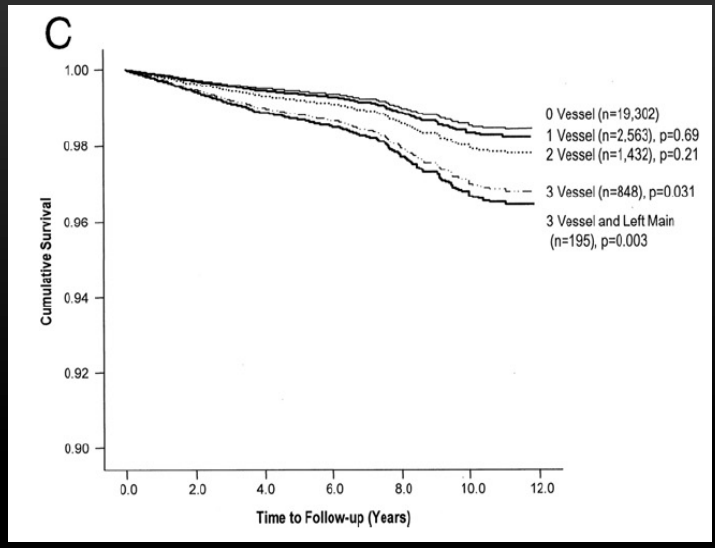
Observations From a Registry of 25,253 Patients

Matthew J. Budoff, MD,* Leslee J. Shaw, PHD,† Sandy T. Liu,* Steven R. Weinstein,* Tristen P. Mosler, Philip H. Tseng,* Ferdinand R. Flores,* Tracy Q. Callister, MD,‡ Paolo Raggi, MD,§ Daniel S. Berman, MD†

Torrance and Los Angeles, California; Nashville, Tennessee; and Atlanta, Georgia

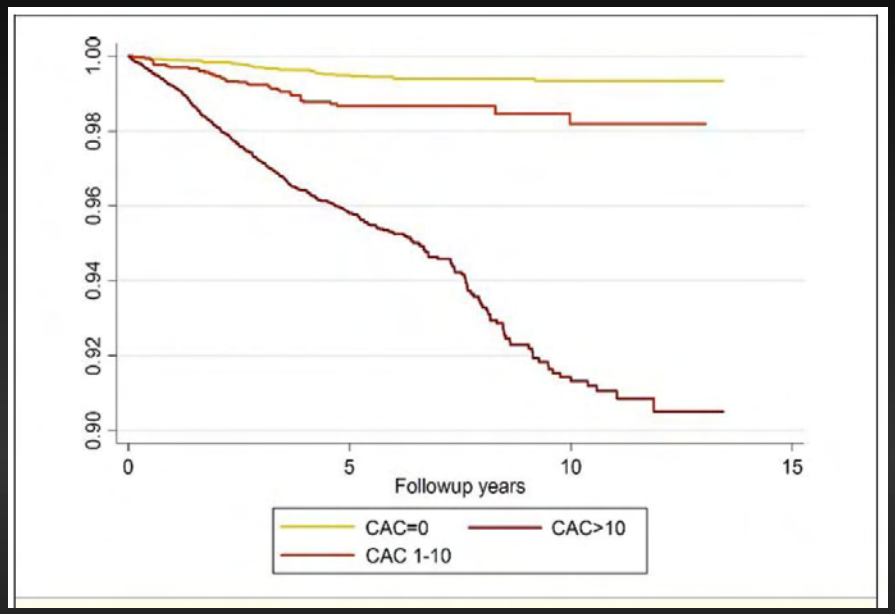
- Prognosis is excellent in setting of zero or very low CAC scores
  - …but not 0 when CACS=0
- Number of vessels involved is important
  - Even with CAC < 100





J Am Coll Cardiol 2007;49:1860–70

The mortality rate associated with a CACS=0 is 0.87/1000 person-yr
44,052 asympto adults referred by risk ff; screening EBCT



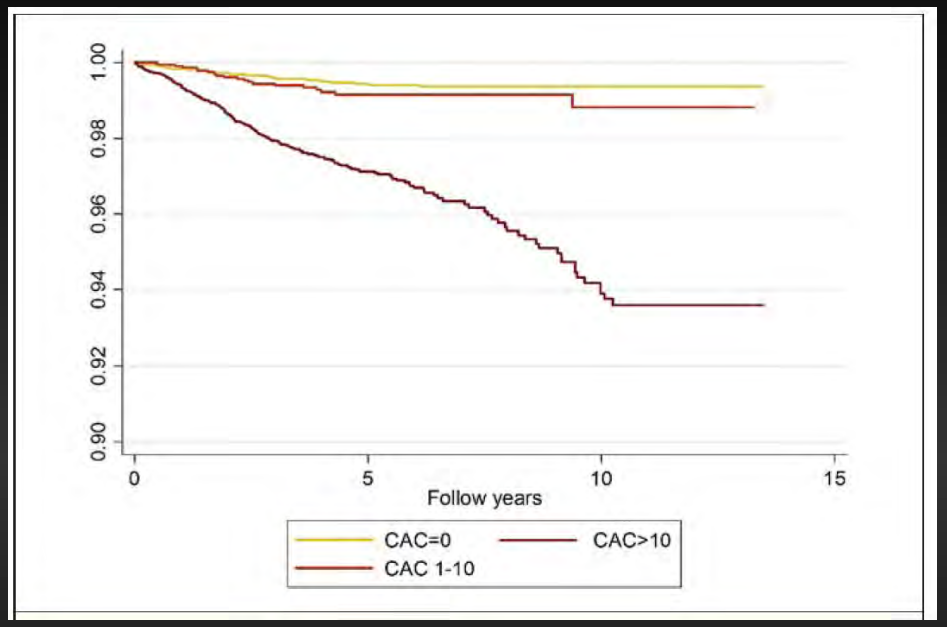


Table 2. All-Cause Mortality Rates by CAC Scores in Overall Population

	No. of Patients	No. of Events	Rate/1,000 Person-Yrs at Risk	95% CI for Rate
CAC = 0	19,898 (45%)	104 (0.52%)	0.87	0.72–1.05
CAC 1 to 10	5,388 (12%)	58 (1.06%)	1.92	1.48–2.48
CAC >10	18,766 (43%)	739 (3.96%)	7.48	6.95–8.04
Total	44,052 (100%)	901 (2.05%)	3.62	3.39–3.89

CAC = coronary artery calcium; CI = confidence interval.

Table 3. All-Cause Mortality (HR, 95% CI) for All-Cause Mortality With Low CAC (CAC 1 to 10) and CAC >10 Compared With CAC = 0

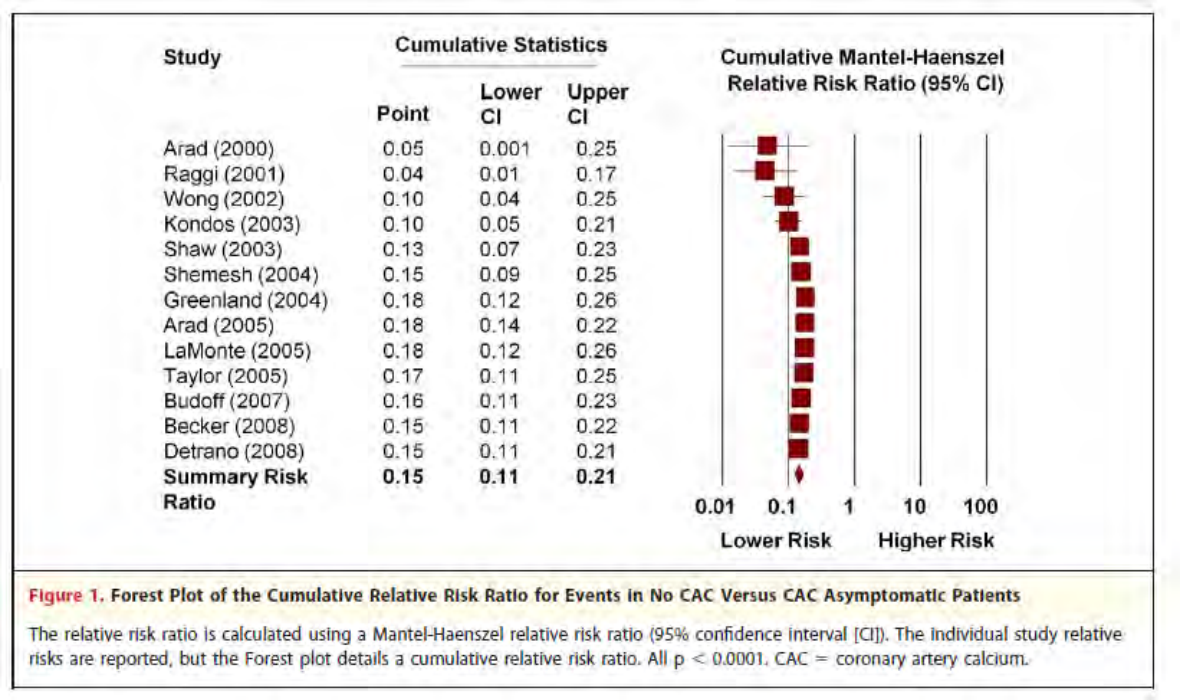
	CAC = 0	CAC 1 to 10	CAC >10
Model 1	1 (ref)	2.19 (1.57–2.99)	8.38 (6.82–102.9)
Model 2	1 (ref)	2.02 (1.47–2.79)	4.96 (4.02–6.11)
Model 3	1 (ref)	1.99 (1.45–2.75)	4.08 (3.30–5.04)

Model 1: unadjusted; Model 2: age-, sex-adjusted; Model 3: age-, sex-, hypertension-, smoking-, diabetes mellitus–, hyperlipidemia-, and family history of coronary heart disease–adjusted.
CAC = coronary artery calcium; CI = confidence interval; HR = hazard ratio.

Blaha M, Budoff MJ, Shaw LJ, et al. JACC Img 2009;2:692-700

Meta-analysis of 71,595 asymptomatic adults Mean f/u 4 yr

- 29,312 (41%) had CACS=0 → 0.47% had event
- 42,283 had CAC → 4.14% had event
- RR ratio 0.15 [0.11-0.21, p<0.001]



Study	Cumulative Statistics Point	Lower CI	Upper CI
Arad (2000)	0.05	0.001	0.25
Raggi (2001)	0.04	0.01	0.17
Wong (2002)	0.10	0.04	0.25
Kondos (2003)	0.10	0.05	0.21
Shaw (2003)	0.13	0.07	0.23
Shemesh (2004)	0.15	0.09	0.25
Greenland (2004)	0.18	0.12	0.26
Arad (2005)	0.18	0.14	0.22
LaMonte (2005)	0.18	0.12	0.26
Taylor (2005)	0.17	0.11	0.25
Budoff (2007)	0.16	0.11	0.23
Becker (2008)	0.15	0.11	0.22
Detrano (2008)	0.15	0.11	0.21
Summary Risk Ratio	**0.15**	**0.11**	**0.21**

Figure 1. Forest Plot of the Cumulative Relative Risk Ratio for Events in No CAC Versus CAC Asymptomatic Patients

The relative risk ratio is calculated using a Mantel-Haenszel relative risk ratio (95% confidence interval [CI]). The individual study relative risks are reported, but the Forest plot details a cumulative relative risk ratio. All $p < 0.0001$. CAC = coronary artery calcium.

Sarwar A, Shaw LJ, Shapiro MD, et al. JACC Img. 2009;2:675-88

Case Example

- 55 yr old man
- Total cholesterol: 170 mg/dL
- HDL cholesterol: 30 mg/dL
- Non-smoker
- Systolic BP: 133 mmHg (on medication)
- 10-yr Framingham risk: 10%

Case Example

- 55 yr old man
- 10-yr Framingham risk: 10%
- Agatston score:
  - <100: No significant impact on CHD risk
  - 100-400: 2-4x increase of CHD risk: **high risk**
  - >400: 5-10x increased of CHD risk: **high risk**

2010 ACCF/AHA Guideline for Assessment of Cardiovascular Risk in Asymptomatic Adults

Developed in Collaboration with the American Society of Echocardiography, American Society of Nuclear Cardiology, Society of Atherosclerosis Imaging and Prevention, Society for Cardiovascular Angiography and Interventions, Society of Cardiovascular Computed Tomography, and Society for Cardiovascular Magnetic Resonance

Recommendations for Calcium Scoring Methods

Measurement of CAC is reasonable for cardiovascular risk assessment in asymptomatic adults at intermediate risk (10% to 20% 10-year risk.

Measurement of CAC may be reasonable for cardiovascular risk assessment in adults at low to intermediate risk (6% to 10% 10-year risk).

Persons at low risk (<6% 10-year risk) should not undergo CAC measurement for cardiovascular risk assessment.

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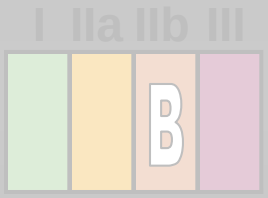
Risk Assessment Considerations for Patients with Diabetes Mellitus

In asymptomatic adults with diabetes, 40 years of age and older, measurement of CAC is reasonable for cardiovascular risk assessment.

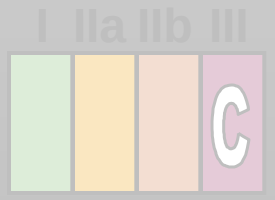


Measurement of hemoglobin A1C may be considered for cardiovascular risk assessment in asymptomatic adults with diabetes.

Stress MPI may be considered for advanced cardiovascular risk assessment in asymptomatic adults with diabetes or when previous risk assessment testing suggests high risk of CHD, such as a CAC score of 400 or greater.

Recommendations for Myocardial Perfusion Imaging

Stress MPI may be considered for advanced cardiovascular risk assessment in asymptomatic adults with diabetes or asymptomatic adults with a strong family history of CHD or when previous risk assessment testing suggests high risk of CHD, such as a coronary artery calcium (CAC) score of 400 or greater.



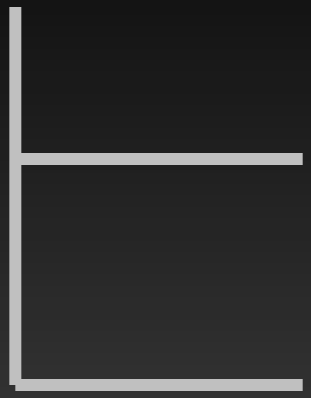
Stress MPI is not indicated for cardiovascular risk assessment in low- or intermediate-risk asymptomatic adults. (Exercise or pharmacologic stress MPI is a technology primarily used and studied for its role in advanced cardiac evaluation of symptoms suspected of representing CHD and/or estimation of prognosis in patients with known coronary artery disease.)

What about coronary CTA?

- Currently used to identify or exclude stenosis in symptomatic patients
- Prognostic power in this role?
- Role in the asymptomatic individual?

R/o Stenoses in Symptomatic Patients

421 patients with stable chest pain and positive SPECT ("intermediate risk"): 64 slice CT



78 Pt: Coronary angiography (50 revasc., 1MI, 1†)

343 Pt: Medical

15 month FU: 6 Coronary Angiographies

1 Revascularization

Usefulness of Multislice Computed Tomographic Coronary Angiography to Identify Patients With Abnormal Myocardial Perfusion Stress in Whom Diagnostic Catheterization May Be Safely Avoided

Sorin C. Danciu, MD[a,*], Cesar J. Herrera, MD[a,b], Peter J. Stecy, MD[a,b], Edgar Carell, MD[b], Frank Saltiel, MD[b], and Jerome L. Hines, MD[b]

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R/o Stenoses in Symptomatic Patients

2230 patients with suspected CAD

64 slice CT or DSCT

Cardiac Death, MI, unstable angina, revascularization > 90 days after CT

"Clean Coronaries":	0% event rate/year
No stenosis:	0.3% event rate/year
Stenosis > 50%:	3.9% event rate/year
Stenosis > 75%:	4.2% event rate/year

Prognostic Value of Coronary Computed Tomographic Angiography in Comparison with Calcium Scoring and Clinical Risk Scores

Running Title: Hadamitzky et al: Prognostic Value of Coronary CTA

Hadamitzky et al, Circ CV Imaging 2010

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R/o Stenoses in Symptomatic Patients

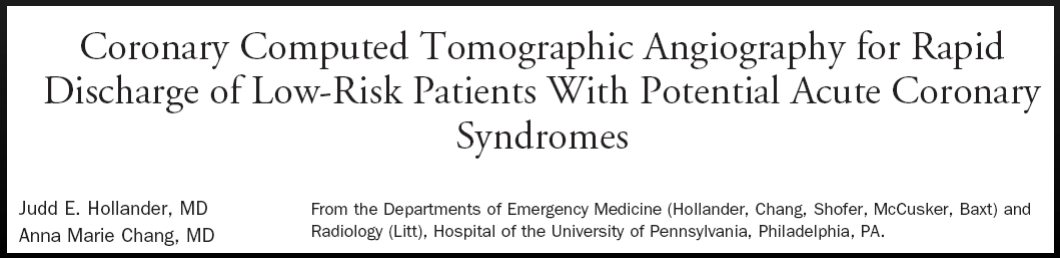
486 acute chest pain patients in ER, low TIMI score

64 slice CT

84% discharged home after normal CT

No events in 30 days (vs. 7)

1 year (481 pts): 1 unclear death, no MI



Coronary Computed Tomographic Angiography for Rapid Discharge of Low-Risk Patients With Potential Acute Coronary Syndromes

Judd E. Hollander, MD
Anna Marie Chang, MD

From the Departments of Emergency Medicine (Hollander, Chang, Shofer, McCusker, Baxt) and Radiology (Litt), Hospital of the University of Pennsylvania, Philadelphia, PA.

Ann Emerg Med 2009
Acad Emerg Med 2009

R/o Stenoses in Symptomatic Patients

"Close to zero" event rate after ruling out coronary stenosis by CT in symptomatic patients

Stable Chest Pain

- Hadamitzki et al, iJACC 2009
- Lesser et al, Cath Card Interv 2007
- Danciu et al, Am J Cardiol 2007
- Schussler et al, Am J Cardiol 2009
- Ostrom et al, JACC 2008
- Abidov et al, J Nucl Cardiol 2009
- Chow et al, JACC 2010

Acute Chest Pain

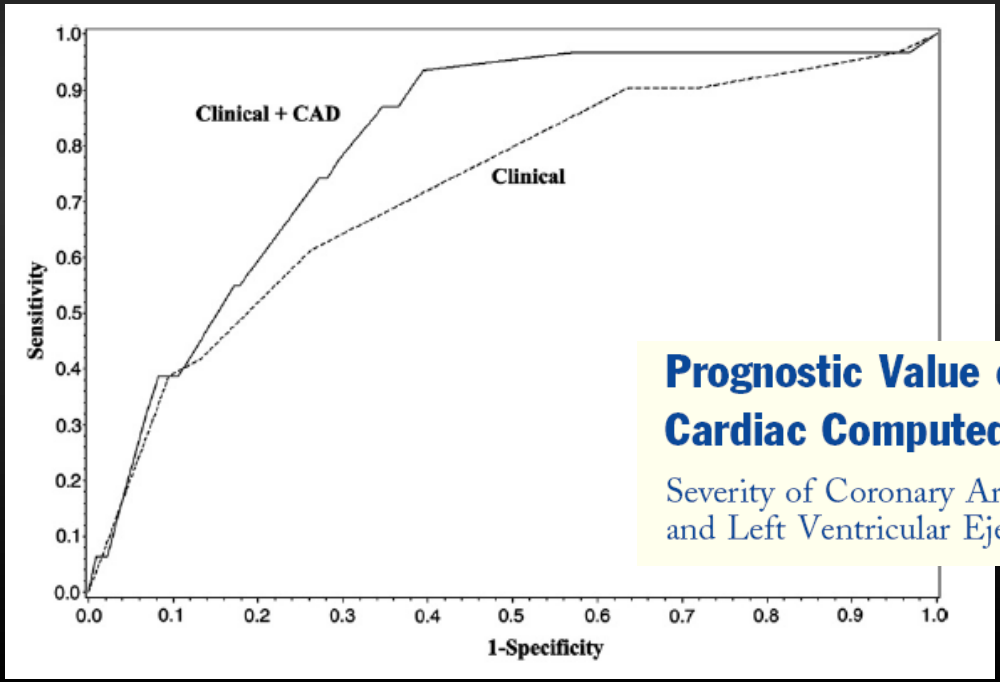
- Rubinshtein et al, AJC 2007
- Hollander et al, Ann Emerg Med 2009

Non-stenotic Plaque?

2076 Patients without known CAD

64-slice CT

2 years follow-up: Death, non-fatal MI (n = 47)



CT normal:	0.1%/year
Plaque:	0.5%/year
Stenosis:	2.7%/year

Prognostic Value of 64-Slice Cardiac Computed Tomography

Severity of Coronary Artery Disease, Coronary Atherosclerosis, and Left Ventricular Ejection Fraction

Chow et al, JACC 2010

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Non-stenotic Plaque?

Segment Involvement Score:

0 = no plaque

1 = plaque present

max. 16 for 16 segments

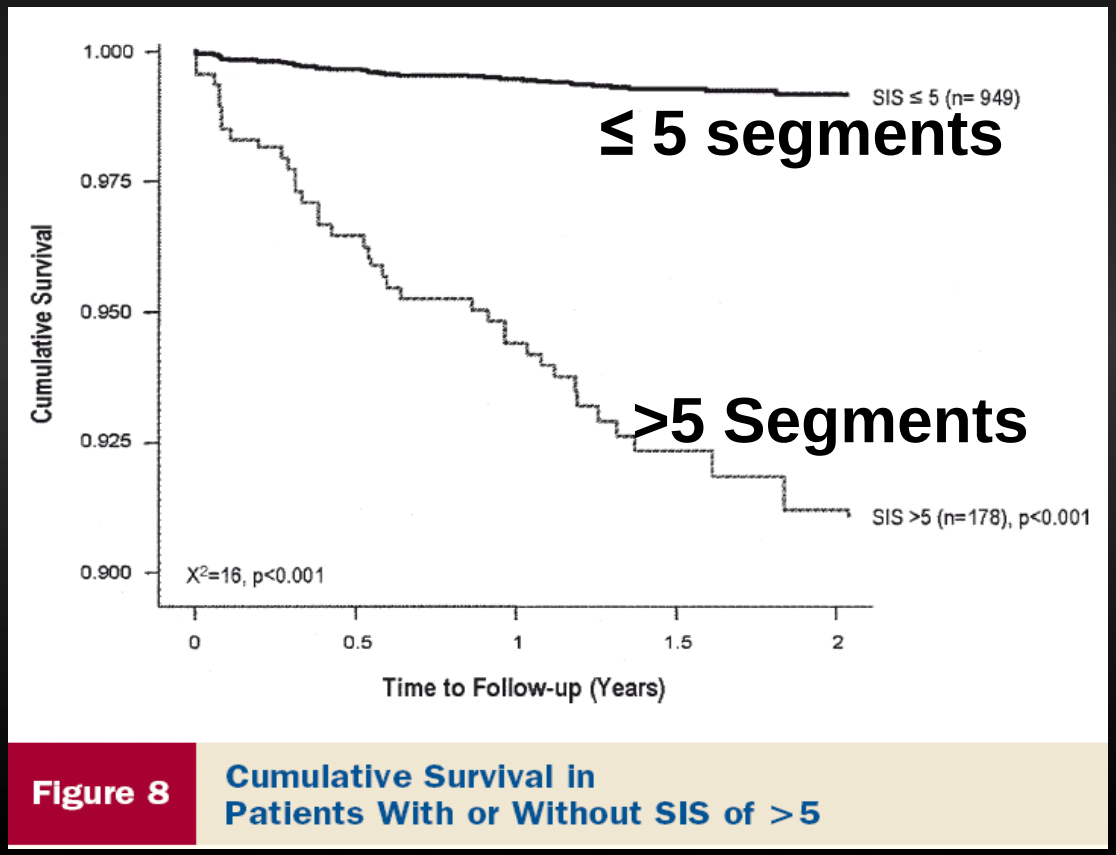

Figure 8 Cumulative Survival in Patients With or Without SIS of >5

Prognostic Value of Multidetector Coronary Computed Tomographic Angiography for Prediction of All-Cause Mortality

Min et al, JACC 2007

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Non-stenotic Plaque?

2538 pts. , EBT-CTA. 12 years f/u („survival“).

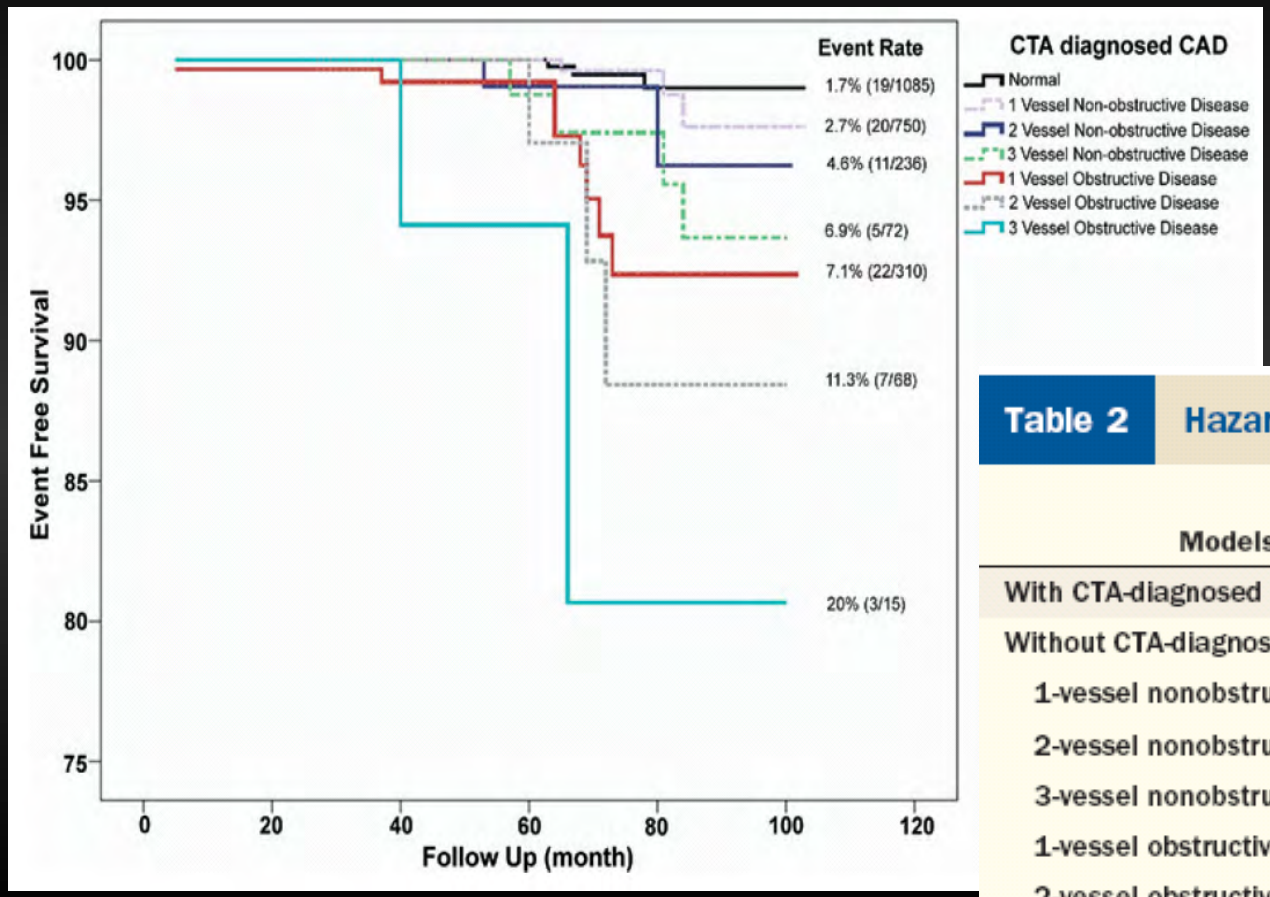

Table 2 Hazard Ratios

Models	Risk Factors Adjusted Model
With CTA-diagnosed any CAD	2.69 (1.59–4.53), p = 0.0001
Without CTA-diagnosed CAD	1.0 (Reference)
1-vessel nonobstructive disease	1.03 (0.30–1.75), p = 0.69
2-vessel nonobstructive disease	1.02 (0.68–1.9), p = 0.52
3-vessel nonobstructive disease	1.77 (1.34–2.34), p = 0.0001
1-vessel obstructive disease	1.87 (1.4–2.51), p = 0.0001
2-vessel obstructive disease	2.37 (1.91–2.93), p = 0.0001
3-vessel obstructive disease	2.61 (2–3.37), p = 0.0001

Ostrom et al, JACC 2008

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Non-stenotic Plaque?

Meta Analysis: 9952 symptomatic patients 20 months f/u – Death, MI, Revasc.

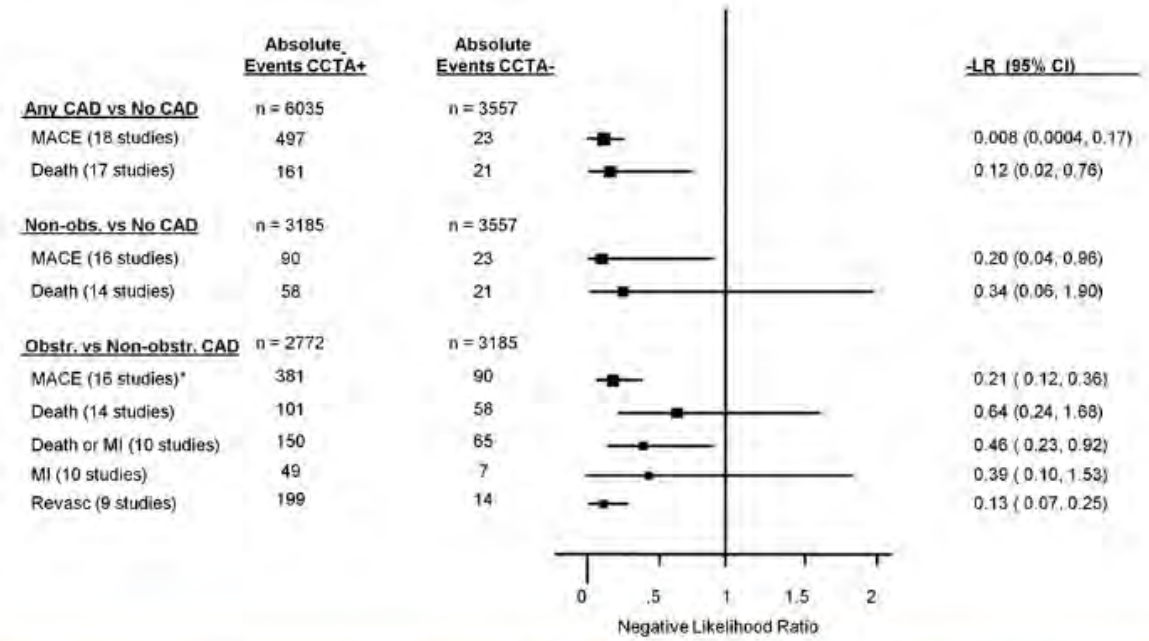


Figure 5 Pooled –LR for Future MACE, Death, Death or MI, MI, and Revascularization Stratified by CCTA Findings

Absolute event rates are displayed. Likelihood ratios were pooled by annualized event rates using a bivariate mixed-effects binomial regression model to calculate test parameters and summary receiver-operating characteristic curves. There were no MI or revascularization events in the no CAD group; therefore no likelihood ratio is calculated for those comparisons. *Two heterogeneous studies (Min et al. [16] and Ostrom et al. [18]) removed from this end point. –LR = negative likelihood ratio; other abbreviations as in Figures 1, 2, and 4.

- LR= 0.008 (strong) but + LR =1.7 (weak)

Prognostic Value of Cardiac Computed Tomography Angiography

A Systematic Review and Meta-Analysis

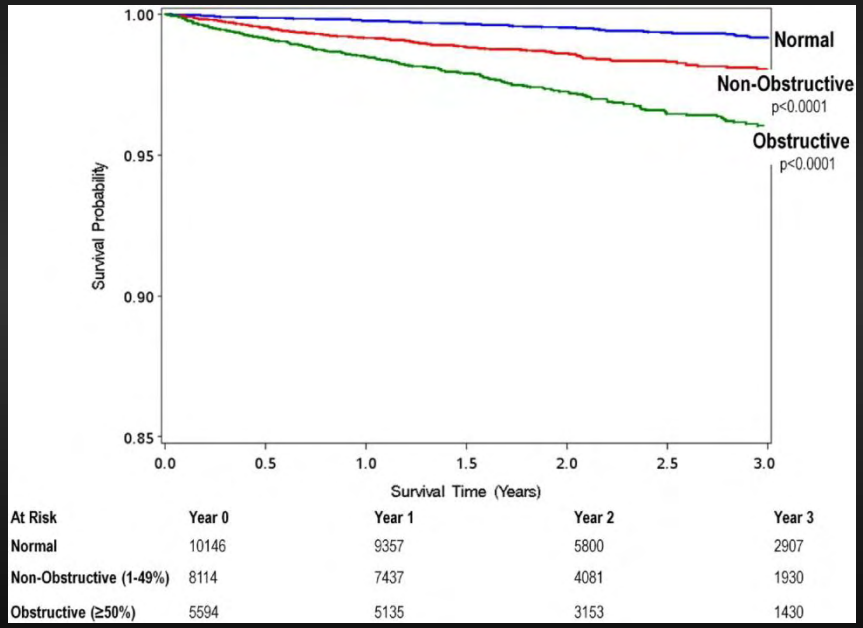
Edward A. Hulten, MD, MPH,* Salvatore Carbonaro, MD,* Sara P. Petrillo, MD,‡ Joshua D. Mitchell, MD,† Todd C. Villines, MD*

J Am Coll Cardiol 2011

Washington Hospital Center

CONFIRM: Obstructive and Non-Obstructive CAD Predict Mortality

23,854 patients, clinical cor CTA, mean follow-up 2.3 yr



At Risk	Year 0	Year 1	Year 2	Year 3
Normal	10146	9357	5800	2907
Non-Obstructive (1-49%)	8114	7437	4081	1930
Obstructive (≥50%)	5594	5135	3153	1430

- Hazard Ratios for Death (compared to pts with No CAD):
  - Obstructive dz: 2.6
  - Non-obstr dz: 1.6 (1.2-2.2)

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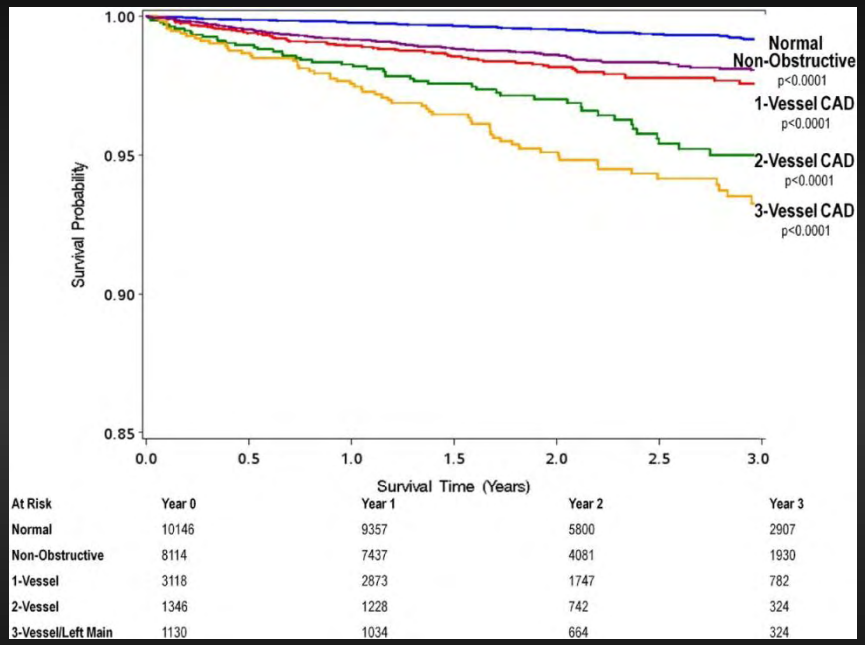
CONFIRM Registry of Cor CTA



At Risk	Year 0	Year 1	Year 2	Year 3
Normal	10146	9357	5800	2907
Non-Obstructive	8114	7437	4081	1930
1-Vessel	3118	2873	1747	782
2-Vessel	1346	1228	742	324
3-Vessel/Left Main	1130	1034	664	324

"Dose-Response relationship"

- HR for death related to number of diseased vessels:
  - 0 (non-obstr CAD): 1.62
  - 1 vessel: 2.00
  - 2 vessel: 2.92
  - 3 vessel or LM: 3.70

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Non-stenotic Plaque?

Meta Analysis: 9952 symptomatc patients 20 months f/u – Death, MI, Revasc.

Conclusions

Adverse cardiovascular events among patients with normal CCTA findings are very rare and comparable to a baseline risk among healthy patients. Increasing burden of CAD on CCTA is associated with an increasing rate of revascularization, MI, and death. However, for prediction of clinical events, the specificity and +LR are not useful for abnormal CCTA findings (as expected and consistent with other noninvasive tests because many patients with disease will not have clinical events and, as such, are "test positive without events" in the context of this analysis). For predicting prognosis of adverse clinical events, the −LR of CCTA with normal findings is comparable to reported values for stress myocardial perfusion scan or stress echocardiography.

Figure 5 Pooled –

Absolute event rates are … parameters and summary … culated for those comparisons. … abbreviations as in Figures …

Prognostic Value of Cardiac

Computed Tomography Angiography

A Systematic Review and Meta-Analysis

Edward A. Hulten, MD, MPH,* Salvatore Carbonaro, MD,* Sara P. Petrillo, MD,‡
Joshua D. Mitchell, MD,† Todd C. Villines, MD*

- LR= 0,008 (strong)

+ LR =1.7 (weak)

J Am Coll Cardiol 2011

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Non-stenotic Plaque?

Low event rates overall.

Very low event rates in patients without stenoses,
but plaque in CT indicates somewhat elevated risk

Plaque seemingly has to be rather extensive
(3 vessels, 5 segments)

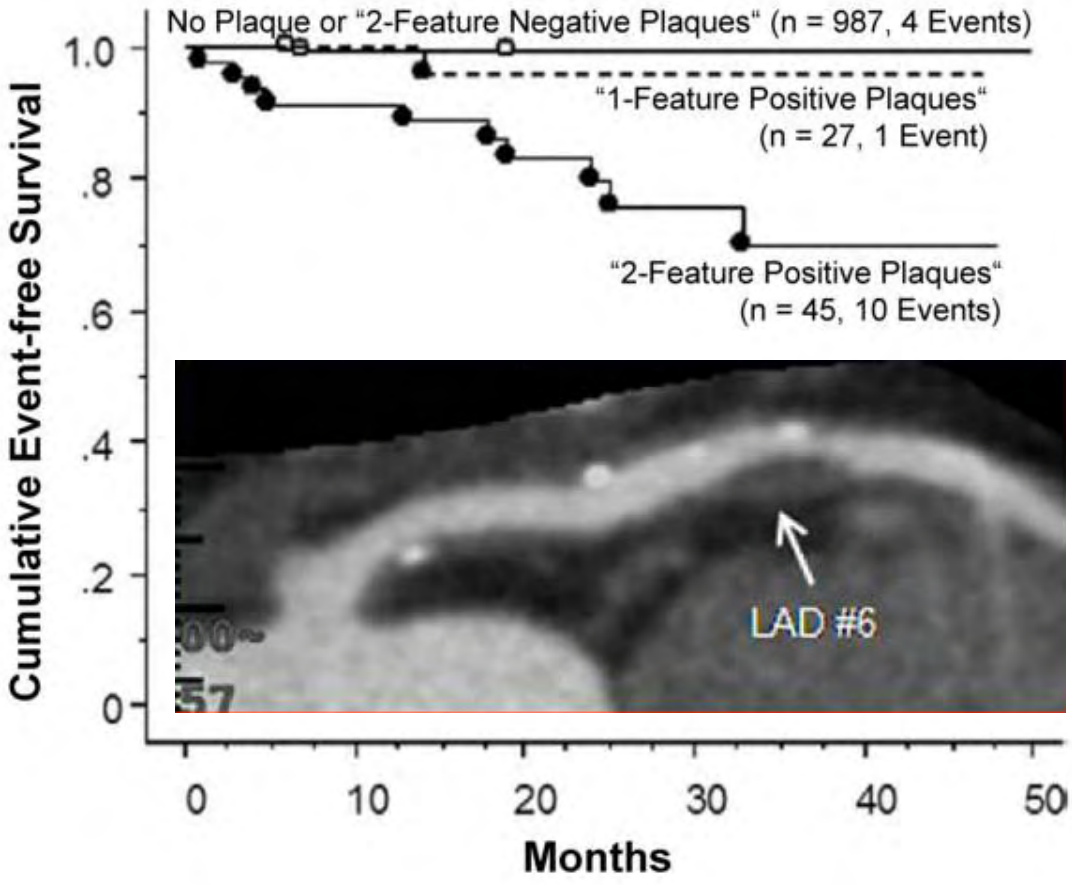
Non-stenotic Plaque?

Some plaque features seem to indicate especially high risk:

Low density, positive remodeling

Non-stenotic Plaque?

Computed Tomographic Angiography Characteristics of Atherosclerotic Plaques Subsequently Resulting in Acute Coronary Syndrome



1039 symptomatic patients

10037 coronary segments > 2 mm

Positive remodeling?

Low attenuation (< 30 HU)?

Motoyama, JACC 2009

Washington Hospital Center

Asymptomatic Individuals?

451 asymptomatc individuals.

229 (54%) had nonobstructive plaque

107 (24%) had obstructive disease

28 months follow up: 2 cases of unstable angina

8 cases of revascularization for stable angina

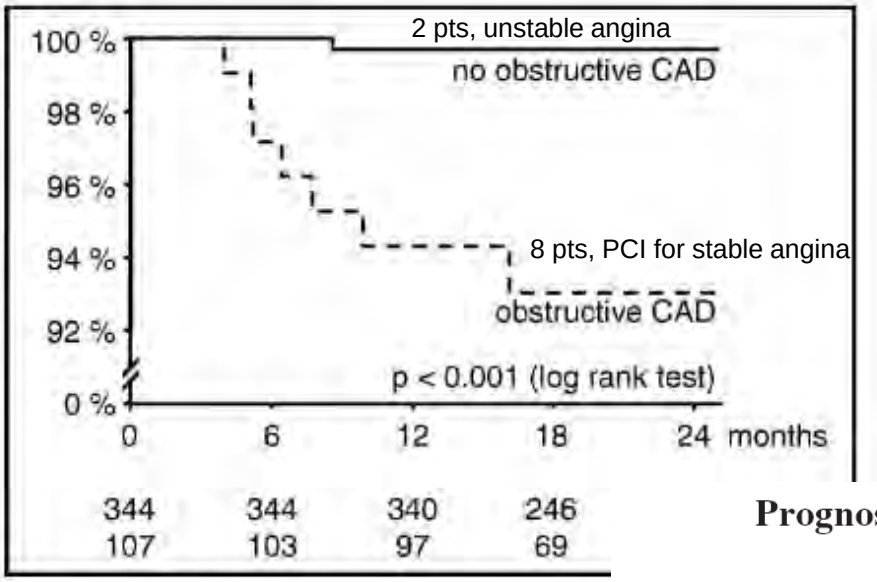


Figure 2. Kaplan-Meier curve for cardiac events, defined as cardiac death, nonfatal myocardial inf
gina requiring hospitalization, or coronary revascularization >90 days
after CCTA.

Prognostic Value of Coronary Computed Tomographic Angiography in Asymptomatic Patients

Martin Hadamitzky, MD[a,*], Tanja Meyer, MD[a], Franziska Hein, MD[a], Bernhard Bischoff, MD[a], Stefan Martinoff, MD[b], Albert Schömig, MD[a], and Jörg Hausleiter, MD[a]

Am J Cardiol 2010

Asymptomatic Individuals?

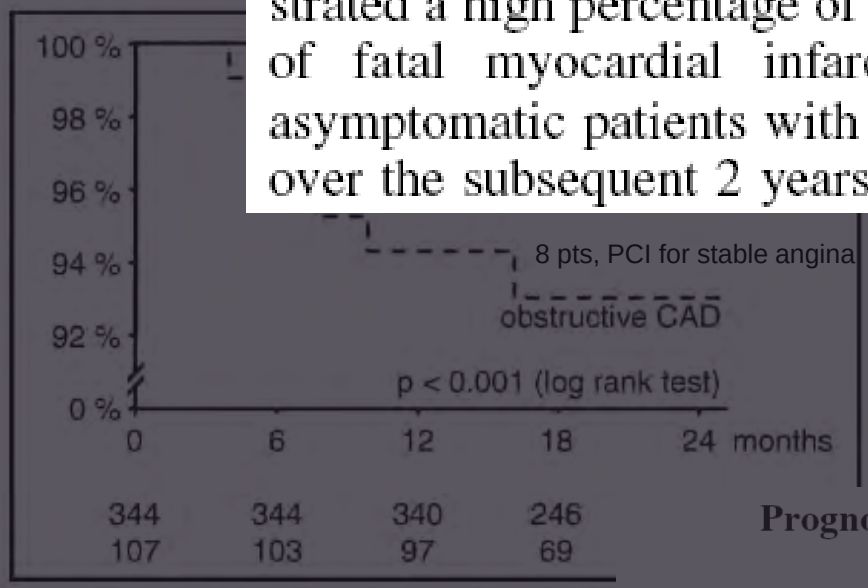
451 asympto

229 (54%) ha

107 (24%) ha

28 months fo

The high prevalence of atherosclerotic lesions in the coronary arteries contrasts with a lower prevalence of 23% for obstructive CAD. The high prevalence of 50% for patients with only nonobstructive coronary lesions combined with the very low cardiac event rate (<1%) and the virtual nonexistence of severe cardiac events illustrates the difficulties in attributing a relevant cardiovascular risk to these subtle changes. Although retrospective studies demonstrated a high percentage of nonobstructive lesions as cause of fatal myocardial infarctions,[18–20] the prognosis of asymptomatic patients with nonobstructive lesions, at least over the subsequent 2 years after CCTA, is excellent.



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The event rate of patients with obstructive CAD on CCTA of 5% per year is significantly higher than the event rate of 0.4% in patients without obstructive CAD and clearly defines a high-risk patient population warranting maximal primary prevention by lifestyle modification and medical therapy.

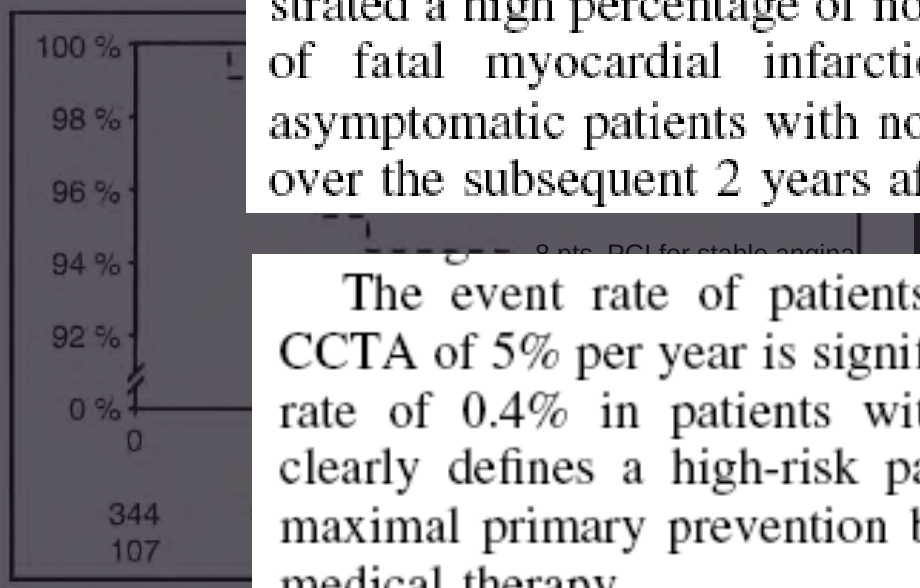

Figure 2. Kaplan-Meier curve for cardiac events, defined as cardiac death, nonfatal myocardial infarction, unstable angina requiring hospitalization, or coronary revascularization ~90 days after CCTA.

graphic

Martin Hadamitzky, MD[a,*], Tanja Meyer, MD[a], Franziska Hein, MD[a], Bernhard Bischoff, MD[a], Stefan Martinoff, MD[b], Albert Schömig, MD[a], and Jörg Hausleiter, MD[a]

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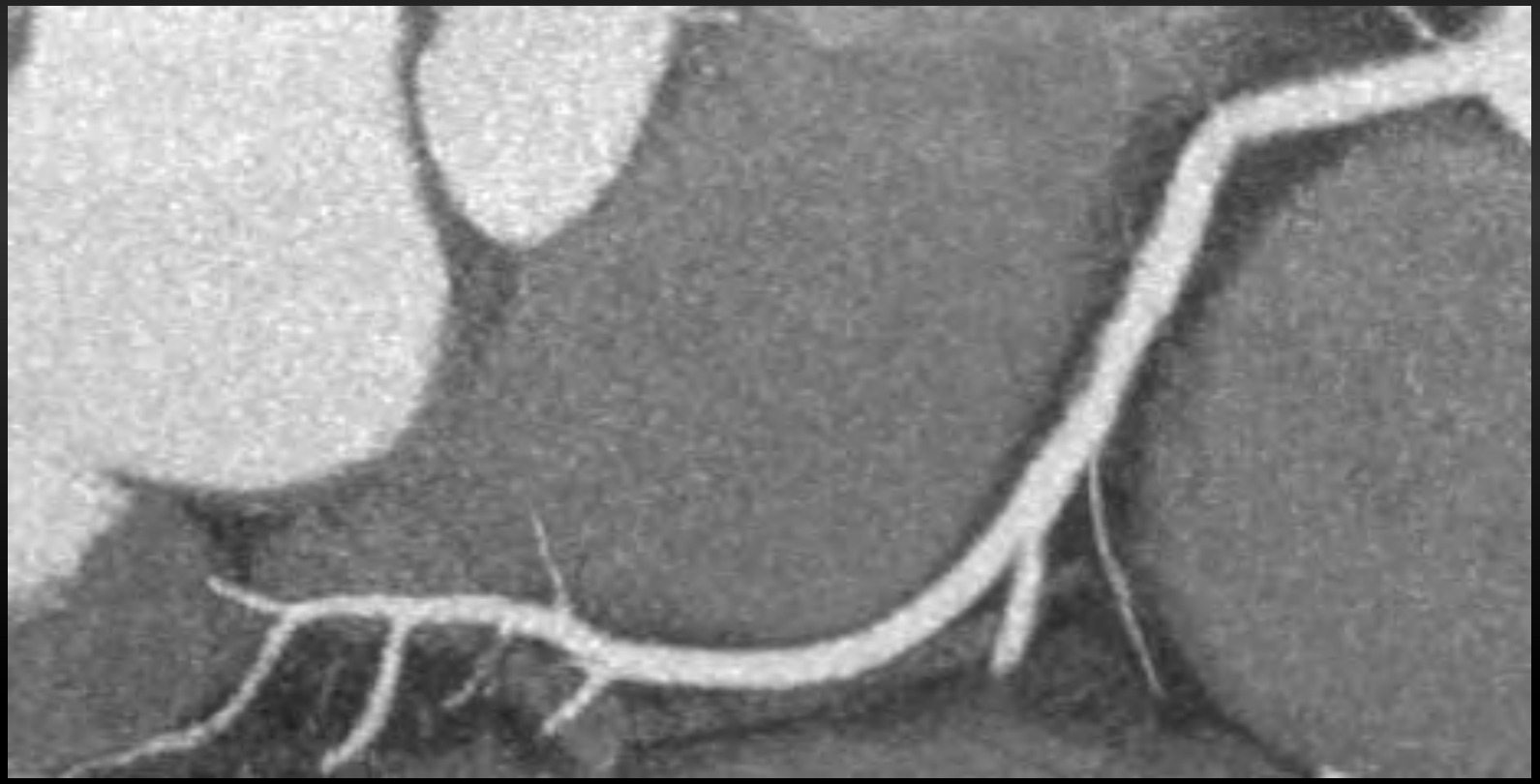
Asymptomatic Individuals?

In truly asymptomatic individuals, overall event rates are very low.

Contribution of coronary CT angiography as a “screening“is questionable.



Washington Hospital Center

Appropriateness Criteria

APPROPRIATE USE CRITERIA

ACCF/SCCT/ACR/AHA/ASE/ASNC/SCAI/SCMR 2010 Appropriate Use Criteria for Cardiac Computed Tomography

A Report of the American College of Cardiology Foundation Appropriate Use Criteria Task Force, the Society of Cardiovascular Computed Tomography, the American College of Radiology, the American Heart Association, the American Society of Echocardiography, the American Society of Nuclear Cardiology, the Society for Cardiovascular Angiography and Interventions, and the Society for Cardiovascular Magnetic Resonance

Table 8. Appropriate Indications (Median Score 7–9)

	Indication	Appropriate Use Score (1–9)
	Detection of CAD in Symptomatic Patients Without Known Heart Disease Symptomatic—Nonacute Symptoms Possibly Representing an Ischemic Equivalent	
1.	• ECG interpretable AND • Able to exercise • Intermediate pretest probability of CAD	A (7)
2.	• ECG uninterpretable or unable to exercise • Low pretest probability of CAD	A (7)
2.	• ECG uninterpretable or unable to exercise • Intermediate pretest probability of CAD	A (8)
	Detection of CAD in Symptomatic Patients Without Known Heart Disease Symptomatic—Acute Symptoms With Suspicion of ACS (Urgent Presentation)	
6.	• Normal ECG and cardiac biomarkers • Low pretest probability of CAD	A (7)
6.	• Normal ECG and cardiac biomarkers • Intermediate pretest probability of CAD	A (7)
		A (7)
		A (7)
		A (7)
		A (7)
	ic Individuals Without Known CAD—Noncontrast CT for CCS	
		A (7)
		A (7)
	w-Onset or Newly Diagnosed Clinical HF and No Prior CAD	
		A (7)
		A (7)
	tive Coronary Assessment Prior to Noncoronary Cardiac Surgery	
	gery	A (7)
	Test Results—Prior ECG Exercise Testing	
		A (7)
		A (7)
	—Sequential Testing After Stress Imaging Procedures	
		A (8)
		A (8)
	Use of CTA in the Setting of Prior Test Results—Prior CCS	
26.	• Diagnostic impact of coronary calcium on the decision to perform contrast CTA in symptomatic patients • CCS <100	A (8)
26.	• Diagnostic impact of coronary calcium on the decision to perform contrast CTA in symptomatic patients • CCS 100–400	A (8)
	Use of CTA in the Setting of Prior Test Results—Evaluation of New or Worsening Symptoms in the Setting of Past Stress Imaging Study	
29.	• Previous stress imaging study normal	A (8)
	Risk Assessment Postrevascularization (PCI or CABG)—Symptomatic (Ischemic Equivalent)	
39.	• Evaluation of graft patency after CABG	A (8)
	Risk Assessment Postrevascularization (PCI or CABG)—Asymptomatic—Prior Coronary Stenting	
43.	• Prior left main coronary stent with stent diameter ≥3 mm	A (7)
	Evaluation of Cardiac Structure and Function—Adult Congenital Heart Disease	
46.	• Assessment of anomalies of coronary arterial and other thoracic arteriovenous vessels	A (9)
47.	• Assessment of complex adult congenital heart disease	A (8)
	Evaluation of Cardiac Structure and Function—Evaluation of Ventricular Morphology and Systolic Function	
49.	• Evaluation of left ventricular function • Following acute MI or in HF patients • Inadequate images from other noninvasive methods	A (7)
50.	• Quantitative evaluation of right ventricular function	A (7)
51.	• Assessment of right ventricular morphology • Suspected arrhythmogenic right ventricular dysplasia	A (7)
	Evaluation of Cardiac Structure and Function—Evaluation of Intra- and Extracardiac Structures	
53.	• Characterization of native cardiac valves • Suspected clinically significant valvular dysfunction • Inadequate images from other noninvasive methods	A (8)
54.	• Characterization of prosthetic cardiac valves • Suspected clinically significant valvular dysfunction • Inadequate images from other noninvasive methods	A (8)
56.	• Evaluation of cardiac mass (suspected tumor or thrombus) • Inadequate images from other noninvasive methods	A (8)
57.	• Evaluation of pericardial anatomy	A (8)
58	• Evaluation of pulmonary vein anatomy • Prior to radiofrequency ablation for atrial fibrillation	A (8)
59.	• Noninvasive coronary vein mapping • Prior to placement of biventricular pacemaker	A (8)
60.	• Localization of coronary bypass grafts and other retrosternal anatomy • Prior to reoperative chest or cardiac surgery	A (8)

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	Test Results—Prior ECG Exercise Testing	
		A (7)
		A (7)
	—Sequential Testing After Stress Imaging Procedures	
		A (8)
23.	• Stress imaging results: equivocal	A (8)
	Use of CTA in the Setting of Prior Test Results—Prior CCS	
26.	• Diagnostic impact of coronary calcium on the decision to perform contrast CTA in symptomatic patients • CCS <100	A (8)
26.	• Diagnostic impact of coronary calcium on the decision to perform contrast CTA in symptomatic patients	A (8)
	• Inadequate images from other noninvasive methods	
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60.	• Localization of coronary bypass grafts and other retrosternal anatomy • Prior to reoperative chest or cardiac surgery	A (8)

Use of CTA in the Setting of Prior Test Results—Prior ECG Exercise Testing

• Normal ECG exercise test • Continued symptoms	A (7)
• Prior ECG exercise testing • Duke Treadmill Score—intermediate risk findings	A (7)

Use of CTA in the Setting of Prior Test Results—Sequential Testing After Stress Imaging Procedures

• Discordant ECG exercise and imaging results	A (8)
• Stress imaging results: equivocal	A (8)

Appropriateness Criteria

Appropriate Indications for Coronary CT Angiography

Stable, Suspected CAD
- Testing for ischemia not possible, equivocal, or discordant to symptoms

Stable, Suspected CAD
- Intermediate pre test likelihood of CAD (10% - 90%)

Acute Chest Pain
- ECG and enzymes normal or equivocal
- Low to intermediate likelihood for CAD

Planned Non-coronary Cardiac Surgery
- Intermediate likelihood for CAD

Progressive Chest Pain
- Earlier testing for ischemia was negative

New Heart Failure
- Low to intermediate likelihood for CAD

Bpyass Patency if post-CABG with Chest Pain

Left Main Stent ≥ 3.0 mm, Asymptomatic

Evaluation of Coronary Anomalies

Summary

- Coronary calcium scanning predicts CHD events, independent of and in addition to clinical risk stratification
- Best suited for intermediate and low-to-intermediate risk population
- Absence of coronary calcium confers excellent prognosis
- In symptomatic individuals, absence of plaque associated with excellent outcome…
- …and absence of stenosis associated with good outcome…
- …but in asymptomatic individuals, the role of coronary CTA for risk stratification (over CACS) remains unclear