High Value Evaluation of Chest Pain

California Quality Collaborative's
Cardiology Webinar Series
Webinar 1

CQC
California Quality Collaborative
Breakthroughs for Better Healthcare

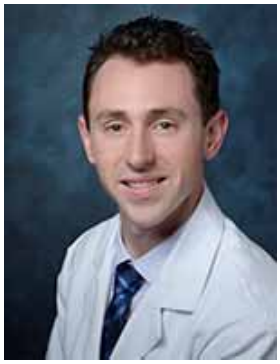
December 7, 2017

Zoom Tips

- Attendees are automatically MUTED upon entry
- Refrain from using the hold button
- **Type your questions in the chat box**; we will address them during the Q&A session at the end of the presentation
- Message **Jen** through the **chat box** if you have any technical issues

Today's Speakers

Bart Wald, MD
California Quality Collaborative



Raymond Zimmer, MD
Cedars-Sinai Medical Center

Cardiology Webinar Series

- **High-Value Treatment of Chest Pain:** 12/07/17
- **High-Value Treatment of Congestive Heart Failure** – 01/23/18
- **High-Value Interventional Cardiology** - Date TBD
- **High-Value Electrophysiology** - Date TBD

High Value Evaluation of Chest Pain

Raymond Zimmer, MD, FACC
Attending Cardiologist
Cedars-Sinai Medical Group
Los Angeles, California
December 7, 2017

Disclosures

- None

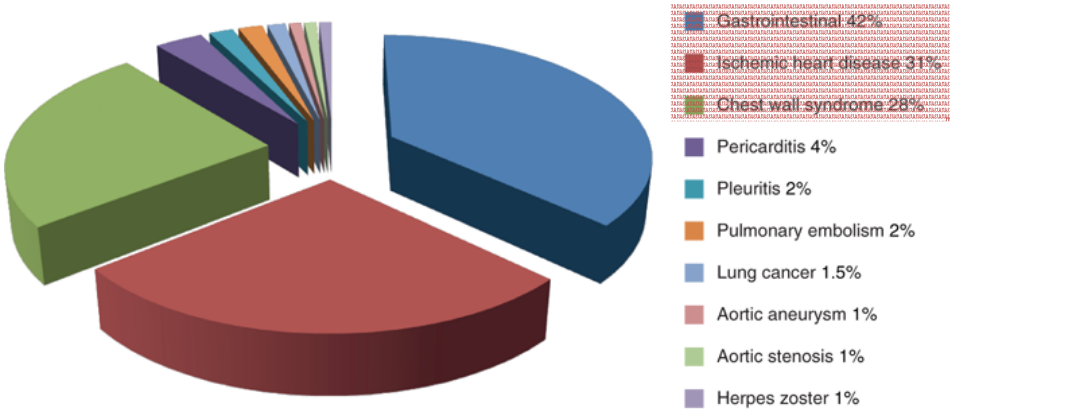
Objectives

- Briefly review chest pain epidemiology
- Evaluate value-based strategies for pre-hospital and ED evaluation of chest pain
- Compare the indications, appropriateness, and value of diagnostic cardiac tests for chest pain assessment
- Highlight emerging technologies and practices that can facilitate evidence-based, cost-effective chest pain evaluation

Chest pain epidemiology

- More than **8-10 million** U.S. ED visits per year
- **Second most common** reason for ED visit
- Cardiac etiology accounts for **less than 1/3** of ED visits for chest pain
- Most common causes of chest pain in outpatients are actually musculoskeletal (one third to one half of patients) and gastrointestinal (10-20%)

A symptom with many faces

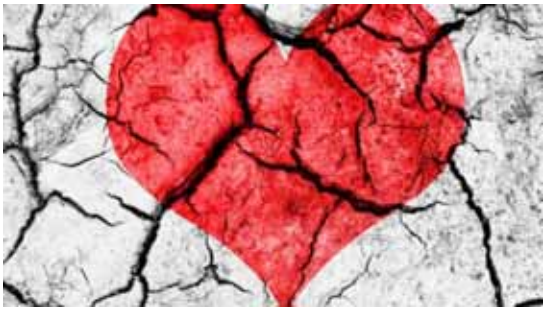


Source: D. L. Kasper, A. S. Fauci, S. L. Hauser, D. L. Longo, J. L. Jameson, J. Loscalzo: Harrison's Principles of Internal Medicine, 19th Edition
www.accessmedicine.com

Fear vs. Fact

- More than 50% of ED patients presenting with chest pain receive comprehensive cardiac evaluation (serial biomarkers, noninvasive imaging, observation period, etc.)
- Yet, **less than 10%** of patients presenting to the ED with chest pain are ultimately diagnosed with an acute coronary syndrome (ACS)
- **Only 1.5%** of patients presenting to PCP with chest pain will have unstable angina/acute MI
- However, **1.5-2%** of patients with acute MI are unrecognized at ED evaluation

$10-13 billion per year spent for unnecessary chest pain hospital admissions and evaluations



2012 ACCF/AHA Focused Update Incorporated Into the ACCF/AHA 2007 Guidelines for the Management of Patients With Unstable Angina/Non–ST-Elevation Myocardial Infarction

A Report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines

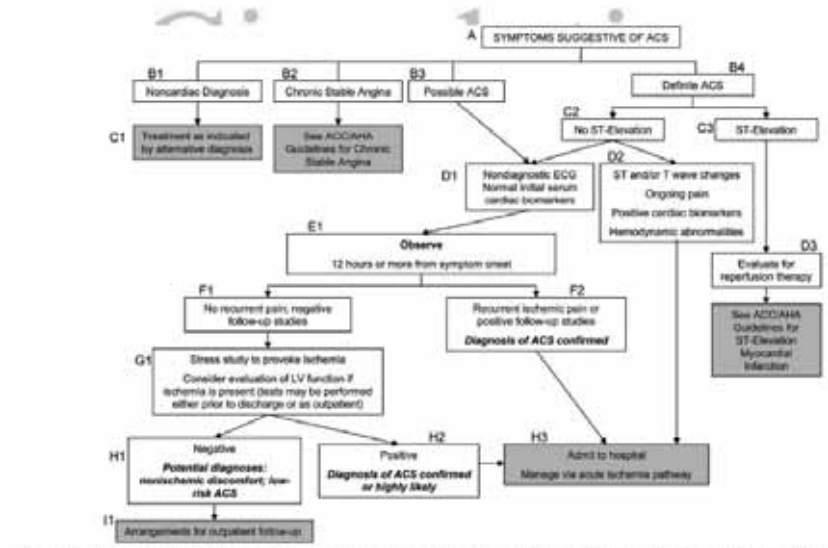


Figure 2. Algorithm for Evaluation and Management of Patients Suspected of Having ACS. To facilitate interpretation of this algorithm and a more detailed discussion in the text, each box is assigned a letter code that reflects its level in the algorithm and a number that is allocated from left to right across the diagram on a given level. ACC/AHA = American College of Cardiology/American Heart Association; ACS = acute coronary syndrome; ECG = electrocardiogram; LV = left ventricular.

History, history, history

- Obtaining a detailed history is critical for differentiating cardiac vs. non-cardiac causes of chest pain
- History alone can reduce referrals for testing that is likely to be low yield

History, history, history

Descriptions increasing likelihood of cardiac pain	Descriptions decreasing likelihood of cardiac pain
Exertional	Non-exertional
Diffuse pressure/heaviness	Sharp
Radiation to either arm/shoulder and neck	Positional
Associated nausea/vomiting	Reproducible with palpation
Associated diaphoresis	Well localized
Similar to previous MI	Associated with meals
	Short duration (few seconds or less)

- Atypical symptoms (particularly in women, the elderly, and diabetics) can include isolated jaw/neck/arm discomfort, exertional dyspnea, palpitations, nausea/vomiting, and generalized fatigue

Developing an accurate pretest probability

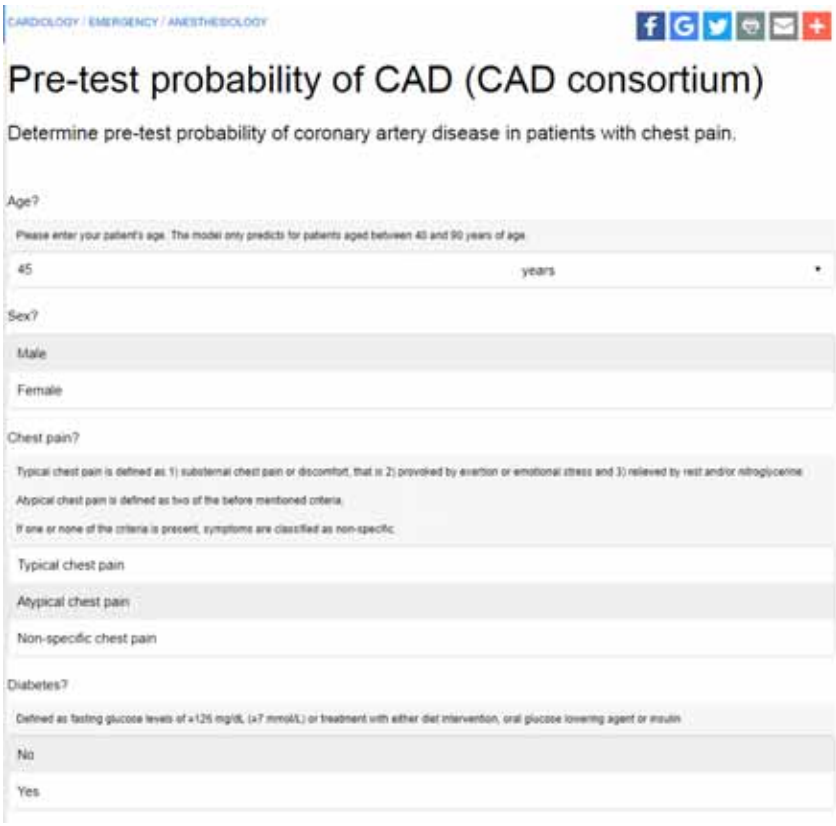
- ACC/AHA definitions of chest pain
- Typical Angina
  - Substernal chest pain or discomfort
  - Provoked by exertion or emotional stress
  - Relieved by rest or sublingual nitroglycerin
- Atypical Angina
  - Lacks one of the characteristics
- Non-anginal chest pain
  - Chest pain or discomfort that only meets one of the criteria

The probability of coronary disease depending on the quality of chest pain

Table A. Diamond and Forrester Pre-Test Probability of Coronary Artery Disease by Age, Sex, and Symptoms*

Age (years)	Sex	Typical/Definite Angina Pectoris	Atypical/Probable Angina Pectoris	Nonanginal Chest Pain
≤39	Men	Intermediate	Intermediate	Low
	Women	Intermediate	Very low	Very low
40–49	Men	High	Intermediate	Intermediate
	Women	Intermediate	Low	Very low
50–59	Men	High	Intermediate	Intermediate
	Women	Intermediate	Intermediate	Low
≥60	Men	High	Intermediate	Intermediate
	Women	High	Intermediate	Intermediate

High: >90% pre-test probability. **Intermediate:** between 10% and 90% pre-test probability. **Low:** between 5% and 10% pre-test probability. **Very low:** <5% pre-test probability. *Modified from the ACC/AHA 2002 Guideline Update for Exercise Testing (30a).



https://qxmd.com/calculate/calculator_287/pre-test-probability-of-cad-cad-consortium

Results

Basic Model

11 %

The Basic Model estimates the probability based on age, sex, and symptoms

Clinical Model

9 %

The Clinical Model estimates the probability based on age, sex, symptoms, and cardiovascular risk factors

Clinical + CCS Model

Without coronary calcium score, unable to provide %

The Clinical + CCS Model estimates the probability based on age, sex, symptoms, cardiovascular risk factors, and the coronary calcium score (CCS)

ECG

- ECG should be performed for almost all patients with new-onset chest pain
- Sensitivity for diagnosing cardiac ischemia is about 68%, while specificity about 97%*
- Normal ECG reduces likelihood of acute MI as etiology of active chest pain, but does not completely exclude myocardial ischemia
  - 2% frequency of MI in patients with non-ischemic EKG and no history of CAD (4% in patients with history of CAD)
- Serial ECGs generally recommended in acute evaluation

*Ioannidis JP, Salem D, Chew PW, Lau J. Accuracy and clinical effect of out-of-hospital electrocardiography in the diagnosis of acute cardiac ischemia: A meta-analysis. *Ann Emer Med*2001;37:461-470.

Troponin

- Should be checked in all patients **suspected of myocardial ischemia**
- Positive troponin suggests myocardial ischemia (though can have multiple causes)
- Negative troponin does not completely rule out acute coronary syndrome
- Current assays can identify most acute MIs within 3 hours of ED arrival
- Newer high sensitivity troponin increases sensitivity but decreases specificity

Point of care troponin assay (POCT)

- Reduce delays that might be seen with transport and processing in a central lab, or lack of availability
- Results from POCT assays have previously been qualitative rather than quantitative
- Concerns regarding lower sensitivity, especially in early hours after symptom onset
- Cost effectiveness has not been well demonstrated
  - May decrease cost by reducing referrals to higher levels of care
  - May also lead to increased cost due to additional testing that might not otherwise have been pursued and which may not have any clinical benefit
- Studies evaluating changes in LOS and outcomes have had mixed results

Hindawi Publishing Corporation
International Journal of Family Medicine
Volume 2013, Article ID 532093, 7 pages
http://dx.doi.org/10.1155/2013/532093

Research Article

Point-of-Care Troponin T Testing in the Management of Patients with Chest Pain in the Swedish Primary Care

Staffan Nilsson,[1] Per O. Andersson,[2] Lars Borgquist,[3] Ewa Grodzinsky,[4] Magnus Janzon,[5,6] Magnus Kvick,[7] Eva Landberg,[8] Håkan Nilsson,[2] and Jan-Erik Karlsson[9]

Table 2: Management of chest pain patients in primary health care (PHC) centres with and without point-of-care Troponin T testing (POCT-TnT).

	Patients from PHC centres with POCT-TnT $n = 128$[1]	Patients from PHC centres without POCT-TnT $n = 68$[1]	P value
Management in PHC centres			
Emergency referral, n (%)	32 (25)	29 (43)	0.011
Another visit booked, n (%)	18 (14)	2 (3.0)	0.013
Telephone call, n (%)	25 (20)	9 (13)	0.276
Back when necessary[2], n (%)	52 (41)	27 (40)	0.083

[1]Information missing for one patient not emergently referred. [2]No contacts planned by the GP.

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Table 4: Diagnostic accuracy of GPs' decision to refer chest pain patients emergently, with and without the support of point-of-care Troponin T (POCT-TnT).

		Sensitivity		Specificity		PPV		NPV	
		n	%	n	%	n	%	n	%
GP's decision with POCT-TnT $n = 128$	AMI[1]	2/3	67	95/125	76	2/32	6,3	95/96	99
	AMI + UA[2]	5/7	71	94/121	78	5/32	16	94/96	98
GP's decision without POCT-TnT $n = 68$	AMI	5/5	100	39/63	62	5/29	17	39/39	100
	AMI + UA	6/6	100	39/62	63	6/29	21	39/39	100

[1]Acute myocardial infarction, [2]unstable angina.

International Journal of Cardiology 177 (2014) 182–186

Contents lists available at ScienceDirect

International Journal of Cardiology

journal homepage: www.elsevier.com/locate/ijcard

Comparison of new point-of-care troponin assay with high sensitivity troponin in diagnosing myocardial infarction

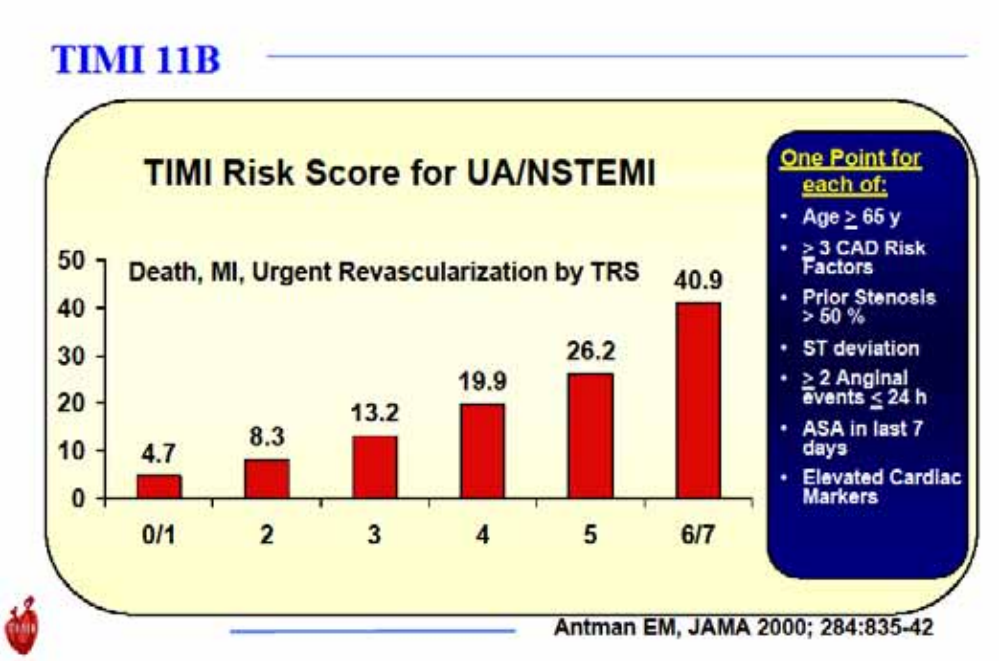
Sally Aldous [a,*], A. Mark Richards [b,c,d], Peter M. George [e], Louise Cullen [f], William A. Parsonage [f], Dylan Flaws [g], Christopher M. Florkowski [e], Richard W. Troughton [b,c], Jack W. O'Sullivan [f], Christopher M. Reid [h], Laura Bannister [b], Martin Than [b]

Table 4
Diagnostic accuracy of cardiac troponins for myocardial infarction 2 h after presentation.

% (95% C.I.)	Sensitivity	Specificity	PPV	NPV	Accuracy
Old POC cTnI	70.0 (65.4–73.9)	94.7 (93.4–95.9)	79.8 (74.6–84.3)	91.4 (90.1–92.5)	89.1 (87.0–90.9)
New POC cTnI	93.6 (89.9–96.2)	90.2 (89.0–90.9)	73.8 (70.9–75.9)	98.0 (96.7–98.8)	91.0 (89.2–92.1)
Hs-cTnI	95.0 (91.5–97.3)	92.5 (91.4–93.1)	78.9 (76.0–80.7)	98.4 (97.3–99.1)	93.0 (91.5–94.1)

PPV—positive predictive value, NPV—negative predictive value, POC—point of care, and (hs)-cTnI—(high sensitivity) cardiac troponin I.

Risk scores



GRACE risk score

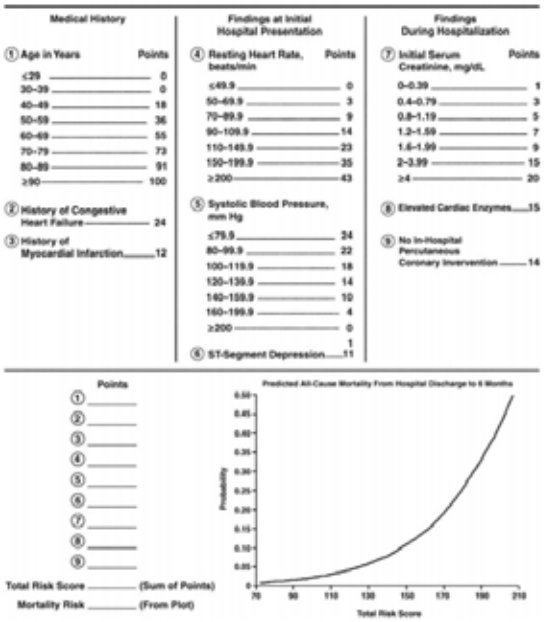


Figure 4. GRACE Prediction Score Card and Nomogram for All-Cause Mortality From Discharge to 6 Months. Reprinted with permission from Eagle KA, Lim MJ, Dabbous OH, et al. A validated prediction model for all forms of acute coronary syndrome: estimating the risk of 6-month postdischarge death in an international registry. JAMA 2004;291:2727–33.[18] Copyright © 2004 American Medical Association.

Chest pain in the emergency room: value of the HEART score

A.J. Six, B.E. Backus, J.C. Kelder

The HEART Score for Chest Pain Patients in the ED		
History	• Highly Suspicious • Moderately Suspicious • Slightly or Non-Suspicious	• 2 points • 1 point • 0 points
ECG	• Significant ST-Depression • Nonspecific Repolarization • Normal	• 2 points • 1 point • 0 points
Age	• ≥ 65 years • > 45 - < 65 years • ≤ 45 years	• 2 points • 1 point • 0 points
Risk Factors	• ≥ 3 Risk Factors or History of CAD • 1 or 2 Risk Factors • No Risk Factors	• 2 points • 1 point • 0 points
Troponin	• ≥ 3 x Normal Limit • > 1 - < 3 x Normal Limit • ≤ Normal Limit	• 2 points • 1 point • 0 points
Risk Factors: DM, current or recent (<one month) smoker, HTN, HLP, family history of CAD, & obesity		
Score 0 – 3: 2.5% MACE over next 6 weeks → Discharge Home **Score 4 – 6:** 20.3% MACE over next 6 weeks → Admit for Clinical Observation **Score 7 – 10:** 72.7% MACE over next 6 weeks → Early Invasive Strategies		

Neth Heart J 2008;16:191-6.

Crit Pathw Cardiol. 2011 September ; 10(3): 128–133. doi:10.1097/HPC.0b013e3182315a85.

Can the HEART Score Safely Reduce Stress Testing and Cardiac Imaging in Patients at Low Risk for Acute Coronary Syndrome?

Background—Patients with low risk chest pain have high utilization of stress testing and cardiac imaging, but low rates of acute coronary syndrome (ACS). The objective of this study was to determine if the HEART score could safely reduce objective cardiac testing in patients with low risk chest pain.

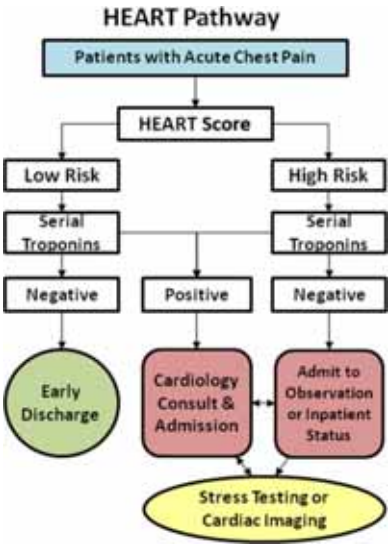
Methods—A cohort of chest pain patients was identified from an Emergency Department-based observation unit registry. HEART scores were determined using registry data elements and blinded chart review. HEART scores were dichotomized into low (0–3) or high risk (>3). The outcome was MACE; a composite endpoint of all cause mortality, myocardial infarction, or coronary revascularization during the index visit or within 30 days. Sensitivity, specificity, and potential reduction of cardiac testing were calculated.

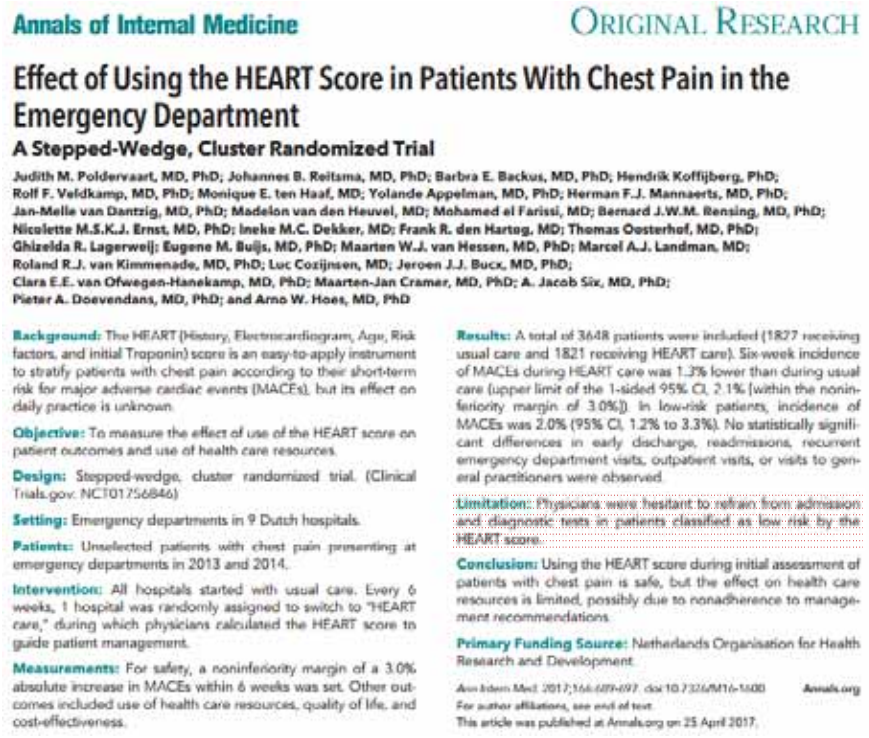
Results—Over 28 months, the registry included 1070 low risk chest pain patients. MACE occurred in 0.6% (5/904) of patients with low-risk HEART scores compared to 4.2% (7/166) with a high-risk HEART scores, OR=7.92, (95%CI 2.48–25.25). A HEART score >3 was 58% sensitive (95% CI 32–81%) and 85% specific (95% CI 83–87%) for MACE. The HEART score missed 5 cases of ACS among 1070 patients (0.5%) and could have reduced cardiac testing by 84.5% (904/1070). Combination of serial troponin > 0.065 ng/ml or HEART score >3 resulted in 100% sensitivity (95% CI 72–100%), specificity of 83% (95%CI 81–85%), and potential reduction in cardiac testing of 82% (879/1070).

Circ Cardiovasc Qual Outcomes. 2015 March ; 8(2): 195–203. doi:10.1161/CIRCOUTCOMES.114.001384.

The HEART Pathway Randomized Trial:

Identifying Emergency Department Patients With Acute Chest Pain for Early Discharge





Annals of Internal Medicine ORIGINAL RESEARCH

Effect of Using the HEART Score in Patients With Chest Pain in the Emergency Department

A Stepped-Wedge, Cluster Randomized Trial

Judith M. Poldervaart, MD, PhD; Johannes B. Reitsma, MD, PhD; Barbra E. Backus, MD, PhD; Hendrik Koffijberg, PhD; Rolf F. Veldkamp, MD, PhD; Monique E. ten Haaf, MD; Yolande Appelman, MD, PhD; Herman F.J. Mannaerts, MD, PhD; Jan-Melle van Dantzig, MD, PhD; Madelon van den Heuvel, MD; Mohamed el Farissi, MD; Bernard J.W.M. Rensing, MD, PhD; Nicolette M.S.K.J. Ernst, MD, PhD; Ineke M.C. Dekker, MD; Frank R. den Hartog, MD; Thomas Oosterhof, MD, PhD; Ghizelda R. Lagerweij; Eugene M. Buijs, MD, PhD; Maarten W.J. van Hessen, MD, PhD; Marcel A.J. Landman, MD; Roland R.J. van Kimmenade, MD, PhD; Luc Cozijnsen, MD; Jeroen J.J. Bucx, MD, PhD; Clara E.E. van Ofwegen-Hanekamp, MD, PhD; Maarten-Jan Cramer, MD, PhD; A. Jacob Six, MD, PhD; Pieter A. Doevendans, MD, PhD; and Arno W. Hoes, MD, PhD

Background: The HEART (History, Electrocardiogram, Age, Risk factors, and initial Troponin) score is an easy-to-apply instrument to stratify patients with chest pain according to their short-term risk for major adverse cardiac events (MACEs), but its effect on daily practice is unknown.

Objective: To measure the effect of use of the HEART score on patient outcomes and use of health care resources.

Design: Stepped-wedge, cluster randomized trial. (Clinical Trials.gov: NCT01756846)

Setting: Emergency departments in 9 Dutch hospitals.

Patients: Unselected patients with chest pain presenting at emergency departments in 2013 and 2014.

Intervention: All hospitals started with usual care. Every 6 weeks, 1 hospital was randomly assigned to switch to "HEART care," during which physicians calculated the HEART score to guide patient management.

Measurements: For safety, a noninferiority margin of a 3.0% absolute increase in MACEs within 6 weeks was set. Other outcomes included use of health care resources, quality of life, and cost-effectiveness.

Results: A total of 3648 patients were included (1827 receiving usual care and 1821 receiving HEART care). Six-week incidence of MACEs during HEART care was 1.3% lower than during usual care (upper limit of the 1-sided 95% CI, 2.1% [within the noninferiority margin of 3.0%]). In low-risk patients, incidence of MACEs was 2.0% (95% CI, 1.2% to 3.3%). No statistically significant differences in early discharge, readmissions, recurrent emergency department visits, outpatient visits, or visits to general practitioners were observed.

Limitation: Physicians were hesitant to refrain from admission and diagnostic tests in patients classified as low risk by the HEART score.

Conclusion: Using the HEART score during initial assessment of patients with chest pain is safe, but the effect on health care resources is limited, possibly due to nonadherence to management recommendations.

Primary Funding Source: Netherlands Organisation for Health Research and Development.

Ann Intern Med. 2017;166:689-697. doi:10.7326/M16-1600 Annals.org
For author affiliations, see end of text.
This article was published at Annals.org on 25 April 2017.

Chest pain centers (CPCs)

- Key role in the evaluation of low to moderate risk patients presenting with chest pain
- Over 1,000 accredited CPCs in the U.S.
- Accredited through the American College of Cardiology
- Staffed by ED physicians, cardiologists, and/or ancillary staff (NP, PA, etc.)
- Facilitate rapid triage and management using accelerated diagnostic protocols

Chest pain centers (CPCs)

- Multiple studies have demonstrated significant advantages of CPCs without increase in adverse cardiac events
  - Reduction in care variability
  - Decreased length of stay
  - Decreased readmission rates
  - Decreased cost of care
  - Consistent process improvement

November 26, 1997

Costs of an Emergency Department–Based Accelerated Diagnostic Protocol vs Hospitalization in Patients With Chest Pain

A Randomized Controlled Trial

Rebecca R. Roberts, MD; Robert J. Zalenski, MA, MD; Edward K. Mensah, PhD; et al

- Compared admission rate, total cost, and LOS in low risk patients treated using accelerated diagnostic protocols (ADP) vs. inpatient controls

Parameter	ADP	Control	P value
Admission rate	45.2%	100%	< 0.001
Mean total cost per patient	$1528	$2095	< 0.001
Mean LOS (hours)	33.1	44.8	< 0.01

Cardiology consultation reduces provocative testing rates in an ED observation unit☆,☆☆

Troy Madsen, MD *, Cameron Smyres, MD, Talmage Wood, BS, Tamara Moores, MD, Matthew Fuller, MD, Virgil Davis, MD, Kurt Bernhisel, MD

University of Utah School of Medicine, Salt Lake City, UT

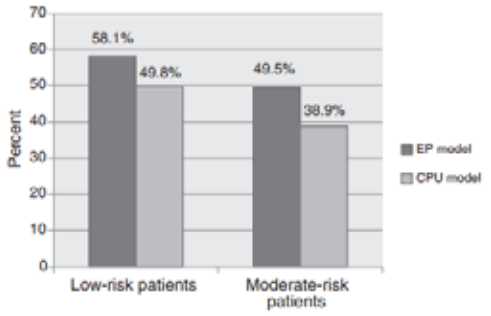


Fig. 1. Comparison of provocative testing rates. Difference between low-risk patients was significant ($P = .011$) but was not significant between moderate-risk patients ($P = .087$).

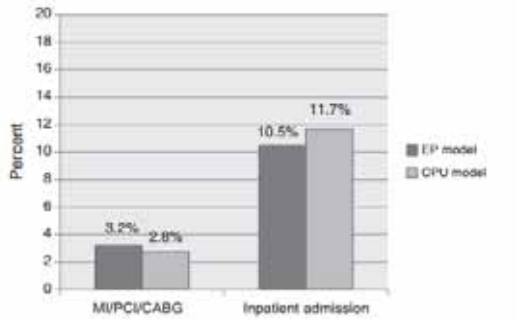


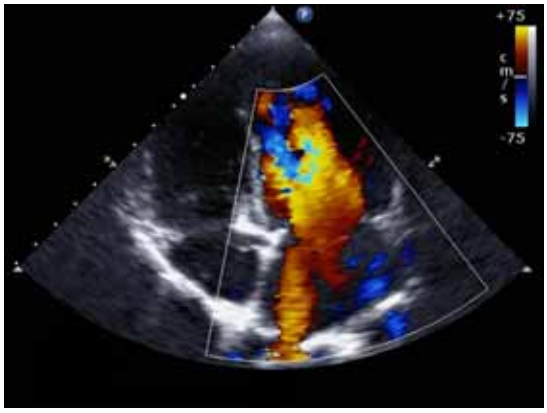
Fig. 2. Comparison of rates of MI, PCI, and CABG, as well as inpatient admission. Differences were nonsignificant for both ($P = .140$, $P = .430$).

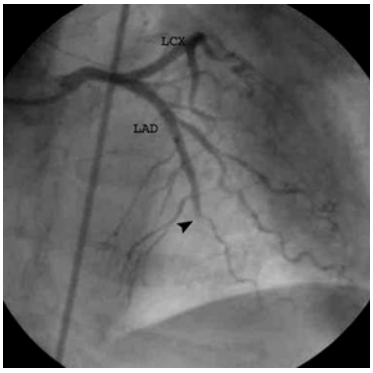
American Journal of Emergency Medicine 35 (2017) 25–28

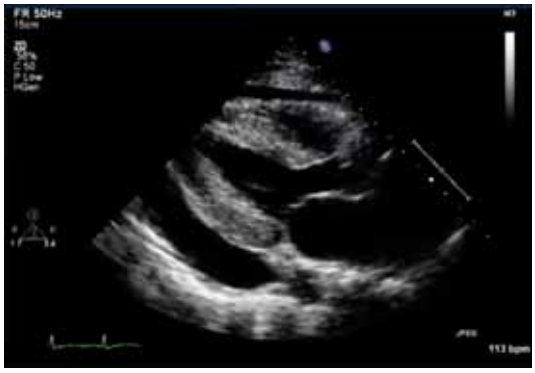
Diagnostic Testing

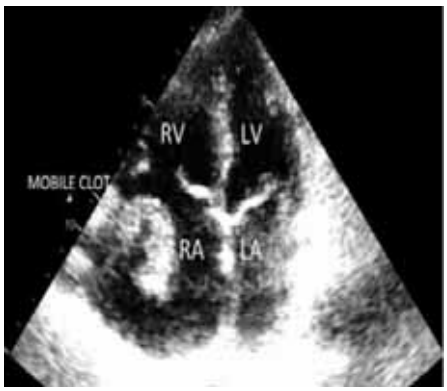
Echocardiogram

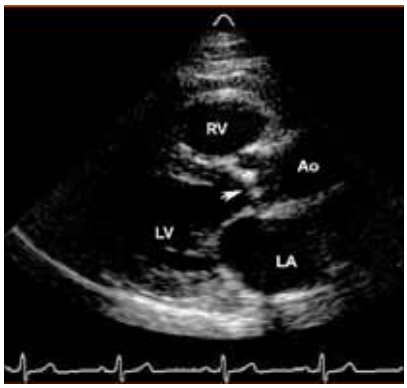
- Valuable diagnostic tool for evaluation of chest pain
  - Readily available
  - Relatively low cost
  - No radiation
  - Can evaluate multiple potential etiologies of chest pain simultaneously
  - Useful to help rule out ischemia as cause of active chest pain











Handheld Ultrasound

- Provides most of the same diagnostic information as a full echocardiogram
- Advantages
  - Rapid
  - Accurate
  - Superior sensitivity and specificity compared to physical exam
  - Portable, lightweight, durable
  - Improves access to care
  - Can evaluate multiple organ systems
- Disadvantages
  - Requires training
  - Possibly limited imaging windows
  - Cost of device (?)

ACCF/AHA/ASE/ASNC/HFSA/HRS/SCAI/SCCT/SCMR/STS 2013 Multimodality Appropriate Use Criteria for the Detection and Risk Assessment of Stable Ischemic Heart Disease

Table 1.1. Symptomatic

Refer to pages 16 and 17 for relevant definitions, in particular Table A and text and risk factors relevant to each pre-test probability				
	Indication Text	Exercise ECG	Stress RNI	Stress Echo
1.	• Low pre-test probability of CAD • ECG interpretable AND able to exercise	A	R	M
2.	• Low pre-test probability of CAD • ECG uninterpretable OR unable to exercise		A	A
3.	• Intermediate pre-test probability of CAD • ECG interpretable AND able to exercise	A	A	A
4.	• Intermediate pre-test probability of CAD • ECG uninterpretable OR unable to exercise		A	A
5.	• High pre-test probability of CAD ECG interpretable AND able to exercise	M	A	A
6.	• High pre-test probability of CAD • ECG uninterpretable OR unable to exercise		A	A

2012 ACCF/AHA Focused Update Incorporated Into the ACCF/AHA 2007 Guidelines for the Management of Patients With Unstable Angina/Non–ST-Elevation Myocardial Infarction

A Report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines

In patients with suspected ACS in whom ischemic heart disease is present or suspected, if the follow-up 12-lead ECG and cardiac biomarkers measurements are normal, a stress test (exercise or pharmacological) to provoke ischemia should be performed in the ED, in a chest pain unit, or on an outpatient basis in a timely fashion (within 72 h) as an alternative to inpatient admission. Low-risk patients with a negative diagnostic test can be managed as outpatients. *(Level of Evidence: C)*

Exercise Stress Test

- Main confirmatory test in accelerated diagnostic protocols and generally always preferred
- Exercise variables which have been shown to have prognostic value
  - **exercise duration**
  - chronotropic incompetence
  - heart rate recovery
  - exercise-induced hypotension
  - exercise-induced hypertension
  - ventricular ectopy
- If a person can walk for more than 5 minutes on flat ground or up one to two flights of stairs without needing to stop, they most likely can achieve an adequate workload during exercise stress testing.

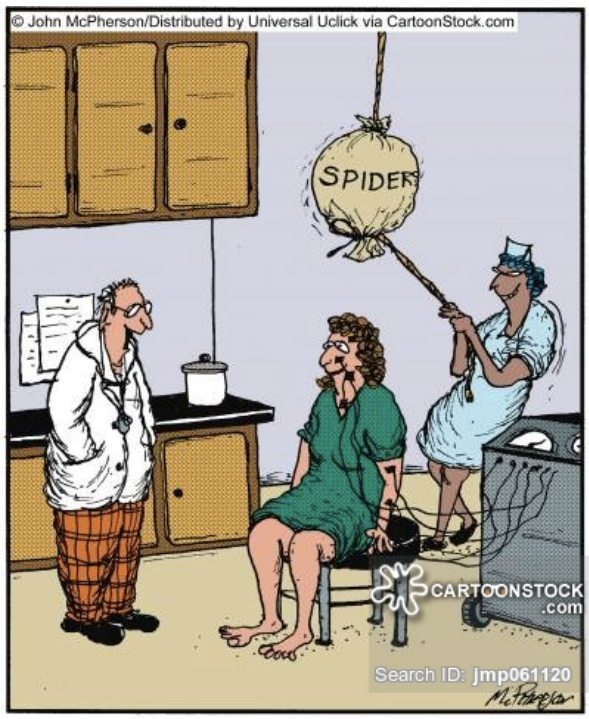
Type of stress	Sensitivity	Specificity	LR + (95%CI)	LR - (95%CI)
Exercise treadmill test (ETT)	68 %	77 %	3.57 (2.71- 4.71)	0.34 (0.28- 0.41)
Stress echo	76%	88%	7.94 (4.7- 13.5)	0.24 (0.17- 0.32)
SPECT radionuclide myocardial perfusion imaging	88%	77%	6.14 (4.27- 8.82)	0.24 (0.18- 0.31)

Banarjee A et al., Diagnostic accuracy of exercise stress testing for coronary artery disease: a systematic review and meta-analysis of prospective studies ICJP April, 2012

ETT alone or with Imaging?

- Generally ETT alone should still be the first test for patients who:
  - Can exercise
  - Have an interpretable ECG (RBBB included)

- Annual event rates in patients with a low risk exercise treadmill stress test are as low as 0.2-0.3%



"That's right! No huffing and puffing for 30 minutes on a treadmill. We've developed a new stress test that is faster and more accurate."

Relative strengths of ETT vs. Imaging Tests

ETT	SPECT/Echo
More widely available	Pharmacologic stress
Less technically demanding	Localization of ischemia
Lower cost	Ancillary information
No radiation	Higher diagnostic accuracy
	Higher prognostic accuracy

Current Opinion in Cardiology 2011, 26:363–369

Original Article

Cost-effectiveness of diagnostic evaluation strategies for individuals with stable chest pain syndrome and suspected coronary artery disease

James K. Min [a,*], Amanda Gilmore [b], Erica C. Jones [a], Daniel S. Berman [d], Wijnand J. Stuijfzand [a], Leslee J. Shaw [c], Ken O'Day [b], Ibrahim Danad [a]

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[d] *Emory University School of Medicine, Atlanta, GA, United States*

Table 1
Costs, effectiveness and incremental cost effectiveness ratio for individuals with a 20% prevalence of obstructive CAD.

Strategy	Cost	Effect	Δ Cost	Δ Effect	ICER
ETT-SE-ICA	$10,995	16.106	–	–	–
SE-CCTA-ICA	$11,235	16.1102	$240	0.0042	ExtDominated
ETT-MPS-ICA	$11,269	16.1045	$34	-0.0057	Dominated
SE-ICA	$11,356	16.1097	$122	-0.0005	Dominated
ETT-CCTA-ICA	$11,564	16.1176	$569	0.0116	$49,021
MPS-CCTA-ICA	$11,677	16.1078	$113	-0.0098	Dominated
MPS-ICA	$11,798	16.1073	$122	-0.0005	Dominated
CCTA-SE-ICA	$12,087	16.1275	$524	0.0099	$52,899
CCTA-MPS-ICA	$12,119	16.1274	$32	-0.0001	Dominated
CCTA-ICA	$12,274	16.1283	$187	0.0008	$233,138
ETT-ICA	$12,635	16.1127	$361	-0.0156	Dominated
ICA	$14,003	16.1205	$1729	-0.0078	Dominated

Table 3
Costs, effectiveness and incremental cost effectiveness ratio for individuals with a 80% prevalence of obstructive CAD.

Strategy	Cost	Effect	Δ Cost	Δ Effect	ICER
ETT-MPS-ICA	$31,498	13.9581	–	–	–
ETT-SE-ICA	$31,747	13.9646	$249	0.0065	$38,234
MPS-CCTA-ICA	$32,554	13.9678	$807	0.0032	Ext Dominated
ETT-CCTA-ICA	$32,554	13.9749	$808	0.0103	$78,404
MPS-ICA	$32,624	13.9684	$69	−0.0065	Dominated
SE-CCTA-ICA	$32,956	13.9784	$401	0.0035	Ext Dominated
SE-ICA	$33,026	13.979	$70	0.0006	Ext Dominated
ETT-ICA	$33,196	13.9804	$170	0.0014	Ext Dominated
CCTA-MPS-ICA	$34,144	13.993	$948	0.0126	Ext Dominated
CCTA-SE-ICA	$34,171	13.9938	$1616	0.0189	$85,523
CCTA-ICA	$34,330	13.9955	$160	0.0017	$93,841
ICA	$35,366	14.0044	$1035	0.0089	$116,337

- Key point: across a range of pre-test likelihood of obstructive CAD, **no strategy that employed initial testing by imaging was cost-effective**

Cardiac Imaging Tests

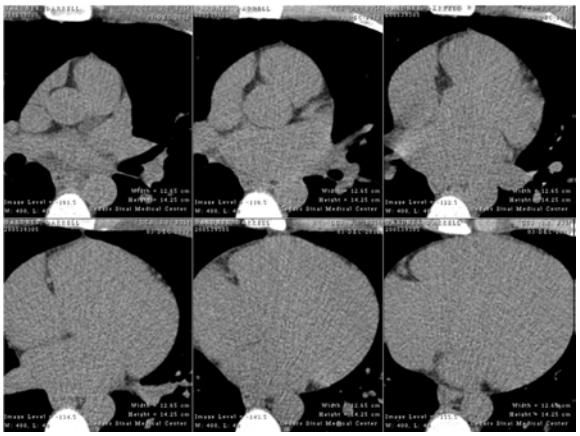
- Favored by some as initial test for symptomatic patients with at least intermediate pre-test probability of CAD
  - Superior ability to diagnose CAD
  - Superior ability to reclassify CAD likelihood
  - Superior power for predicting CAD events
  - Improved ability to guide subsequent short term and long term treatment
  - Superior diagnostic ability in patients with prior PCI

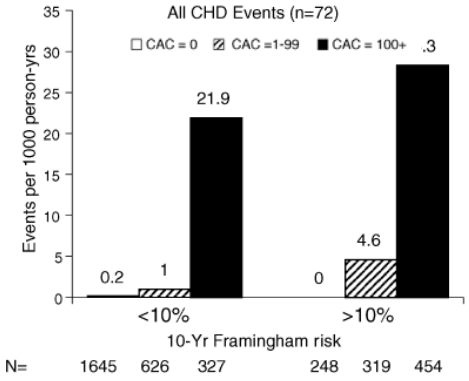
Clinical Considerations in Choosing the Cardiac Imaging Modality

Myocardial Perfusion Imaging	Stress echocardiography
LBBB	Desire to minimize radiation
Ventricular pacing	Valvular information needed
Atrial fibrillation	Hemodynamic information desired
Significant resting wall motion abnormality on echo	
Obesity	
Contraindication to dobutamine	

A role for the calcium score?

Indication		Appropriate Use Score (1–9)		
Noncontrast CT for CCS				
Global CHD Risk Estimate		Low	Intermediate	High
9.	• Family history of premature CHD	A (7)		
10.	• Asymptomatic • No known CAD	I (2)	A (7)	U (4)





Taylor AJ, et al. 2010 Appropriate Use Criteria for Cardiac Computed Tomography J Am Coll Cardiol. 2010;56(22):1864-1894.
Timothy S. Church, Benjamin D. Levine, Darren K. McGuire, Michael J. LaMonte, Shannon J. FitzGerald, et al., Coronary artery calcium score, risk factors, and incident coronary heart disease events, Atherosclerosis, Volume 190, Issue 1, January 2007

JACC: CARDIOVASCULAR IMAGING
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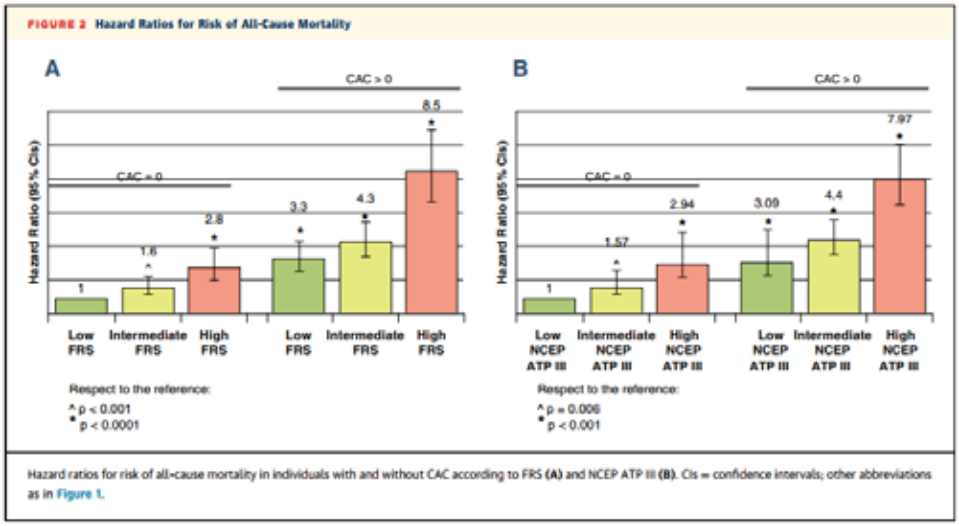
VOL. 8, NO. 8, 2015
ISSN 1936-878X/$36.00

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

A Prospective Follow-Up of 9,715 Individuals

Valentina Valenti, MD,* Brian ó Hartaigh, PhD,*† Ran Heo, MD,* Ikoung Cho, MD,* Joshua Schulman-Marcus, MD,‖ Heidi Gransar, MS,‖ Quynh A. Truong, MD, MPH,* Leslee J. Shaw, PhD,‖ Joseph Knapper, MD,‖ Anita A. Kelkar, MD,‖ Pratik Sandesara, MD,‖ Fay Y. Lin, MD,¶ Sebastiano Sciarretta, MD,#** Hyuk-Jae Chang, MD, PhD,†† Tracy Q. Callister, MD,‡‡ James K. Min, MD*

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.

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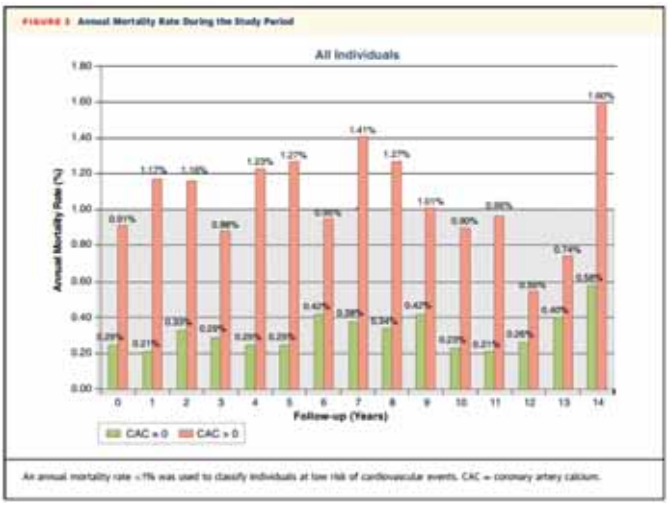

An annual mortality rate <1% was used to classify individuals at low risk of cardiovascular events. CAC = coronary artery calcium.

News > Conference News

Zero Coronary Calcium a 'Gatekeeper' Screen in Acute Chest Pain?

Marlene Busko
August 07, 2017

- Retrospective study of 5129 patients with acute chest pain presenting to ED from 2010-2015 identified as low to intermediate risk of ACS (TIMI < 2, negative troponins, normal/nondiagnostic EKG) and referred for coronary calcium scan

- More than half of the patients (2895; 56%) had CAC = 0
  - 95.4% of those patients had no CAD
  - 3.9% had non-obstructive CAD
  - 0.7% (21 patients) had obstructive CAD, of whom 11 had undergone stenting

- Rate of obstructive CAD was twice as high in smokers and patients with type 2 diabetes

- CAC test had sensitivity 96% (NPV 99.3%), specificity 62% (PPV 22.4%)

Diagnostic role of coronary calcium scoring in the rapid access chest pain clinic: prospective evaluation of NICE guidance

Ajay Yerramasu[1], Avijit Lahiri[1,2], Shreenidhi Venuraju[1], Alain Dumo[1], David Lipkin[1], S. Richard Underwood[3,4,*], Roby D. Rakhit[5], and Deven J. Patel[6]

[1]Clinical Imaging and Research Centre, Wellington Hospital, London, UK; [2]University of Middlesex, London, UK; [3]National Heart and Lung Institute, Imperial College London, London, UK; [4]Royal Brompton Hospital, Sydney St, London SW3 6NP, UK; [5]Royal Free London Foundation Trust, London, UK; and [6]Barnet and Chase Farm Hospitals NHS Trust, London, UK

Received 19 August 2013; accepted after revision 6 January 2014; online publish-ahead-of-print 9 February 2014

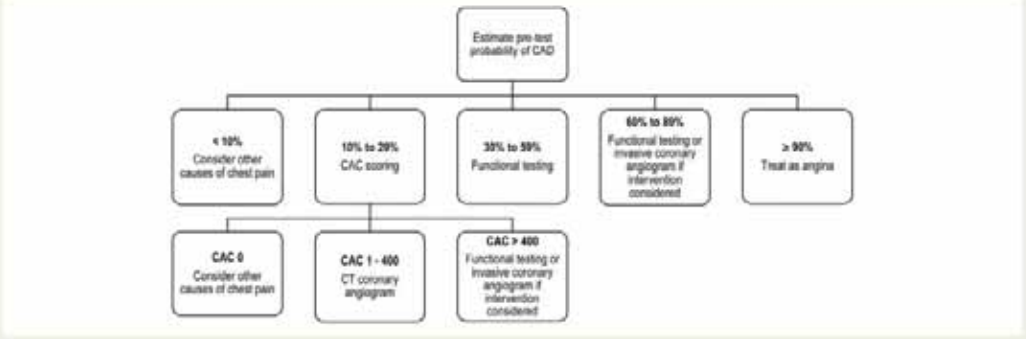

Figure 1 Diagnostic algorithm proposed by NICE for the investigation of patients with stable chest pain (adapted from National Institute for Health and Clinical Excellence. Chest Pain of Recent Onset: Assessment and Diagnosis of Recent Onset Chest Pain or Discomfort of Suspected Cardiac Origin. London: NICE, 2010).

Diagnostic role of coronary calcium scoring in the rapid access chest pain clinic: prospective evaluation of NICE guidance

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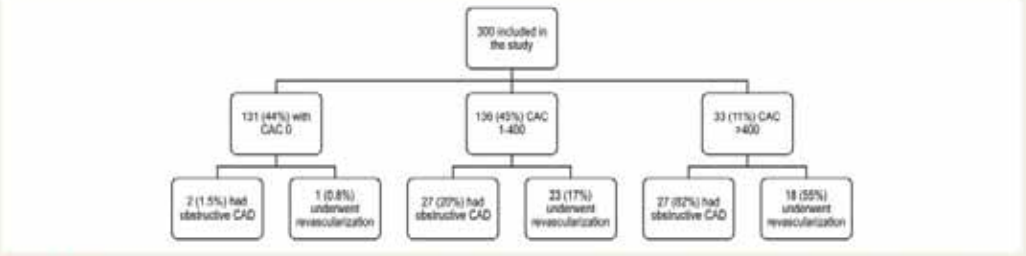
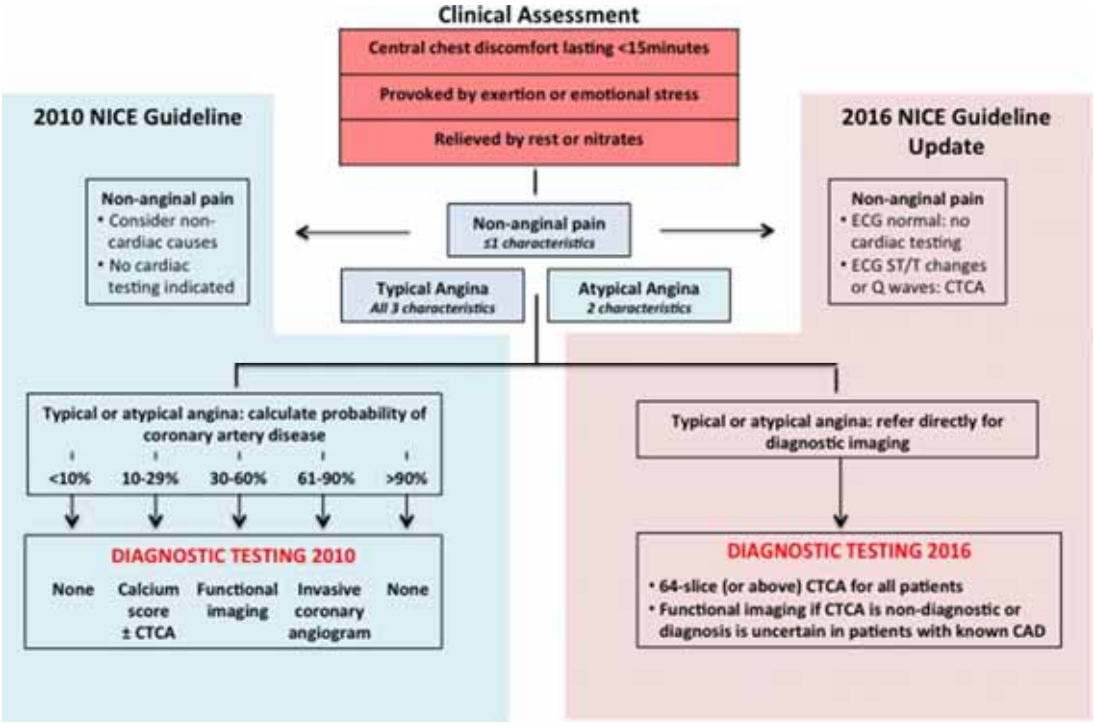
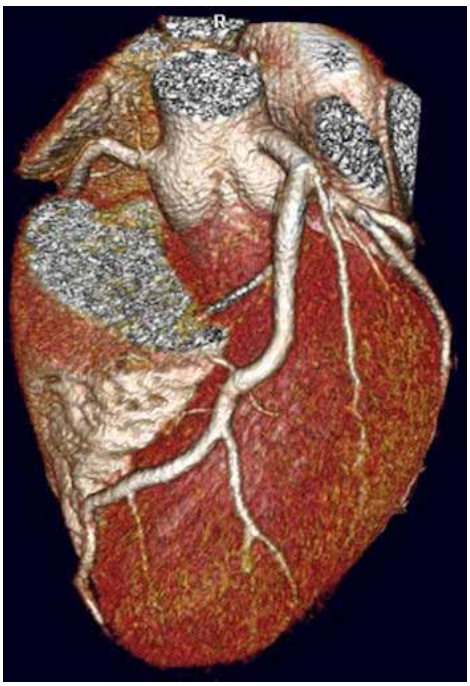


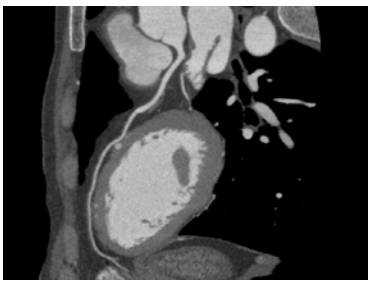
Figure 3 Distribution of patients according to the CAC score and the presence of obstructive CAD. Obstructive CAD was defined as ≥70% stenosis on coronary angiogram or presence of ischaemia on a functional test (MPS, stress echo, or fractional flow reserve).

NICE Guidelines



Coronary CT angiography





Coronary CT angiography

- Sensitivity ranges from 95-100% for detection of CAD (high negative predictive value)
- Specificity of about 80%
  - Decreased accuracy in patients with increasing calcium scores (> 400)
- Relatively low radiation exposure
  - Often less than 5 mSv
  - Can be reduced to less than 1 mSv with newer CT scans and prospective gating protocols

Limitations of Coronary CT Angiography

- Availability
- Need for expertise in analysis of studies
- Evaluation may be limited in patients with arrhythmias
- Renal impairment

Coronary CT angiography

- High utility in patients with lower ranges of pretest probability of CAD
- Multiple recent studies have suggested that the use of CCTA in the ED evaluation of chest pain results in:
  - Reduced ED LOS
  - Reduced admissions
  - Increase accuracy for identification of CAD
- Concern for increased need for downstream testing

Coronary CT Angiography versus Standard Evaluation in Acute Chest Pain

Udo Hoffmann, M.D., M.P.H., Quynh A. Truong, M.D., M.P.H., David A. Schoenfeld, Ph.D., Eric T. Chou, M.D., Pamela K. Woodard, M.D., John T. Nagurney, M.D., M.P.H., J. Hector Pope, M.D., Thomas H. Hauser, M.D., M.P.H., Charles S. White, M.D., Scott G. Weiner, M.D., M.P.H., Shant Kalanjian, M.D., Michael E. Mullins, M.D., Issam Mikati, M.D., W. Frank Peacock, M.D., Pearl Zakroysky, B.A., Douglas Hayden, Ph.D., Alexander Goehler, M.D., Ph.D., Hang Lee, Ph.D., G. Scott Gazelle, M.D., M.P.H., Ph.D., Stephen D. Wiviott, M.D., Jerome L. Fleg, M.D., and James E. Udelson, M.D., for the ROMICAT-II Investigators

- Followed completion of ROMICAT, which showed that 8% of patients screened for ACS in EDs actually have ACS
- Evaluated 1,000 chest pain patients with suspected ACS
- Randomized 1:1 to CCTA or standard care (MD discretion)
- Primary end point: LOS
- Secondary endpoints: rates of ED discharge, MACE at 28 days, cumulative costs

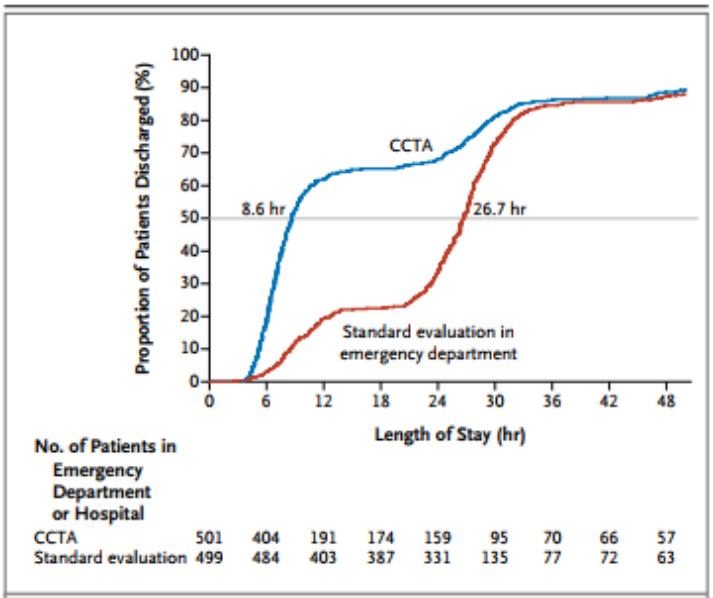


Figure 2. Length of Stay in the Hospital and Proportion of Patients Discharged.

The cumulative frequency of discharge from the index visit according to the length of stay is shown. The horizontal line indicates the median length of stay in the two study groups, which was significantly different (8.6 hours in the CCTA group vs. 26.7 hours in the standard-evaluation group, P<0.001).

Key findings from ROMICAT II

- Average time to diagnosis was 10.4 hours in CCTA group vs. 18.7 hours in control group (P = 0.001)
- CCTA reduced chest pain patients' average hospital stay from 31 hours to 23 hours vs. standard approach (P = 0.0002)
- CCTA patients much more likely to be discharged directly from ED (46.7% vs. 12.4%) and slightly less likely to be admitted to hospital (25.4% vs. 31.7%)
- No missed cases of ACS in either group and similar 30 day MACE rates in both groups
- CCTA costs were similar to standard approach despite more overall diagnostic testing in the CCTA group
  - CCTA cost about 19% less per patient
  - Hospital costs were about 50% more with CCTA approach → underwent more angiography (12% vs. 8%, p = 0.04) and a statistically insignificant greater number of coronary interventions

The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 APRIL 2, 2015 VOL. 372 NO. 14

Outcomes of Anatomical versus Functional Testing for Coronary Artery Disease

Pamela S. Douglas, M.D., Udo Hoffmann, M.D., M.P.H., Manesh R. Patel, M.D., Daniel B. Mark, M.D., M.P.H., Hussein R. Al-Khalidi, Ph.D., Brendan Cavanaugh, M.D., Jason Cole, M.D., Rowena J. Dolor, M.D., Christopher B. Fordyce, M.D., Megan Huang, Ph.D., Muhammad Akram Khan, M.D., Andrzej S. Kosinski, Ph.D., Mitchell W. Krucoff, M.D., Vinay Malhotra, M.D., Michael H. Picard, M.D., James E. Udelson, M.D., Eric J. Velazquez, M.D., Eric Yow, M.S., Lawton S. Cooper, M.D., M.P.H., and Kerry L. Lee, Ph.D., for the PROMISE Investigators*

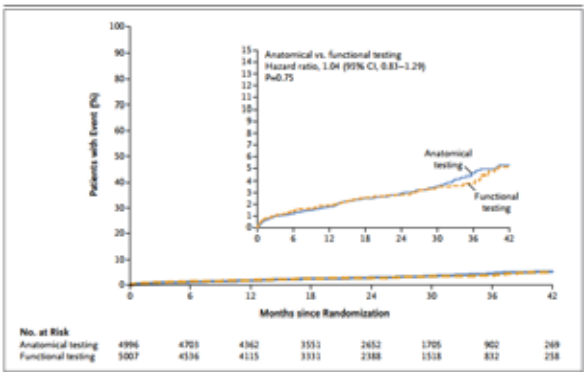


Figure 2. Kaplan–Meier Estimates of the Composite Primary End Point as a Function of Time after Randomization.
The graph shows the unadjusted Kaplan–Meier estimates of the primary composite end point (death from any cause, nonfatal myocardial infarction, hospitalization for unstable angina, or major procedural complication). The adjusted hazard ratio for a CTA strategy, as compared with a usual-care strategy of functional testing, was 1.04 (95% CI, 0.83 to 1.29), with adjustment for age, sex, risk equivalent of coronary artery disease (history of diabetes, peripheral arterial disease, or cerebrovascular disease), and the prespecification of the intended functional test if the patient were to be randomly assigned to the functional-testing group. The inset shows the same data on an enlarged y axis.

ORIGINAL RESEARCH

Annals of Internal Medicine

Economic Outcomes With Anatomical Versus Functional Diagnostic Testing for Coronary Artery Disease

Daniel B. Mark, MD, MPH; Jerome J. Federspiel, MD; Patricia A. Cowper, PhD; Kevin J. Anstrom, PhD; Udo Hoffmann, MD, MPH; Manesh R. Patel, MD; Linda Davidson-Ray, MA; Melanie R. Daniels, BA; Lawton S. Cooper, MD; J. David Knight, MS; Kerry L. Lee, PhD; and Pamela S. Douglas, MD, for the PROMISE Investigators*

Table 1. Estimated Costs of Noninvasive Tests*

Strategy	Tests, *n*	Mean Cost (SD), $	Median Cost (IQR) (Range), $
Stress nuclear testing			
Pharmacologic	3903	1132 (416)	1101 (864–1356) (432–4517)
Exercise	2396	946 (420)	898 (649–1189) (280–3052)
Stress echocardiography			
Pharmacologic	152	501 (135)	487 (408–562) (258–978)
Exercise	632	514 (151)	508 (403–612) (238–1261)
Exercise electrocardiography	455	174 (80)	152 (117–196) (61–465)
CTA with contrast	489	404 (122)	401 (307–486) (167–878)

ORIGINAL RESEARCH

Annals of Internal Medicine

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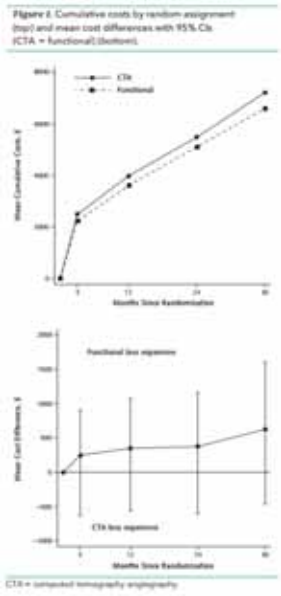


Ann Intern Med. 2016;165:94-102.

So which test do I pick? (If I need one)

- Ideal diagnostic strategy will:
  - Clarify diagnosis
  - Provide prognostic information
  - Inform the need for additional care
  - Maximize efficiency while minimizing cost
  - Optimize clinical outcomes
- Many choices available, and despite multiple studies, after ETT, there is still no clear “best” choice
- Important to remember that among stable patients with chest pain, the prevalence of obstructive CAD is actually very low
  - 88% of patients in the PROMISE trial had no obstructive CAD on CCTA
- May be more important to evaluate strategies for improving patient selection for additional cardiac testing

JAMA Internal Medicine | Original Investigation | LESS IS MORE

Noninvasive Cardiac Testing vs Clinical Evaluation Alone in Acute Chest Pain

A Secondary Analysis of the ROMICAT-II Randomized Clinical Trial

Samuel W. Reinhardt, MD; Chien-Jung Lin, MD, PhD; Eric Novak, MS; David L. Brown, MD

Published online November 14, 2017.

- Patients with clinical evaluation alone had shorter LOS (20.3 vs. 27.9 hours, P < 0.001)
- Clinical evaluation alone associated with lower rates of diagnostic testing and angiography
- Clinical evaluation alone associated with lower median cost ($2261 vs. $2584, P = 0.009)
- No difference in rates of PCI, CABG, return ED visits, or MACE in the 28 day follow up period

JAMA Cardiology | Original Investigation

Identification of Patients With Stable Chest Pain Deriving Minimal Value From Noninvasive Testing

The PROMISE Minimal-Risk Tool, A Secondary Analysis of a Randomized Clinical Trial

Christopher B. Fordyce, MD, MHS, MSc; Pamela S. Douglas, MD; Rhonda S. Roberts, MSPH; Udo Hoffmann, MD, MPH; Hussein R. Al-Khalidi, PhD; Manesh R. Patel, MD; Christopher B. Granger, MD; John Kostis, MD; Daniel B. Mark, MD; Kerry L. Lee, PhD; James E. Udelson, MD; for the Prospective Multicenter Imaging Study for Evaluation of Chest Pain (PROMISE) Investigators

Table 2. Factors Associated With Minimal Risk in the Final Derivation Model[a]

Factor	Odds Ratio (95% CI)[b]	*P* Value	χ^2
Age (per 5-y decrease)	1.50 (1.41-1.60)	<.001	160.0
Female sex	2.59 (2.13-3.16)	<.001	90.8
Racial or ethnic minority	1.29 (1.05-1.59)	.01	6.1
No hypertension	1.55 (1.29-1.85)	<.001	22.7
No dyslipidemia	1.43 (1.19-1.72)	<.001	14.9
Never smoker[c]	1.66 (1.40-1.98)	<.001	32.6
No family history of CAD	1.34 (1.06-1.68)	<.001	24.4
No diabetes	1.48 (1.23-1.78)	.0	7.3
Symptoms unrelated to physical or mental stress[d]	1.48 (1.23-1.78)	.007	6.0
HDL-C (per 5-point increase)	1.04 (1.01-1.07)	.01	6.3

Abbreviations: CAD, coronary artery disease; HDL-C, high-density lipoprotein cholesterol.

[a] Model derivation C statistic = 0.725; model validation C statistic = 0.725.

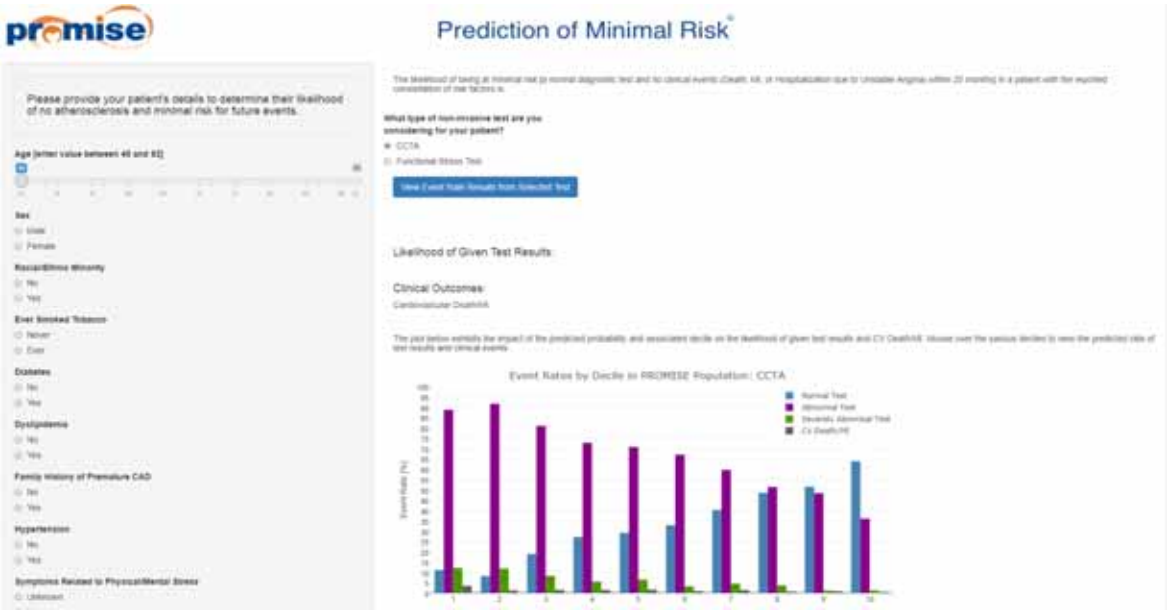
[b] Odds ratios greater than 1.00 indicate increased probability of minimal risk for every 5-unit increase or decrease in continuous variables and when comparing category shift in categorical variables.

[c] Compared with ever smoking.

[d] Compared with symptoms related to physical or mental stress.

JAMA Cardiol. 2017;2(4):400-408. doi:10.1001/jamacardio.2016.5501
Published online February 15, 2017.

www.promiserisktools.com



Conclusions

- Costs for chest pain evaluation are high despite relatively low event rates
- Optimal utilization of clinical assessment can help to better identify lower risk patients in whom additional diagnostic testing would be low yield
- Exercise treadmill test is an appropriate initial diagnostic cardiac test for the evaluation of chest pain
- No clear “best” diagnostic cardiac test after ETT based on current data
- Increasing prevalence of emerging technologies may provide further opportunities to practice high value, cost-effective care in cardiology

THANK YOU!