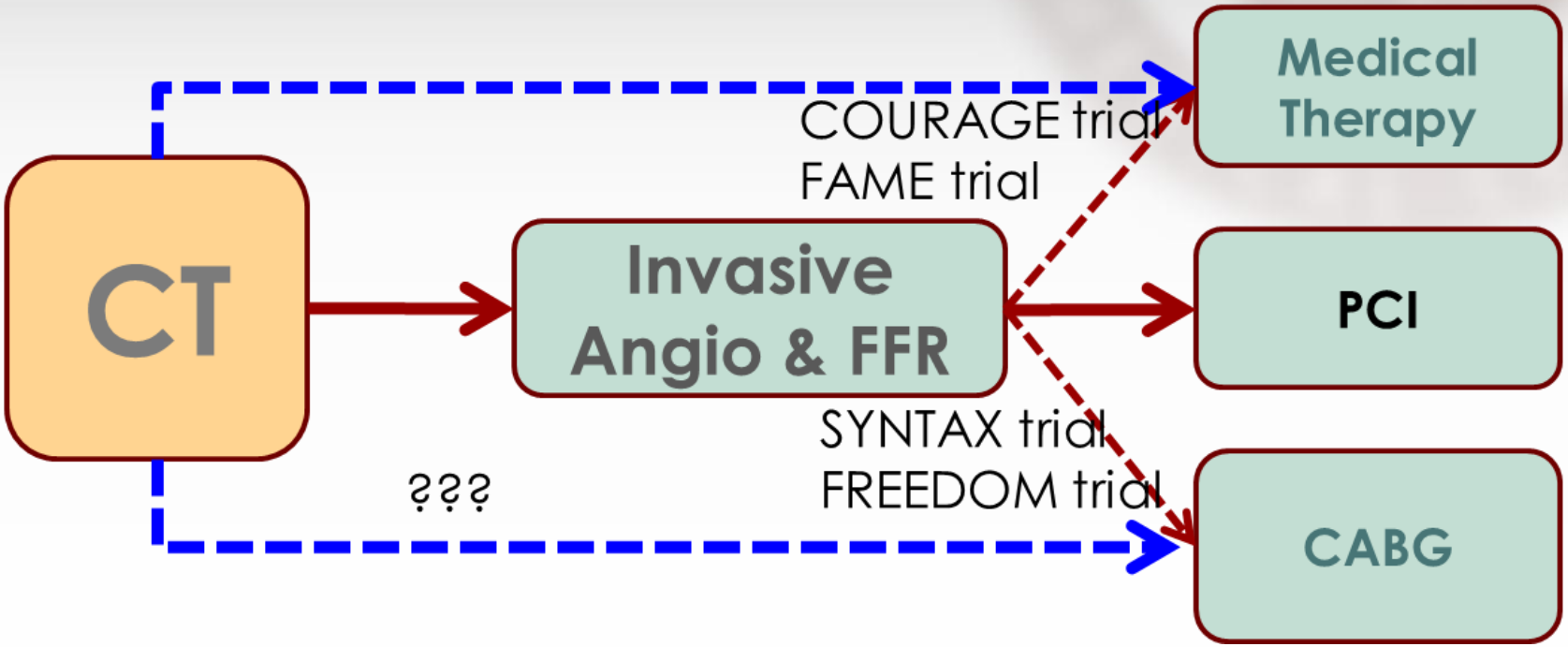
Is Evaluation of Coronary Anatomy by CT *Sufficient* for CAD? Lessons and Un-Lessons from *PROMISE*

Hwanseok YONG

Radiology

Koera Universtiy Guro Hospital

CT as gatekeeper for invasive angiography and invasive FFR



Coronary CTA Fails to Live Up to Its PROMISE in Suspected ...

www.tctmd.com/show.aspx?id=128217

Mar 14, 2015 - In the **PROMISE trial**, investigators led by Pamela S. Douglas, MD, of Duke ... In the **coronary CTA** arm (n = 4,996), 93.8% underwent CTA as an ...

You visited this page on 6/11/15.

PROMISE Trial Shows CT is as Effective as Stress Tests and ...

www.di**cardiology**.com/node/68137

Mar 16, 2015 - Computed tomography, **coronary CT** angiography, **PROMISE trial**, ACC. March 16, 2015 — Results from the **PROMISE** clinical **trial** confirmed ...

You visited this page on 6/11/15.

PROMISE: Prospective Multicenter Imaging Study For Chest ...

www.acc.org/latest-in-**cardiology**/articles/2015/.../8am-pt-314-**promise**

Mar 14, 2015 - In the **trial**, author Pamela S. Douglas, MD, MACC, et al. employed the ... testing versus a **coronary computed tomography** angiography (CTA) or ...

CTA Does Not Reduce Hard Events vs Functional Tests

www.medscape.com/viewarticle/841497 Medscape

Mar 14, 2015 - UPDATED // The **PROMISE** study, designed to test whether CTA offered an ... of anatomic testing with **coronary computed-tomography** angiography (CTA) did ... Among 10 003 symptomatic patients randomized in the **trial**, the ...

PROspective Multicenter Imaging Study for Evaluation of ...

https://clinical**trials**.gov/ct2/show/NCT01174550 ClinicalTrials.gov

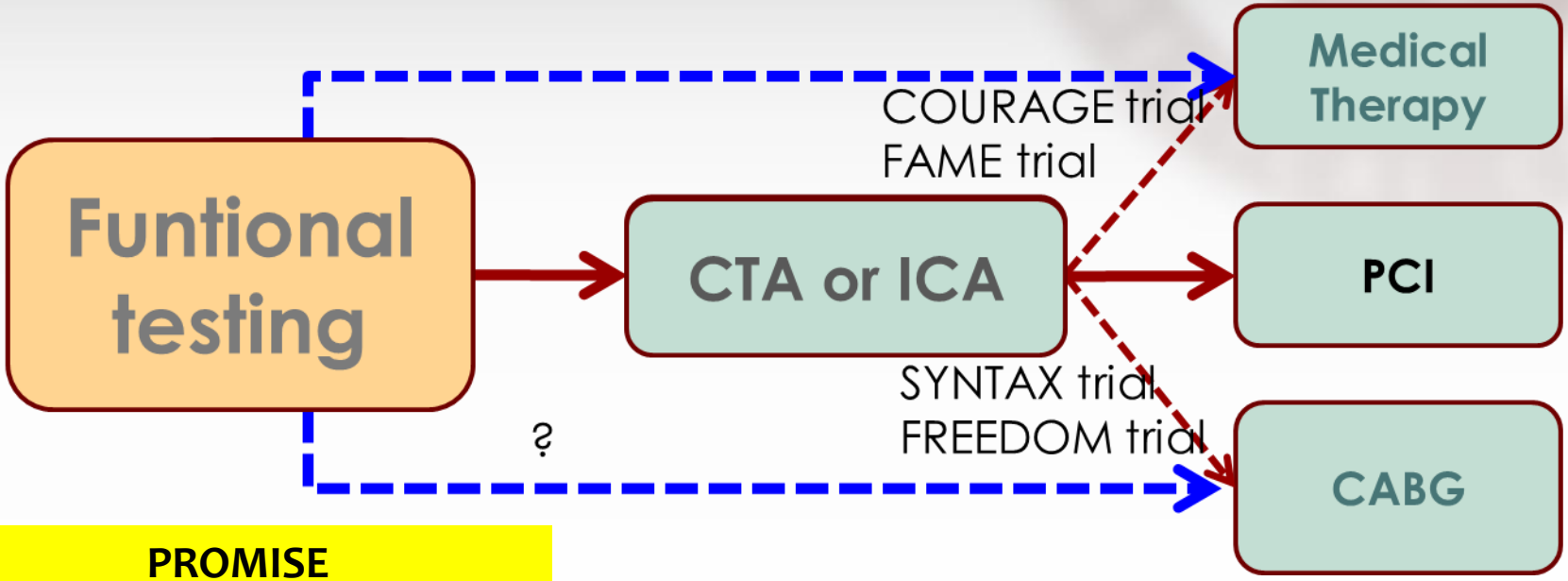
Aug 2, 2010 - ... anatomic imaging strategy with **coronary CT** angiography (CTA) will ... Imaging Study for Evaluation of Chest Pain - The **PROMISE Trial** ...

ACC: CT No Better Than Stress Test as Chest Pain Diagnostic

www.medpagetoday.com/MeetingCoverage/ACC/50481 MedPage Today

Mar 14, 2015 - Anatomic **CT** as the initial screen for suspected stable **coronary** artery ... but did increase overall radiation exposure, the **PROMISE trial** showed.

- Function for decision making
- Anatomy for revascuarization procedure



PROMISE
N Engl J Med 2015;372:1291-300

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*

promise

A Randomized Comparison of Anatomic versus Functional Diagnostic Testing Strategies in Symptomatic Patients with Suspected Coronary Artery Disease

Pamela S. Douglas, Udo Hoffmann, Manesh R. Patel, Daniel Mark, Lawton Cooper, and Kerry Lee

On behalf of the PROMISE Investigators

Duke Clinical Research Institute, Massachusetts General Hospital, and the National Heart, Lung, and Blood Institute

Supported by R01HL098237, R01HL098236, R01HL98305 and R01HL098235 from the National Heart, Lung, and Blood Institute

Duke Clinical Research Institute | NIH National Heart, Lung, and Blood Institute | MASSACHUSETTS GENERAL HOSPITAL

CONCLUSIONS

In symptomatic patients with suspected CAD who required noninvasive testing, a strategy of initial CTA, as compared with functional testing, did not improve clinical outcomes over a median follow-up of 2 years. (Funded by the National Heart, Lung, and Blood Institute; PROMISE ClinicalTrials.gov number, NCT01174550.)

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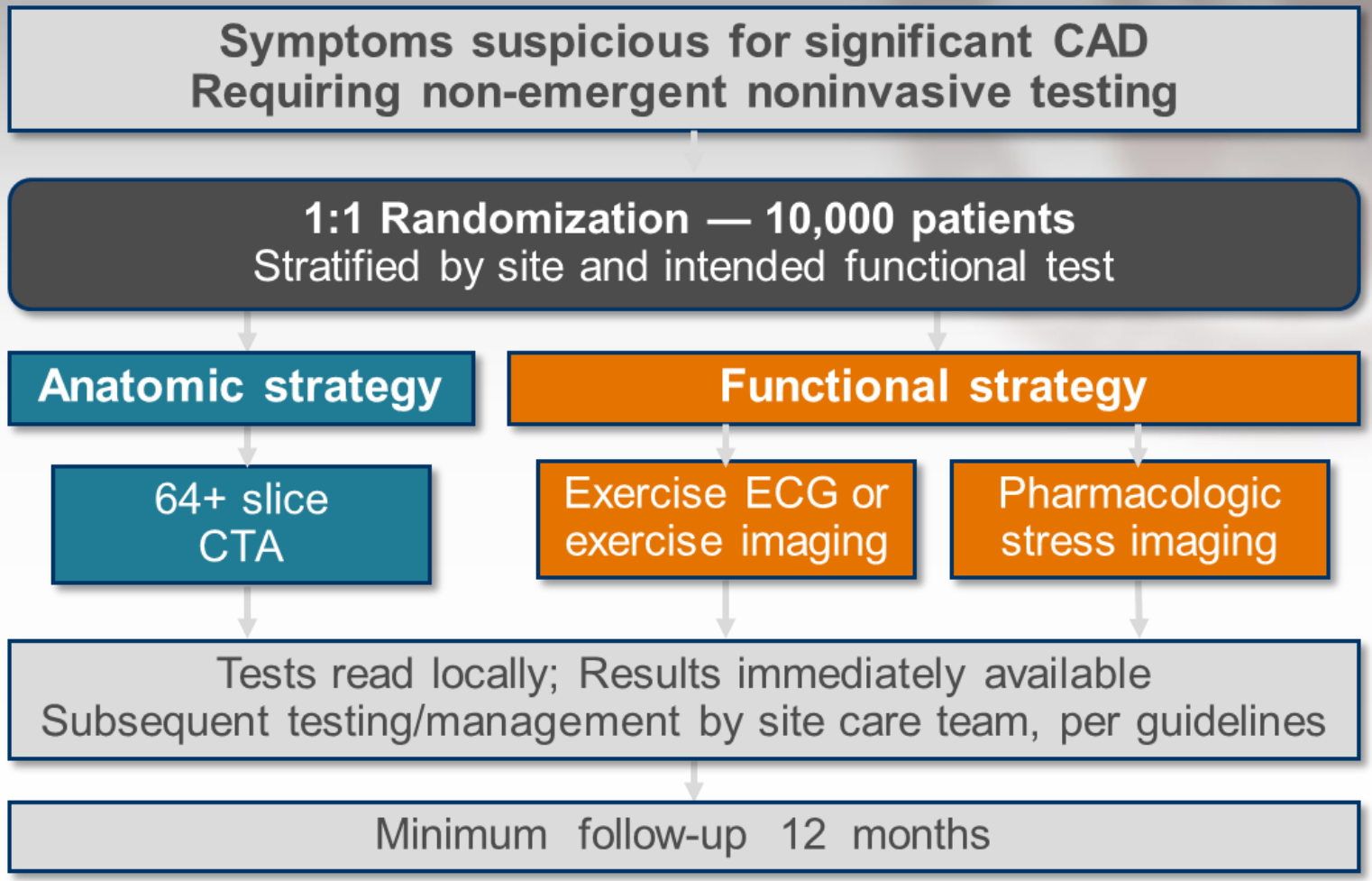
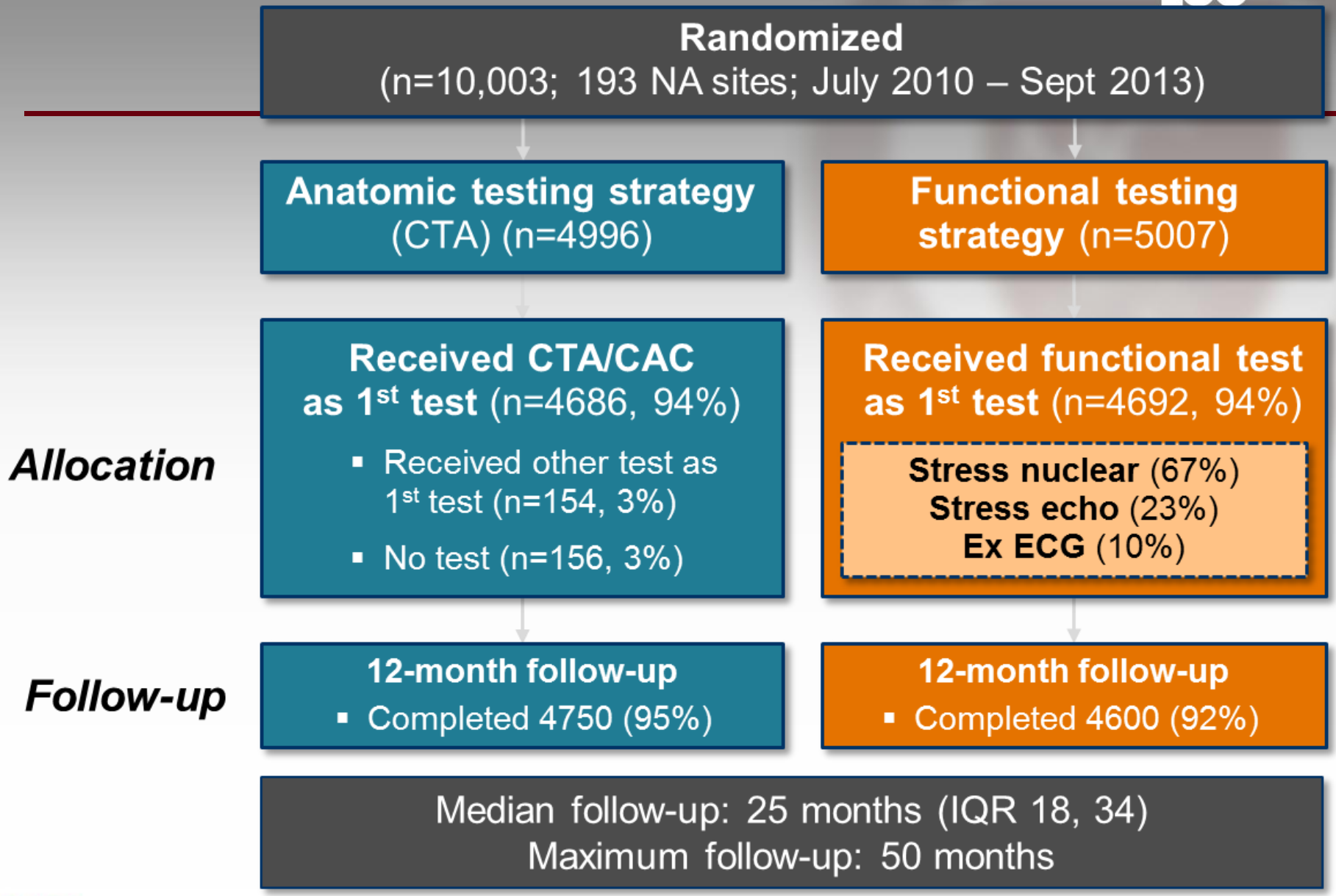
PROMISE Trial Design




Randomized
(n=10,003; 193 NA sites; July 2010 – Sept 2013)
Anatomic testing strategy (CTA) (n=4996)
Functional testing strategy (n=5007)
Allocation
Received CTA/CAC as 1st test (n=4686, 94%)
Received other test as 1st test (n=154, 3%)
No test (n=156, 3%)
Received functional test as 1st test (n=4692, 94%)
Stress nuclear (67%)
Stress echo (23%)
Ex ECG (10%)
Follow-up
12-month follow-up
Completed 4750 (95%)
12-month follow-up
Completed 4600 (92%)
Median follow-up: 25 months (IQR 18, 34)
Maximum follow-up: 50 months

Clinical Endpoint Events

	CTA (n=4996)	Functional (n=5007)	Adj HR (95% CI)	P value
Primary endpoint composite	**164**	**151**	**1.04 (0.83–1.29)**	**0.750**
All-cause death	74	75		
Nonfatal MI	30	40		
Unstable angina hosp	61	41		
Major procedural complications	4	5		
Primary endpoint plus cath without obstructive CAD	**332**	**353**	**0.91 (0.78–1.06)**	**0.217**
Death or nonfatal MI	**104**	**112**	**0.88 (0.67–1.15)**	**0.348**
Death, nonfatal MI, or unstable angina hospitalization	**162**	**148**	**1.04 (0.84–1.31)**	**0.703**

Secondary Endpoint:

Catheterization Without Obstructive CAD ≤90 days

	CTA (n=4996)	Functional (n=5007)	P value
Invasive catheterization without obstructive CAD — N (%)	**170 (3.4)**	**213 (4.3)**	**0.022**
Invasive catheterization	609 (12.2%)	406 (8.1%)	
With obstructive CAD (% of caths)	439 (72.1%)	193 (47.5%)	
Revascularization	311 (6.2%)	158 (3.2%)	
CABG	72	38	

Cumulative Radiation Exposure ≤90 days

Mean ± SD; mSv	CTA (n=4996)	Functional (n=5007)	P value
All patients	**12.0 ± 8.5**	**10.1 ± 9.0**	**<0.001**
No radiation exposure	4%	33%	
Intended nuclear stress test randomization stratum	12.0 ± 8.4	14.1 ± 7.6	<0.001
Intended stress echo randomization stratum	12.6 ± 9.0	1.3 ± 4.3	<0.001
Intended exercise ECG randomization stratum	10.4 ± 7.8	2.3 ± 5.4	<0.001

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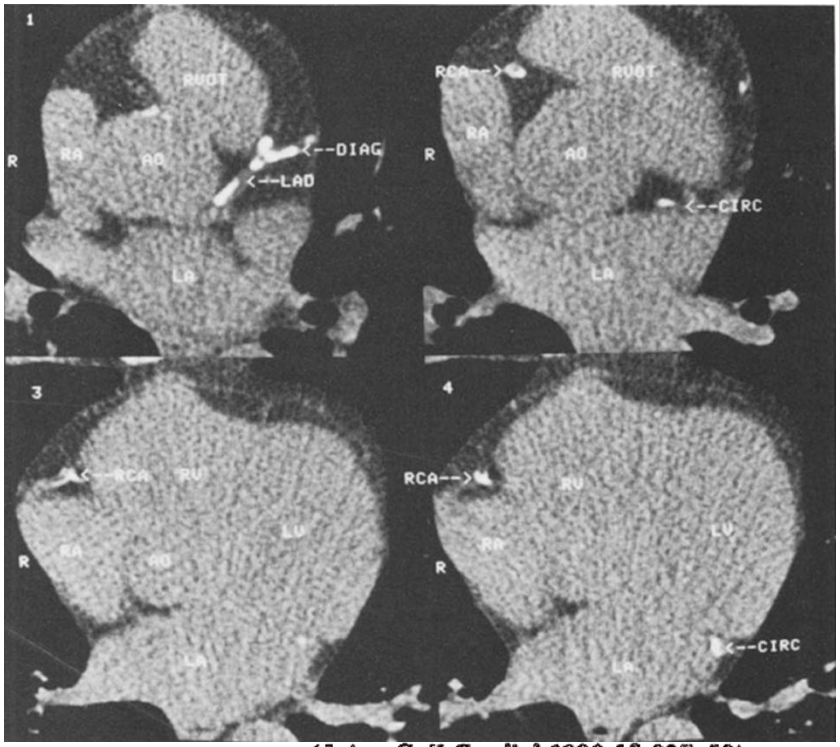
Quantification of Coronary Artery Calcium Using Ultrafast Computed Tomography

ARTHUR S. AGATSTON, MD, FACC, WARREN R. JANOWITZ, MD, FRANK J. HILDNER, MD, FACC, NOEL R. ZUSMER, MD, MANUEL VIAMONTE, JR., MD, ROBERT DETRANO, MD, PHD

Miami Beach, Florida and Long Beach, California

Ultrafast computed tomography was used to detect and quantify coronary artery calcium levels in 584 subjects (mean age 48 ± 10 years) with (n = 109) and without (n = 475) clinical coronary artery disease. Fifty patients who underwent fluoroscopy and ultrafast computed tomography were also evaluated. Twenty contiguous 3 mm slices were obtained of the proximal coronary arteries. Total calcium scores were calculated based on the number, areas and peak Hounsfield computed tomographic numbers of the calcific lesions detected.

In 88 subjects scored by two readers independently, interobserver agreement was excellent with identical total scores obtained in 70. Ultrafast computed tomography was more sensitive than fluoroscopy, detecting coronary calcium in 90% versus 52% of patients. There were significant differences ($p < 0.0001$) in mean total calcium scores for those with versus those without clinical coronary artery



(J Am Coll Cardiol 1990;15:827–32)

Paech and Weston *BMC Cardiovascular Disorders* 2011, **11**:32
http://www.biomedcentral.com/1471-2261/11/32

BMC Cardiovascular Disorders

RESEARCH ARTICLE Open Access

A systematic review of the clinical effectiveness of 64-slice or higher computed tomography angiography as an alternative to invasive coronary angiography in the investigation of suspected coronary artery disease

Daniel C Paech* and Adèle R Weston

2006.12.~2009.3.

Analysis level	No. of included studies [a]	Sensitivity % (95% CI)	Specificity % (95% CI)	PPV Median (range)	NPV Median (range)	Diagnostic accuracy Median (range)
Patient: base case analysis	18	98.2 (97.4-98.8)	81.6 (79.0-84.0)	90.5 (76-100)	99.0 (83-100)	92.0 (80-100)
Patient: alternative analysis	22	98.0 (97.2-98.6)	83.2 (81.1-85.2)	89.0 (63-100)	98.0 (83-100)	92.0 (80-100)
Vessels: all	17	94.9 (93.9-95.8)	89.5 (88.8-90.2)	75.0 (53-95)	99.0 (93-100)	91.5 (74-98)
RCA	8	94.8 (92.0-96.9)	91.0 (89.0-92.7)	84.0 (73-94)	98.5 (95-100)	94.5 (84-99)
LM	8	95.7 (85.2-99.5)	97.1 (95.7-98.1)	89.0 (24-100)	100.0 (98-100)	99.0 (91-100)
LAD	7	97.4 (95.3-98.8)	84.5 (82.1-86.7)	78.0 (57-95)	99.0 (95-100)	93.0 (72-99)
CX	8	94.1 (90.7-96.6)	89.6 (87.7-91.3)	78.5 (52-90)	99.5 (95-100)	94.0 (75-99)
Segments: all	17	91.3 (90.2-92.2)	94.0 (93.7-94.2)	69.0 (44-86)	99.0 (98-100)	95.5 (90-99)

Journal of the American College of Cardiology
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Published by Elsevier Inc.

Vol. 56, No. 22, 2010
ISSN 0735-1097/$36.00
doi:10.1016/j.jacc.2010.07.005

APPROPRIATE USE CRITERIA

ACCF/SCCT/ACR/AHA/ASE/ASNC/NASCI/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 North American Society for Cardiovascular Imaging, the Society for Cardiovascular Angiography and Interventions, and the Society for Cardiovascular Magnetic Resonance

GUIDELINE

ASCI 2010 appropriateness criteria for cardiac computed tomography: a report of the Asian Society of Cardiovascular Imaging cardiac computed tomography and cardiac magnetic resonance imaging guideline Working Group

ASCI CCT & CMR Guideline Working Group · I-Chen Tsai · Byoung Wook Choi · Carmen Chan · Masahiro Jinzaki · Kakuya Kitagawa · Hwan Seok Yong · Wei Yu

Review Article | Cardiovascular Imaging

http://dx.doi.org/10.3348/kjr.2015.16.2.251
pISSN 1229-6929 · eISSN 2005-8330
Korean J Radiol 2015;16(2):251-285

Korean Journal of Radiology
KJR

Korean Guidelines for the Appropriate Use of Cardiac CT

Young Jin Kim, MD[1], Hwan Seok Yong, MD[2], Sung Mok Kim, MD[3], Jeong A Kim, MD[4], Dong Hyun Yang, MD[5], Yoo Jin Hong, MD[1]

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Journal of the American College of Cardiology
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Published by Elsevier Inc.

Vol. 58, No. 8, 2011
ISSN 0735-1097/$36.00
doi:10.1016/j.jacc.2011.02.074

Cardiac Imaging

Age- and Sex-Related Differences in All-Cause Mortality Risk Based on Coronary Computed Tomography Angiography Findings

Resu
CO
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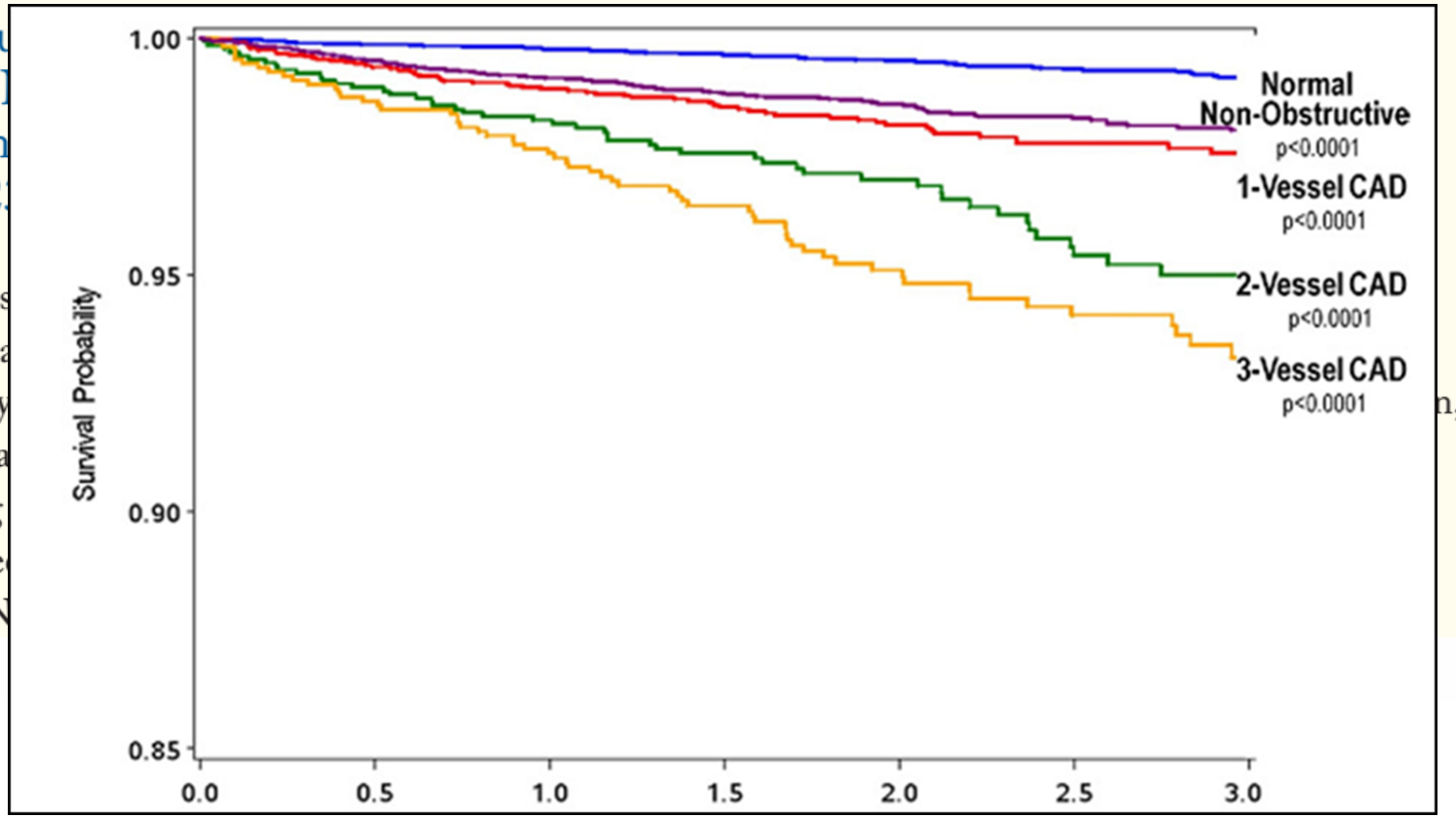
of 2

James
Moua
Tracy
Benja
Joerg
Lesle
CON

n, MD,§§



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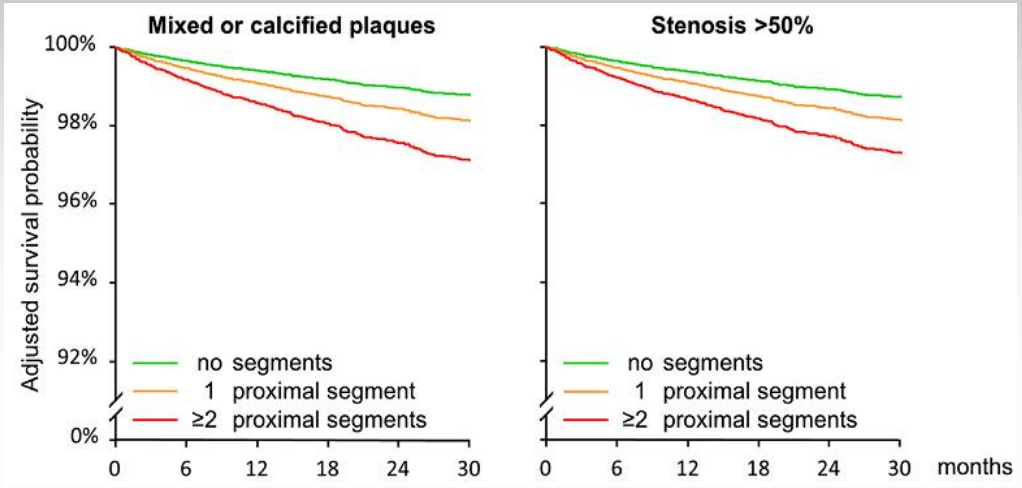
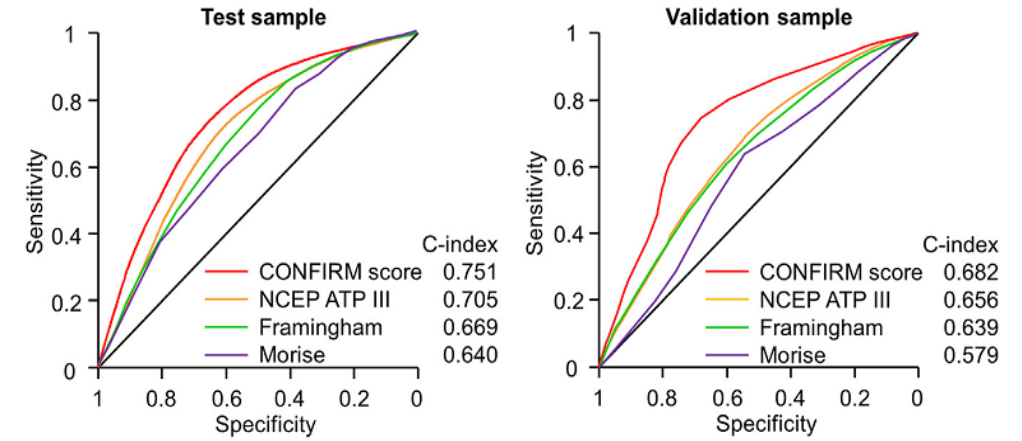
Journal of the American College of Cardiology
© 2013 by the American College of Cardiology Foundation
Published by Elsevier Inc.
Vol. 62, No. 5, 2013
ISSN 0735-1097/$36.00
http://dx.doi.org/10.1016/j.jacc.2013.04.064

Optimized Prognostic Score for Coronary Computed Tomographic Angiography

Results From the CONFIRM Registry (COronary CT Angiography EvaluatioN For Clinical Outcomes: An InteRnational Multicenter Registry)





CONFIRM risk calculator

Clinical risk (NCEP ATP III):

Age:	years
Gender:	female male
Total cholesterol:	mg/dl
HDL cholesterol:	mg/dl
Smoker:	no yes
Systolic blood pressure:	mmHg
currently on meds for high blood pressure?:	no yes
Diabetes:	no yes

Result from coronary CTA:

Left main coronary artery:	calcification stenosis>50%
proximal left anterior descendent:	calcification stenosis>50%
mid left anterior descendent:	calcification stenosis>50%
proximal left circumflex:	calcification stenosis>50%
first obtuse marginal branch:	calcification stenosis>50%
proximal right coronary artery:	calcification stenosis>50%
mid right coronary artery:	calcification stenosis>50%

calculate risk reset form

Prognostic Value of Nonobstructive and Obstructive Coronary Artery Disease Detected by Coronary Computed Tomography Angiography to Identify Cardiovascular Events

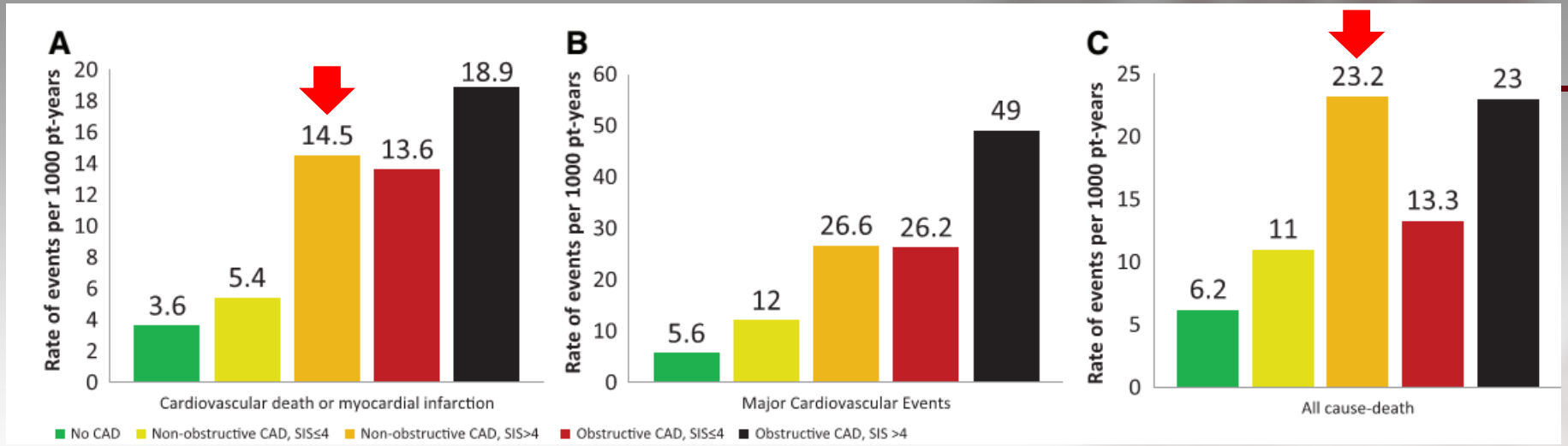
Marcio Sommer Bittencourt, MD, MPH*; Edward Hulten, MD, MPH*;
Brian Ghoshhajra, MD, MBA; Daniel O'Leary, BS; Mitalee P. Christman, BS;
Philip Montana, BS; Quynh A. Truong, MD, MPH; Michael Steigner, MD;
Venkatesh L. Murthy, MD, PhD; Frank J. Rybicki, MD, PhD; Khurram Nasir, MD, MPH;
Luis Henrique W[illegible] J. Brady, MD;
Marcelo F. Di Carli, MD[illegible]D; Ron Blankstein, MD

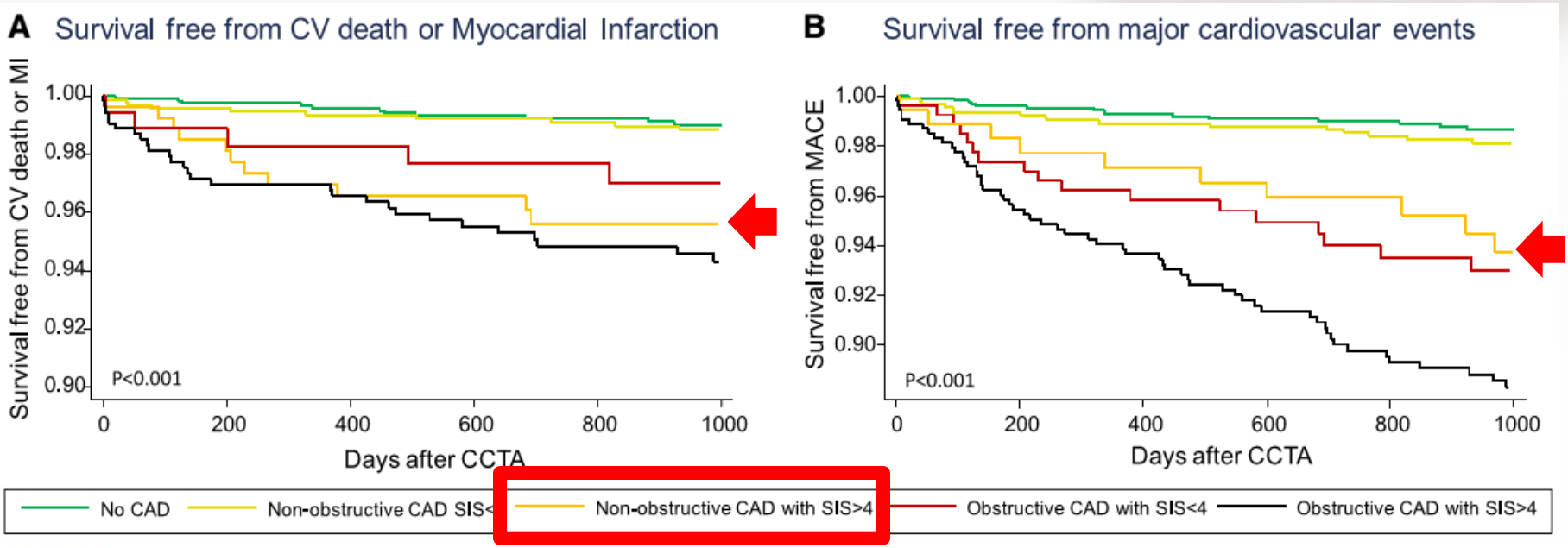
3242 pts.
Stenosis > 50% or not
Segments > 4 or not
FU 3.6 years

Background—The contribution o[illegible] patients with nonobstructive and obstructive coronary artery dis[illegible] evaluate the prognostic value of plaque extent detected by coron[illegible]

Methods and Results—All consec[illegible]mputed tomography angiography to evaluate for CAD were incl[illegible] nonobstructive (<50% stenosis), or obstructive (≥50%). Based [illegible]D was classified as nonextensive (≤4 segments) or extensive (>[illegible]wed for the primary outcome of cardiovascular death or myocardial infarction for a median of 3.6 (2.1–5.0) years. In a multivariable analysis, the presence of extensive nonobstructive CAD (hazard ratio, 3.1; 95% confidence interval, 1.5–6.4), nonextensive obstructive (hazard ratio, 3.0; 95% confidence interval, 1.3–6.9), and extensive obstructive CAD (hazard ratio, 3.9; 95% confidence interval, 2.2–7.2) were associated with an increased rate of events, whereas nonextensive, nonobstructive CAD was not. The addition of plaque extent to a model that included clinical probability as well as the presence and severity of CAD improved risk prediction.

Conclusions—Among patients with nonobstructive CAD, those with extensive plaque experienced a higher rate of cardiovascular death or myocardial infarction, comparable with those who have nonextensive disease. Even among patients with obstructive CAD, greater extent of nonobstructive plaque was associated with higher event rate. Our findings suggest that regardless of whether obstructive or nonobstructive disease is present, the extent of plaque detected by coronary computed tomography angiography enhances risk assessment. (***Circ Cardiovasc Imaging*. 2014;7:282-291.**)


A
Rate of events per 1000 pt-years
3.6
5.4
14.5
13.6
18.9
Cardiovascular death or myocardial infarction
B
Rate of events per 1000 pt-years
5.6
12
26.6
26.2
49
Major Cardiovascular Events
C
Rate of events per 1000 pt-years
6.2
11
23.2
13.3
23
All cause-death
No CAD
Non-obstructive CAD, SIS≤4
Non-obstructive CAD, SIS>4
Obstructive CAD, SIS≤4
Obstructive CAD, SIS >4


A Survival free from CV death or Myocardial Infarction
Survival free from CV death or MI
P<0.001
Days after CCTA
B Survival free from major cardiovascular events
Survival free from MACE
P<0.001
Days after CCTA
No CAD
Non-obstructive CAD SIS<
Non-obstructive CAD with SIS>4
Obstructive CAD with SIS<4
Obstructive CAD with SIS>4

European Heart Journal – Cardiovascular Imaging (2015) **16**, 441–448
doi:10.1093/ehjci/jeu284

A comparison of cardiac computerized tomography and exercise stress electrocardiogram test for the investigation of stable chest pain: the clinical results of the CAPP randomized prospective trial

Aims To determin…iagnostic pathway based on cardiac computerize… electrocardiography test (EST) in stable chest …

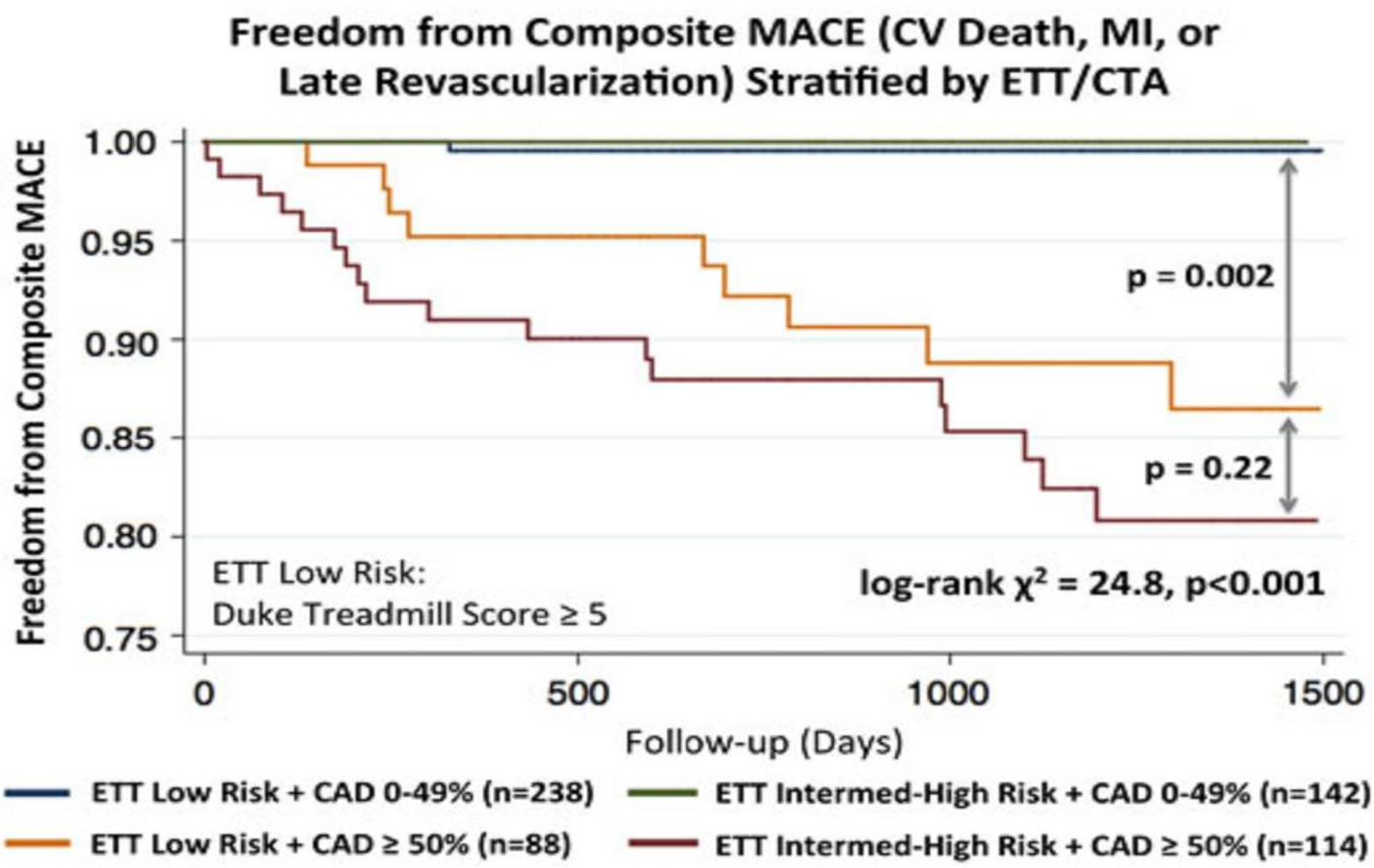
Methods and results A prospecti…s in EST and cardiac CT coronary angiography…pain and without known coronary artery disea…haires (SAQ) at baseline, 3, and 12 months to …ent strategies and clinical events. Over the ye…243 in the CT cohort. There was no significa…tical difference in angina stability and quality-…gina compared with the EST arm. In the CT ar…izations. Significantly, more inconclusive results were seen in the EST arm with a higher number of additional investigations ordered. There was also a longer mean time to management. There were no differences in major adverse cardiac events between the cohorts. At 1 year in the EST arm, there were more Accident and Emergency (A&E) attendances and cardiac admission.

Conclusion Cardiac CT as an index investigation for stable chest pain improved angina symptoms and resulted in fewer investigations and re-hospitalizations compared with EST.

500 pts.
Event /Management
Improved angina Sx.
Fewer investigation
Fewer re-hospitalization

European Heart Journal – Cardiovascular Imaging (2015) **16**, 1338–1346
doi:10.1093/ehjci/jev087

Prognostic value of coronary CTA vs. exercise treadmill testing: results from the Partners registry



European Heart Journal – Cardiovascular Imaging (2014) **15**, 961–971
doi:10.1093/ehjci/jeu027

The diagnostic accuracy and outcomes after coronary computed tomography angiography vs. conventional functional testing in patients with stable angina pectoris: a systematic review and meta-analysis

CCTA, XECG, SPECT
Accuracy (ICA >50% stenosis)
Higher performance
More downstream test
More revascularization

Aims To syst…est outcomes of conventional exercis…(SPECT) compared with cor-onary …able coronary artery disease (CAD)…

Methods and results We sys…ining the diagnostic accuracy (define…omes of coronary CTA (≥16 slice) in…575) comparing the diagnostic accura…PECT. The per-patient sensi-tivity [9…r coronary CTA vs. 67% (54–78%) (…T. The specificity (95% CI) of corona…60–80%) vs. 48% (31–64%) ($P = 0.14$) for SPECT. The odds ratio (OR) of downstream test utilization (DTU) for coronary CTA vs. XECG/SPECT was 1.38 (1.33–1.43, $P < 0.001$), for revascularization 2.63 (2.50–2.77, $P < 0.001$), for non-fatal myocardial infarction 0.53 (0.39–0.72, $P < 0.001$), and for all-cause mortality 1.01 (0.87–1.18, $P = 0.87$).

Conclusion The up-front diagnostic performance of coronary CTA is higher than of XECG and SPECT. When compared with XECG/SPECT testing, coronary CTA testing is associated with increased DTU and coronary revascularization.

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Detection of Significant Coronary Artery Disease by Noninvasive Anatomical and Functional Imaging

Background—The choice of imaging techniques in patients with suspected coronary artery disease (CAD) varies between countries, regions, and hospitals. This prospective, multicenter, comparative effectiveness study was designed to assess the relative accuracy of commonly used imaging techniques for identifying patients with significant CAD.

Methods and Results—A total of 475 patients with stable chest pain and intermediate likelihood of CAD underwent coronary computed tomographic angiography and stress myocardial perfusion imaging by single photon emission computed tomog… …r cardiac magne… …CAD was define… …coronary vessel… …ents. In a patien… …ea under the re… …ng 91%, confi… …acy (area under… …ity (92%, *P*<0.0… …an that of coron…

Conclusions—In a multicenter European population of patients with stable chest pain and low prevalence of CAD, coronary computed tomographic angiography is more accurate than noninvasive functional testing for detecting significant CAD defined invasively.

Clinical Trial Registration—URL: http://www.clinicaltrials.gov. Unique identifier: NCT00979199.

(*Circ Cardiovasc Imaging*. 2015;8:e002179. DOI: 10.1161/CIRCIMAGING.114.002179.)

475 pts.
CT, MPI, Wall motion test
LM> 50%, other >70% or 30~70% & FFR<0.8
CT is more accurate

Annals of Internal Medicine

The Optimal Imaging Strategy for Patients With Stable Chest Pain

A Cost-Effectiveness Analysis

Tessa S.S. Genders, MD, PhD; Steffen E. Petersen, MD, DPhil, MPH; Francesca Pugliese, MD, PhD; Amardeep G. Dastidar, MBBS; Kirsten E. Fleischmann, MD, MPH; Koen Nieman, MD, PhD; and M.G. Myriam Hunink, MD, PhD

Background: The optimal imaging strategy for patients with stable chest pain is uncertain.

Objective: To determine the cost-effectiveness of different imaging strategies for patients with stable chest pain.

Design: Microsimulation state-tr

Data Sources: Published literatu

Target Population: 60-year-old diate probability of coronary arte

Time Horizon: Lifetime.

Perspective: The United States, the United Kingdom, and the Netherlands.

Intervention: Coronary computed tomography (CT) angiography, cardiac stress magnetic resonance imaging, stress single-photon emission CT, and stress echocardiography.

Outcome Measures: Lifetime costs, quality-adjusted life-years (QALYs), and incremental cost-effectiveness ratios.

Results of Base-Case Analysis: The strategy that maximized QALYs and was cost-effective in the United States and the Netherlands began with coronary CT angiography, continued with cardiac stress imaging if angiography found at least 50% stenosis in at least 1 coronary artery, and ended with catheter-based coronary angiography if stress imaging induced ischemia of any severity. For U.K. men, the preferred strategy was optimal medical therapy without catheter-based coronary angiography if coronary CT angiography found only moderate CAD or stress imaging induced only mild ischemia. In these strategies, stress tly more effective and less ex- ng tests. For U.K. women, the chocardiography followed by graphy if echocardiography in- ia.

sis: Results were sensitive to changes in the probability of CAD and assumptions about false-positive results.

Limitations: All cardiac stress imaging tests were assumed to be available. Exercise electrocardiography was included only in a sensitivity analysis. Differences in QALYs among strategies were small.

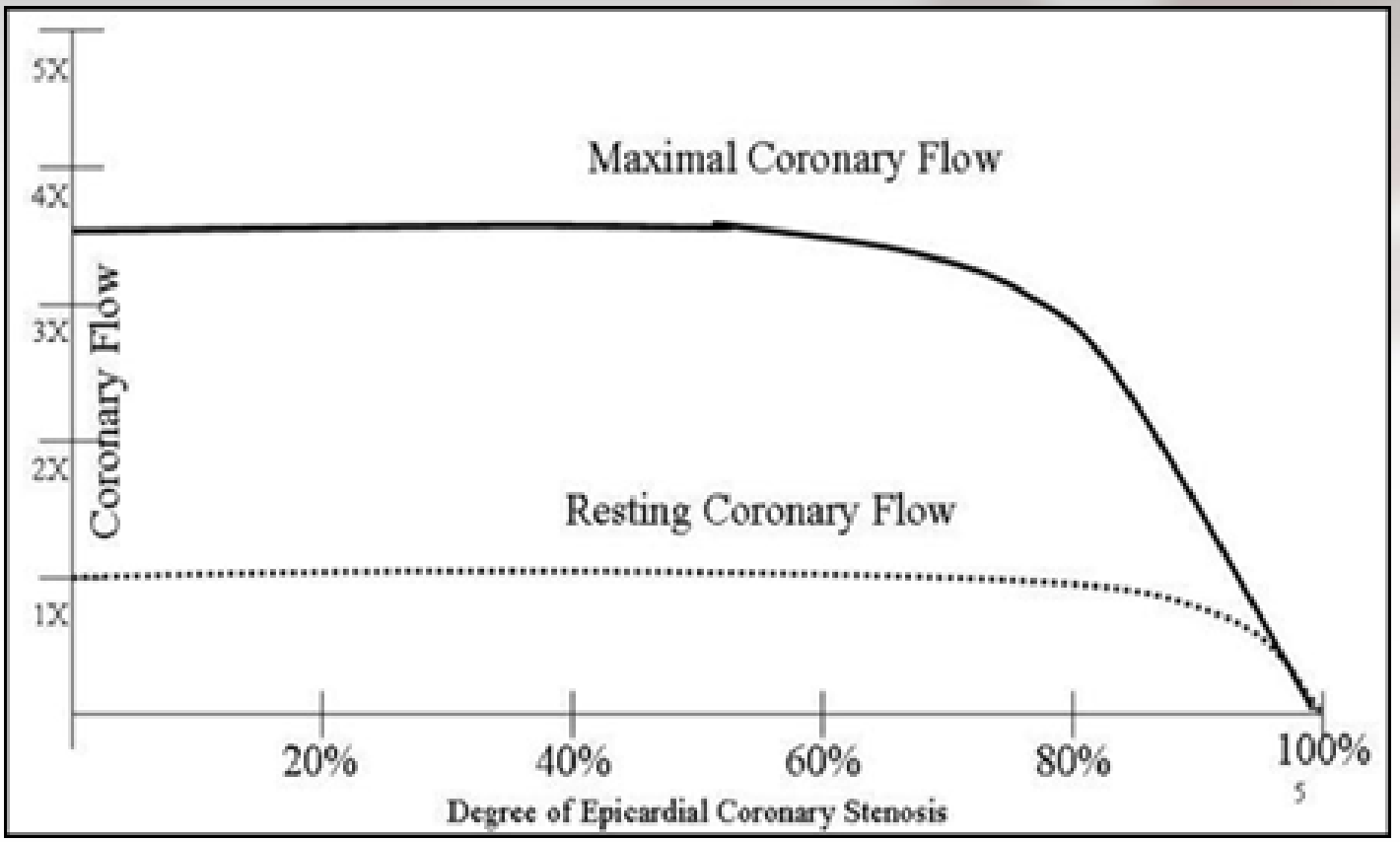
Conclusion: Coronary CT angiography is a cost-effective triage test for 60-year-old patients who have nonacute chest pain and a low to intermediate probability of CAD.

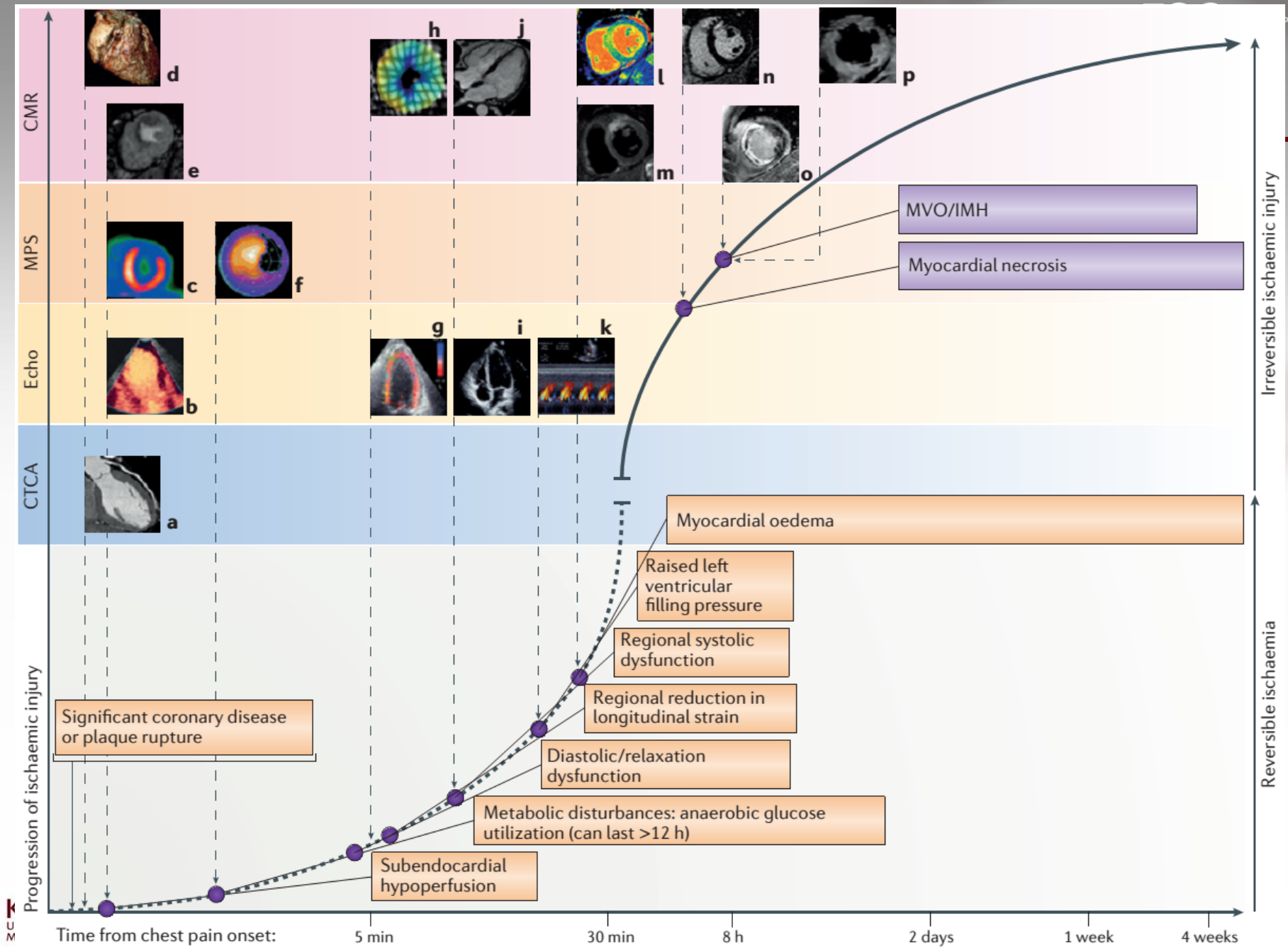
Primary Funding Source: Erasmus University Medical Center.

CCT, CMR, SPECT, SEcho
CCT is cost effective

Ann Intern Med. 2015;162:474-484. doi:10.7326/M14-0027 **www.annals.org**
For author affiliations, see end of text.

CAD *versus* Ischemia




CMR
MPS
Echo
CTCA
a
b
c
d
e
f
g
h
i
j
k
l
m
n
o
p
MVO/IMH
Myocardial necrosis
Myocardial oedema
Raised left ventricular filling pressure
Regional systolic dysfunction
Regional reduction in longitudinal strain
Diastolic/relaxation dysfunction
Metabolic disturbances: anaerobic glucose utilization (can last >12 h)
Subendocardial hypoperfusion
Significant coronary disease or plaque rupture
Irreversible ischaemic injury
Reversible ischaemia
Progression of ischaemic injury
Time from chest pain onset:
5 min
30 min
8 h
2 days
1 week
4 weeks

Low Diagnostic Yield of Elective Coronary Angiography

Manesh R. Patel, M.D., Eric D. Peterson, M.D., M.P.H., David Dai, M.S., J. Matthew Brennan, M.D., Rita F. Redberg, M.D., H. Vernon Anderson, M.D., Ralph G. Brindis, M.D., and Pamela S. Douglas, M.D.

ABSTRACT

BACKGROUND

Guidelines for triaging patients for cardiac catheterization recommend a risk assessment and noninvasive testing. We determined patterns of noninvasive testing and the diagnostic yield of catheterization among patients with suspected coronary artery disease in a contemporary national sample.

METHODS

From January 2004 through April 2008, at 663 hospitals in the American College of Cardiology National Cardiovascular Data Registry, we identified patients without known coronary artery disease who were undergoing elective catheterization. The patients' demographic characteristics, risk factors, and symptoms and the results of noninvasive testing were correlated with the presence of obstructive coronary artery disease, which was defined as stenosis of 50% or more of the diameter of the left main coronary artery or stenosis of 70% or more of the diameter of a major epicardial vessel.

RESULTS

A total of 398,978 patients were included in the study. The median age was 61 years; 52.7% of the patients were men, 26.0% had diabetes, and 69.6% had hypertension. Noninvasive testing was performed in 83.9% of the patients. At catheterization, 149,739 patients (37.6%) had obstructive coronary artery disease. No coronary artery disease (defined as <20% stenosis in all vessels) was reported in 39.2% of the patients. Independent predictors of obstructive coronary artery disease included male sex (odds ratio, 2.70; 95% confidence interval [CI], 2.64 to 2.76), older age (odds ratio per 5-year increment, 1.29; 95% CI, 1.28 to 1.30), presence of insulin-dependent diabetes (odds ratio, 2.14; 95% CI, 2.07 to 2.21), and presence of dyslipidemia (odds ratio, 1.62; 95% CI, 1.57 to 1.67). Patients with a positive result on a noninvasive test were moderately more likely to have obstructive coronary artery disease than those who did not undergo any testing (41.0% vs. 35.0%; P<0.001; adjusted odds ratio, 1.28; 95% CI, 1.19 to 1.37).

CONCLUSIONS

In this study, slightly more than one third of patients without known disease who underwent elective cardiac catheterization had obstructive coronary artery disease. Better strategies for risk stratification are needed to inform decisions and to increase the diagnostic yield of cardiac catheterization in routine clinical practice.

Table 2. Predictors of Obstructive Coronary Artery Disease.

Variable	Wald Chi-Square Statistic	Adjusted Odds Ratio (95% CI)
Age, per 5-yr increase	6146.2	1.29 (1.28–1.30)
Body-mass index, per 5-unit increase*	550.3	0.92 (0.91–0.92)
Male sex	8632.9	2.70 (2.64–2.76)
White race†	50.2	1.21 (1.15–1.28)
Diabetes‡		
Insulin-dependent	1932.3	2.14 (2.07–2.21)
Requiring dialysis	26.9	1.30 (1.18–1.43)
Not requiring dialysis	14.1	1.15 (1.07–1.23)
Chronic lung disease	298.6	0.78 (0.76–0.80)
Presence of symptoms		
Typical	353.6	1.91 (1.78–2.05)
Atypical	84.2	0.76 (0.71–0.80)
Noninvasive testing**		
Positive result	48.9	1.28 (1.19–1.37)
Equivocal result	25.3	0.79 (0.71–0.86)
Negative result	19.4	0.82 (0.74–0.89)

663 hospitals
398,978 pts.
oCAD 37.6 %
(+) on non-invasive test
41 % vs 35% (OR 1.28)

European Heart Journal (2013) **34**, 1335–1344
doi:10.1093/eurheartj/ehs436

REVIEW

Frontiers in cardiovascular medicine

Functional assessment of coronary stenoses: can we live without it?

Nico H. J. Pijls[1,2]*, Nobuhiro Tanaka[3], and William F. Fearon[4]

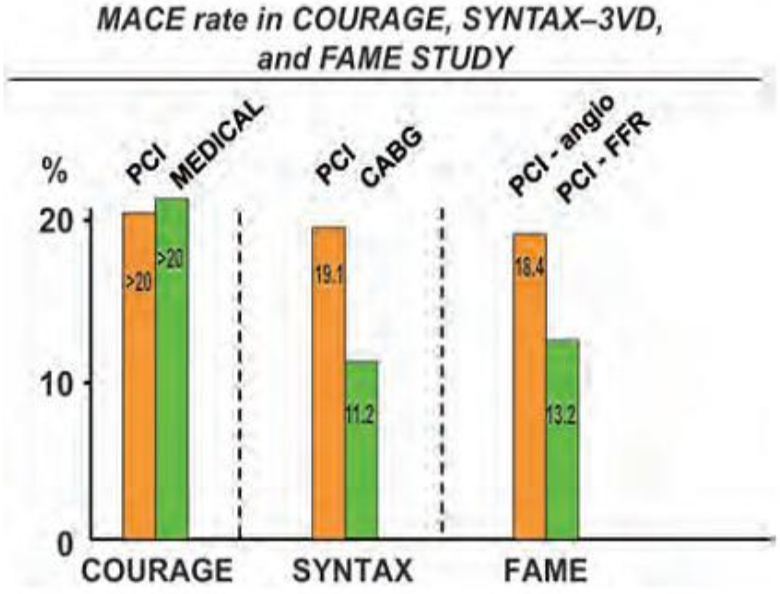


Figure 5 Major adverse event rate (death from all causes, myocardial infarction, and (repeated) revascularization) in the COURAGE study, SYNTAX-3VD study, and FAME study. It is

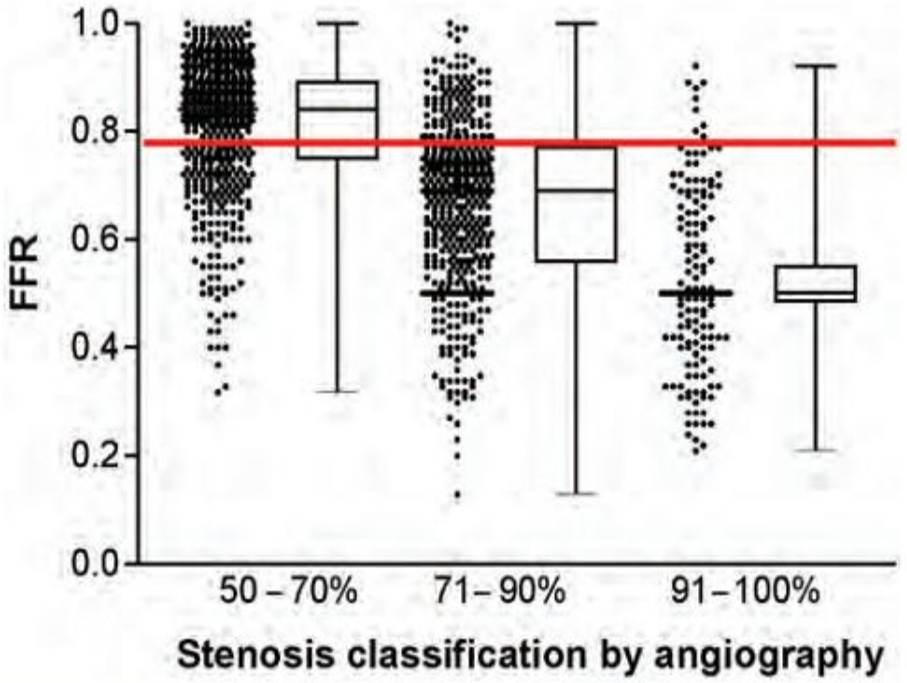


Figure 7 Angiographic severity vs. functional severity of coronary artery stenoses. Box-and-Whisker plot showing the fractional flow reserve values of the lesions in the categories of 50–70, 71–90, and 91–99% diameter stenosis as visually estimated on the basis of the coronary angiogram (from Sant'Ann FM *et al.*,[31]

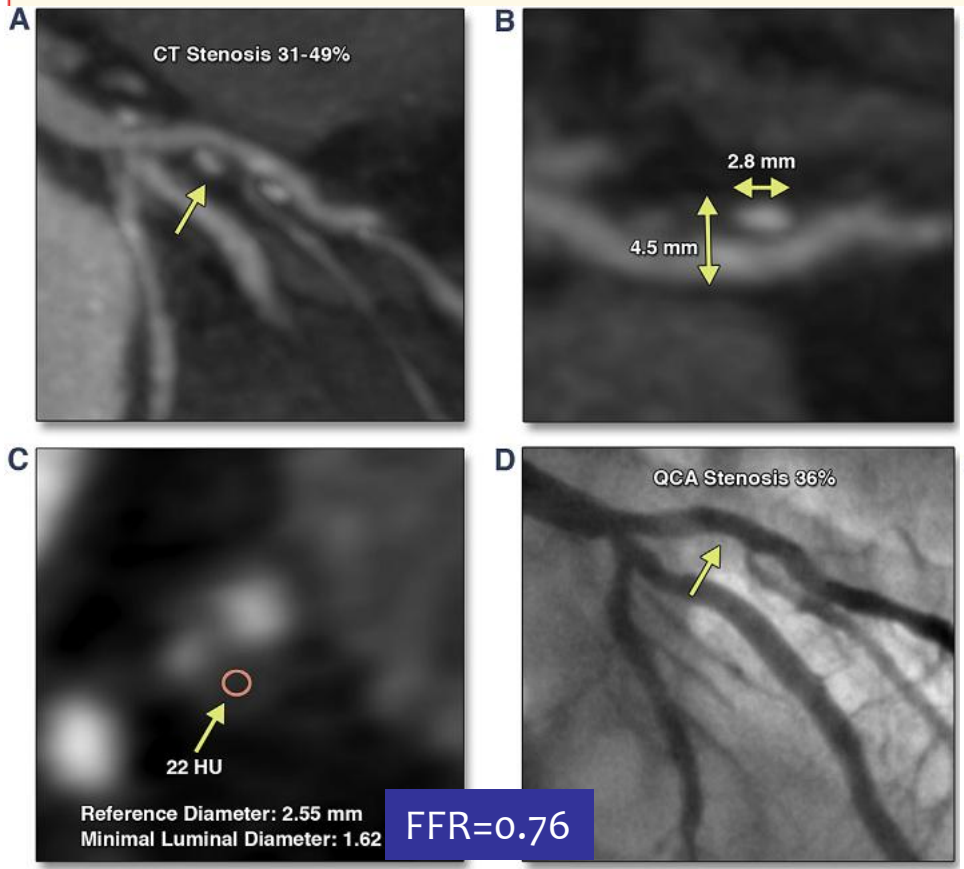
Atherosclerotic Plaque Characteristics by CT Angiography Identify Coronary Lesions That Cause Ischemia

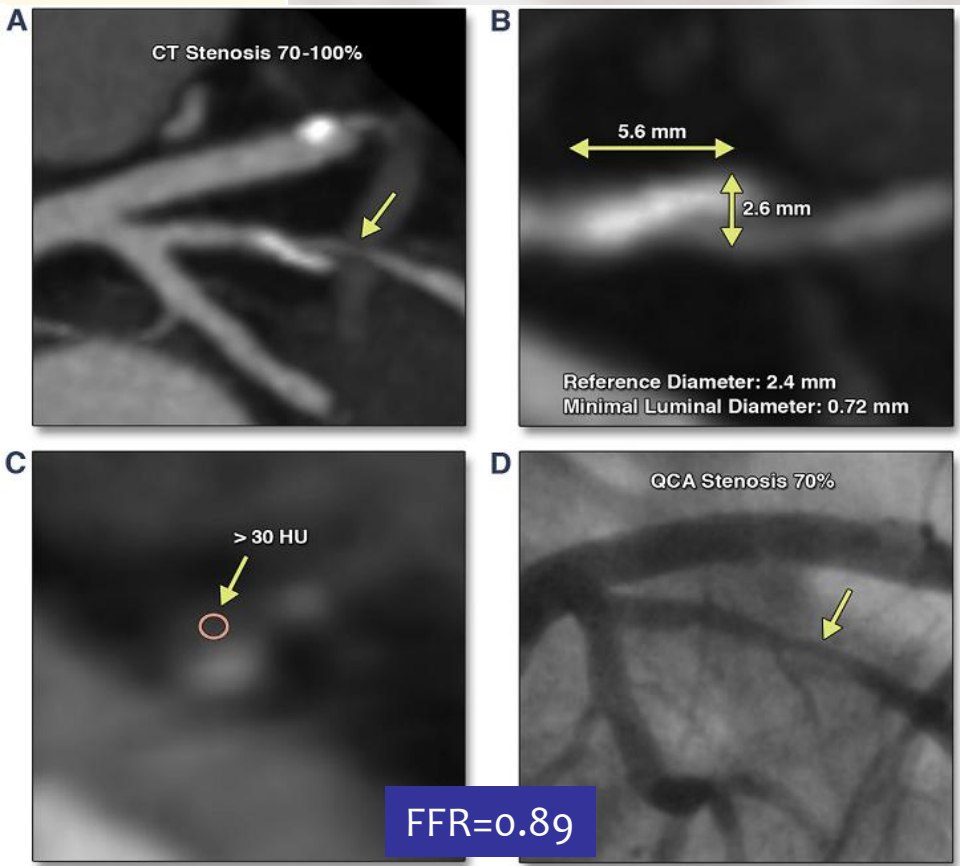
A Direct Comparison to Fractional Flow Reserve

Hyung-Bok Park, MD,*†‡ Ran Heo, MD,*† Bríain ó Hartaigh, PhD,* Iksung Cho, MD,*† Heidi Gransar, MSc,§ Ryo Nakazato, MD,‖ Jonathon Leipsic, MD,¶ G.B. John Mancini, MD,# Bon-Kwon Koo, MD,** Hiromasa Otake, MD,†† Matthew J. Budoff, MD,‡‡ Daniel S. Berman, MD,§ Andrejs Erglis, MD,§§ Hyuk-Jae Chang, MD,† James K. Min, MD*

ABSTRACT

OBJECTIVES This study evaluated the association between atherosclerotic plaque characteristics (APCs) by coronary





CT coronary angiography in patients with suspected angina due to coronary heart disease (SCOT-HEART): an open-label, parallel-group, multicentre trial

*The SCOT-HEART investigators**

Summary

Background The benefit of CT coronary angiography (CTCA) in patients presenting with stable chest pain has not been systematically studied. We aimed to assess the effect of CTCA on the diagnosis, management, and outcome of patients referred to the cardiology clinic with suspected angina due to coronary heart disease.

Methods In this prospective open-label, parallel-group, multicentre trial, we recruited patients aged 18–75 years referred for the assessment of suspected angina due to coronary heart disease from 12 cardiology chest pain clinics across Scotland. We randomly assigned (1:1) participants to standard care plus CTCA or standard care alone. Randomisation was done with a web-based service to ensure allocation concealment. The primary endpoint was certainty of the diagnosis of angina secondary to coronary heart disease at 6 weeks. All analyses were intention to treat, and patients were analysed in the group they were allocated to, irrespective of compliance with scanning. This study is registered with ClinicalTrials.gov, number NCT01149590.

Findings Between Nov 18, 2010, and Sept 24, 2014, we randomly assigned 4146 (42%) of 9849 patients who had been referred for assessment of suspected angina due to coronary heart disease. 47% of participants had a baseline clinic diagnosis of coronary heart disease and 36% had angina due to coronary heart disease. At 6 weeks, CTCA reclassified the diagnosis of coronary heart disease in 558 (27%) patients and the diagnosis of angina due to coronary heart disease in 481 (23%) patients (standard care 22 [1%] and 23 [1%]; p<0·0001). Although both the certainty (relative risk [RR] 2·56, 95% CI 2·33–2·79; p<0·0001) and frequency of coronary heart disease increased (1·09, 1·02–1·17; p=0·0172), the certainty increased (1·79, 1·62–1·96; p<0·0001) and frequency seemed to decrease (0·93, 0·85–1·02; p=0·1289) for the diagnosis of angina due to coronary heart disease. This changed planned investigations (15% *vs* 1%; p<0·0001) and treatments (23% *vs* 5%; p<0·0001) but did not affect 6-week symptom severity or subsequent admittances to hospital for chest pain. After 1·7 years, CTCA was associated with a 38% reduction in fatal and non-fatal myocardial infarction (26 *vs* 42, HR 0·62, 95% CI 0·38–1·01; p=0·0527), but this was not significant.

Interpretation In patients with suspected angina due to coronary heart disease, CTCA clarifies the diagnosis, enables targeting of interventions, and might reduce the future risk of myocardial infarction.

Lancet 2015; 385: 2383–91

Published Online
March 15, 2015
http://dx.doi.org/10.1016/S0140-6736(15)60291-4

This online publication has been corrected. The corrected version first appeared at thelancet.com on June 12, 2015

See Comment page 2334

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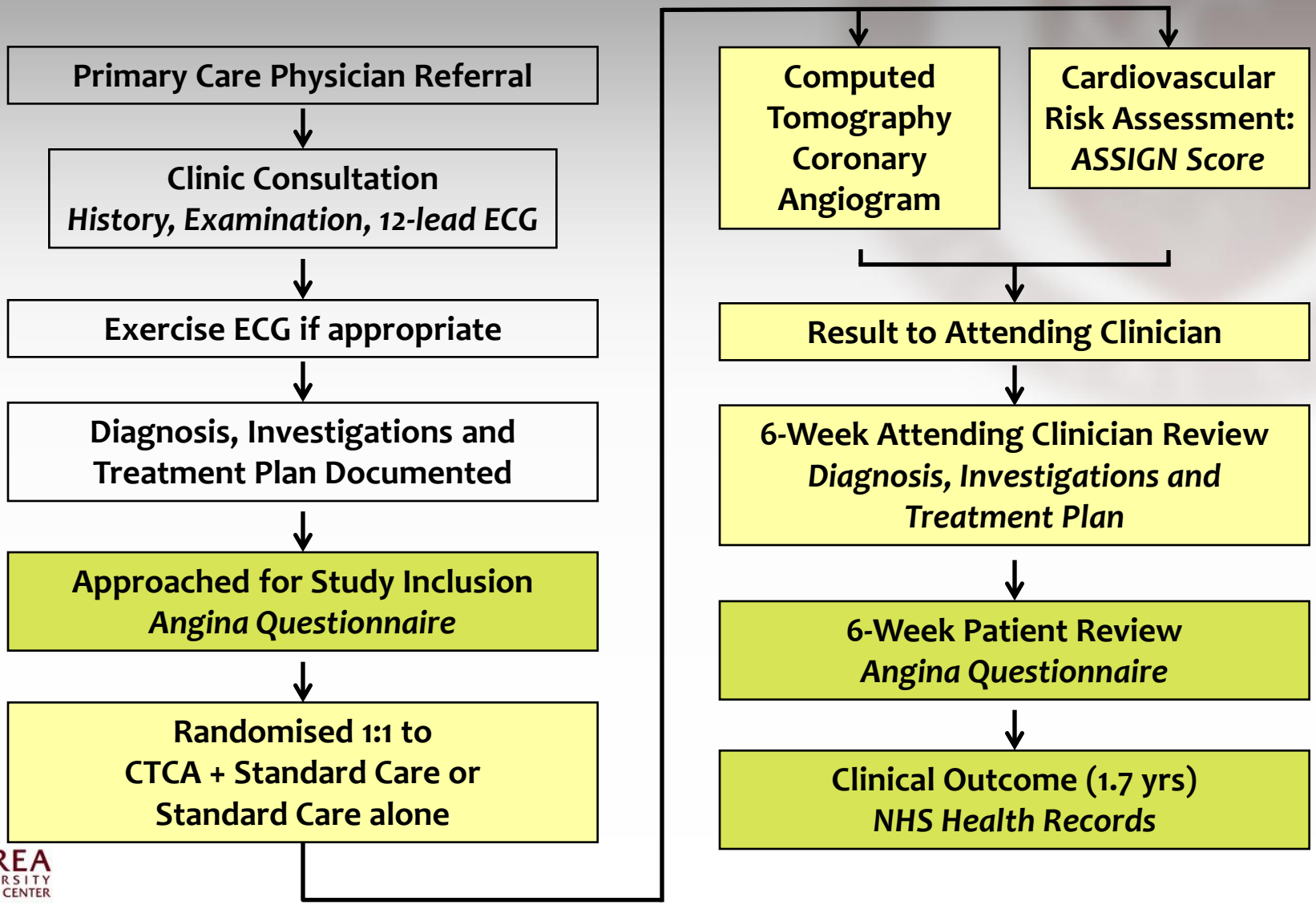
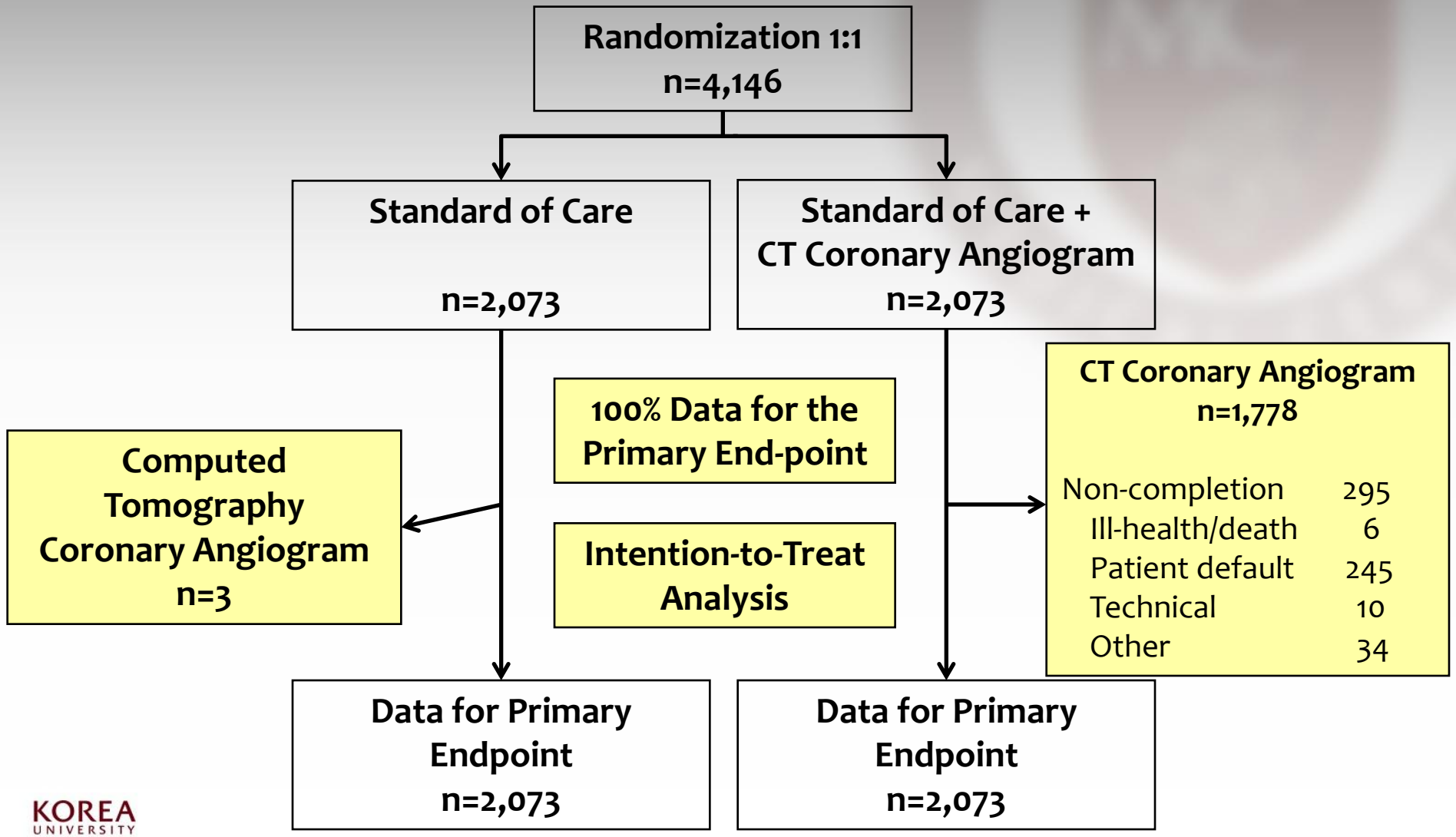
Scottish COmputed Tomography of the HEART (SCOT-HEART) Trial

Study Protocol



KOREA UNIVERSITY MEDICAL CENTER

Scottish COmputed Tomography of the HEART (SCOT-HEART) Trial
Trial Population



Baseline and 6-week diagnoses of coronary heart disease and angina due to coronary heart disease

	6-week diagnosis				
	Yes	Probable	Unlikely	No	Total
Diagnosis of coronary heart disease					
Standard care and CTCA					
Baseline diagnosis					
Yes	197 (10%)*	2 (0%)	4 (0%)	7 (0%)	210 (10%)
Probable	148 (7%)	490 (24%)*	26 (1%)	107 (5%)	771 (37%)
Unlikely	124 (6%)	48 (2%)	698 (34%)*	80 (4%)	950 (46%)
No	7 (0%)	4 (0%)	1 (0%)	126 (6%)*	138 (7%)
Total	476 (23%)	544 (26%)	729 (35%)	320 (15%)	2069 (100%)
Standard care					
Baseline diagnosis					
Yes	220 (11%)*	1 (0%)	0 (0%)	1 (0%)	222 (11%)
Probable	0 (0%)	721 (35%)*	6 (0%)	7 (0%)	734 (35%)
Unlikely	1 (0%)	6 (0%)	975 (47%)*	0 (0%)	982 (47%)
No	0 (0%)	0 (0%)	0 (0%)	132 (6%)*	132 (6%)
Total	221 (11%)	728 (35%)	981 (47%)	140 (7%)	2070 (100%)

558 (27%) vs 22 (1%)

Baseline and 6-week diagnoses of coronary heart disease and angina due to coronary heart disease

	6-week diagnosis				
	Yes	Probable	Unlikely	No	Total
Diagnosis of angina due to coronary heart disease					
Standard care and CTCA					
Baseline diagnosis					
Yes	126 (6%)*	0 (0%)	6 (0%)	8 (0%)	140 (7%)
Probable	69 (3%)	402 (19%)*	52 (3%)	77 (4%)	600 (29%)
Unlikely	33 (2%)	55 (3%)	822 (40%)*	151 (7%)	1061 (51%)
No	3 (0%)	8 (0%)	19 (1%)	237 (11%)*	267 (13%)
Total	231 (11%)	465 (22%)	899 (43%)	473 (23%)	2068 (100%)
Standard care					
Baseline diagnosis					
Yes	139 (7%)*	1 (0%)	1 (0%)	0 (0%)	141 (7%)
Probable	2 (0%)	588 (28%)*	5 (0%)	7 (0%)	602 (29%)
Unlikely	2 (0%)	4 (0%)	1055 (51%)*	0 (0%)	1061 (51%)
No	0 (0%)	0 (0%)	1 (0%)	265 (13%)*	266 (13%)
Total	143 (7%)	593 (29%)	1062 (51%)	272 (13%)	2070 (100%)

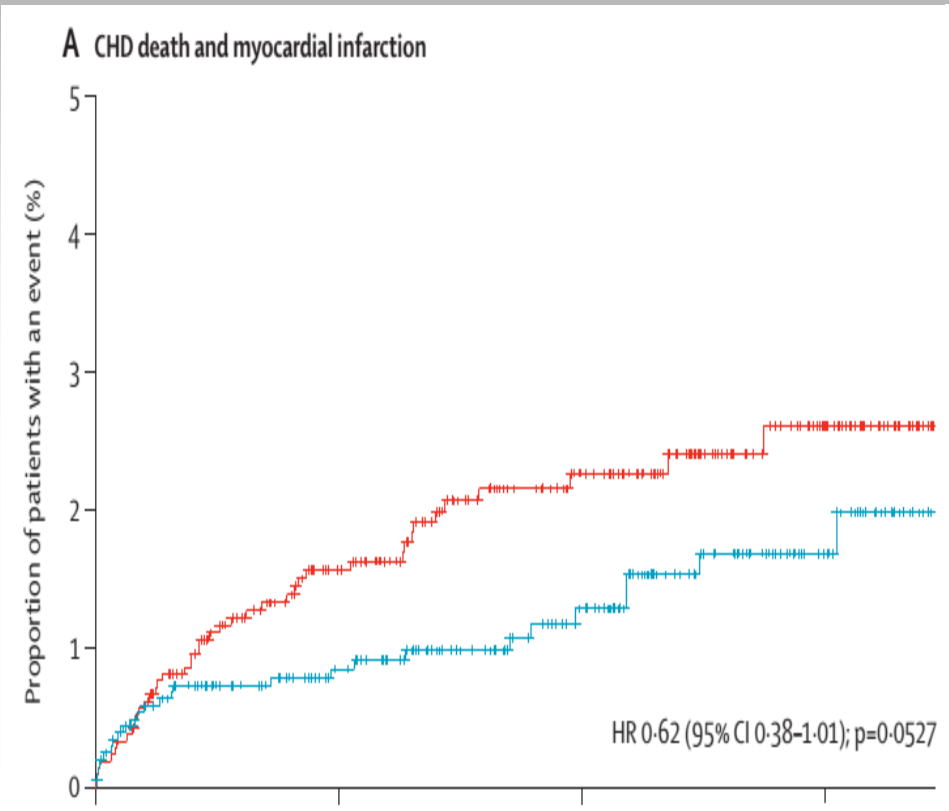
481 (23%) vs 23 (1%)

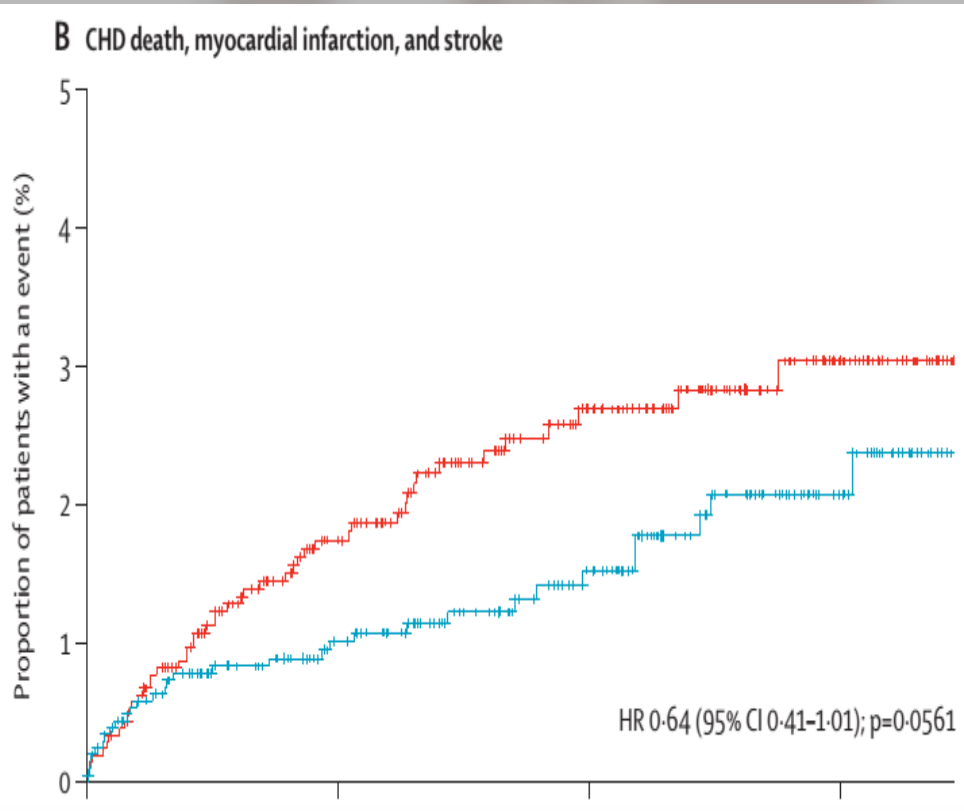
Changes in investigations and treatments at 6 weeks

	Standard care and CTCA		Standard care	
	Cancellation	New	Cancellation	New
Investigations				
Stress imaging	121	5	0	6
Invasive coronary angiography	29	94	1	8
Total	150	99	1	14
Medical treatments				
Preventive treatment	77	293	8	84
Antianginal treatment	112	82	6	11
Total	189	375	14	95

CTCA=CT coronary angiography.

CTCA and Clinical Outcome
1.7 Years of Follow-up





SCOT-HEART Trial: Conclusions

In patients presenting with suspected angina due to coronary heart disease, the addition of CCTA (4.1 mSv)

① Clarifies the diagnosis: 1 in 4
② Increases the diagnosis of CHD but appears to reduce the diagnosis of angina due to CHD
③ Alters subsequent investigations: 1 in 6
④ Changes treatments: 1 in 4
⑤ Does not affect short-term anginal symptoms
⑥ May increase coronary revascularisation and reduce fatal and non-fatal myocardial infarction (38%)

PROMISE trial

- Budget restraints: minimum follow-up of the cohort was decreased to 1 from 2-year
  - With shorter follow-up and less events, the increased use of preventive therapies used in the **CCTA arm had little time to improve outcomes**, and the "warranty period" hypothesis could not be tested.
  - Low event rate (3% for functional test and 3.3 % for CCTA)
  - 34% reduction of death and nonfatal MI at 12 months
  - 25 % of reduction of MI in the CCTA group

PROMISE trial

- Significantly reduced the rate of ICA in patients without obstructive CAD.
- Increasing the rate of revascularization

  → Increases cost to healthcare services

  → Patients with anatomical obstructive CAD needed a test for ischemia before revascularization

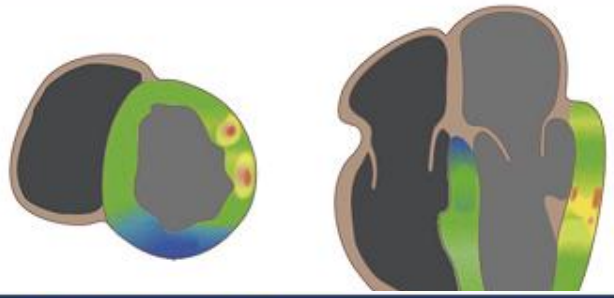
CCTA

- Excellent NPV
  - Best non-invasive rule-out test in patients with low to intermediate likelihood of CAD
  - Absence of CAD on initial CCTA was associated lower costs and decreased downstream utilization

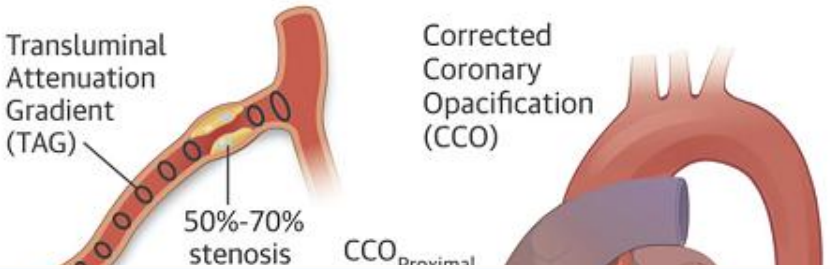
J Cardiovasc Comput Tomogr. 2015;9:329-336

- Radiation dose of CTCA is rapidly decreasing.
- Functional assessment.

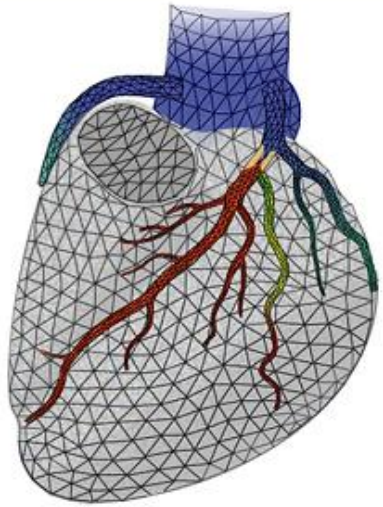
MYOCARDIAL PERFUSION IMAGING



CORONARY ATTENUATION PATTERNS



CTA DERIVED FRACTIONAL FLOW RESERVE



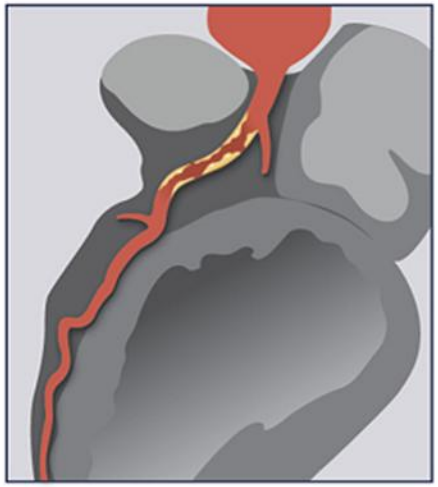
Main Features:

- Computed using computational fluid dynamics from regular CT angiograms without protocol modification or additional medication
- Improved diagnostic accuracy vs CTA alone, mainly due to higher specificity

Current Limitations:

- Remote evaluation
- Dependence on high image quality

ATHEROSCLEROTIC PLAQUE CHARACTERISTICS



Main Features:

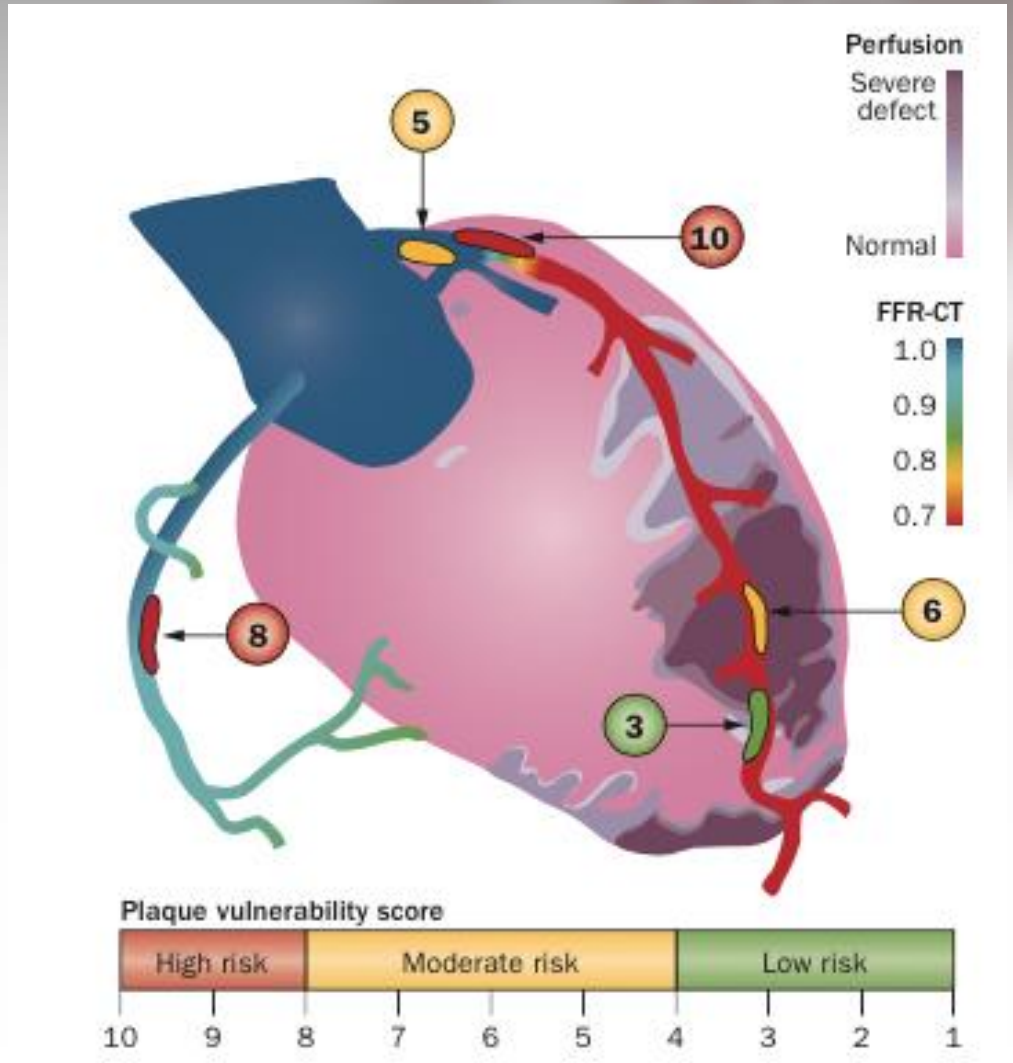
- Lesion length, low attenuation plaque, positive remodeling, and aggregate plaque volume associated with ischemia by invasive FFR

Current Limitations:

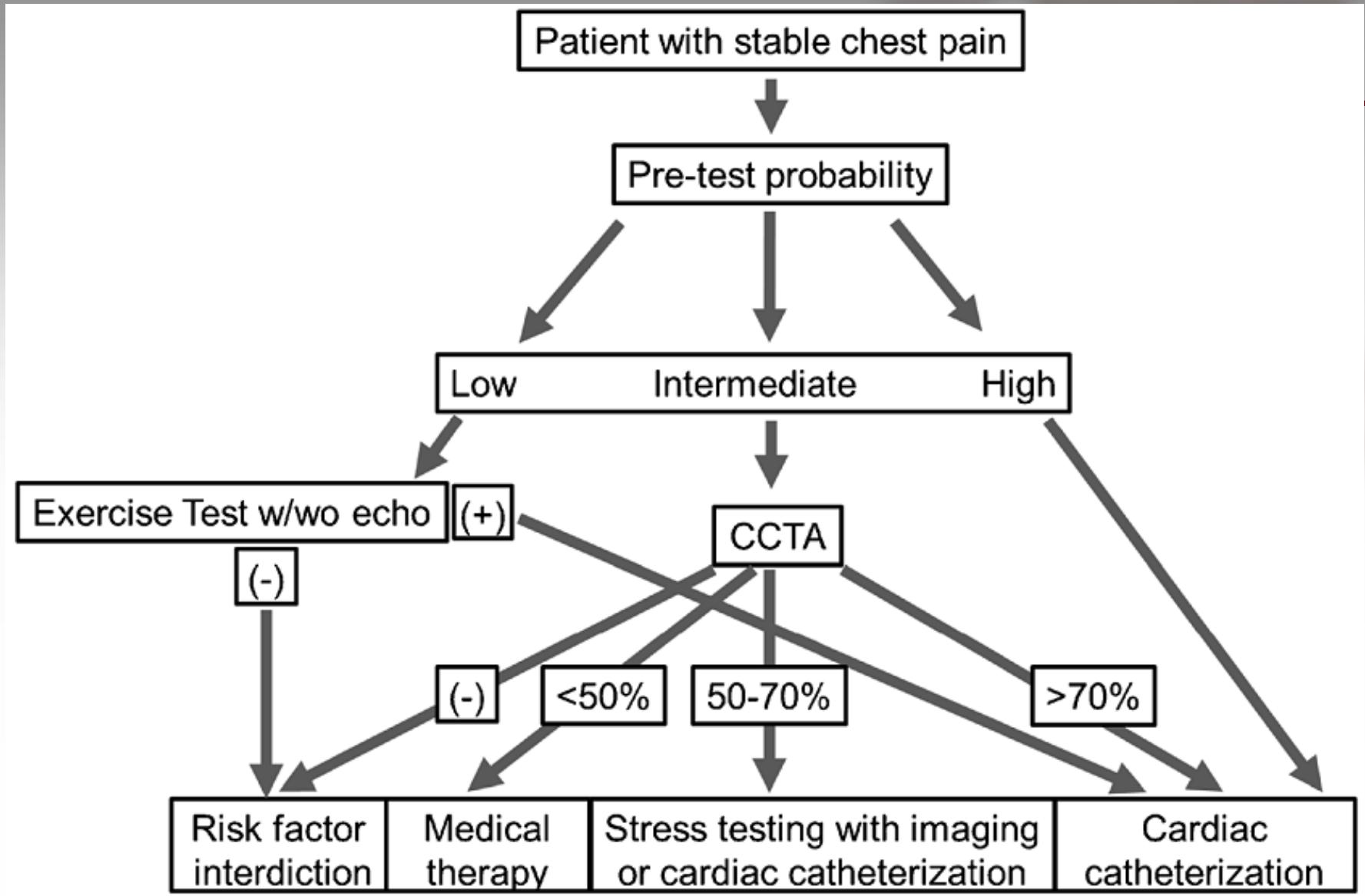
- Dependence on high image quality
- Spatial resolution
- Low attenuation plaque cut-off influenced by several factors

Comprehensive Assessment

- ✓Stenosis
- ✓Plaque
- ✓Perfusion
- ✓FFR, TAG
- ✓Viability



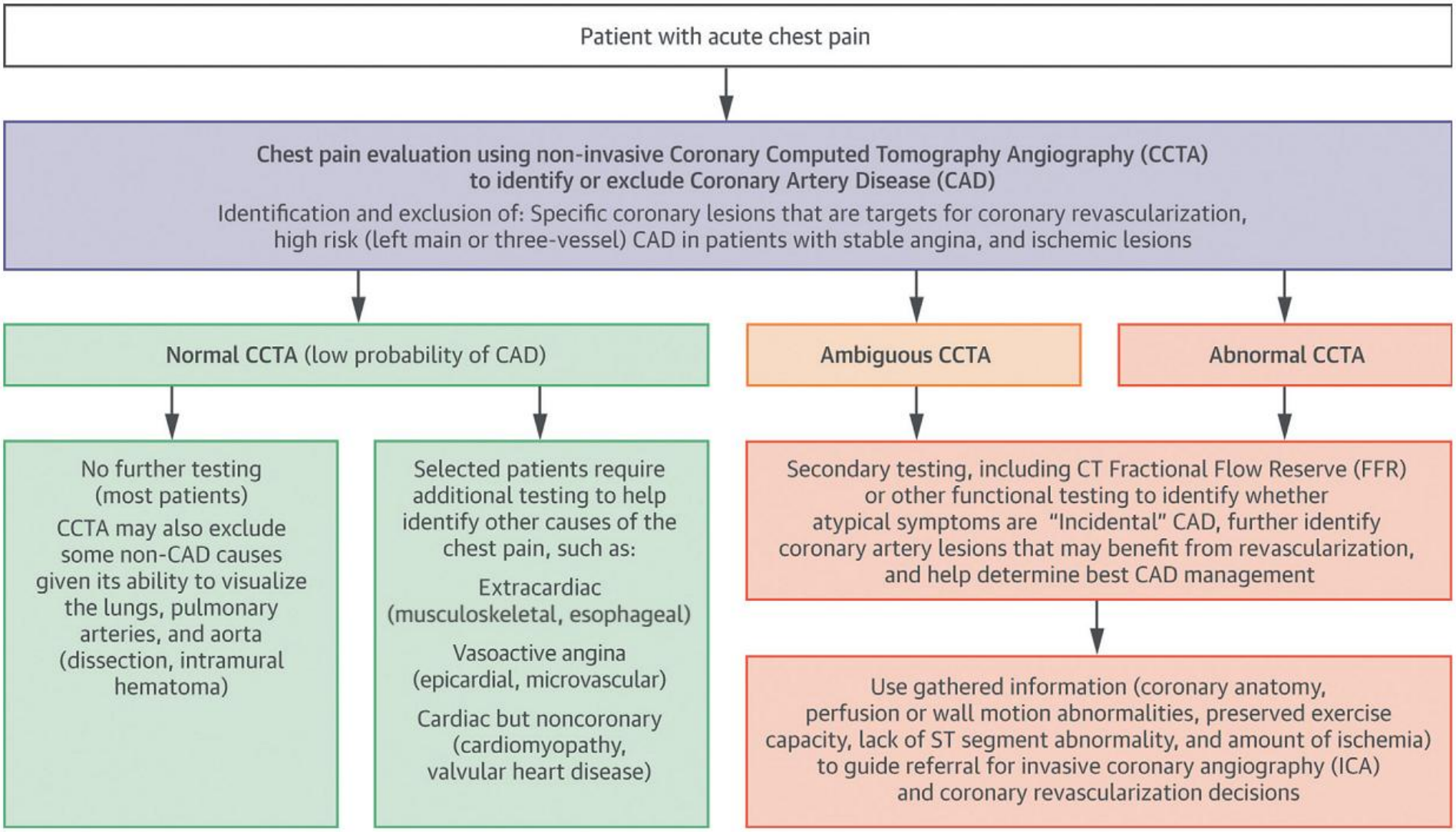
Nature Reviews Cardiology 2014;11390



Curr Cardiovasc Imaging Rep (2015) 8: 29

Finding the Gatekeeper to the Cardiac Catheterization Laboratory

Coronary CT Angiography or Stress Testing?

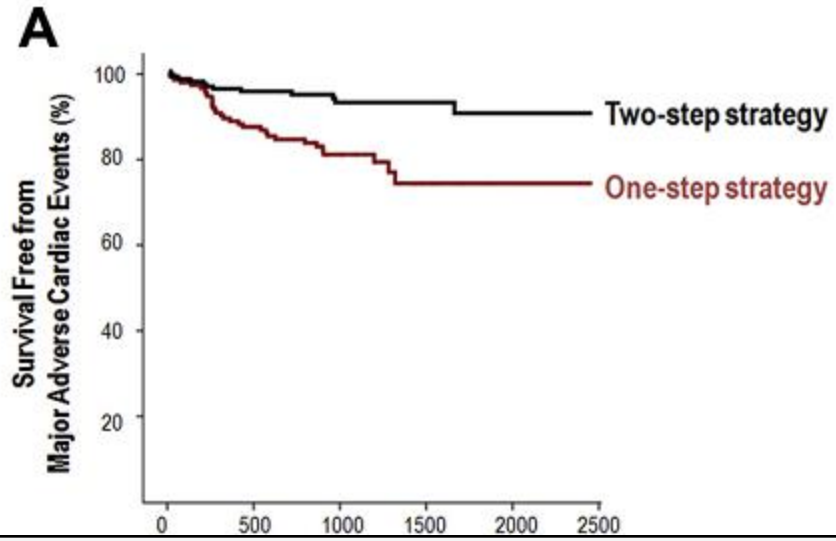


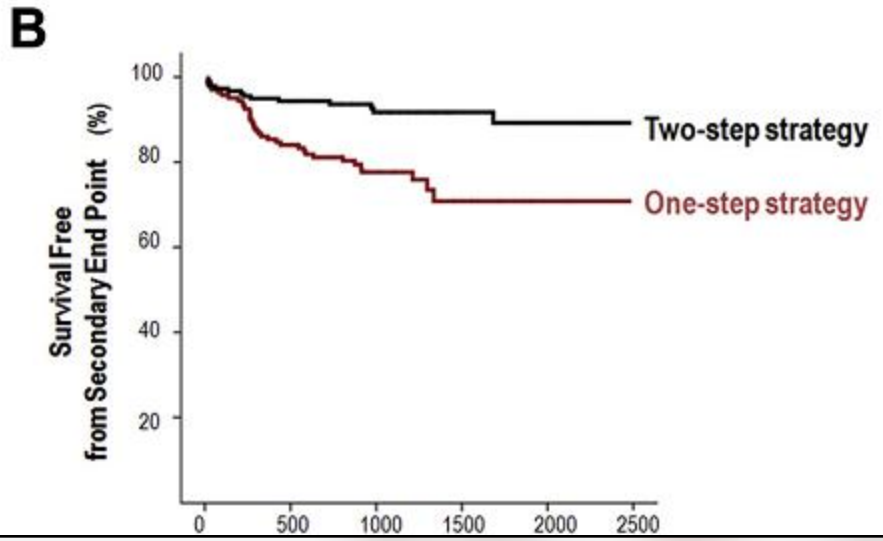
Marwick, T.H. et al. J Am Coll Cardiol. 2015; 65(25):2747- 56.

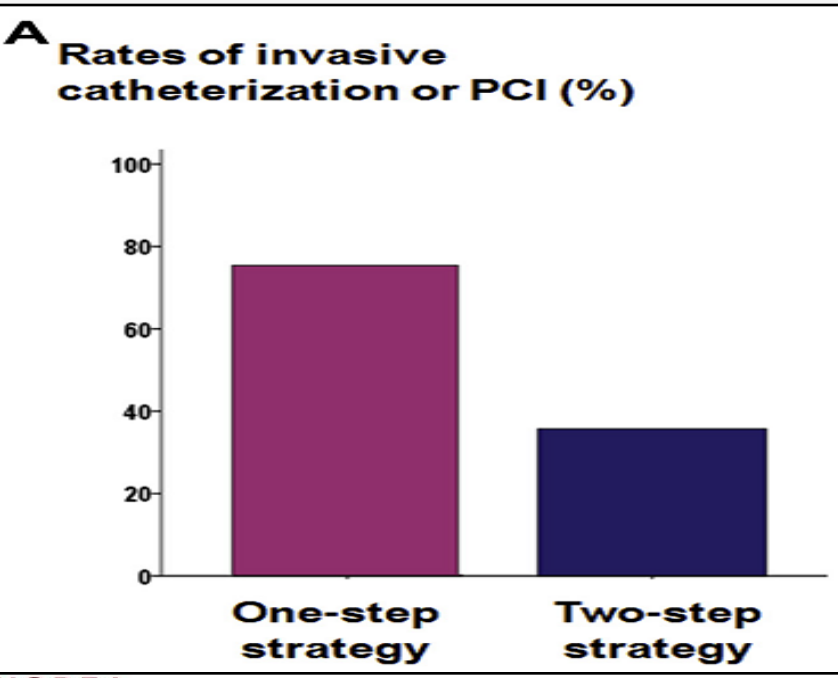
Coronary Computed Tomography Angiography Alone Versus Confirmatory Functional Testing for Guiding Treatment Strategy for Patients With Intermediate Coronary Artery Stenosis

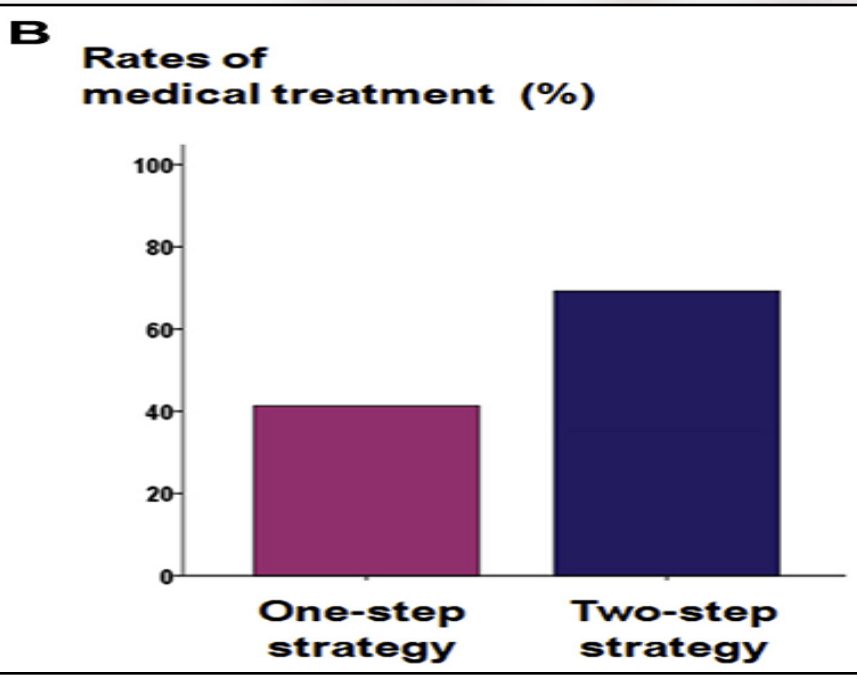
Sahmin Lee, MD, Yong-Jin Kim, MD*, Seung-Pyo Lee, MD, Hyung-Kwan Kim, MD, and Dae-Won Sohn, MD

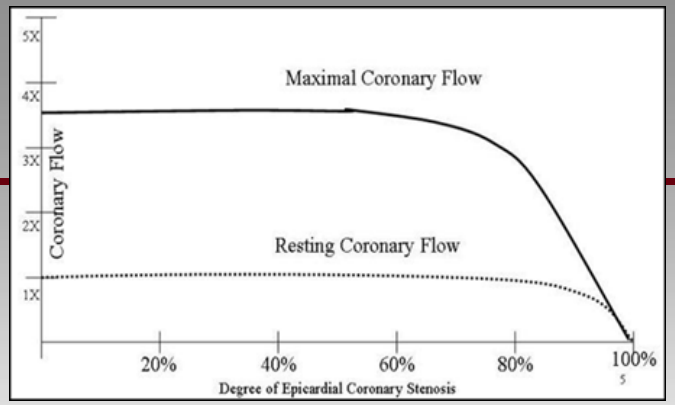
Intermediate coronary artery stenosis (≥50% and <90%) on coronary computed tomography angiography (CTA) is usually considered as a significant lesion. However, anatomical diagnosis is not well correlated with the functional significance of myocardial ischemia. We investigated whether functional testing in addition to coronary CTA improves outcomes of patients with intermediate stenosis, compared with the 1-step CTA-alone–based strategy. From 2006 to 2011, we consecutively enrolled 335 patients with chest pain with intermediate stenosis detected by an initially performed coronary CTA. Of these, 159 patients followed the 1-step strategy, whereas 176 followed the 2-step strategy with confirmatory functional tests. One-year follow-up data were obtained for all patients. The primary end point was a composite of cardiovascular death, nonfatal myocardial infarction, and repeated or delayed revascularization (major adverse cardiac event) within a year. Baseline clinical parameters were comparable between patients of the 2 different strategies. The rate of invasive catheterization or percutaneous intervention was 75.5% in the 1-step group and 35.2% in the 2-step group ($p < 0.001$). Consequently, more patients in the 2-step group were medically treated without unnecessary revascularization compared with patients in the 1-step group (71.0% vs 40.9%, $p < 0.001$). Only 2.5% of the patients who received medical treatment in the 2-step group finally received delayed revascularization, whereas 14% in the 1-step group did. Overall, the primary end point occurred in 11.3% in the 1-step group and 4.0% in the 2-step group ($p = 0.011$). In conclusion, confirmatory functional testing reduces invasive catheterization and coronary intervention and improves clinical outcomes in patients with intermediate stenosis on coronary CTA. (Am J Cardiol 2015;115:602–608)

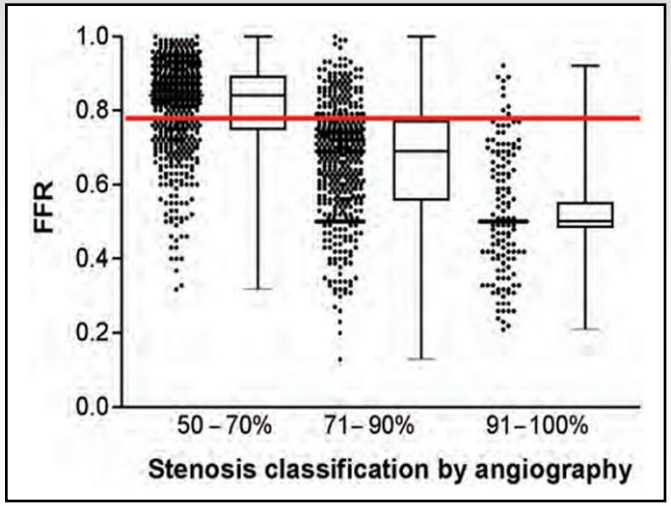

A
Survival Free from Major Adverse Cardiac Events (%)
100
80
60
40
20
0
500
1000
1500
2000
2500
Two-step strategy
One-step strategy

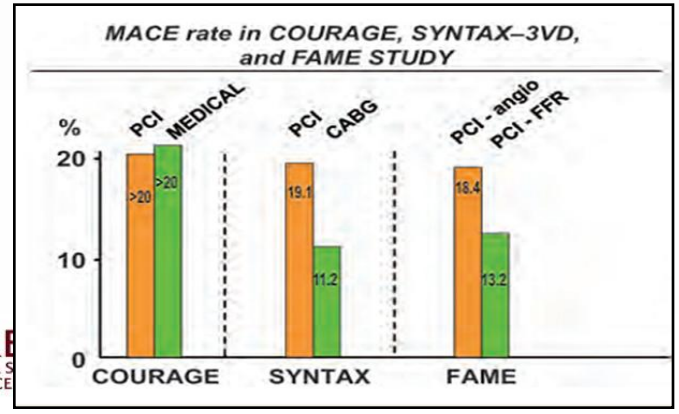

B
Survival Free from Secondary End Point (%)
100
80
60
40
20
0
500
1000
1500
2000
2500
Two-step strategy
One-step strategy


A
Rates of invasive catheterization or PCI (%)
100
80
60
40
20
0
One-step strategy
Two-step strategy

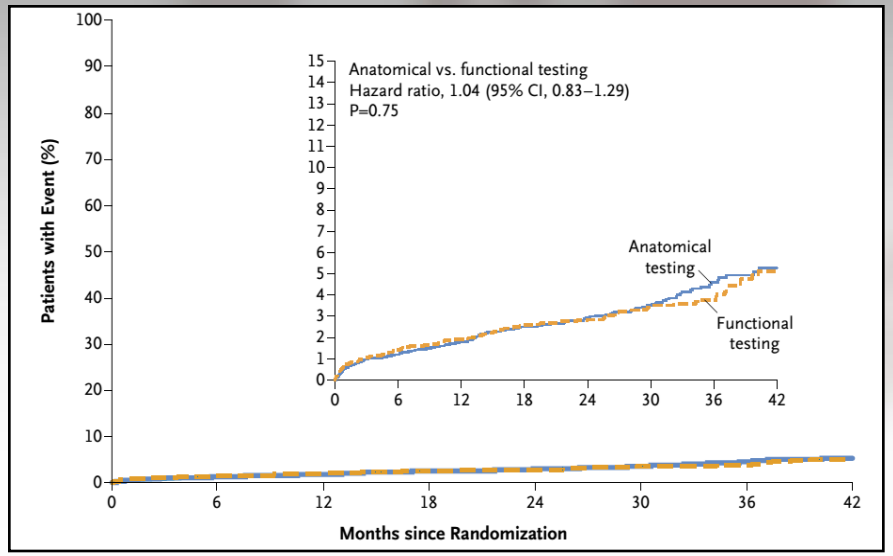

B
Rates of medical treatment (%)
100
80
60
40
20
0
One-step strategy
Two-step strategy







Anatomic luminal stenosis versus Myocardial Ischemia (MPI, FFR, TAG)



- ✓ High NPV
- ✓ Clarified diagnosis
- ✓ Fewer invasive angiograms
- ✓ Focused appropriate treatments
- ✓ Reduction in death/non-fatal MI
- ✓ Cost-effective
- ✓ Decreasing Radiation dose
- ✓ Plaque, MPI, FFR, TAG

Non-invasive test

Anatomic *versus* Functional

NOT Competitive

Comparative

Cooperative / Complementary

감사합니다

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