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Usefulness of Age and Gender in the Early Triage of Patients with Acute Chest Pain Having Cardiac Computed Tomographic Angiography

Fabian Bamberg, MD, MPH^{1,2,6}, Quynh A. Truong, MD, MPH^{1,3}, Ron Blankstein, MD^{1,2}, Khurram Nasir, MD, MPH¹, Hang Lee, PhD⁴, Ian S. Rogers, MD MBA MPH^{1,3}, Stephan Achenbach, MD⁷, Thomas J. Brady, MD^{1,2}, John T. Nagurney, MD, MPH⁵, Maximilian F. Reiser, MD⁶, and Udo Hoffmann, MD, MPH^{1,2}

¹Cardiac MR PET CT Program, Massachusetts General Hospital and Harvard Medical School

²Department of Radiology, Massachusetts General Hospital and Harvard Medical School

³Division of Cardiology, Massachusetts General Hospital and Harvard Medical School

⁴Biostatistics Center, Massachusetts General Hospital and Harvard Medical School

⁵Department of Emergency Medicine, Massachusetts General Hospital and Harvard Medical School

⁶Department of Clinical Radiology, Ludwig-Maximilians University, Klinikum Grosshadern, Munich, Germany

⁷Department of Cardiology, University of Erlangen, Germany

Abstract

To identify age- and gender- specific sub-populations of patients with acute chest pain in whom coronary CT angiography (CTA) yields the highest diagnostic benefit. Subjects with acute chest pain and an inconclusive initial evaluation (non-diagnostic electrocardiogram, negative cardiac biomarkers) underwent contrast-enhanced 64-slice CT coronary angiography as part of an observational cohort study. Independent investigators determined the presence of significant coronary stenosis (>50% luminal narrowing) and the occurrence of acute coronary syndrome (ACS) during index hospitalization. We determined diagnostic accuracy and impact on pretest probability of ACS using Bayes' theorem. Among 368 patients (52.7±12 age, 61% males), 8% had ACS. Presence of significant coronary stenosis by CT and the occurrence of ACS increased with age for both men and women ($p<0.001$). Cardiac CTA was highly sensitive and specific in women younger than 65 years of age (sensitivity: 100% and specificity >87%) and men younger than 55 years of age (sensitivity: 100% in <45 and 80% in 45-54 years old men; specificity: >88.2%). Moreover, in these patients coronary CTA led to restratification from low to high (for a positive CTA) or from low to very low risk (for a negative CTA). In contrast, a negative CTA result did not result in restratification to low risk category in women >65 and men >55 years of age. In conclusion, this analysis provides initial evidence that men <55 and women <65 might benefit more from cardiac CTA than elderly

Address for Correspondence: Fabian Bamberg, MD MPH, Cardiac MR PET CT Program, Massachusetts General Hospital and Harvard Medical School, 165 Charles River Plaza Suite 400; Boston, MA 02114, Phone: 617-726-1255, Fax: 617-724-4152; fbamberg@partners.org.

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patients. Thus, age and gender may serve as simple criteria to appropriately select patients who may derive the greatest diagnostic benefit from coronary CTA in the setting of acute chest pain.

Introduction

While there is growing evidence demonstrating that cardiac CT angiography (CTA) may enhance the current work-up of patients with acute chest pain, it remains unclear in which sub-population cardiac CTA yields the highest diagnostic benefit.¹⁻⁴ To establish a usefulness classification for patients with suspected acute coronary syndrome (ACS) undergoing cardiac CTA, we determined the pretest probability of ACS based on ACS event rates, the diagnostic accuracy of coronary CTA, and posttest probability in age and gender specific patient strata in the Rule Out Myocardial Infarction using Computer Assisted Tomography cohort. Our hypothesis was that younger men and women benefit the most from coronary CTA.

Methods

The study sample was drawn from the “Rule Out Myocardial Infarction using Computer Assisted Tomography” (ROMICAT) trial which enrolled patients who had a chief complaint of acute chest pain for >5 minutes during the past 24 hours, normal initial troponin, an initial ECG without evidence of myocardial ischemia, and normal sinus rhythm. Subjects were excluded if their serum creatinine was >1.3 mg/dl and they had a history of coronary artery disease (CAD), defined as stent implantation or coronary artery bypass grafting. Detailed inclusion and exclusion criteria have been previously reported.⁴ Notably, all patients had sufficient clinical suspicion ACS by the emergency department (ED) physicians to be admitted to the hospital for the assessment of ACS. Data on demographics, cardiovascular risk factors, TIMI risk score, medication history, and clinical course of the study participants were prospectively collected during the hospitalization. All study participants underwent contrast-enhanced coronary CTA prior to admission to the hospital floor where they received standard of care. All physician caregivers and the study participants remained blinded to the result of coronary CTA. The institutional review board approved the study protocol and all patients provided written informed consent.

Coronary CTA was performed using a 64-slice CT scanner (Sensation 64; Siemens Medical Solutions, Forchheim, Germany). Per standard protocol, subjects received intravenous beta-blocker (if heart rate >60 beats per minute; metoprolol, 5-20 mg) and sublingual nitroglycerin prior to the scan unless contraindications were present. The detailed protocol has been described previously.⁴ Axial images were reconstructed (slice thickness: 0.75 mm; increment: 0.4 mm) at different intervals of the cardiac cycle to minimize motion artifacts. The best phase was selected for analysis and transferred to an offline workstation for analysis (Leonardo, Siemens Medical Solutions, Forchheim, Germany). The presence of significant coronary stenosis (>50% luminal narrowing) was determined in a consensus reading by two experienced investigators with a third expert reader adjudicating any disagreement and previously described. If image quality did not permit definite exclusion of the presence of a significant stenosis (due to the presence of motion artifacts, calcification, or low contrast-to-noise ratio), the segment was classified as inconclusive. For clinical applicability of the analysis, inconclusive segments were counted as positives for the determination of test characteristics of cardiac CTA.

Outcome of interest was ACS defined as either an acute myocardial infarction with positive troponin during serial testing (6 hour or 9 hours after ED presentation) or unstable angina pectoris (UAP) according to the AHA/ACC/ESC guidelines.⁵⁻⁷ UAP was defined as clinical symptoms suggestive of ACS (unstable pattern of chest pain - at rest, new onset, or crescendo

angina), optimally with objective evidence of myocardial ischemia such as a positive stress test as previously defined.⁴ Occurrence of ACS was determined by an independent outcome panel of two experienced physicians with more than 10 years experience (one ED physician and one cardiologist) who reviewed all patient data pertaining to the index hospitalization, including other test results. Disagreement was resolved by consensus, which included an additional cardiologist.⁸

Demographics, traditional risk factors and clinical events as well as the prevalence of coronary stenosis as detected by coronary CTA are presented as mean $\pm$ SD or medians and interquartile range for continuous variables, and percentages for categorical variables. Because age and gender are the most easily obtainable independent strong predictors for both ACS and CAD⁹⁻¹¹, analysis was performed in age (per 10-year increments) and gender specific strata (women: ≤ 45 , >45 to ≤ 55 , >55 to ≤ 65 , and >65 years of age; men: ≤ 45 , >45 to ≤ 55 , >55 to ≤ 65 , and >65 years of age). For each strata, we determined the prevalence of ACS and the diagnostic accuracy for detecting ACS by coronary CTA (sensitivity and specificity, including 95% confidence intervals using the exact binominal distribution, as well as positive and negative likelihood ratio [LR+ and LR-; respectively). Chi-square trend test was used to test for differences of the prevalence of significant coronary stenosis and ACS across the subgroups. Pretest probability of ACS was defined as the prevalence of ACS within the strata. The change in probability of ACS given a positive and negative coronary CTA (defined as presence of $>50\%$ significant coronary artery stenosis or inconclusive coronary segment) were subsequently determined using Baye's theorem (for a negative test result: pretest odds $\times$ LR- = posttest odds for ACS; for a positive test result: pretest odds $\times$ LR+ = posttest odds for ACS). To translate the nominal change of probability of ACS into clinically relevant re-stratification of risk for ACS, we used the classification suggested by Goldman et al.¹² and defined very low risk as $\leq 1\%$ ACS event rate, low risk as 1 to $\leq 4\%$ ACS event rate, intermediate risk as 4 to $\leq 16\%$ ACS event rate, and high risk as $>16\%$ ACS event rate.

A two-sided p-value of <0.05 was considered to indicate statistical significance. All analyses were performed using SAS (Version 9.1, SAS Institute Inc., Cary, NC, USA).

Results

A total of 368 patients, who were predominantly middle-aged relatively young males at low TIMI risk (61% males, mean age: 52.7 ± 12 , 95% low TIMI risk), were included in this analysis (Table 1). The prevalence of ACS, significant coronary stenosis, and the prevalence of exams with inconclusive coronary segments increased significantly across age strata for both women and men (all $p < 0.001$, Table 2A and B).

In women younger than 65 years of age, coronary CTA correctly identified 2 subjects with ACS (sensitivity: 100% for 45 to 65 years of age; Table 2A) and correctly excluded ACS in all but 4 cases (specificity 90.7% and 87.0% for women between 45-54 and 55-64 years, respectively). In contrast, coronary CTA had low sensitivity and moderate specificity for ACS in women ≥ 65 years of age (sensitivity: 66.7% and specificity: 72.7%).

In men <45 years of age, cardiac CT correctly identified all subjects with ACS (sensitivity: 100%) and correctly identified 4 out of 5 ACS subjects age 45-54 years (sensitivity: 80%; Table 2B). Similarly, cardiac CT correctly excluded ACS in a significant fraction of patients in men younger than 45 years and between 45 and 54 years of age (specificity 98.4% and specificity: 88.2%; respectively). In contrast, cardiac CT had a moderate sensitivity and low specificity for ACS in men ≥ 55 years of age (Table 2B).

Because of the low prevalence of ACS, absolute change in pretest probability was higher after a positive coronary CTA compared to a negative coronary CTA in all strata except in males

≥65 years of age (Table 3). In women between 45-54 and 55-64 years (prevalence of ACS 2%), a negative coronary CTA resulted in a post test probability of 0% and a positive coronary CT was associated with a posttest probability of 33% and 14%. In men <45 and men 45-54 years of age, a positive coronary CTA resulted in a dramatic increase in post test probability of 75% and 27%, respectively, while a negative coronary CT resulted in 0 and 1% post test probability in men <45 and 45-54 years of age; respectively.

Figure 1 demonstrates the change of probability of ACS given a negative or positive coronary CT within the risk classification suggested by Goldman et al.¹² Both a negative and a positive coronary CT resulted in a change of risk category, except a positive test in women >65 years of age and in men 55-64 years of age. For women between 45-54 and 55-64 years of age and men <45 and 45-54 years of age both a positive and negative test resulted in a change of the risk estimate into the very low or high risk category. A positive coronary CTA restratified men and women into high risk, except in men >65 years of age.

Discussion

In this study, we demonstrate that coronary CTA in patients with acute chest pain substantially changes probability of ACS both for a negative and a positive test result (based on the presence of a 50% stenosis or inconclusive CT exams) in men <55 years of age and women <65 years of age. Moreover, applying these results to a risk classification scheme, demonstrates that coronary CTA leads to a restratification from low risk to high (for a positive CTA) or very low risk (for a negative CTA). Thus, coronary CTA might have the greatest clinical utility in women <65 years of age and men <55 years of age.

Several recent studies have demonstrated that coronary CTA may be helpful to guide management of patients presenting with acute chest pain in the ED, especially in the early triage of patients with low to intermediate likelihood for ACS where CT may facilitate early discharge. However, these studies report a wide range of ACS rates (0-34%)^{1,2,4}, which suggests heterogeneity of the populations studied. In the analysis presented here, we demonstrate that the clinical utility of coronary CTA in the setting of acute chest pain appears to vary with age and gender even within a population of patients overwhelmingly classified as low risk according to the TIMI risk score (95%). This observation is based on differences in the prevalence of ACS, the prevalence of a significant stenosis in coronary CTA and the accuracy of this finding for identifying patients with ACS in age and gender specific strata.

Age and gender are well known strong predictors of CAD, myocardial infarction, and ACS⁹⁻¹¹. Consequently, we observed a significant increase of prevalence of ACS and significant CAD from 0 to 21% and 0 to 35% in women and 5% to 25% and 6% to 64% in men across age strata; respectively. Diagnostic accuracy of CTA for ACS was related to the prevalence of CAD (sensitivity range: 100 to 66.7% and 100 to 62.5% for women and men; respectively). Importantly, the observed difference of 10 years between women and men mirror exactly the gender difference which has been described previously with respect to intima media thickness or coronary artery calcification.^{13,14} Thus, our findings are consistent with the high accuracy for the detection of stenosis in populations with a low prevalence of CAD and the close association of CAD and ACS.¹⁵

While the ultimate assessment of clinical efficiency of a diagnostic test is performed within the framework of a cost-effectiveness analysis, changes in pretest probability within clinically accepted risk categories based on basic clinical and demographic variables are often used. Examples are the TIMI risk score in patients with unstable angina and non-ST elevation MI acute chest pain and suspicion for ACS¹⁶, the Diamond and Forrester classification in patients with suspected CAD^{17,18}, and the Framingham Risk Score for asymptomatic patients.¹⁹

Definition of high, low or intermediate risk is usually arbitrary but reflects the severity and consequences of an event. For example, low risk is considered as <4% ACS in patients with acute chest pain¹², <30% significant CAD (>50%) in patients with suspected CAD²⁰, and <10% (Death or myocardial infarction) over 10 years (1% annually) in asymptomatic patients.²¹ In contrast to Meijboom et al.²⁰, who based the pretest probability for CAD on the Duke score, we based pretest probability for ACS on the observed prevalence of ACS in each subgroup. This was necessary because 95% of our patient population was at low TIMI risk score and thus further stratification was not feasible. However, our results are consistent with those of Meijboom in that coronary CTA was not useful in patients with a high pretest probability.²⁰

Instead, in women <65 years of age and men <55 years of age both a positive and negative test resulted in a change of the risk estimate either to very low (<1%) or high risk (≥16%) indicating the highest clinical utility. Most remarkable is that a finding of a significant stenosis in men <45 years of age carries an absolute increase of 70% in probability for ACS. Cost-effectiveness of coronary CTA, at least cost saving in younger patients, has been suggested by recent cost-effectiveness analyses^{22,23} and a small randomized CT trial in patients with acute chest pain (\$1,586 vs. \$1,872, $p < 0.001$).¹ Overall, this is consistent with the notion that the clinical value of coronary CT is mostly derived from its ability to safely exclude significant coronary artery disease.²⁴ Although our results indicate that a large portion of women <65 and men <55 years of age with a negative CT may be safely discharged without further testing, it remains to be determined whether re-stratification into very low risk or high-risk will consistently result in immediate and significant management decisions such as discharge (as suggested by Goldman et al.) or referral for invasive angiography, respectively. Such determination is typically done within registries or randomized trials.

In contrast, clinical utility in women older than 65 years and men older than 55 years of age cardiac CT may be low as the observed prevalence of significant stenosis by CT (>30%), ACS (>20%), and inconclusive coronary segments (>9%) is already high and coronary CT only results in re-stratification to intermediate/high risk. One explanation for this finding is that CAC, a known reason for low PPV of coronary CTA, becomes highly prevalent in this age group.²⁵ Thus, alternative testing modalities may be superior in triaging these patients.²⁶

Our finding that women <45 years of age did not have any stenosis detectable in CT and did not develop any event deserves further comment. Primarily, this finding can be attributed to our limited sample size as it is known that in these subjects ACS occur. Moreover, these women were all admitted to the hospital as a standard of care and 28% underwent myocardial perfusion imaging (data not shown). Thus, cardiac CTA may prove beneficial in these subjects. However, associated radiation exposure with an increased risk in younger women warrants further research on the feasibility of low dose-CT protocols (<5 mSv) and subsequent risk-benefit analysis of CT imaging in these younger females.

The major limitation is the low number of events within subgroups, resulting in wide confidence intervals. However, ROMICAT currently is the largest observational cohort study in patients with low to intermediate likelihood undergoing coronary CTA in the ED. More importantly, at this point it may be impossible to repeat a study in which caregivers remain blinded to the results of coronary CTA, given the proven high negative predictive value of coronary CTA and the fact that randomized trials are already underway. Also, optimally our probability revision would have included a clinical risk stratification algorithm such as the TIMI score, to demonstrate the incremental value. However, 95% of patients in this population were at low TIMI risk score and stratification was not possible. This may emphasize the limitations of the TIMI score in the large population of low risk patients. This is a single center trial and the population, due to IRB recommendations (i.e. conservative creatinine threshold

<1.3 mmol/ml) may have resulted in a slightly healthier population than the chest pain population in that CT would be used in clinical practice. However, the observed event rate of 8% is consistent with a low to intermediate risk of ACS.²⁷

References

1. Goldstein JA, Gallagher MJ, O'Neill WW, Ross MA, O'Neil BJ, Raff GL. A randomized controlled trial of multi-slice coronary computed tomography for evaluation of acute chest pain. *J Am Coll Cardiol* 2007;49:863–71. [PubMed: 17320744]
2. Rubinshtein R, Halon DA, Gaspar T, Jaffe R, Karkabi B, Flugelman MY, Kogan A, Shapira R, Peled N, Lewis BS. Usefulness of 64-slice cardiac computed tomographic angiography for diagnosing acute coronary syndromes and predicting clinical outcome in emergency department patients with chest pain of uncertain origin. *Circulation* 2007;115:1762–8. [PubMed: 17372178]
3. Hoffmann U, Nagurney JT, Moselewski F, Pena A, Ferencik M, Chae CU, Cury RC, Butler J, Abbara S, Brown DF, Manini A, Nichols JH, Achenbach S, Brady TJ. Coronary multidetector computed tomography in the assessment of patients with acute chest pain. *Circulation* 2006;114:2251–60. [PubMed: 17075011]
4. Hoffmann U, Bamberg F, Chae CU, Nichols JH, Rogers IS, Seneviratne SK, Truong QA, Cury RC, Abbara S, Shapiro MD, Moloo J, Butler J, Ferencik M, Lee H, Jang IK, Parry BA, Brown DF, Udelson JE, Achenbach S, Brady TJ, Nagurney JT. Coronary computed tomography angiography for early triage of patients with acute chest pain: the ROMICAT (Rule Out Myocardial Infarction using Computer Assisted Tomography) trial. *J Am Coll Cardiol* 2009;53:1642–50. [PubMed: 19406338]
5. Braunwald E, Antman EM, Beasley JW, Califf RM, Cheitlin MD, Hochman JS, Jones RH, Kereiakes D, Kupersmith J, Levin TN, Pepine CJ, Schaeffer JW, Smith EE 3rd, Steward DE, Theroux P, Gibbons RJ, Alpert JS, Faxon DP, Fuster V, Gregoratos G, Hiratzka LF, Jacobs AK, Smith SC Jr. ACC/AHA guideline update for the management of patients with unstable angina and non-ST-segment elevation myocardial infarction--2002: summary article: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee on the Management of Patients With Unstable Angina). *Circulation* 2002;106:1893–900. [PubMed: 12356647]
6. Gibler WB, Cannon CP, Blomkalns AL, Char DM, Drew BJ, Hollander JE, Jaffe AS, Jesse RL, Newby LK, Ohman EM, Peterson ED, Pollack CV. Practical implementation of the guidelines for unstable angina/non-ST-segment elevation myocardial infarction in the emergency department: a scientific statement from the American Heart Association Council on Clinical Cardiology (Subcommittee on Acute Cardiac Care), Council on Cardiovascular Nursing, and Quality of Care and Outcomes Research Interdisciplinary Working Group, in Collaboration With the Society of Chest Pain Centers. *Circulation* 2005;111:2699–710. [PubMed: 15911720]
7. Gibler WB, Cannon CP, Blomkalns AL, Char DM, Drew BJ, Hollander JE, Jaffe AS, Jesse RL, Newby LK, Ohman EM, Peterson ED, Pollack CV. Practical implementation of the Guidelines for Unstable Angina/Non-ST-Segment Elevation Myocardial Infarction in the emergency department. *Ann Emerg Med* 2005;46:185–97. [PubMed: 16046952]
8. Nagurney JT, Brown DF, Chae C, Chang Y, Chung WG, Cranmer H, Dan L, Fisher J, Grossman S, Tedrow U, Lewandrowski K, Jang IK. Disagreement between formal and medical record criteria for the diagnosis of acute coronary syndrome. *Acad Emerg Med* 2005;12:446–52. [PubMed: 15860697]
9. Morise AP, Haddad WJ, Beckner D. Development and validation of a clinical score to estimate the probability of coronary artery disease in men and women presenting with suspected coronary disease. *Am J Med* 1997;102:350–6. [PubMed: 9217616]
10. Kasser IS, Bruce RA. Comparative effects of aging and coronary heart disease on submaximal and maximal exercise. *Circulation* 1969;39:759–74. [PubMed: 5785289]
11. Ho KT, Miller TD, Hodge DO, Bailey KR, Gibbons RJ. Use of a simple clinical score to predict prognosis of patients with normal or mildly abnormal resting electrocardiographic findings undergoing evaluation for coronary artery disease. *Mayo Clin Proc* 2002;77:515–21. [PubMed: 12059120]
12. Goldman L, Cook EF, Johnson PA, Brand DA, Rouan GW, Lee TH. Prediction of the need for intensive care in patients who come to the emergency departments with acute chest pain. *N Engl J Med* 1996;334:1498–504. [PubMed: 8618604]

13. Davis PH, Dawson JD, Riley WA, Lauer RM. Carotid intimal-medial thickness is related to cardiovascular risk factors measured from childhood through middle age: The Muscatine Study. *Circulation* 2001;104:2815–9. [PubMed: 11733400]
14. Hoffmann U, Massaro JM, Fox CS, Manders E, O'Donnell CJ. Defining normal distributions of coronary artery calcium in women and men (from the Framingham Heart Study). *Am J Cardiol* 2008;102:1136–41. [PubMed: 18940279]
15. Stein PD, Yaekoub AY, Matta F, Sostman HD. 64-slice CT for diagnosis of coronary artery disease: a systematic review. *Am J Med* 2008;121:715–25. [PubMed: 18691486]
16. Antman EM, Cohen M, Bernink PJ, McCabe CH, Horacek T, Papuchis G, Mautner B, Corbalan R, Radley D, Braunwald E. The TIMI risk score for unstable angina/non-ST elevation MI: A method for prognostication and therapeutic decision making. *Jama* 2000;284:835–42. [PubMed: 10938172]
17. Chaitman BR, Rosen AD, Williams DO, Bourassa MG, Aguirre FV, Pitt B, Rautaharju PM, Rogers WJ, Sharaf B, Attubato M, Hardison RM, Srivatsa S, Kouchoukos NT, Stocke K, Sopko G, Detre K, Frye R. Myocardial infarction and cardiac mortality in the Bypass Angioplasty Revascularization Investigation (BARI) randomized trial. *Circulation* 1997;96:2162–70. [PubMed: 9337185]
18. Gibbons RJ, Chatterjee K, Daley J, Douglas JS, Fihn SD, Gardin JM, Grunwald MA, Levy D, Lytle BW, O'Rourke RA, Schafer WP, Williams SV. ACC/AHA/ACP-ASIM guidelines for the management of patients with chronic stable angina: executive summary and recommendations. A Report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee on Management of Patients with Chronic Stable Angina). *Circulation* 1999;99:2829–48. [PubMed: 10351980]
19. Wilson PW, D'Agostino RB, Levy D, Belanger AM, Silbershatz H, Kannel WB. Prediction of coronary heart disease using risk factor categories. *Circulation* 1998;97:1837–47. [PubMed: 9603539]
20. Pryor DB, Harrell FE Jr, Lee KL, Califf RM, Rosati RA. Estimating the likelihood of significant coronary artery disease. *Am J Med* 1983;75:771–80. [PubMed: 6638047]
21. Executive Summary of The Third Report of The National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, And Treatment of High Blood Cholesterol In Adults (Adult Treatment Panel III). *Jama* 2001;285:2486–97. [PubMed: 11368702]
22. Khare RK, Mark Courtney D, Powell ES, Venkatesh AK, Lee TA. Sixty-four-slice Computed Tomography of the Coronary Arteries: Cost-Effectiveness Analysis of Patients Presenting to the Emergency Department with Low-risk Chest Pain. *Acad Emerg Med*. 2008
23. Ladapo JA, Hoffmann U, Bamberg F, Nagurny JT, Cutler DM, Weinstein MC, Gazelle GS. Cost-effectiveness of coronary MDCT in the triage of patients with acute chest pain. *Am J Roentgenol* 2008;191:455–63. [PubMed: 18647917]
24. Budoff MJ, Achenbach S, Blumenthal RS, Carr JJ, Goldin JG, Greenland P, Guerci AD, Lima JA, Rader DJ, Rubin GD, Shaw LJ, Wiegers SE. Assessment of coronary artery disease by cardiac computed tomography: a scientific statement from the American Heart Association Committee on Cardiovascular Imaging and Intervention, Council on Cardiovascular Radiology and Intervention, and Committee on Cardiac Imaging, Council on Clinical Cardiology. *Circulation* 2006;114:1761–91. [PubMed: 17015792]
25. Raff GL, Gallagher MJ, O'Neill WW, Goldstein JA. Diagnostic accuracy of noninvasive coronary angiography using 64-slice spiral computed tomography. *J Am Coll Cardiol* 2005;46:552–7. [PubMed: 16053973]
26. Wang FP, Amanullah AM, Kiat H, Friedman JD, Berman DS. Diagnostic efficacy of stress technetium 99m-labeled sestamibi myocardial perfusion single-photon emission computed tomography in detection of coronary artery disease among patients over age 80. *J Nucl Cardiol* 1995;2:380–8. [PubMed: 9420817]
27. Lee TH, Goldman L. Evaluation of the patient with acute chest pain. *N Engl J Med* 2000;342:1187–95. [PubMed: 10770985]

Figure 1.

Impact of positive and negative findings by cardiac CT on the pre-test probability (horizontal black bar) of acute coronary syndrome according to age group. Either positive (red arrow, +) or negative (blue arrow, -) CT finding revise the probability for ACS upwards or downwards; respectively and may result in restratification of risk categories (very low [$\leq 1\%$], low risk [$< 4\%$], intermediate [$< 16\%$], and high risk [$> 16\%$], according to Goldman et al.¹²).

Table 1

Patient demographics and clinical outcomes of 368 consecutive patients who presented with acute chest pain but inconclusive initial evaluation and underwent 64-slice computed tomography prior to admission.

Age (years)	52.7±12
Men	223 (61%)
Body Mass Index (kg/m ²)	29.0±6
Diabetes mellitus	40 (11%)
Hypertension	145 (39%)
Hyperlipidemia or statin use	135 (37%)
Current or former smoker	180 (49%)
TIMI Score (low/intermediate/high)	94.3%, 5.4%, 0.3%
Acute Coronary Syndrome during index hospitalization	31 (8%)
Unstable angina pectoris	23 (74%)
Myocardial infarction	8 (26%)

Table 2

Table 2A: Diagnostic accuracy of cardiac computed tomography for the detection of acute coronary syndrome (ACS) among 142 women enrolled in the ROMICAT trial according to age strata. 95% confidence intervals of the estimates of the diagnostic accuracy are provided in parenthesis.

Table 2B: Diagnostic accuracy of cardiac computed tomography for the detection of acute coronary syndrome among 226 men enrolled in the ROMICAT trial according to age strata. 95% confidence intervals of the estimates of the diagnostic accuracy are provided in parenthesis.

Variable	Women (Age in Years)			
	All ages	<45	45-54	55-64
Number	142	28	48	28
Acute Coronary Syndrome	8 (6%)	0	1 (2%)	1 (2%)
Coronary stenosis	20 (14%)	0	3 (6%)	7 (15%)
Inconclusive segments	15 (11%)	0	1 (2%)	6 (13%)
Sensitivity	75.0% (6/8) (0.35-0.96)	-	100% (1/1) (0.03-1.00)	100% (1/1) (0.03-1.00)
Specificity	89.6% (120/134) (0.83-0.94)	-	95.7% (45/47) (0.85-0.99)	87.0% (40/46) (0.74-0.95)
				66.7% (4/6) (0.22-0.96)
				72.7% (16/22) (0.50-0.89)
Variable	Men (Age in Years)			
	All ages	<45	45-54	55-64
Number	226	65	98	35
Acute Coronary Syndrome	23 (10%)	3 (5%)	5 (5%)	8 (23%)
Coronary Stenosis	48 (21%)	7 (6%)	13 (15%)	11 (31%)
Inconclusive segments	19 (8%)	1 (2%)	6 (6%)	3 (9%)
Sensitivity	78.3% (18/23) (0.56-0.93)	100% (3/3) (0.29-1.00)	80.0% (4/5) (0.28-0.99)	62.5% (5/8) (0.24-0.91)
Specificity	85.2% (173/178) (0.94-0.99)	98.4% (61/62) (0.91-1.00)	88.2% (82/93) (0.80-0.94)	77.8% (21/27) (0.58-0.91)
				85.7% (6/7) (0.42-0.99)
				42.9% (9/21) (0.23-0.66)

Table 3
Pre- and posttest probability of acute coronary syndrome (ACS) contingent on either positive or negative cardiac CT finding (presence of significant coronary stenosis or indeterminate) stratified by gender and age. Pretest probability equals the observed prevalence of ACS in each subgroup. Risk classified according to Goldman et al.¹². The diagnostic gain is provided in parenthesis.

Age group (Years)	Pretest Probability	Risk Category	Probability given neg. Test Result (diagnostic gain)	Risk Category	Probability given pos. Test Result (diagnostic gain)	Risk Category
Women						
<45	0%	Very low	-	-	-	-
45-54	2%	Low	0% (2%)	Very low	33% (31%)	High
55-64	2%	Low	0% (4%)	Very low	16% (14%)	High
≥65	21%	High	11% (10%)	Intermediate	40% (19%)	High
Men						
<45	5%	Low	0% (5%)	Very low	75% (70%)	High
45-54	5%	Low	1% (4%)	Very low	27% (22%)	High
55-64	23%	High	13% (10%)	Intermediate	45% (22%)	High
≥65	25%	High	10% (15%)	Intermediate	33% (8%)	High