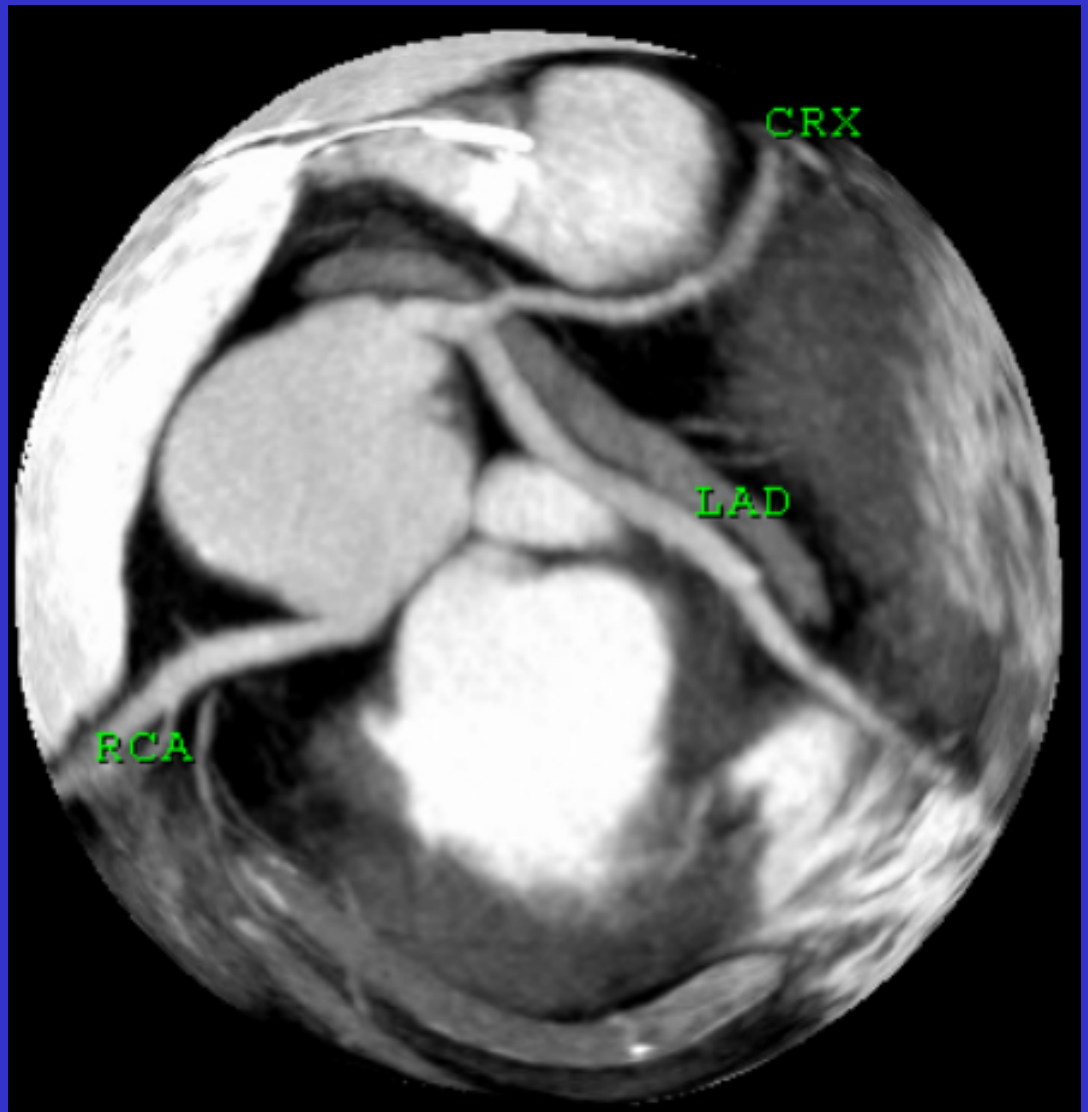
Η στεφανιαία CT
ΔΕΝ έχει θέση στην πρόληψη των καρδιαγγειακών επεισοδίων.
(έχει όμως θέση στην αύξηση του πελατολογίου των ογκολόγων)

ΔΗΜΗΤΡΗΣ ΡΙΧΤΕΡ
Διευθυντής Β' Καρδιολογικής Κλινικής Ευρωκλινικής Αθηνών
τ. Πρόεδρος ΟΕ Επιδημιολογίας, Πρόληψης κ Μεταβολικού Συνδρόμου της ΕΚΕ

CARDIAC CT:

The wave of the future



CARDIAC IMAGING

- Chest Radiography
- MRI
- Echocardiography
- Angiography
- CT

HISTORY OF CARDIAC CT

- 1972-1995: Fluoroscopy-based CT for physiologic research.
- 1975-1980: Clinical CT-based exploration.
- 1980-present (interest is fading): Electron beam CT—first approach at clinical cardiology.
- 1990-present: Multidetector row scanning—4 slice→ 16 slice→ 64 slice. Expanding clinical applications.

Impediments to Clinical Use

- Image quality: Spatial resolution.
- Time: 1. Study itself.
  2. Scanning entire 3-D heart within 1 cardiac cycle—motion artifact.
- Clinical application: Assessing blood flow and wall motion.
- Radiation.
- Renal toxicity and allergy to dye load.

Advancing Technology

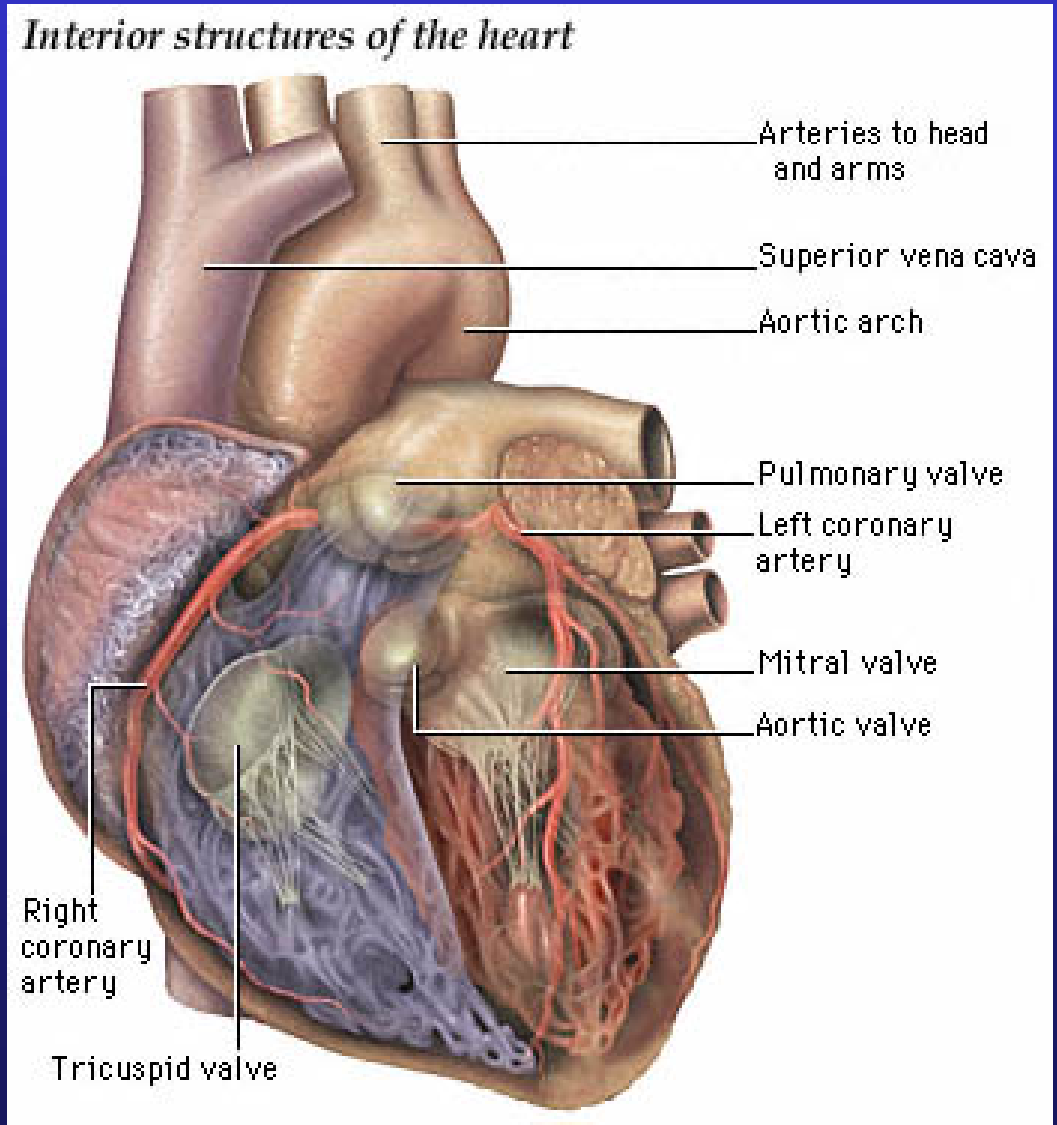
- Increasing scanning speed→ scan heart within one cardiac cycle.
- More detectors→better image resolution.
- Awareness: Good interobserver agreement.

CURRENT CLINICAL USES OF CARDIAC CT

1. Calcium scoring

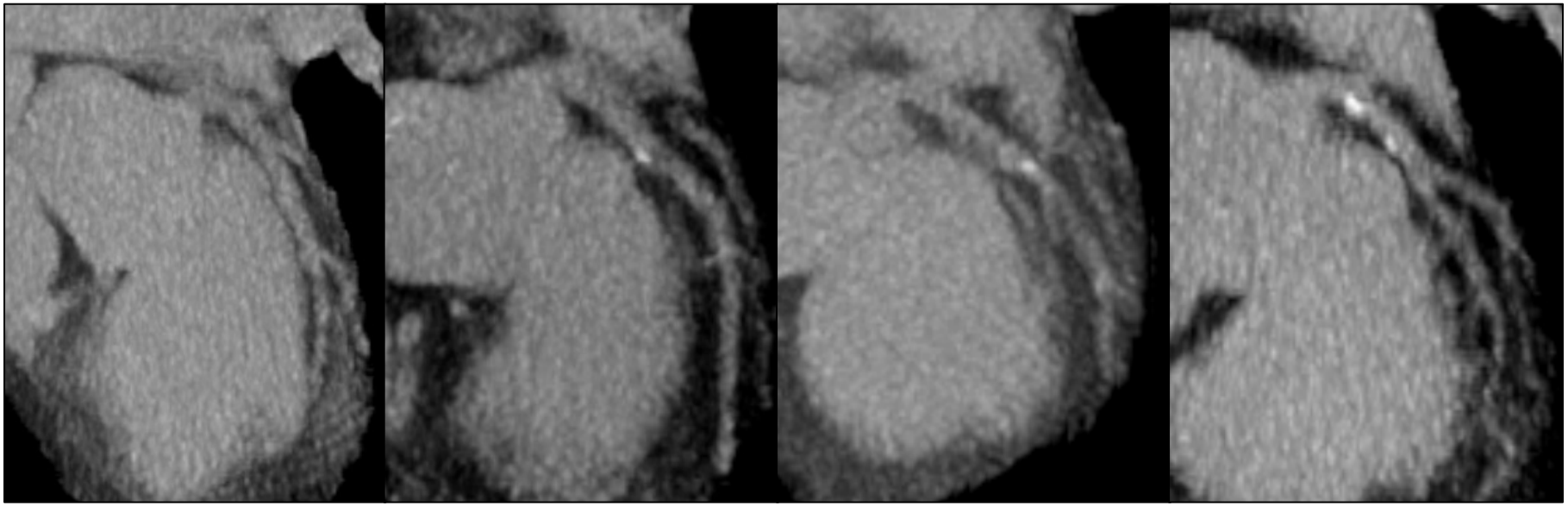
2. CT angiography

EVALUATING CAD

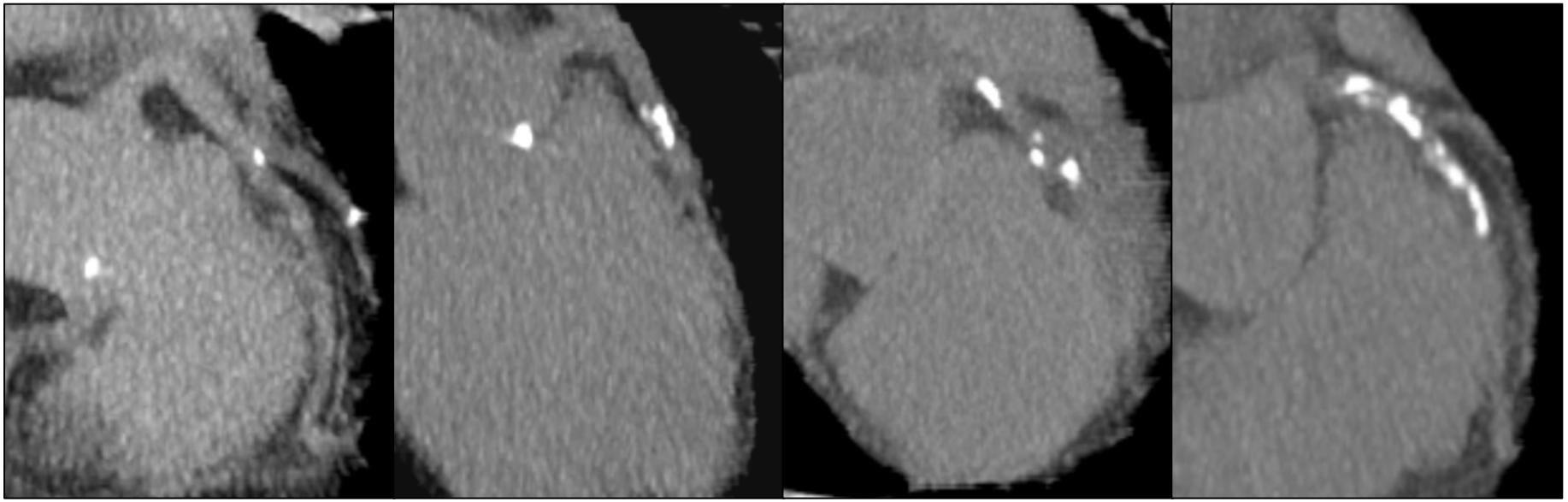


Calcium scoring: Technique

- No patient preparation.
- No intravenous contrast.
- First done with EBCT, since late 1980's.
- Now can do on MDCT. Usually do prospective gating from carina through base of heart with slice thickness (trigger at 75-80% of RR interval). Usually end up with 30-40 contiguous images.
- In 1990, Agatston introduced scoring method called "Agatston Score", which has been widely used.

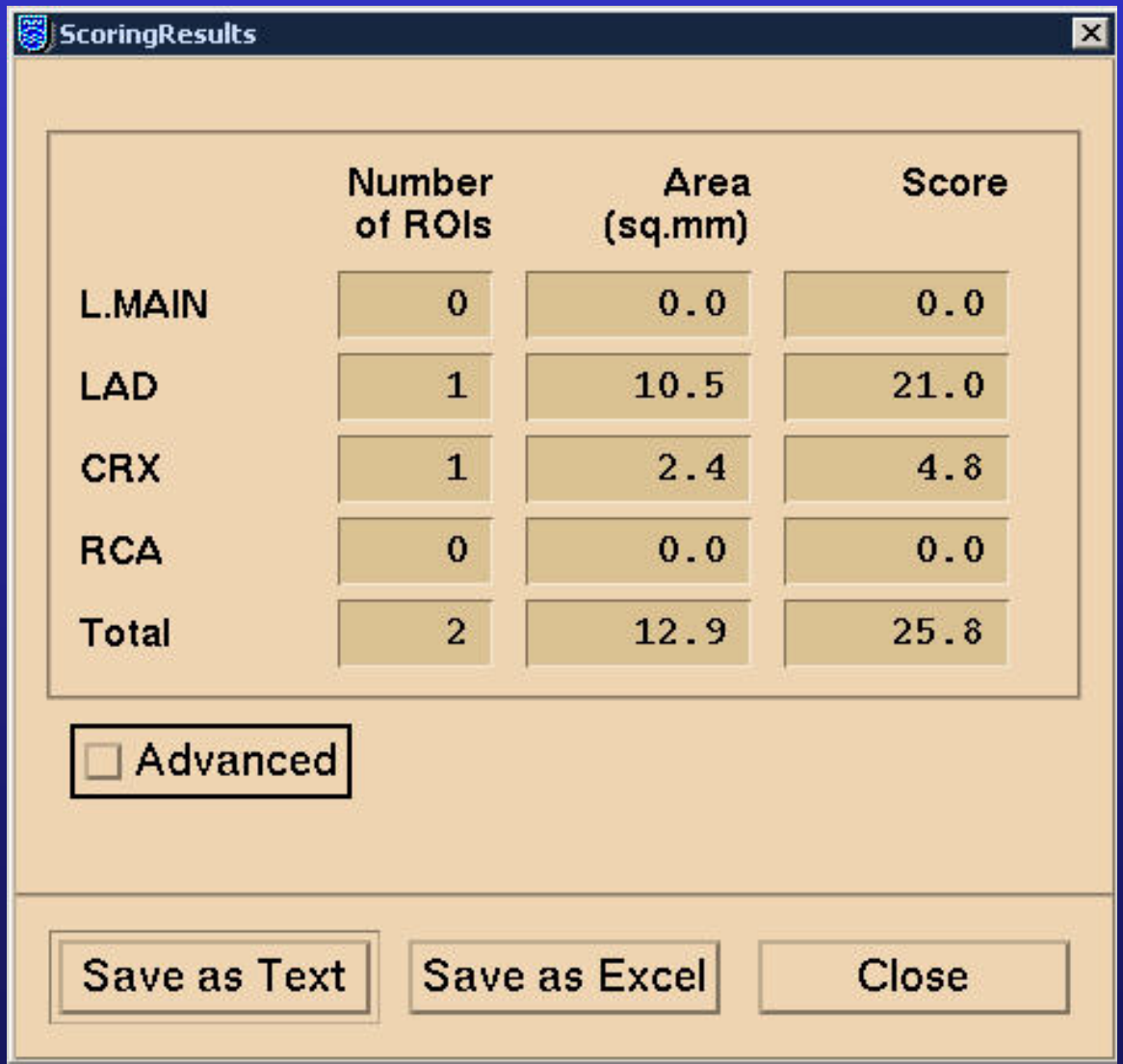


Score 0 | Score 1,81 | Score 5,2 | Score 7,7



Score 41 | Score 86 | Score 390 | Score 419

EXAMPLE OF AGATSTON SCORE



Clinical application

- Score > 0 is indicative of significant CAD.
  -Sensitivity 85-100%
  -Specificity 31-62%
  -Negative predictive value 84-100%

- Nikolaou., Poon M., Sirol M., Becker C., Fayad Z., Complementary Results of Computed Tomography and Magnetic Resonance Imaging of the Heart and Coronary Arteries: A Review and Future Outlook. *Cardiology Clinics.* November 2003. Vol. 21, Nr. 4.

Implications

- 44% of males > 40 years old and 67% of females > 60 years old have calcification without symptoms of CAD.

- Information for “worried well” or clinically relevant.

Does coronary artery calcium scoring add any information?

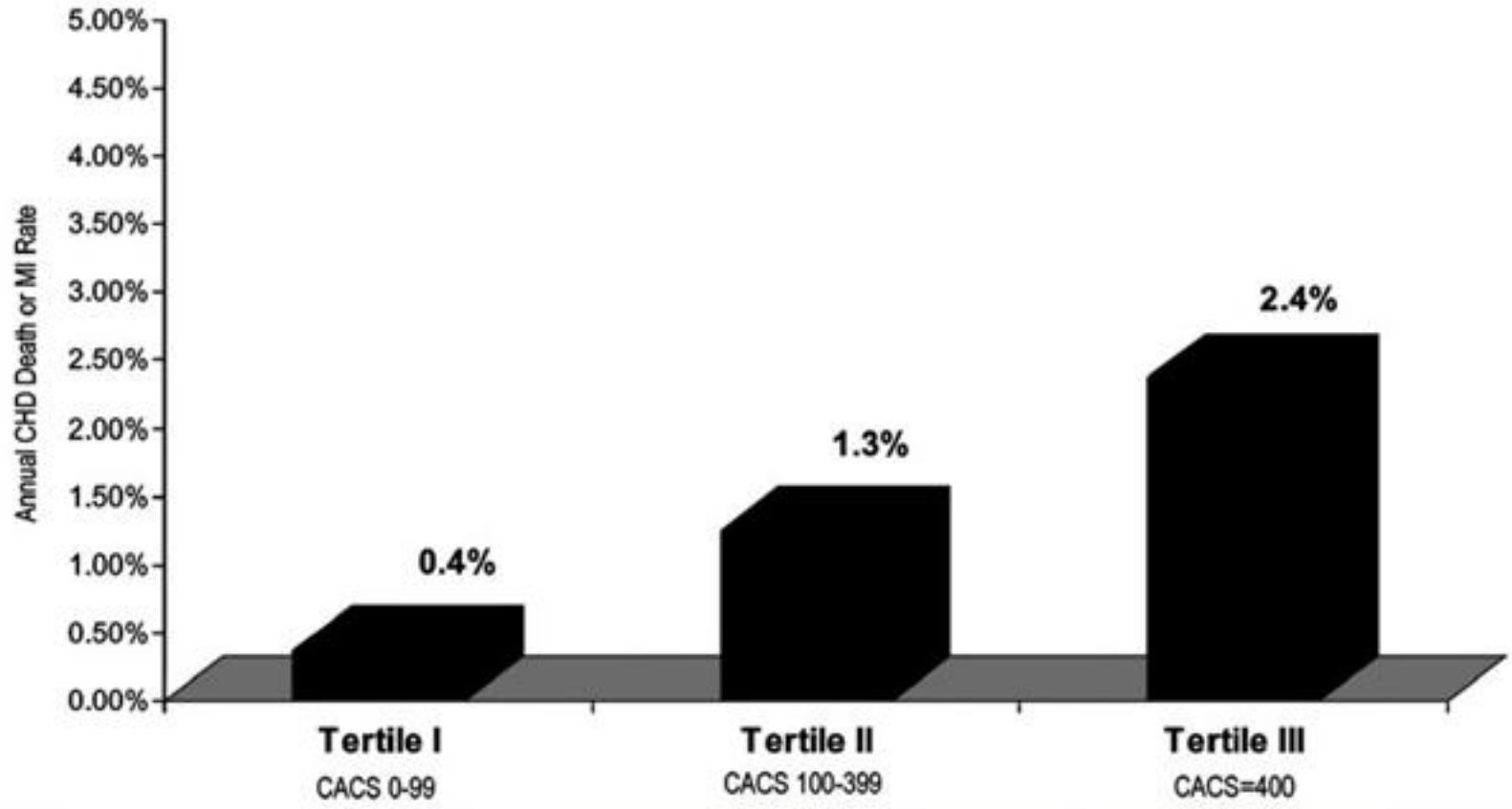
- 1,461 patients. Showed coronary artery calcium score can modify predicted risk obtained from Framingham Risk Score alone.

- Across categories of FRS, CACS was predictive of risk among patients with an FRS > 10% (P<.001) but not with an FRS less than 10%.

- Intermediate risk group with Framingham Risk Score 10-15%:
  1. If coronary artery calcium score was 0, 2.5% of patient suffered cardiac event.
  2. If coronary artery calcium score was > 300, 19.5% suffered cardiac event.

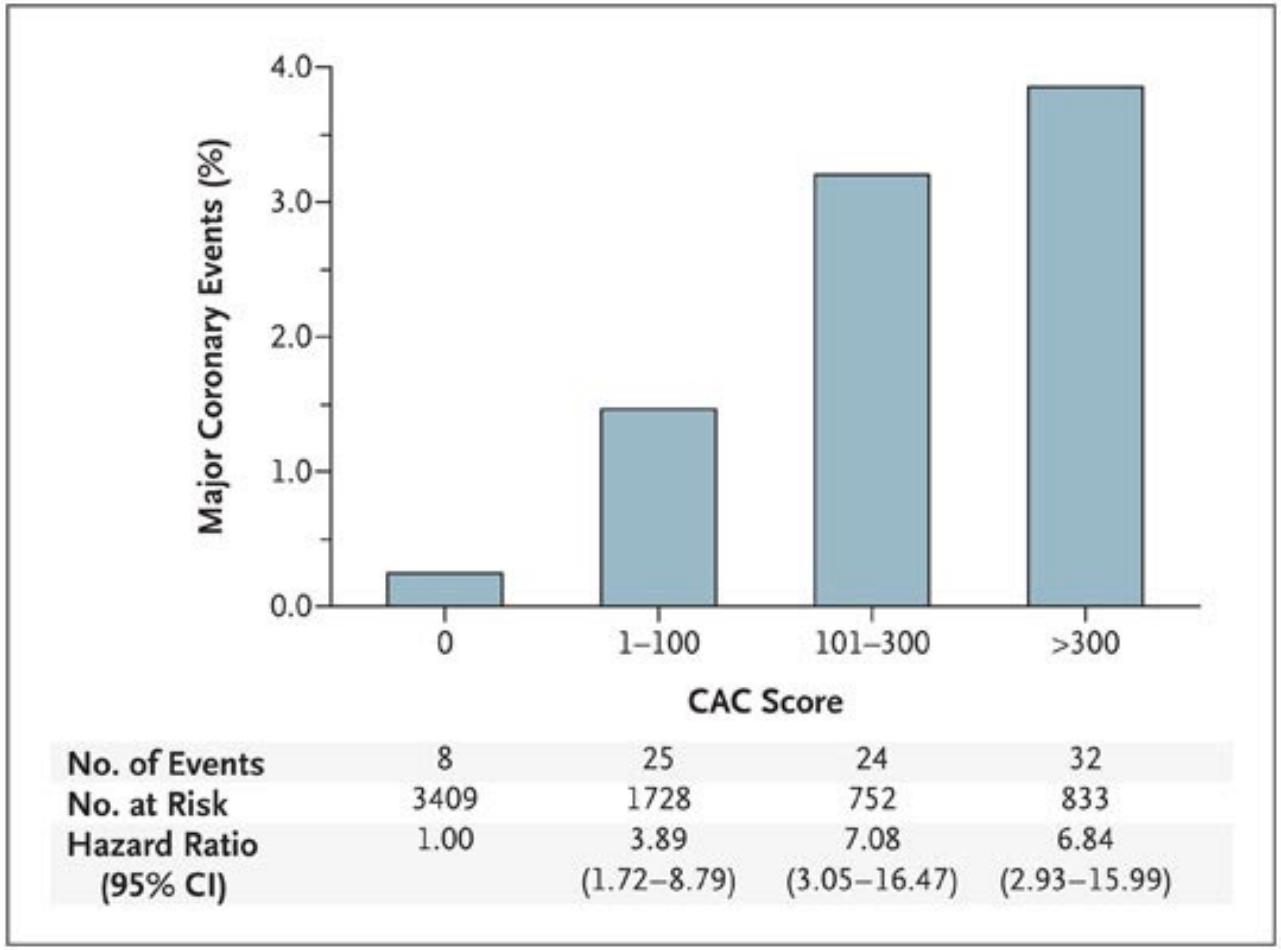
Philip Greenland, MD; Laurie LaBree, MS; Stanley P. Azen, PhD; Terence M. Doherty, BA; Robert C. Detrano, MD, PhD *JAMA.* 2004;291:210-215.

Death or MI in Intermediate Risk Subjects According to Calcium Scores



Greenland et al JACC 2007;49:378-402

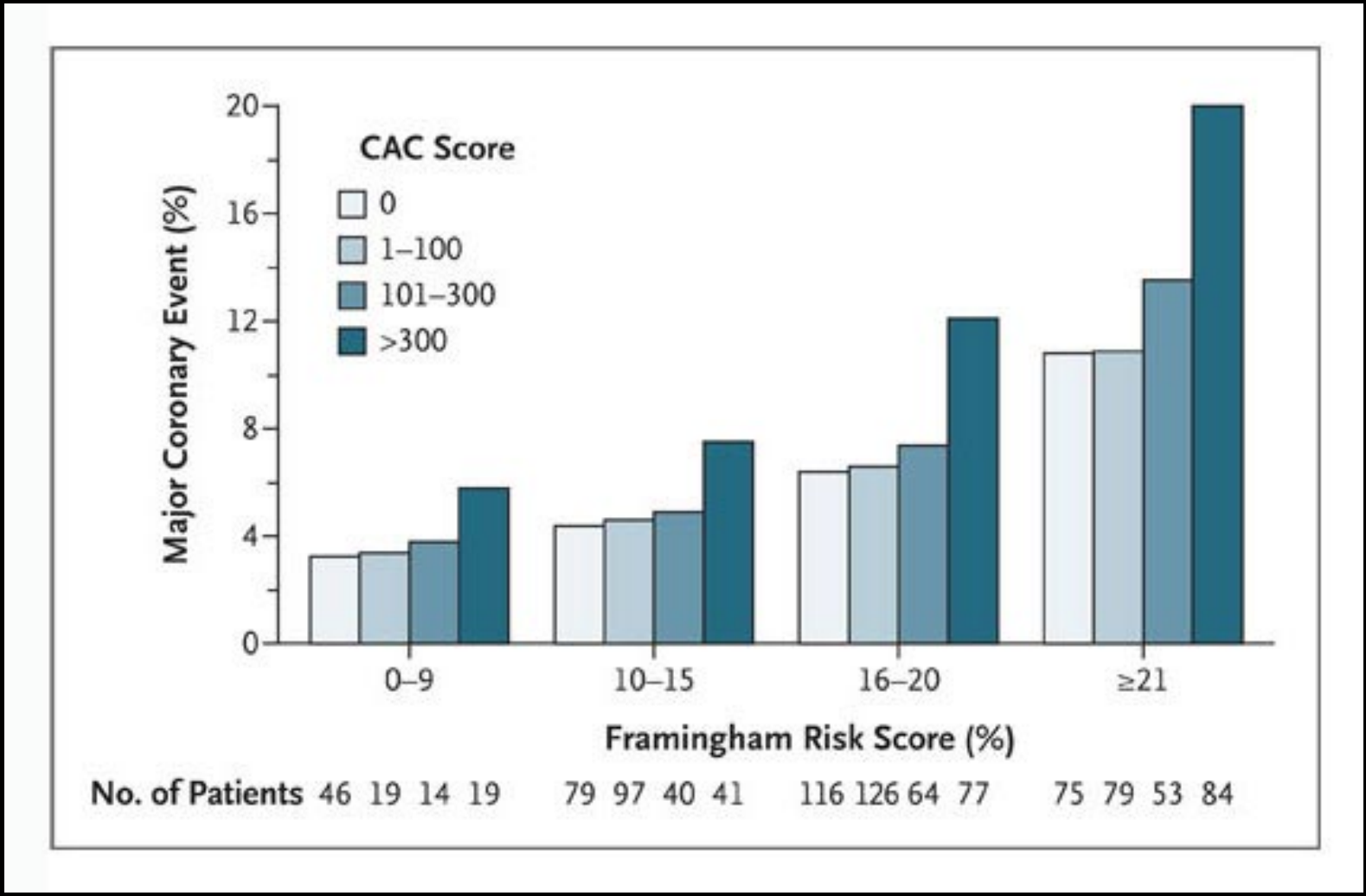
Risk of Major Coronary Events with Increasing Coronary-Artery Calcium Score



No. of Events	8	25	24	32
No. at Risk	3409	1728	752	833
Hazard Ratio (95% CI)	1.00	3.89 (1.72–8.79)	7.08 (3.05–16.47)	6.84 (2.93–15.99)

Bonow R. N Engl J Med 2009;361:990-997

The 7-Year Rate of Major Coronary Events Predicted on the Basis of the Framingham Risk Score and the Coronary-Artery Calcium Score



Bonow R. N Engl J Med 2009;361:990-997

The NEW ENGLAND JOURNAL of MEDICINE

CLINICAL PRACTICE

Should Coronary Calcium Screening Be Used in Cardiovascular Prevention Strategies?

Robert O. Bonow, M.D.

The scientific statement from the American Heart Association[14] and the expert-consensus document from the American College of Cardiology–American Heart Association[15] conclude that it may be reasonable to consider CAC screening in asymptomatic persons identified as having an intermediate risk of coronary events on the basis of an assessment of multiple risk factors; this view is based on the possibility that such patients might be reclassified in a higher risk group on the basis of the CAC score and that the management of risk factors might then be intensified. As noted previously, no studies have shown that improved outcomes are associated with this approach. The

organizations,[51] which concluded that CAC screening is inappropriate in asymptomatic patients who are at low risk for coronary events according to the ATP III criteria; the authors of the report were uncertain about the appropriateness of screening for those at intermediate or high risk.

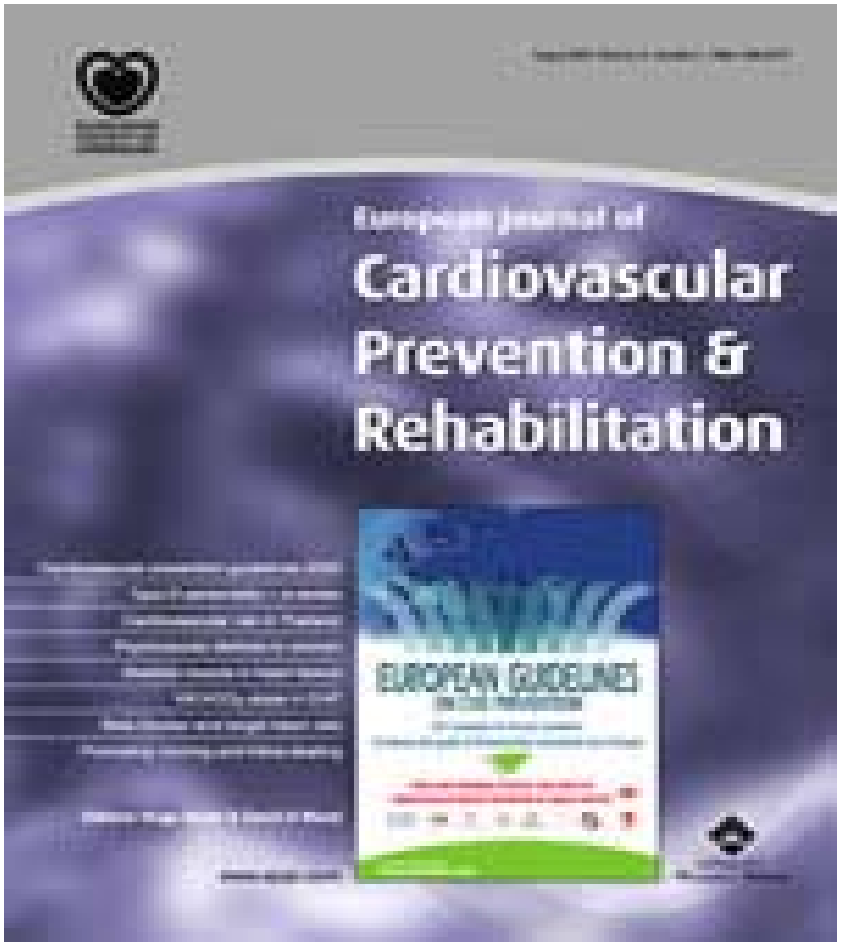
European Guidelines on CVD Prevention
EJCPR 2003, 10(Suppl 1): S1-S78

CAC

Conclusion:

-It should not be uncritically used as a screening method.

-Class I indication with evidence class A does not exist.



European Guidelines on CVD Prevention EJCPR 2003, 10(Suppl 1): S1-S78

- Coronary calcification is neither an indicator for stability nor instability of an atherosclerotic plaque.
- The vast majority of scientific data concerning Agatston score results of EB-CT experience. EB-Ct is however predominantly limited by its high cost and thus limited availability.

European Guidelines on CVD Prevention EJCPR 2003, 10(Suppl 1): S1-S78

- The proof of coronary calcium is not in the least identical with the presence of relevant coronary stenosis, because its specificity regarding the presence of ≥ 50% stenosis is only 50%.

- If coronary calcium scanning is applied inappropriately, the proof of coronary calcium may lead to unnecessary increase of diagnostic catheterisations.

New imaging methods

- Atherosclerosis in often advanced before the first clinical manifestation such as sudden death, myocardial infarction or stroke. Therefore it is logical to seek easy and reliable methods to detect sub clinical disease.
- Criteria for accepting the clinical utility of new imaging techniques have been defined; clinical benefit without harm is required.
- MR imaging of carotid and coronary plaque is possible but remains a research tool thus far.
- Multi-slice CT coronary arteriography has a high negative predictive value. The presence of coronary calcium seems to add independent prognostic information, especially in medium risk subjects, but may also lead to unnecessary tests and interventions.
- Ultrasound carotid intima-media thickness appears to allow a modest improvement in risk estimation after allowing for conventional risk factors; the hazard ratio may be greater in women. Meticulous technique is required.
- Ankle-brachial index is easy, cheap and inexpensive and relates strongly to future CVD. It deserves further study to define its role in risk estimation.

Circulation announces it will not publish statement on coronary calcium scanning

8 October 2004

- An announcement from *Circulation: Journal of the American Heart Association* (AHA) states that the journal will not after all publish a statement that was prepared for it on coronary calcium screening. The decision by editor-in-chief **Dr Joseph Loscalzo** comes after publication of a story in the *Wall Street Journal* and subsequently other news outlets that indicated the AHA would be changing its position on the use of coronary calcium scanning
- “Just today, I received a letter from a physician who is trying to sell me previously owned EBCT scanners. And he's basing this letter, which is clearly being written to many other people besides myself, on the fact that the AHA is now endorsing this product."

AHA/ACC release consensus statement on EBCT, but the writing group is still sharply divided. 30 June 2000.

- Diversity of opinion actually led to the resignation of one of the committee members dissatisfied with the process.

- "When you go to Chicago and it's advertised every half hour to the lay public; when you go to southern California and everybody over age 20 gets a letter saying you should have one of these ... who knows?" (O' Rourke)

- Because of his outspoken stand against what he sees as the misuse of this testing, O'Rourke claims to have received "boxes and boxes of hate mail, from supposed people who say they have had their life saved by EBCT."

Annual Progression of Coronary Calcification in Trials of Preventive Therapies

A Systematic Review

Peter A. McCullough, MD, MPH; Kavitha M. Chinnaiyan, MD

Background: Coronary artery calcification (CAC) measured by computed tomography is radiographic confirmation of atherosclerosis, predicts cardiovascular events, and has been evaluated as a surrogate measure in randomized trials.

Methods: We performed a literature search for prospective randomized trials in which CAC was measured at baseline and at 1 year or more of follow-up. We computed the weighted mean annualized rate of CAC progression for a variety of therapies tested in these trials.

Results: Ten trials (n=2612) met our criteria and were included. Electron-beam, double-helix, and multislice computed tomography were used in 6, 2, and 2 trials, respectively. Agatston (8 trials) and volumetric (2 trials) methods were used for CAC evaluation. In 5 trials in subjects with cardiovascular disease (CVD) (n=2135; age, ~64 years; ~39% women; follow-up, ~26 months), therapies included statins (n=1370), placebo (n=564), and antihypertensives (n=201). In 5 trials in subjects with chronic kidney disease (n=477; age, ~55 years; ~34% women; follow-up, ~14 months), interventions included low-phosphorus diet (n=29), sevelamer hydrochloride (n=229), and calcium-based phosphate binders (n=219). The mean (SD) weighted annualized CAC increase overall and in patients with CVD and chronic kidney disease was 17.2% (6.7%), 16.9% (5.2%), and 18.4 (11.1%), respectively ($P<.001$). The rate among those assigned blinded placebo was 14.6% (1.0%) (2 trials). There was no consistent or reproducible treatment effect of any therapy on this outcome measured at 1 year.

Conclusion: The 1-year change in CAC does not appear to be a suitable surrogate end point for treatment trials in patients with CVD or chronic kidney disease.

Arch Intern Med. 2009;169(22):2064-2070

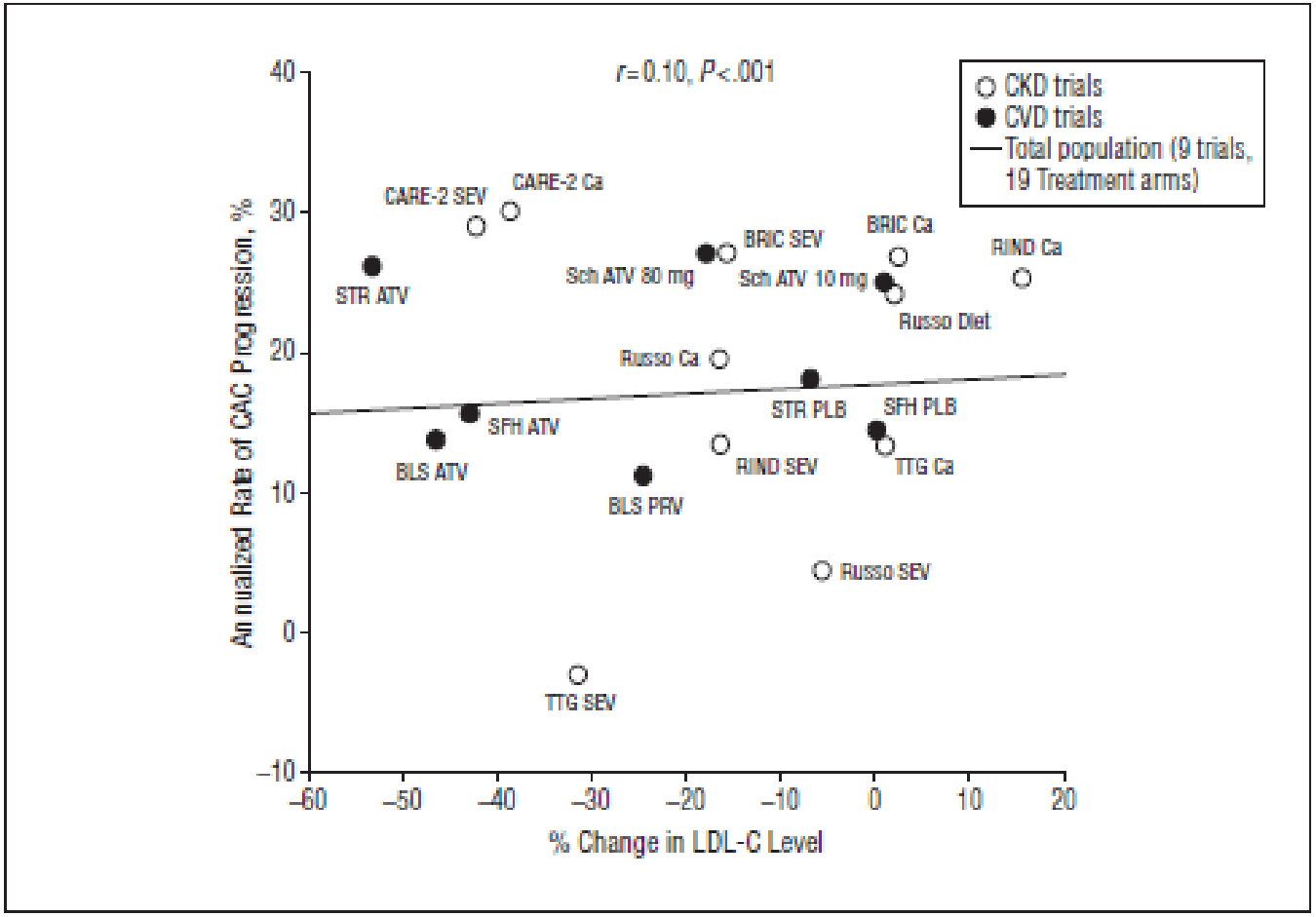


Figure 4. Scatterplot of the low-density lipoprotein cholesterol (LDL-C) reduction and the weighted mean annual change in coronary artery calcification (CAC) in 9 trials with 19 treatment groups in whom baseline and follow-up LDL-C levels were reported. See the legend to Figure 3 for expansion of abbreviations.

A Double Take on Serial Measurement of Coronary Artery Calcification

The answer to the problem of rescanning in the community, though, is to stop the current practice of initial screening first. Since it seems that the medical community is unwilling to self-regulate in this probably enormously wasteful endeavor, it will require policy makers to be more forceful in reining in the madness, whether it be the Food and Drug Administration or financiers of health care. To be fair, there are strong logic, rationale, and even promise for this technology, but any further resources invested in this area should first go to large randomized clinical trials to prove its clinical impact. Those trials that use change in calcification scores as a marker for atherosclerosis progression should clearly be using longer intervals than 1 year (likely at least 3 years) for repeated measurements.

Coronary Artery Calcification Screening

Estimated Radiation Dose and Cancer Risk

Kwang Pyo Kim, PhD; Andrew J. Einstein, MD, PhD; Amy Berrington de González, DPhil

Background: Multidetector computed tomography has been proposed as a tool for routine screening for coronary artery calcification in asymptomatic individuals. As proposed, such screening could involve tens of millions of individuals, but detailed estimates of radiation doses and potential risk of radiation-induced cancer are not currently available. We estimated organ-specific radiation doses and associated cancer risks from coronary artery calcification screening with multidetector computed tomography according to patient age, frequency of screening, and scan protocol.

Methods: Radiation doses delivered to adult patients were calculated from a range of available protocols using Monte Carlo radiation transport. Radiation risk models, derived using data from Japanese atomic bomb survivors and medically exposed cohorts, were used to estimate the excess lifetime risk of radiation-induced cancer.

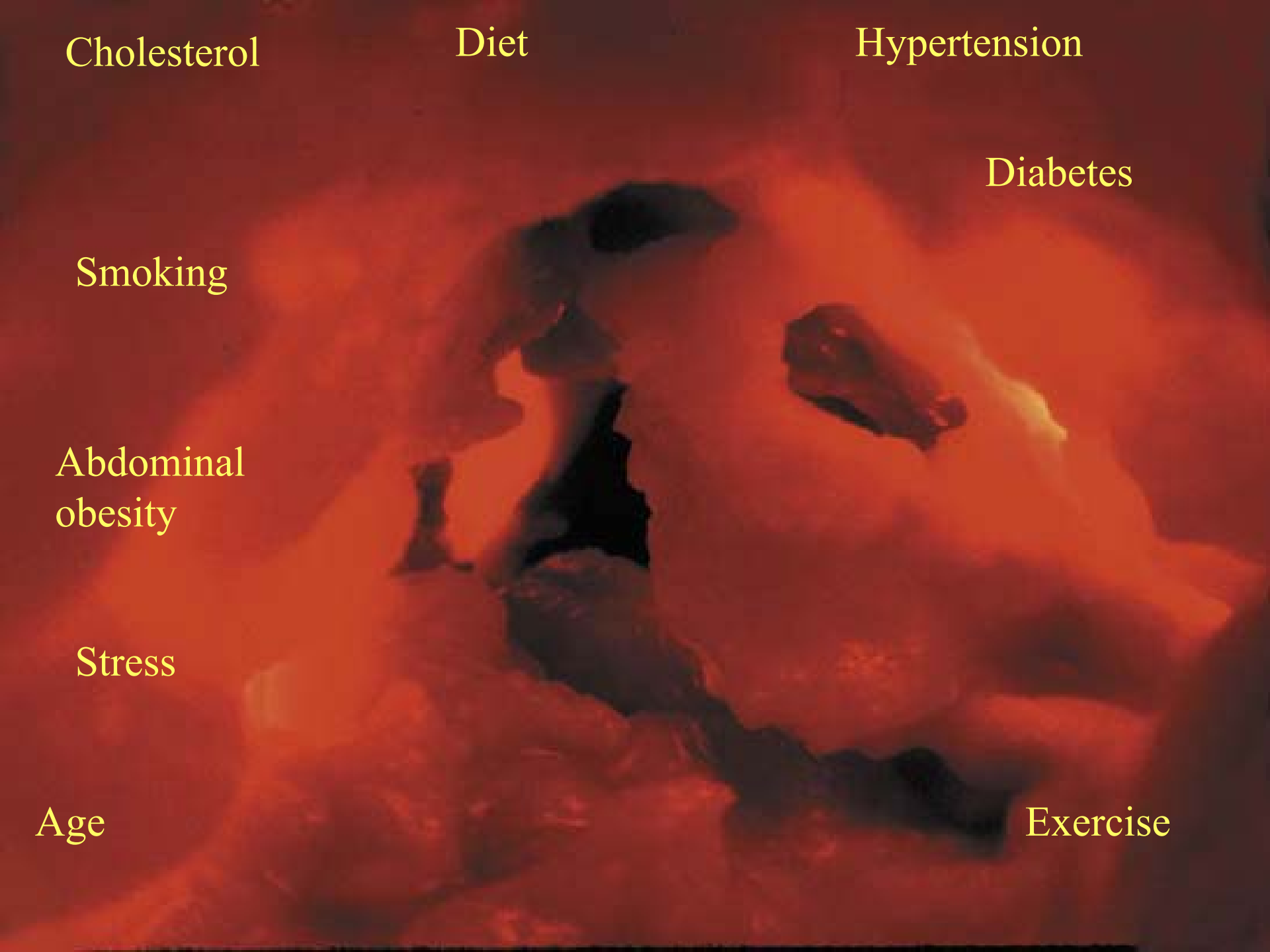
Results: The radiation dose from a single coronary artery calcification computed tomographic scan varied more than 10-fold (effective dose range, 0.8-10.5 mSv) depending on the protocol. In general, higher radiation doses were associated with higher x-ray tube current, higher tube potential, spiral scanning with low pitch, and retrospective gating. The wide dose variation also resulted in wide variation in estimated radiation-induced cancer risk. Assuming screening every 5 years from the age of 45 to 75 years for men and 55 to 75 years for women, the estimated excess lifetime cancer risk using the median dose of 2.3 mSv was 42 cases per 100 000 men (range, 14-200 cases) and 62 cases per 100 000 women (range, 21-300 cases).

Conclusions: These radiation risk estimates can be compared with potential benefits from screening, when such estimates are available. Doses and therefore risks can be minimized by the use of optimized protocols.

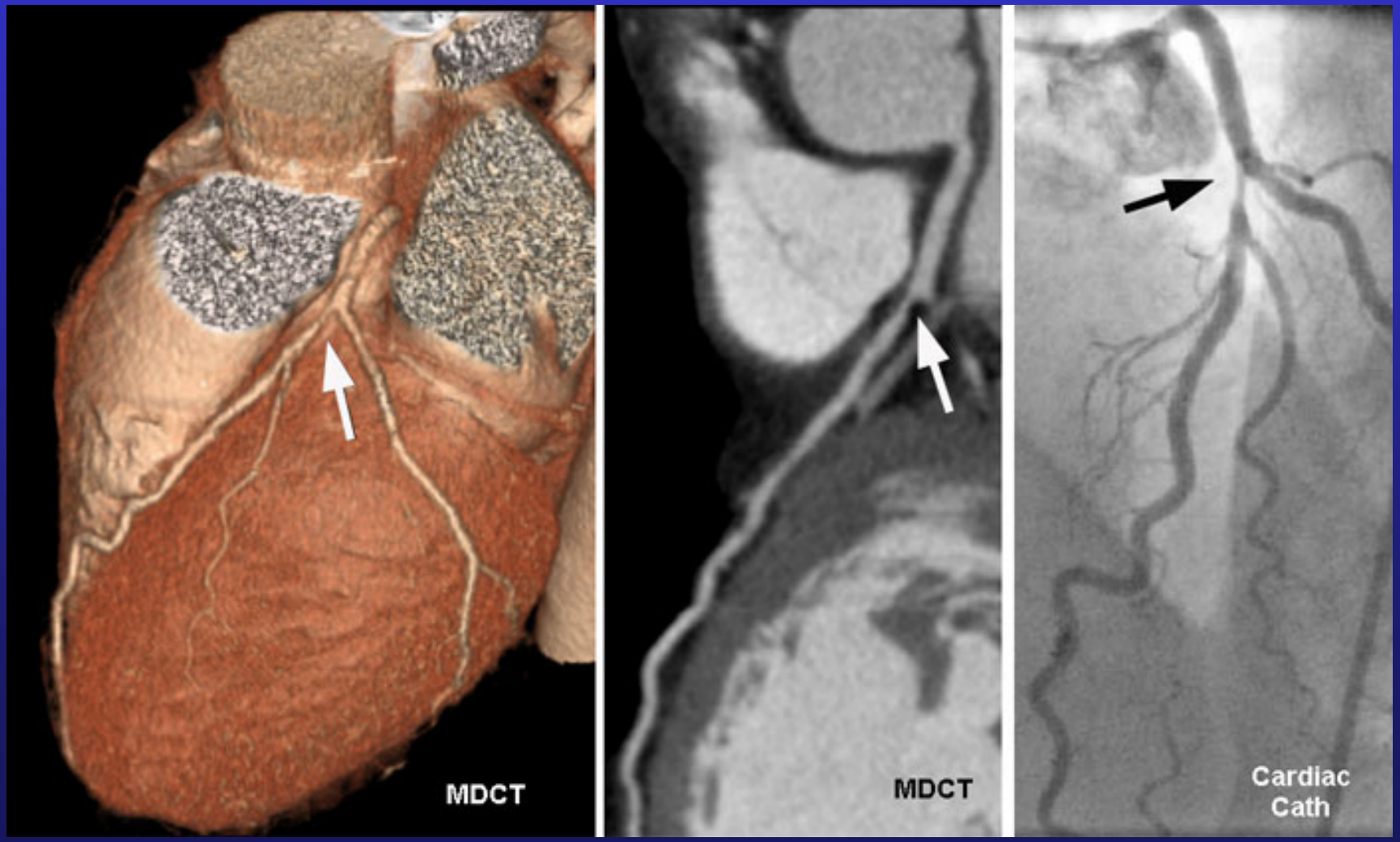
Arch Intern Med. 2009;169(13):1188-1194

Coronary artery calcification Conclusions

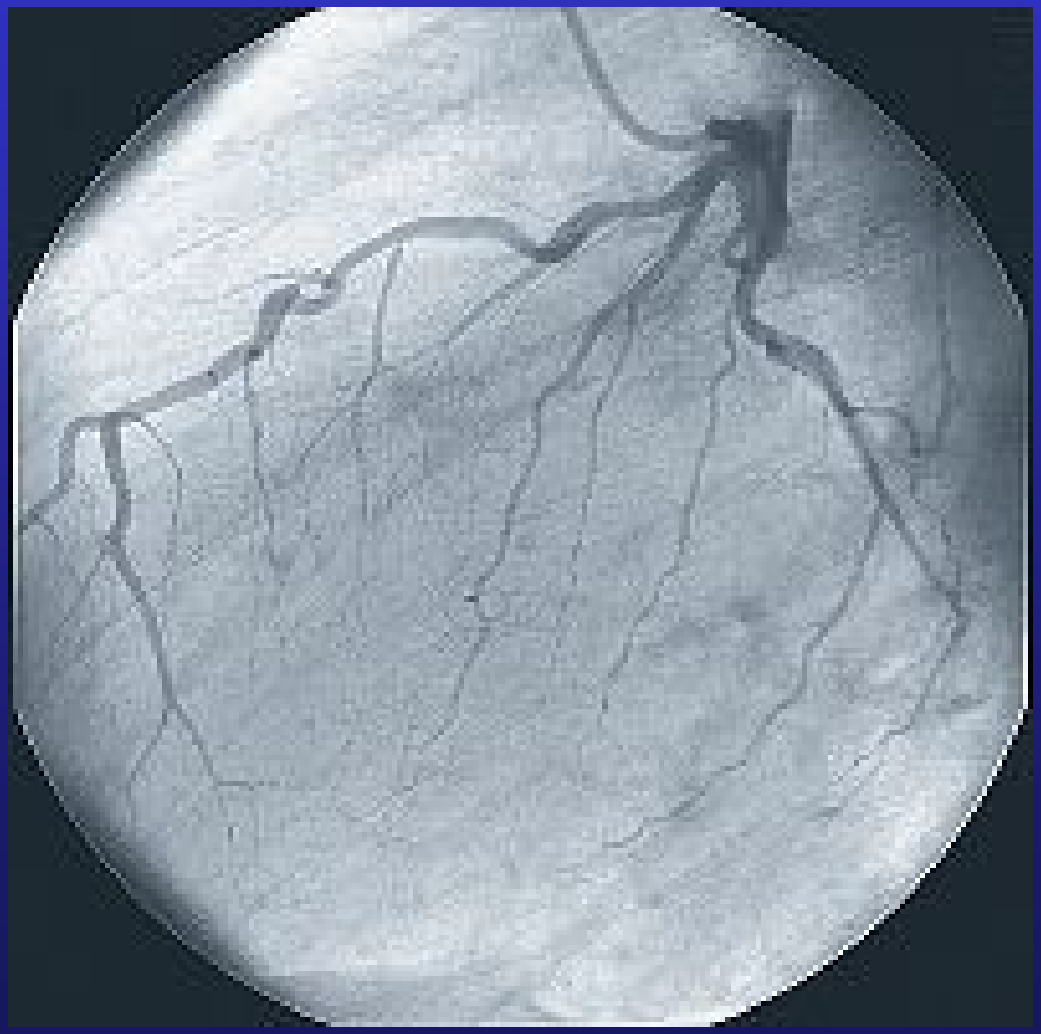
- Correlates with plaque burden and CHD risk
- Poorly correlated with risk factors and presence of obstruction
- Is an independent marker of CHD events
- Mostly recommended for subjects at intermediate risk according to clinical criteria
- Low risk of events at short term for CAC=0
- Treat aggressively high calcium burdens !


Cholesterol
Diet
Hypertension
Diabetes
Smoking
Abdominal obesity
Stress
Age
Exercise

CARDIAC CT ANGIOGRAPHY



GOLD STANDARD: CORONARY ANGIOGRAPHY



CORONARY CATHETERIZATION

- 1999—1.83 million catheterizations in the United States and the number is increasing abundantly.
- Approximately 1/3 require intervention and as many as 50% of diagnostic catheterization studies show no significant coronary disease.

CORONARY CATHETERIZATION CONT.

PROS

- High resolution
- Option for intervention

CONS

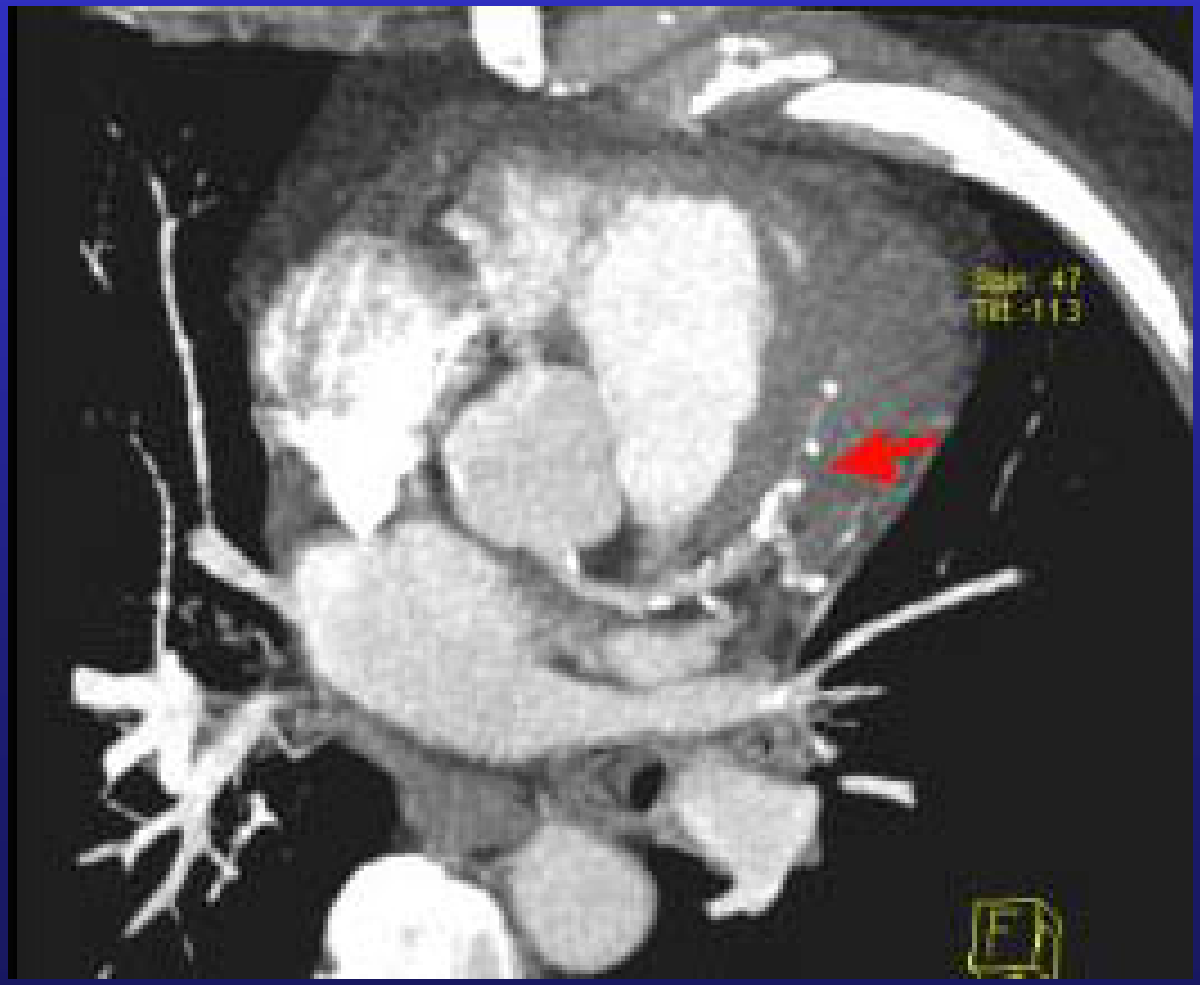
- X-ray exposure
- Hospitalization
- Invasive complications

ANOTHER WAY?

- Estimated more than 40% of invasive coronary angiograms are not followed up by subsequent interventional or surgical therapy, but are done to rule out coronary artery disease.
- Can multidetector CT serve as a non-invasive quick study?

  - Especially in atypical chest pain without a significant CAD history?

EMERGING FIELD OF CARDIAC CT



Technique

- +/- Beta-blocker→HR < 70 optimal for 16 head scanner. Otherwise no patient preparation.
- Visipaque intravenous contrast 100-120 cc.
- Do with retrospective gating from carina through base of heart.
- Scan usually goes from carina through base of heart. Involves < 25 second breath hold.
- Timing (bolus pro) - scan starts as contrast reaches the aortic root.
- Reconstruct at ~ 8 phases. Usually 75% is best for visualizing coronary arteries.

Original Article

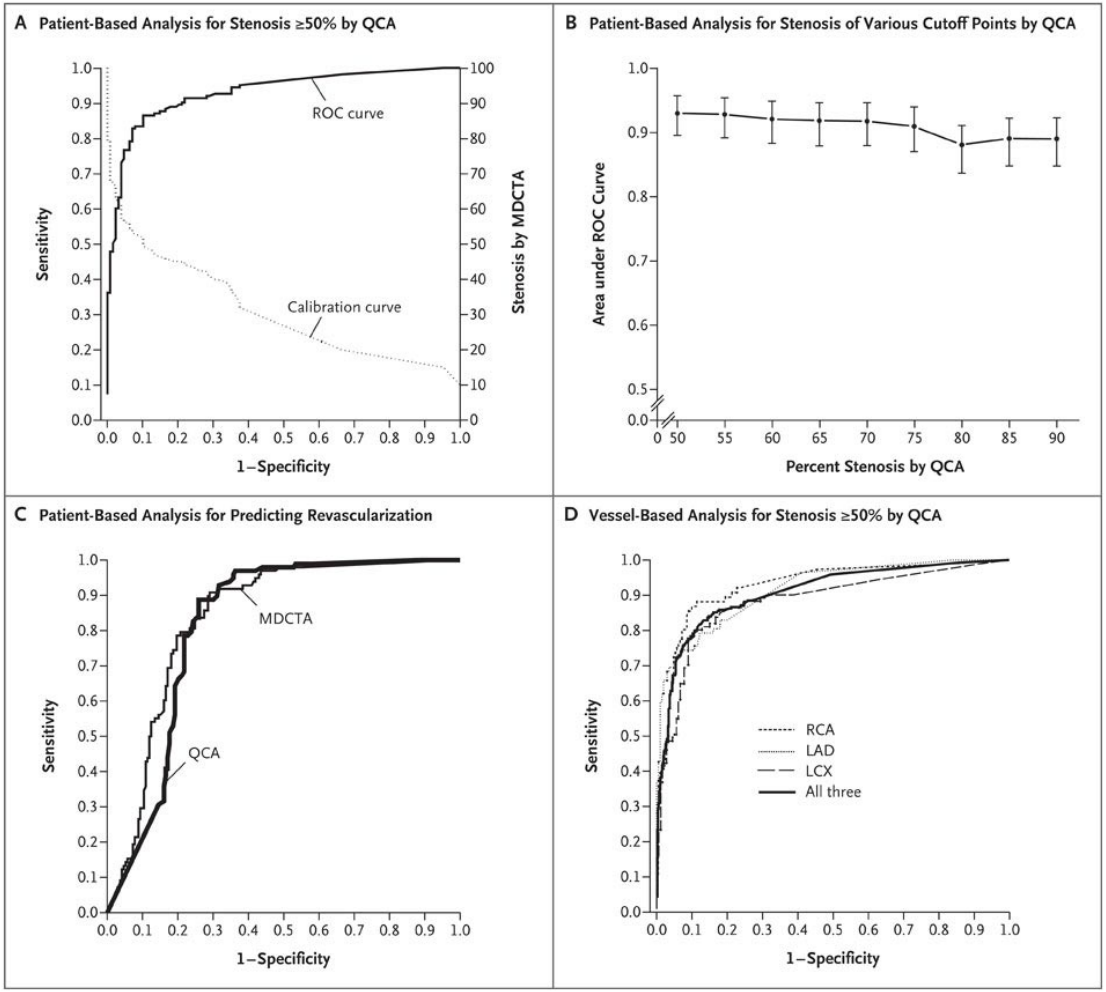
Diagnostic Performance of Coronary Angiography by 64-Row CT

Julie M. Miller, M.D., Carlos E. Rochitte, M.D., Marc Dewey, M.D., Armin Arbab-Zadeh, M.D., Hiroyuki Niinuma, M.D., Ph.D., Ilan Gottlieb, M.D., Narinder Paul, M.D., Melvin E. Clouse, M.D., Edward P. Shapiro, M.D., John Hoe, M.D., Albert C. Lardo, Ph.D., David E. Bush, M.D., Albert de Roos, M.D., Christopher Cox, Ph.D., Jeffery Brinker, M.D., and João A.C. Lima, M.D.

N Engl J Med
Volume 359(22):2324-2336
November 27, 2008

The NEW ENGLAND JOURNAL of MEDICINE

Diagnostic Performance of 64-Row Multidetector Computed Tomographic Angiography (MDCTA)



Miller JM et al. N Engl J Med 2008;359:2324-2336

Diagnostic Accuracy of 64-Row Multidetector CT Angiography (MDCTA) for Patient- and Vessel-Based Detection of Coronary Stenosis of ≥50%

Table 4. Diagnostic Accuracy of 64-Row Multidetector CT Angiography (MDCTA) for Patient- and Vessel-Based Detection of Coronary Stenosis of ≥50%.*

Measure of Accuracy	Patient-Based Detection				
	Quantitative MDCTA (N=291)	Visual MDCTA (N=291)			
AUC — median (95% CI)	0.93 (0.90–0.96)	0.93 (0.89–0.95)			
Stenosis by CCA — no.	163	163			
Stenosis by MDCTA — no.	152	146			
False positive — no.	13	11			
False negative — no.	24	28			
Sensitivity — % (95% CI)	85 (79–90)	83 (76–88)			
Specificity — % (95% CI)	90 (83–94)	91 (85–96)			
Positive predictive value — % (95% CI)	91 (86–95)	92 (87–96)			
Negative predictive value — % (95% CI)	83 (75–89)	81 (73–87)			
	Vessel-Based Detection†				
	Three-Vessel Quantitative MDCTA (N=866)	Three-Vessel Visual MDCTA (N=868)	LM–LAD (N=291)	LCX (N=288)	RCA (N=287)
AUC — median (95% CI)	0.91 (0.89–0.93)	0.90 (0.88–0.93)	0.88 (0.84–0.92)	0.92 (0.88–0.95)	0.93 (0.89–0.95)
Stenosis by CCA — no.	269	271	111	82	76
Stenosis by MDCTA — no.	247	243	110	73	64
False positive — no.	44	41	21	13	10
False negative — no.	66	69	22	22	22
Sensitivity — % (95% CI)	75 (69–81)	75 (68–80)	80 (72–87)	73 (63–82)	71 (60–80)
Specificity — % (95% CI)	93 (90–94)	93 (91–95)	88 (83–92)	94 (89–96)	95 (91–97)
Positive predictive value — % (95% CI)	82 (77–86)	83 (78–87)	81 (72–87)	82 (72–89)	84 (73–91)
Negative predictive value — % (95% CI)	89 (86–92)	89 (86–91)	88 (82–92)	90 (85–93)	90 (85–93)

* AUC denotes area under the receiver-operator-characteristic curve, CCA conventional coronary angiography, LCX left circumflex artery, LM–LAD left main and left anterior descending coronary arteries, and RCA right coronary artery.
† Of the 868 vessels analyzed visually, 866 could be analyzed with the use of quantitative conventional coronary angiography (defined here as quantitative coronary angiography).

Miller JM et al. N Engl J Med 2008;359:2324-2336

Conclusion

- Multidetector CT angiography accurately identifies the presence and severity of obstructive coronary artery disease and subsequent revascularization in symptomatic patients
- The negative and positive predictive values indicate that multidetector CT angiography cannot replace conventional coronary angiography at present

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

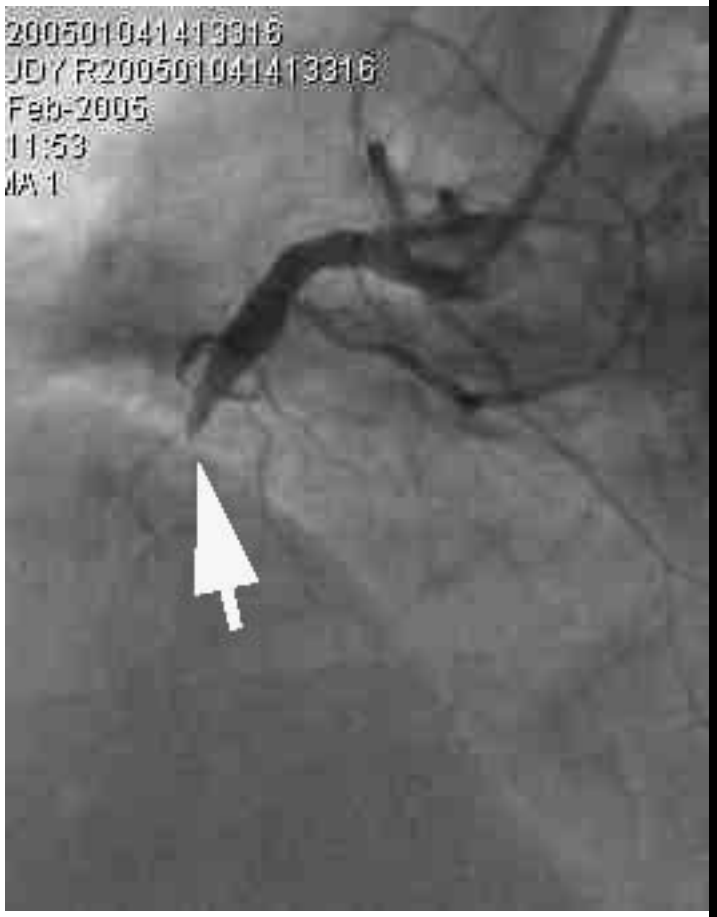
Ronen Rubinshtein, MD; David A. Halon, MB, ChB; Tamar Gaspar, MD; Ronen Jaffe, MD; Basheer Karkabi, MD; Moshe Y. Flugelman, MD; Asia Kogan, MD; Reuma Shapira, MD; Nathan Peled, MD; Basil S. Lewis, MD, FRCP

Background—Multidetector computed tomography (MDCT) has high diagnostic value for detecting or excluding coronary artery stenosis. We examined performance characteristics of MDCT for diagnosing or excluding an acute coronary syndrome in patients presenting to the emergency department (ED) with possible ischemic chest pain and examined relation to clinical outcome during a 15-month follow-up period.

Methods and Results—We prospectively studied 58 patients (56±10 years of age, 36% female) with chest pain possibly ischemic in origin and no new ECG changes or elevated biomarkers. The patients underwent 64-slice contrast-enhanced MDCT, which showed normal coronary vessels (no or trivial atheroma) in 15 patients, nonobstructive plaque in 20 (MDCT-negative patients), and obstructive coronary disease (≥50% luminal narrowing) in 23 (MDCT-positive group). By further investigation (new elevation of cardiac biomarkers, abnormal myocardial perfusion scintigraphy, and/or invasive angiography), acute coronary syndrome was diagnosed in 20 of the 23 MDCT-positive patients (ED MDCT sensitivity 100% [20/20], specificity 92% [35/38], positive predictive value 87% [20/23], negative predictive value 100% [35/35]). During a 15-month follow-up period, no deaths or myocardial infarctions occurred in the 35 patients discharged from the ED after initial triage and MDCT findings. One patient underwent late percutaneous coronary intervention (late major adverse cardiovascular events rate, 2.8%). Overall, ED MDCT sensitivity for predicting major adverse cardiovascular events (death, myocardial infarction, or revascularization) during hospitalization and follow-up was 92% (12/13), specificity was 76% (34/45), positive predictive value was 52% (12/23), and negative predictive value was 97% (34/35).

Conclusions—We found that 64-slice cardiac MDCT is a potentially valuable diagnostic tool in ED patients with chest pain of uncertain origin, providing early direct noninvasive visualization of coronary anatomy. ED MDCT had high positive predictive value for diagnosing acute coronary syndrome, whereas a negative MDCT study predicted a low rate of major adverse cardiovascular events and favorable outcome during follow-up. (*Circulation*. 2007;115:&NA;-.)

Key Words: angina ■ diagnosis ■ imaging ■ angiography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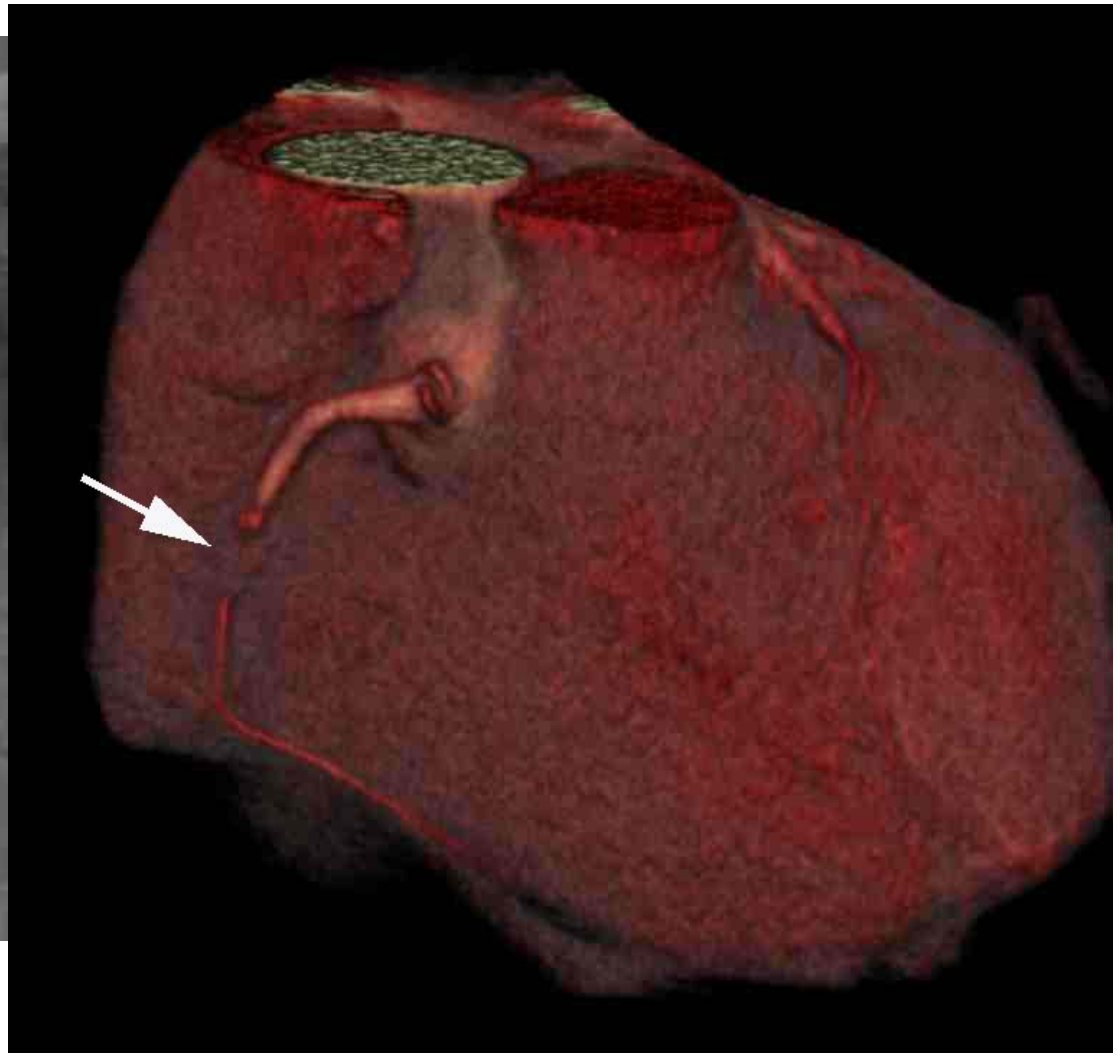

New Technology for Noninvasive Evaluation of Coronary Artery Disease

Marcelo F. Di Carli, MD; Rory Hachamovitch, MD, MSc

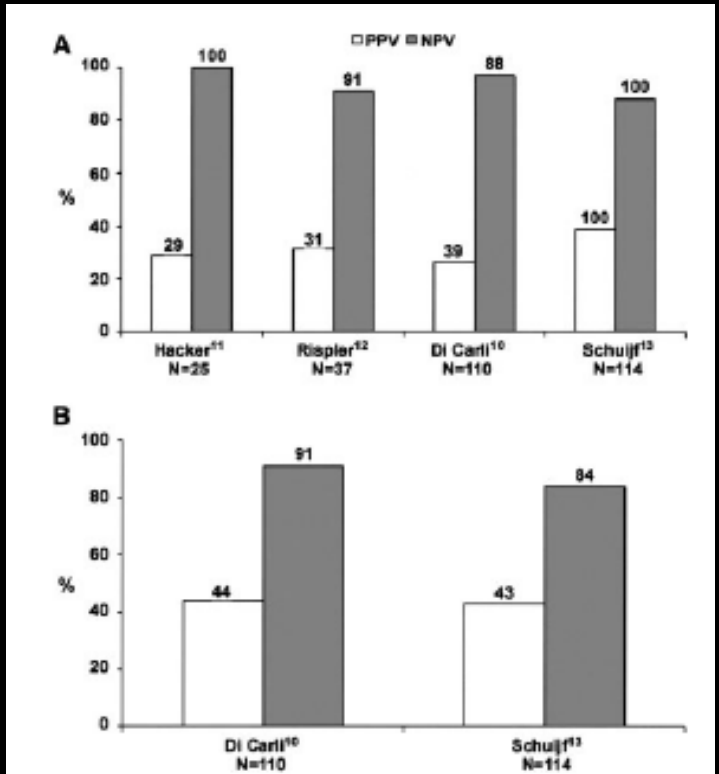

Figure 3. Frequency of inducible ischemia by myocardial perfusion imaging in territories supplied by stenosis >50% on CTA. A, Per-vessel analysis; B, per-patient analysis.

Projected Cancer Risks From Computed Tomographic Scans Performed in the United States in 2007

Amy Berrington de González, DPhil; Mahadevappa Mahesh, MS, PhD; Kwang-Pyo Kim, PhD; Mythreyi Bhargavan, PhD; Rebecca Lewis, MPH; Fred Mettler, MD; Charles Land, PhD

Background: The use of computed tomographic (CT) scans in the United States (US) has increased more than 3-fold since 1993 to approximately 70 million scans annually. Despite the great medical benefits, there is concern about the potential radiation-related cancer risk. We conducted detailed estimates of the future cancer risks from current CT scan use in the US according to age, sex, and scan type.

Methods: Risk models based on the National Research Council's "Biological Effects of Ionizing Radiation" report and organ-specific radiation doses derived from a national survey were used to estimate age-specific cancer risks for each scan type. These models were combined with age- and sex-specific scan frequencies for the US in 2007 obtained from survey and insurance claims data. We estimated the mean number of radiation-related incident cancers with 95% uncertainty limits (UL) using Monte Carlo simulations.

Results: Overall, we estimated that approximately 29 000 (95% UL, 15 000-45 000) future cancers could be related to CT scans performed in the US in 2007. The largest contributions were from scans of the abdomen and pelvis (n=14 000) (95% UL, 6900-25 000), chest (n=4100) (95% UL, 1900-8100), and head (n=4000) (95% UL, 1100-8700), as well as from chest CT angiography (n=2700) (95% UL, 1300-5000). One-third of the projected cancers were due to scans performed at the ages of 35 to 54 years compared with 15% due to scans performed at ages younger than 18 years, and 66% were in females.

Conclusions: These detailed estimates highlight several areas of CT scan use that make large contributions to the total cancer risk, including several scan types and age groups with a high frequency of use or scans involving relatively high doses, in which risk-reduction efforts may be warranted.

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Perspective
AUGUST 27, 2009

Elements of Danger — The Case of Medical Imaging

Michael S. Lauer, M.D.

steps. First, we must approach imaging with the same humility with which others in our profession approached experimental methods for treating acute coronary syndromes and other conditions that today have a strong evidence base. We have come a long way since the time when the primary management of acute myocardial infarction was prophylactic lidocaine. Many of the interventions that we now consider standard do come with their own elements of danger, but we can feel comfortable recommending them because a large body of data from well-powered randomized trials has clearly shown a net benefit.

Ionizing Radiation in Cardiac Imaging: A Science Advisory From the American Heart Association Committee on Cardiac Imaging of the Council on Clinical Cardiology and Committee on Cardiovascular Imaging and Intervention of the Council on Cardiovascular Radiology and Intervention

Thomas C. Gerber, J. Jeffrey Carr, Andrew E. Arai, Robert L. Dixon, Victor A. Ferrari, Antoinette S. Gomes, Gary V. Heller, Cynthia H. McCollough, Michael F. McNitt-Gray, Fred A. Mettler, Jennifer H. Mieres, Richard L. Morin and Michael V. Yester

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DOI: 10.1161/CIRCULATIONAHA.108.191650

Table 1. Representative Values and Ranges of Effective Dose Estimates Reported in the Literature for Selected Radiological Studies[20]

Examination	Representative Effective Dose Value (mSv)	Range of Reported Effective Dose Values (mSv)	Administered Activity (MBq)
Chest x-ray PA and lateral	0.1	0.05–0.24	NA
CT chest	7	4–18	NA
CT abdominal	8	4–25	NA
CT pelvis	6	3–10	NA
Coronary calcium CT*	3	1–12	NA
Coronary CT angiogram†	16	5–32	NA
64-Slice coronary CTA‡			
Without tube current modulation	15	12–18	NA
With tube current modulation[21]	9	8–18	NA
Dual-source coronary CTA‡			
With tube current modulation	13	6–17	NA
Prospectively triggered coronary CTA‡[22]	3	2–4	NA
Diagnostic invasive coronary angiogram	7	2–16	NA
Percutaneous coronary intervention or radiofrequency ablation	15	7–57	NA
Myocardial perfusion study			
Sestamibi (1-day) stress/rest	9	—	1100
Thallium stress/rest	41	—	185
F-18 FDG	14	—	740
Rubidium-82	5	—	1480

PA indicates posteroanterior; CTA, CT angiography; and FDG, fluorodeoxyglucose; NA, not applicable.

is 41%, and the risk of dying of a malignancy is 21%.[29] Compared with these risks, the relative risk of carcinogenesis resulting from radiation exposure due to a cardiac imaging study is small. Using the example of a typical coronary CT angiogram, the estimated increase in the lifetime risk of dying of a malignancy associated with 10 mSv of ionizing radiation is ≈0.05%. This 0.05% increase in risk is added to the 21% background risk for the US population. More specific estimates for relative risk require the use of estimated organ doses, age- and gender-specific organ radiation risk data, and the intrinsic risk data from the National Cancer Institute, which are stratified for age, race, gender, and type of malignancy.[30]

with appropriate statistics, because there are no prospective, randomized trials that demonstrate that cardiac imaging with ionizing radiation can convey survival benefit.

for example, the rapidly expanding use of cardiac CT[40] conveys individual and societal benefits. The present Writing Group does not endorse screening for heart disease in asymptomatic low-risk patients with imaging modalities that expose asymptomatic individuals to ionizing radiation.

Estimated Radiation Dose Associated With Cardiac CT Angiography

Context Cardiac computed tomography (CT) angiography (CCTA) has emerged as a useful diagnostic imaging modality in the assessment of coronary artery disease. However, the potential risks due to exposure to ionizing radiation associated with CCTA have raised concerns.

Objectives To estimate the radiation dose of CCTA in routine clinical practice as well as the association of currently available strategies with dose reduction and to identify the independent factors contributing to radiation dose.

Design, Setting, and Patients A cross-sectional, international, multicenter, observational study (50 study sites: 21 university hospitals and 29 community hospitals) of estimated radiation dose in 1965 patients undergoing CCTA between February and December 2007. Linear regression analysis was used to identify independent predictors associated with dose.

Main Outcome Measure Dose-length product (DLP) of CCTA.

Results The median DLP of 1965 CCTA examinations performed at 50 study sites was 885 mGy×cm (interquartile range, 568-1259 mGy×cm), which corresponds to an estimated radiation dose of 12 mSv (or 1.2 × the dose of an abdominal CT study or 600 chest x-rays). A high variability in DLP was observed between study sites (range of median DLPs per site, 331-2146 mGy×cm). Independent factors associated with radiation dose were patient weight (relative effect on DLP, 5%; 95% confidence interval [CI], 4%-6%), absence of stable sinus rhythm (10%; 95% CI, 2%-19%), scan length (5%; 95% CI, 4%-6%), electrocardiographically controlled tube current modulation (–25%; 95% CI, –23% to –28%; applied in 73% of patients), 100-kV tube voltage (–46%; 95% CI, –42% to –51%; applied in 5% of patients), sequential scanning (–78%; 95% CI, –77% to –79%; applied in 6% of patients), experience in cardiac CT (–1%; 95% CI, –1% to 0%), number of CCTAs per month (0%; 95% CI, 0%-1%), and type of 64-slice CT system (for highest vs lowest dose system, 97%; 95% CI, 88%-106%). Algorithms for dose reduction were not associated with deteriorated diagnostic image quality in this observational study.

Conclusions Median doses of CCTA differ significantly between study sites and CT systems. Effective strategies to reduce radiation dose are available but some strategies are not frequently used. The comparable diagnostic image quality may support an increased use of dose-saving strategies in adequately selected patients.

JAMA. 2009;301(5):500-507 www.jama.com


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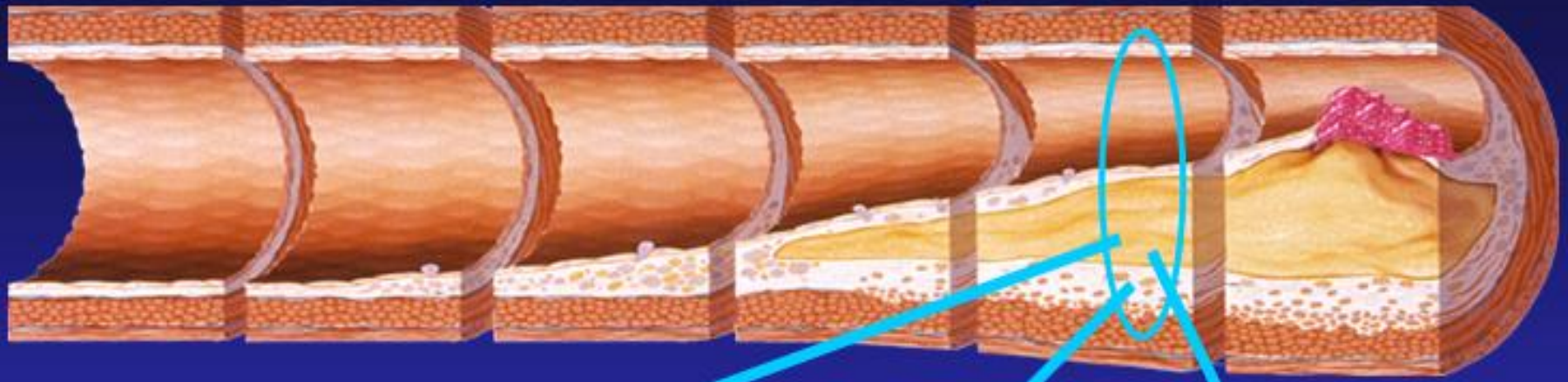
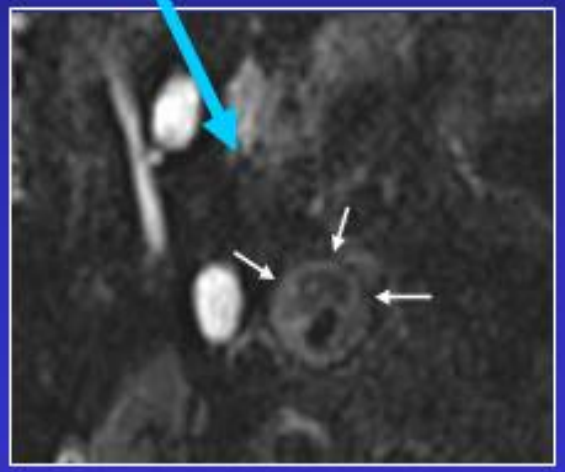
Atheroma plaque: hallmark of atherosclerosis
Noninvasive imaging



Carotid US

MDCT - CAC



MRI

New techniques: Proton MR spectroscopy, PET, PET/CT

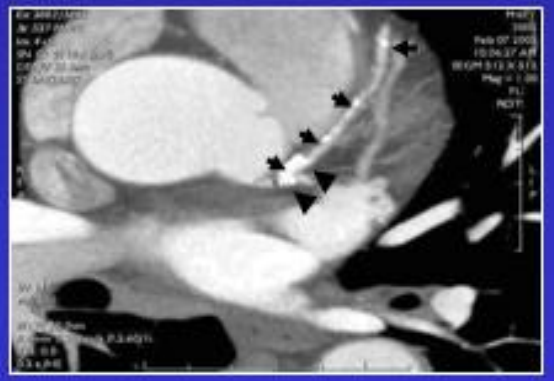
Plaque characterization by noninvasive imaging techniques. US & CT.

- Doppler Color US (carotids, femoral arteries)
  - Composition (hypoechoic vs echogenic)
  - Surface regularity
  - Degree of obstruction

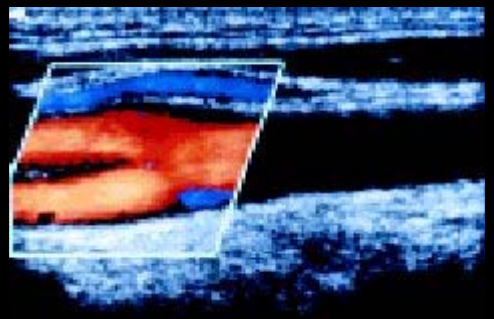
  (available, simple, low-cost, no radiation)

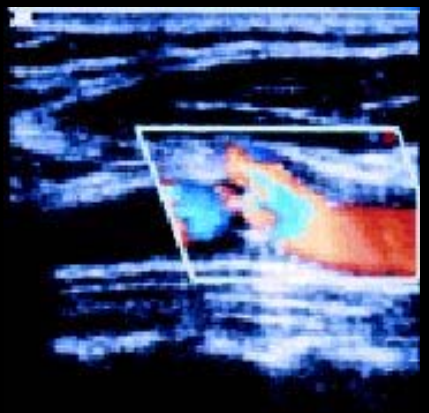
- MDCT (coronary arteries)
  - Plaque burden (calcium score)
  - Soft plaques (angio – selected patients)

  (less available, more complex, expensive, radiation)



- CIMT measured by carotid artery ultrasound[1]
  - SHAPE Task Force: Warranted for screening asymptomatic men 45 to 75 years old and women 55 to 75 years old who are not in the category of very low cardiovascular risk





European Heart Journal (2007) 28, 2967–2971
doi:10.1093/eurheartj/ehm487

Current opinion

Comparative performance of subclinical atherosclerosis tests in predicting coronary heart disease in asymptomatic individuals

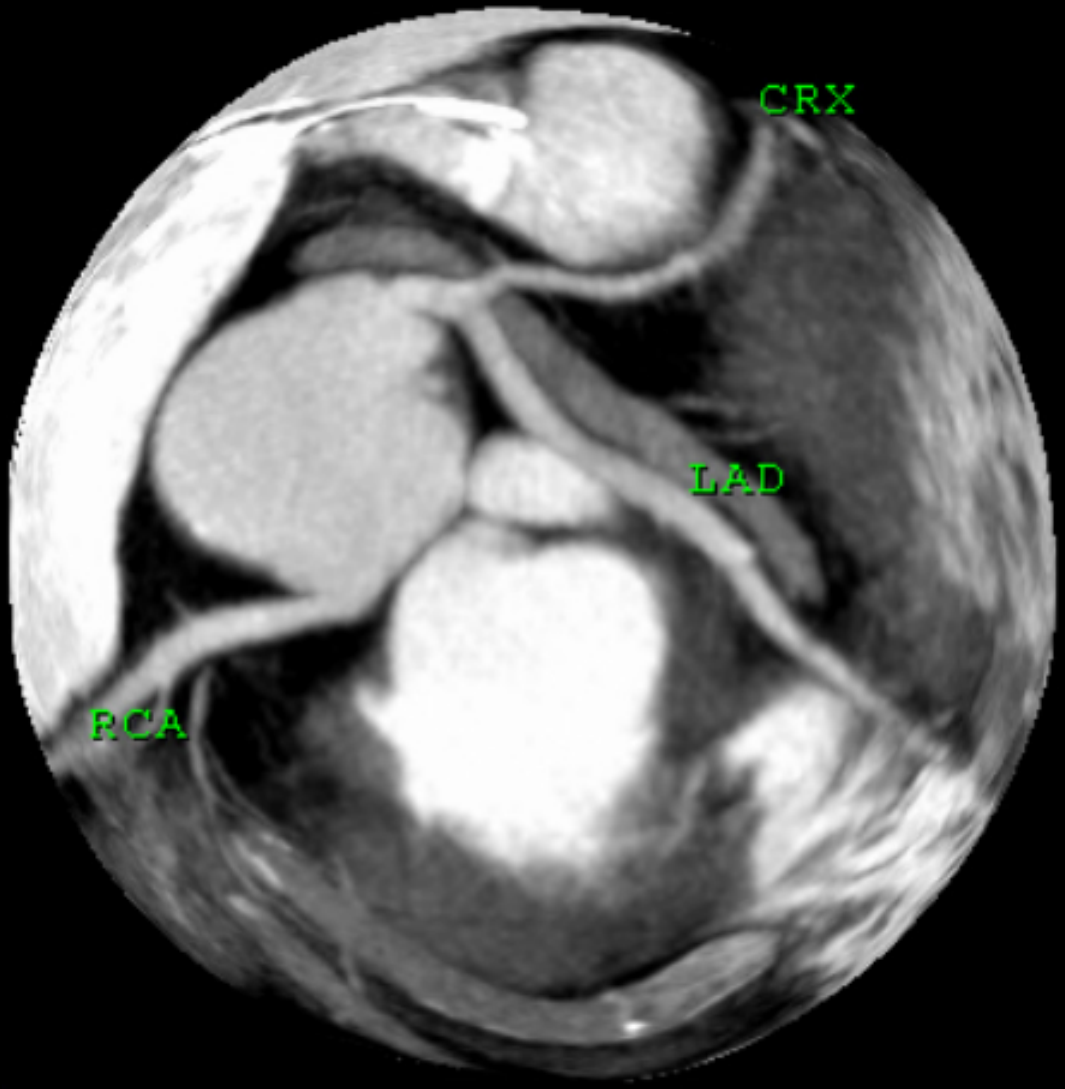
Alain Simon*, Gilles Chironi, and Jaime Levenson

Table 2 Ten-year CHD risk by absence or presence of subclinical atherosclerosis in asymptomatic people

Type of test	Test result	Sex, age (years)	CHD risk (%)	Study
Positive				
Carotid IMT	Overall mean ≥1.13 mm (>95th percentile)	Men, 45–65	14	ARIC[13]
Carotid IMT	Overall mean ≥0.97 mm (>95th percentile)	Women, 45–65	11	ARIC[13]
Carotid IMT	Maximal common ≥1.18 mm (>5th quintile)	Men/women, ≥65	15	CHS[14]
Aortic PWV	>14.6 m/s, males;14.2 m/s, females (>3rd tertile for age and sex)	Men/women, ≥55	13	ROT[18]
Ankle arm index	<0.90	Men/women, ≥65	15	CHS[23]
Carotid plaque	Focal protrusion >1.5 mm or mineralization	Men, 42–60	25	KIHD[15]
Coronary calcium	Total calcium score ≥301	90% men, >45	20	SBHW[16]
Coronary calcium	Total calcium score ≥400	Men/women, 50–70	28	SFHS[17]
Negative				
Carotid IMT	Overall mean <0.67 mm (<1st tertile)	Men, 45–65	3	ARIC[13]
Carotid IMT	Overall mean <0.61 mm, (<1st tertile)	Women, 45–65	1	ARIC[13]
Carotid IMT	Maximal common <0.87 mm (1st quintile)	Men/women, ≥65	4	CHS[14]
Aortic PWV	<12.3 m/s, males; 11.9 m/s, females (<1st tertile for age and sex)	Men/women, ≥55	4	ROT[18]
Ankle–arm index	≥0.90	Men/women, ≥65	8	CHS[23]
Carotid plaque	No discernible plaque nor wall thickening	Men, 42–60	8	KIHD[15]
Coronary calcium	Total calcium score = 0	90% men, >45	6	SBHW[16]
Coronary calcium	Total calcium score = 0	Men/women, 50–70	1	SFHS[17]

CARDIAC CT:

The wave of the future

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The Alexopoulos-Richter Consensus Statements

CAC

- **Χρήσιμη σε ασθενείς ενδιάμεσου κινδύνου με άτυπα συμπτώματα για στεφανιαία νόσο, καθώς η ανίχνευση μικρού CCS τους επανακατατάσσει στην ομάδα χαμηλού κινδύνου**
- **Χαμηλή ειδικότητα, μπορεί να οδηγήσει σε υπερκατανάλωση περαιτέρω διαγνωστικών εξετάσεων**