Cardiovascular Screening in Asymptomatic Adults: Lessons for the Diving World

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Case Presentation: 2004

- 58 yo healthy WM, No Sx
- Multiple cardiac risk factors
  - Family history
  - High blood pressure (Rx'd)
  - High cholesterol (LDL 177)
  - Obesity, High stress, Poor diet
- Statin started, discontinued
- Negative Stress MPI
- CP at rest→ repeat MPI
- Urgent CABG x 4

Another Case: 2008

- 58 yo healthy WM, No Sx
  - HBP, Low HDL, High TG, LVH, overweight, stress
  - Negative yearly stress tests
  - Coronary Ca++ = 210 in 1998
- Clinical risk stratification
  - Framingham Risk <10%
  - Diamond & Forrester - low risk
  - CASS likelihood of CAD – 20%
- LAD plaque rupture; SCD

Another Case: 2010

- 48 yo AA male, No Sx
  - Smoker, high stress
  - Good diet, exercise
  - LDL 138, HDL 62
  - BP 105/62
  - HsCRP 0.015
- ECG, EBCT: ‘normal’
- Outcome??

Cardiovascular Screening

- Principles of screening
- Screening tools and tests
- Current recommendations
- What is being done now in diving?
- Program design issues to consider

WHO Screening Principles

- There should be an important problem
- There should be an accepted treatment
- Facilities must exist for diagnosis and treatment
- There should be a recognizable latent or early symptom stage
- A suitable test or examination must exist
- The test must be acceptable to the population
- The natural history must be understood
- Agreed policy on treatment
- Cost must be related to other medical care expenditure
- There must be a continuing process

Wilson JM. J R Coll Gen Pract. 1968;16 Suppl 2:48-57.

Cardiovascular Screening

- Principles of screening
- Screening tools and tests
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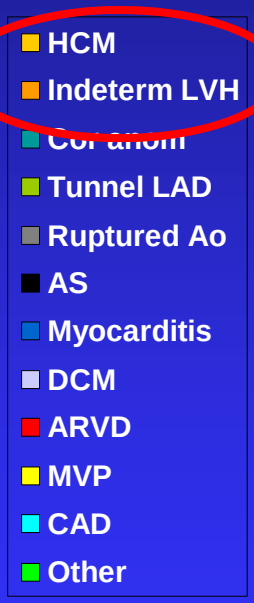
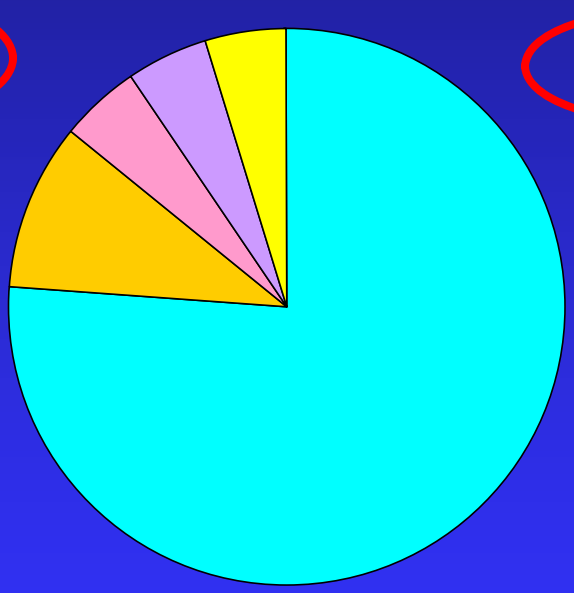
Ideal Screening Tests

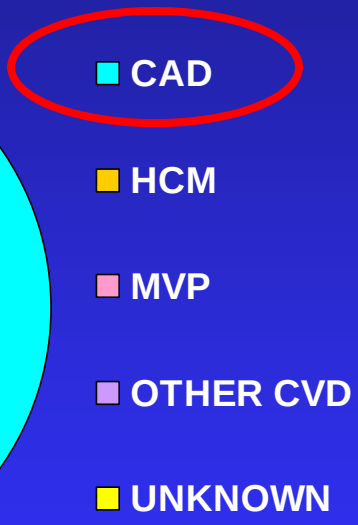
- Easy, inexpensive, and comfortable
- Valid for diagnosis of disease(s) of interest
- High sensitivity / specificity
- Valid for prognosis
- Reliable: Low variability of test results

Lancet 2002 359:881

Causes of Sudden Death in Athletes: What Diseases Are Relevant?







< 35 yo

HCM, LVH ~40% deaths

CAD is rare

>35 yo

CAD ~75% deaths

Two Screening Programs: Focus for Younger Athletes

- Genetic cause
- Structural abnormalities
- Abnormalities are detectable at rest
- Screening approach:
  - History is very important
  - Physical exam for murmurs
- Most screening data in this group

Two Screening Programs: Focus for Older Athletes

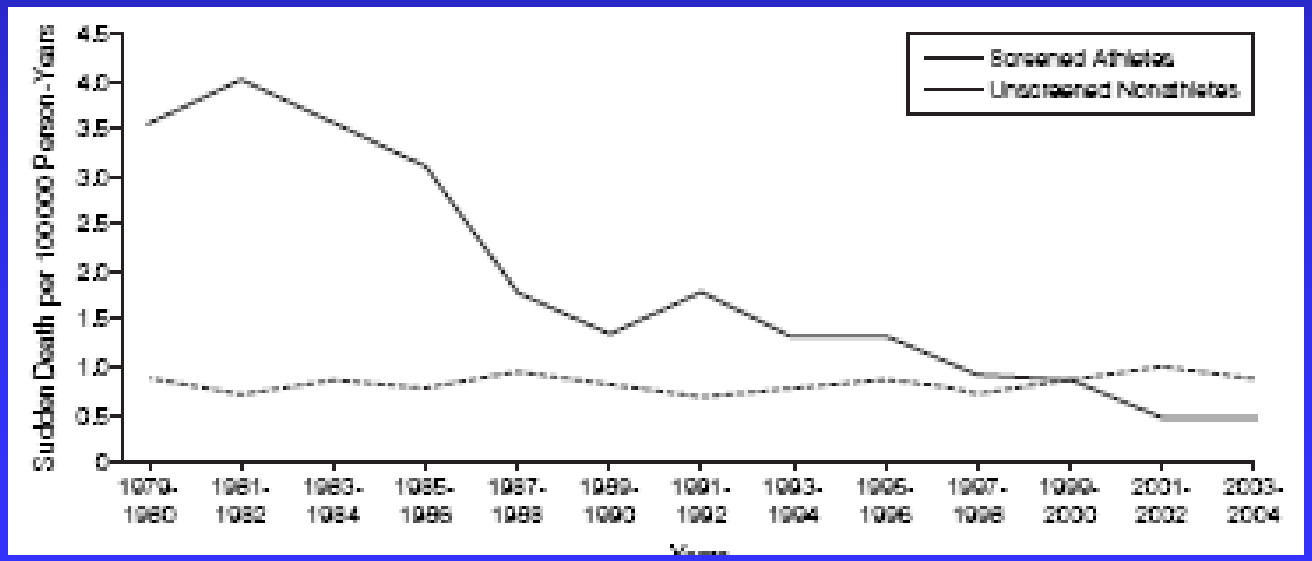
- Multi-factoral cause
- Vascular abnormalities (atherosclerosis)
- Few abnormalities at rest; spontaneous events
- Screening approach:
  - History helpful for RFs
  - Physical exam for BP
  - Current tests are poor for vulnerable plaque
- Little screening data

Screening for Younger Athletes

- Extensive guidelines and experience
- Generally limited to competitive athletes
- Universal: History and physical exam
  - AHA 12 point tool- Pre-participation Checklist
  - Cardiac exam
- Controversial: Testing
  - ECG - required in Europe, not in US
  - Echocardiography - not widely used
- Goals are to detect those who need additional testing…not to diagnose disease.

Additive Value of Pre-Participation ECG

- History and physical exam *plus* ECG
  - Feasibility in US: Cost, qualified practitioners, false (+)s
- Remarkable reduction in SCD in Italy
- Young, competitive athletes



Corrado JAMA 2006;296:1593

Annals of Internal Medicine | ARTICLE

Cardiovascular Screening in College Athletes With and Without Electrocardiography

- 510 Harvard athletes; 11 w Abns ID by Echo
- 5 ID'd by H&P alone (sens 45%, spec 94%)
- 10 ID'd by H&P + ECG (sens 91%; spec 83%)

ARTICLE | Annals of Internal Medicine

Cost-Effectiveness of Preparticipation Screening for Prevention of Sudden Cardiac Death in Young Athletes

- H&P screening (cost $199) adds 2.6 life years per 1000 young athletes; Cost/year = $76,100
- Addn of ECG (cost $89) to screening saves 2 life years; Cost/year = $42,900

AIM 2010 152: 265, & 276

Screening in Older Athletes

- Few guidelines; Limited literature
- Focus on CAD risk
- Universal: History and physical
  - Cardiac symptoms and risk factors
  - Cardiac exam
- Controversial: Testing
  - Several options
  - No consensus
- Goals are to detect those who are at risk for CAD…not to diagnose disease.

NCEP - ATP III: 10 year vs Global Risk Calculation

- 10 year CVD risk calculation
  - FRS: Age, sex, HBP, cholesterol, smoking
  - CAD 'equivalent' - Diabetes or PVD
  - Stroke: Use same risk calculator
- Interventions based on 10 y CVD risk results
  - Low: 10 year risk <10%
    → Reassurance, No further risk assmts for 5 yrs
  - High: 10 year risk >20%
    → Aggressive risk factor modification
  - Intermediate: 10 year risk 10-20%
    → Further tests for reclassification ???

STATE-OF-THE-ART PAPER

JACC
Journal of the American College of Cardiology

Screening for Cardiovascular Risk in Asymptomatic Patients

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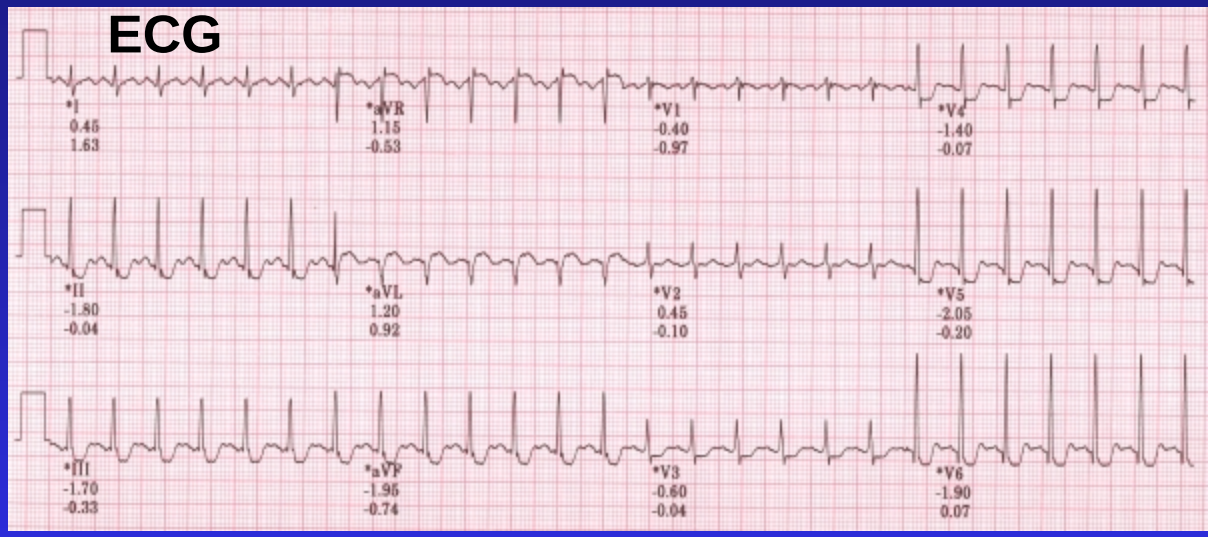
New York, New York; Philadelphia, Pennsylvania; Minneapolis, Minnesota; Chicago, Illinois; and Baltimore, Maryland

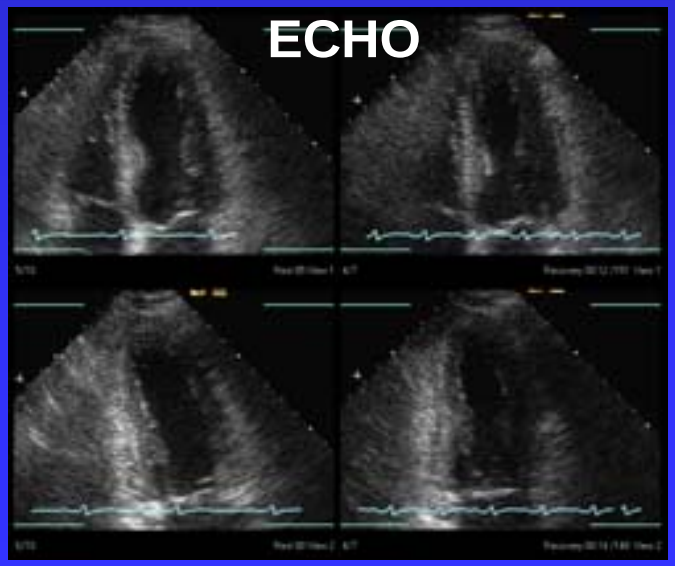
- Clinical case: 56 yo F, s/p CVA, TC 210

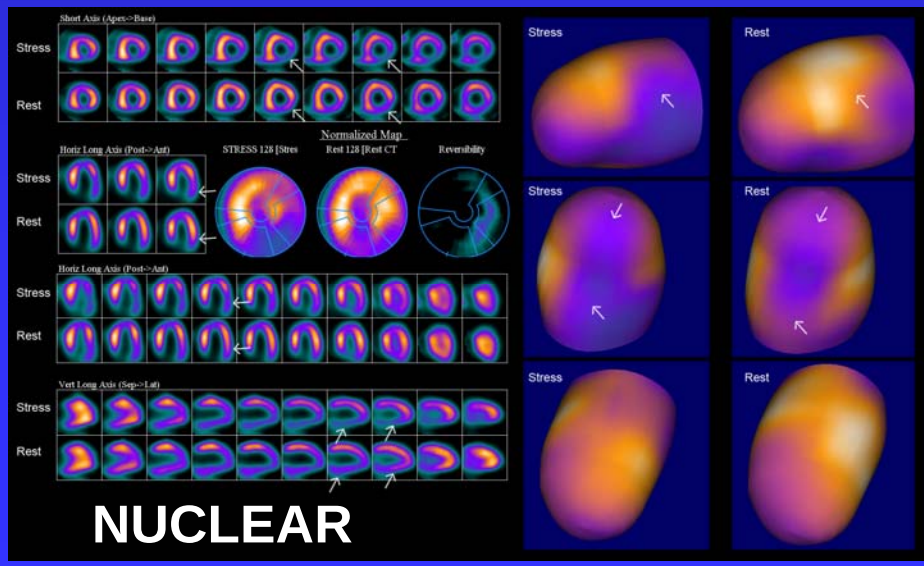
Risk Score	Estimated Risk
Framingham	
10-yr CHD risk score	2%
Global CVD score	10%¶
Heart age/vascular age	73
Reynolds	6%
SCORE (fatal CVD)	1%–2%†
QRISK	11%
ASSIGN	14%
Lifetime risk for CVD	39%

JACC 2010 55:1169

Stress Testing

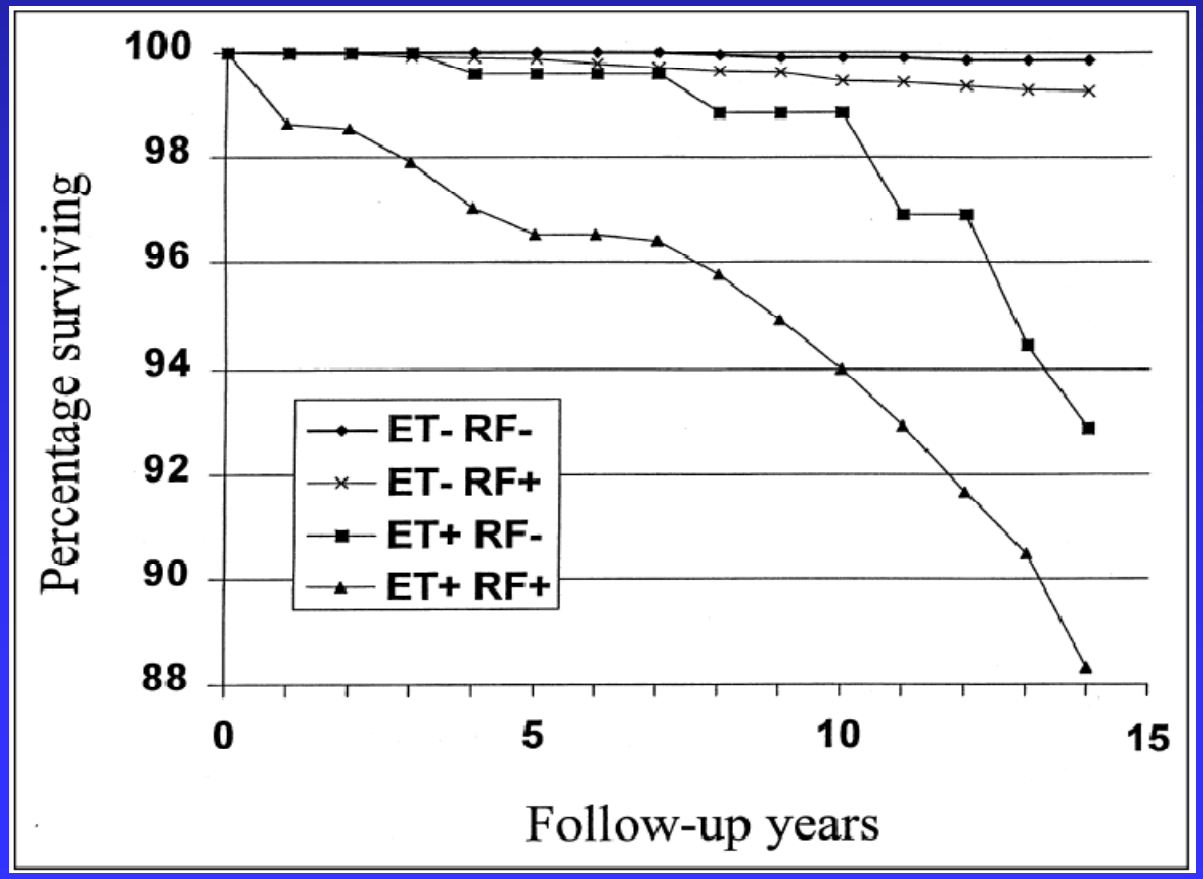






Predictive Value of Screening ETT

- 25,927 healthy men (20-82 yo); 8.4 y f/u
- Positive tests: 6%
- Sensitivity 61%; enhanced in those w RFs



AJC 2000 86:53

ACC/AHA Practice Guidelines

ACC/AHA 2002 Guideline Update for Exercise Testing: Summary Article

In asymptomatic individuals:

Class IIa

1. Evaluation of asymptomatic persons with diabetes mellitus who plan to start vigorous exercise. *(Level of Evidence: C)*

Class IIb

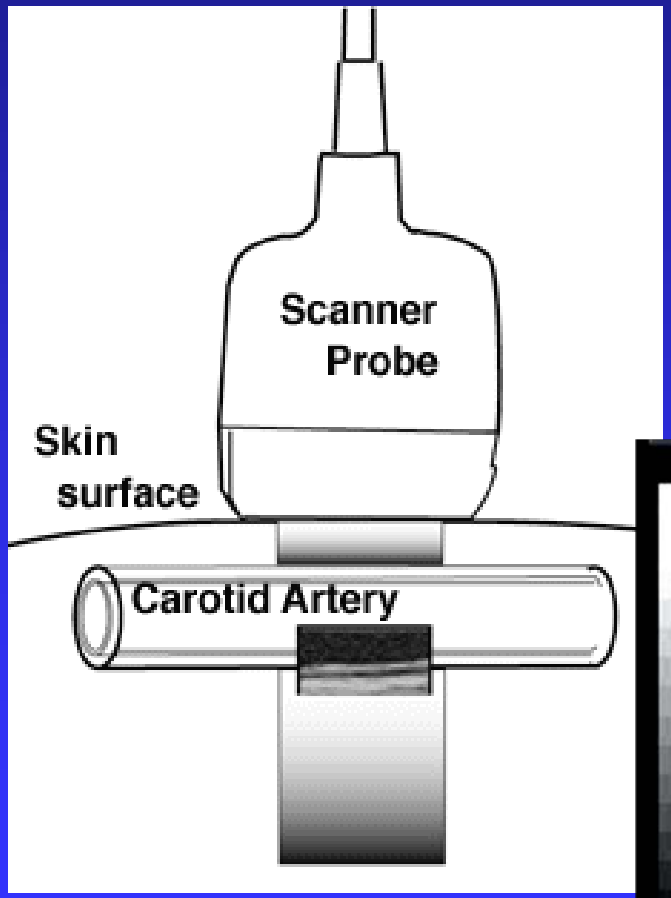
1. Evaluation of asymptomatic men > 45 y, women > 55 y:
   - Who plan to start vigorous exercise (esp if sedentary)
   - With occupations in which impairment might impact public safety

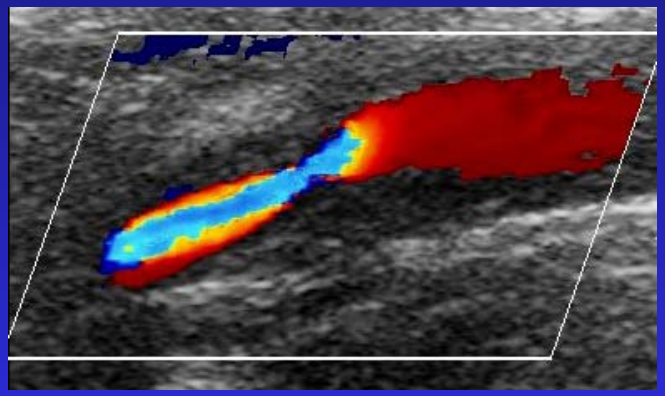
Class III

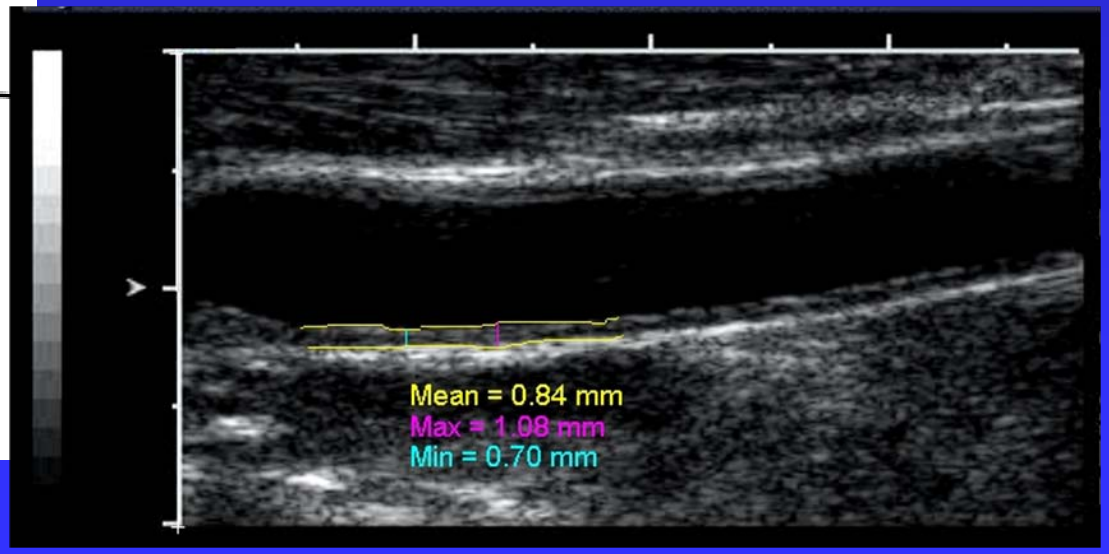
1. Routine screening of asymptomatic men or women.

Circ 2002 106:1883

B-mode Measurement of Carotid Intima-Media Thickness (CIMT)

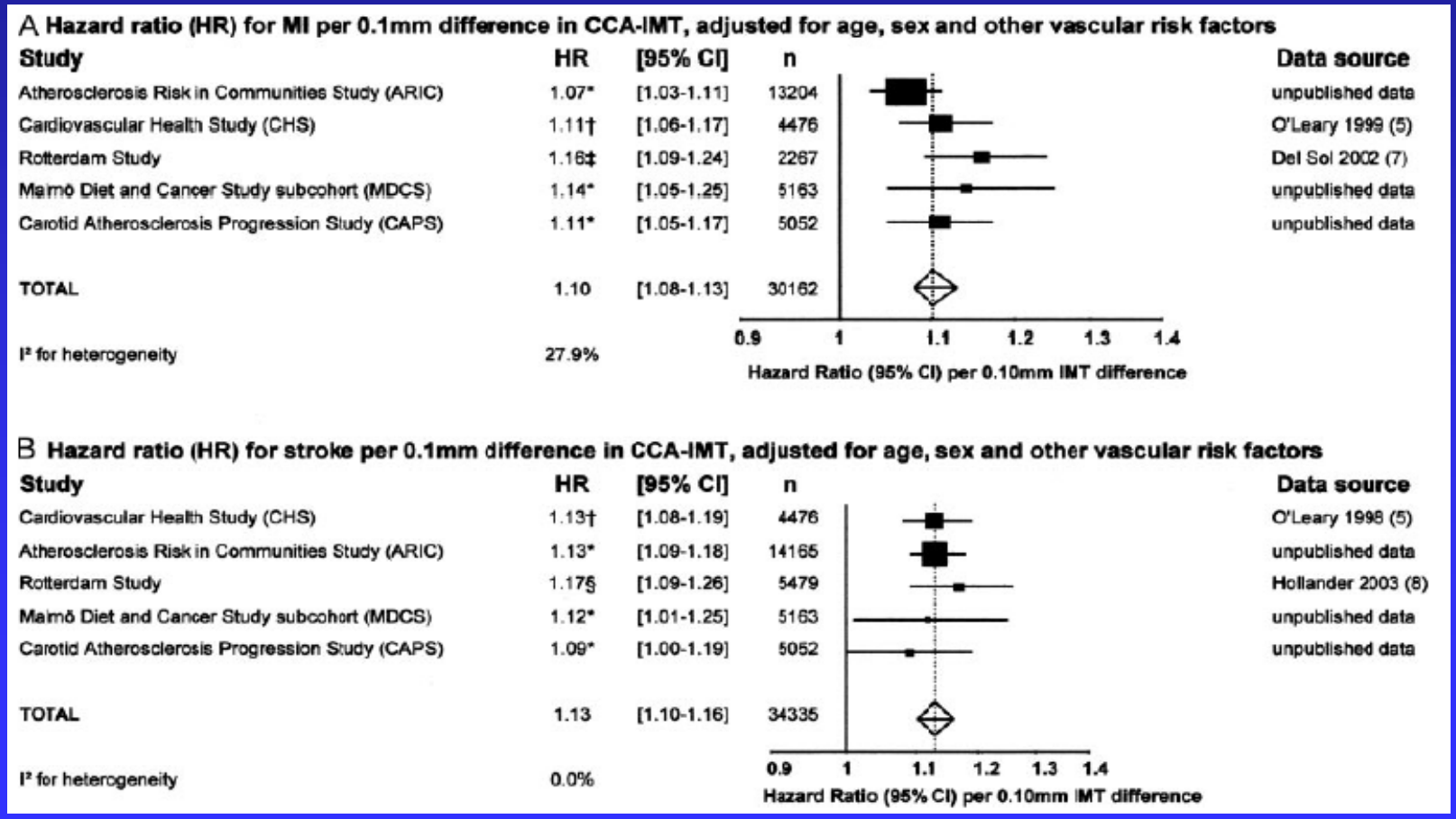






Predictive Value of CIMT

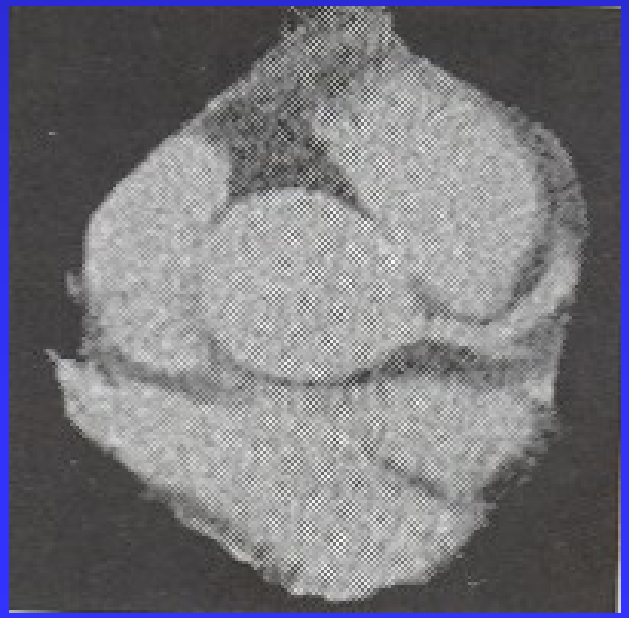
- Meta analysis: 12 studies, ~50,000 older subjects

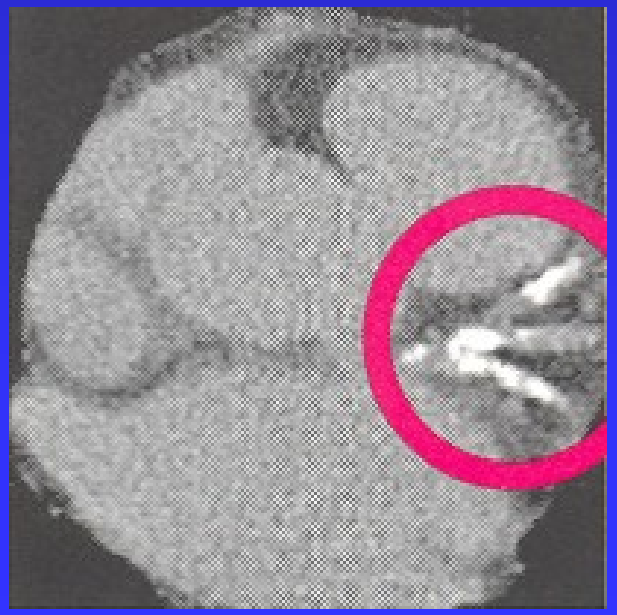


Circ 2007 115:459

Coronary Artery Calcium (CAC) Score

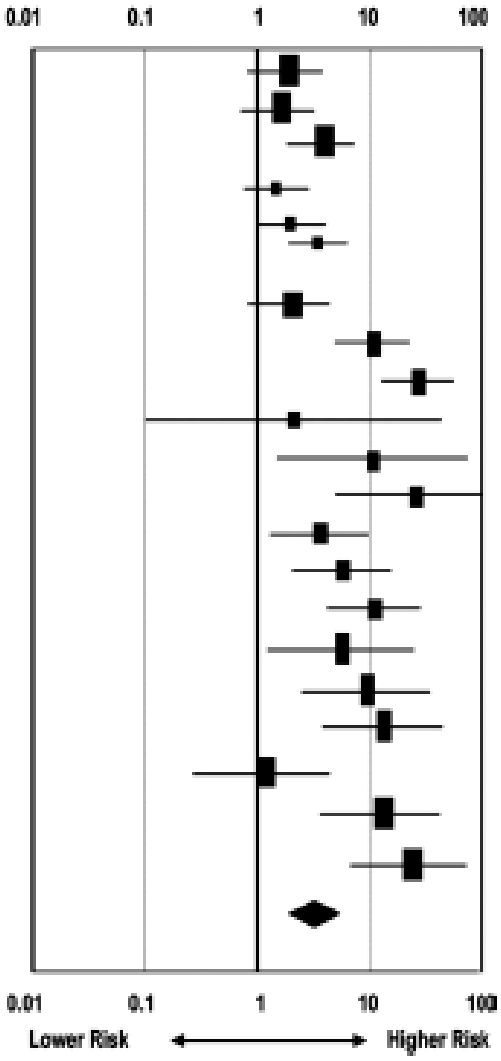
Variable CAC Despite Similar RF Burden





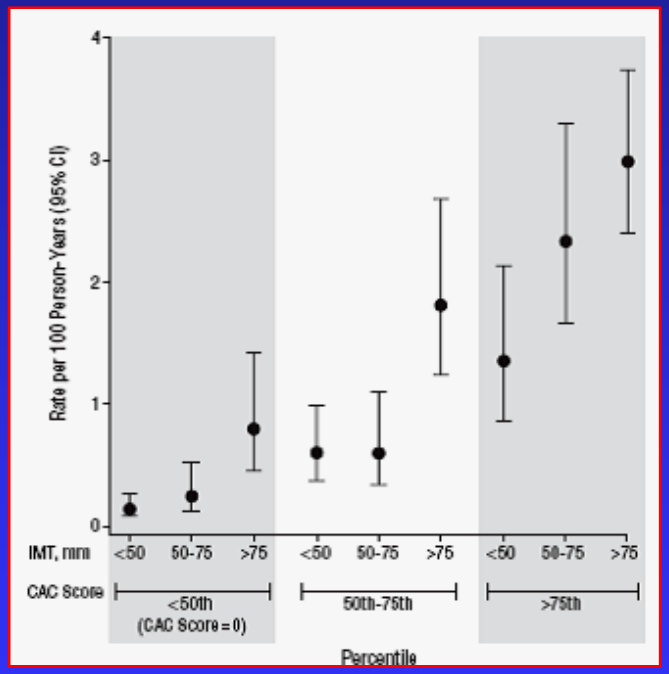
Predictive Value of CAC

Study (Year)	CACS Range	Effect	(95% CI)	Events / N: Higher Risk	Events / N: Low Risk	p
Kondos (2003)	4-30.5	1.8	(0.8-3.8)	15 / 1,633	12 / 2,349	0.12
	31-169	1.5	(0.7-3.2)	16 / 2,045	12 / 2,349	0.26
	170-1,700	3.7	(1.9-7.3)	27 / 1,424	12 / 2,349	<0.0001
Greenland (2004)	1-100	1.5	(0.8-2.9)	21 / 321	14 / 316	0.24
	101-299	2.0	(0.98-4.0)	15 / 171	14 / 316	0.053
	≥300	3.5	(1.9-6.3)	34 / 221	14 / 316	<0.0001
Arad (2005)	1-100	1.9	(0.8-4.3)	20 / 1,973	8 / 1,512	0.12
	101-399	10.5	(4.9-22.3)	38 / 686	8 / 1,512	<0.0001
	≥400	25.5	(12.8-54.8)	63 / 450	8 / 1,512	<0.0001
Taylor (2005)	1-9	2.1	(0.1-43.2)	0 / 120	2 / 1,261	0.63
	10-44	10.5	(1. 5-73.9)	2 / 120	2 / 1,261	0.003
	≥45	25.4	(5.0-129.9)	5 / 124	2 / 1,261	<0.0001
Vliegenthart (2005)	101-400	3.5	(1.3-9.7)	10 / 425	6 / 905	0.008
	401-1,000	5.6	(2.1-15.3)	10 / 269	6 / 905	<0.0001
	>1,000	10.8	(4.2-27.7)	14 / 196	6 / 905	<0.0001
LaMonte (2005)	1-16	5.5	(1.2-24.5)	3 / 379	4 / 2,780	0.012
Women	17-112	9.2	(2.5-34.3)	5 / 376	4 / 2,780	<0.0001
	113	12.9	(3.8-44.0)	7 / 376	4 / 2,780	<0.0001
	1-38	1.1	(0.3-4.3)	6 / 4,968	3 / 2,692	0.91
Men	39-249	12.3	(3.7-41.6)	19 / 1,382	3 / 2,692	<0.0001
	≥250	22.1	(6.8-71.9)	34 / 1,380	3 / 2,692	<0.0001
Summary RR Ratio		**4.3**	**(3.5-5.2)**	**364 / 19,039**	**49 / 11,815***	**<0.0001**



JACC 2007;49:378

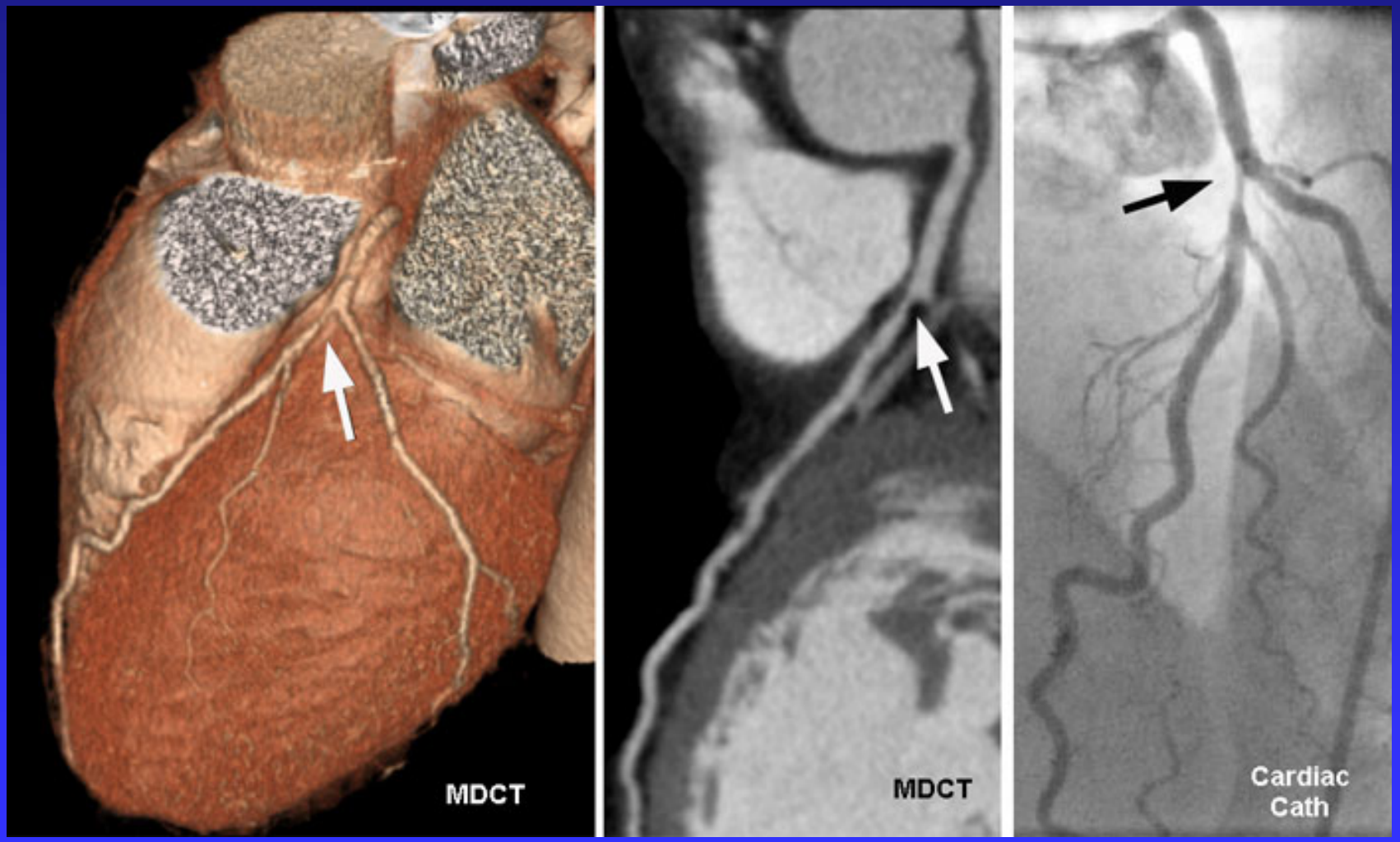
CAC vs CIMT: MESA Head to Head



- 6700 pts; F/u 3.9 y
- Composite: CV death, MI stroke
- CIMT HR 1.3 (1.1-1.4); AUC 0.78
- CAC HR 2.1 (1.8-2.5); AUC 0.81

Arch Intern Med. 2008; 168:1333

CT Angiography



STATE-OF-THE-ART PAPER

The Present State of Coronary Computed Tomography Angiography

A Process in Evolution

James K. Min, MD,* Leslee J. Shaw, PhD,† Daniel S. Berman, MD‡

New York, New York; Atlanta, Georgia; and Los Angeles, California

JACC
Journal of the American College of Cardiology

- High NPV for obstructive CAD
- High false positive rate
- Anatomy, not ischemia
- Unclear if px info better than ex testing
- Radiation exposure

JACC 2010 55:957

Data That ***ANY*** CAD Risk Assessment or Testing Strategy Improves Outcomes in Asymptomatic People

Cardiovascular Screening

- Principles of screening
- Screening tools and tests
- Current recommendations
- What is being done now in diving?
- Program design issues to consider

Screening Recommendations

- Younger athletes
  - AHA Pre Participation checklist
- Older individuals (not athletes)
  - Medicare
  - ACC/AHA Primary Prevention
  - USPSTF
- Older athletes
  - As above PLUS
  - AHA Exercise testing
  - Further testing in intermediate risk individuals?

AHA Pre Participation Screening: Targeted at Young Athletes

Medical history

Personal history

1. Exertional chest pain/discomfort
2. Unexplained syncope/near-syncope†
3. Excessive exertional and unexplained dyspnea/fatigue, associated with exercise
4. Prior recognition of a heart murmur
5. Elevated systemic blood pressure

Family history

6. Premature death < 50 years due to heart disease, in 1 relative
7. Disability from heart disease in a close relative 50 years of age
8. Specific knowledge of certain cardiac conditions in family members: hypertrophic or dilated cardiomyopathy, long-QT syndrome or other ion channelopathies, Marfan syndrome, or clinically important arrhythmias

Physical examination

9. Heart murmur
10. Femoral pulses to exclude aortic coarctation
11. Physical stigmata of Marfan syndrome
12. Brachial artery blood pressure (sitting position)

Maron Circ 2007; 115:1643

Journal of the American College of Cardiology
© 2009 by the the American College of Cardiology Foundation and the American Heart Association, Inc.
Published by Elsevier Inc.
Vol. 54, No. 14, 2009
ISSN 0735-1097/09/$36.00
doi:10.1016/j.jacc.2009.08.005

PERFORMANCE MEASURES

ACCF/AHA 2009 Performance Measures for Primary Prevention of Cardiovascular Disease in Adults

- Lifestyle/Risk factor screening
- Dietary intake counseling
- Physical activity counseling
- Tobacco use assessment/cessation
- Weight/adiposity assmt/mgmt
- Blood pressure measurement/control
- Blood lipid therapy/control
- Global risk estimation
- Aspirin use

JACC 2009 54:1364

Medicare Coverage for CV Screening Tests

- Tests covered - once every 5 years
  - Total Cholesterol
  - HDL
  - Triglycerides
- Not covered- everything else
  - ECG, Stress test, CIMT, CAC, CTA

AHA Scientific Statement

Recommendations and Considerations Related to Preparticipation Screening for Cardiovascular Abnormalities in Competitive Athletes: 2007 Update

- For older competitive athletes (>35 to 40 yo)
  - Knowledge of a personal history of CAD risk factors
  - Familial occurrence of premature CAD
- Selectively perform stress testing IF
  - Performing vigorous training and competitive sports
  - Men >40 y; women >55 y
  - With ≥ 2 RF or 1 severe RF (other than age)
- Education: prodromal cardiac symptoms, such as exertional chest pain.

Maron Circ 2007; 115:1643

Cardiovascular Risk Assessment: Which Tests Are Suitable and Acceptable for Screening?

	< 35 yo	> 35 yo
History	+++	+++
Physical Exam	+++	+++
Noninvasive Testing		
Resting ECG	+++	+
Exercise ECG	+	++
Stress Imaging	-	+
CIMT	-	+++
Coronary Ca++	-	+++
CT Angio	-	+

Cardiovascular Screening

- Principles of screening
- Screening tools and tests
- Current recommendations
- What is being done now in diving?
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The UK Experience: Pre-Dive Screening

- 3 UK organizations
- Questionnaire = legal declaration
- Required general MD exam
  - Q 5y if <40y, Q3 y if 40-50y, Annual > 50y
- Data on 2962 exams on 2094 divers
  - CV sx 1.2%, murmur 1%, med use 4%
  - 2% failure rate, 1% referral to CV MD
  - No significant unknown abns detected

BJSM 2000 34:375

The UK Experience: Pre-Dive Screening - Conclusions

"Diving is a safe sport requiring medical supervision, but routine clinical examination of all divers is unlikely to detect significant abnormalities relevant to their fitness to dive."

"A carefully designed questionnaire will allow most relevant conditions to be identified and save unnecessary expense for both divers and doctors."

BJSM 2000 34:375

INTERNAL MEDICINE JOURNAL

Internal Medicine Journal **39** (2009) 763–770

BRIEF COMMUNICATIONS

Utility of regular medical examinations of occupational divers

C. Sames,[1,2] D. Gorman,[2,3] S. J. Mitchell[2,3] and G. Gamble[3]

- NZ Dept of Labour q 5 y interview, MD exam
- 3% with issues, 1/336 DQ'd
- "Q 5y exams have a low detection rate for important health problems"

Category	Sex/age	Method of identification	Medical problem
Permanently unfit for diving	M/35	Questionnaire	Spinal injury
Temporarily unfit for diving	M/33	Spirometry	Impaired lung function
	M/55	Questionnaire	Heart surgery
	M/36	Questionnaire	Deafness and tinnitus
	M/36	Questionnaire	Deafness and head injury
Conditional certification for diving	F/45	Spirometry	Impaired lung function
	M/34	Questionnaire	Otic barotrauma
	M/49	Questionnaire	Heart surgery
	M/58	Questionnaire	Asthma
	M/53	Questionnaire	Atrial fibrillation

Internal Med J 2009 39:763

Cardiovascular Screening

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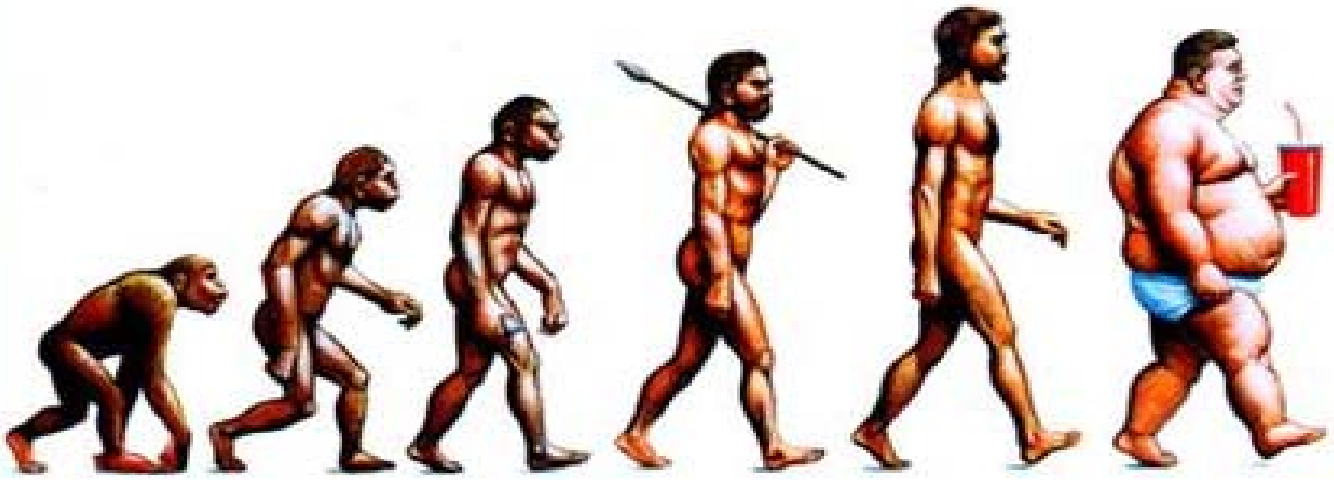
The Economist

DECEMBER 13TH-19TH 2003 www.economist.com

The shape of things to come



Goals for Screening

- Improved health of divers
- Identify individuals for additional evaluation/testing
- Identify individuals with CV disease
- Prevention of incidents
- Prevention of deaths
- Improve safety of diving environment
- Reduce insurance premiums

Screening Considerations

- Who to screen?
- When to screen? How often? (Surveillance)
- What disease(s) to screen for?
- What screening questions and tests to use?
- Who will perform screening? Who will perform any needed additional evaluation?
- What will additional evaluation consist of?
- How will results be translated into clearance for diving? What happens if someone ‘fails’?
- Who will pay for all this?

Possible CV Screening Content

- All ages
  - Fitness level assessment
  - ACC/AHA Primary Prevention Performance Measures
  - Cardiovascular history, symptoms and signs
    - Under 35 yo: AHA Pre-Participation check list
    - Over 35 yo: CAD risk factors, symptoms, signs
- Over 35 years old or at least intermediate risk
  - All of the above
  - Selective testing of some kind
  - Stress testing or CAC score?
    - Evidence does not favor CIMT or CT Angio

Education

- Divers, diving staff and physicians
  - Prodromal symptoms and how to respond
  - Management of cardiovascular emergencies
  - What to do if health status changes

Possible Positive Screening F/U

- Positive questionnaire screens
  - All ages:
    - History and physical by MD
    - CAD risk factors modification
  - < 35 yo: ECG, Echo for HCM, congenital abns
  - >35 yo: CAC, ? ETT
- All symptomatic people need a full medical evaluation before diving

Other Considerations

- Ability to respond in an emergency
- The hyperbaric environment
  - PFO, PHTN
  - Altered drug metabolism
- Dive specific risks
  - Sport diving vs professional diving
- How often should screening be repeated?
- Would screening really change behavior?

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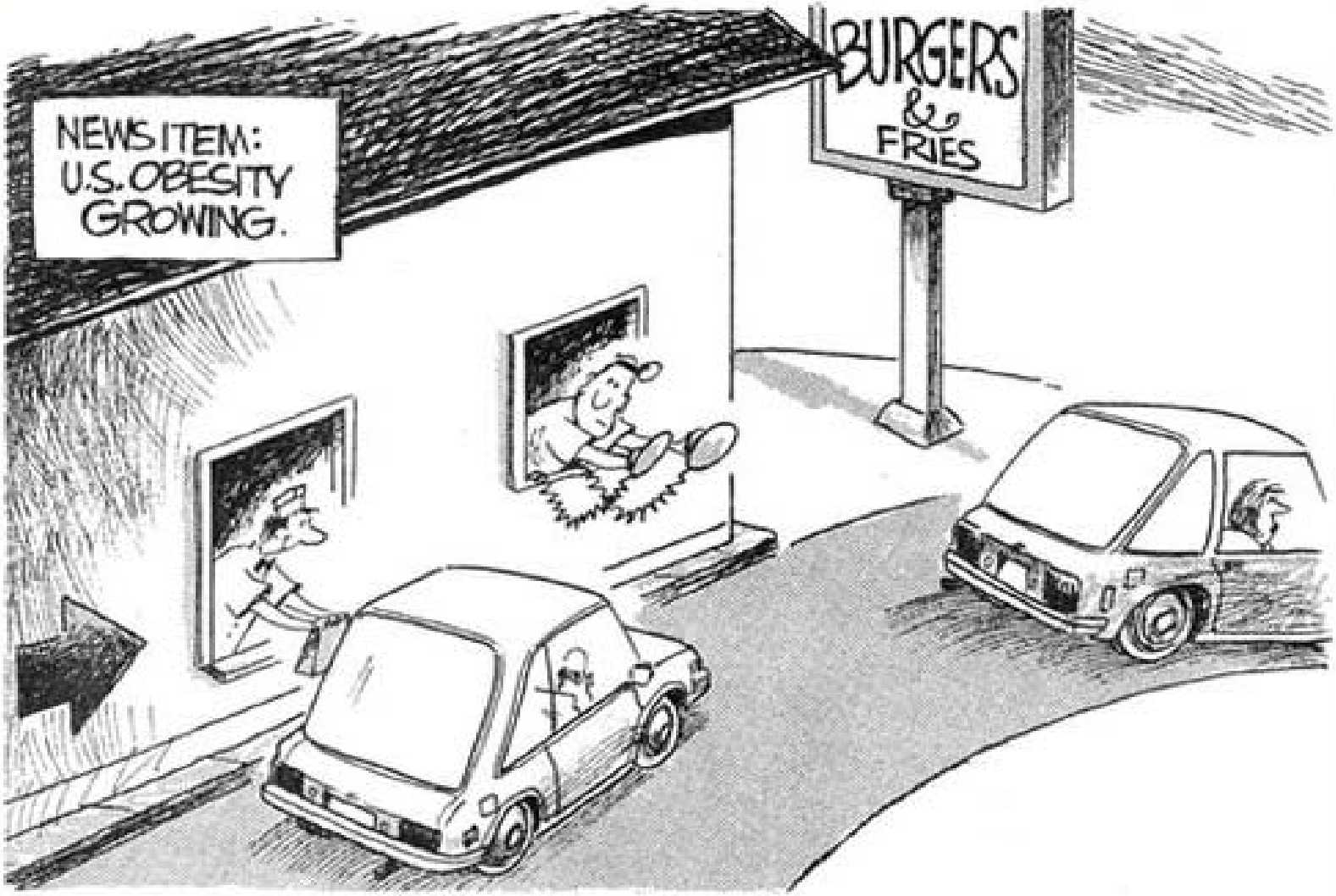

Dana Summers
The Orlando Sentinel
Tribune Media Services

Comparison of CAC vs CIMT for Risk Assessment in Asymptomatic Pts

	CAC Scoring CT	CIMT by US
Imaging Focus	Calcium within plaque	Arterial wall thickening
Invasive	Non-invasive	Non-invasive
Radiation	1.0– 1.8 mSv	No ionizing radiation
Sensitivity for dx obs CHD	85%	50-70%
Specificity for dx obs CHD	75%	60-80%[7]
HR for incident CAD/SD	2.1	1.3
Availability	++	++
Ease of use	+++	++
Operator dependence	Automated	User dependent
Estimated test cost	$300-600	$200
Payer reimbursement	None	None
Cost of implementation	Capital $1.5M+ Operating $800,000/y	Capital $100,000 Operating $50,000/y

Circ Imaging 2009 2:150