

Angioplasty Summit 2008 - TCT Asia Pacific

Noninvasive Plaque Imaging

Koen Nieman, MD, PhD

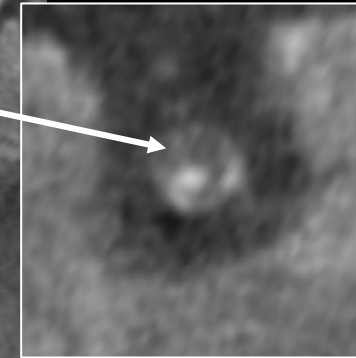
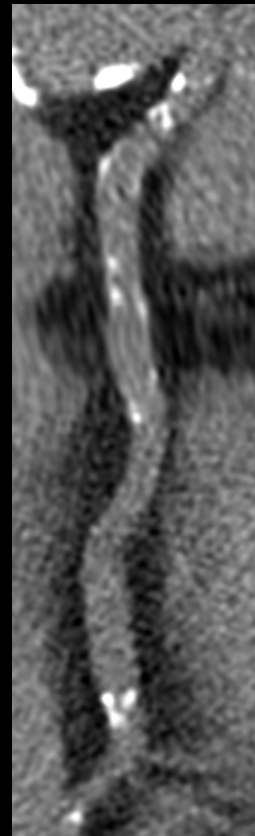
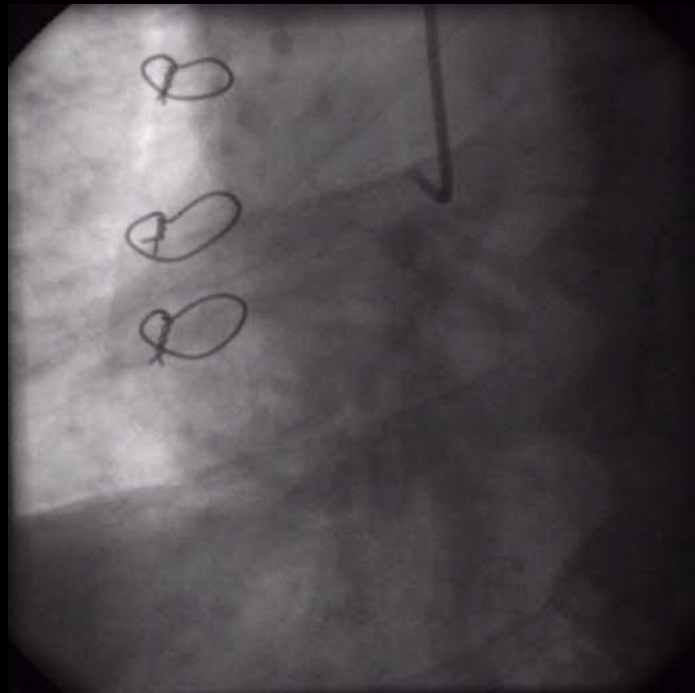


Rotterdam Thoraxcenter
Erasmus Medical Center
Departments of Cardiology & Radiology
The Netherlands

Introduction

- Computed Tomography
- Magnetic Resonance Imaging
- Nuclear imaging (PET)

- Plaque detection & quantification
- Serial plaque imaging
- Plaque characterization



CT Plaque Imaging

- Non-enhanced CT for coronary calcium
- Contrast-enhanced CT for lumen and plaque

Coronary Calcium

- Low-dose scan
- High sensitivity (IVUS)
- Calcium = atherosclerosis
- CCS \approx total plaque burden
- CCS \approx vulnerable plaque
- CCS \approx prognosis

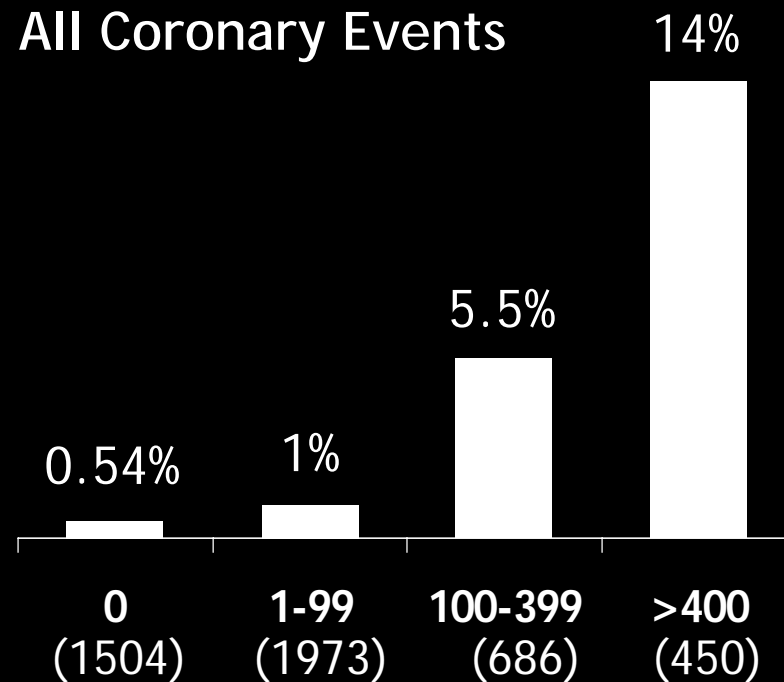


St Francis Heart Study

Arad, et al, JACC 2005



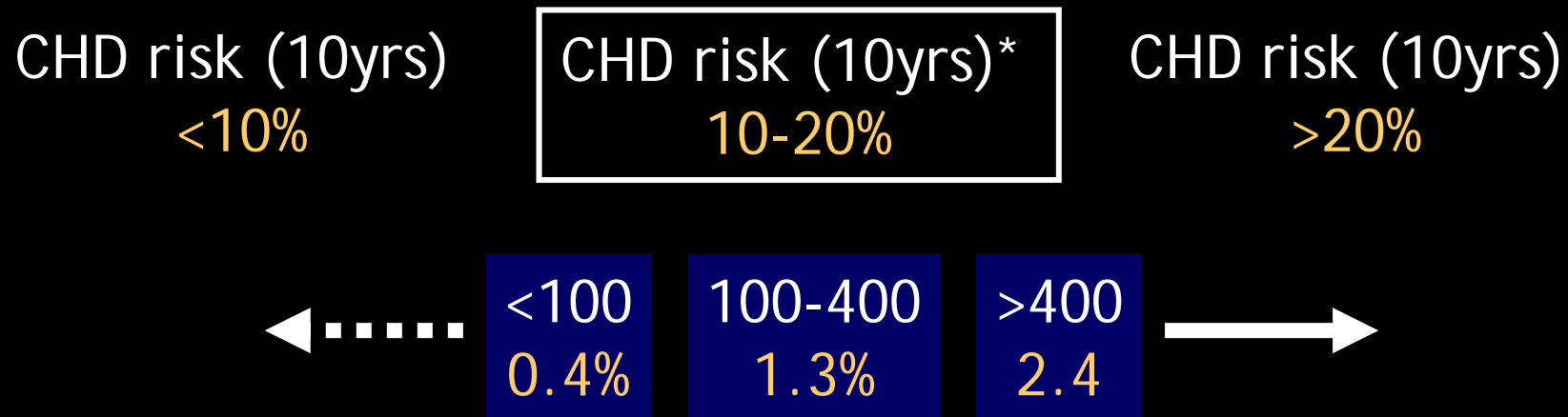
Prospective
Population-based
4613 individuals
Mean follow-up 4.3 years
50-70y Caucasians



Relative risk 9.2 for death/non-fatal MI (CCS>100)
CCS predicts CAD events independently of FRS
CCS more accurately predicts events: AUROC .79 vs .68 (FRS)



Calcium Screening



*No diabetes, no history of CVD, no very high single risk factor

Greenland, et al, JACC/Circulation 2007,
ACCF/AHA Expert Consensus Document on Coronary Calcium Scoring



Plaque Progression

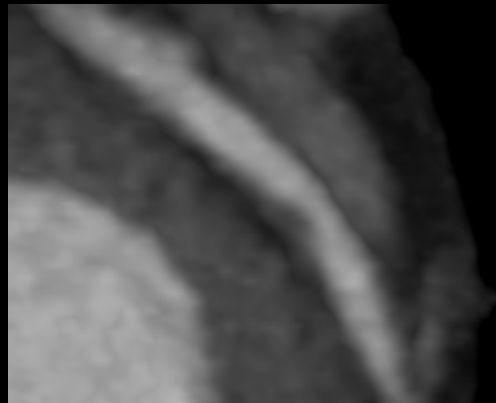
- Annual progression >20%
- Interscan variability 10-15%
- Progression rate associated with outcome [Raggi '03]
- Progression slowed by statins
- Delayed progression unrelated to CV events [Arad '05]

- Calcium related to plaque stabilization?
- Calcified plaque less modifiable?

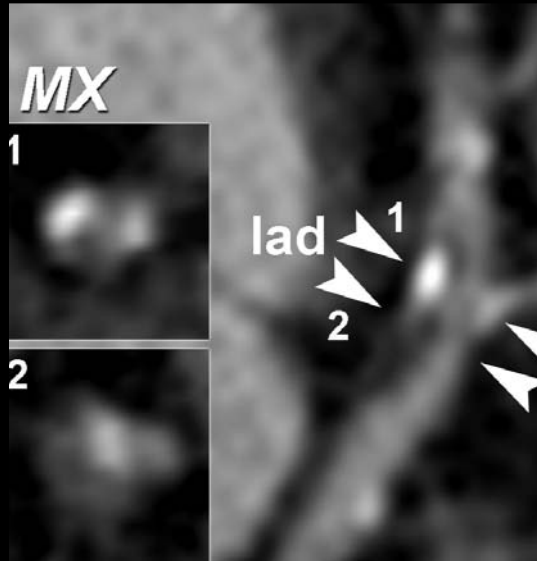
Coronary Plaque Detection

CT vs IVUS

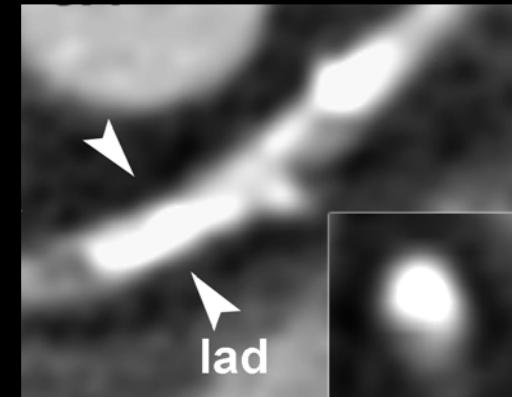
Erasmus MC
University Medical Center Rotterdam



Non-calcified
Sensitivity 53%*
Sensitivity 83%**



Any Plaque
Sensitivity 82%*
Sensitivity 90%**

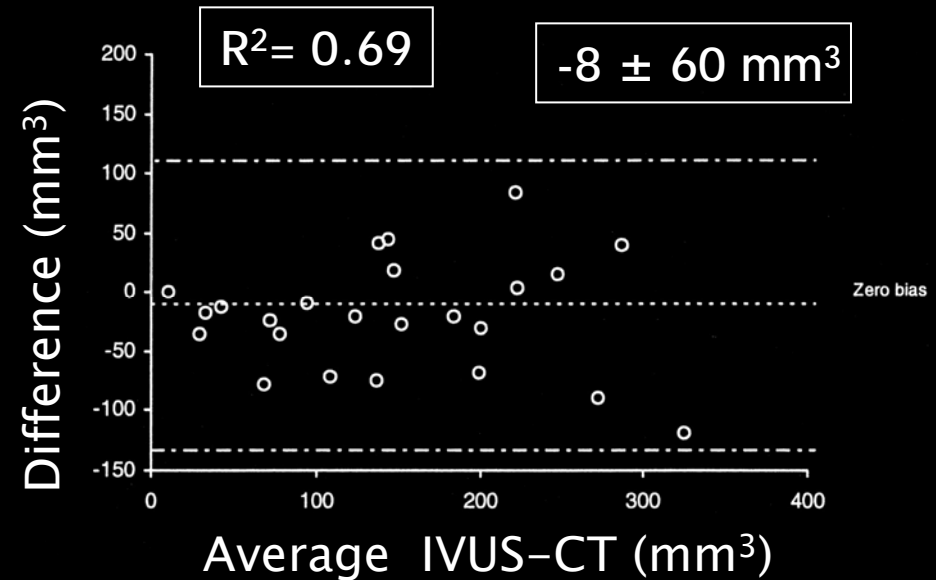
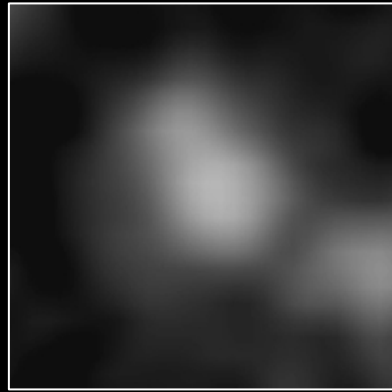


Calcified
Sensitivity 94%*
Sensitivity 95%**

*16-slice - Achenbach, Circ. '00

**64-slice - Leber, JACC '06

Coronary Plaque Volume 64-CT vs IVUS



N=20, 36 vessel segments

Underestimation of non-calcified/total plaque volume

Overestimation of calcified plaque volume

Inter-observer variability 37%

Leber, et al, JACC 2006

Plaque Progression

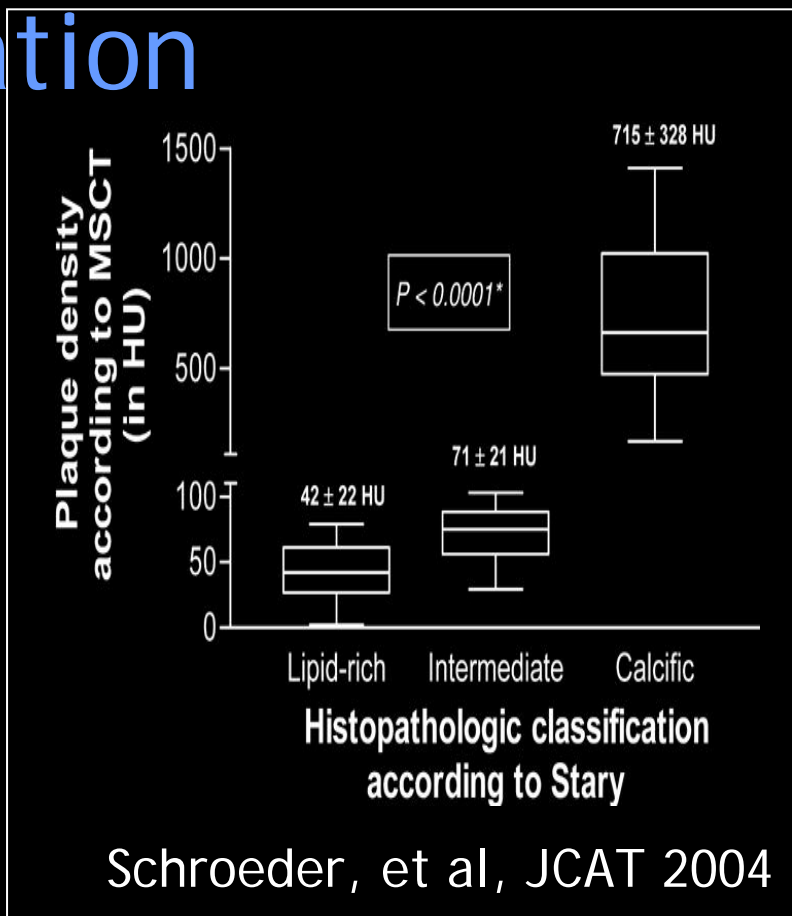
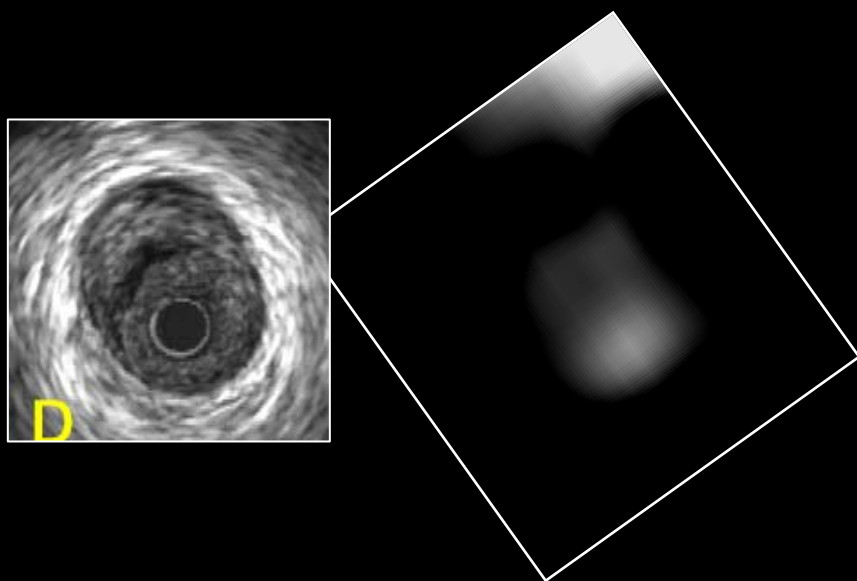
Coronary calcium:

- Annual progression: >20% (variability 10-15%)
- Progression rate associated with outcome [Raggi '03]
- Progression slowed by statins
- Slow progression \neq CV events [Arad '05]

Non-calcified coronary plaque:

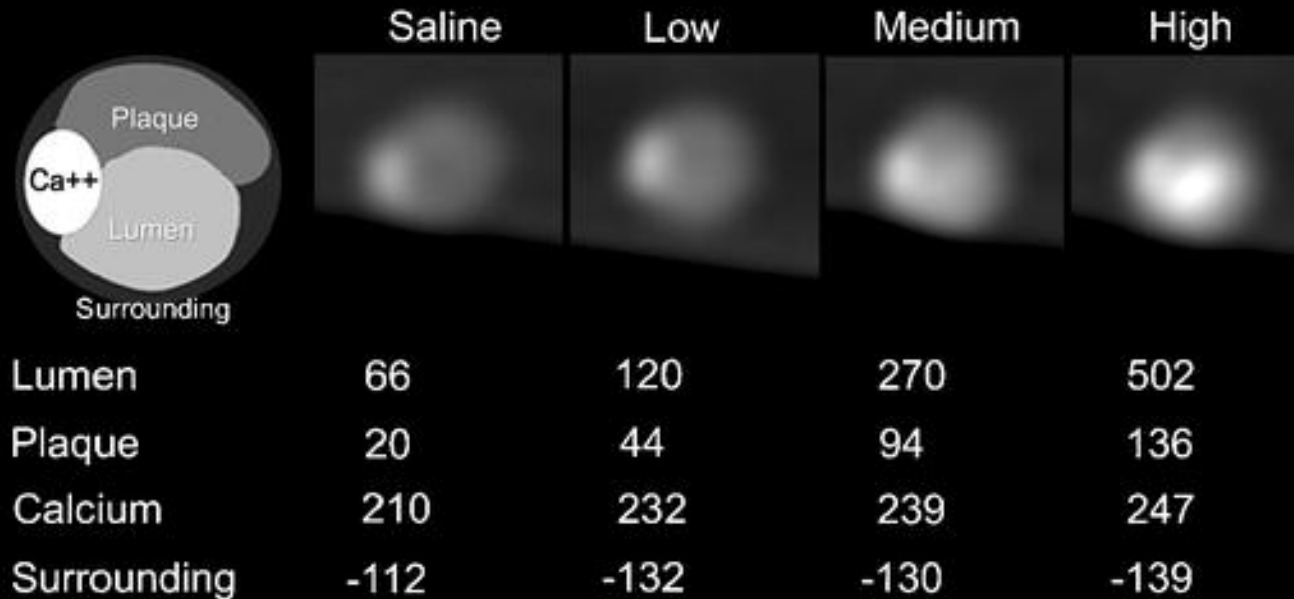
- Interobserver-variability 37% [Leber '06]
- Annual progression 24% (LM/pLAD) [Schmid '08]
- ?Progression slowed by statins: 24% [Burgstahler '07]

Plaque Characterization



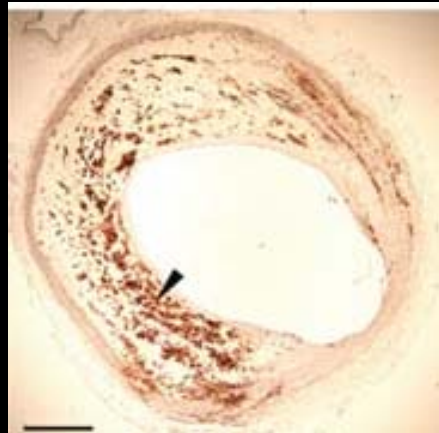
Author	CT	N	Soft	Intermediate	Calcified
Schroeder '01	4×1	15	-42 - 47	61 - 112	126 - 736
Leber '04	16×.75	37	14 - 82	34 - 125	162 - 820
Pohle '06	16×.75	32	-39 - 167	60 - 201	

Limitations

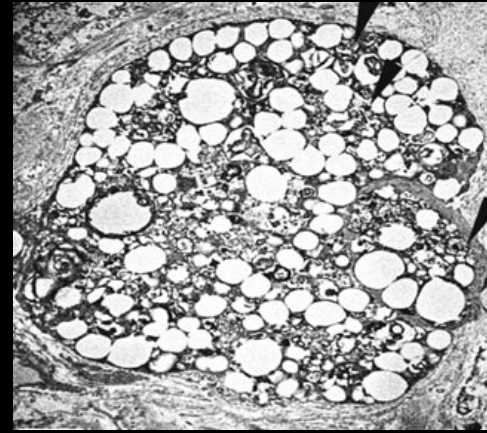


- Luminal contrast effect
- Subtle motion and beam hardening
- Plaque enhancement
- Outer border differentiation

Macrophage Imaging

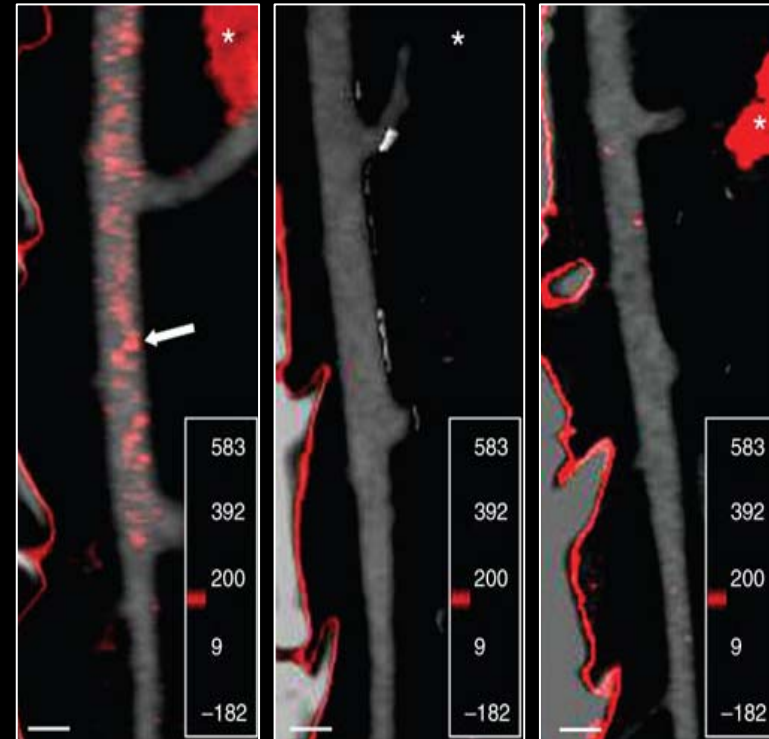


Macrophage staining



EM macrophage containing iodine

Iodinated particles (256nm)
Atherosclerotic rabbit aorta



Atherosclerotic

Contro

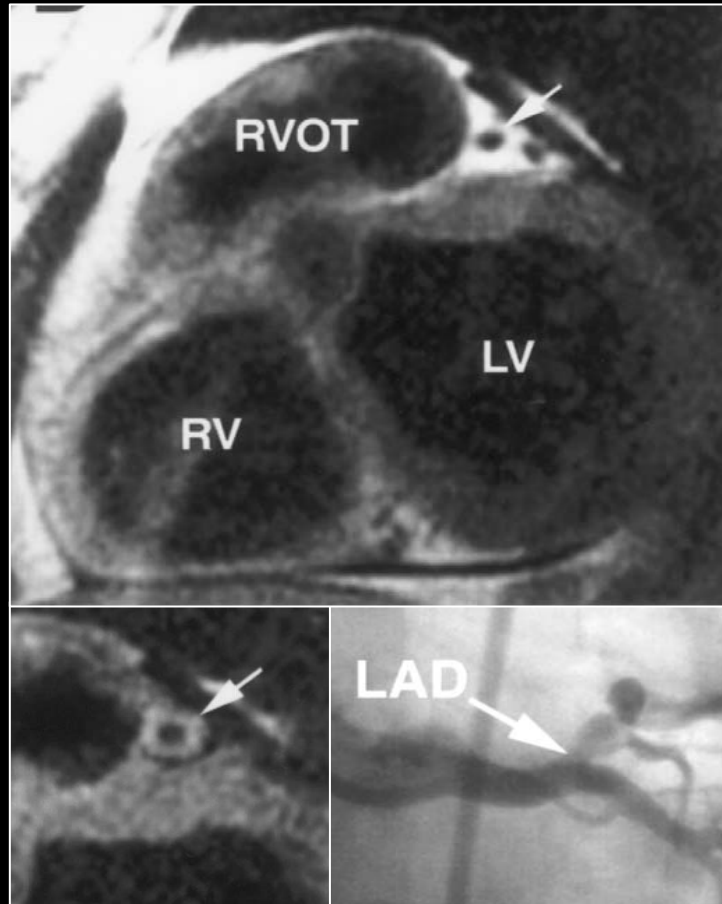
N1177

Convent

N1177

Hyafil et al, Nature Med. 2007

Coronary Plaque by MRI



Fayad, Circulation 2000

- Versatile, but difficult
- Harmless
- Continuous trade-off:
 - Image quality
 - Scan time
- Coronary most challenging:
 - Size & tortuosity
 - Depth
 - Pericardial fat
 - Coronary motion
 - Breathing

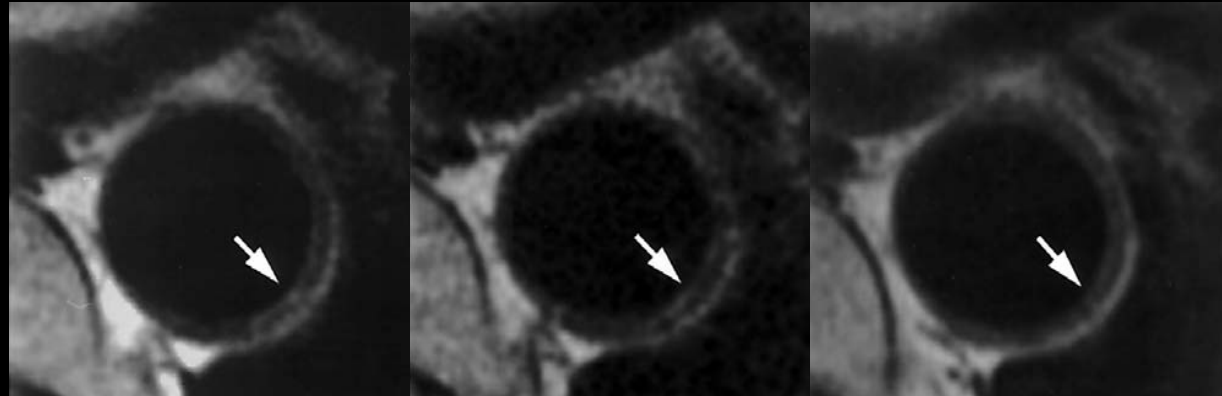
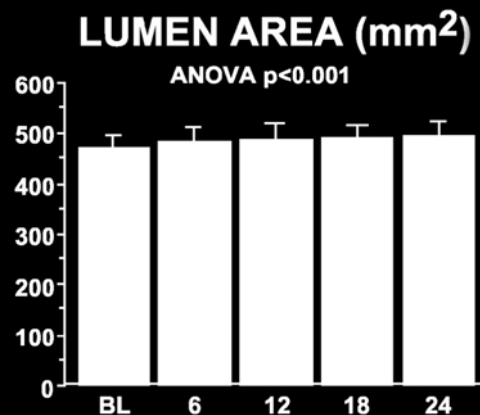
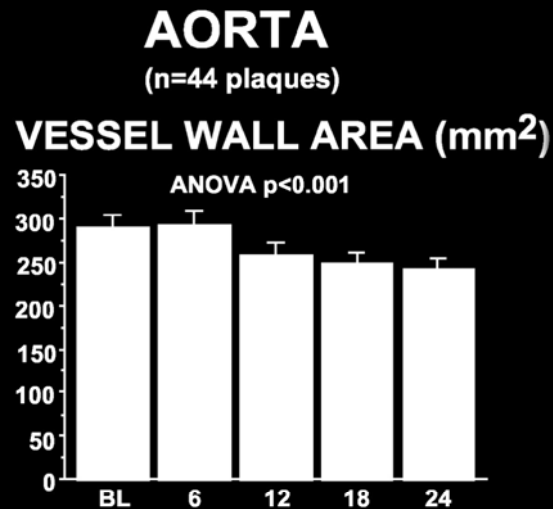
Multi-Contrast Plaque Imaging



T1w, T2w, proton-density weighted
imaging

Aortic Plaque Regression by Simvastatin

Corti, et al, Circulation 2001 and 2002



Baseline 6 Months 12 Months

MRI monitoring of aortic and carotid plaque during Simvastatin

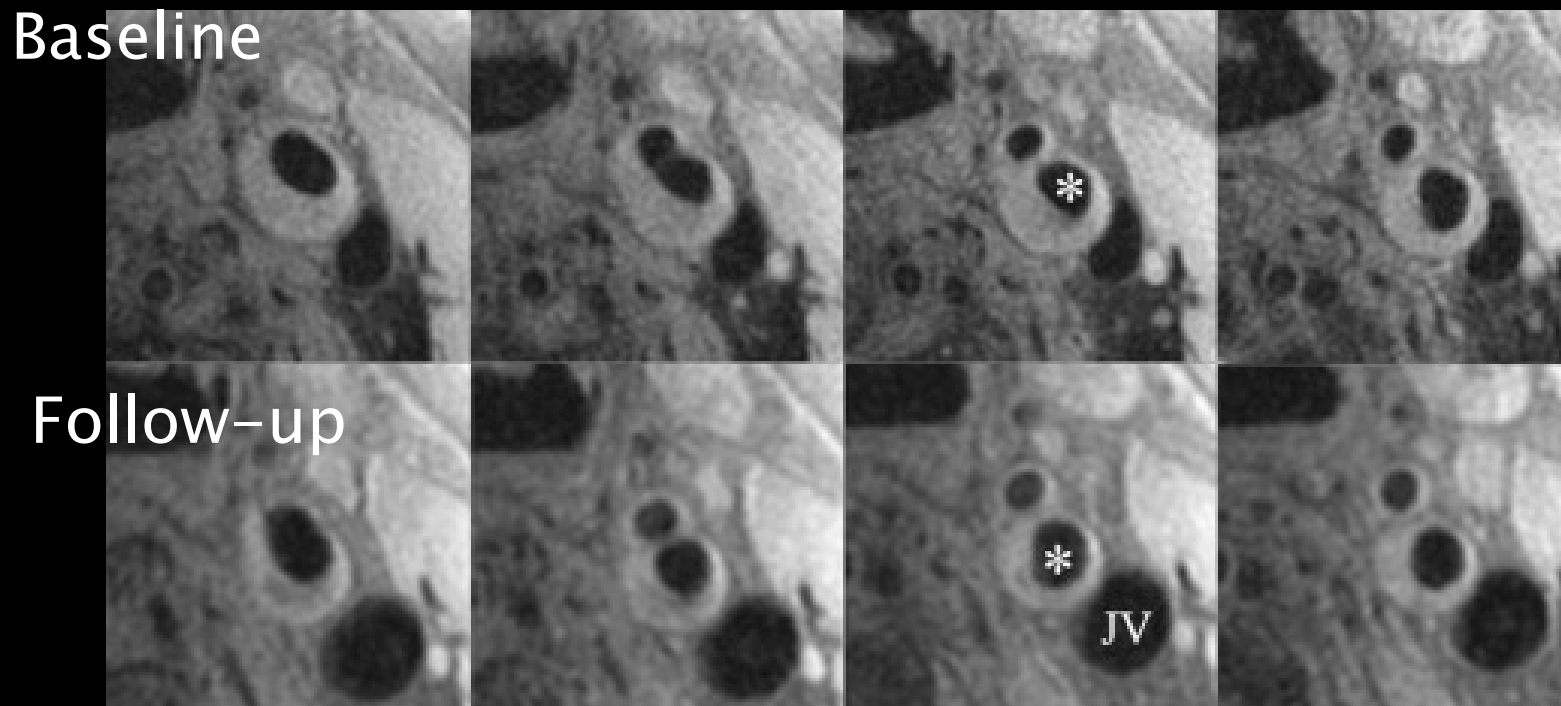
Measurement error:

Aorta 2.6% [Summers, 1998]

Carotid arteries 3.5% [Corti, 2001]

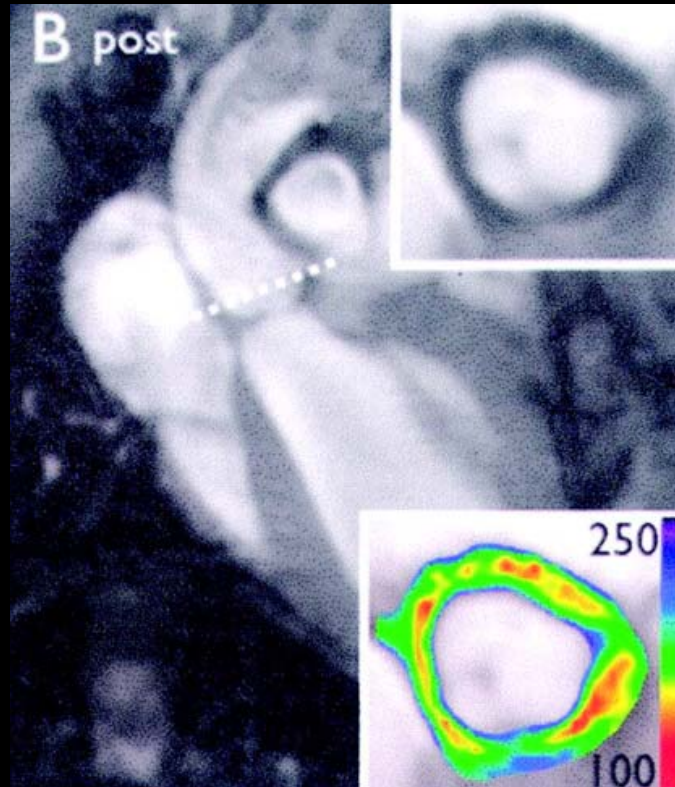
Carotid Plaque Regression by Rosuvastatin

Underhill, et al, AHJ 2008

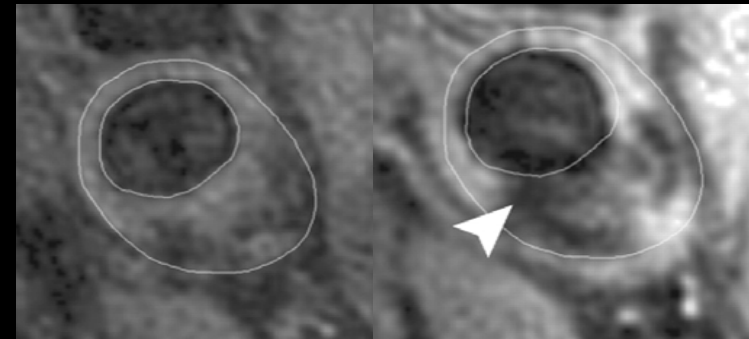


41% reduction lipid-core-containing plaque over 24 months

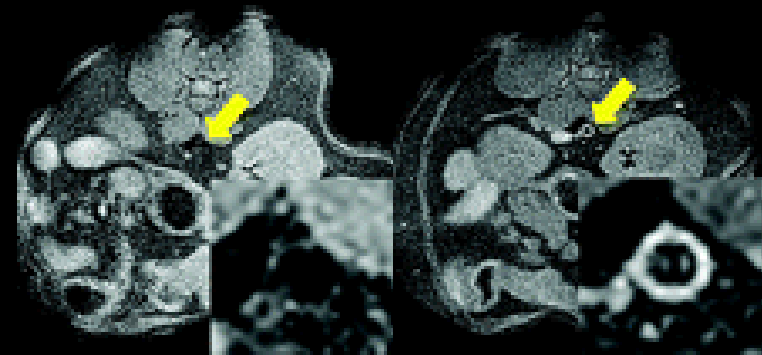
Molecular MRI



VCAM-1 imaging in an ApoE^{-/-} mouse on high-cholesterol diet (compared with atorvastatin)
[Nahrendorf, Circulation 2007]

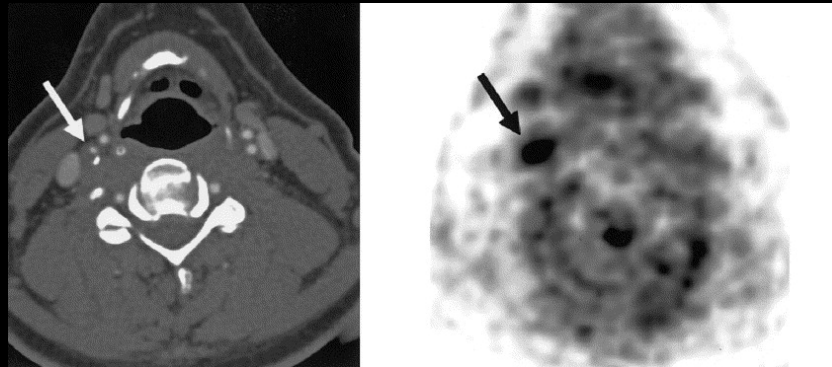
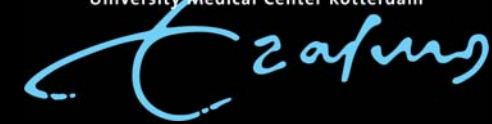


Macrophage uptake of ultra-small super-paramagnetic iron oxide (USPIO), carotid arteries
[Ruehm, Circulation 2001]

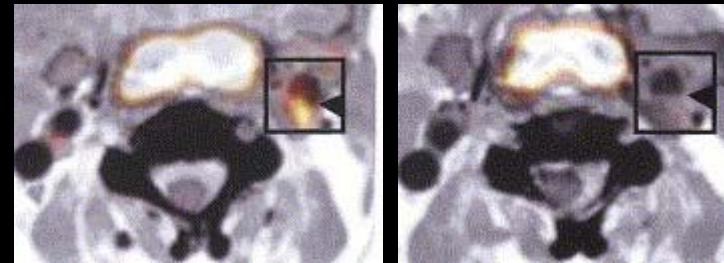


Gadolinium-labeled HDL
In animals

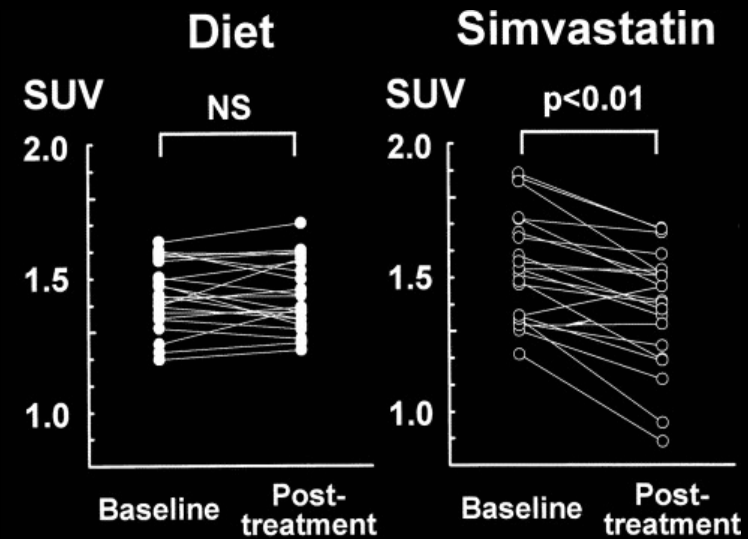
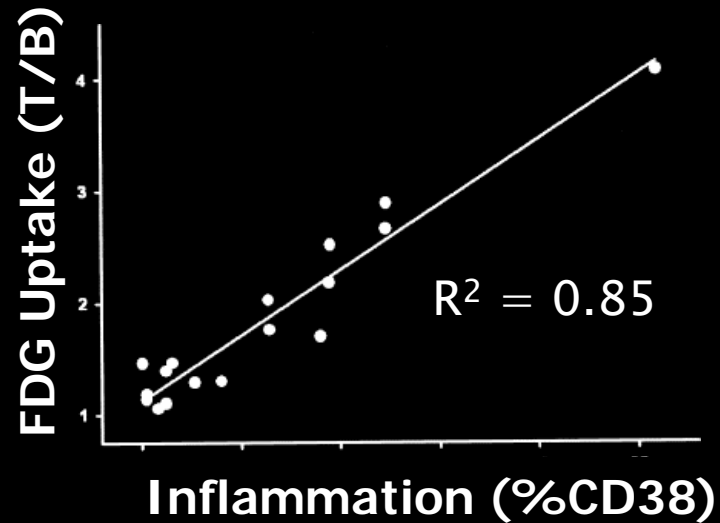
^{18}F FDG PET-CT



Simvastatin treatment



Baseline and 6-months CT/PET





Conclusion

	CT	MRI	Nuclear
Technical:	Coverage speed Sensitivity (Ca)	Differentiation Reproducibility Harmlessness	Sensitive to inflammatio n
Applics:	Detection Risk stratification Angiography	Serial studies Risk	Serial studies
Challenges	Radiation Non-calcified plaque	Exam time Coronaries	Spatial resol.