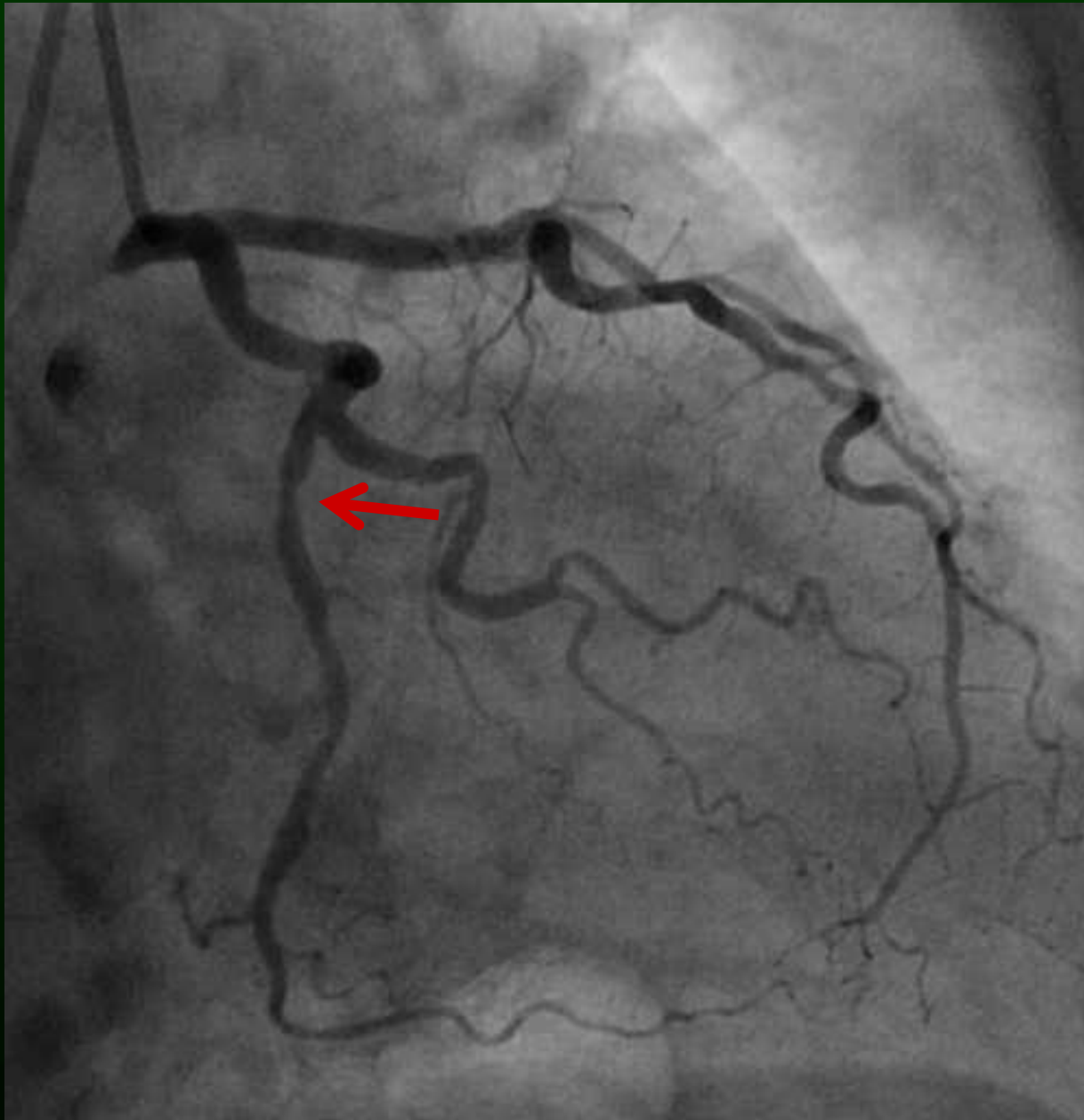




# Noninvasive Coronary Imaging: *Plaque Imaging by MDCT*

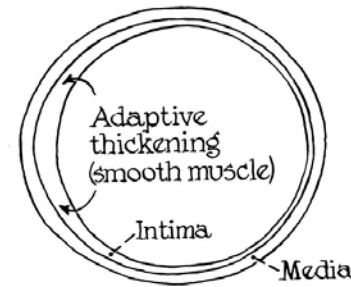


Byoung Wook Choi  
Department of Radiology  
Yonsei University, Seoul, Korea

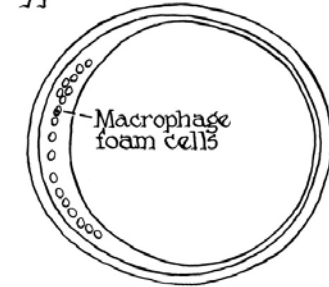




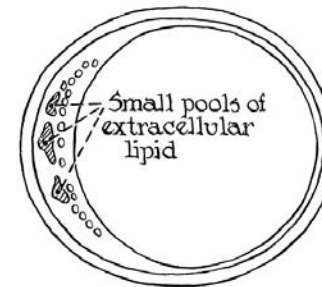
Coronary artery at lesion-prone location



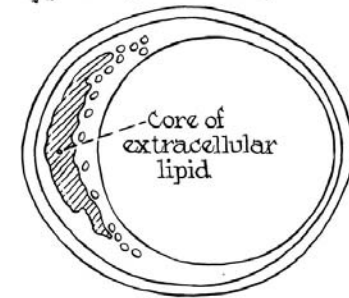
Type II lesion



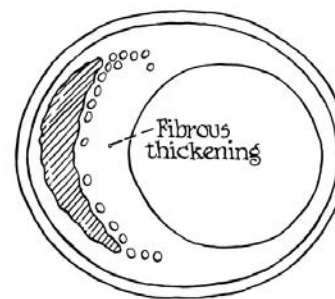
Type III (preatheroma)



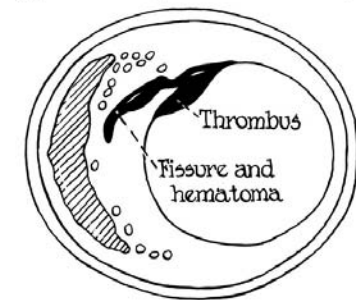
Type IV (atheroma)



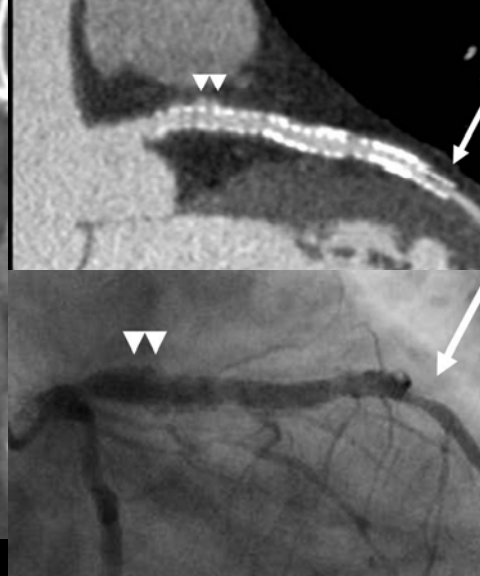
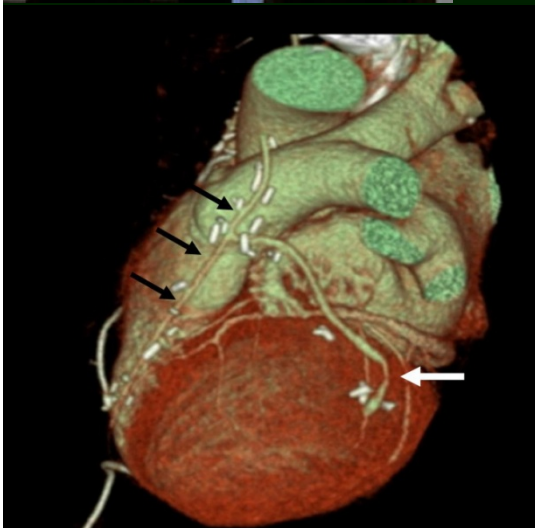
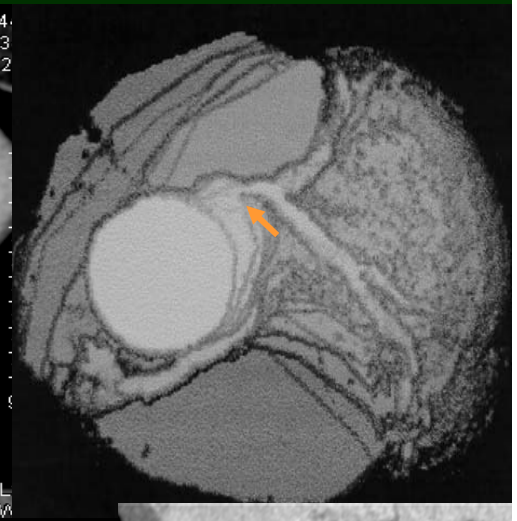
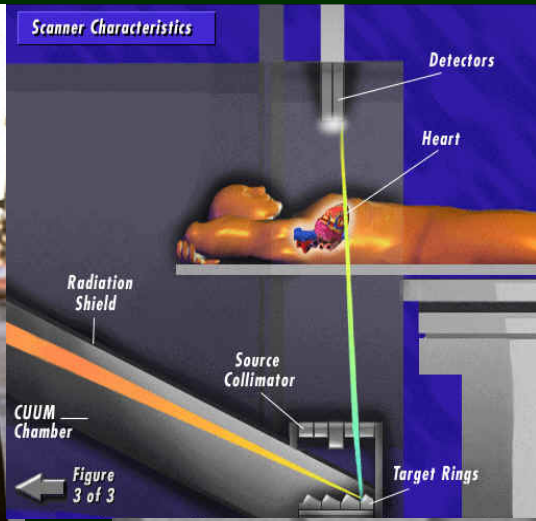
Type V (fibroatheroma)



Type VI (complicated lesion)



# Introduction of noninvasive coronary artery imaging



# What can MDCT show?

- Coronary Artery Anatomy
- Coronary Artery stenosis
- Coronary Artery In-stent restenosis
  
- Lumen & Plaque
  - Different CT attenuation value of plaques according to different composition could be used to differentiate vulnerable plaque that has lipid-rich core.



# Accuracy of 64-MDCT for stenosis

<i>First author</i>	<i>patient number</i>	<i>Exclusion (%)</i>	<i>Sensitivity (%)</i>	<i>Specificity (%)</i>	<i>Analyzed segments</i>
Ehara	69	8	90	94	All
Fine	66	6	95	96	>1.5mm
Leber	59	–	73–88	97	All
Leschka	67	–	94	97	>1.5mm
Mollet	52	2	99	95	All
Pugliese	35	–	99	96	All
Raff	70	12	86	95	All
Ropers	82	4	95	93	>1.5mm



# Major Limitation is Resolution.

	Left main	Left anterior descending	Left circumflex	Right coronary	Total
Cardiac motion/arrhythmia	0	0	2	14	16
Extensive calcifications	1	6	5	3	15
Small vessel (<1.5 mm)	0	0	12	0	12
Adjacent contrast-filled structures*	0	1	6	3	10
Non-cardiac motion (breathing)	0	0	2	5	7
Poor opacification	0	1	2	1	4

\*Veins or ventricle.

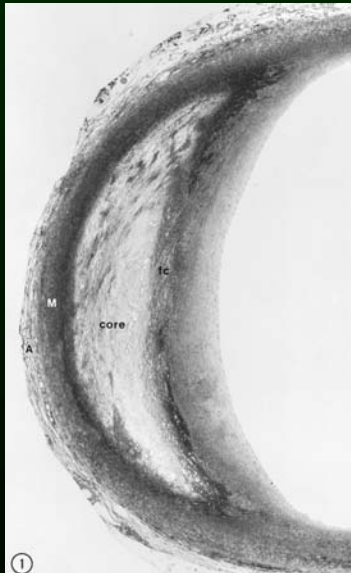
Table 2: **Reasons for non-assessability of vessel segments**

*Nieman et al. Lancet 2001;357:599-603*



# CT classification of coronary artery plaque

- Calcified
- Mixed
- Noncalcified
  - Fibrous
  - **Lipid-rich**

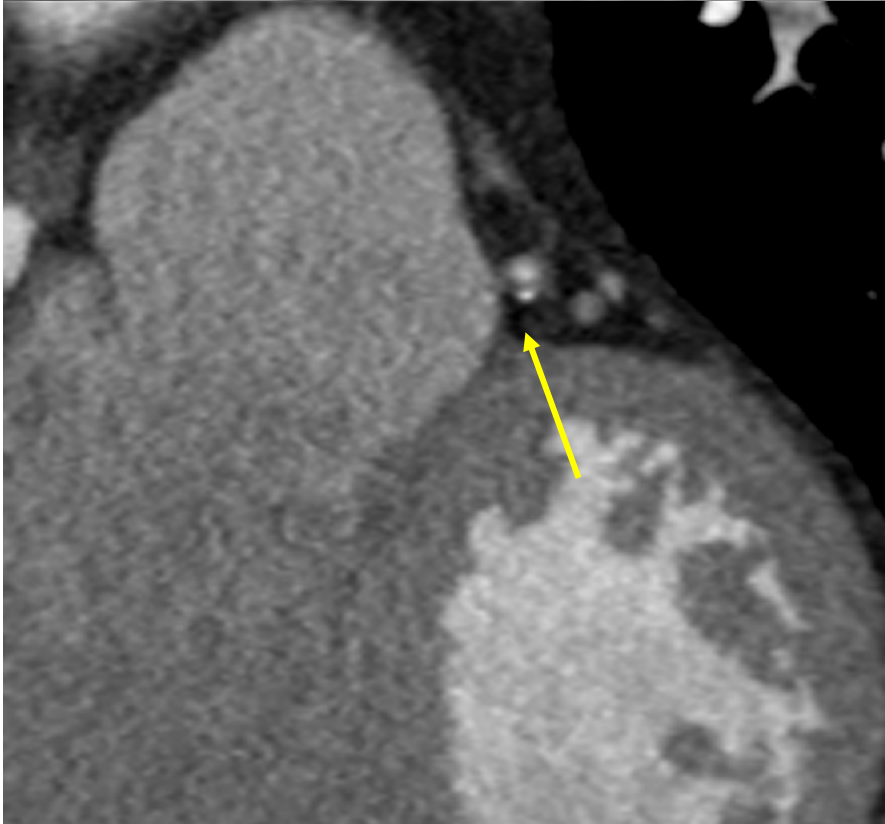
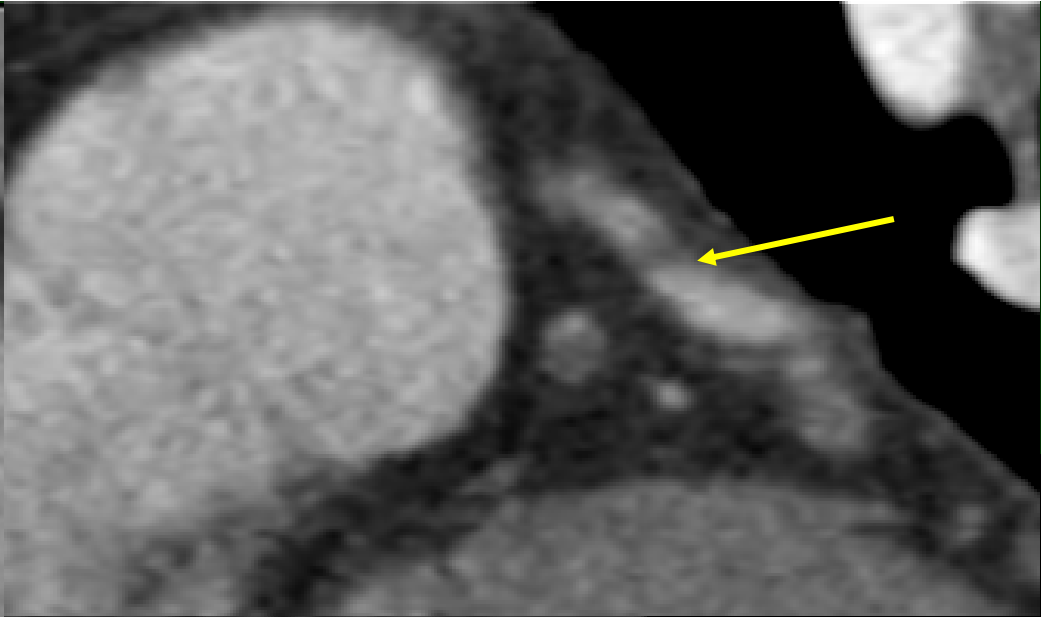
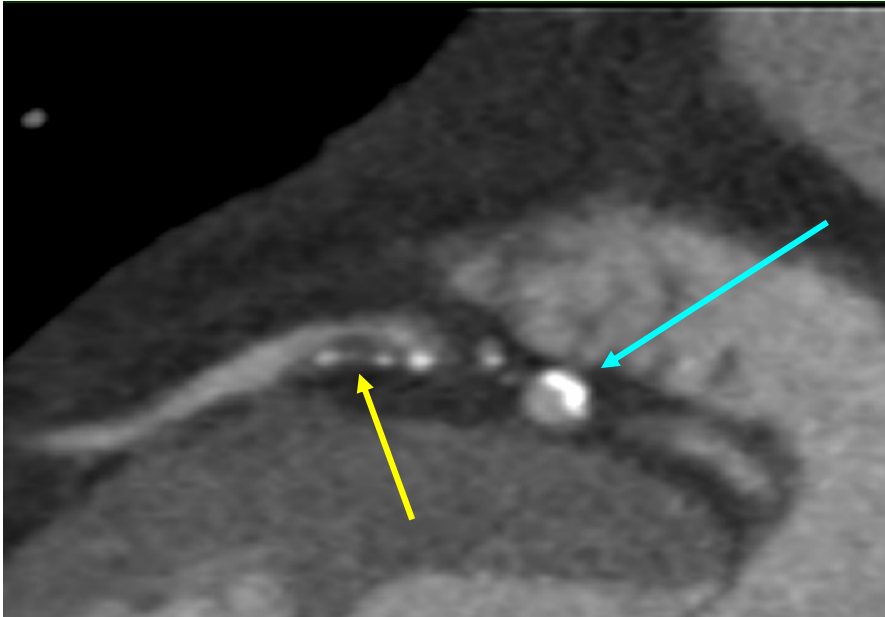


Type I lesion	Initial lesion	
Type IIa lesion	Progression-prone type II lesion	Fatty dot or streak
IIb	Progression-resistant type II	
Type III lesion	Intermediate lesion (preatheroma)	
Type IV lesion	Atheroma	Atheromatous plaque,
Type Va lesion	Fibroatheroma (type V lesion)	fibrolipid plaque,
		fibrous plaque, plaque
Vb	Calcific lesion (type VII lesion)	Calcified plaque
Vc	Fibrotic lesion (type VIII lesion)	Fibrous plaque
Type VI lesion	Lesion with surface defect, and/or hematoma-hemorrhage, and/or thrombotic deposit	Complicated lesion, complicated plaque

Stary, H. C. et al. *Circulation* 1995;92:1355-1374

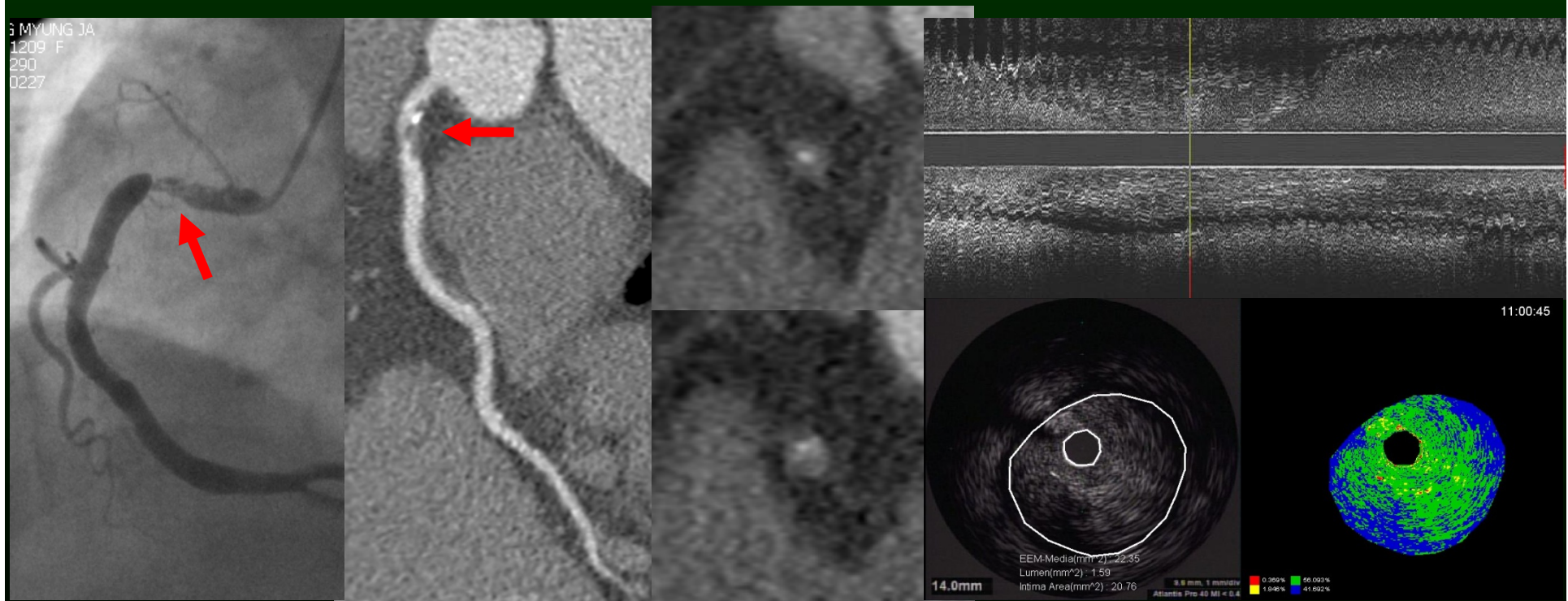






# MDCT-IVUS correlation

- Calcified plaque
- Hypoechoic/echolucent plaque (soft plaque)
- Hyperechoic/intermediate plaque (fibrous plaque)



# CT attenuation value for different plaque composition



<i>First Author</i>	<i>Detectors</i>	<i>subjects</i>	<i>Standard of reference</i>	<i>Lipid-rich plaque (HU)</i>	<i>Fibrous plaque (HU)</i>	<i>Calcified plaque (HU)</i>
Leber	16	46	IVUS <sup>[1]</sup>	49±22	91±22	391±156
Viles-Gonzalez	16	6	Histopathology	51±25	116±27	-
Schroeder	4	12	Histopathology	42±22	70±21	715±328
Becker	4	11	Histopathology	47±9	104±28	
Schroeder	4	15	IVUS	14±26	91±21	419±194

## For detection of plaque by CT

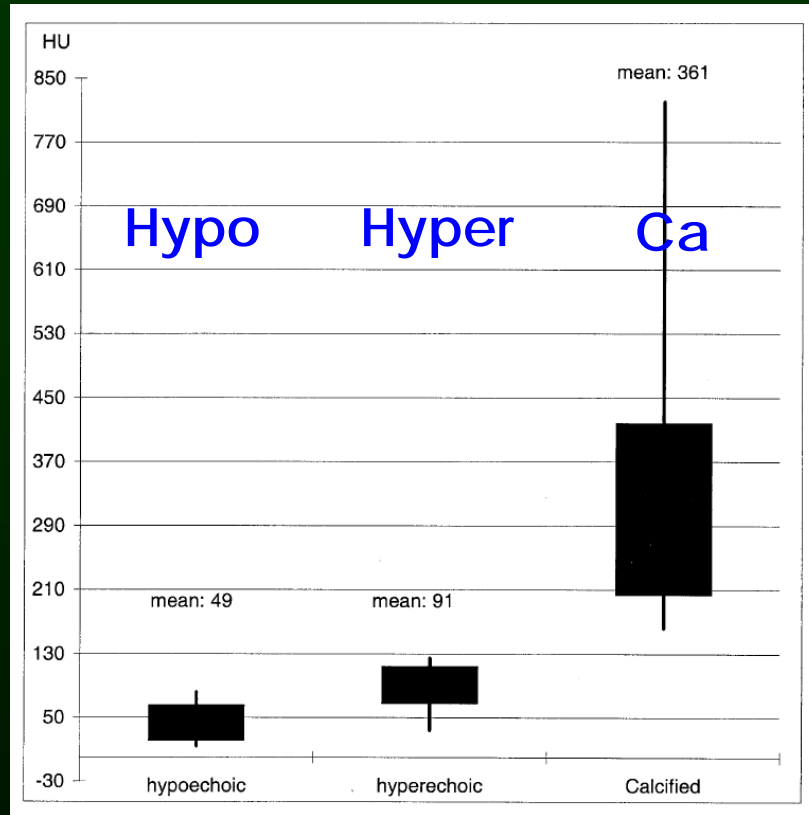
Sensitivity 86%,  
 Specificity 69%,  
 positive predictive value 90%,  
 negative predictive value 61%

<sup>[1]</sup> Intravascular ultrasound

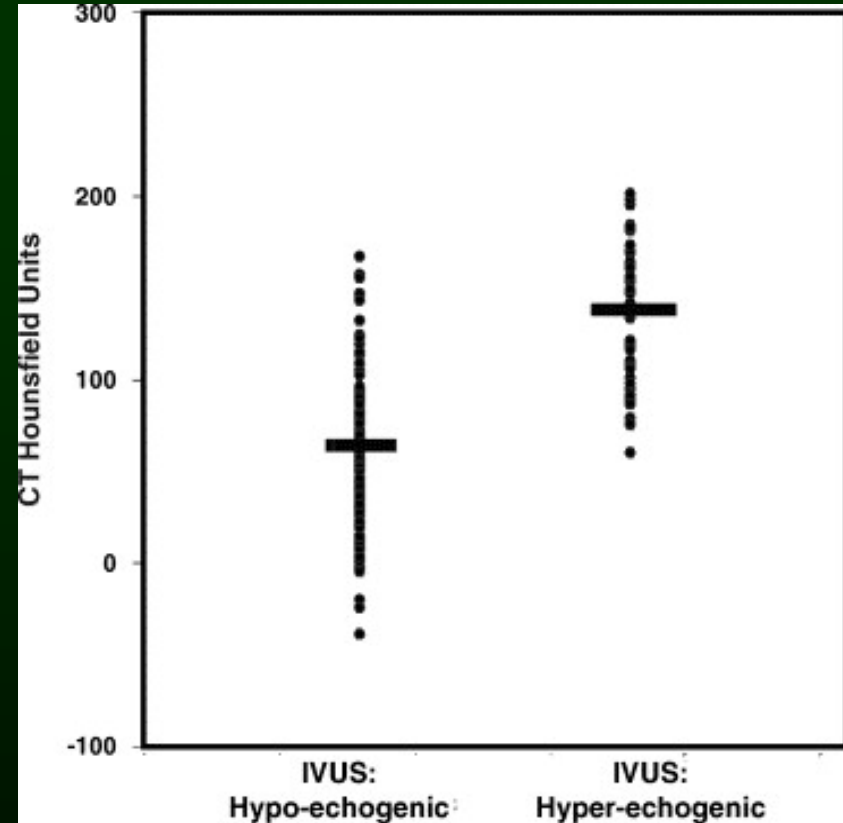
*Van Mieghem et al. J Am Coll Cardiol 2006;47:1134-42*



# Is there cut-off value?



*Leber et al. J Am Coll Cardiol 2006;47:672-7*



*Pohle et al. Atherosclerosis 2007;190:174-80*

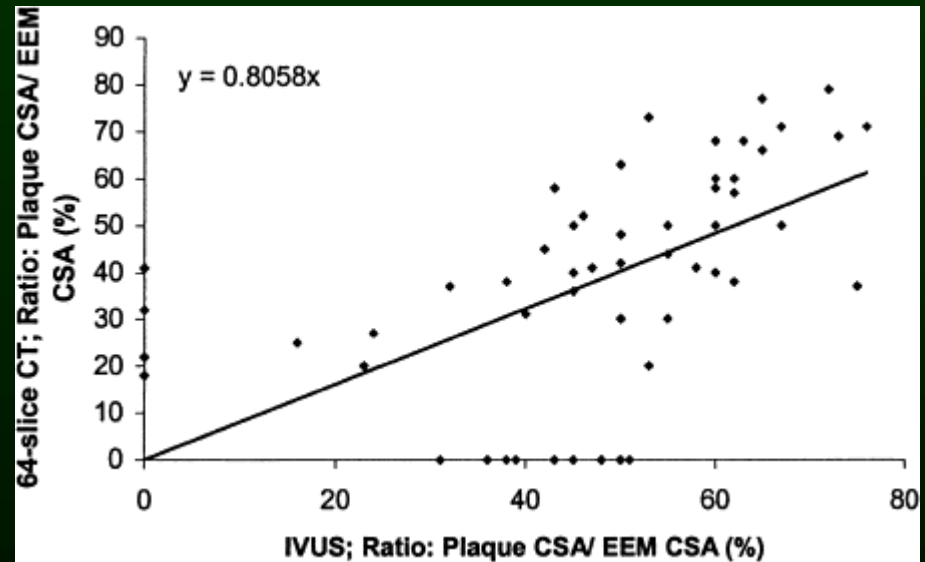
Characterizing a single atherosclerotic plaques as stable or vulnerable does  
Not seem possible based on measurement of its CT density alone.



# Plaque area and volume

Correlation of the percentage of plaque area contributing to entire vessel area

- MDCT can underestimate or overestimate plaque area or volume depending on different methods to measure.



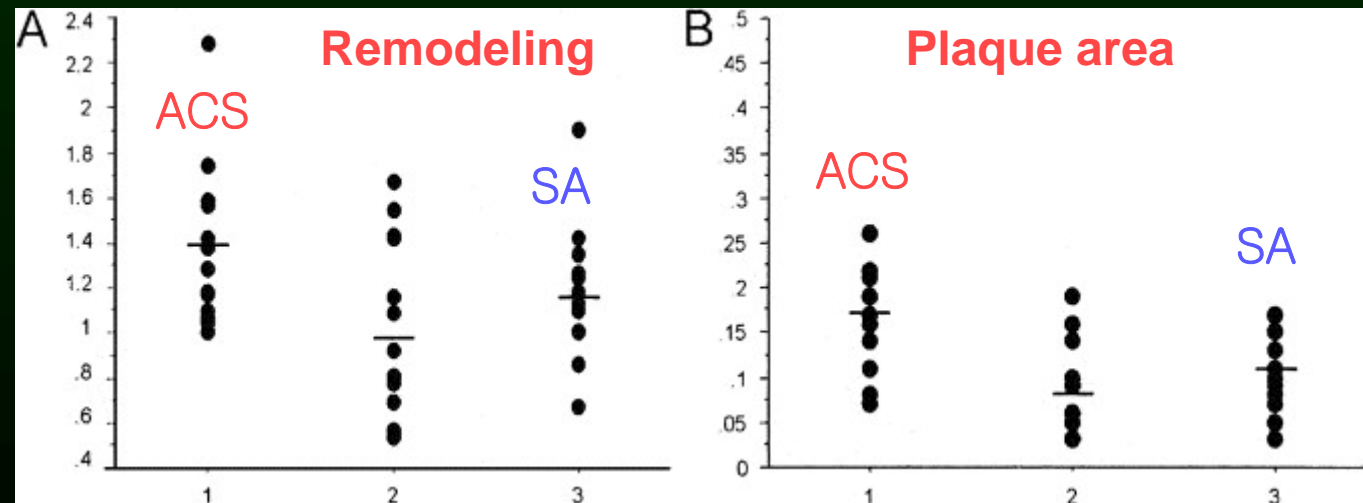
*Leber et al. J Am Coll Cardiol 2006;47:672–7*



# Plaque Remodeling

Sensitivity: 100%, specificity 90%

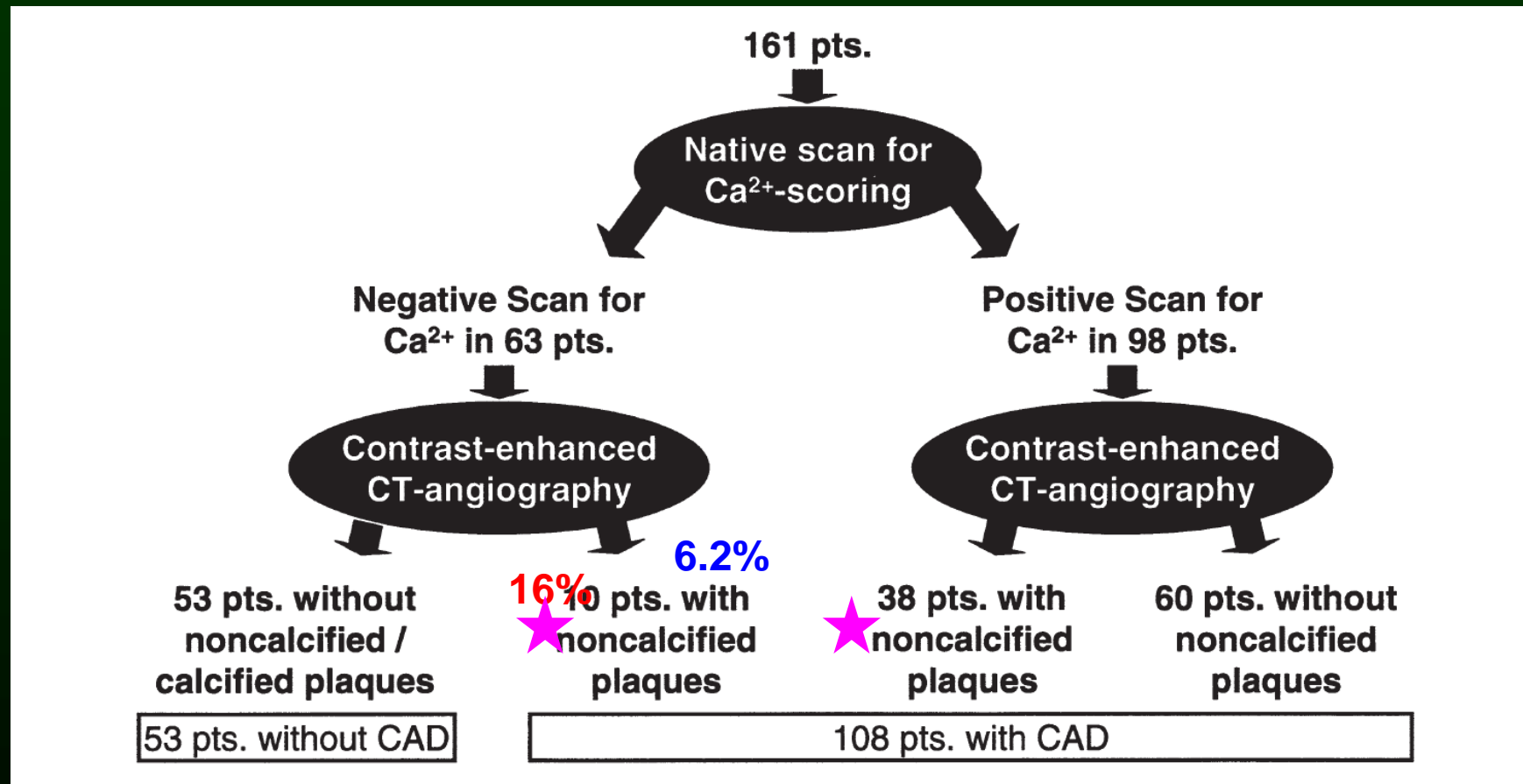
Author	detectors	Patients	MDCT(mm <sup>2</sup> )	IVUS(mm <sup>2</sup> )
Achenbach	16	13	20 ± 7	18 ± 8
Leber	64	59	9.4 ± 5.1	8.4 ± 4.5



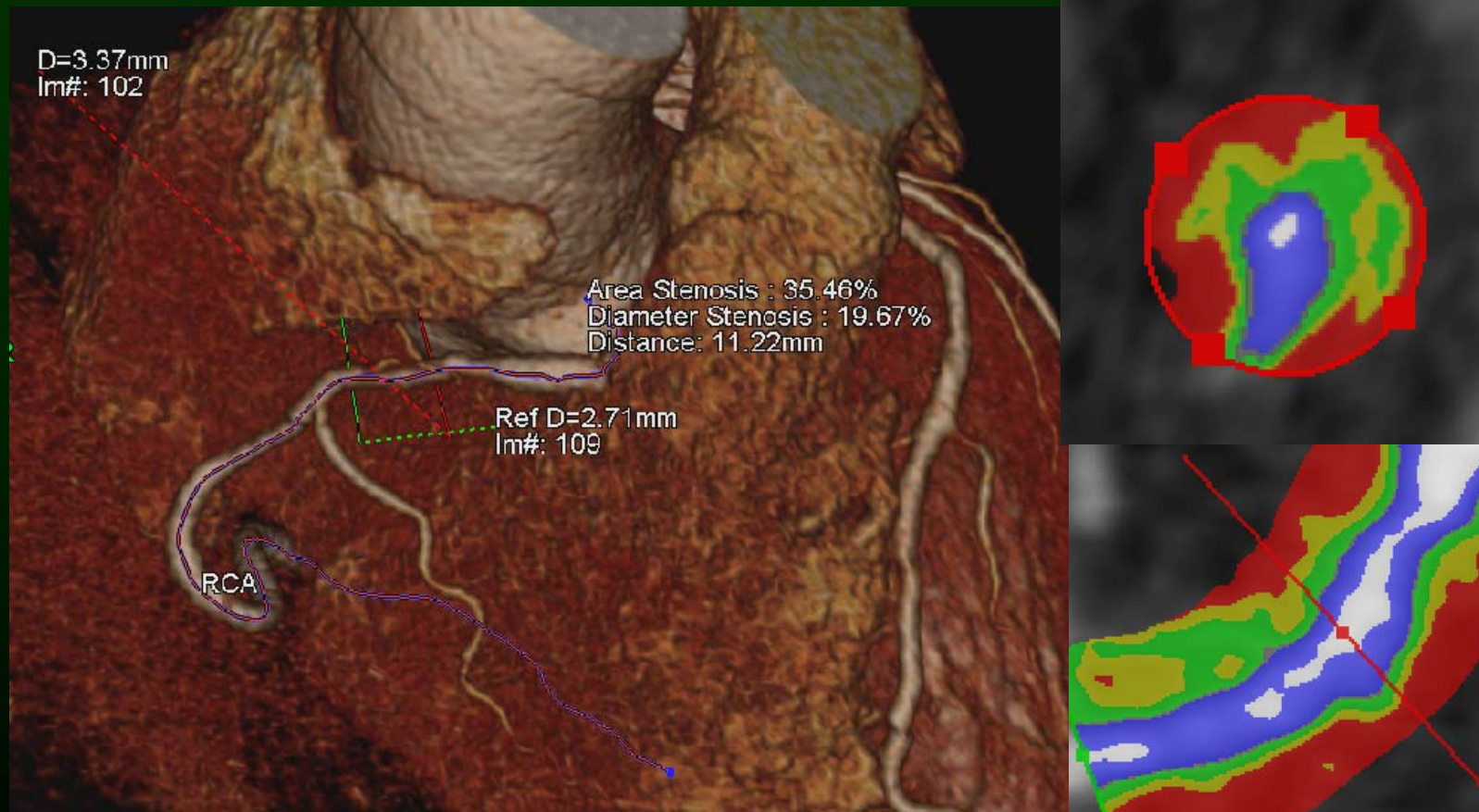
Hoffmann et al. *J Am Coll Cardiol* 2006;47:1655–62



# Prevalence of Noncalcified Plaque by 64-CT in Patients with an Intermediate Risk for Significant CAD



# Plaque Characterization & Volume Quantification

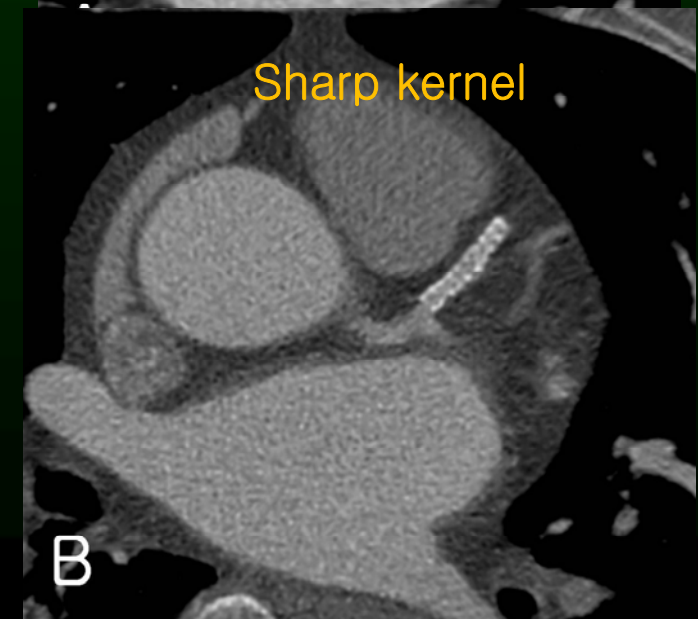
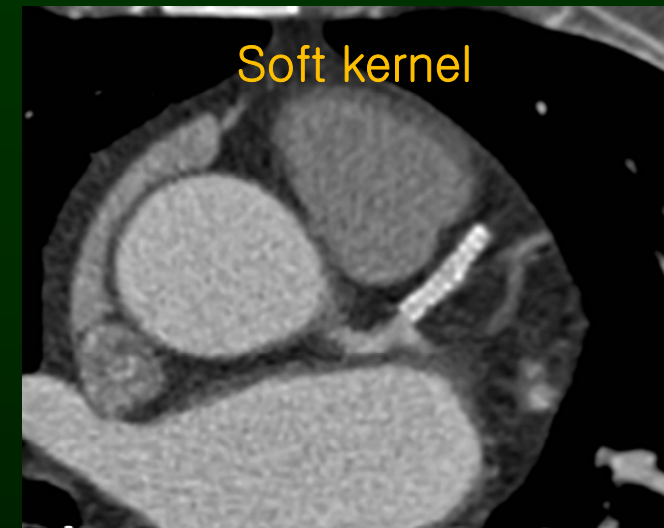




# Limitations

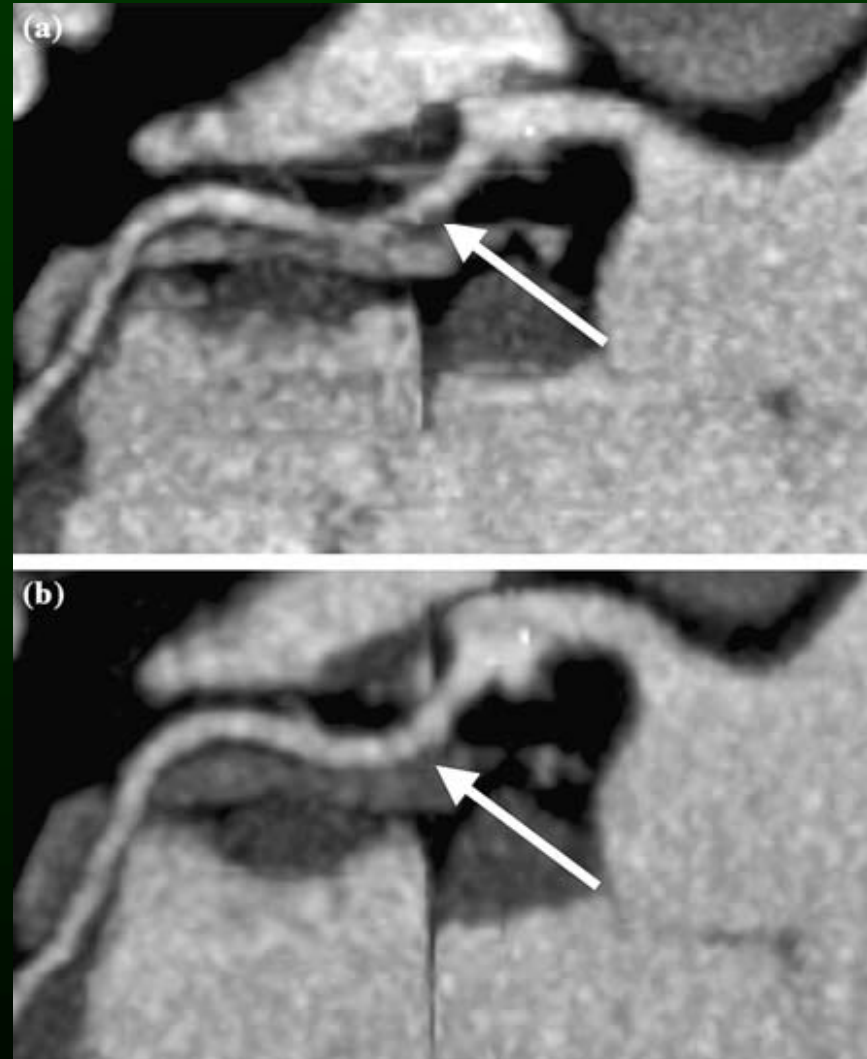
- CT:
  - Protocol
  - Contrast agent, calcification
  - Image noise, partial volume effect
  - External contour
  - Convolution kernel
  - Reproducibility
    - Interobserver agreement 92% for nocalcified plaque

*Ferencik et al. JACC 2006;47:207–9*



# regressive coronary soft plaque

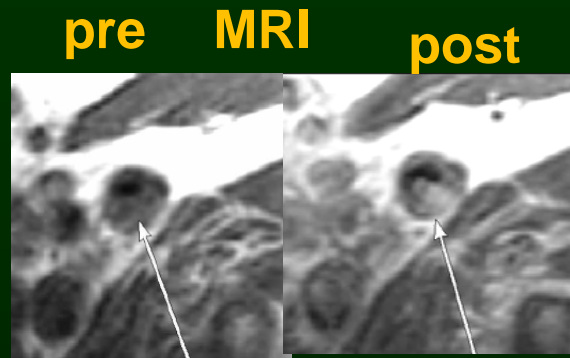
- Regression of soft plaque under lipid lowering therapy one year later
  - Atorvastatin 20mg/d
  - Acetylsalicylated acid 100mg/d



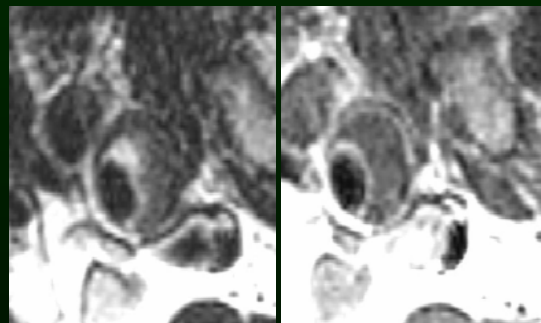
*Burgstahler et al. Int J Cardiovasc Imaging 2006;22:119–21*



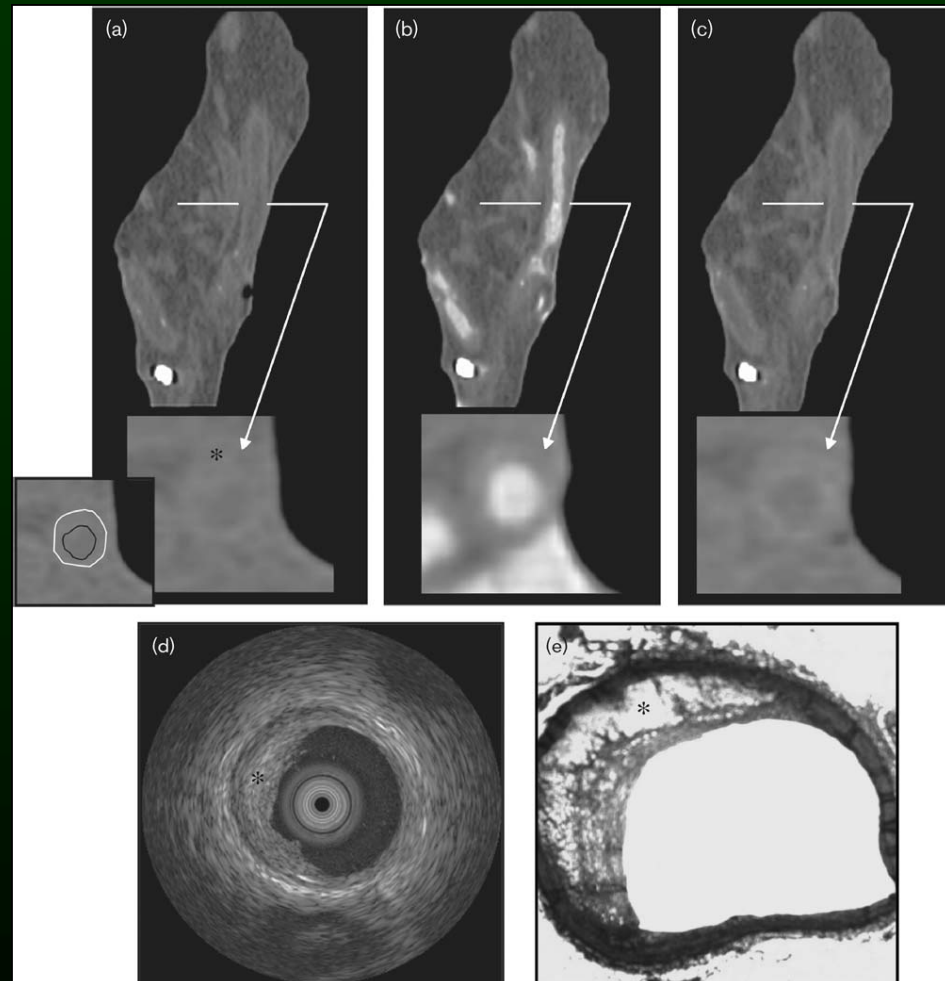
# Contrast enhancement of plaques



**Fibrous plaque**



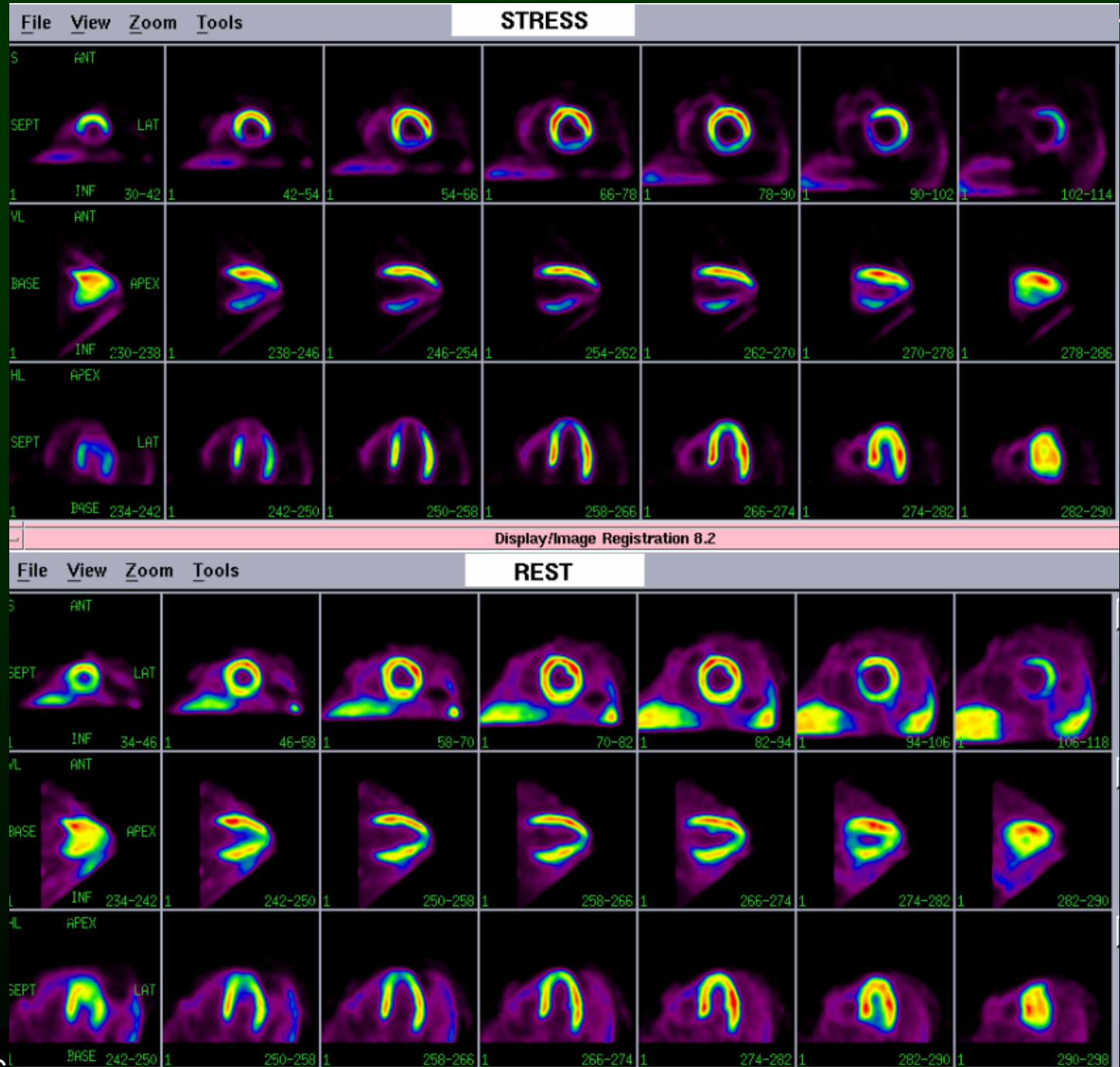
**Necrotic plaque**



*Halliburton et al. Coron Artery Dis 2006;17:553-60*



M/46 Chest pain



$^{13}\text{N}$ -  $\text{NH}_3$  PET



Yonsei University College of Medicine



RCA

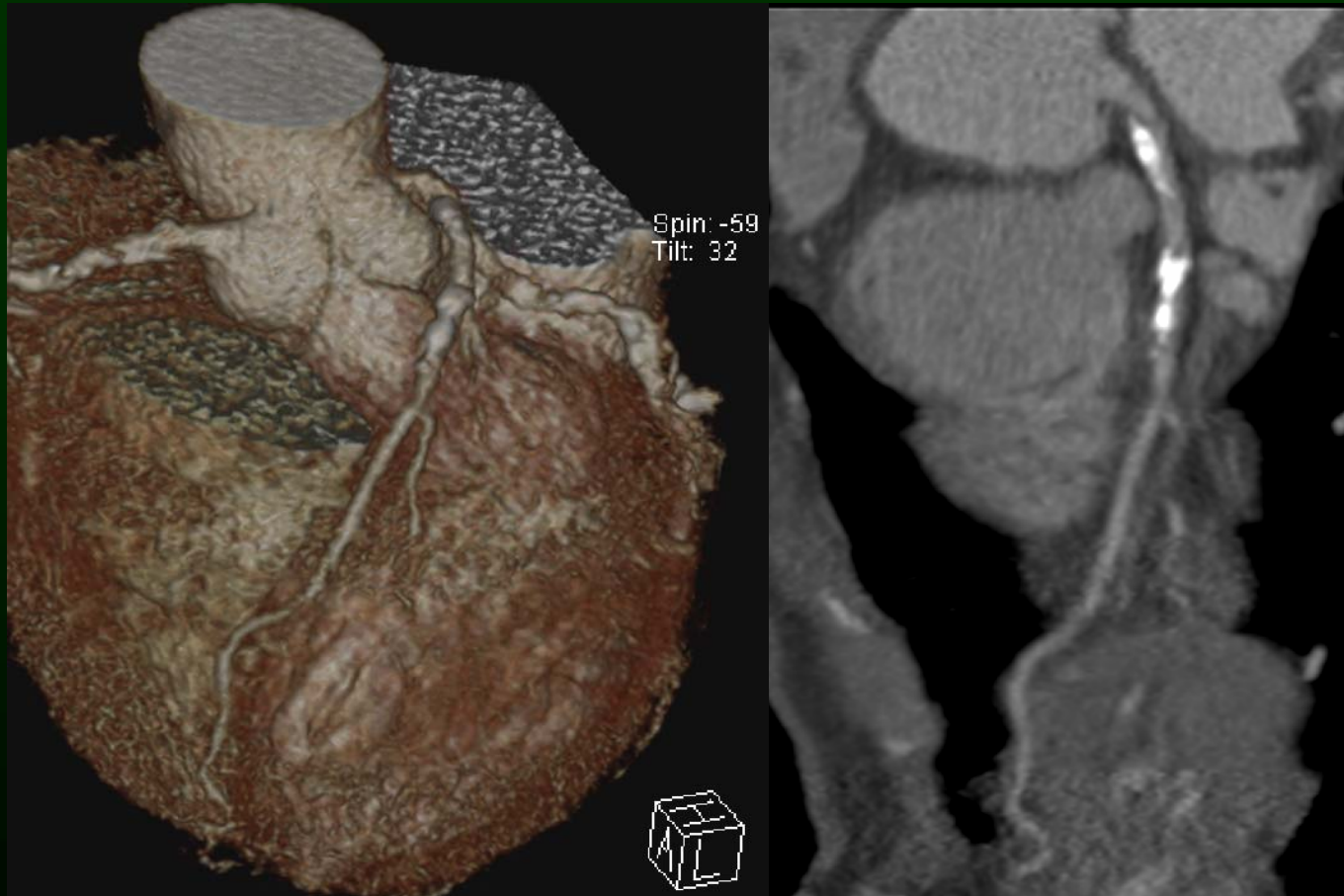


M/75

CC; 3 months of effort angina

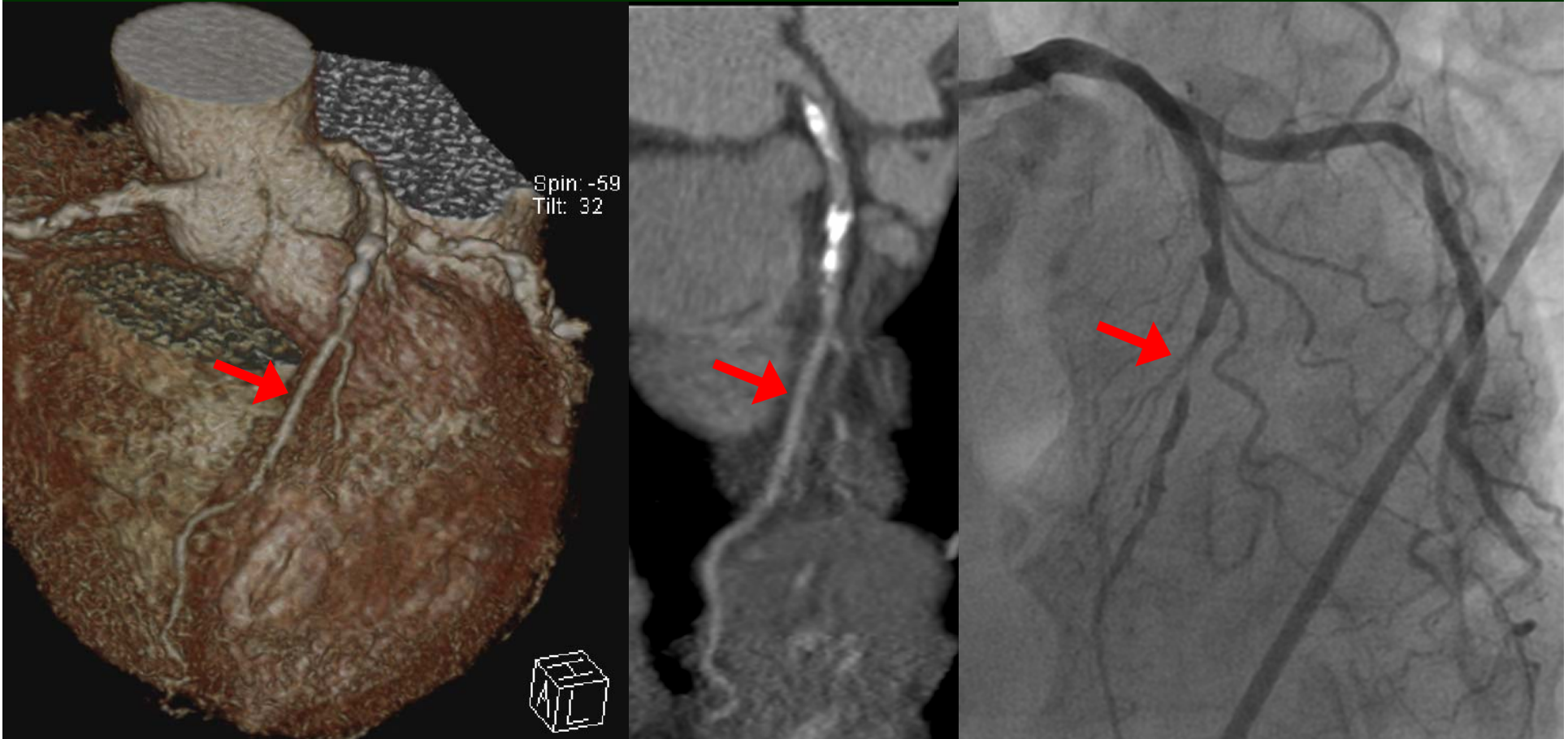
PHx: No DM, No HTN

EKG: NSR, Normal EKG



Emergency room with prolonged chest pain 4 days later.  
marked ST-segment elevation in Leads V2-V4 with cardiac enzyme elevation,  
suggesting STEMI  
→ Emergency PCI







# *Is it meaningful to classify plaques on the basis of their density?*

- Atherosclerotic lesions typically consist of multiple different components ranging from necrotic to calcified tissue.
- High-risk plaques with a lipid core and a thin fibrous cap may be either predominantly calcified [Stary IVa], fibrous [Stary IVb], or soft [Stary IVc], but all are assigned to Stary class IV.
- “Lipid pools and spotty calcifications” embedded in atherosclerotic lesions are associated with plaque vulnerability.

*Ehara et al. Circulation 2004;110:3424-9*



# Why CT?

- Noninvasive
- Technically easy to use
- Simple to interpret the results
- Convenient to the patients
  
- With ongoing technical developments image quality will improve permitting a comprehensive assessment of plaque morphology and composition.



# Summary

- Clinical application not yet supported by any scientific evidence...
- Further studies are necessary.
- Long-term follow-up studies in larger populations...

