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Current Status of CT for Plaque Evaluation

Wm. Guy Weigold, MD

Director of Cardiac CT

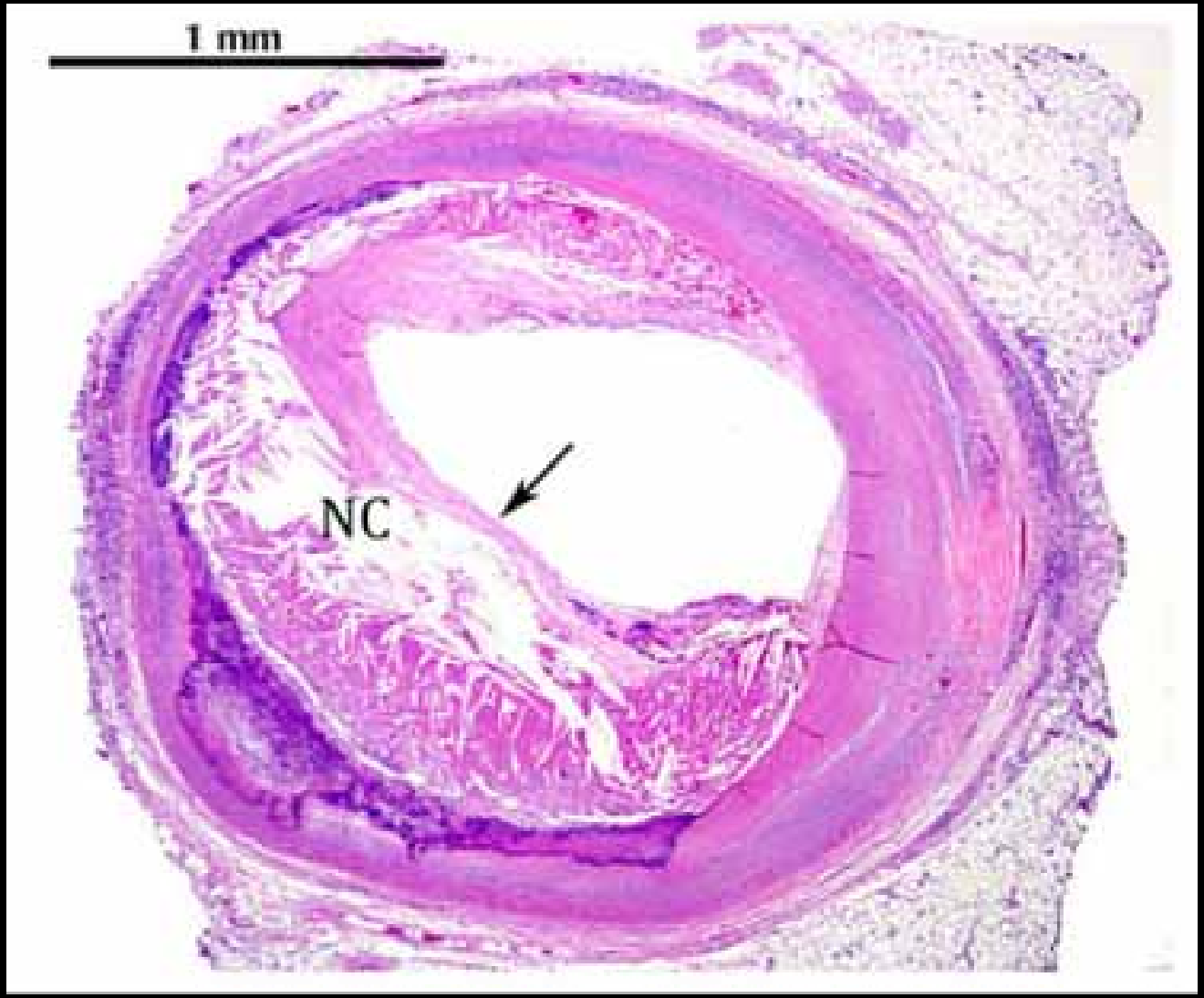
MedStar Heart Institute

MedStar Washington Hospital Center

Washington, DC

Washington Hospital Center

The Thin Cap Fibroatheroma



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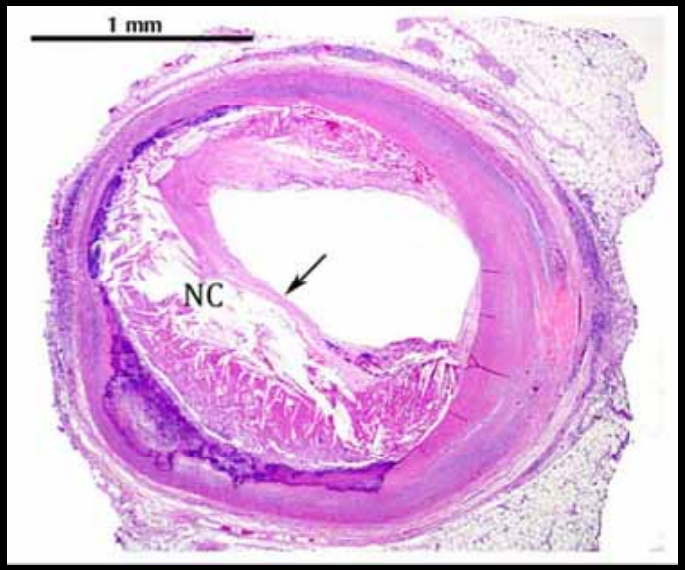

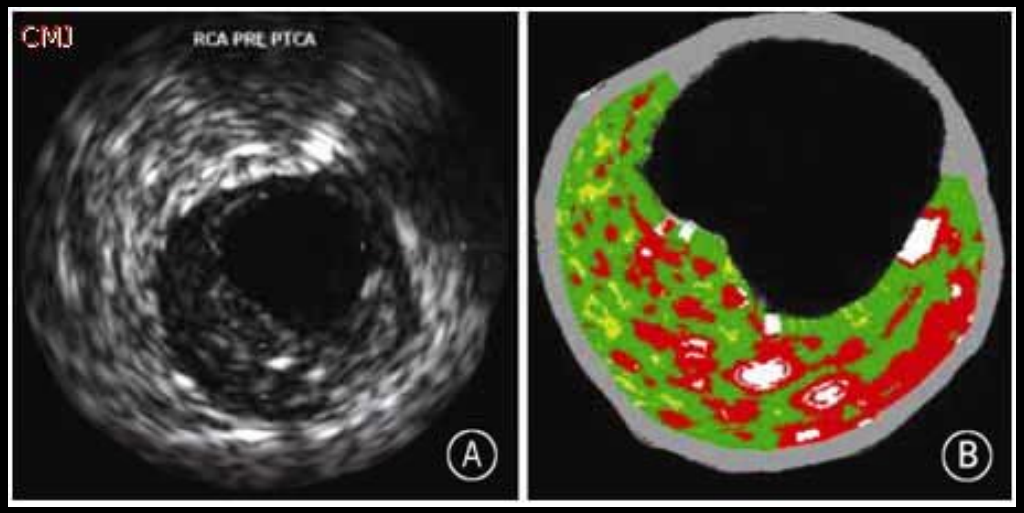

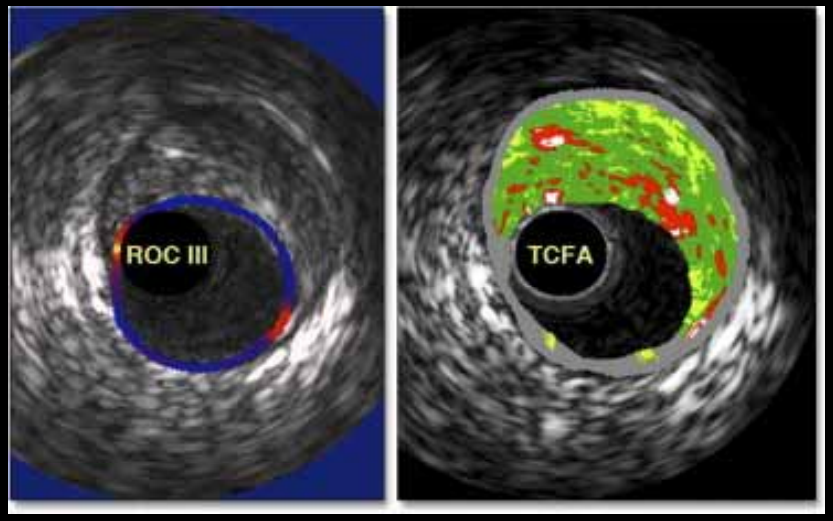

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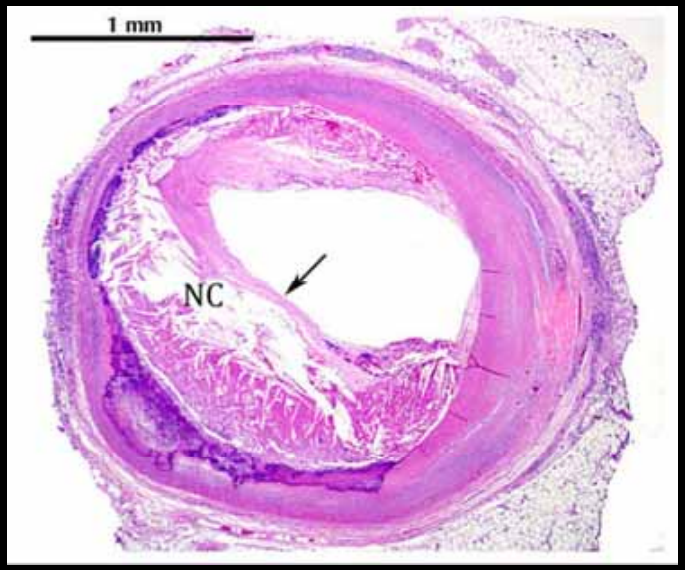

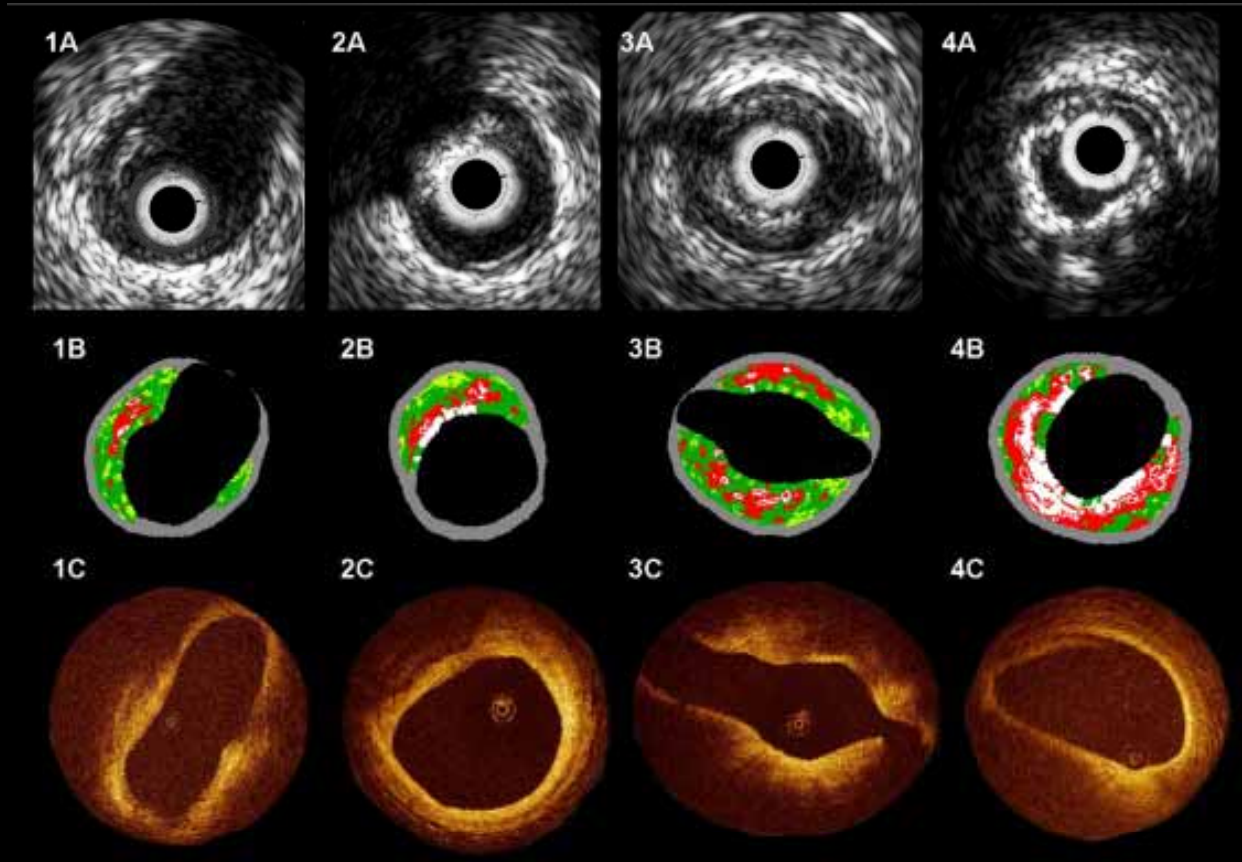

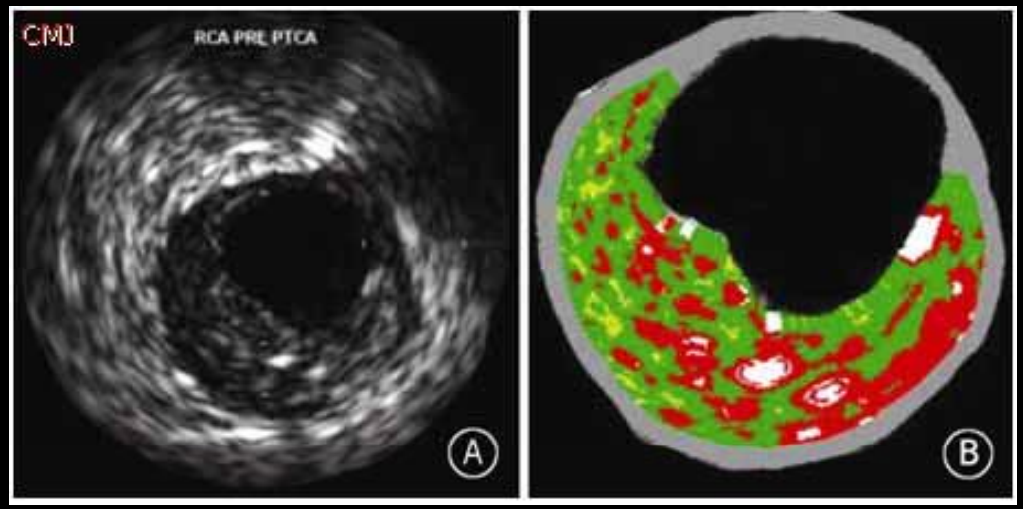

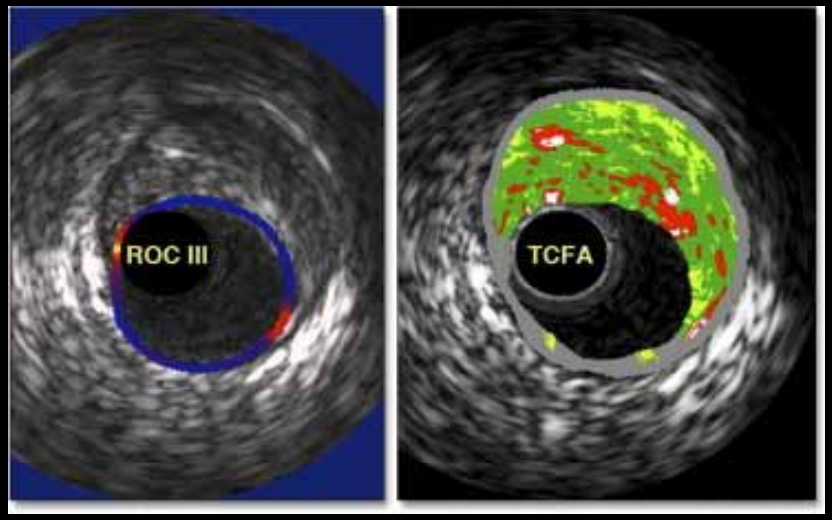

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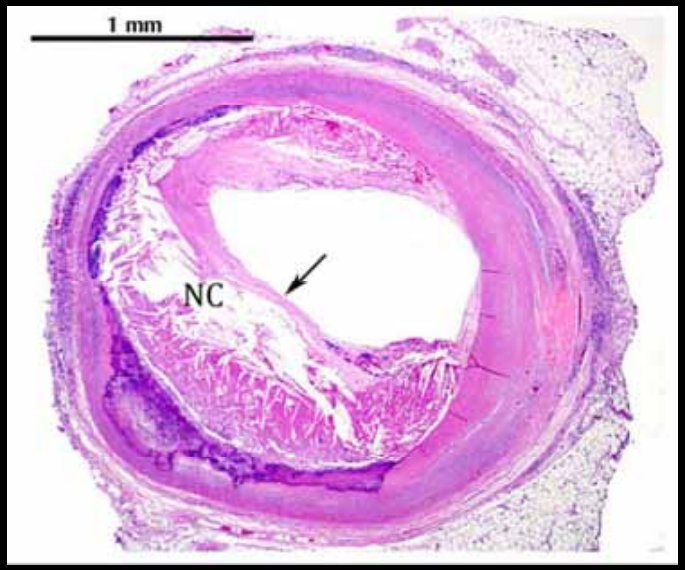

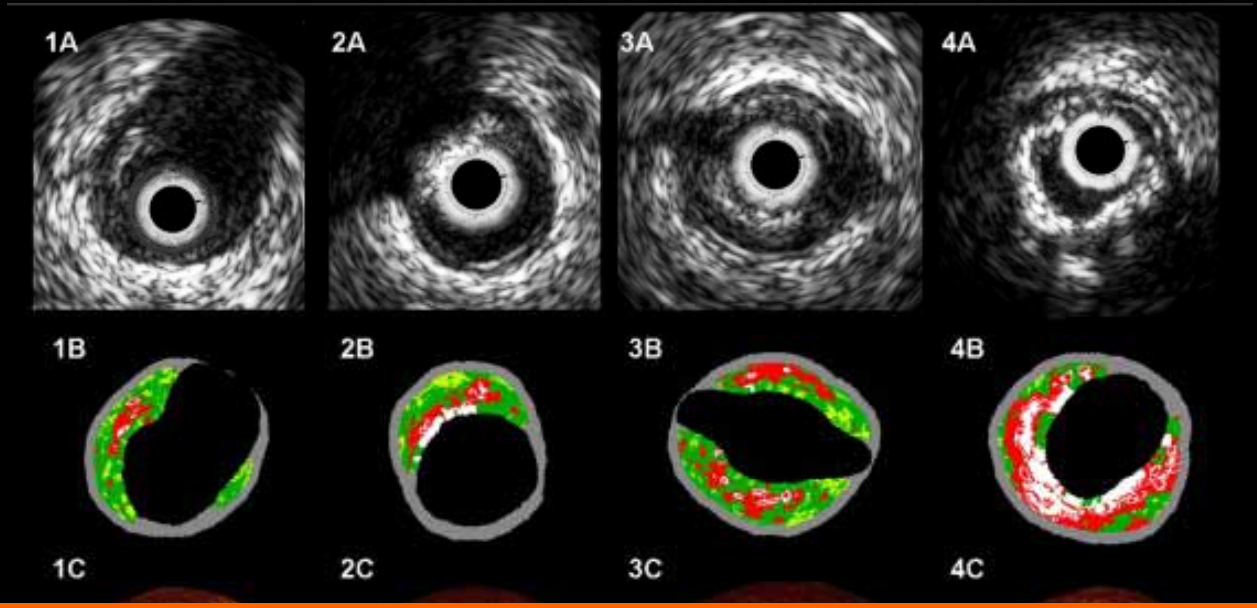

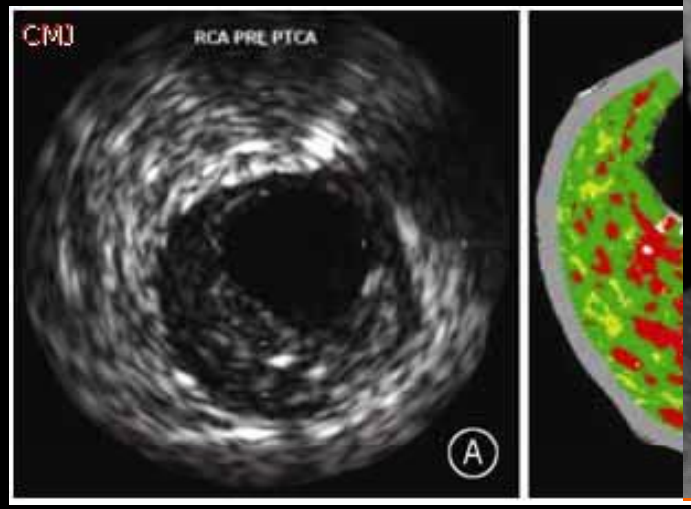

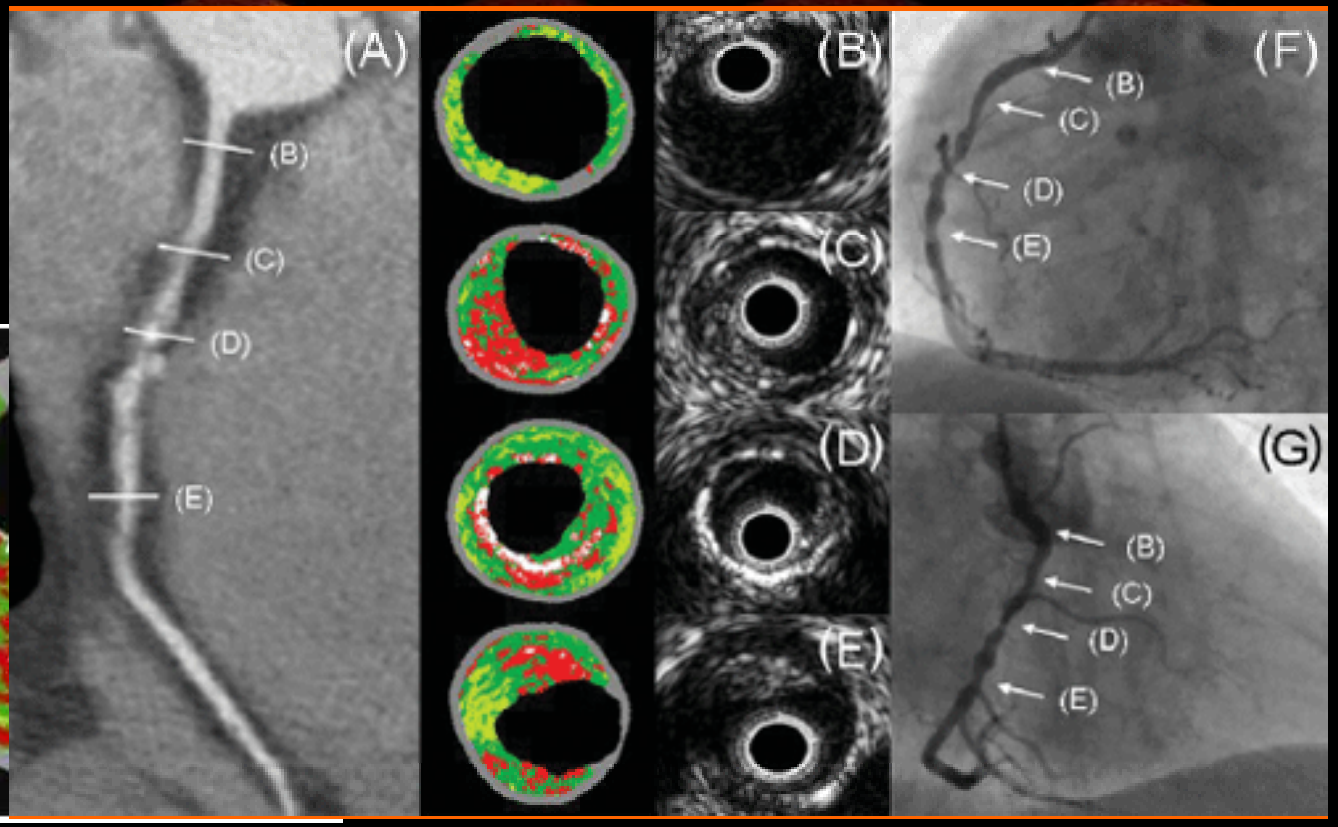

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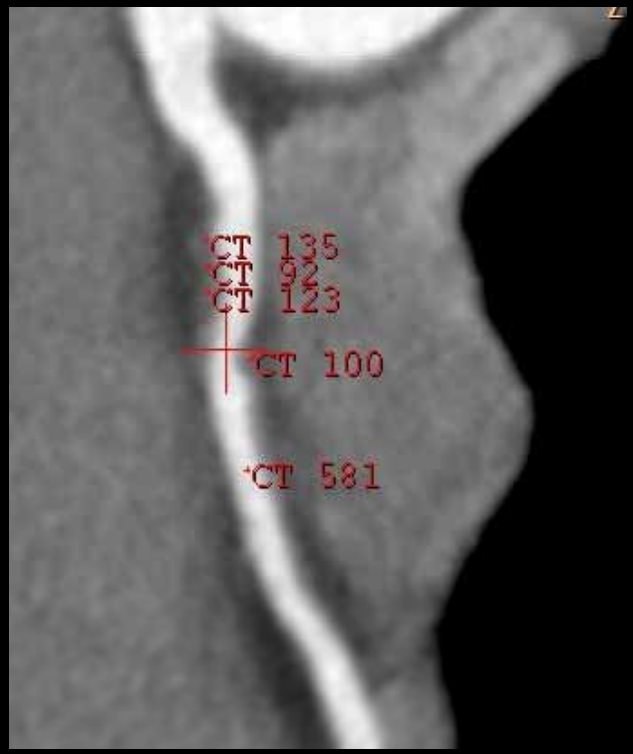
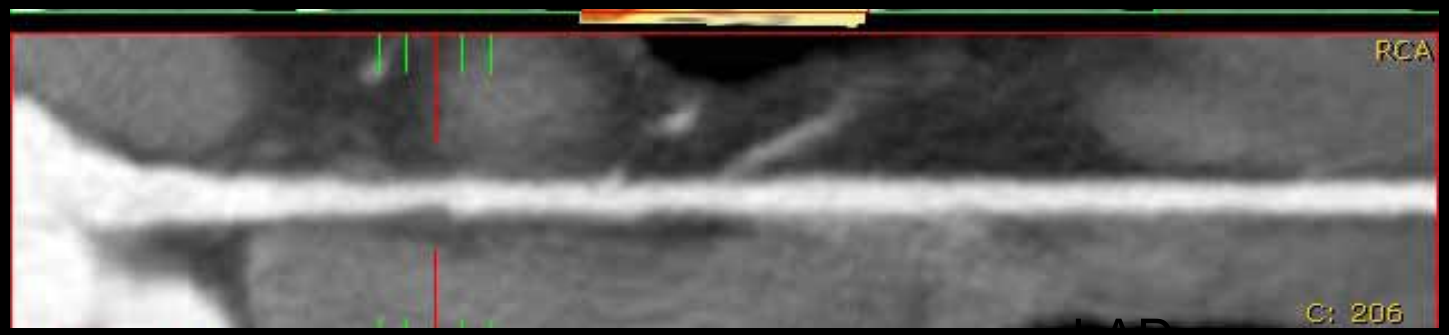
Non-Calcified Plaque (RCA)

- 49 yr old woman
  - Dyspnea, negative MPS
- HTN
- LDL 156, HDL 61
- CAC score 0
- Noncalcified plaque RCA and LAD
  - Outward remodeling





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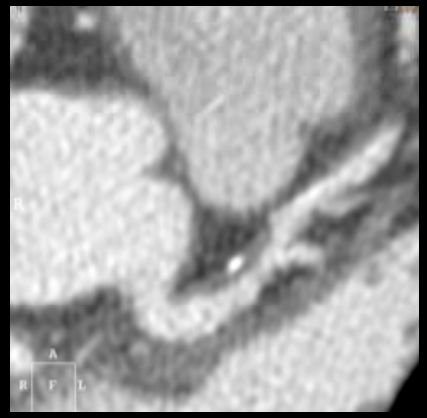
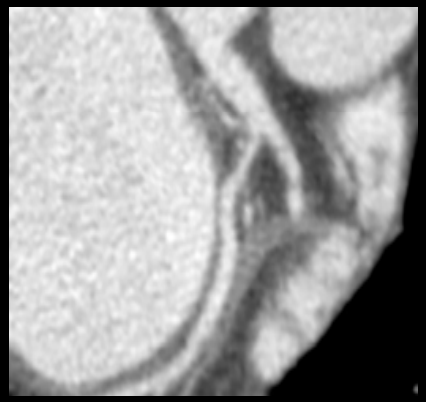
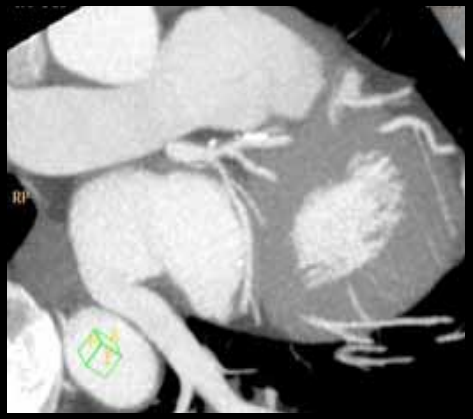
Partially Calcified Plaque (LAD)

- 47 yr old man - atypical CP
- HTN- 160/100, LDL 112, HDL 38
- CAC score 165, Mixed plaque: LAD, LCX







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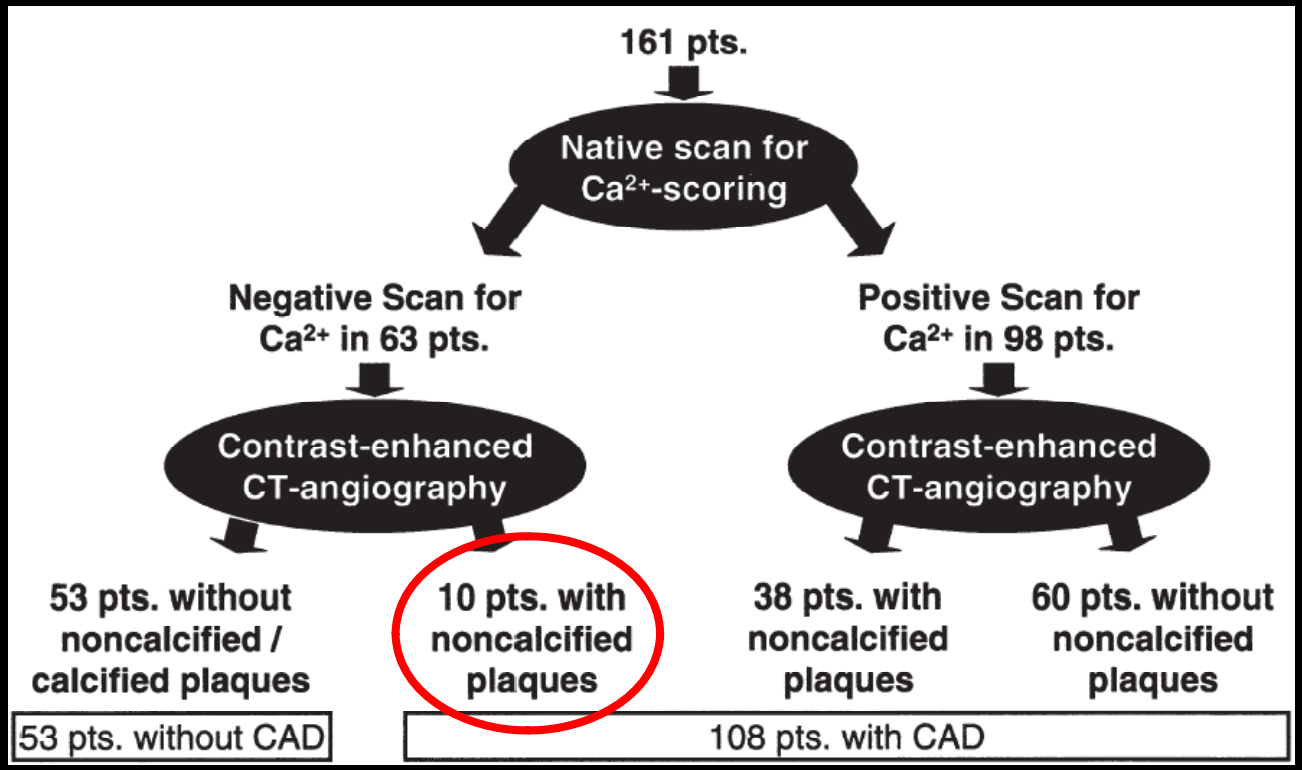
Problems with Detection of Non- and Partially-Calcified Plaque

- Conceptual:
  - Well understood that atherosclerosis is a diffuse process
  - Present as an isolated finding in the minority
- Practical:
  - Difficult to quantify
  - Limited accuracy
  - Low reproducibility
  - Independent predictive value unknown

How common is the finding of isolated non-calcified plaque?

Relatively uncommon in intermediate risk patients!



J Am Coll Cardiol 2006;48;312-318

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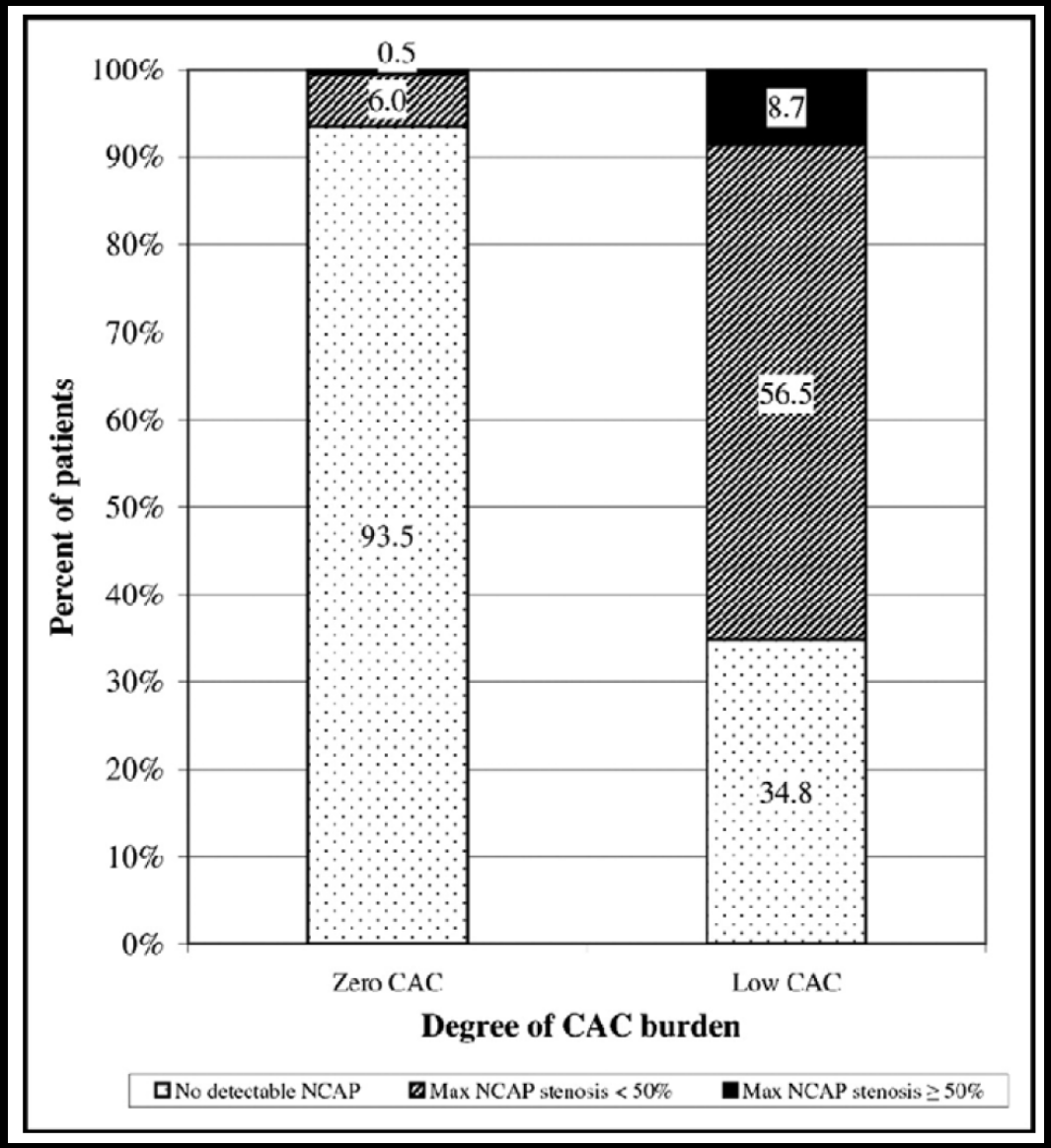
Non-calcified plaque: uncommon when CAC = 0 in lower risk patients

- **N = 554**
  - **zero or low (<50) CAC scores**
- **Prevalence**
  - **6.5% in patients with 0 CAC**
  - **65.2% in those with low CAC**



AJC **2007;99:1183-1186**

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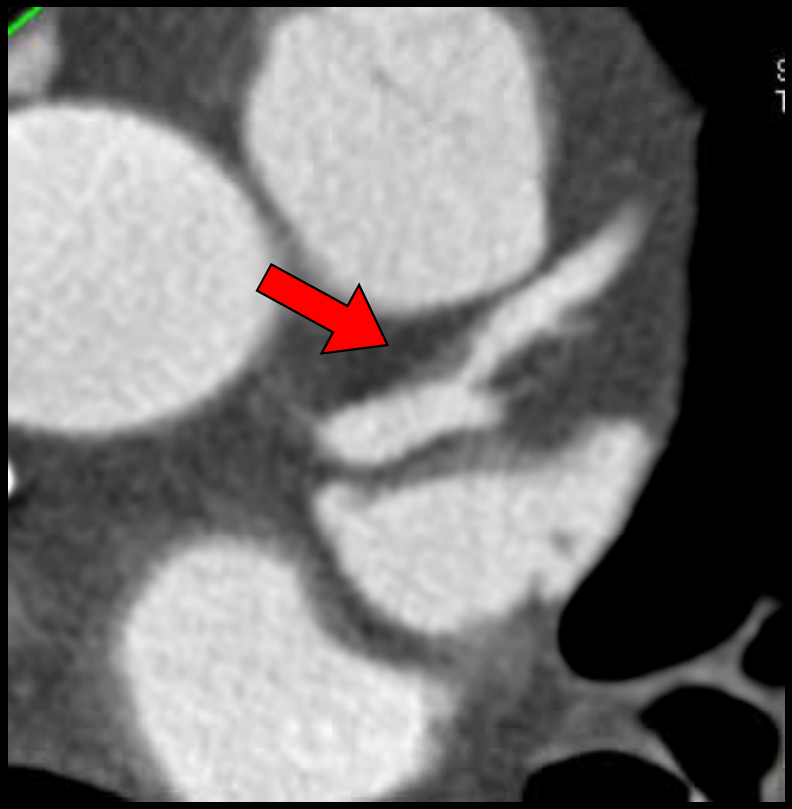
Imaging non-calcified plaque is difficult

- Requires: maximal spatial resolution, minimized image noise:
  - Radiation, contrast



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Accuracy of 64-Slice Computed Tomography to Classify and Quantify Plaque Volumes in the Proximal Coronary System

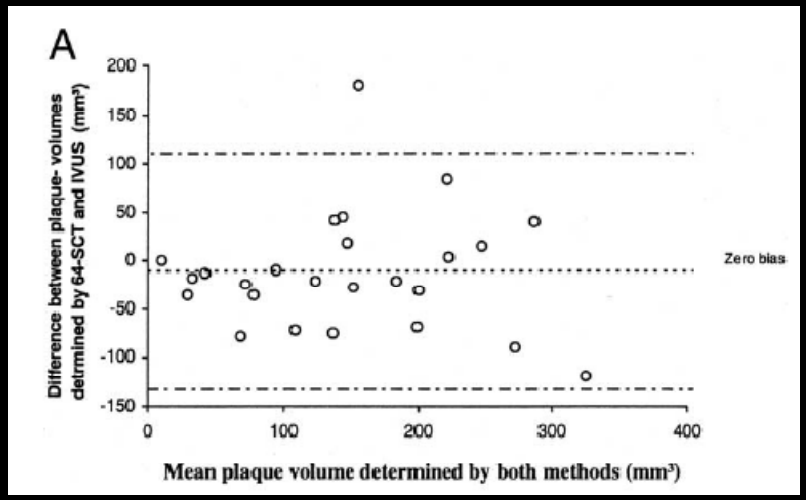
A Comparative Study Using Intravascular Ultrasound

Alexander W. Leber, MD,*§ Alexander Becker, MD,* Andreas Knez, MD,* Franz von Ziegler, MD,* Marc Sirol, MD,§ Konstantin Nikolaou, MD,† Bernd Ohnesorge, PHD,‡ Zahi A. Fayad, PHD,§ Christoph R. Becker, MD,† Maximilian Reiser, MD,† Gerhard Steinbeck, MD,* Peter Boekstegers, MD*

Munich and Forchheim, Germany; and New York, New York

- Spearman's correlation coefficient for plaque volumes determined by 64-slice CT and IVUS was r^2 0.69, p 0.001
- Noncalcified and mixed plaque volumes: underestimated
  - Sensitivity <80%
- Calcified plaques: overestimated

	IVUS			
64-Slice CT	**None**	**Calcified**	**Mixed**	**Noncalcified**
None	192	2	3	11
Calcified	1	34	8	0
Mixed	1	7	38	4
Noncalcified	10	0	4	50



J. Am. Coll. Cardiol. 2006;47;672-677

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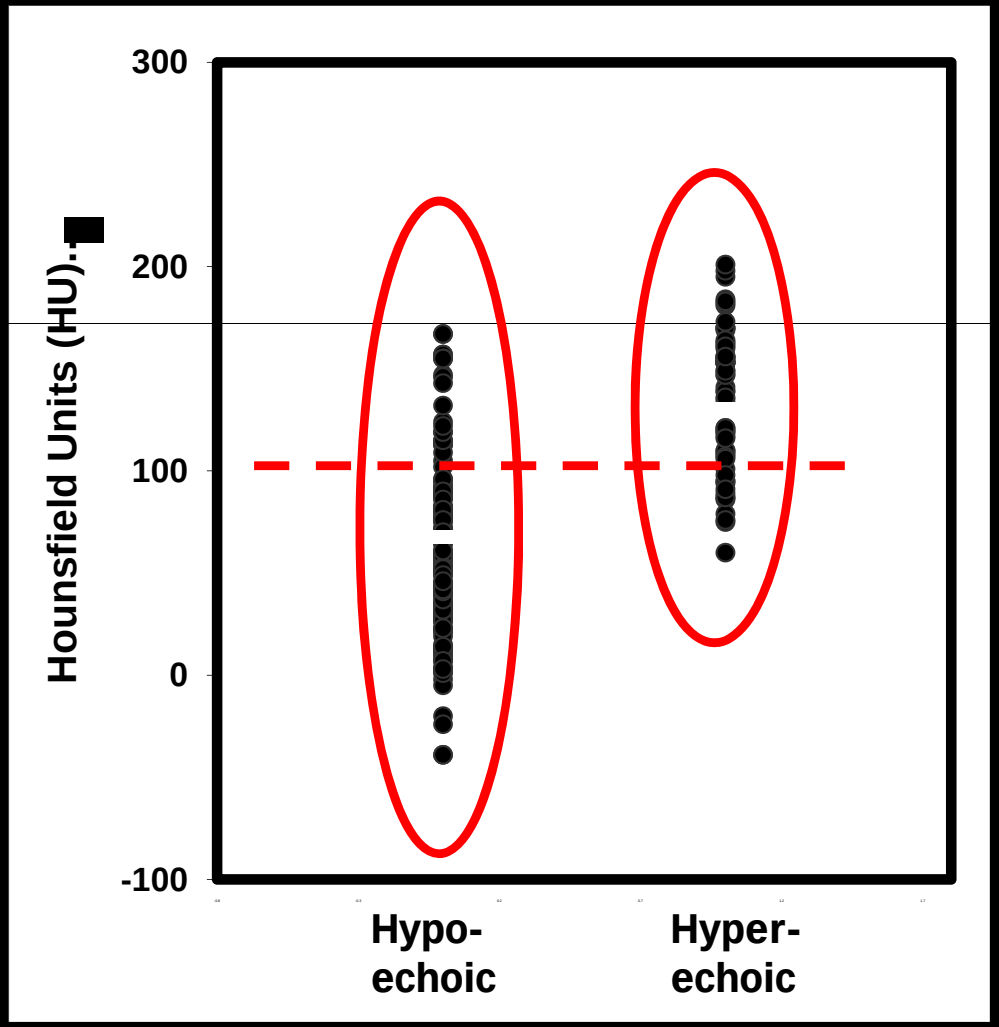
Is characterization of plaque vulnerability possible?

Lower CT attenuation values in lipid-rich versus fibrous plaques- acute vs. stable culprit lesions

	LR	Fib
Schroeder JACC 2001	14 HU	91 HU
Becker Eur Radiol 2006	47 HU	104 HU
Leber JACC 2004	49 HU	91 HU
Carrascosa Am J Cardiol 2006	71 HU	116 HU
Pohle Atherosclerosis 2006	58 HU	121 HU

Overlap in HU values



Pohle et al, Atherosclerosis 2006

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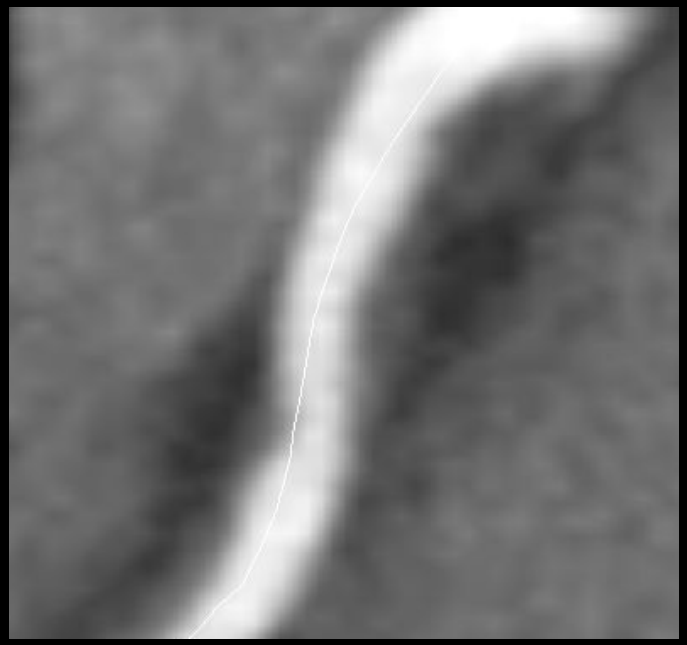
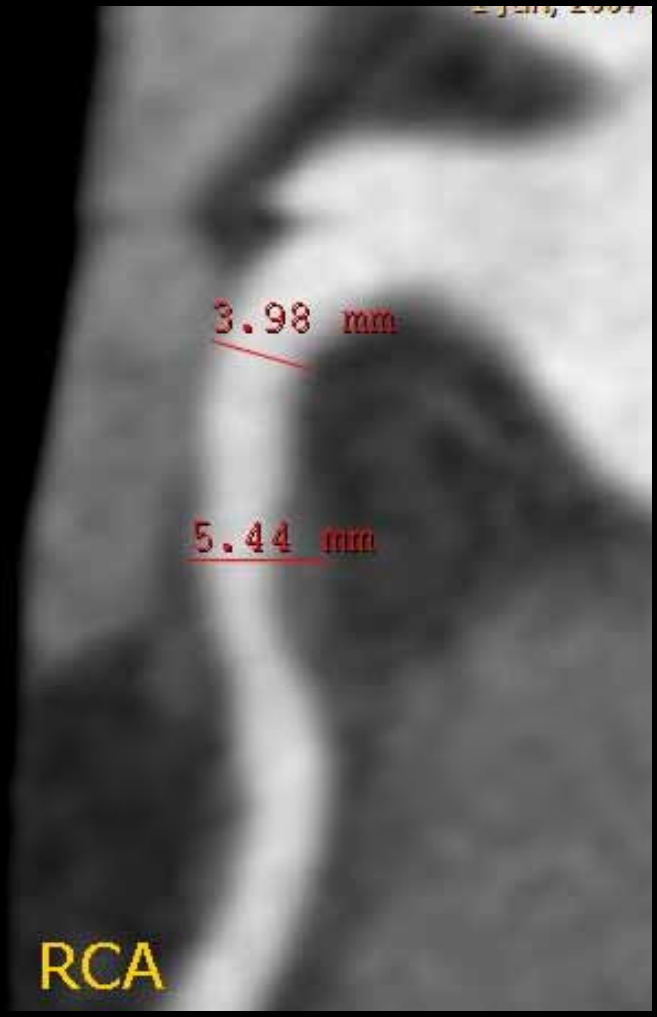
Outward remodeling

- Remodeling Index:
- Ratio of diameter of lesion to reference
  - "Index" 1.37





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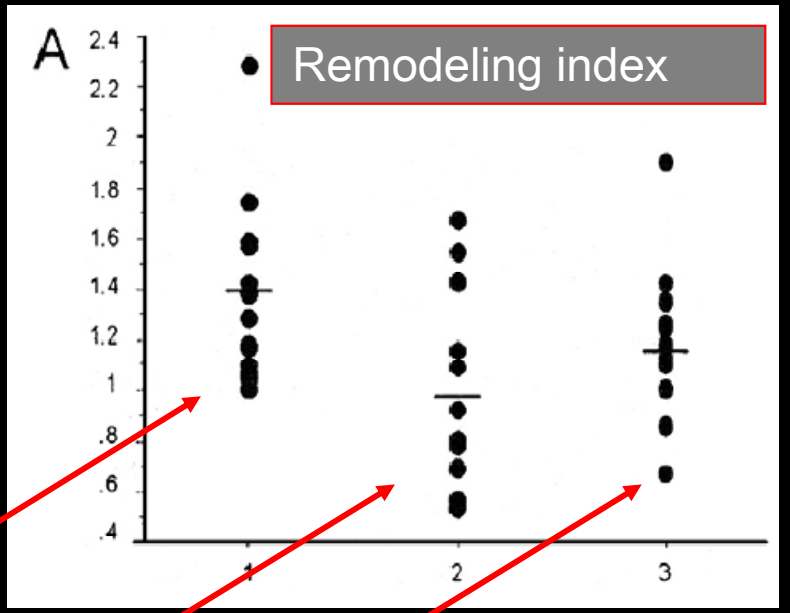
Noninvasive Assessment of Plaque Morphology and Composition in Culprit and Stable Lesions in Acute Coronary Syndrome and Stable Lesions in Stable Angina by Multidetector Computed Tomography

Udo Hoffmann, MD,* Fabian Moselewski, BS,*† Koen Nieman, MD,*† Ik-Kyung Jang, MD, PHD,† Maros Ferencik, MD, PHD,* Ayaz M. Rahman, MD,* Ricardo C. Cury, MD,* Suhny Abbara, MD,* Hamid Joneidi-Jafari, BS,* Stephan Achenbach, MD,*†‡ Thomas J. Brady, MD*

Boston, Massachusetts; and Erlangen, Germany

- ACS lesions by CT:
  - Larger plaques
  - Greater remodeling→
  - Similar degree of stenosis

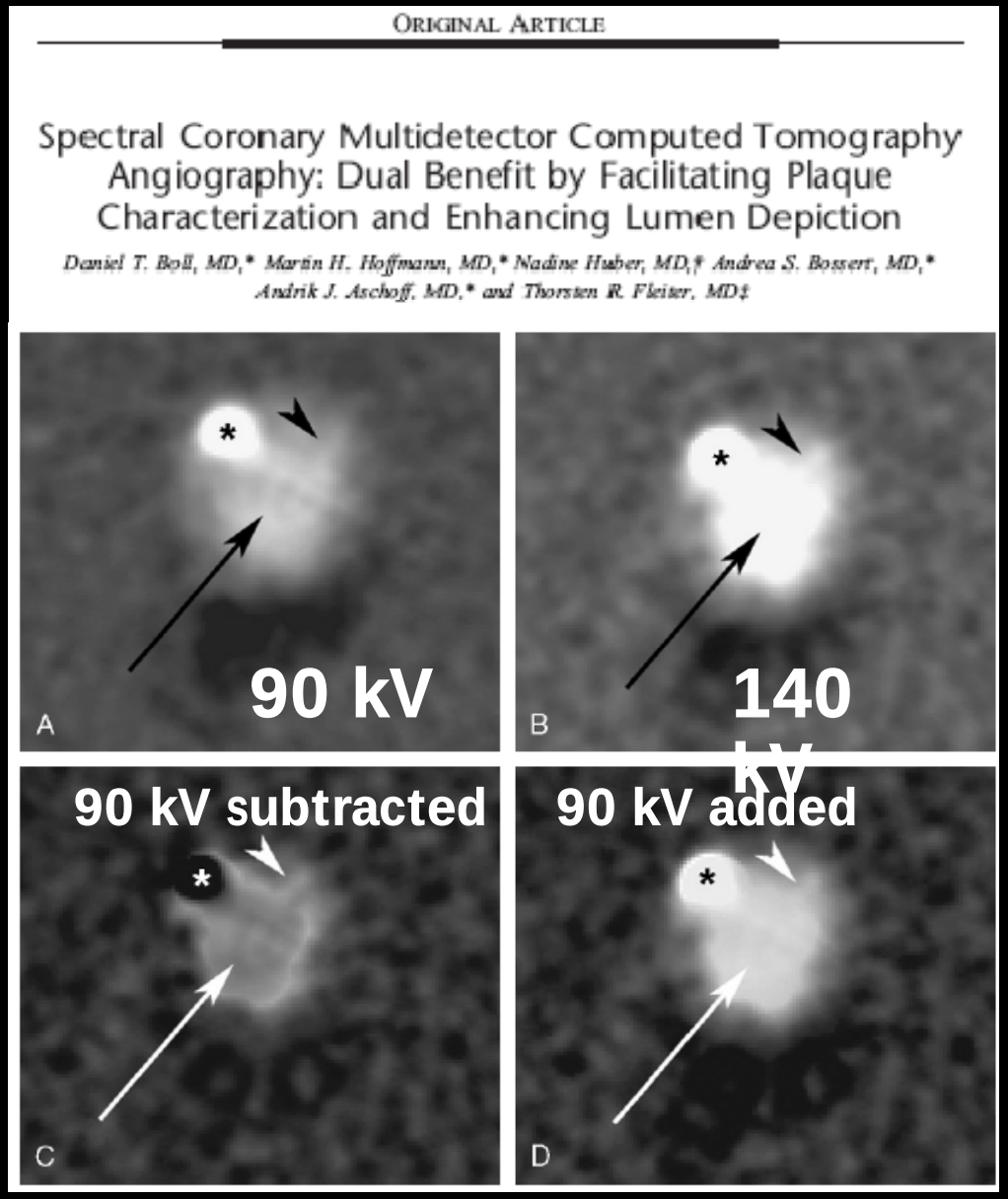
J Am Coll Cardiol 2006;47:1655– 62



	Culprit Lesions in ACS (n = 14)	Stable Lesions in ACS (n = 13)	Lesions in SA (n = 13)	p Value
Outer vessel area at stenosis (mm^2)	21.2 ± 7.0	11.8 ± 5.7	15.6 ± 10.5	0.01
Luminal area at stenosis (mm^2)	3.7 ± 1.6	2.7 ± 3.3	2.1 ± 1.4	0.18*
Plaque area (mm^2)	17.5 ± 5.9	9.1 ± 4.8	13.5 ± 10.7	0.02*
Degree of stenosis (%)	79.8 ± 7.2	80.2 ± 16.9	82.7 ± 9.7	0.79*
RI	1.4 ± 0.3	1.0 ± 0.4	1.2 ± 0.3	0.04

Noninvasive characterization of the morphology of 40 lesions with >50% luminal narrowing as derived from contrast enhanced 16-slice multidetector computed tomography (MDCT). The measurements were performed on cross-sectional images. Outer vessel area at stenosis includes both luminal and plaque area. *Differences between groups were determined with analysis of variance or Kruskal-Wallis test.

Emerging technique: Dual Energy CT



- **Dual energy CT to improve resolution of the coronary arterial wall**
- **"Subtracted" images**
- **Early work:**
  - **Ex vivo artery study**
  - Using DECT, vascular wall showed a 5.6 fold increase in contrast to noise ratio
- **Why important:**
  - **May permit more accurate vascular wall, plaque burden and luminal assessments**

J Comput Assist Tomogr. 2006;30:804-811

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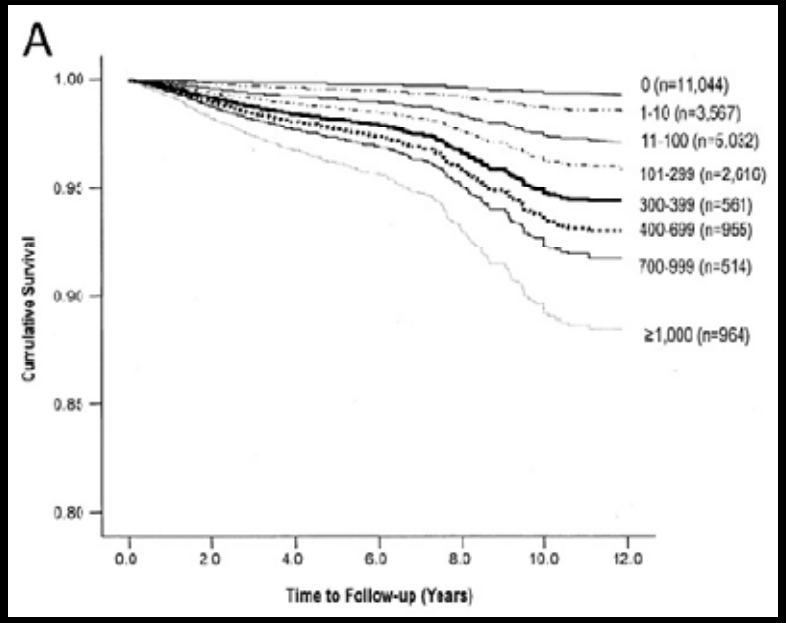
Cardiac Imaging

Long-Term Prognosis Associated With Coronary Calcification

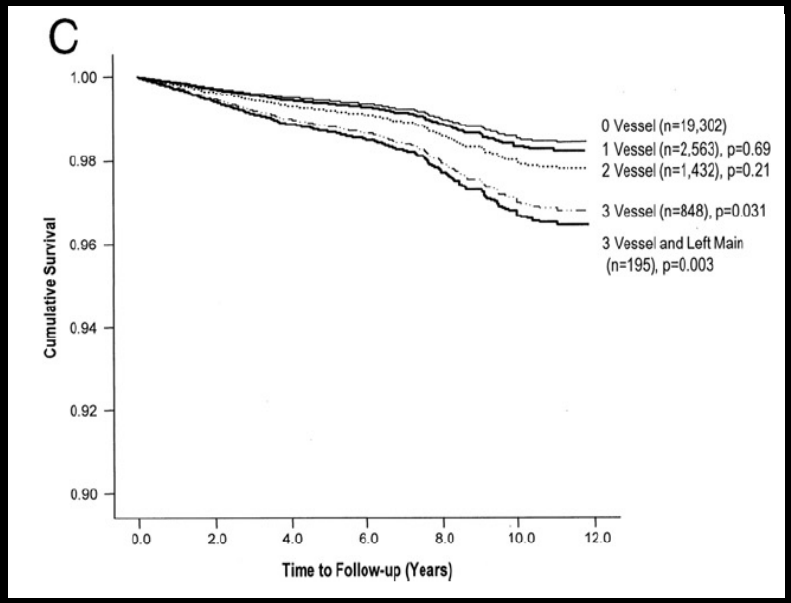
Observations From a Registry of 25,253 Patients

Matthew J. Budoff, MD,* Leslee J. Shaw, PHD,† Sandy T. Liu,* Steven R. Weinstein,* Tristen P. Mosler, Philip H. Tseng,* Ferdinand R. Flores,* Tracy Q. Callister, MD,‡ Paolo Raggi, MD,§ Daniel S. Berman, MD†

Torrance and Los Angeles, California; Nashville, Tennessee; and Atlanta, Georgia



- Prognosis is excellent in setting of zero or very low CAC scores
  - Little refinement possible?
- Number of vessels involved is important modifer
  - Even with CAC < 100



J Am Coll Cardiol 2007;49:1860–70

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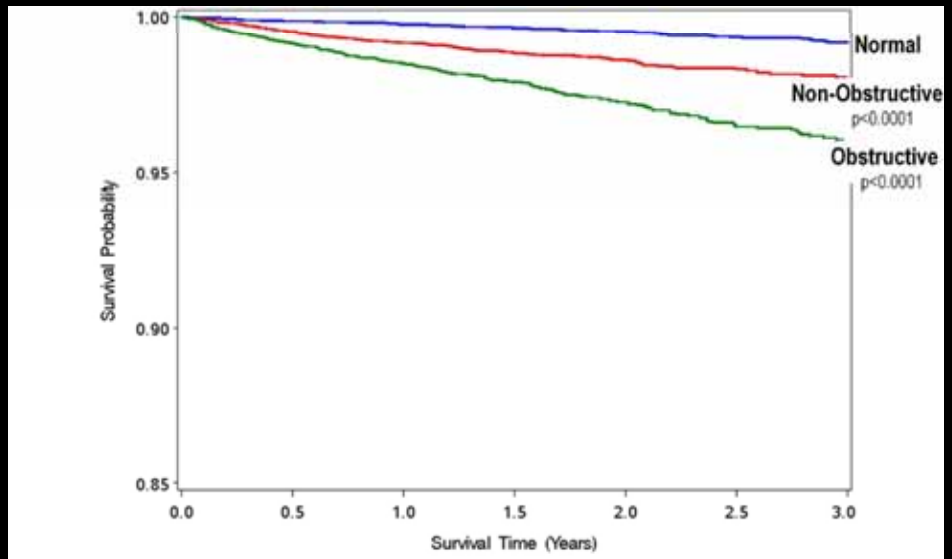
CONFIRM: Obstructive and Non-Obstructive CAD Predict Mortality

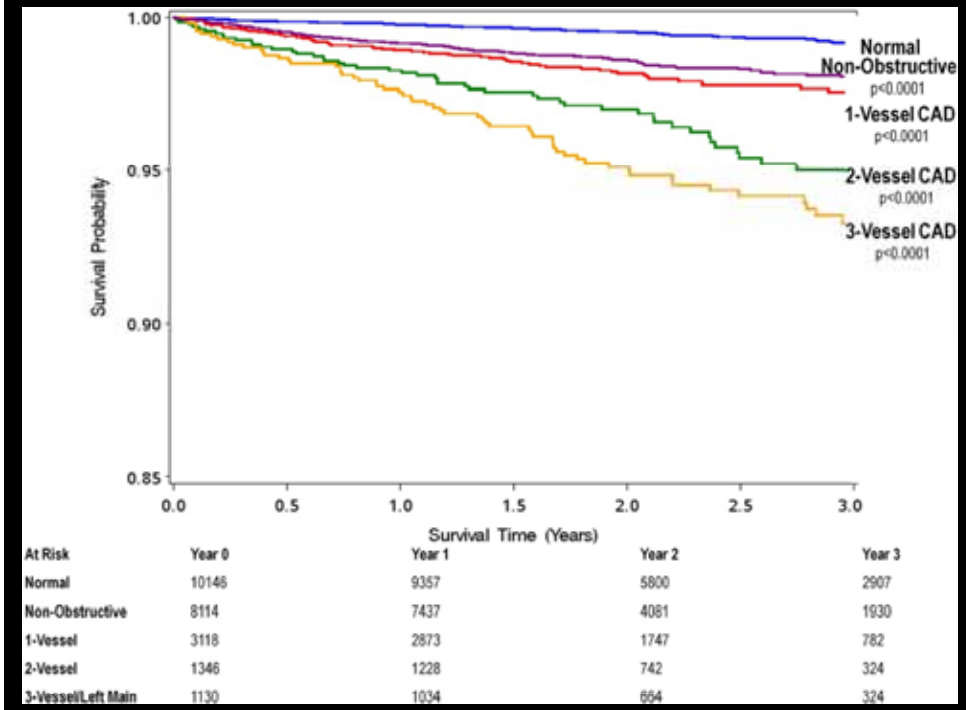
23,854 patients, clinical cor CTA, mean follow-up 2.3 yr



At Risk	Year 0	Year 1	Year 2	Year 3
Normal	10146	9357	5800	2907
Non-Obstructive (1-49%)	8114	7437	4081	1930
Obstructive (≥50%)	5594	5135	3153	1430

- Hazard Ratios for Death (compared to pts with No CAD):
  - Obstructive dz: 2.6
  - Non-obstr dz: 1.6 (1.2-2.2)

CONFIRM Registry of Cor CTA



At Risk	Year 0	Year 1	Year 2	Year 3
Normal	10146	9357	5800	2907
Non-Obstructive	8114	7437	4081	1930
1-Vessel	3118	2873	1747	782
2-Vessel	1346	1228	742	324
3-Vessel/Left Main	1130	1034	664	324

"Dose-Response relationship"

- HR for death related to number of diseased vessels:
  - 0 (non-obstr CAD): 1.62
  - 1 vessel: 2.00
  - 2 vessel: 2.92
  - 3 vessel or LM: 3.70

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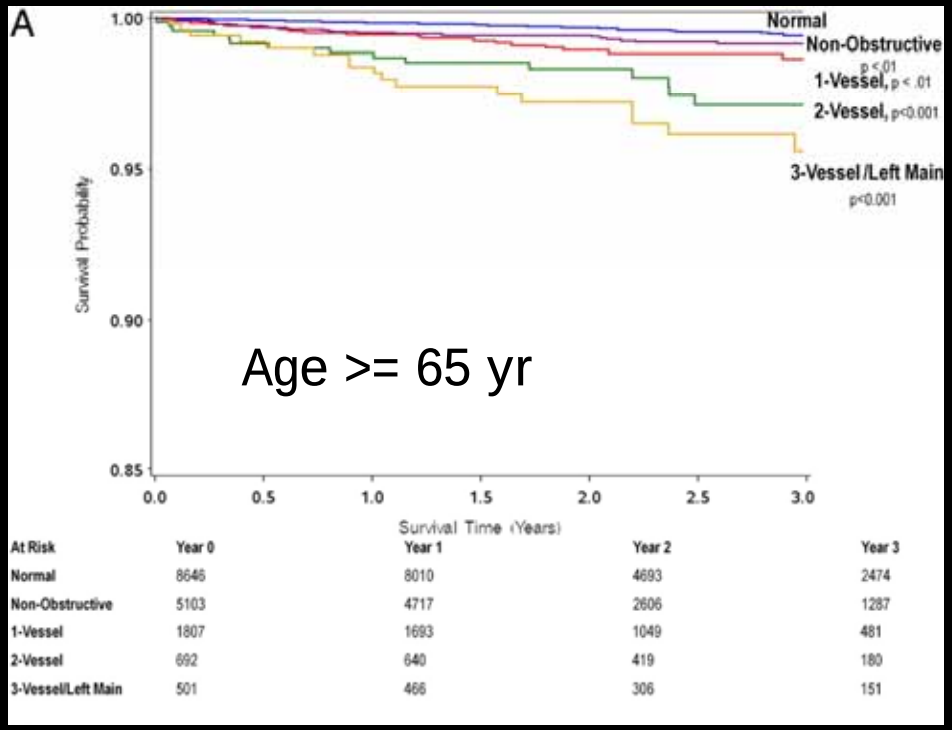
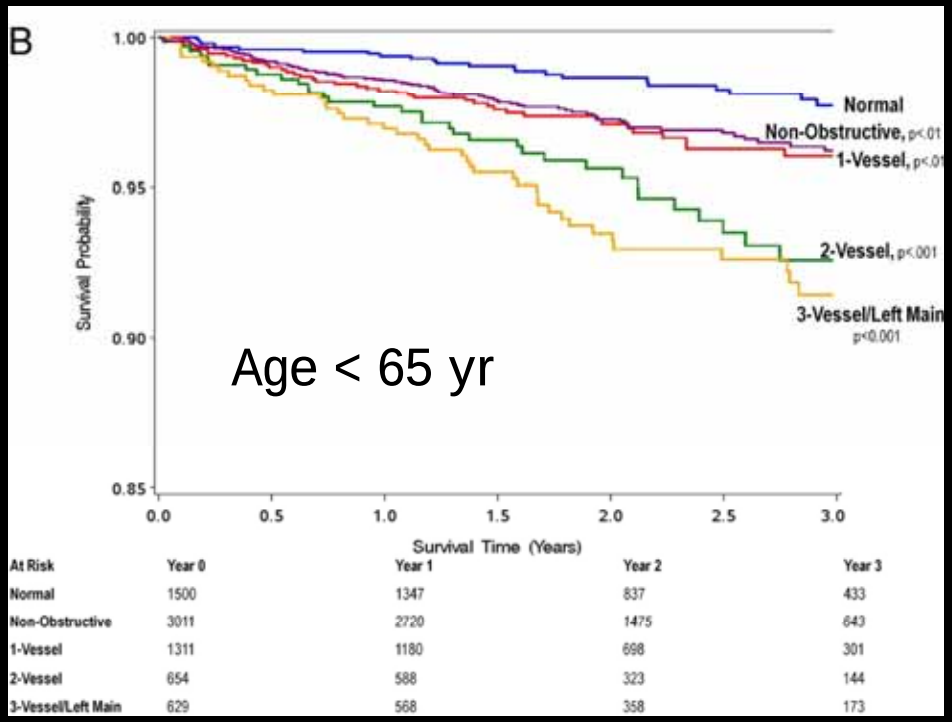
CONFIRM
Risk higher in younger pts (<65 yo)





Highest risk: patients < 65 years of age with 3-vessel disease: hazard ratio = 6.19 (upper confidence limit: 11.2) compared to same aged patient with no CAD

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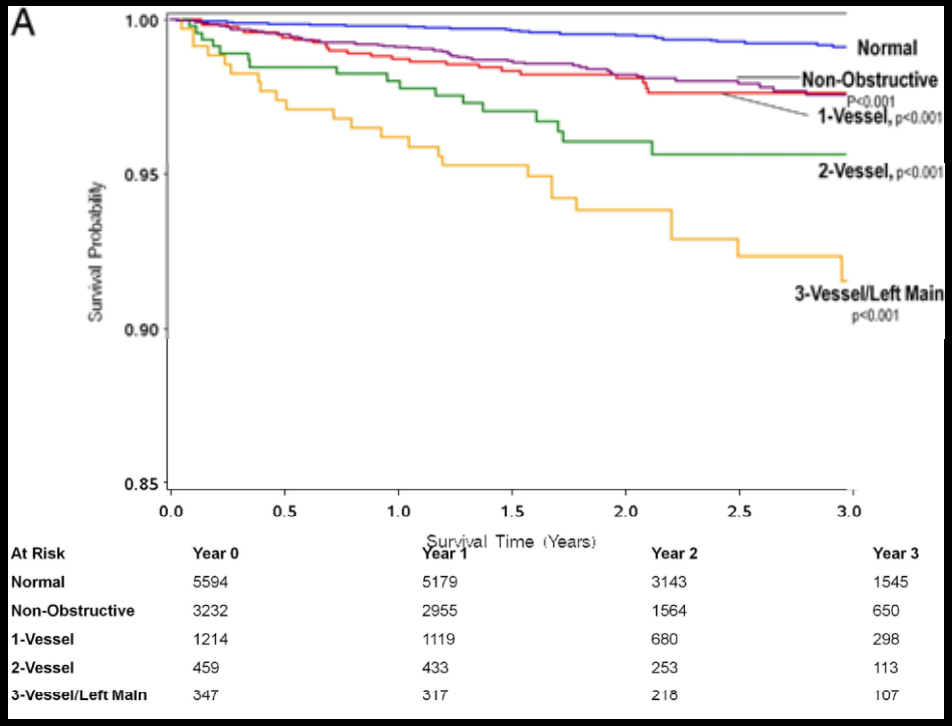
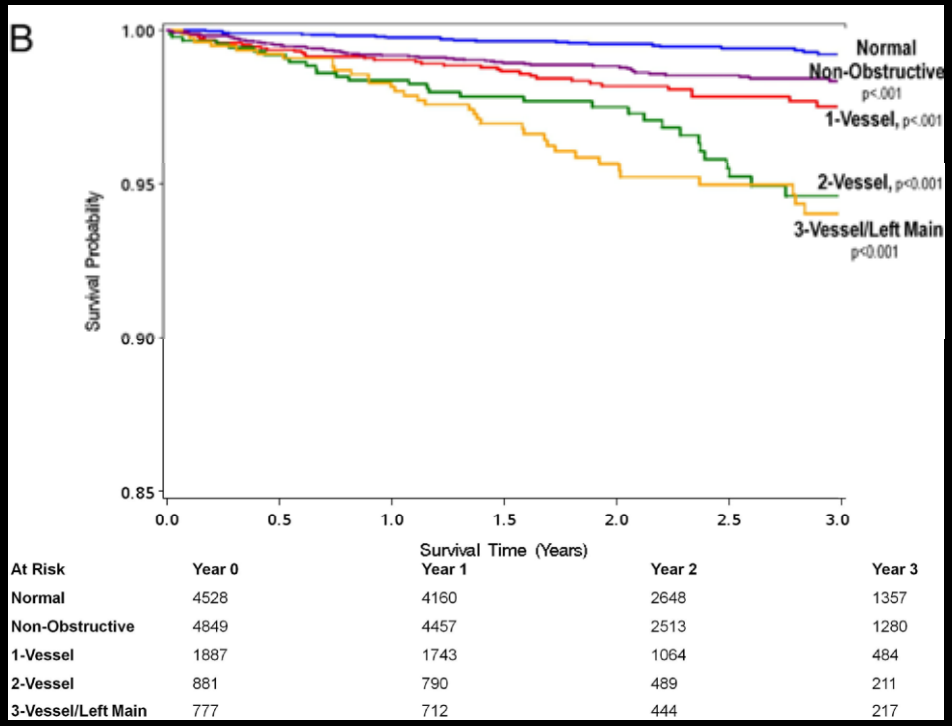
CONFIRM
Risk higher in women



At Risk	Year 0	Year 1	Year 2	Year 3
Normal	5594	5179	3143	1545
Non-Obstructive	3232	2955	1564	650
1-Vessel	1214	1119	680	298
2-Vessel	459	433	253	113
3-Vessel/Left Main	347	317	218	107



At Risk	Year 0	Year 1	Year 2	Year 3
Normal	4528	4160	2648	1357
Non-Obstructive	4849	4457	2513	1280
1-Vessel	1887	1743	1064	484
2-Vessel	881	790	489	211
3-Vessel/Left Main	777	712	444	217

Most statistically significant in 3-vessel disease:

HR for women: 4.21

HR for men: 3.27 ($p<0.05$)

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Conclusion: Non-calcified coronary atherosclerotic plaque can be visualized, however-

- Difficult quantification – unknown reproducibility
- Limited, but growing, information on outcomes

Per current guidelines, do not support using contrast-enhanced coronary CTA for risk stratification

May change in the future…

…for now use calcium score!

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