

ΕΘΝΙΚΟ ΚΑΙ ΚΑΠΟΔΙΣΤΡΙΑΚΟ ΠΑΝΕΠΙΣΤΗΜΙΟ ΑΘΗΝΩΝ ΙΑΤΡΙΚΗ ΣΧΟΛΗ

Α' ΚΑΡΔΙΟΛΟΓΙΚΗ ΚΛΙΝΙΚΗ & ΟΜΟΙΟΥΜΟ (Α' ΚΑΡΔΙΟΛΟΓΙΚΟ - ΑΙΜΟΔΥΝΑΜΙΚΟ) ΕΡΓΑΣΤΗΡΙΟ

ΚΑΡΔΙΑΓΓΕΙΑΚΗ ΑΠΕΙΚΟΝΙΣΗ
ΠΡΟΓΡΑΜΜΑ ΜΕΤΑΠΤΥΧΙΑΚΩΝ ΣΠΟΥΔΩΝ



- Διαδραστικά μαθήματα
- Hands on σεμινάρια
- Ερευνητική δραστηριότητα

Ιατρική Σχολή
Εθνικό και Καποδιστριακό Πανεπιστήμιο Αθηνών

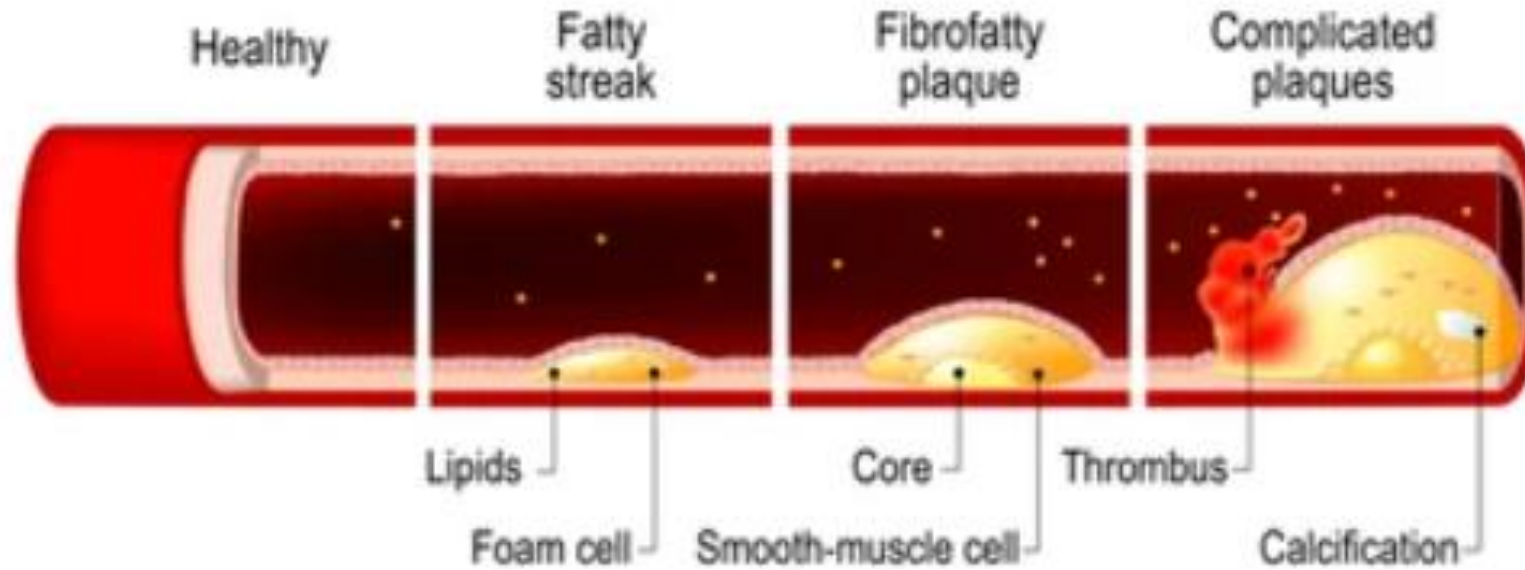
General - No Additional Protection

Αξονική στεφανιογραφία: Χαρακτηρισμός αθηρωματικής πλάκας & διαστρωμάτωση καρδιαγγειακού κινδύνου

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Consultant Cardiologist
Affidea Greece

EACVI Level 3 certified in cardiac CT and CMR
EACVI certification in Multimodality Imaging

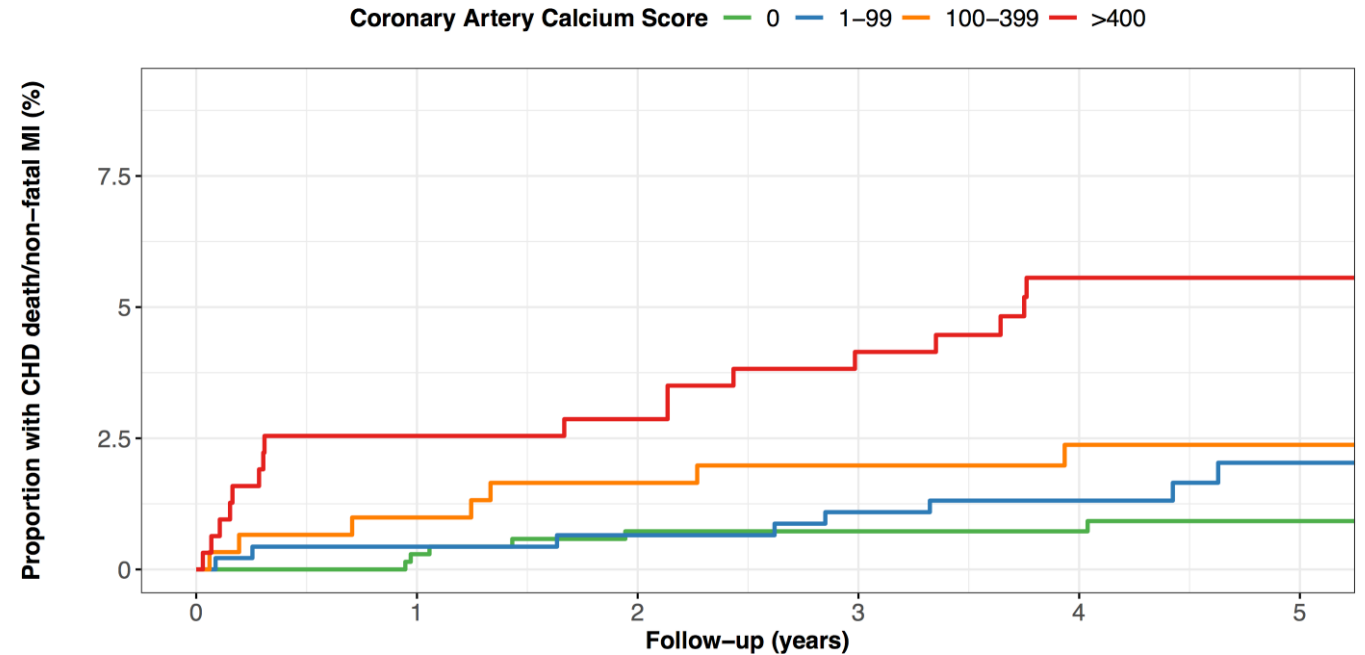
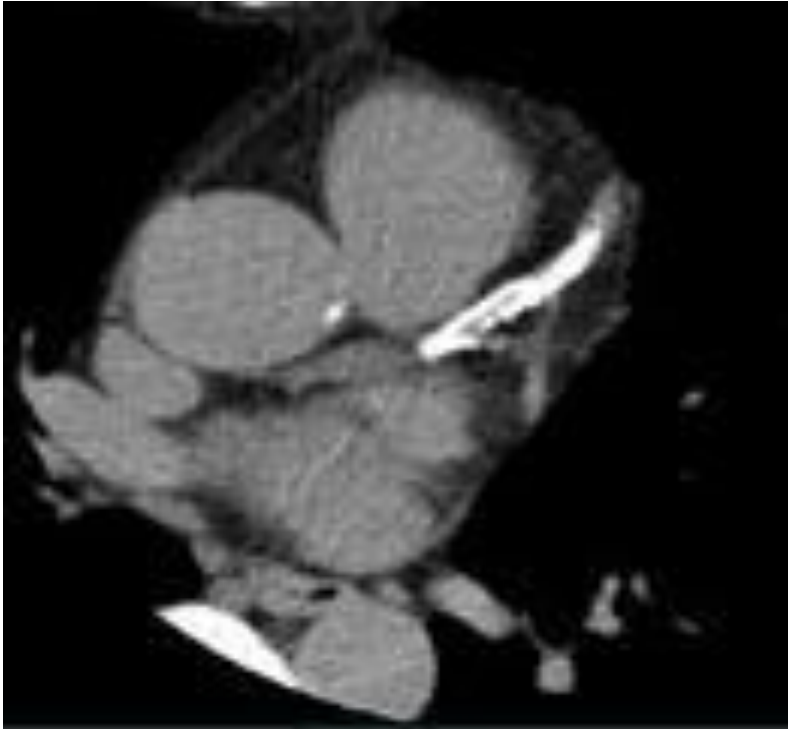
STAGES OF ATHEROSCLEROSIS



- **IVUS (intravascular ultrasound)** is the traditional gold standard for coronary plaque analysis
- IVUS provides cross-sectional imaging of coronary arteries, allowing precise measurement of plaque burden and morphology
- IVUS can differentiate between calcified and noncalcified plaque



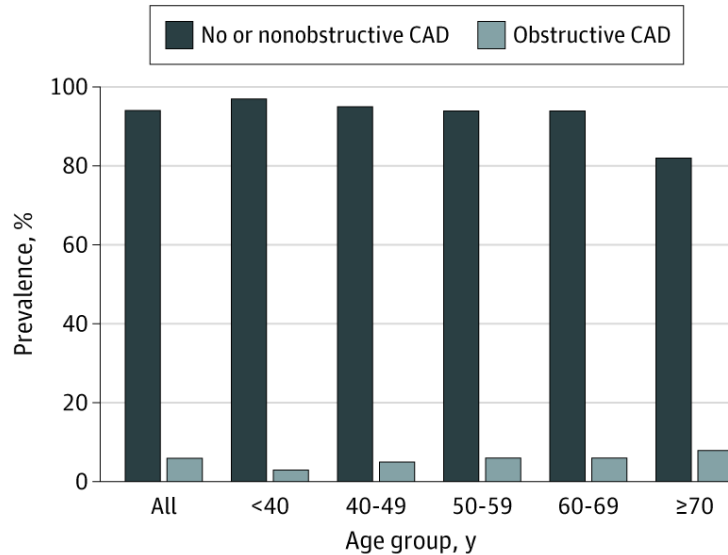
Calcium Score- Power of zero



- First non-invasive method of measuring plaque burden
- Predicts risk in some but not all populations (e.g. statins)
- Calcium scores increase not decrease with statins

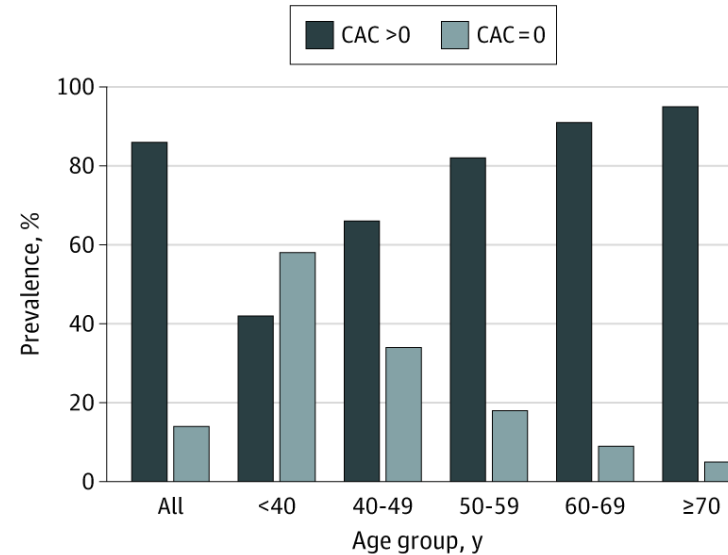
Obstructive disease and CACS 0

A Patients with CAC = 0



No. at risk						
CAC=0	12 771	1 278	3 684	4 453	2 737	619
CAC=0 + obstructive CAD	725	39	192	268	174	52

B Patients with obstructive CAD



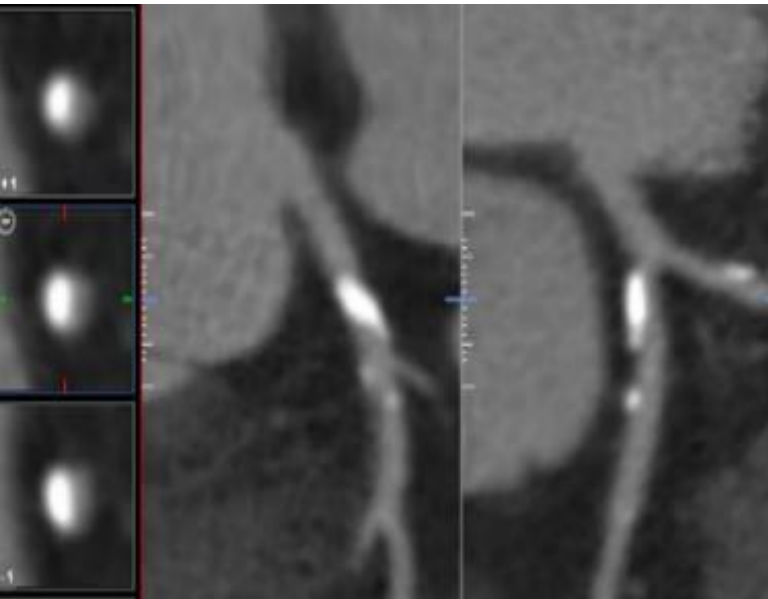
No. at risk						
Obstructive CAD	5 043	68	562	1 486	1 963	964
CAC=0 + obstructive CAD	725	39	192	268	174	52

23,759 patients
Symptomatic

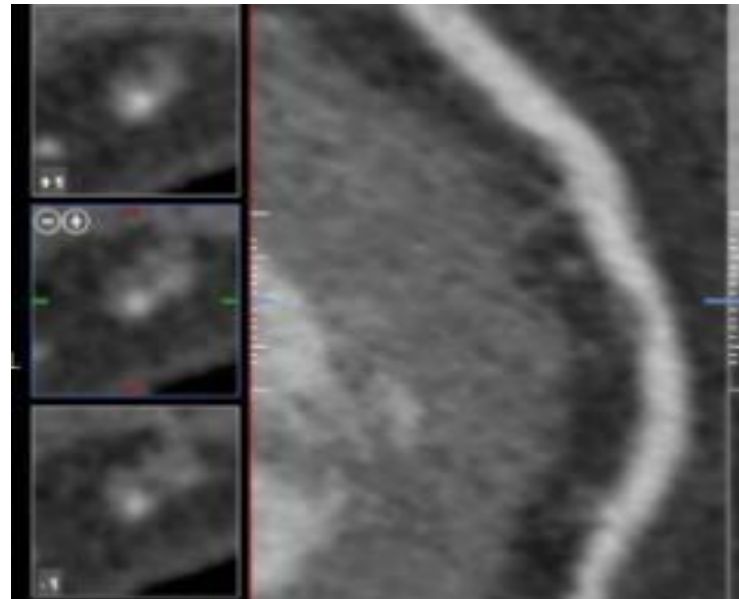
Obstructive disease with CAC 0
58% < 40years
5% >70 years

Plaque morphology

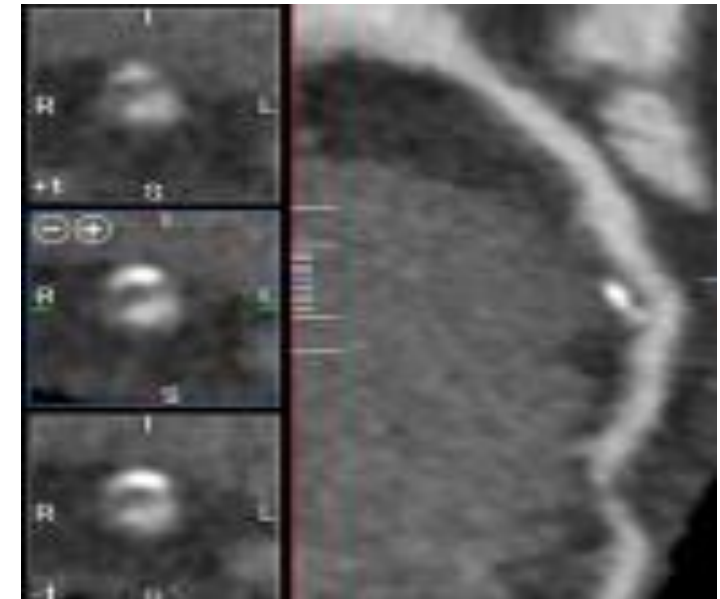
Calcified



Non-calcified (ie fibrous)



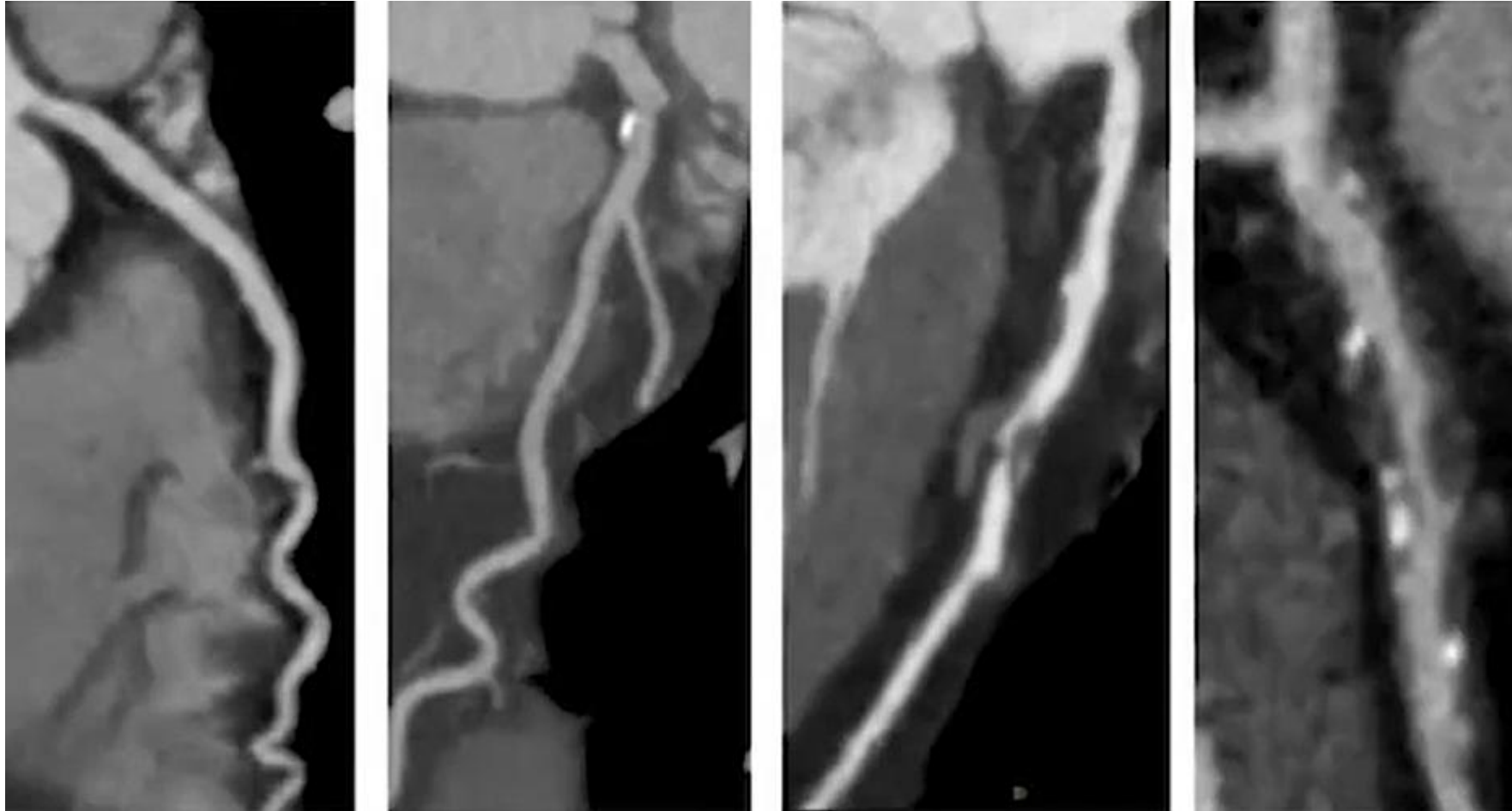
Mixed (calcified + non-calcified)





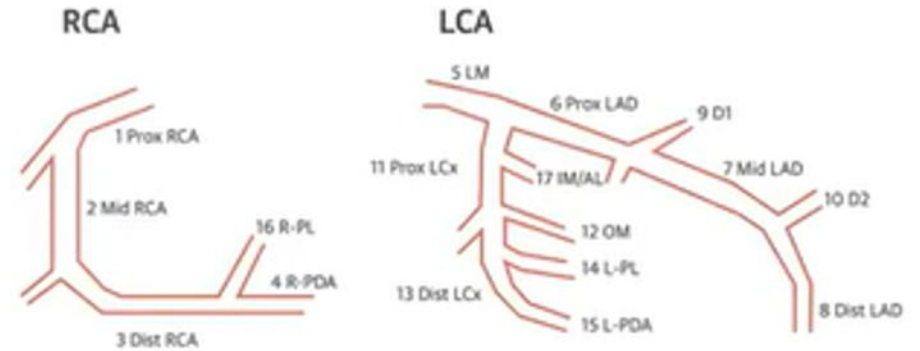
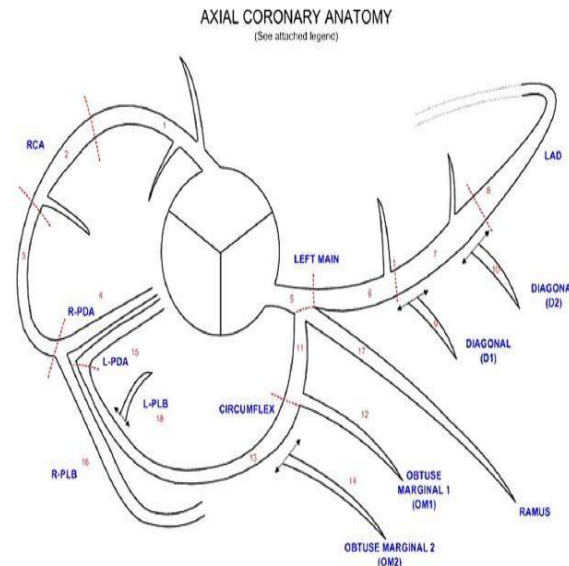
Stenosis grading on CTA: CAD-RAD

Stenosis Grade	Stenosis range (diameter)	CAD-RAD	Recommendation
Normal	Absent	0	None, non-cardiac cause
Minimal	<25%	1	Prevention
Mild	25-49%	2	Prevention
Moderate	50-69%	3	Stress-imaging
Severe	70-99%	4 A & B	Stress-imaging/ Cath angiogram
Occlusion	100%	5	Cath angiogram



Overall plaque burden scoring/Semi-quantitative assessment

- Segment Involvement Score (SIS)
- Segment Stenosis Score (SSS)
- CT-Leaman Score (CT-LeSc)



Location Weight Factor		
Segment	Right dominant	Left Dominant
LM	5	6
Prox LAD	3.5	3.5
Mid LAD	2.5	2.5
Dist LAD	1	1
D1	1	1
D2	0.5	0.5
Prox LCx	1.5	2.5
Dist LCx	1	1.5
AL/IM	1	1
OM	1	1
L-PL	0.5	0.5
L-PDA	0	1
Prox RCA	1	0
Mid RCA	1	0
Dist RCA	1	0
R-PL	0.5	0
R-PDA	1	0

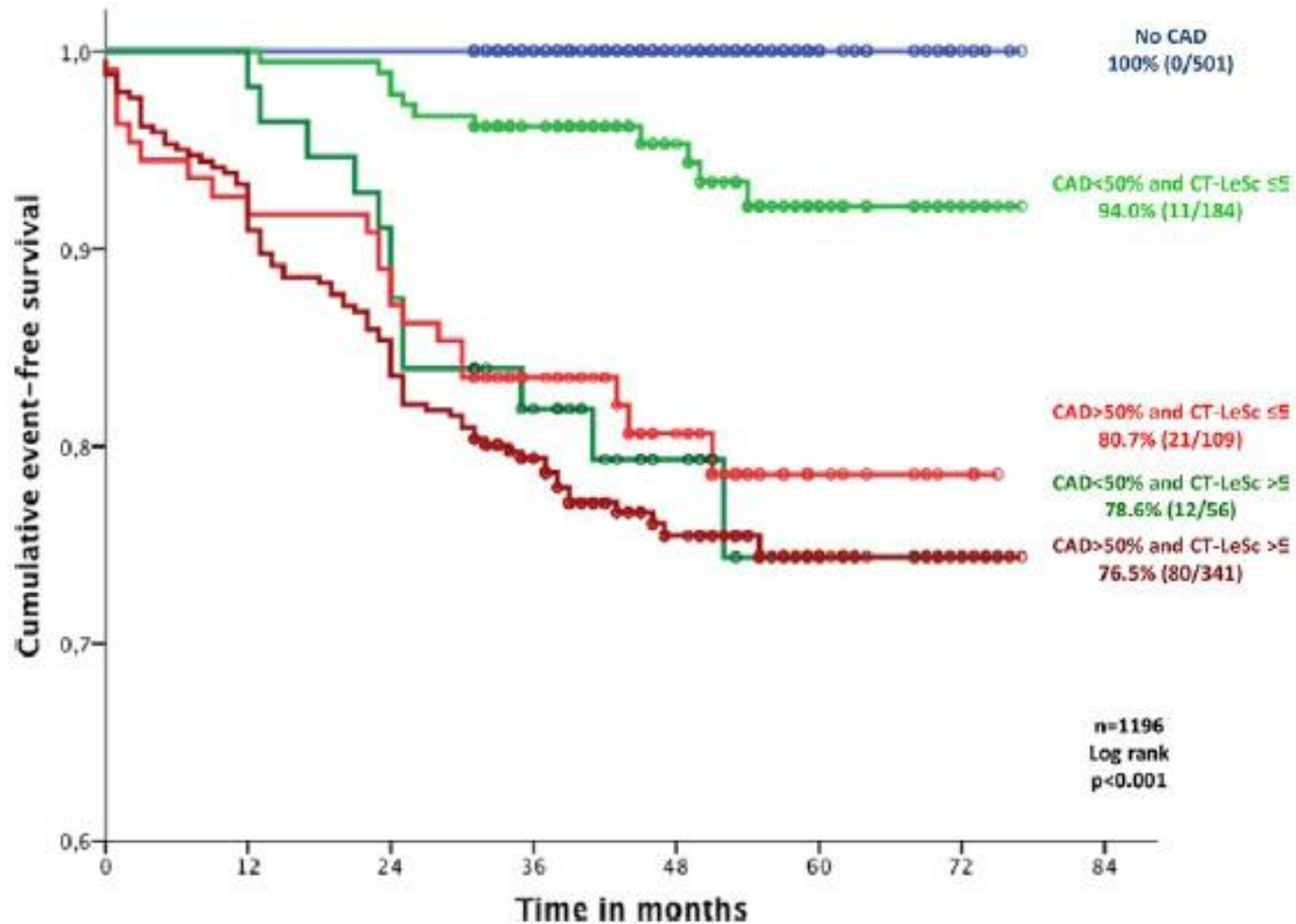
Plaque Weight Factor	
No Plaque	0
Calcified	1.1
Non-Calcified	1.2
Mixed	1.3

Stenosis Weight Factor	
<50%	1
≥50%	1.4

Segment (n) score =	
Plaque Weight Factor	
X	
Stenosis Weight Factor	
X	
Location Weight Factor	

Comprehensive / Leiden CTA risk score = Σ Segment (1-17) score

Plaque burden scoring on CTA



1200 patients, f/u 52 months

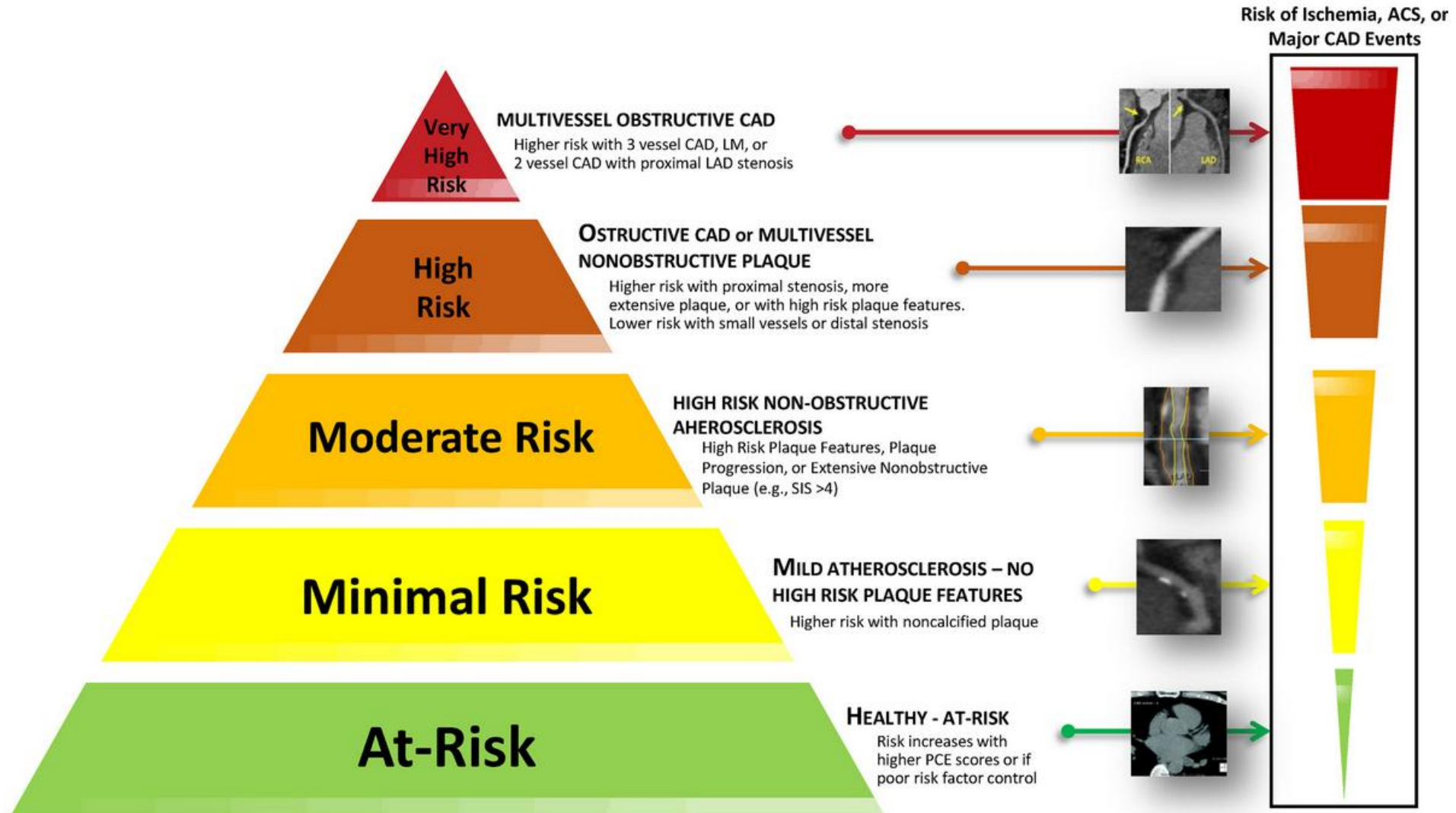
Modifier "P" - Plaque

P	Overall amount of coronary plaque	CAC	SIS	Visual assessment
1	Mild	1-100	<=2	1-2 vessels, mild plaque
2	Moderate	101-300	3-4	1-2 vessels, moderate plaque 3 vessel, mild plaque
3	Severe	301-999	5-7	3 vessel, moderate plaque 1 vessel severe plaque
4	Extensive	>1000	>=8	2-3 vessels, severe plaque

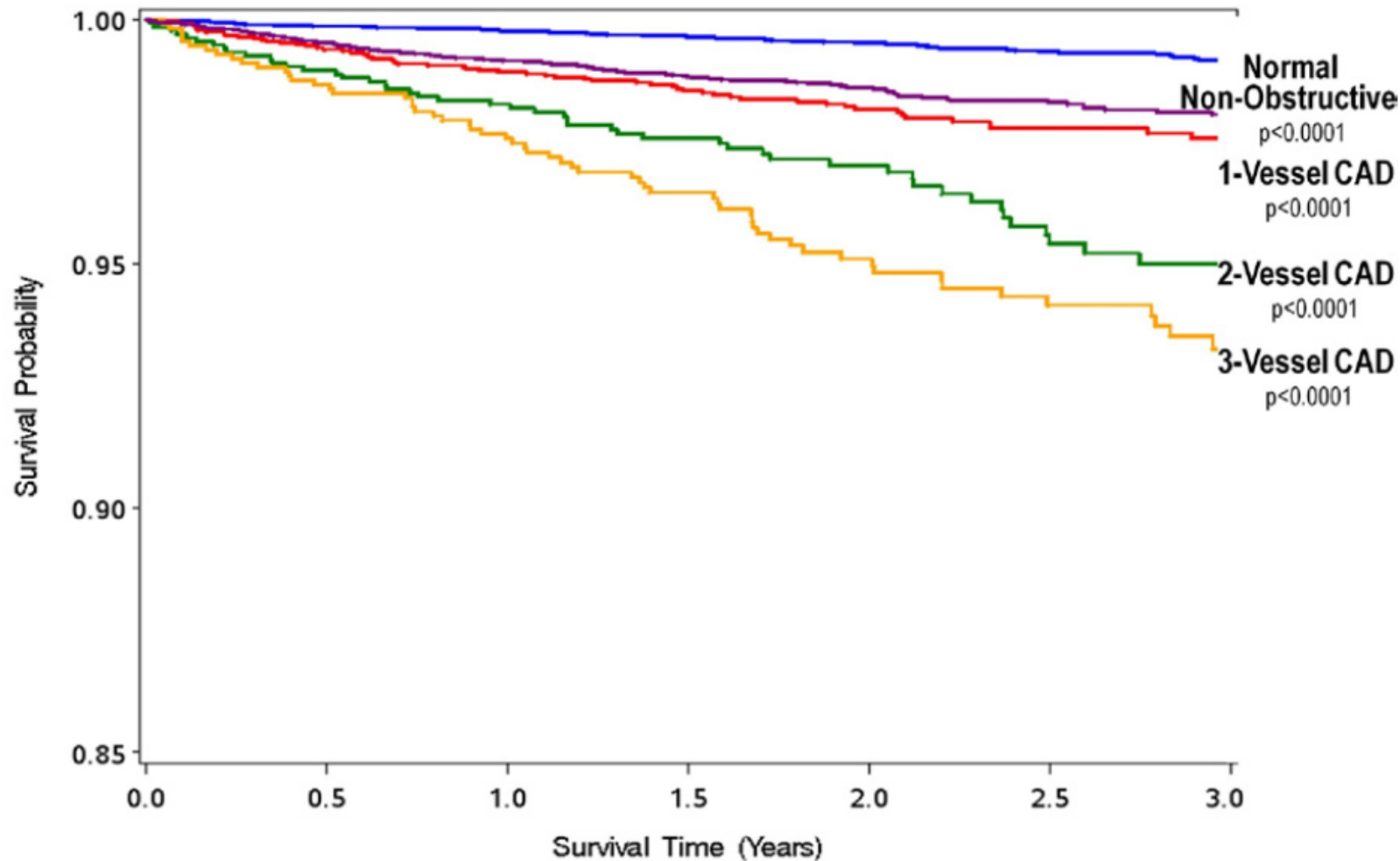
Stages of atherosclerosis detected by CCTA



SOCIETY OF
CARDIOVASCULAR
COMPUTED TOMOGRAPHY



General - No Additional Protection



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

Age- and Sex-Related Differences in All-Cause Mortality Risk Based on Coronary Computed Tomography Angiography Findings

Results From the International Multicenter CONFIRM (Coronary CT Angiography Evaluation for Clinical Outcomes: An International Multicenter Registry) of 23,854 Patients Without Known Coronary Artery Disease

James K. Min, MD,* Allison Dunning, MS,‡ Fay Y. Lin, MD,† Stephan Achenbach, MD,§ Mouaz Al-Mallah, MD,|| Matthew J. Budoff, MD,¶ Filippo Cademartiri, MD,# Tracy Q. Callister, MD,** Hyuk-Jae Chang, MD,†† Victor Cheng, MD,‡‡ Kavitha Chinnaiyan, MD,§§ Benjamin J. W. Chow, MD,||| Augustin Delago, MD,¶¶ Martin Hadamitzky, MD,## Joerg Hausleiter, MD,## Philipp Kaufmann, MD,*** Erica Maffei, MS,# Gilbert Raff, MD,§§ Leslee J. Shaw, PhD,††† Todd Villines, MD,‡‡‡ Daniel S. Berman, MD,‡‡ for the CONFIRM Investigators

ORIGINAL ARTICLE

Coronary CT Angiography and 5-Year Risk of Myocardial Infarction

The SCOT-HEART Investigators*

4146 χρόνια θωρακικό άλγος
CTA VS standard care
3-7 έτη

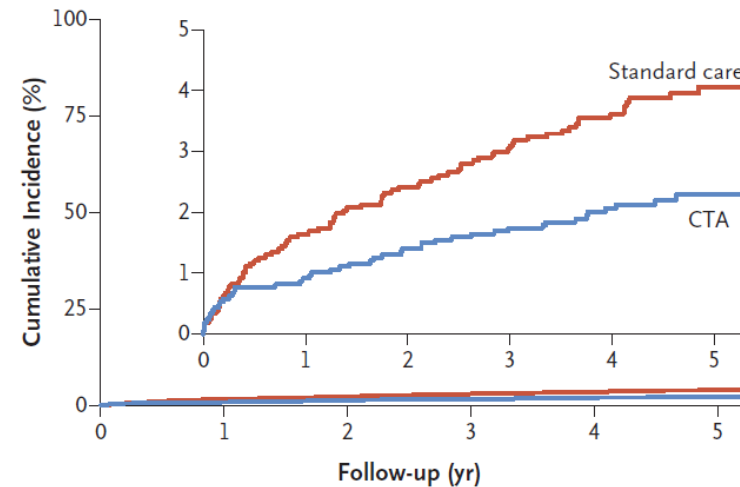
42% αποφρακτική ΣΝ

CTCA arm: 50% ΕΜ μη-αποφρακτική ΣΝ

CTA group: 2.3% [48 patients]
Standard-care group: 3.9% [81 patients]
HR =0.59 (95% CI = 0.41 - 0.84); p=0.004

41%

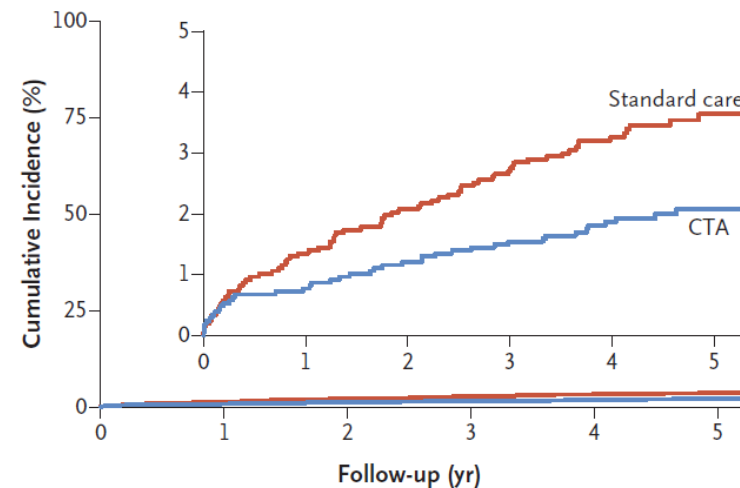
A Death from Coronary Heart Disease or Nonfatal Myocardial Infarction



No. at Risk

Standard care	2073	2033	2008	1994	1572	856
CTA	2073	2051	2029	2015	1588	872

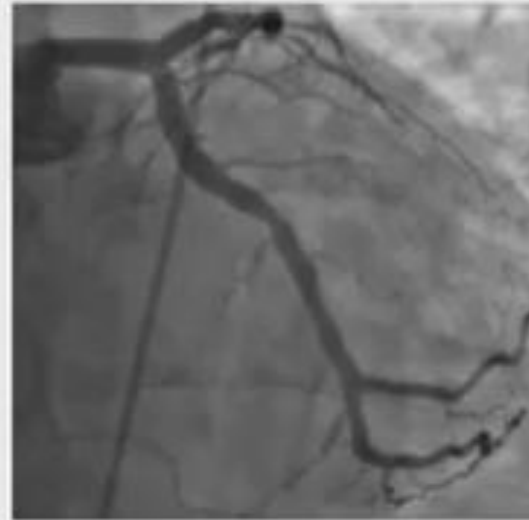
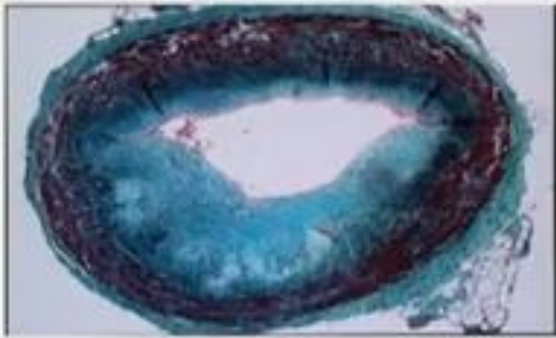
B Nonfatal Myocardial Infarction



No. at Risk

Standard care	2073	2045	2030	2017	1597	881
CTA	2073	2057	2048	2041	1618	891

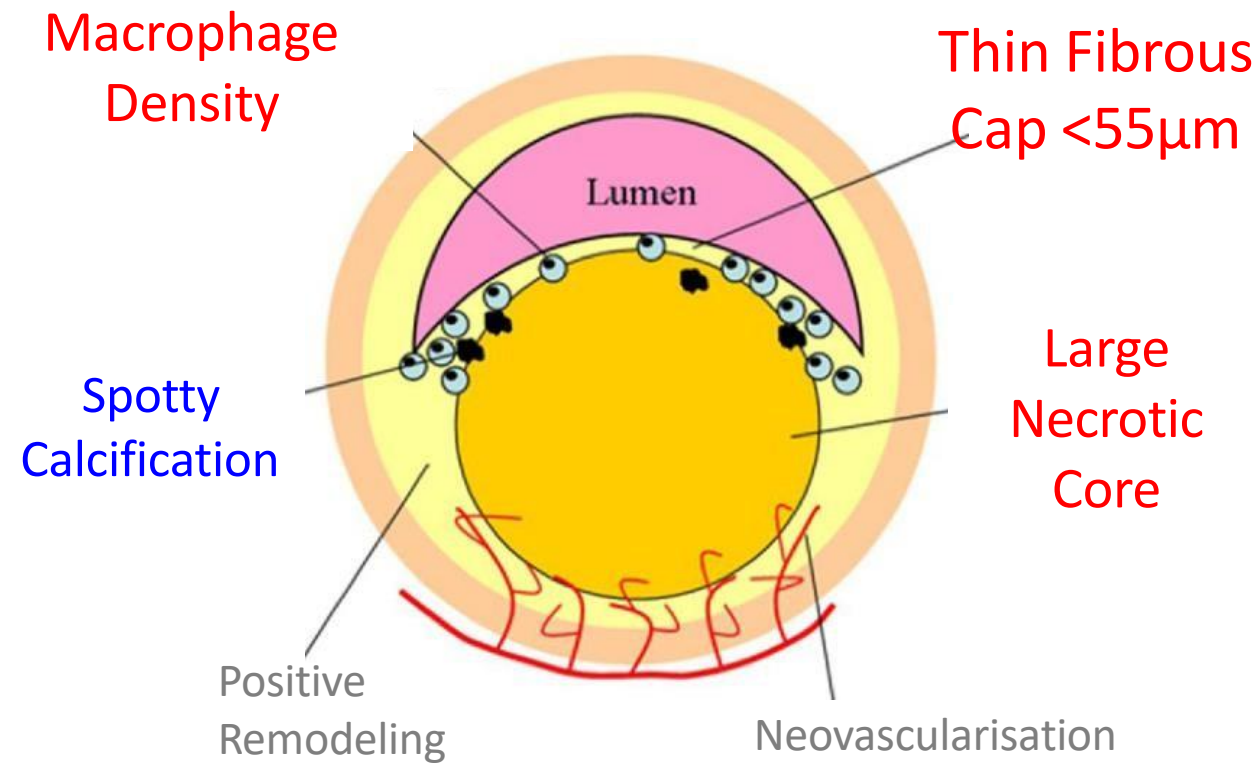
The “stable”
atherosclerotic
plaque



The “vulnerable”
atherosclerotic
plaque



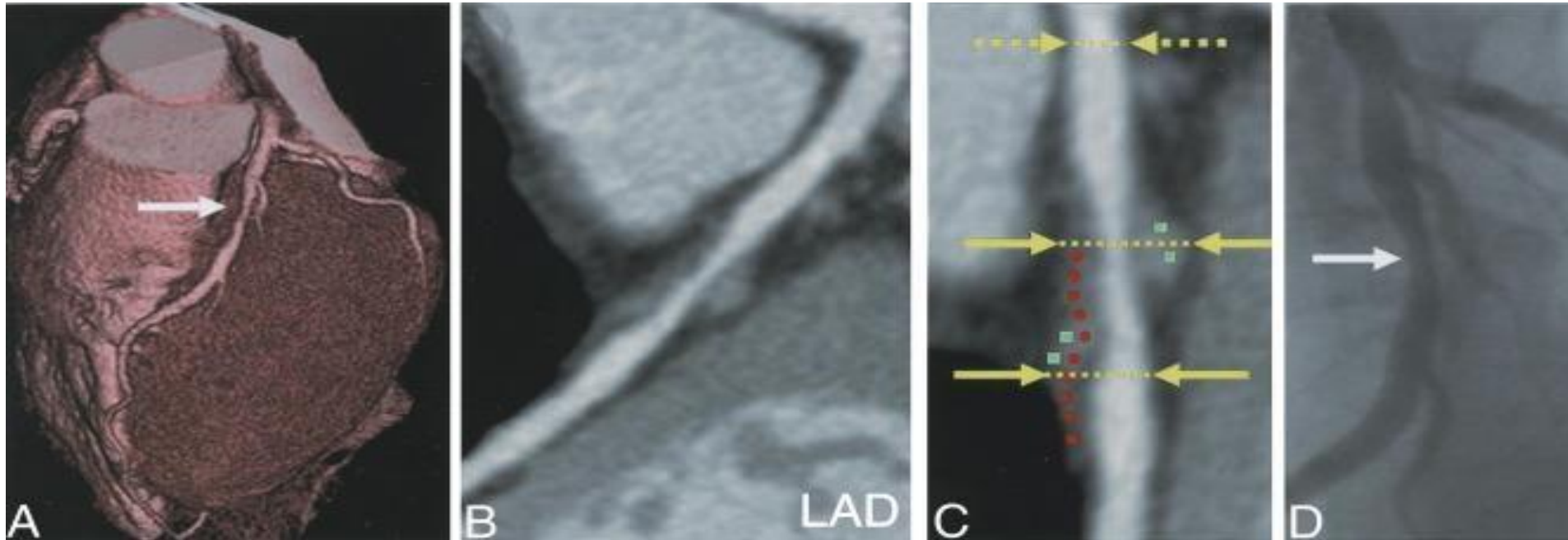
High Risk Plaque (Vulnerable plaque)



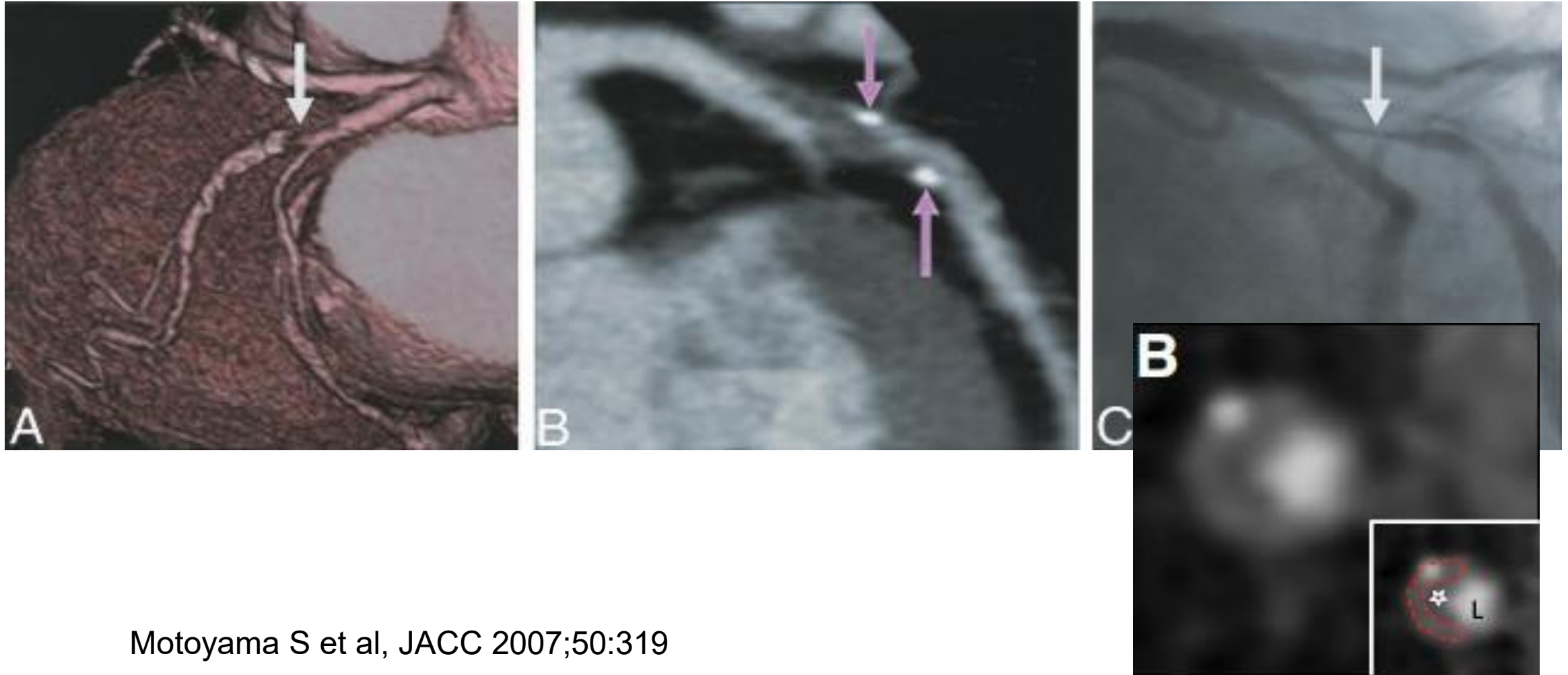
CTCA spatial resolution

High Risk Plaque – Positive remodelling

Diameter of artery at plaque/ diameter of proximal normal ≥ 1.1 (Remodelling Index)



High Risk Plaque (Spotty Calcifications ≤ 3 mm)

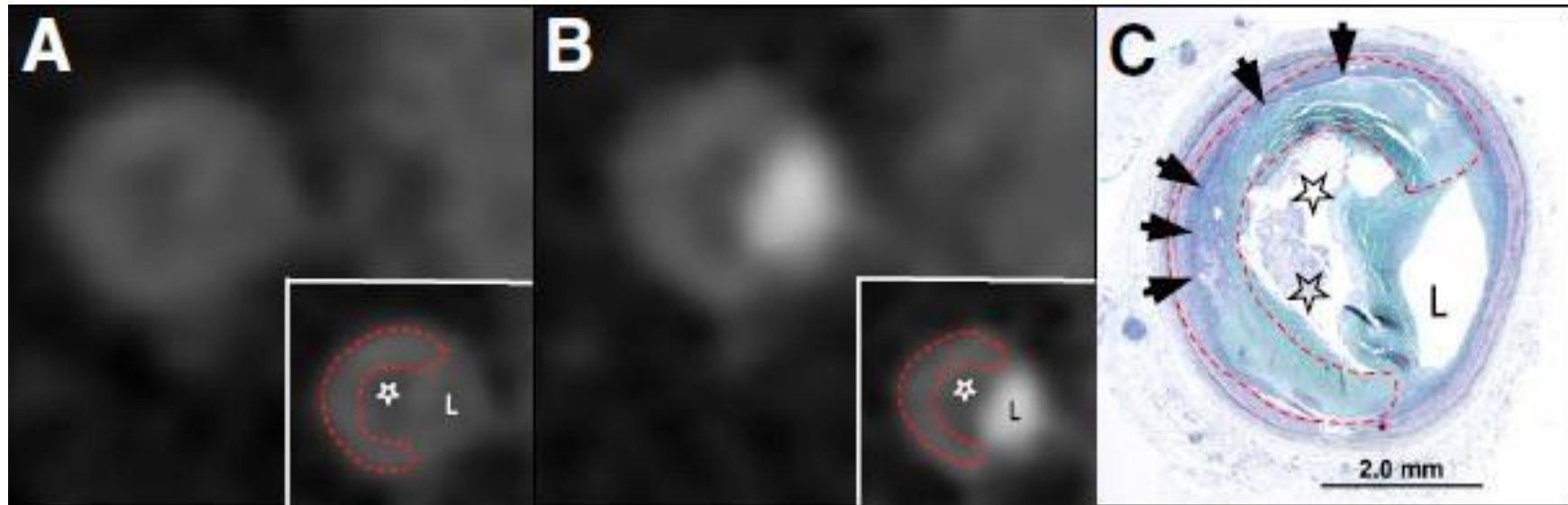


Motoyama S et al, JACC 2007;50:319

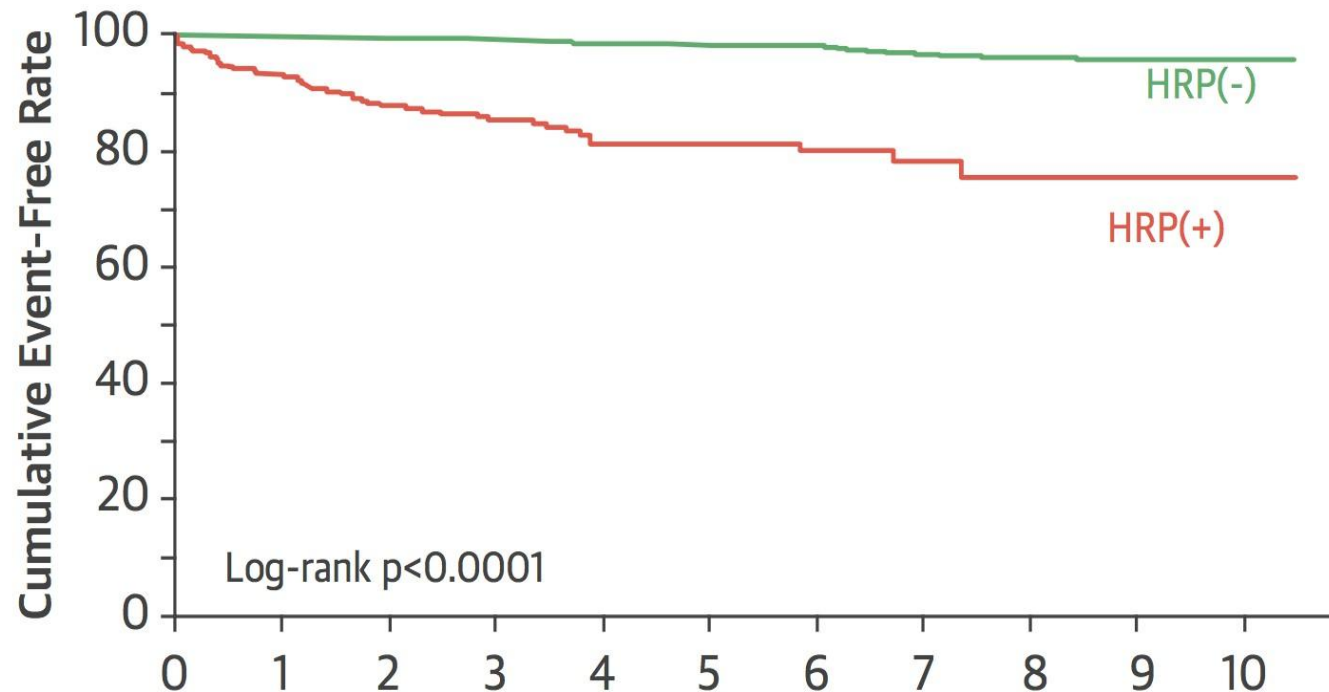
High Risk Plaque – Lipid core

Low Attenuation Plaque (<30 HU)

Napkin ring sign (NRS) – area of low attenuation surrounded by high density (non-calcified)



High Risk for ACS



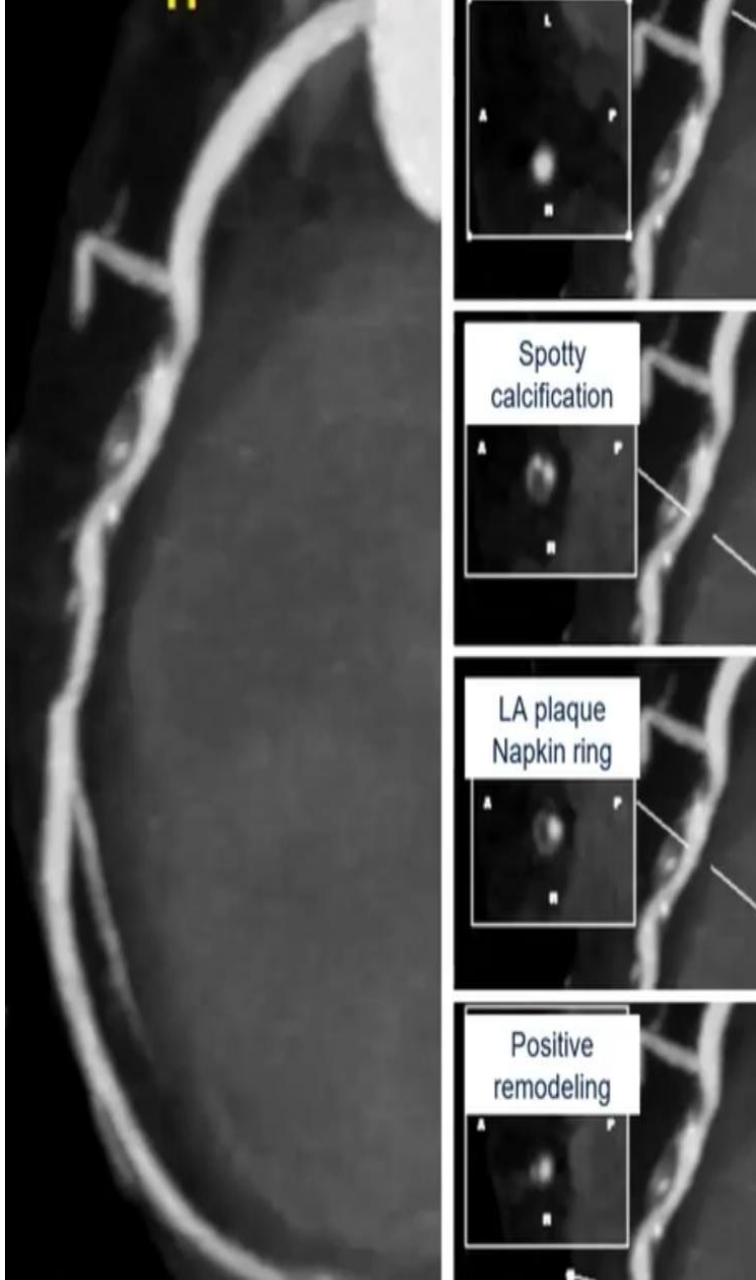
N=3158 patients:

294 had adverse plaques
ACS in 16% of these patients (n=48)

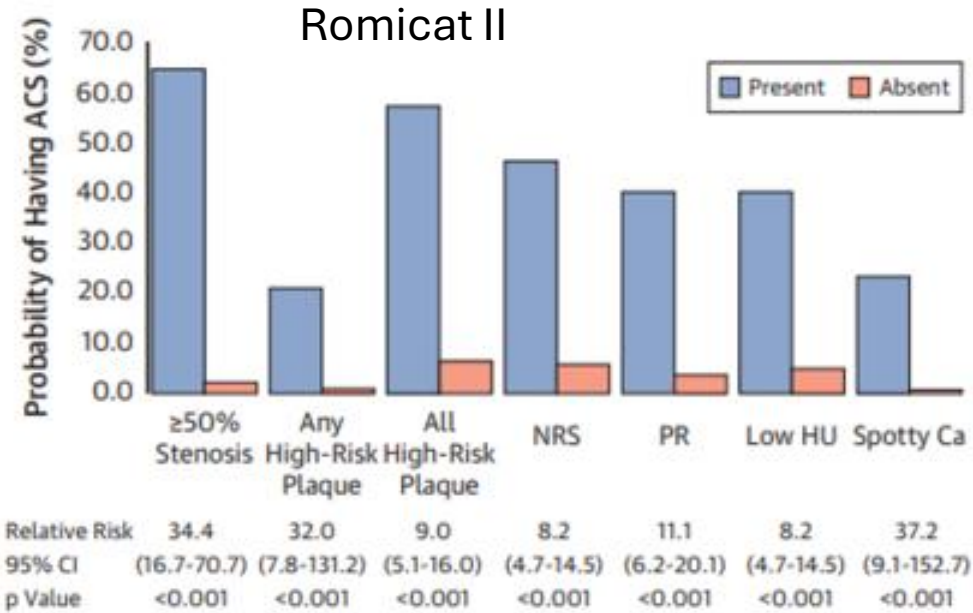
2864 did not have adverse plaques
ACS in 1.4% of these patients (n=40)

Patients at risk

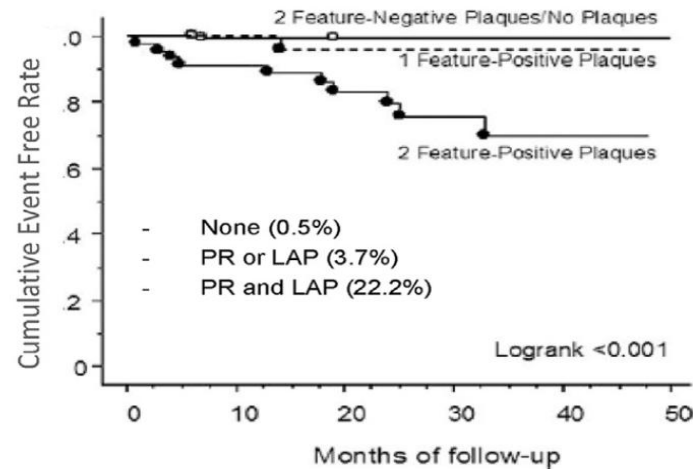
HRP(-)	2,864	2,856	2,091	1,485	1,020	880	645	433	263	89	18
HRP(+)	294	274	193	163	106	92	64	35	15	6	2



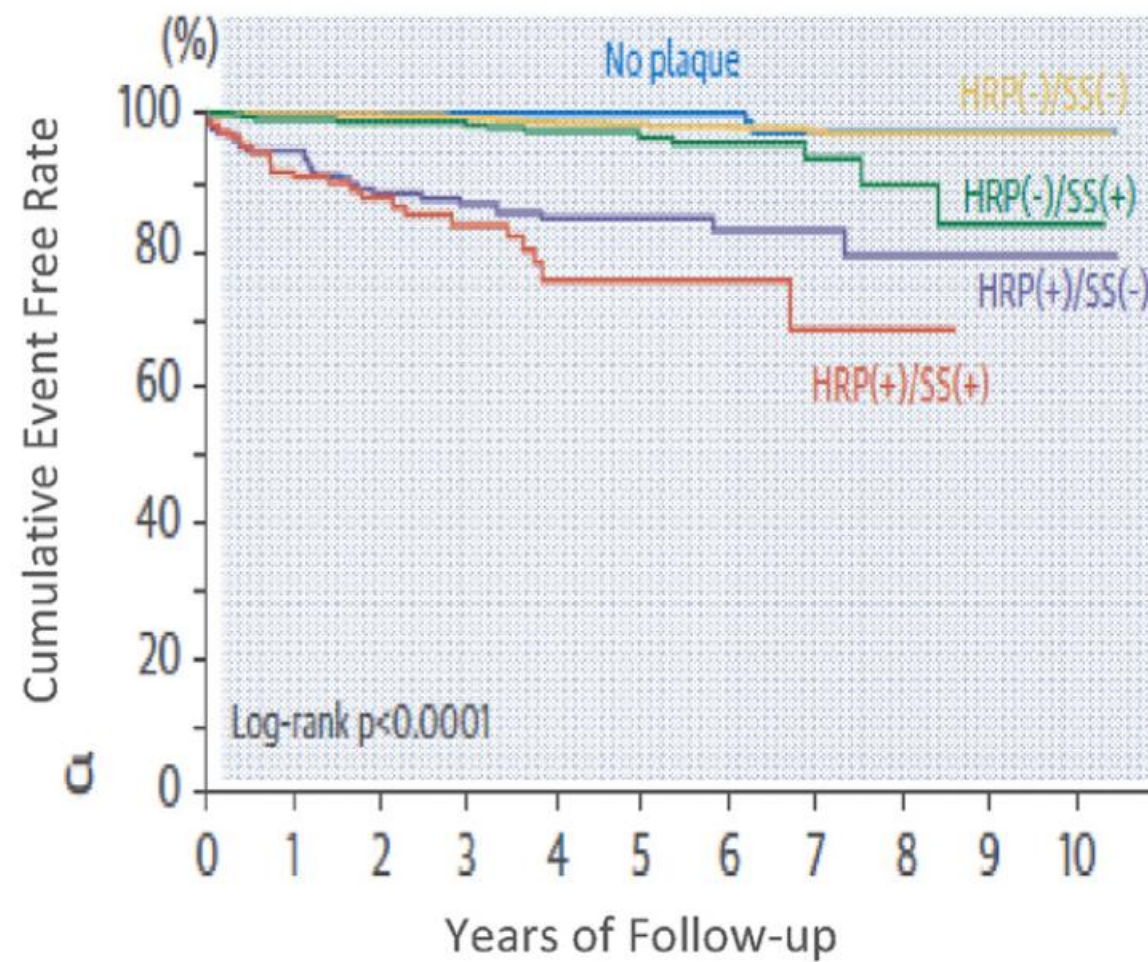
***General - No Additional Protect



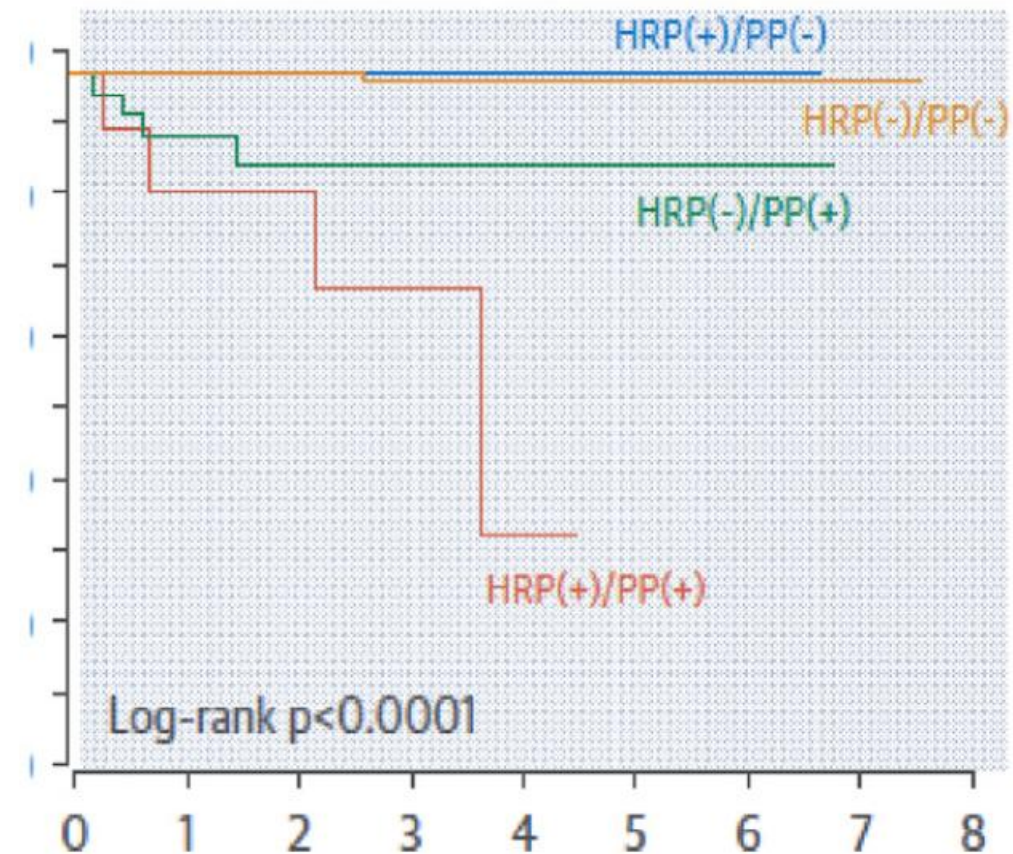
A



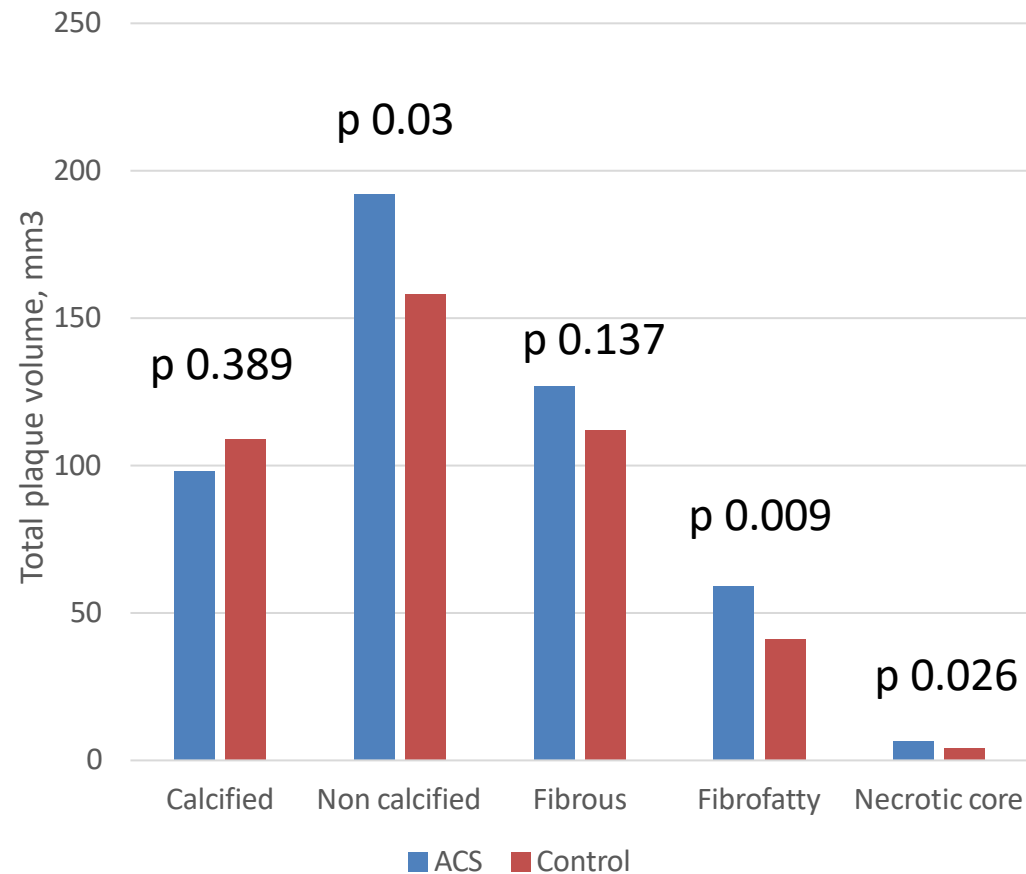
D



E

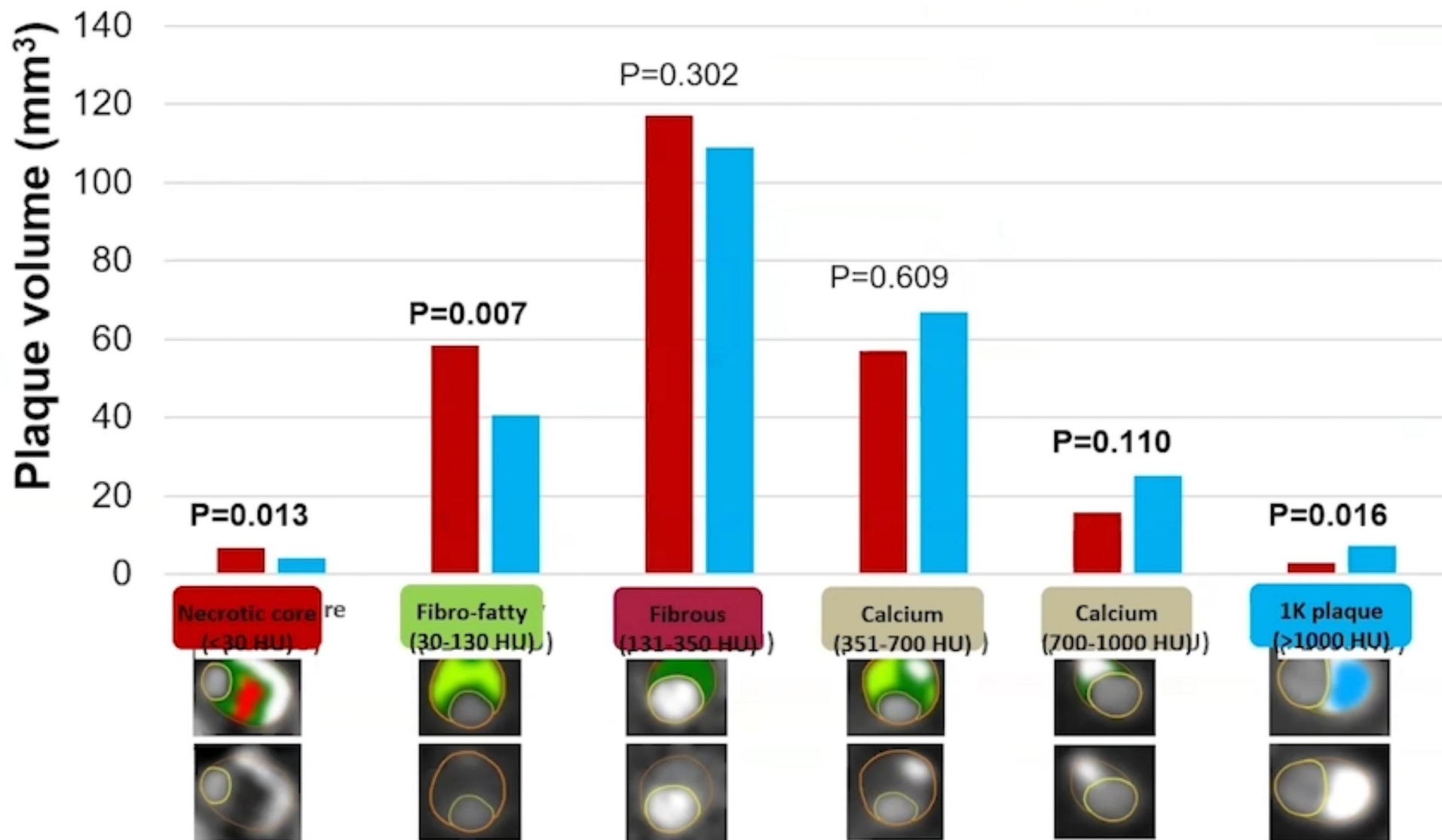


Precursors of myocardial infarction

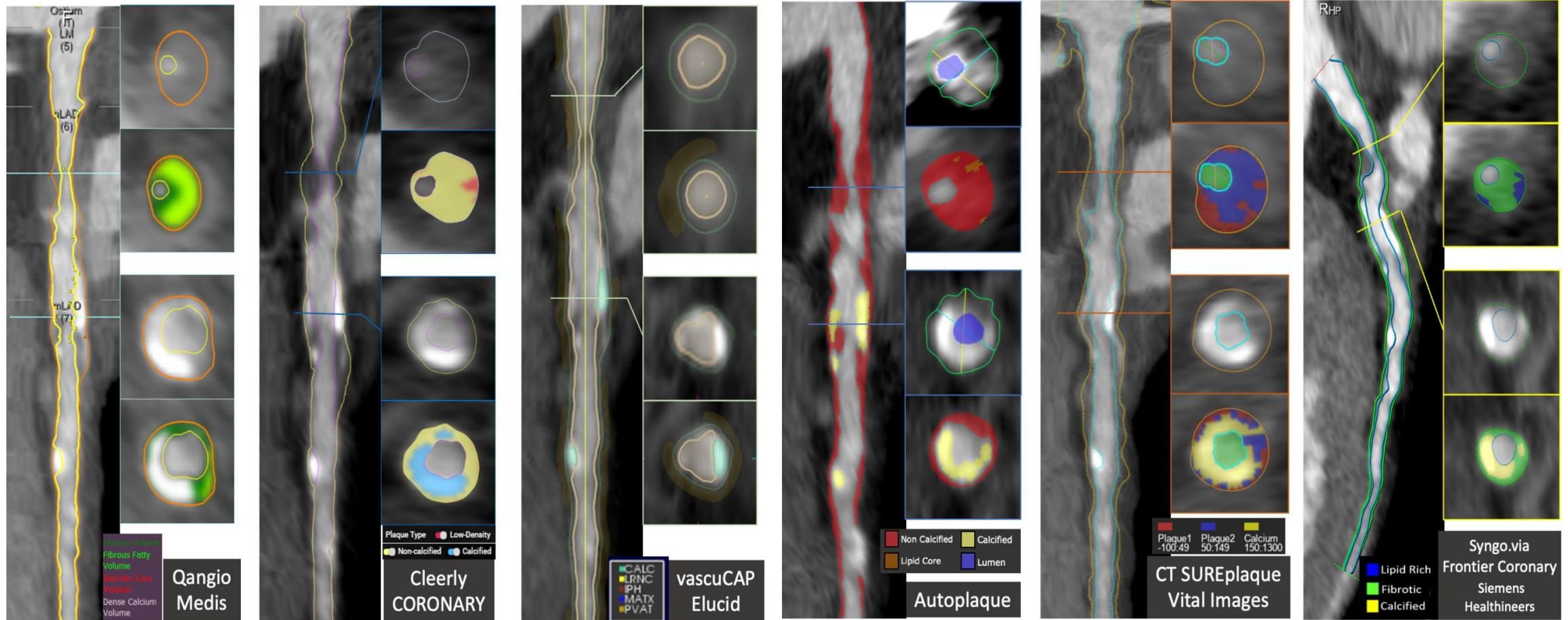


- ICONIC
- 234 acute coronary syndrome patients and control pairs from the CONIFRM registry
- ACS patients
 - Less calcified plaque
 - More non-calcified plaque
 - More fibrofatty and necrotic core

CTA Enables Stratification of High- and Low-Risk Atherosclerosis



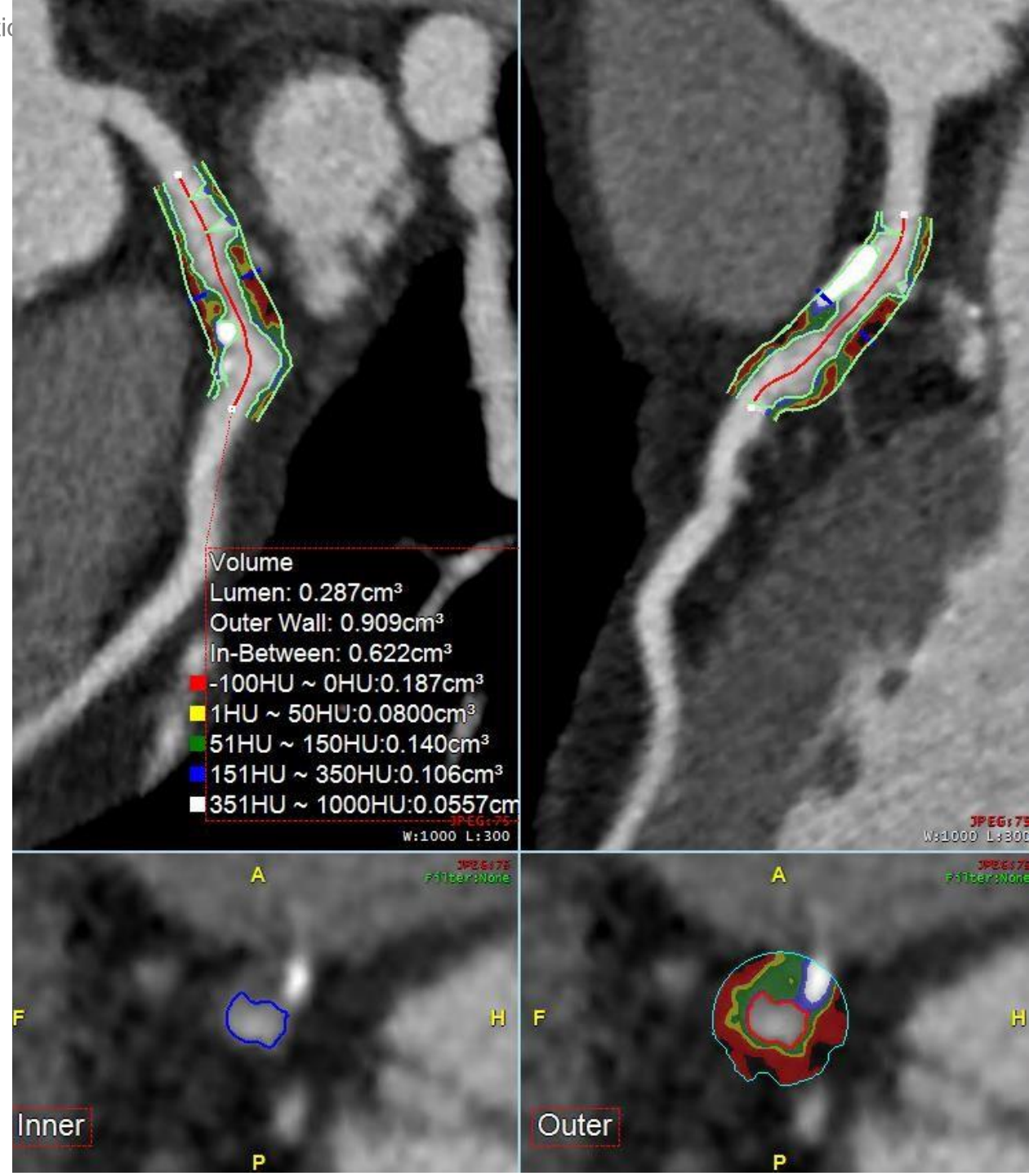
Quantitative plaque burden



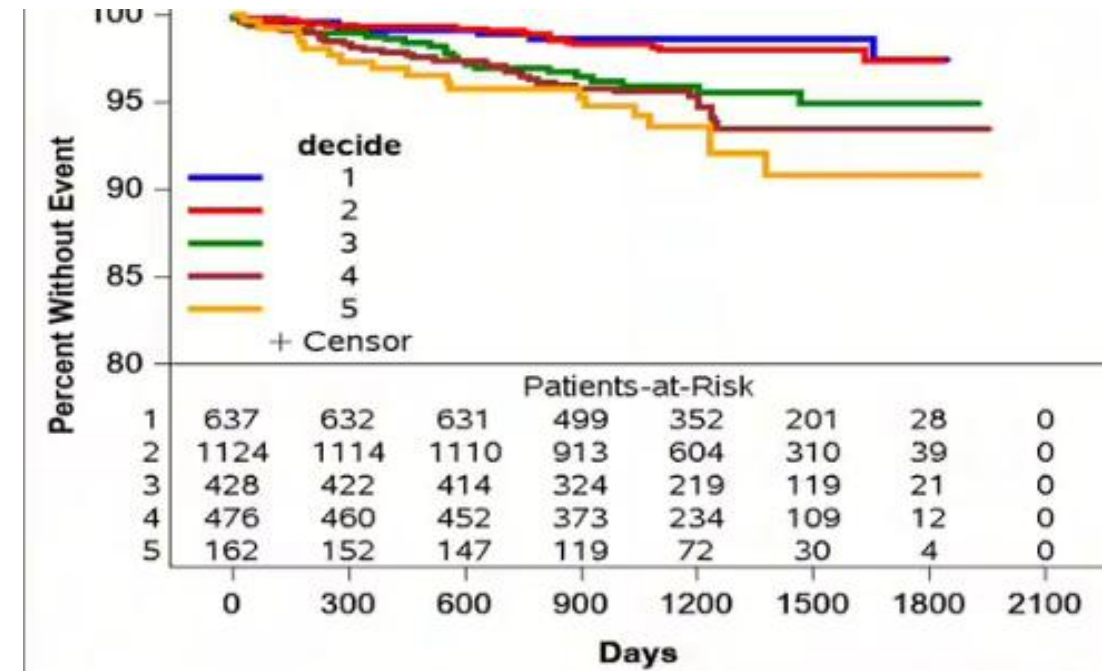
Quantitative Plaque Analysis

Automatic quantification

- Total atheroma volume (TAV, mm³)
- Percentage atheroma volume (PAV, %)
- Volume of LAP (<30/50 HU)
- Volume of fibrous plaque (50-349 HU)
- Volume of calcified plaque (≥ 350 HU)
- Maximum diameter stenosis
- Maximum area stenosis
- Minimal luminal area

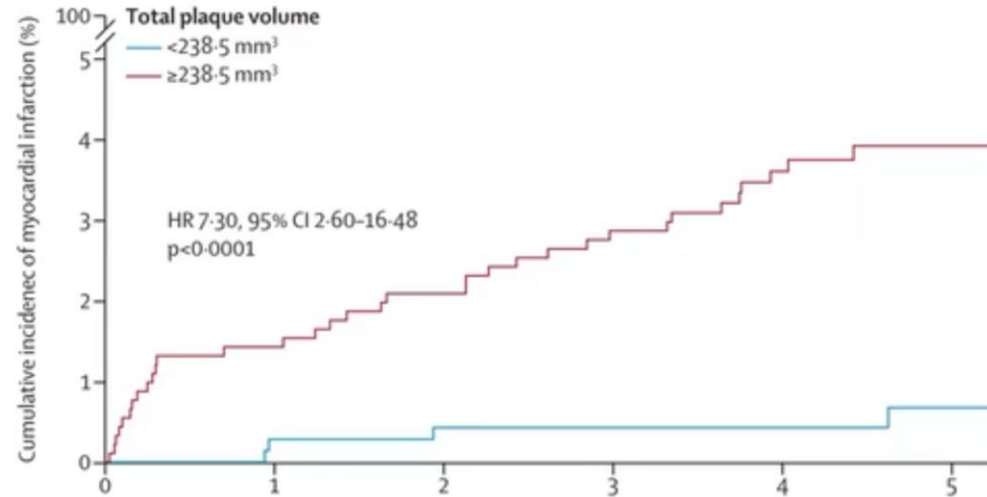


	TPV	HR (95% CI)	Wald P-value
	0	Reference	--
	1-100	1.24 (0.51-3.01)	0.6292
	101-250	2.81 (1.11-7.10)	0.0285
	250-750	3.58 (1.39-9.22)	0.0083
	>750	4.79 (1.66-13.81)	0.0037



Plaque Informs Risk

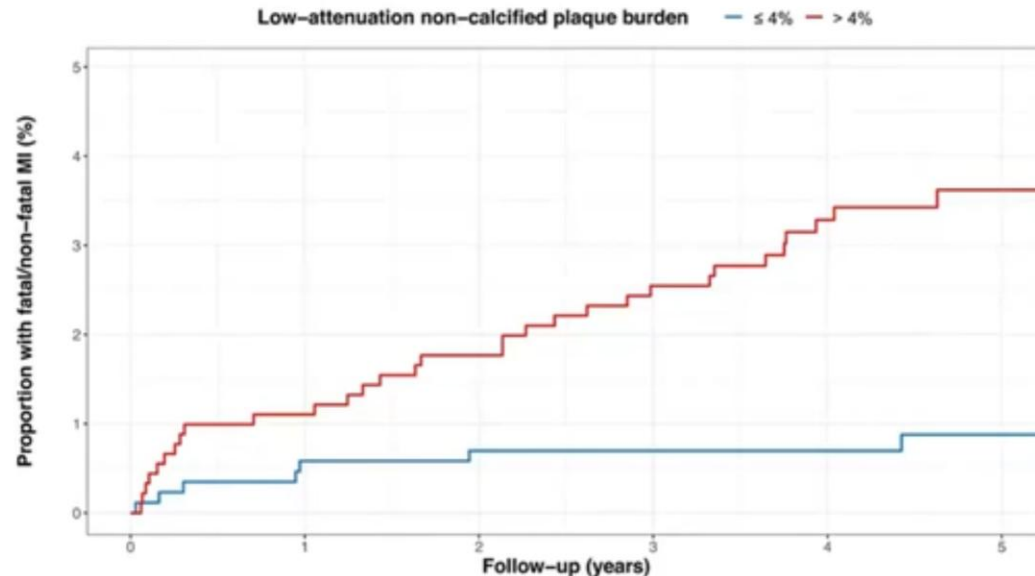
Incident MI by Low Attenuation Plaque (LAP) burden (SCOT-HEART)



HR 7.3

TOTAL PLAQUE VOLUME

- Higher total plaque volume is associated with higher patient risk of MI



HR 4.7

LOW ATTENUATION PLAQUE

- Low attenuation plaque (LAP) on coronary CTA is indicative of plaque with a lipid-rich core
- Higher LAP is associated with higher risk of MI, even for non-obstructive stenosis
- Outperformed CV risk scores, luminal stenosis severity, CAC scores

What then drives events?

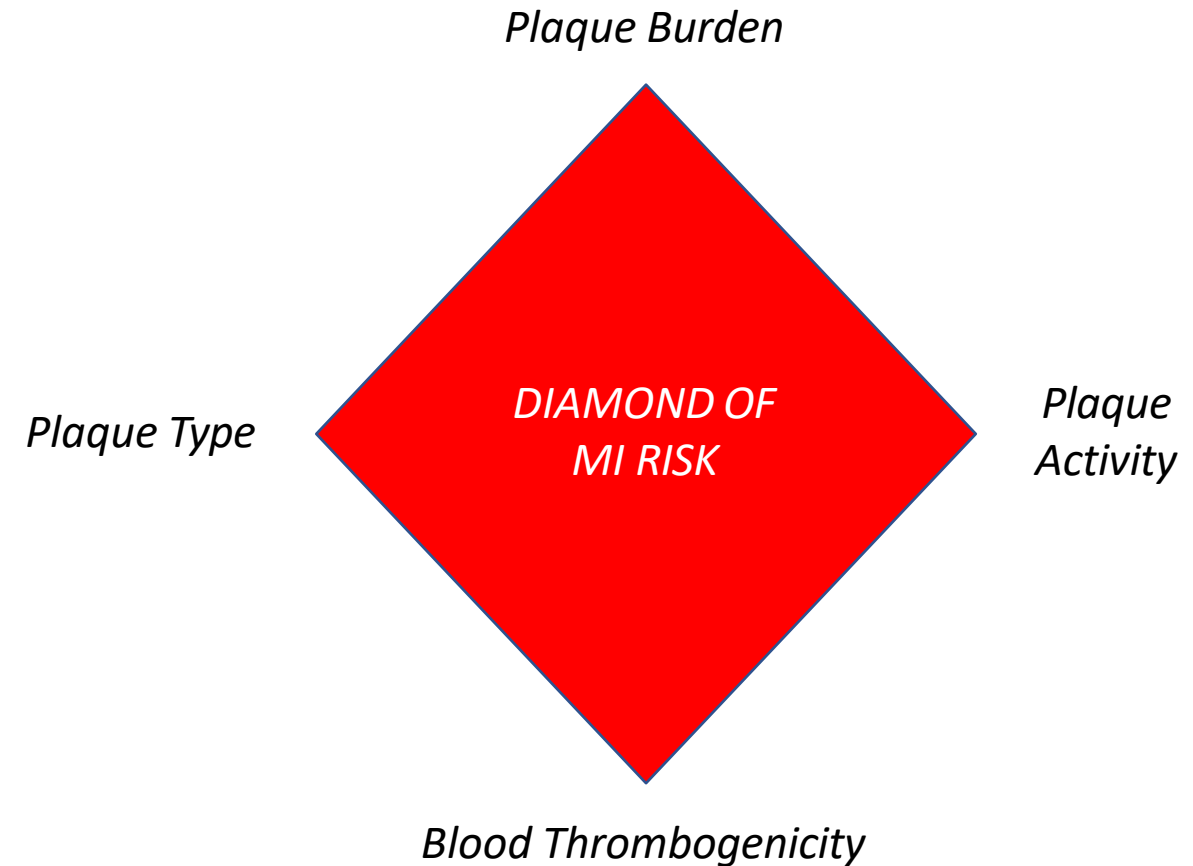
PLAQUE & BLOOD

1) Tendency to Plaque Rupture

- Plaque burden
- Plaque type

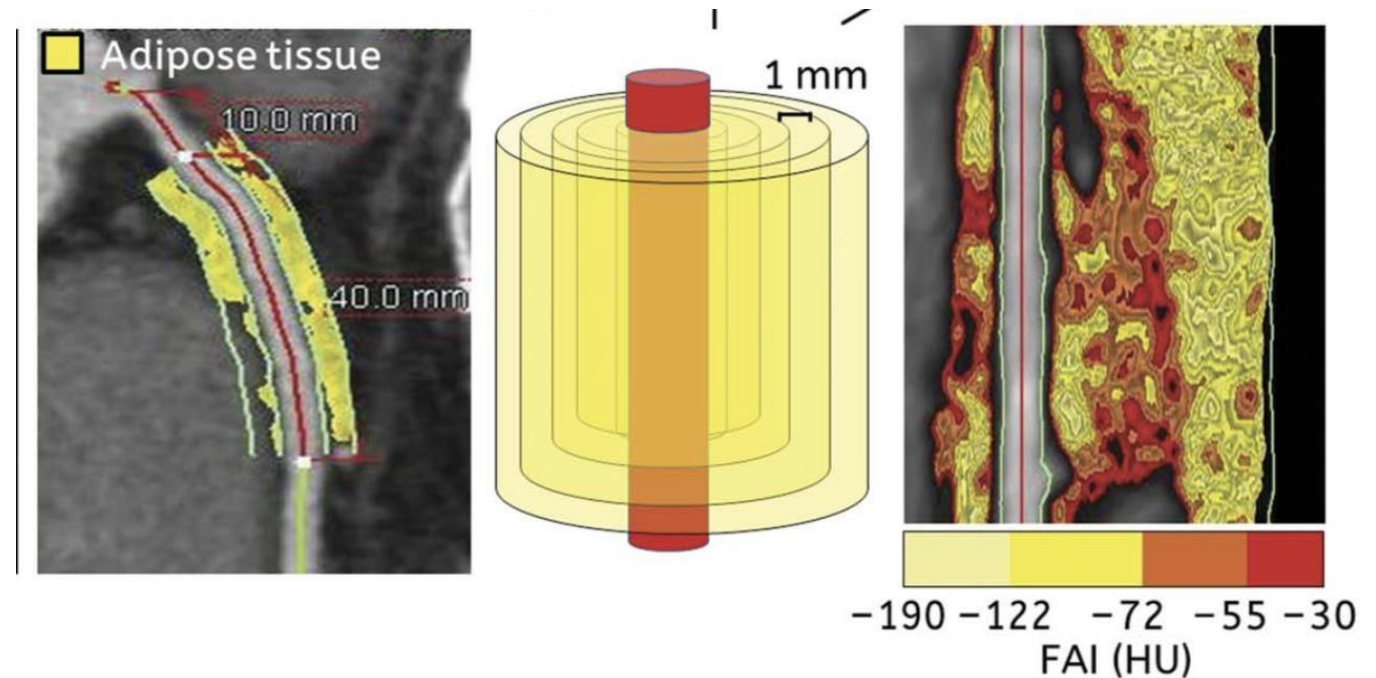
2) Tendency of the blood to clot

- Intensity of the stimulus
- Stickiness of the blood

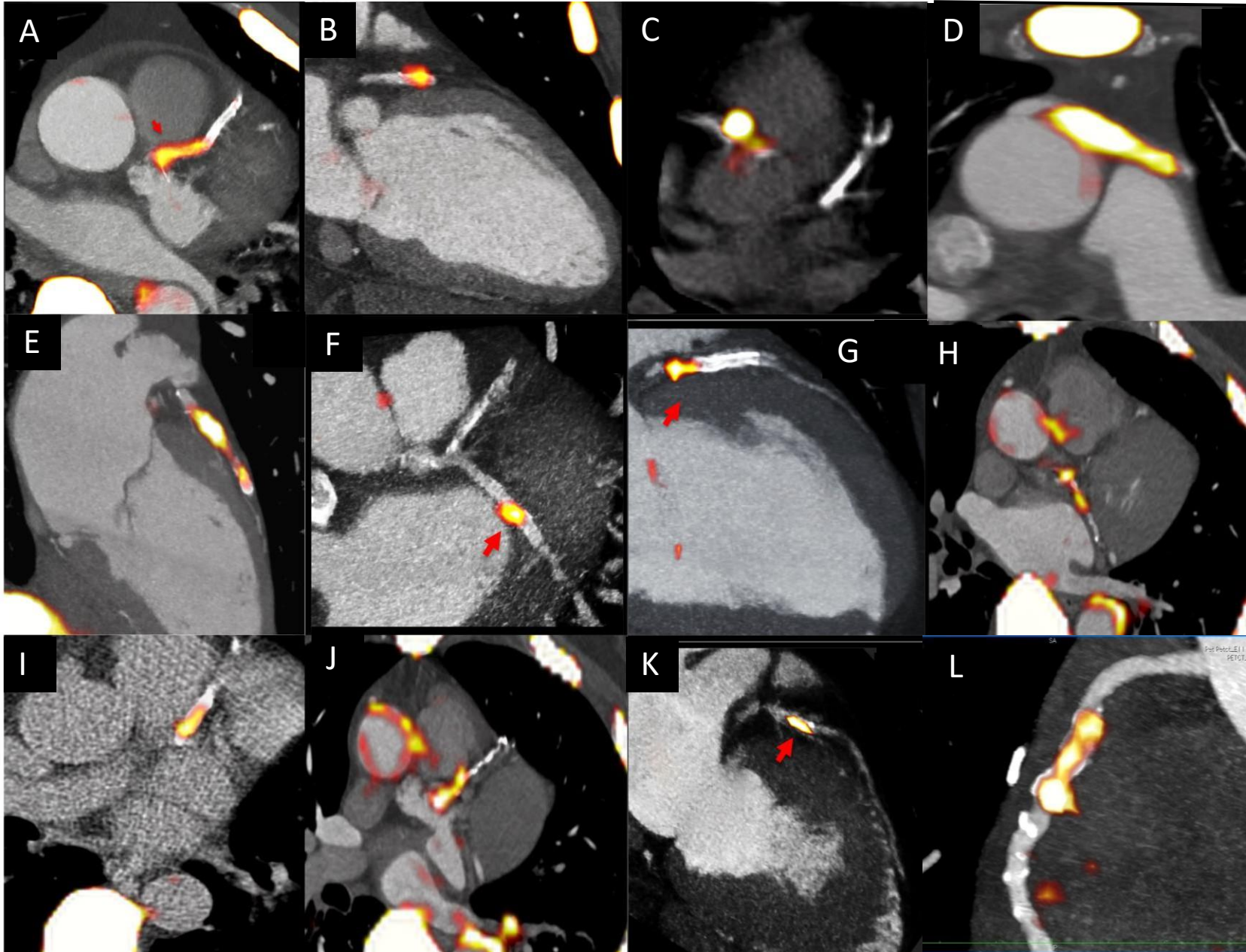


Pericoronary Fat Attenuation

- Coronary inflammation induces structural changes in the surrounding perivascular adipose tissue (PVAT)
- These changes can be detected on routine CT imaging on the basis of changes in CT signal attenuation
- PVAT CT attenuation can, therefore, provide a surrogate measure of coronary inflammation
- This novel methodology could provide useful additional information from routine clinical scans
- Further multicentre validation and prospective outcome data are now required



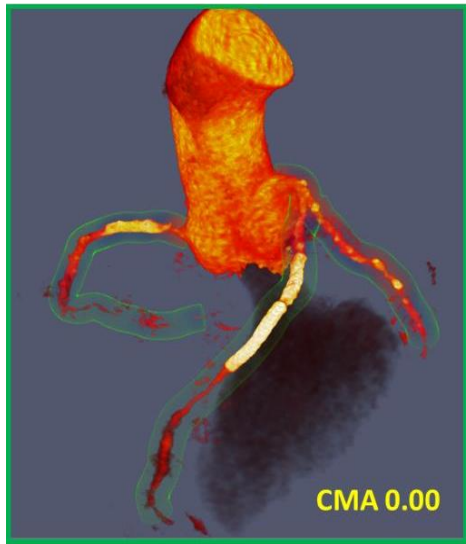
Coronary Artery Disease



Patients with advanced established
coronary artery disease n=292

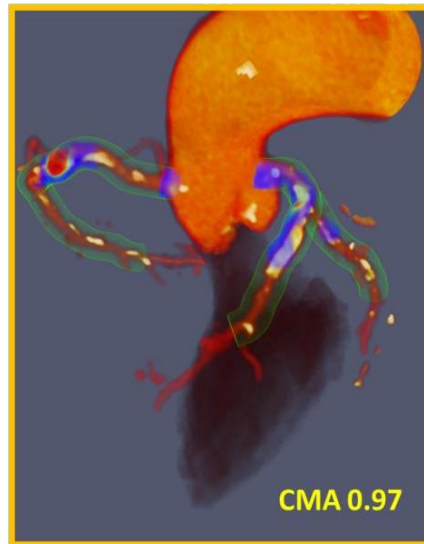


Coronary disease activity on ^{18}F -NaF PET:
the only predictor of fatal or non-fatal MI
(independent of calcium score, coronary artery lumen stenosis,
risk scores & co-morbidities)

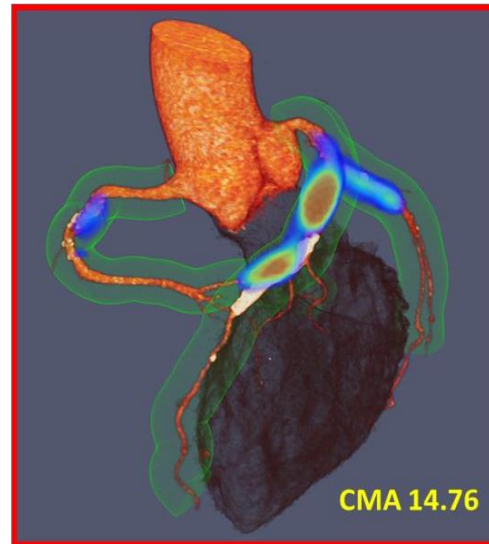


No Activity
(CMA=0)

NO MI on FU

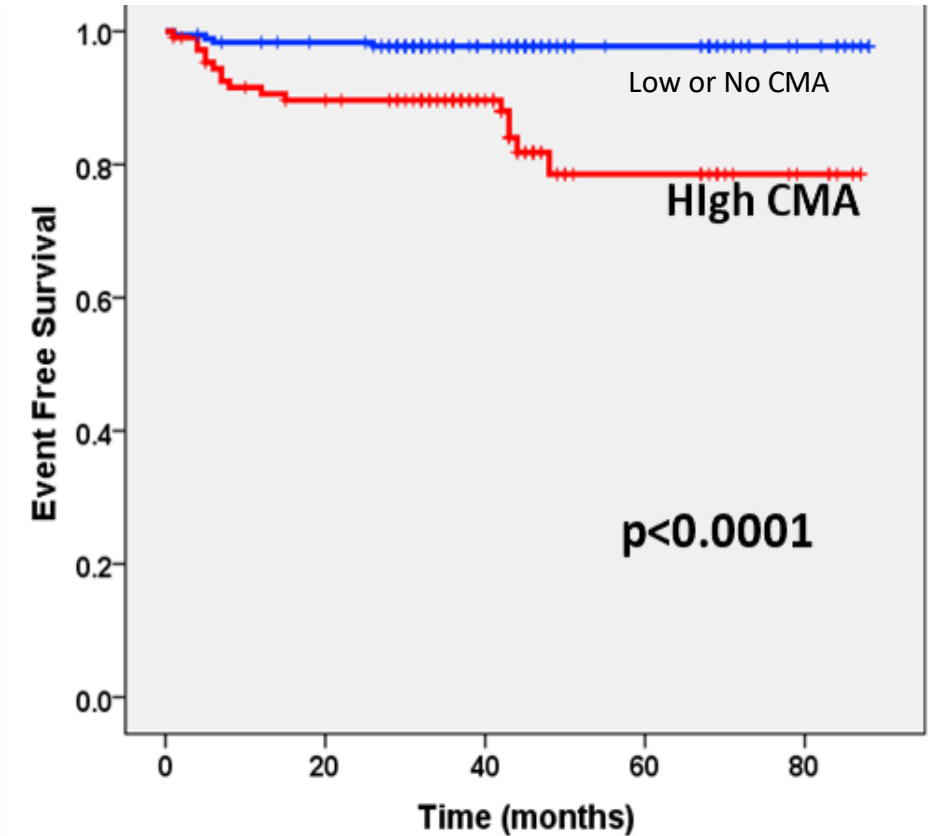


Low Activity
(CMA 0.01 to 1.56)



High Activity
(CMA > 1.56)

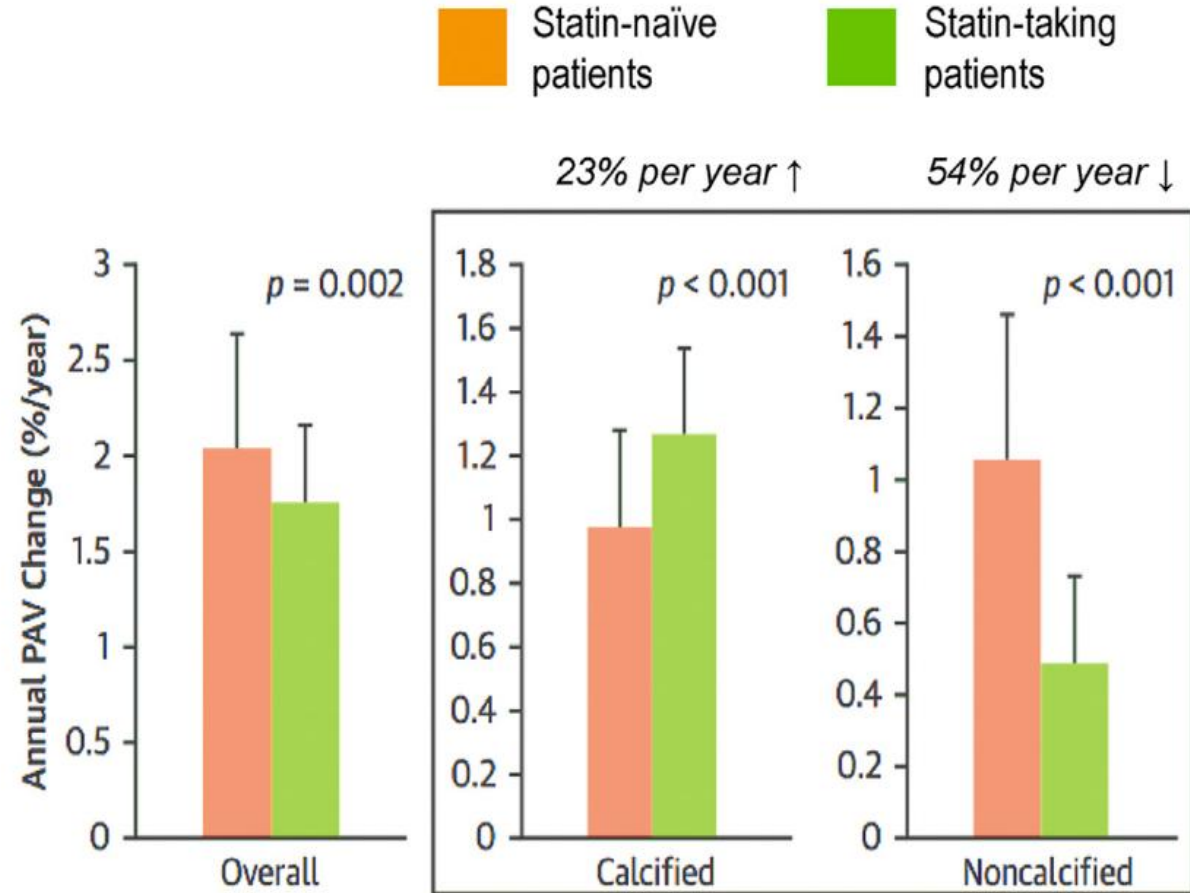
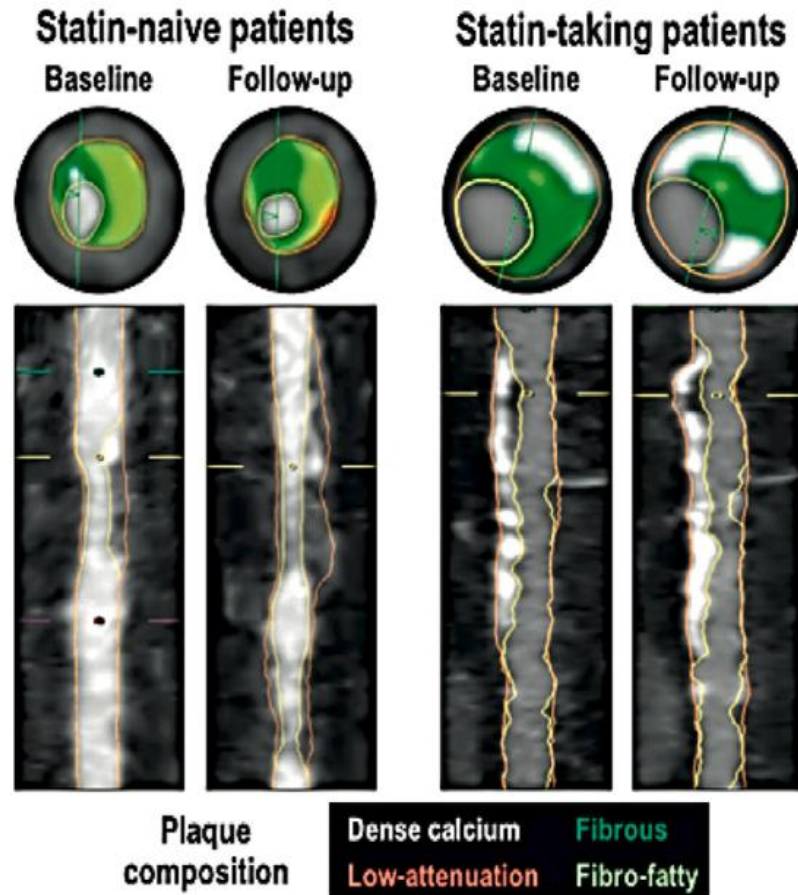
8-fold risk of MI



^{18}F -fluoride PET outperformed all
clinical risk scores and CT
assessments in the prediction of
subsequent MI

PARADIGM study

Paired CT Scans ≥ 2 Years Apart 1255 pt



Conclusions

- CTCA enables detection of early stages of CAD
- Characterisation of the plaques
- HRP characteristics are associated with ACS and future MACE
- Plaque burden and CAD extent is better predictor of future MI than the degree of lumen stenosis
- AI driven plaque quantification for individual risk assessment