Cardiology CME 2018

Imaging for Chest Pain Evaluation in the Emergency Department

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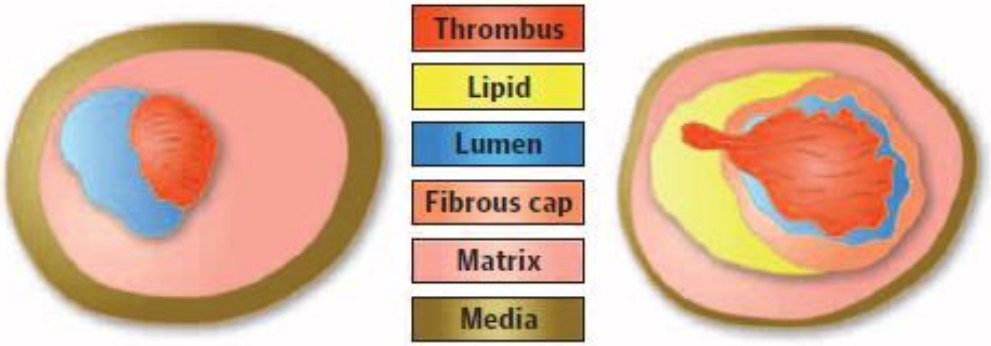
האיגוד הקרדיולוגי בישראל
ISRAEL HEART SOCIETY

Disclosures

- Arineta inc. – Research grant
- Philips medical systems – Research grant

What is the mechanism of ACS ?

Figure 1. Main Characteristics of Superficial Erosion and Plaque Rupture as Causes of Thrombosis in Acute Coronary Syndrome



Plaque erosion	Plaque rupture
Lipid poor	Lipid rich
Proteoglycan and glycosaminoglycan rich	Collagen poor, thin fibrous cap
Nonfibrillar collagen breakdown	Interstitial collagen breakdown
Few inflammatory cells	Abundant inflammation
Endothelial cell apoptosis	Smooth muscle cell apoptosis
Secondary neutrophil involvement	Macrophage predominance
Female predominance	Male predominance
High triglycerides	High LDL

Libby, Pasterkamp. Eur Heart J 2015;36

OCT images of underlying plaque morphology in STEMI

Figure 2. Representative Optical Coherence Tomography Images of Underlying Plaque Morphologies in ST-Segment Elevation Myocardial Infarction

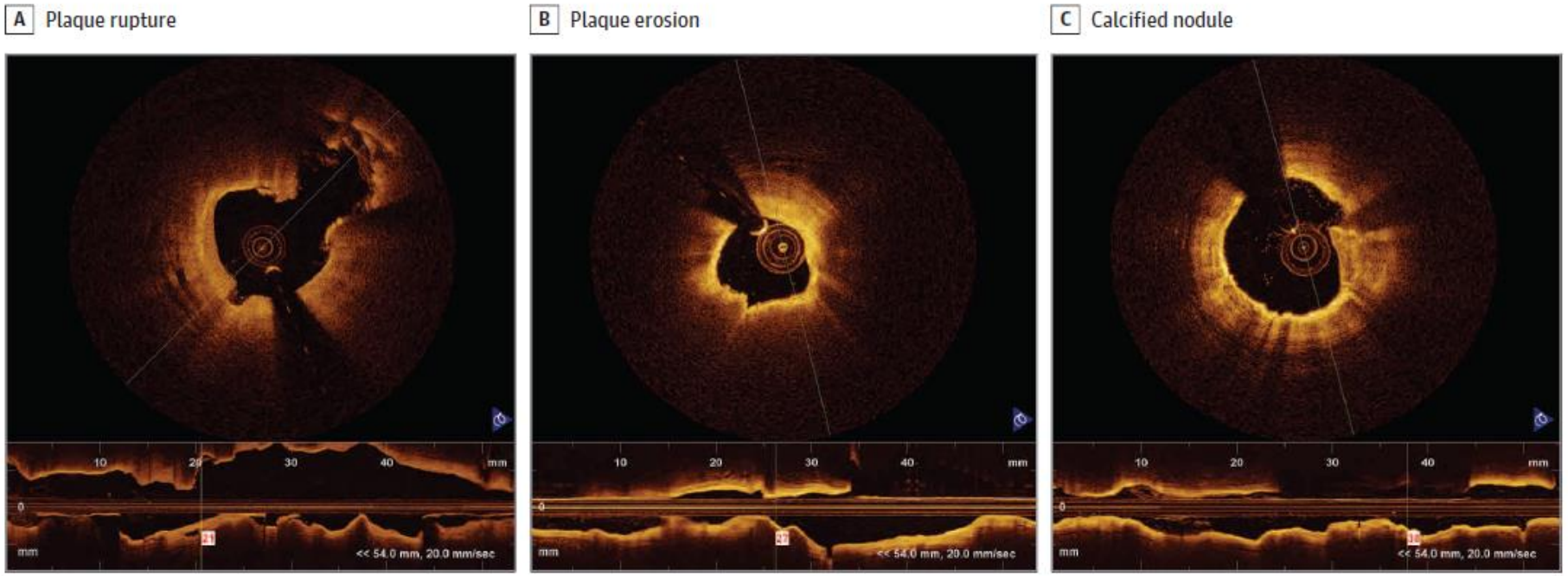
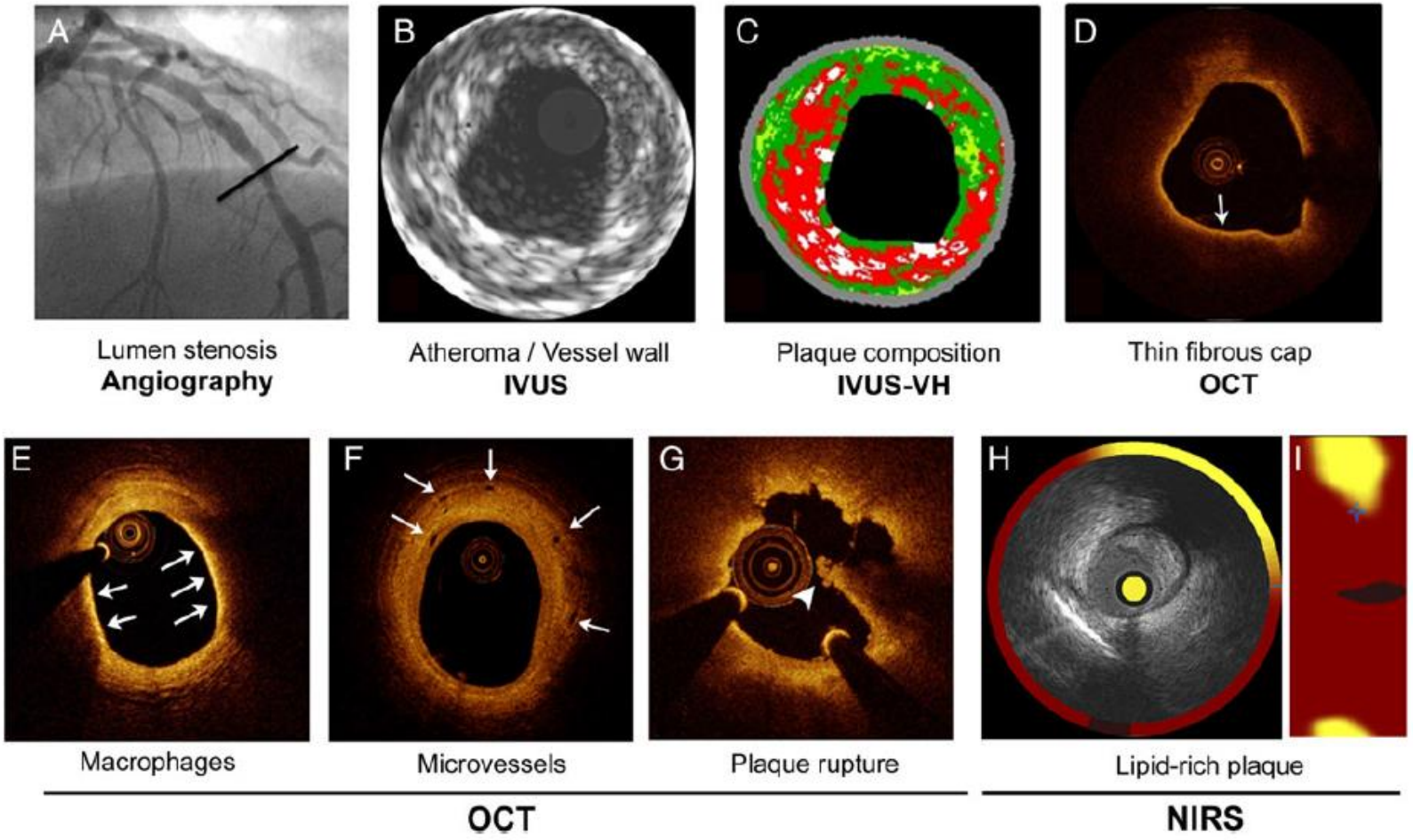


Figure provided by Ik-Kyung Jang, MD, PhD, Massachusetts General Hospital, Boston. sec Indicates seconds.

Libby, Pasterkamp. Eur Heart J 2015;36

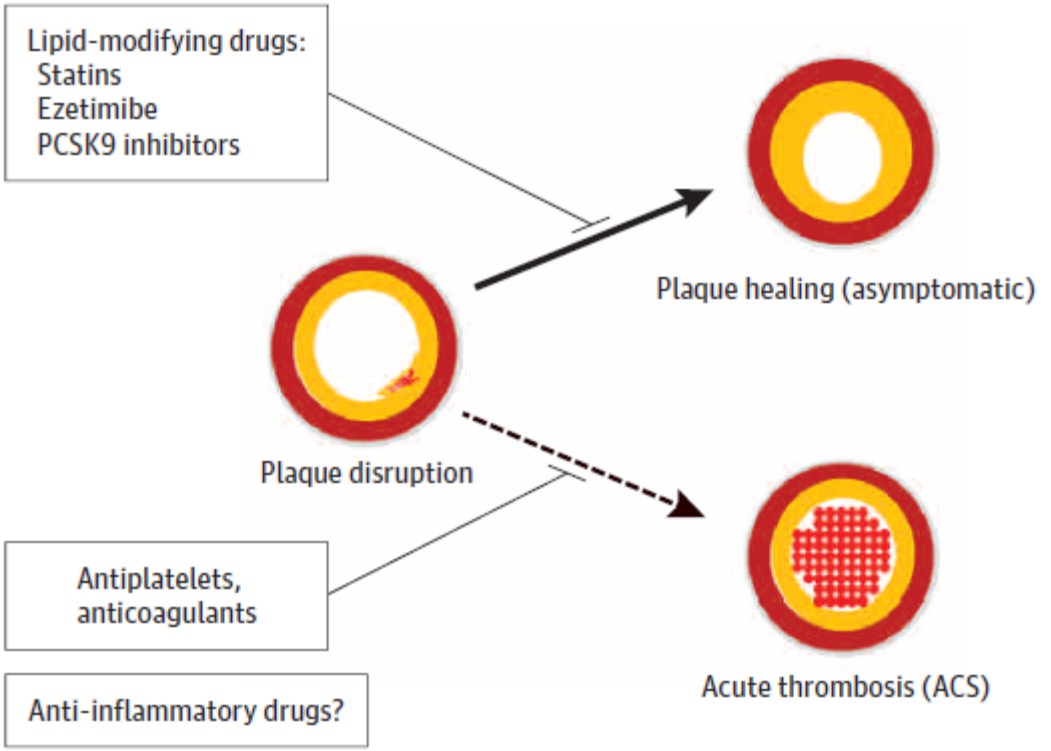
Multi modality intra-coronary imaging of atherosclerotic plaques



Eur Heart J 2016;37

Most disrupted plaques heal spontaneously

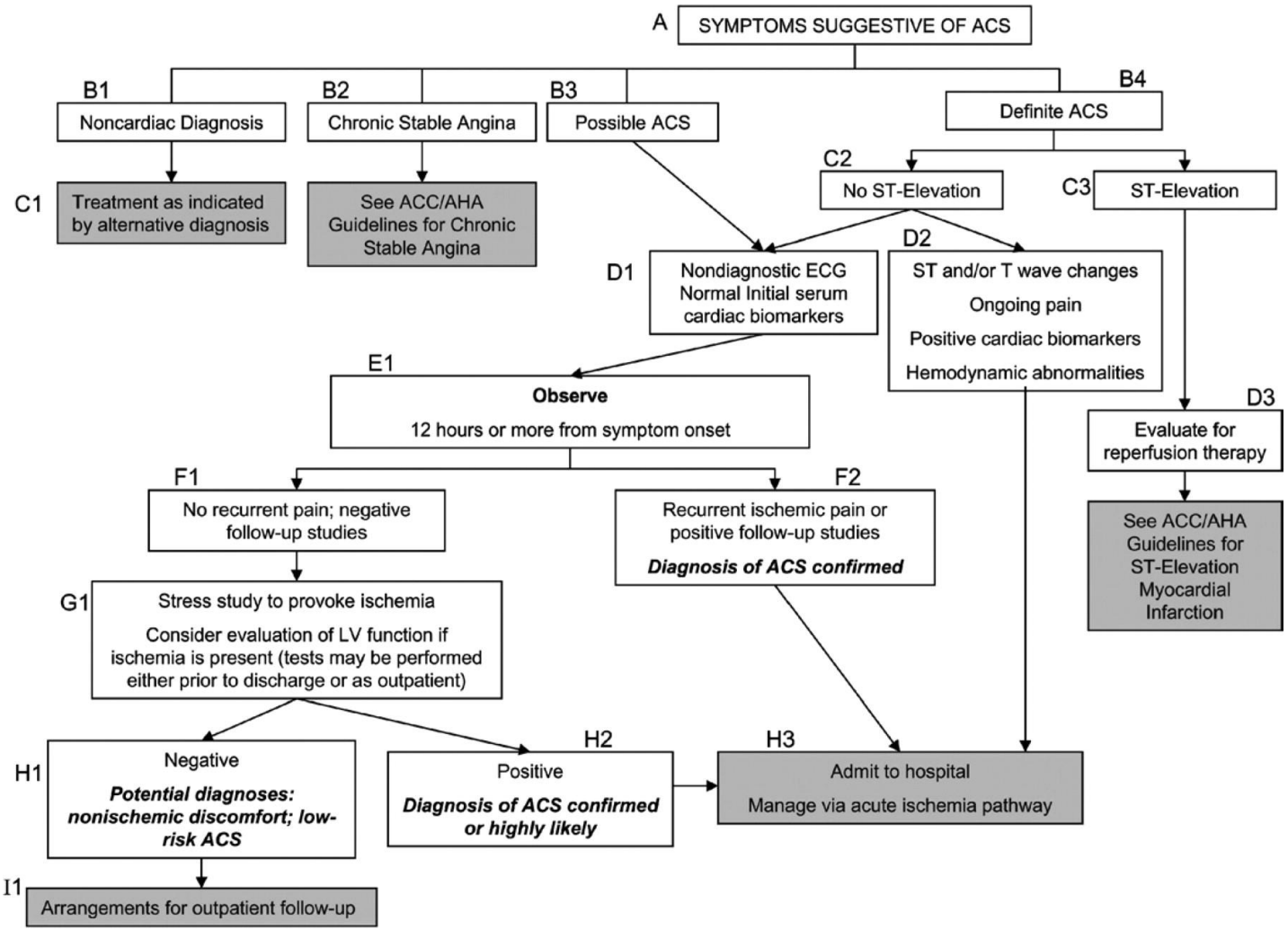
Figure 7. Nature of the Disrupted Plaque and Possible Targets for Current and Future Therapies



ACS indicates acute coronary syndrome; PCSK9, proprotein convertase subtilisin kexin type 9.

Eisen, Giugliano, Braunwald. JAMA Cardiol 2016;1

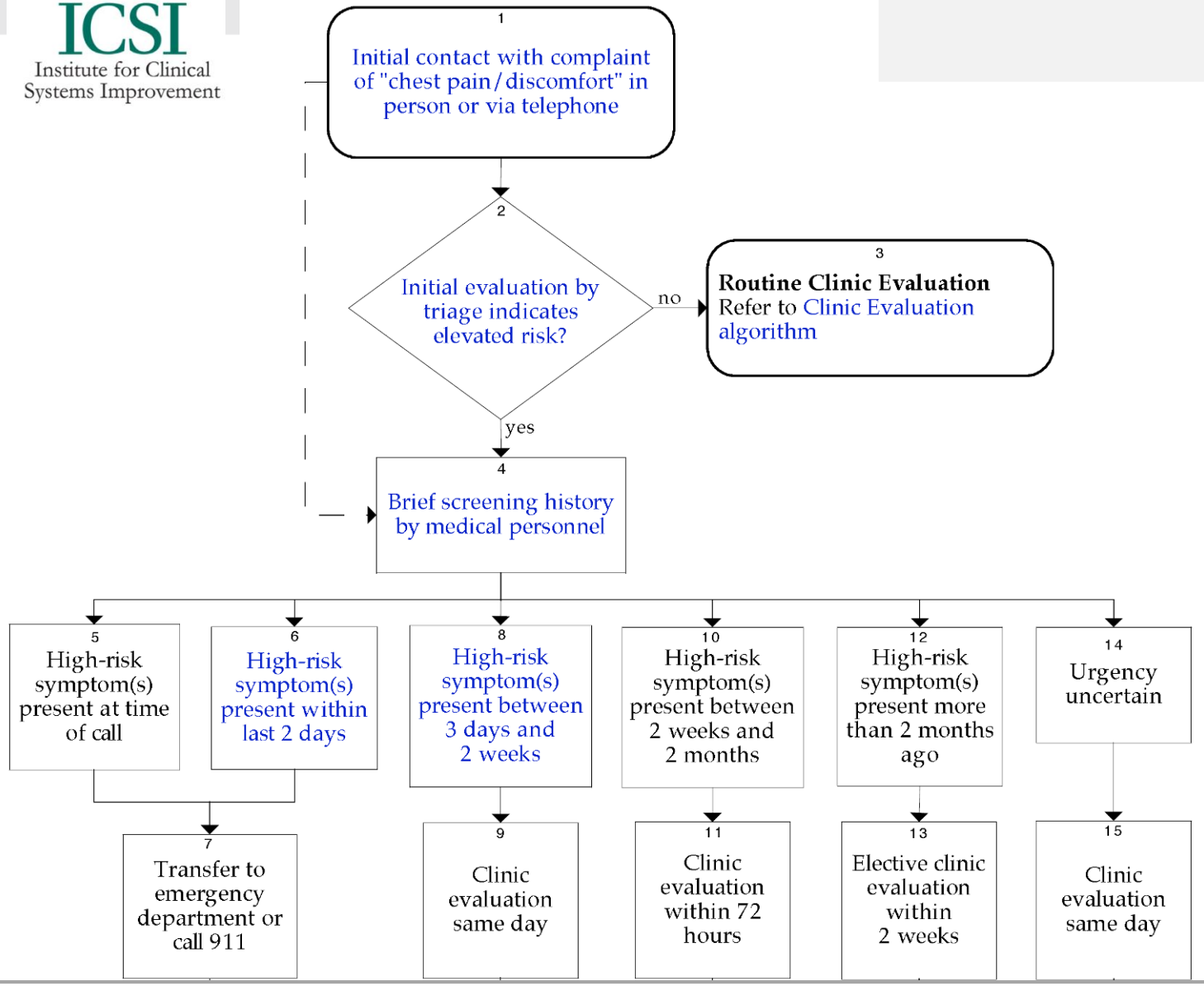
Algorithm for Evaluation and Management of Patients Suspected of Having ACS. To facilitate interpretation of this algorithm and a more detailed discussion in the text, each box is assigned a letter code that reflects its level in the algorithm and a number that is allocated from left to right across the diagram on a given level.



Anderson J et al. Circulation 2011;123:e426-e579

Chest Pain Screening Algorithm

ICSI
Institute for Clinical Systems Improvement



ORIGINAL ARTICLE

Early Diagnosis of Myocardial Infarction with Sensitive Cardiac Troponin Assays

Tobias Reichlin, M.D., Willibald Hochholzer, M.D., Stefano Bassetti, M.D., Stephan Steuer, M.D., Claudia Stelzig, M.Sc., Sabine Hartwiger, M.D., Stefan Biedert, M.Sc., Nora Schaub, M.D., Christine Buerge, M.D., Mihael Potocki, M.D., Markus Noveanu, M.D., Tobias Breidthardt, M.D., Raphael Twerenbold, M.D., Katrin Winkler, M.D., Roland Bingisser, M.D., and Christian Mueller, M.D.

ABSTRACT

BACKGROUND

The rapid and reliable diagnosis of acute myocardial infarction is a major unmet clinical need.

METHODS

We conducted a multicenter study to examine the diagnostic accuracy of new, sensitive cardiac troponin assays performed on blood samples obtained in the emergency department from 718 consecutive patients who presented with symptoms suggestive of acute myocardial infarction. Cardiac troponin levels were determined in a blinded fashion with the use of four sensitive assays (Abbott–Architect Troponin I, Roche High-Sensitive Troponin T, Roche Troponin I, and Siemens Troponin I Ultra) and a standard assay (Roche Troponin T). The final diagnosis was adjudicated by two independent cardiologists.

RESULTS

Acute myocardial infarction was the adjudicated final diagnosis in 123 patients (17%). The diagnostic accuracy of measurements obtained at presentation, as quantified by the area under the receiver-operating-characteristic curve (AUC), was significantly higher with the four sensitive cardiac troponin assays than with the standard assay (AUC for Abbott–Architect Troponin I, 0.96; 95% confidence interval [CI], 0.94 to 0.98; for Roche High-Sensitive Troponin T, 0.96; 95% CI, 0.94 to 0.98; for Roche Troponin I, 0.95; 95% CI, 0.92 to 0.97; and for Siemens Troponin I Ultra, 0.96; 95% CI, 0.94 to 0.98; vs. AUC for the standard assay, 0.90; 95% CI, 0.86 to 0.94). Among patients who presented within 3 hours after the onset of chest pain, the AUCs were 0.93 (95% CI, 0.88 to 0.99), 0.92 (95% CI, 0.87 to 0.97), 0.92 (95% CI, 0.86 to 0.99), and 0.94 (95% CI, 0.90 to 0.98) for the sensitive assays, respectively, and 0.76 (95% CI, 0.64 to 0.88) for the standard assay. We did not assess the effect of the sensitive troponin assays on clinical management.

CONCLUSIONS

The diagnostic performance of sensitive cardiac troponin assays is excellent, and these assays can substantially improve the early diagnosis of acute myocardial infarction, particularly in patients with a recent onset of chest pain. (ClinicalTrials.gov number, NCT00470587.)

From the Department of Internal Medicine, University Hospital, Basel (T.R., W.H., C.S., S.H., S. Biedert, N.S., C.B., M.P., M.N., T.B., R.T., R.B., C.M.); Kantonsspital Olten, Olten (S. Bassetti); and Limmattalspital, Zurich (S.S.) — all in Switzerland; Herz Zentrum Bad Krozingen, Bad Krozingen, Germany (M.P.); and Centro de Investigación en Red de Enfermedades Respiratorias, SC 111 Servicio de Pneumologia, Hospital del Mar–Institut Municipal d'Investigació Mèdica, Barcelona (K.W.). Address reprint requests to Dr. Mueller at the Department of Internal Medicine, University Hospital Basel, Petersgraben 4, CH-4031 Basel, Switzerland, or at chmueller@uhbs.ch.

N Engl J Med 2009;361:858-67.

Traditional clinical classification of chest pain

Typical angina (definite)	Meets all three of the following characteristics: • substernal chest discomfort of characteristic quality and duration; • provoked by exertion or emotional stress; • relieved by rest and/or nitrates within minutes.
Atypical angina (probable)	Meets two of these characteristics.
Non-anginal chest pain	Lacks or meets only one or none of the characteristics.

This slide corresponds to Table 4 in the full text.

Eur Heart J 2013;34:2949–3003. doi:10.1093/eurheartj/eht296

Clinical pre-test probabilities[a] in patients with stable chest pain symptoms

	Typical angina		Atypical angina		Non-anginal pain	
Age	Men	Women	Men	Women	Men	Women
30-39	59	28	29	10	18	5
40-49	69	37	38	14	25	8
50-59	77	47	49	20	34	12
60-69	84	58	59	28	44	17
70-79	89	68	69	37	54	24
>80	93	76	78	47	65	32

[a] Probabilities of obstructive coronary disease shown reflect the estimates for patients aged 35, 45, 55, 65, 75, and 85 years. This slide corresponds to Table 13 in the full text.

From: Genders TS, et al. Eur Heart J 2011;32:1316–1330.

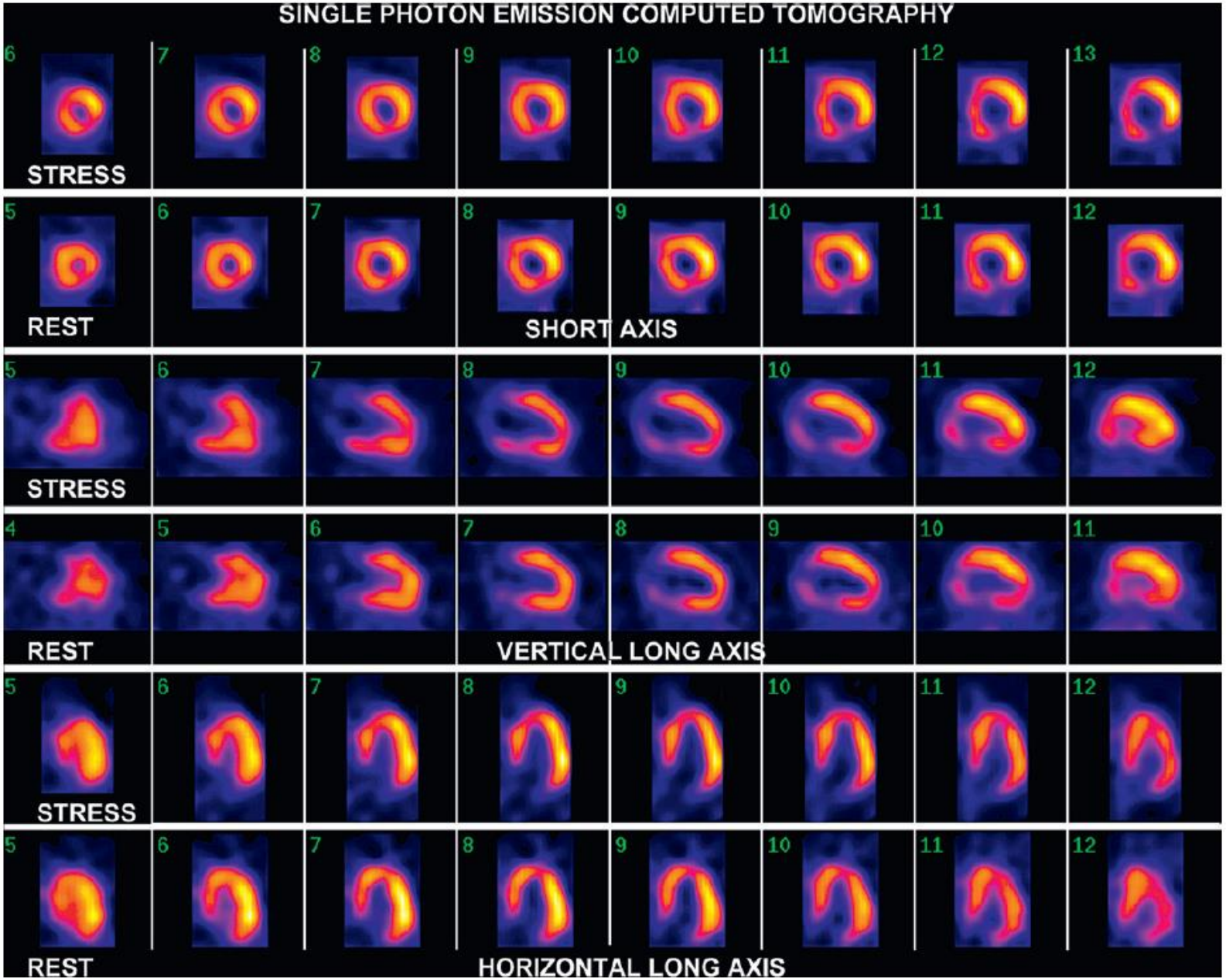
Eur Heart J 2013;34:2949–3003. doi:10.1093/eurheartj/eht296

Characteristics of tests commonly used to diagnose the presence of CAD

	Diagnosis of CAD	
	Sensitivity (%)	Specificity (%)
Exercise ECG[a]	45-50	85-90
Exercise stress echocardiography	80-85	80-88
Exercise stress SPECT	73-92	63-87
Dobutamine stress echocardiography	79-83	82-86
Dobutamine stress MRI[b]	79-88	81-91
Vasodilator stress echocardiography	72-79	92-95
Vasodilator stress SPECT	90-91	75-84
Vasodilator stress MRI[b]	67-94	61-85
Coronary CTA[c]	95-99	64-83
Vasodilator stress PET	81-97	74-91

CAD = coronary artery disease; CTA = computed tomography angiography; ECG = electrocardiogram; MRI = magnetic resonance imaging; PET = positron emission tomography; SPECT = single photon emission computed tomography.
[a]Results without/with minimal referral bias; [b]Results obtained in populations with medium-to-high prevalence of disease without compensation for referral bias; [c]Results obtained in populations with low-to-medium prevalence of disease.
This slide corresponds to Table 12 in the full text.

Eur Heart J 2013;34:2949–3003. doi:10.1093/eurheartj/eht296


SINGLE PHOTON EMISSION COMPUTED TOMOGRAPHY
6 7 8 9 10 11 12 13
STRESS
5 6 7 8 9 10 11 12
REST
SHORT AXIS
5 6 7 8 9 10 11 12
STRESS
4 5 6 7 8 9 10 11
REST
VERTICAL LONG AXIS
5 6 7 8 9 10 11 12
STRESS
5 6 7 8 9 10 11 12
REST
HORIZONTAL LONG AXIS

Risk stratification using ischaemia testing

Recommendations	Class	Level
Risk stratification is recommended based on clinical assessment and the result of the stress test initially employed for making a diagnosis of SCAD.	I	B
Stress imaging for risk stratification is recommended in patients with a non-conclusive exercise ECG[a]	I	B
Risk stratification using stress ECG (unless they cannot exercise or display ECG changes which make the ECG non-evaluable) or preferably stress imaging if local expertise and availability permit is recommended in patients with stable coronary disease after a significant change in symptom level.	I	B
Stress imaging is recommended for risk stratification in patients with known SCAD and a deterioration in symptoms if the site and extent of ischaemia would influence clinical decision making.	I	B
Pharmacological stress with echocardiography or SPECT should be considered in patients with LBBB.	IIa	B
Stress echocardiography or SPECT should be considered in patients with paced rhythm.	IIa	B

ECG = electrocardiogram; LBBB = left bundle branch block; SCAD = stable coronary artery disease; SPECT = single photon emission computed tomography.

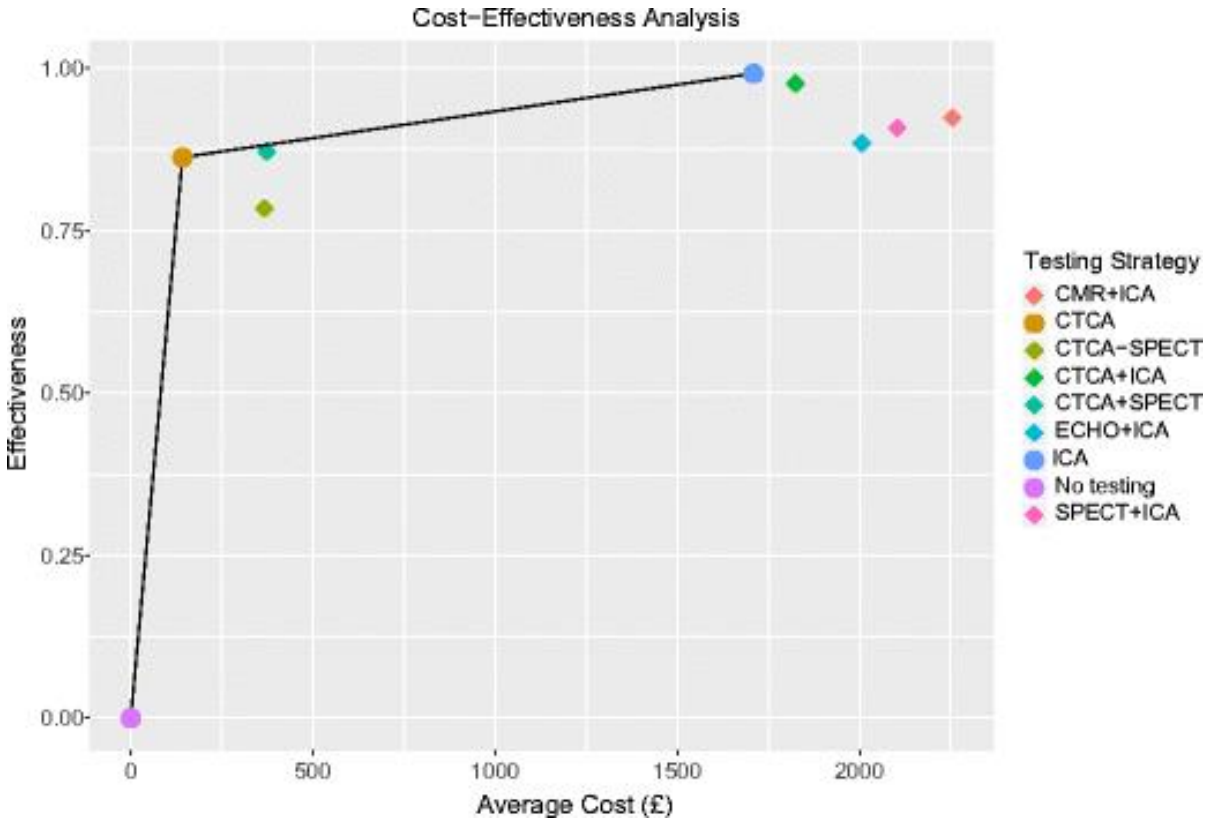
[a]Stress imaging has usually been performed for establishing a diagnosis of SCAD in most of these patients.

This slide corresponds to Table 19 in the full text.

Eur Heart J 2013;34:2949–3003. doi:10.1093/eurheartj/eht296

Updated UK NICE Guidelines 2016

Coronary CTA as the first line test



התוויות מתאימות לביצוע טומוגרפיה מחשבית של הלב: מסמך עמדה משותף מטעם האיגוד לקרדיולוגיה והאיגוד לרדיולוגיה בישראל

תקציר: טומוגרפיה מחשבית של הלב היא טכנולוגיית דימות חדשה יחסית, המאפשרת להדגים היטב את העורקים הכליליים ומבני הלב השונים. עם ההתקדמות הטכנולוגית של הסורקים והעלייה בשימוש בסורקים אלו בהתוויות של הלב, עולה גם הצורך להגדיר בצורה מדויקת יותר את ההתוויות לביצוע הבדיקה. במאמר זה מסוכמות ההתוויות המתאימות לביצוע טומוגרפיה מחשבית של הלב, כפי שסוכמו על ידי ועדה משותפת לאיגוד לקרדיולוגיה ורדיולוגיה בישראל [1].

רונן רובינשטיין[1] גלית אבירם[2]
אריק וולק[1] אריאל רוגין[1]
אורלי גויטיין[2] ג'ורג' בלינדר[2]
רן קורנובסקי[1] יוסף שמש[1]
תמר נספר[2] אלי קונן[2]

[1]האיגוד לקרדיולוגיה בישראל [2]האיגוד לרדיולוגיה בישראל
*שני המחברים הראשונים תרמו למאמר במידה זהה.

טבלה ו:
התוויות מומלצות כמתאימות לביצוע טומוגרפיה מחשבית של הלב

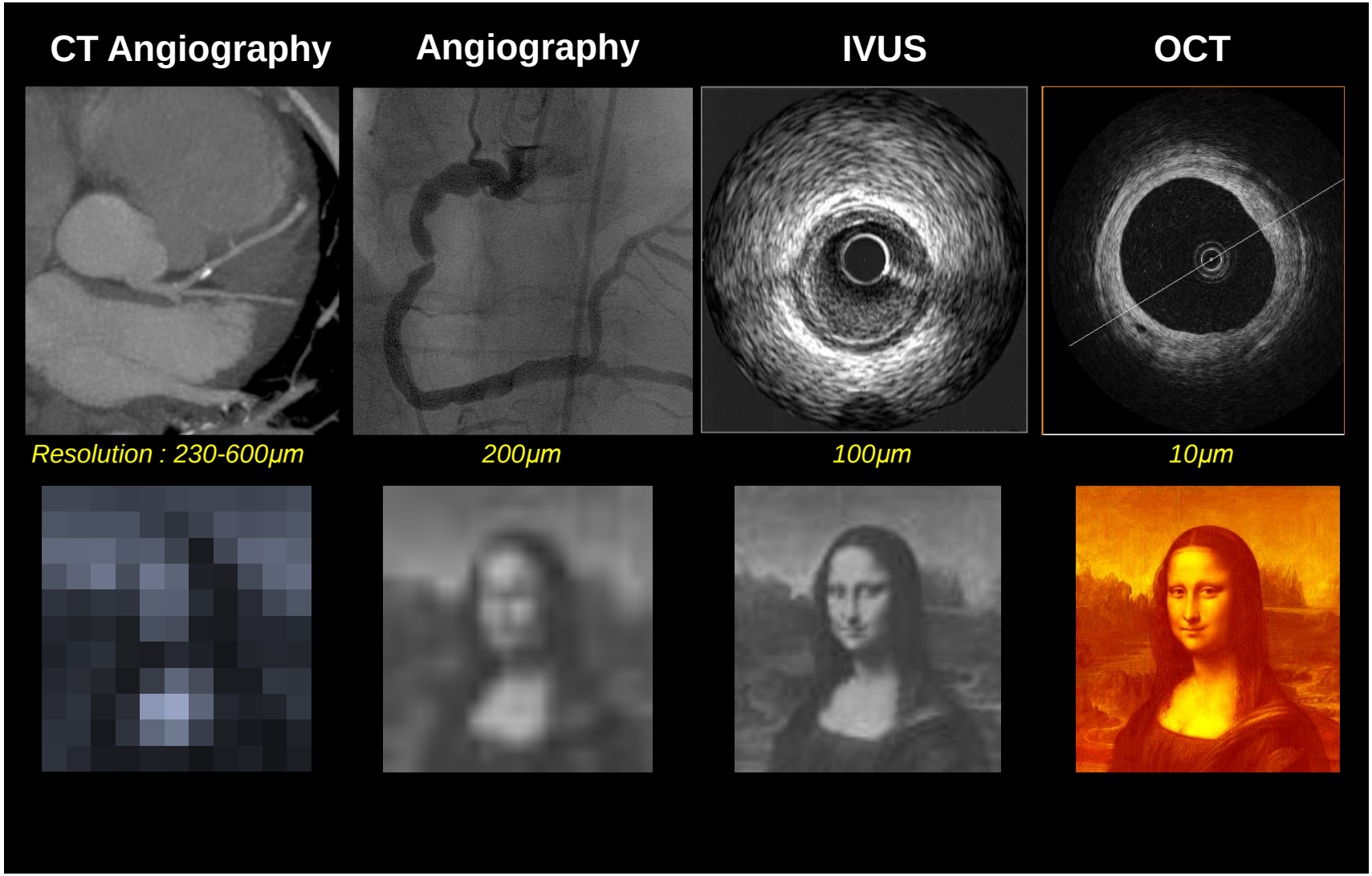
בירור אמבולטורי של כאבים בבית החזה	
1	בנבדק בסבירות נמוכה עד בינונית למחלה כלילית חסימתית, בפרט אם אינו מסוגל לבצע מאמץ אבחוני, ו/או בנוכחות תרשים אק"ג שמקשה על פענוח (כגון CLBBB, שינויי רה-פולריזציה).
2	בנבדק עם תבחין מאמץ, מיפוי או אקו לב במאמץ שאינם חד משמעיים או שאינם ניתנים לפענוח, אך נדרש המשך בירור.
3	אבחון חסימות של מעקפים כליליים בחולים לאחר ניתוח מעקפים (CABG) הסובלים מכאבים לא טיפוסיים בבית החזה.
כאבים חדים בבית החזה (Acute chest pain)	
4	כאבים בבית החזה בנבדק בסבירות נמוכה עד בינונית למחלה כלילית חסימתית, ללא שינויים איסכמים בתרשים האק"ג וללא עלייה בסמני הלב בדם בבדיקות עוקבות.
5	לשלילת מחלה כלילית, תסחיף ריאתי ודיסקציה של הוותין (אאורטה) בהסתמנות חדה (Triple rule-out), כשקיימת אבחנה מבדלת עם חשד קליני סביר לבעיות הנ"ל.
צורך בהערכה של הלב במצבים קליניים שונים	
6	הדגמה של עורקים כליליים בחולים עם חשד קליני לקרדיומיופתיה לא איסכמית חדשה New-onset non-ischemic cardiomyopathy
7	לצורך אבחון משלים של המהלך האנטומי של עורק השד הפנימי (IMA) ומעקפים כליליים לפני ניתוח נשנה REDO, או ניתוח מסתמים בחולה לאחר CABG, על מנת להעריך את מרחק המעקפים מן הסטרנום וכן מידת קרבת חדר ימין לסטרנום.
8	לשלילת מחלה כלילית חסימתית בחולים עם סיכון נמוך עד בינוני לקיום מחלה כלילית חסימתית, לפני ניתוח במסתמי הלב או לתיקון בעיות מבניות בלב.
9	כאשר לא ניתן לבצע בדיקת דימות מיטבית של העורקים הכליליים באמצעות בדיקת צנתור לב מסיבות טכניות או בטיחותיות, או בשל היעדר מידע אבחוני מלא בצנתור כלי דם כליליים (סעיף א' בהמלצת משרד הבריאות משנת 2005).
10	כחלופה לא פולשנית לביצוע מעקב לאחר הכנסת תומכן בעורק שמאלי ראשי (Left main coronary artery).
אבחון תחלואה מבנית של הלב או של כלי הדם הגדולים	
11	חשד לחריגויות (אנומליות) של העורקים הכליליים.
12	הערכה של מומים בלב מלידה, כולל חריגויות של מהלך עורקים כליליים, כלי דם גדולים, חדרי לב ומסתמים, כאשר בדיקת הדימות באקו לב וב-CMR מוגבלת.
13	בירור משלים של גוש בלב (שאת או קריש דם), כשאקו לב (TTE או TEE) ותהודה מגנטית של הלב (CMR) מוגבלים טכנית או אינם אבחוניים.
14	הערכת קרום הלב (מסה פריקרדיאלית, Constrictive pericarditis, או סיבוכים לאחר ניתוחי לב) כשאקו לב (TTE או TEE) ובדיקת תהודה מגנטית של הלב (CMR) מוגבלים טכנית או אינם אבחוניים.
15	הערכת וירידי הריאה בחולים עם פרפור פרוזדורים לפני ביצוע צריבה של וורידים אלה (RF ablation) או בחשד קליני לסיבוך לאחר הפעולה.
16	מיפוי הווורידים הכליליים טרם השתלת קוצב דו חדרי.
17	חשד למעורבות מוצא העורקים הכליליים במסגרת הערכה של מפרצת אאורטלית ו/או דיסקציה של האאורטה חזית.
18	הערכת מורפולוגיית ותפקוד חדר ימין כאשר ההדמיה באקו לב (TTE או TEE) מוגבלת ו-CMR אינו זמין.
אבחון וכימות טרשת עורקים מסוידת - Calcium Score (ללא חומר ניגוד ובמינון קרינה נמוכה)	
19	בדיקת Coronary calcium score בנבדקים ללא תסמינים עם סיכון בינוני (10%-20% למוות שמקורו בלב או מאוטם שריר הלב בעשור על פי מדד פרמינגהם) לצורך אופטימיזציה של Risk stratification והתוויית טיפול מונע ראשוני.

הרפואה,
אוקטובר 2011

New Generation CT Scanners Show High Accuracy for Detection of Obstructive CAD in Symptomatic Patients

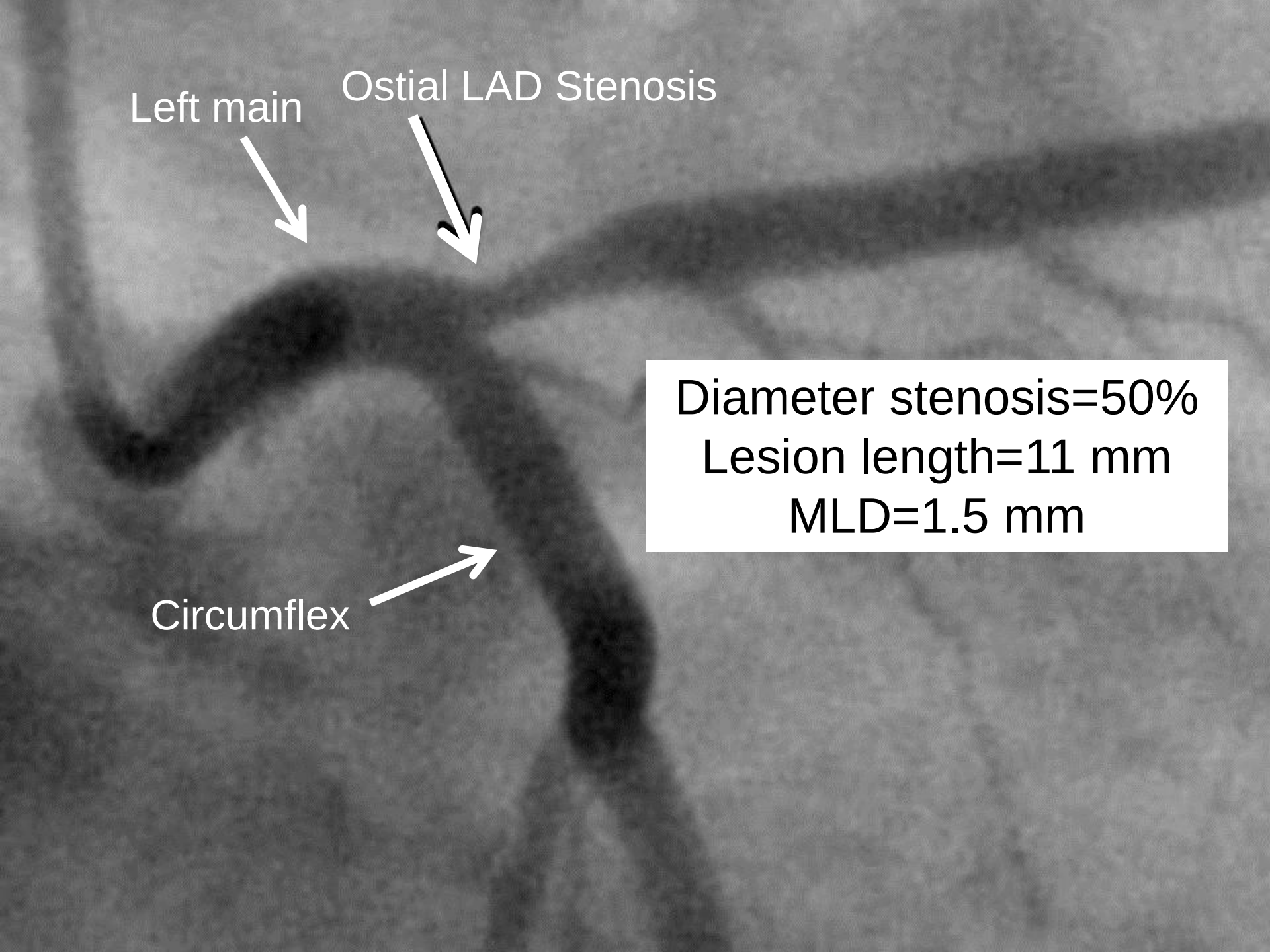
Scanner	Sensitivity (per patient)	Specificity (per patient)	Sensitivity (per segment)	Specificity (per segment)	Reference
GE HD750	100%	85-93%	72-80%	94%	LaBounty, AJC 2010
Philips 256	99-100%	50-69%	94-97%	95-97%	Chao EHJ 2010 Rubinshtein AJC 2013
Siemens DSCT	99%	89%	94%	97%	Salvaty JCCT 2012 (24 studies)
Toshiba 320	100%	81%	88%	96%	De Graaf EHJ 2010

CCTA has lower spatial resolution than intra coronary imaging



Case Presentation - 1
Atypical Angina in a diabetic patient

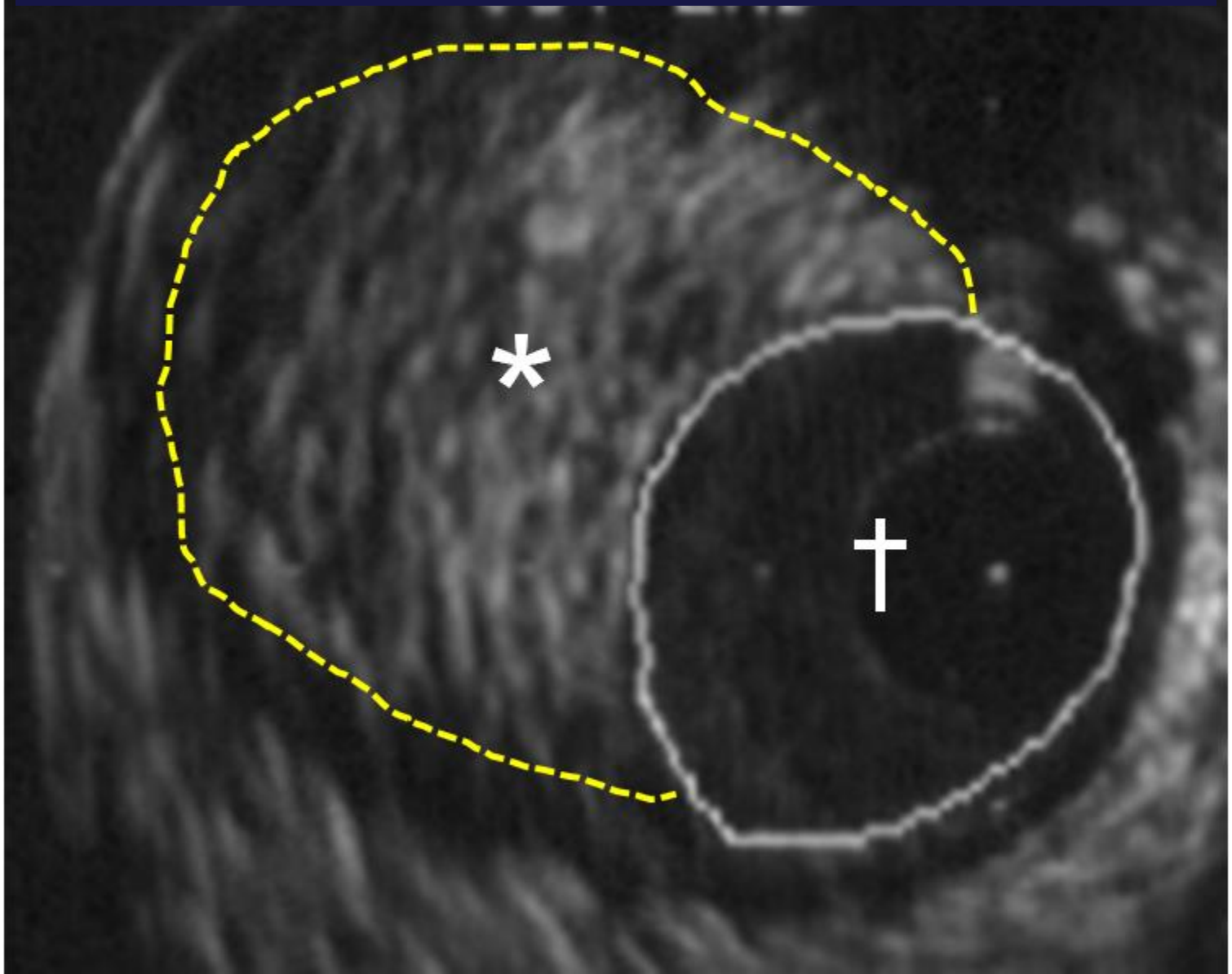
- 65 year-old diabetic woman
- New onset atypical angina
- Positive exercise stress test


Left main
Ostial LAD Stenosis
Diameter stenosis=50%
Lesion length=11 mm
MLD=1.5 mm
Circumflex

Treatment options:

- Revascularization (PCI or CABG) based on angiography
- Further anatomic evaluation-IVUS
- Physiological evaluation-FFR

IVUS:
Eccentric plaque, MLA=4.1 mm^2



Clinical Validation of Intravascular Ultrasound Imaging for Assessment of Coronary Stenosis Severity

Comparison With Stress Myocardial Perfusion Imaging

IVUS-derived MLA < 4 mm^2 had 92% sensitivity and 90% specificity for identifying a functionally significant coronary lesion

RESULTS The lesion lumen area and three IVUS-derived stenosis indexes showed sensitivities and specificities ranging between 80% and 90% using stress myocardial perfusion imaging as the gold standard. The lesion lumen area ≤4 mm^2 is a simple and highly accurate criterion for significant coronary narrowing.

Nishioka JACC 1999 33 1870

Guidelines on myocardial revascularization

The Task Force on Myocardial Revascularization of the European Society of Cardiology (ESC) and the European Association for Cardio-Thoracic Surgery (EACTS)

"…FFR is indicated for the assessment of the functional consequences of moderate coronary stenoses when functional information is lacking…"

EHJ 2010;31:2501

Importance of lesion length in determining the hemodynamic significance of a coronary stenosis

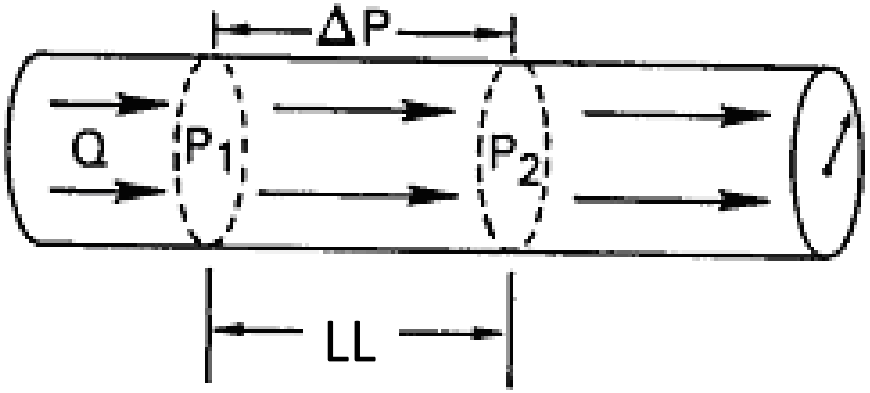
A Poiseuille-based Coronary Angiographic Index for Prediction of Fractional Flow Reserve

Jaffe…Rubinshtein et al. Int J Cardiol 2013, 167

Poiseuille equation

$$\frac{R}{1} = \frac{8\eta LL}{\pi P r^4}$$

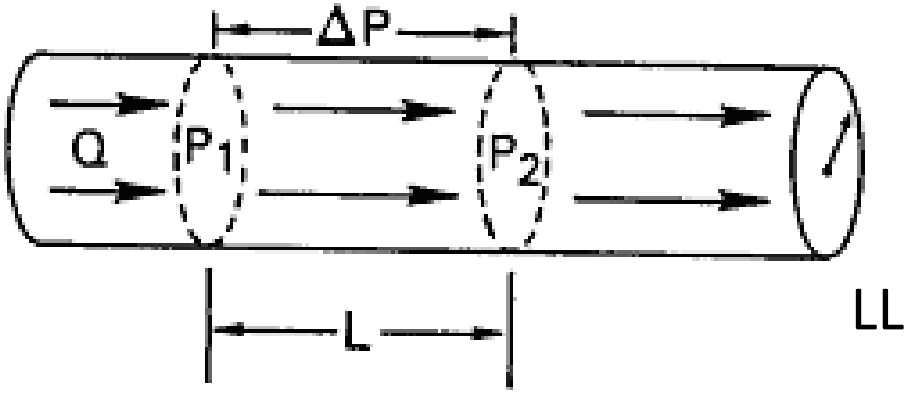
R=resistance
P=pressure
η=fluid viscocity
LL =stenosis length
r=lesion radius



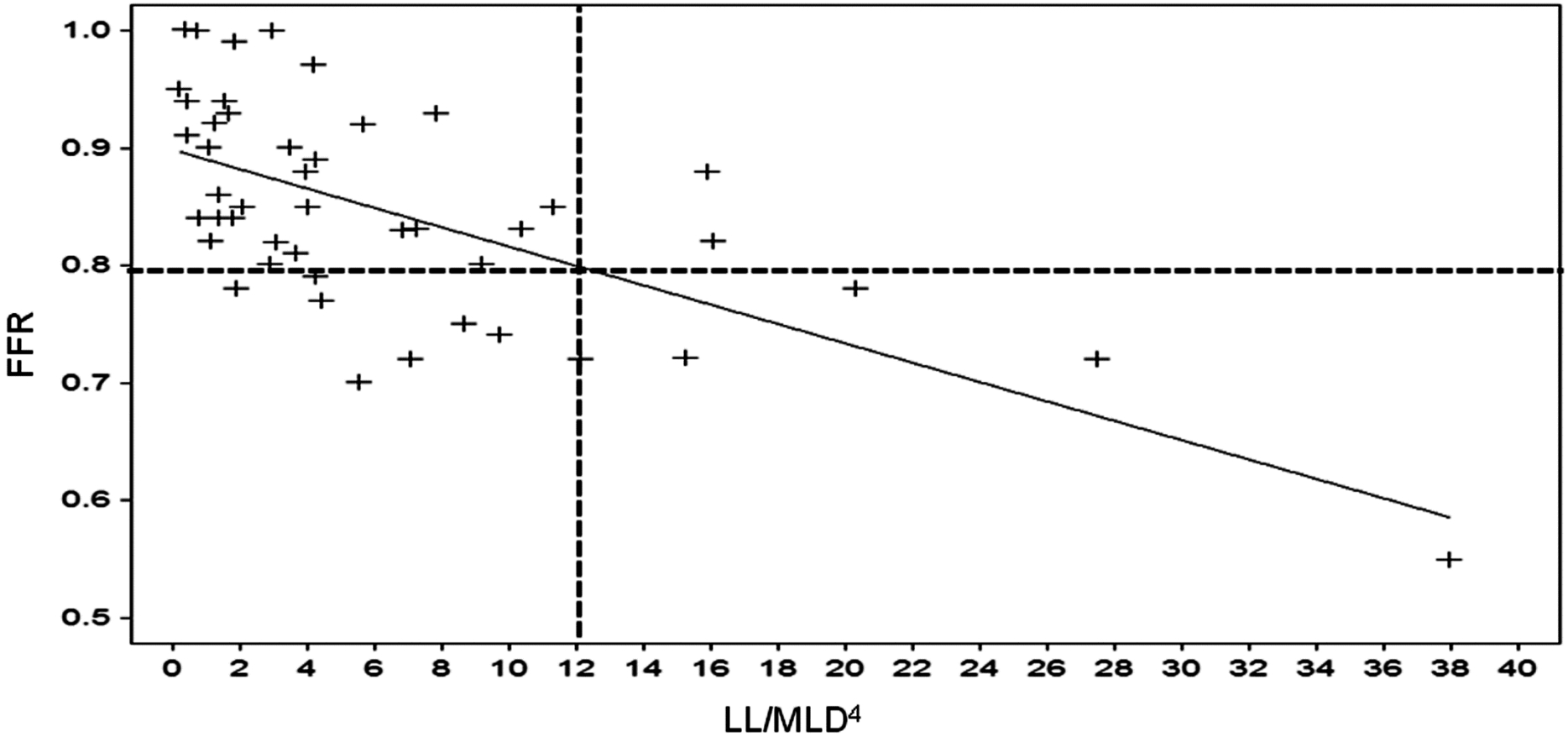
Poiseuille-based angiographic index:

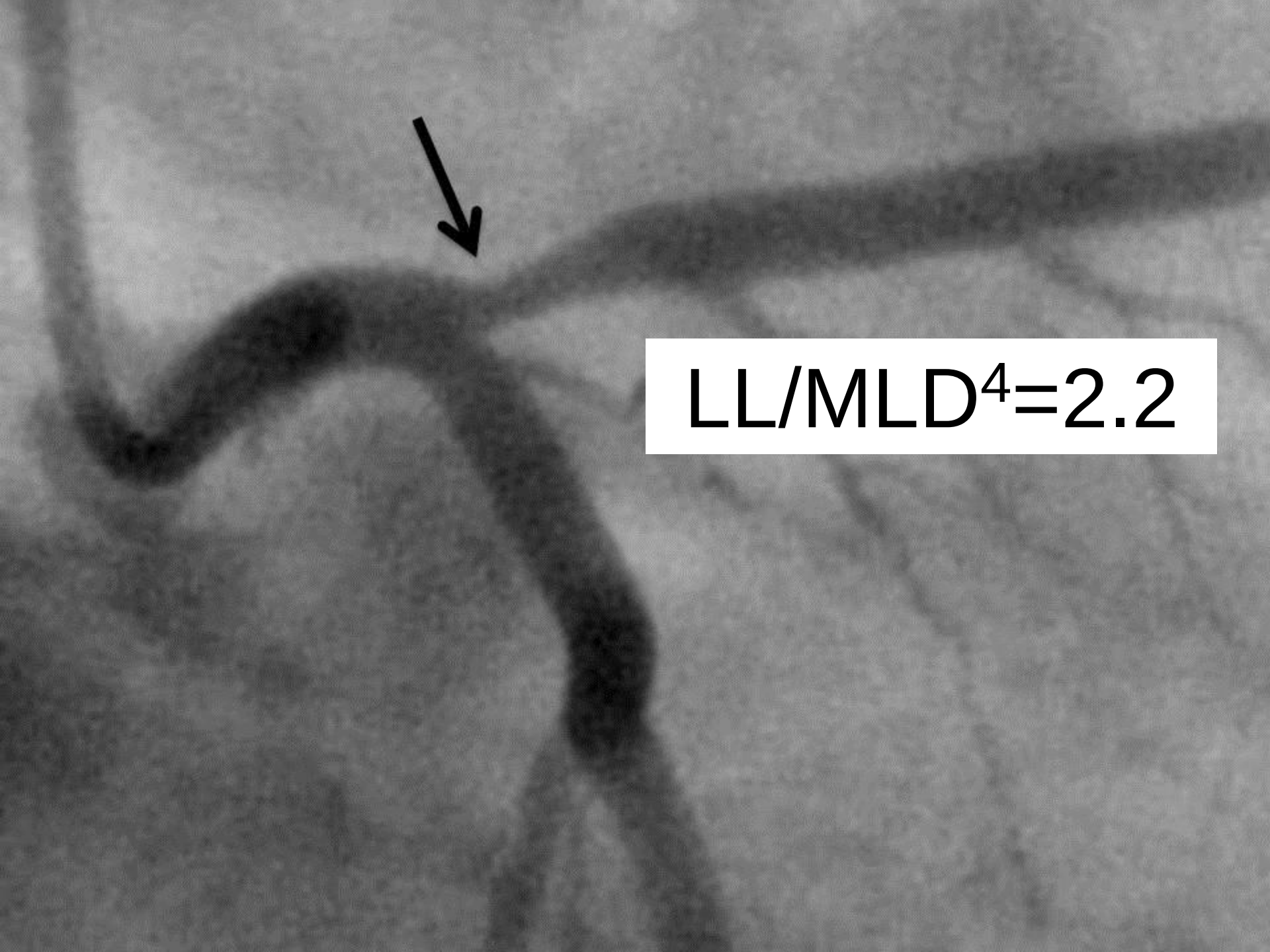
$$LL/MLD^4$$

MLD = minimal lumen diameter
LL = lesion length

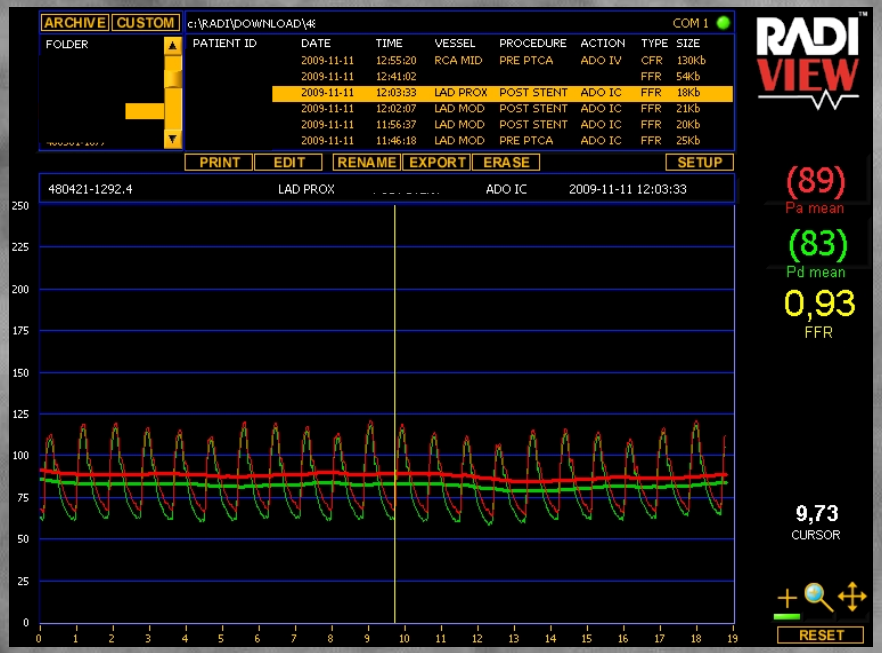


FFR vs. LL/MLD^4: R= -0.6620




LL/MLD4=2.2

FFR=0.93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FOLDER
PATIENT ID
DATE TIME VESSEL PROCEDURE ACTION TYPE SIZE
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2009-11-11 12:41:02 FFR 54Kb
2009-11-11 12:03:33 LAD PROX POST STENT ADO IC FFR 18Kb
2009-11-11 12:02:07 LAD MOD POST STENT ADO IC FFR 21Kb
2009-11-11 11:56:37 LAD MOD POST STENT ADO IC FFR 20Kb
2009-11-11 11:46:18 LAD MOD PRE PTCA ADO IC FFR 25Kb
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ERASE
SETUP
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ADO IC
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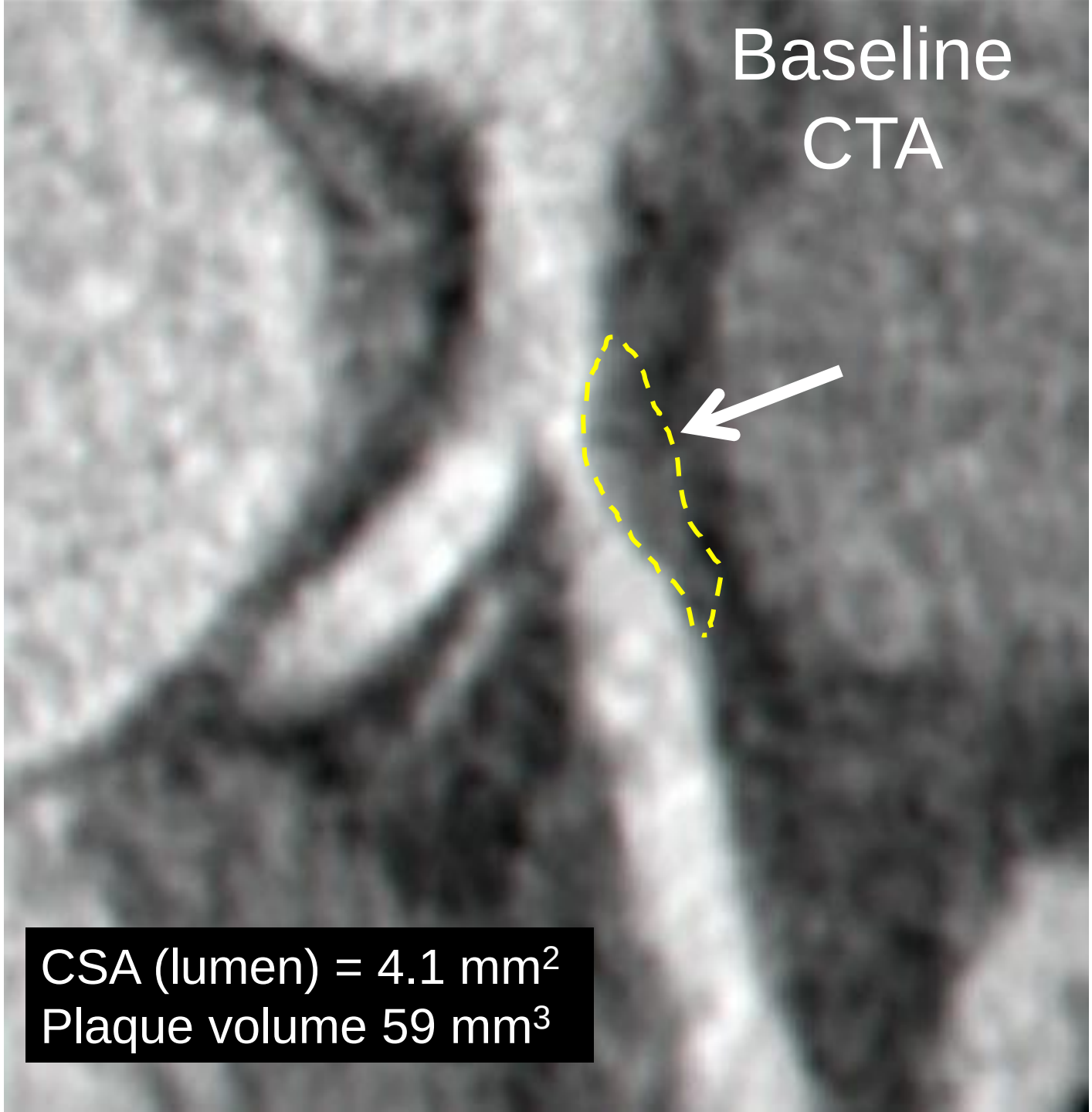
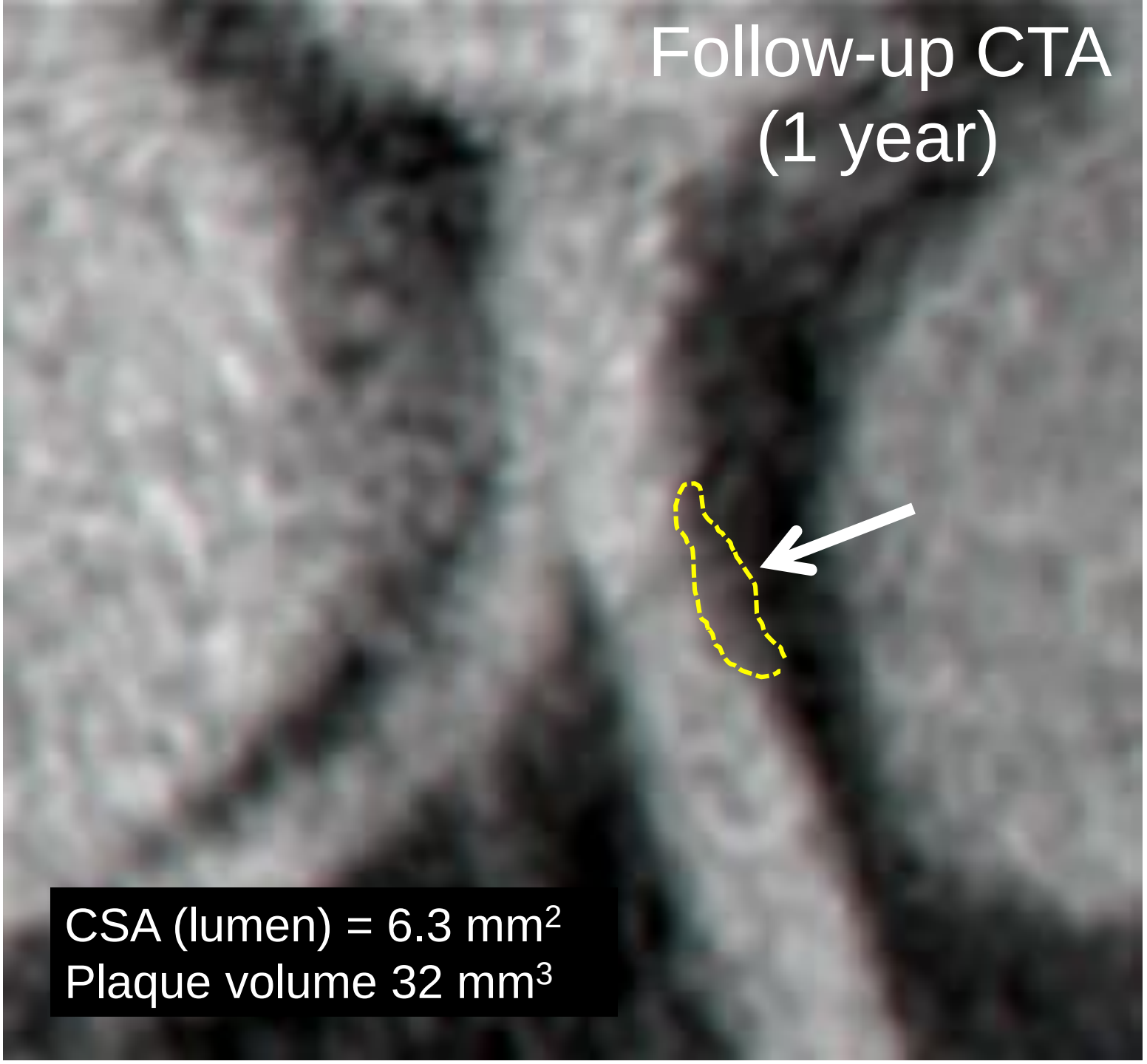
125
100
75
50
25
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
RADI VIEW
(89)
Pa mean
(83)
Pd mean
0,93
FFR
9,73
CURSOR
RESET

Decision based on FFR:

- Defer revascularization
- Administer optimal medical therapy including high-dose statin (and Aspirin)
- 1-year follow-up with 256-slice coronary CT angiography


Baseline
CTA
CSA (lumen) = 4.1 mm²
Plaque volume 59 mm³


Follow-up CTA
(1 year)
CSA (lumen) = 6.3 mm2
Plaque volume 32 mm3

Case 1 Based Conclusions

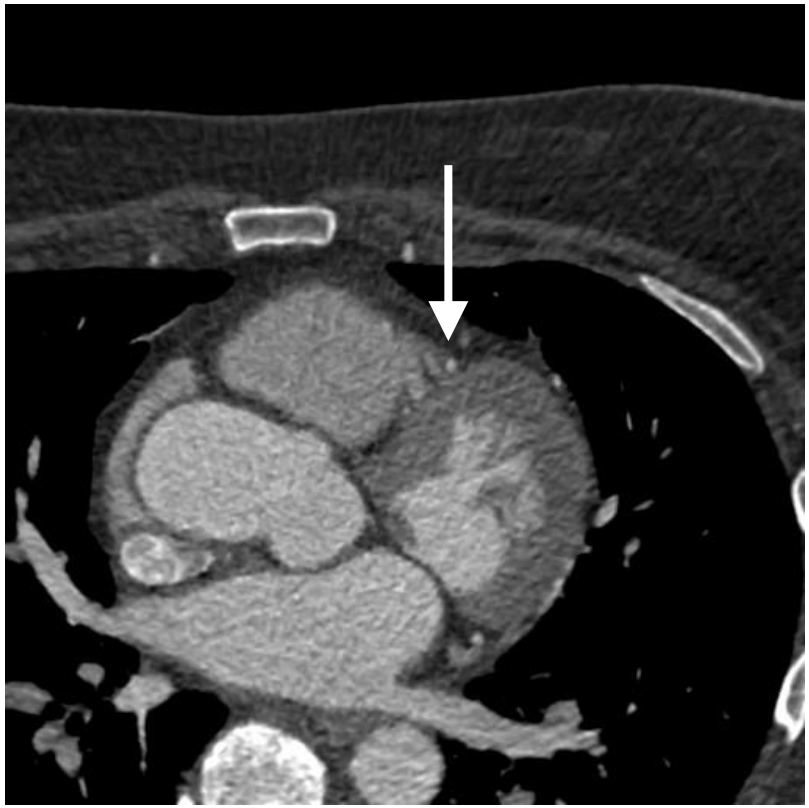
- Physiological assessment of an intermediate coronary lesion enabled deferral of an unnecessary revascularization procedure

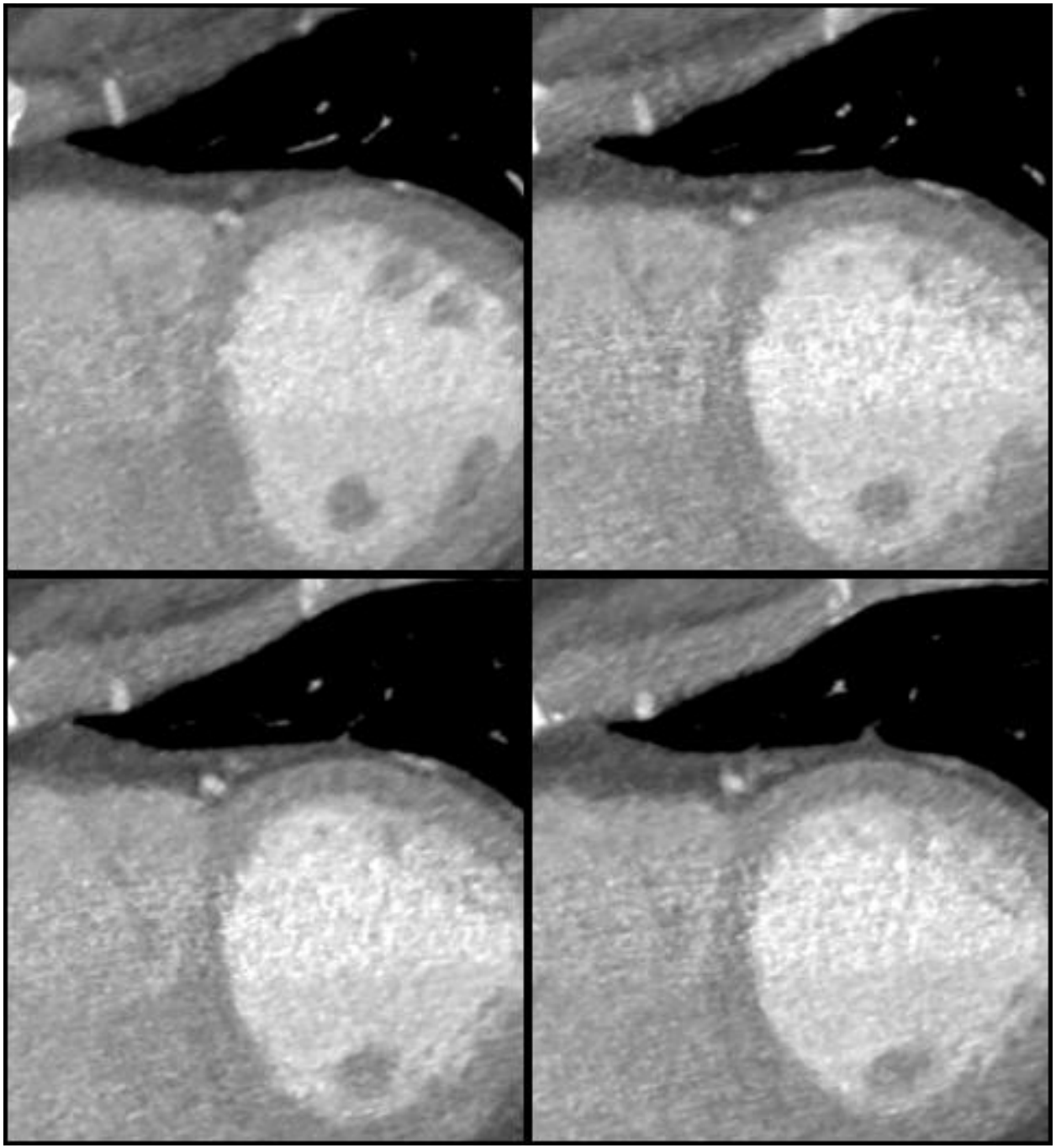
- CT angiography might be useful for diagnosis and follow-up of coronary atheroma

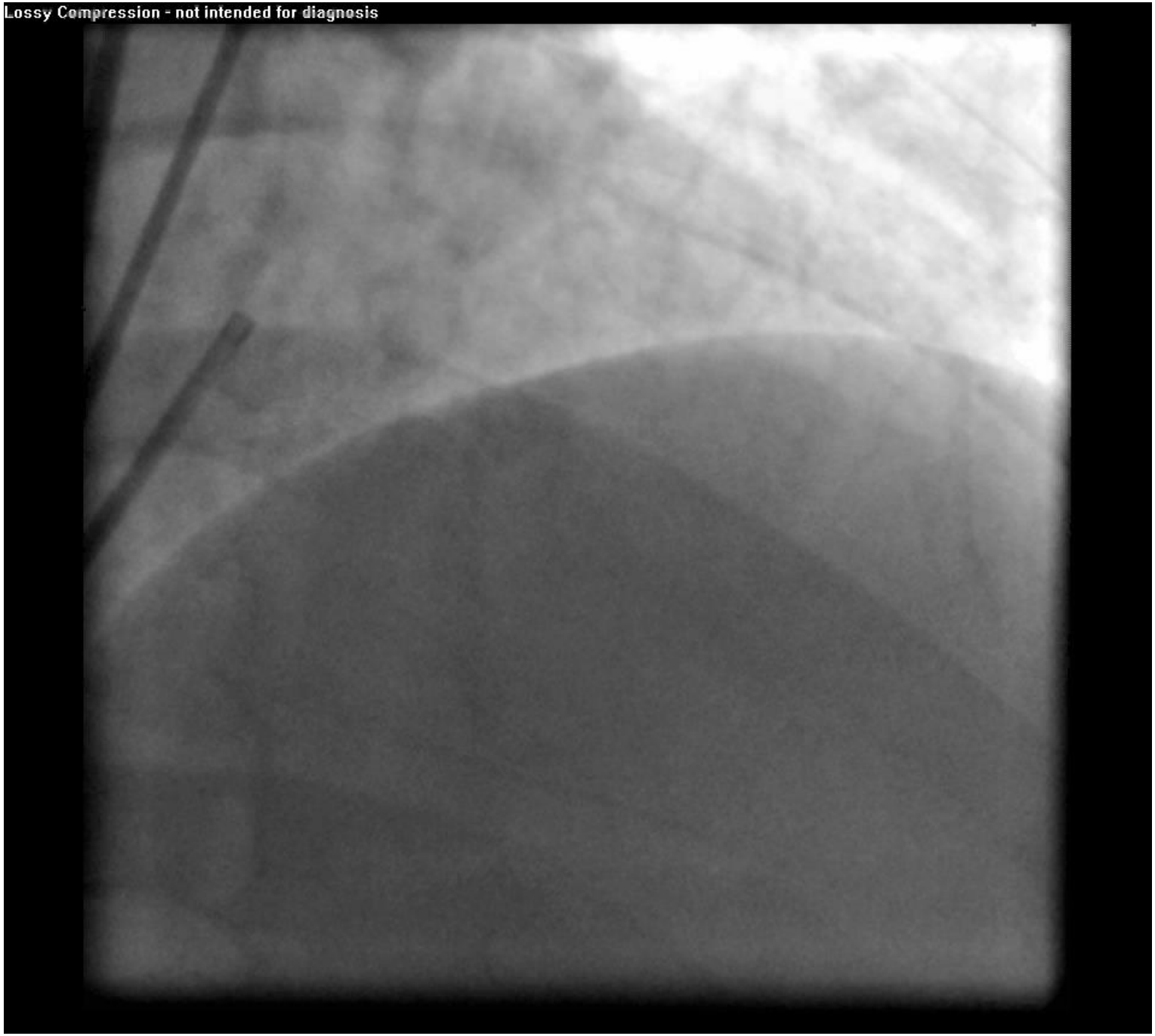
Case 2 Presentation

Recurrent episodes of typical angina

- 49 year old female
- Recurrent episodes of typical angina, referred for coronary CTA



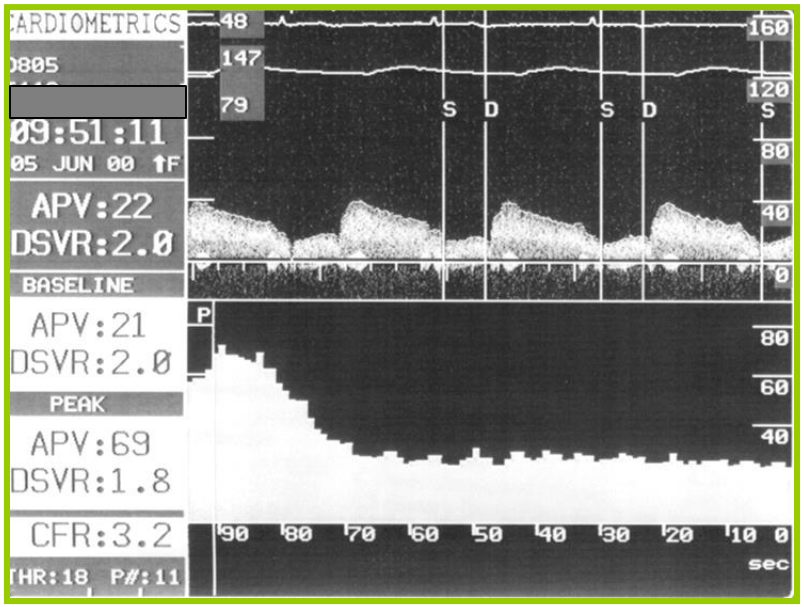



Lossy Compression - not intended for diagnosis

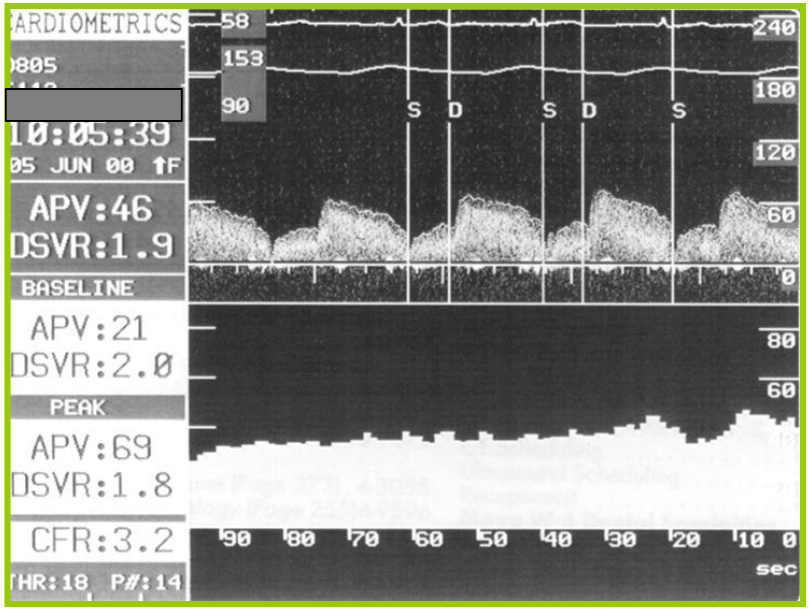
Invasive Endothelial Function Tests

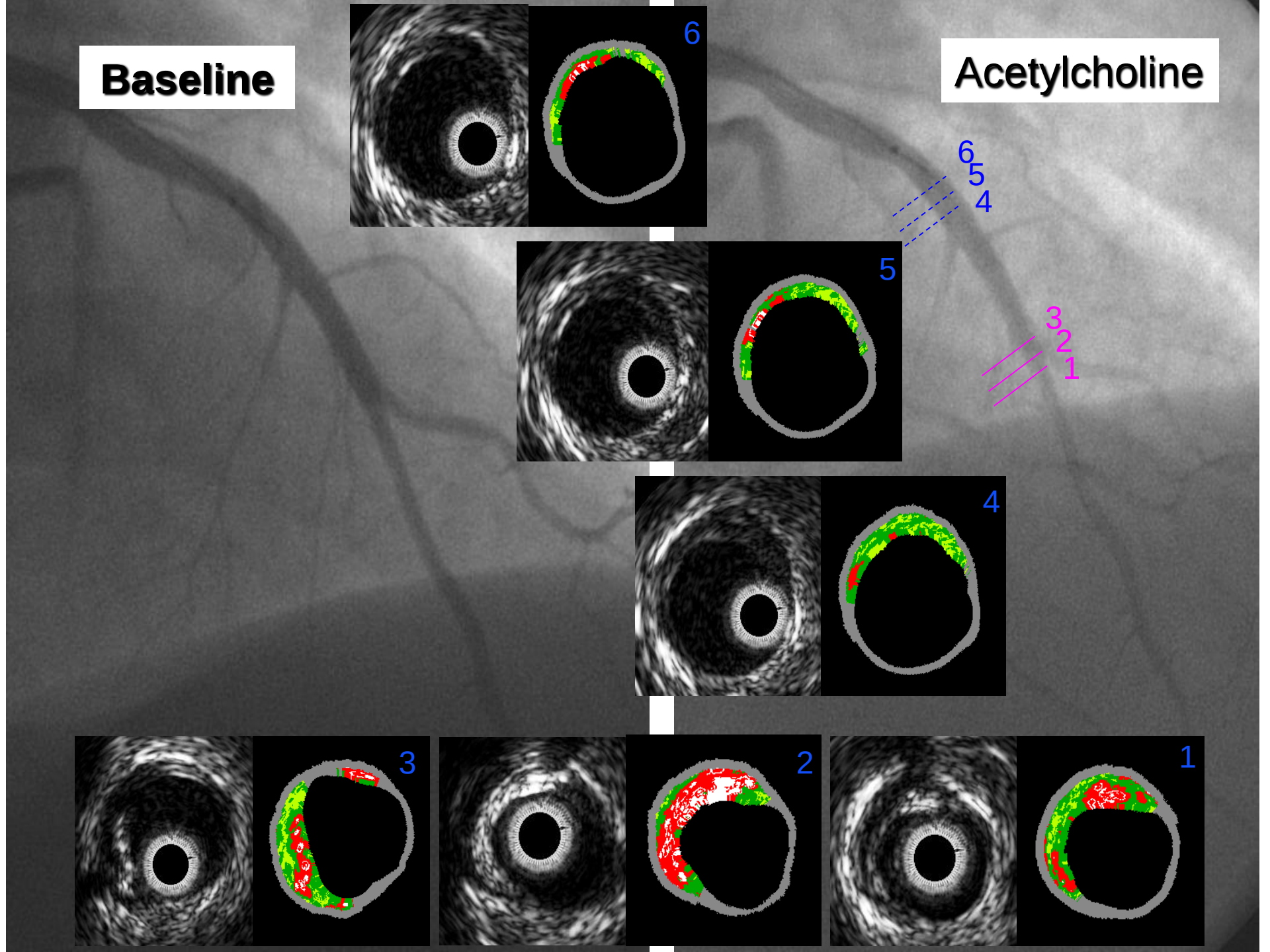
Acetylcholine test

Baseline



Acetylcholine




Baseline
Acetylcholine
6
5
4
3
2
1

Follow - Up

- Minimal atherosclerosis p/cath
- Negative Acetylcholine study p/cath
- Normal CFR p/cath
- Continue medical Tx

European Heart Journal – Cardiovascular Imaging
doi:10.1093/ehjci/jet010

Long-term prognosis and outcome in patients with a chest pain syndrome and myocardial bridging: a 64-slice coronary computed tomography angiography study

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Received 13 September 2012; revised 6 December 2012; accepted after revision 3 January 2013

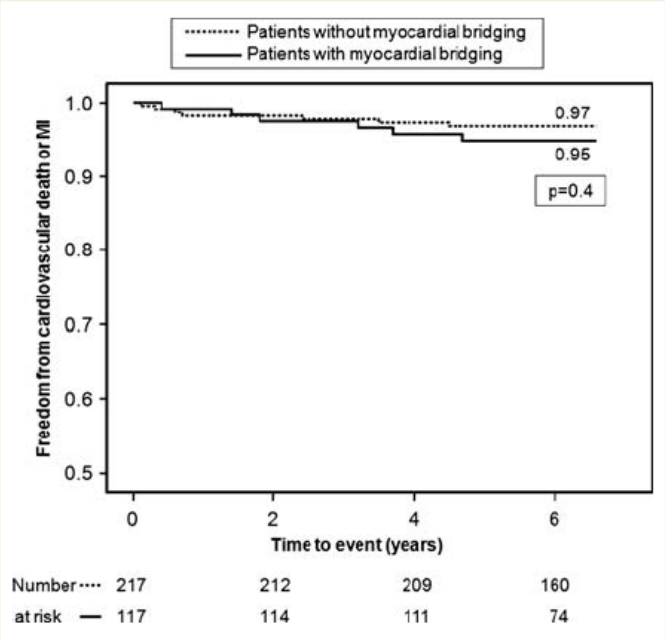


Figure 3 Survival free of CV death or non-fatal MI in relation to the presence of MB among 334 patients with chest pain but without obstructive CAD.

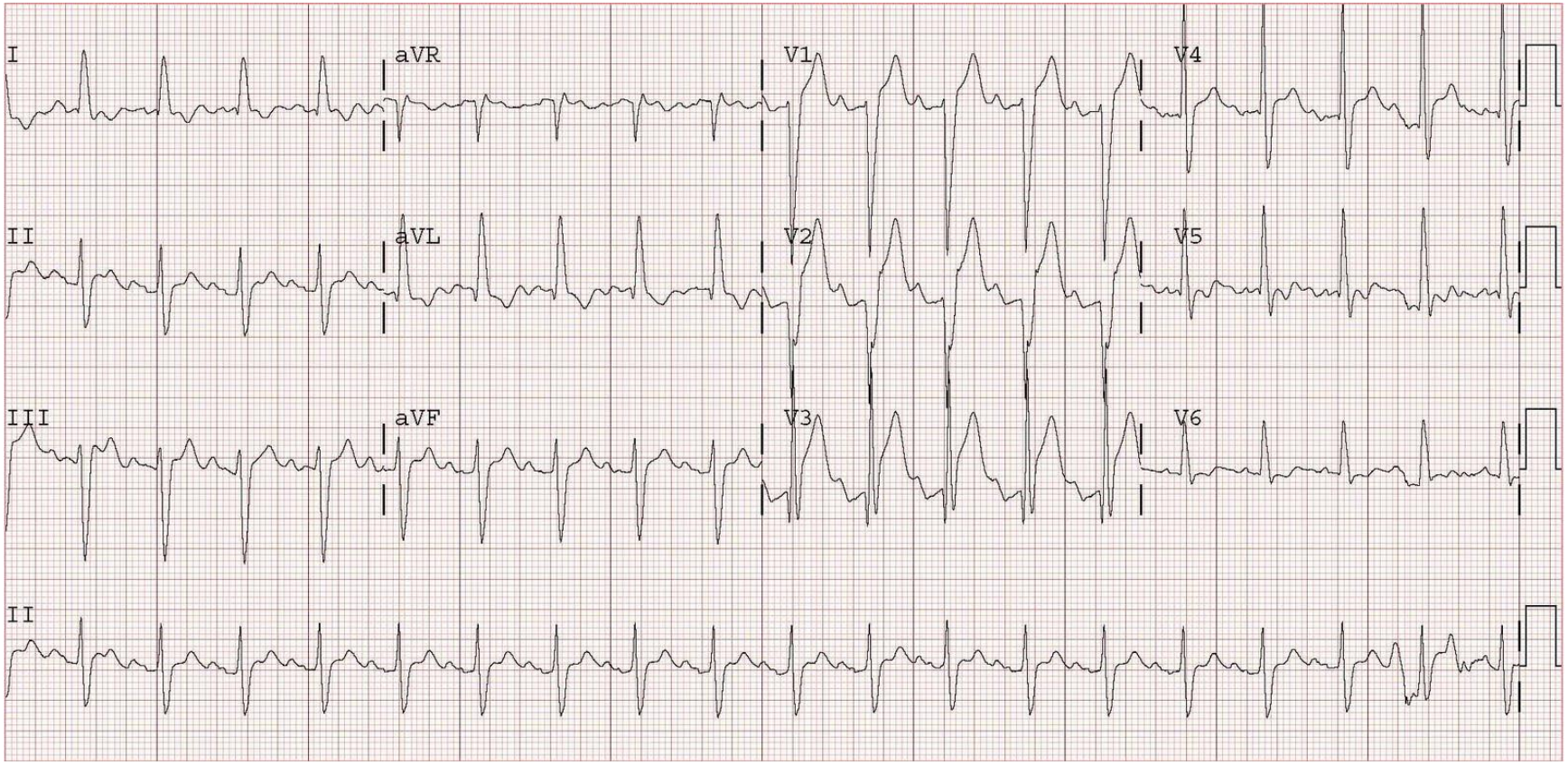
Case 2 Based Conclusions

- Myocardial bridging is a common finding on coronary CTA (35% in our series)
- Prognosis is usually excellent
- Physiologic findings do not always match morphological findings

Case 3:
New onset chest pain in a 59 y/o female

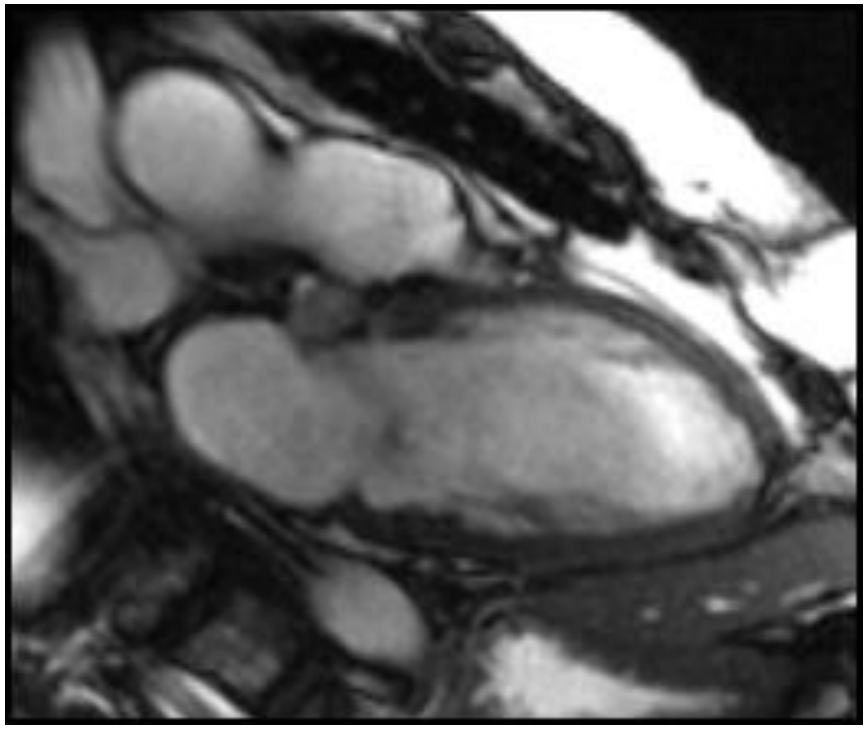
- PMH: hyperlipidemia, hypertension
- Spouse died 2 weeks earlier from CHD
- 2 hours of chest pain

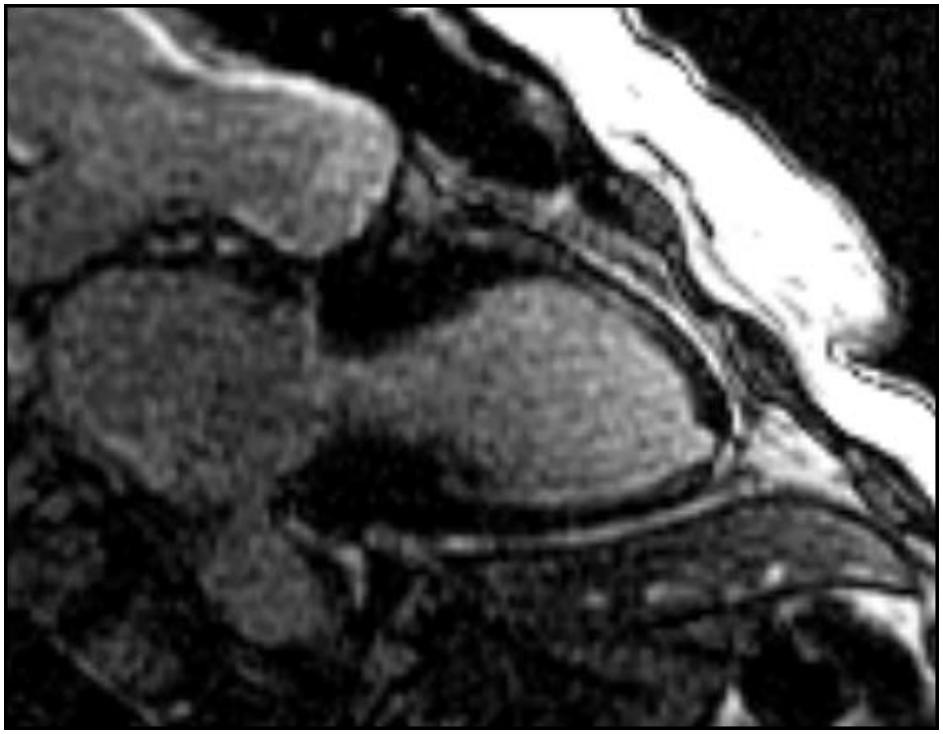
Admission ECG



Emergent cath = normal coronary arteries

Cardiac MRI



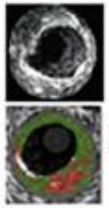
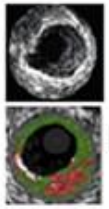
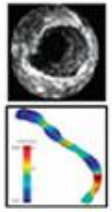


Diagnosis ? MI ?

Maybe Plaque Imaging is the way to go in the ED

- Invasive ?
- Non – invasive ?

PPV & NPV of intra-coronary imaging variables to predict clinical outcome events

Study	Modality	Lesion characteristic(s)	Clinical endpoint	Positive predictive value	Negative predictive value
PROSPECT *n*=697	 IVUS & IVUS-VH	PB ≥70% & MLA <4mm² & IVUS-VH TCHA	MACE	18%	98%
ATHEROREMO IVUS *n*=581	 IVUS & IVUS-VH	PB ≥70% & MLA <4mm² & IVUS-VH TCHA	MACE	23%	93%
PREDICTION *n*=506	 IVUS & ESS	PB ≥58% & Low ESS <1.0 Pa	PCI	41%	92%
ATHEROREMO NIRS *n*=203	 NIRS	$LCBI_{4mm}$ >43	MACE	12%	99%

Eur Heart J 2016;37

Plaque imaging is THE ultimate “crystal ball” and critical to predict cardiac events

CCTA stenosis has good diagnostic performance and excellent NPV in acute chest pain patients

Table 4. Most relevant single-centre studies evaluating the performance of cardiac CT in the triage of patients with acute chest pain

Study	Number of patients	Risk	Inclusion criteria	ACS definition (rate)	Outcome (last follow-up)	CT criteria	SE	SP	PPV	NPV
Gallagher et al[67]	85	Low risk (Reilly/ Goldman criteria)	Negative troponin; normal ECG	AMI, UA + CAG >70% (8%)	Cardiac death or ACS (30 days)	Stenosis >50% CS>400	86	92	50	99
Beigel et al[68]	340	High risk excluded	Negative troponin; non-ischaemic ECG	CAG significant stenosis (4.4%)	MACE (5 months)	Stenosis >50%	100	97	65	100
Rubinshtein et al[69]	58	Intermediate risk	Negative troponin; normal ECG	CAG ≥50% or positive troponins or positive stress test (34%)	MACE (15 months)	Stenosis ≥50%	100	92	87	100
ROMICAT I[70]	368	Low risk	Negative troponin; non-ischaemic ECG	AMI, UA (8.4%)	MACE (6 months)	Plaque	100	54	17	100
						Stenosis >50%	77	87	35	98
Johnson et al[71]	109	Any risk	Negative troponin; non-ischaemic ECG	CAG >50% (14%)	CAG (6 months)	Stenosis >50% (per segment)	100	99	79	100
Dedic et al[72]	111	Any risk	Troponine ≤0.15 $\mu g l^{-1}$	AMI, UA (17%)	AMI or revascularization (3 months)	Calcium	89	41	24	95
						Any plaque	100	40	26	100
						Stenosis>50%	89	79	47	97

ACS, acute coronary syndrome; AMI, acute myocardial infarction; CAG, invasive coronary angiography; CS, calcium score; ECG, electrocardiogram; MACE, major adverse cardiac events including cardiac deaths, acute myocardial infarction, unstable angina and revascularization; NPV, negative-predictive value; PPV, positive-predictive value; SE, sensitivity; SP, specificity; UA, unstable angina.

Maffei, Seitun, Guaricci, Cadematriti. Br J Radiol 2016;89

CCTA stenosis was the main variable evaluated in the RCTs that established CT usefulness in acute chest pain patients

Table 5. Randomized controlled trials evaluating clinical outcomes of early cardiac CT in the emergency department (ED) for the evaluation of patients with suspected acute coronary syndrome (ACS)

Trial	Sites	Risk score	Number of patients (randomization)	Randomization	LOS (h)	ED discharge	ACS rate	MACE (30 days)	MACE (6 months)	MACE (12 months)	ED Cost ($)
Goldstein et al[75]	1	Low risk	197 (1:1)	CTA *vs* SPECT	3.4 *vs* 15[a,b]	89% *vs* 97%[c]	5.1%	NA	0%	NA	1586 *vs* 1872[a] (USD)
CT-STAT[76]	16	TIMI 0–4	699 (1:1)	CT *vs* SPECT	2.9 *vs* 6.2[a,b]	73% *vs* 81%[c]	1.7%	NA	0.8% *vs* 0.4%[d]	NA	2137 *vs* 3458[a] (USD)
ACRIN-PA[77]	5	TIMI 0–2	1370 (2:1)	CTA *vs* SOC	18 *vs* 24.8[a]	50% *vs* 23%[a]	3.5%	1.1 % *vs* 1.1%	NA	NA	NA
ROMICAT II[78]	9	Low–intermediate risk	985 (1:1)	CTA *vs* SOC	23.2 *vs* 30.8[a]	47% *vs* 12%[a]	7.5%	0.4% *vs* 1.2%	NA	NA	2101 *vs* 2566[a] (USD)
CT-COMPARE[79]	1	Low–intermediate risk	562 (1:1)	CTA *vs* Ex-ECG	13.5 *vs* 20.7[a]	90% *vs* 89%	4.2%	0%	NA	0.9% *vs* 0.4%	2193 *vs* 2704[a] (AUD)

ACRIN-PA, American College of Radiology Imaging Network and Pennsylvania Department of Health; AUD, Australian dollar; CT-COMPARE, CT coronary angiography compared with exercise electrocardiography; CT-STAT, coronary CT angiography for systematic triage of patients with acute chest pain to treatment; Ex-ECG, exercise stress electrocardiography; LOS, length of stay; MACE, major adverse cardiovascular events, defined as cardiac death, myocardial infarction or unstable angina; NA, non-assessable; ROMICAT, Rule-Out Myocardial Infarction/Ischaemia Using Computer Assisted Tomography; SOC, standard of care; SPECT, single-photon emission CT; TIMI, thrombolysis in myocardial infarction; USD, United States dollar.

[a] $p<0.001$.

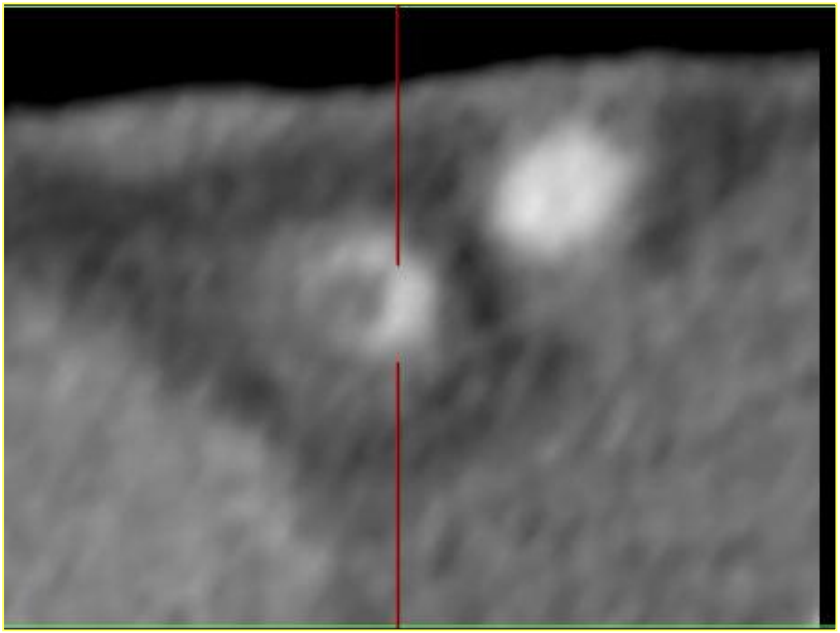
[b] Goldstein et al and CT-STAT reported time to diagnosis instead of LOS.

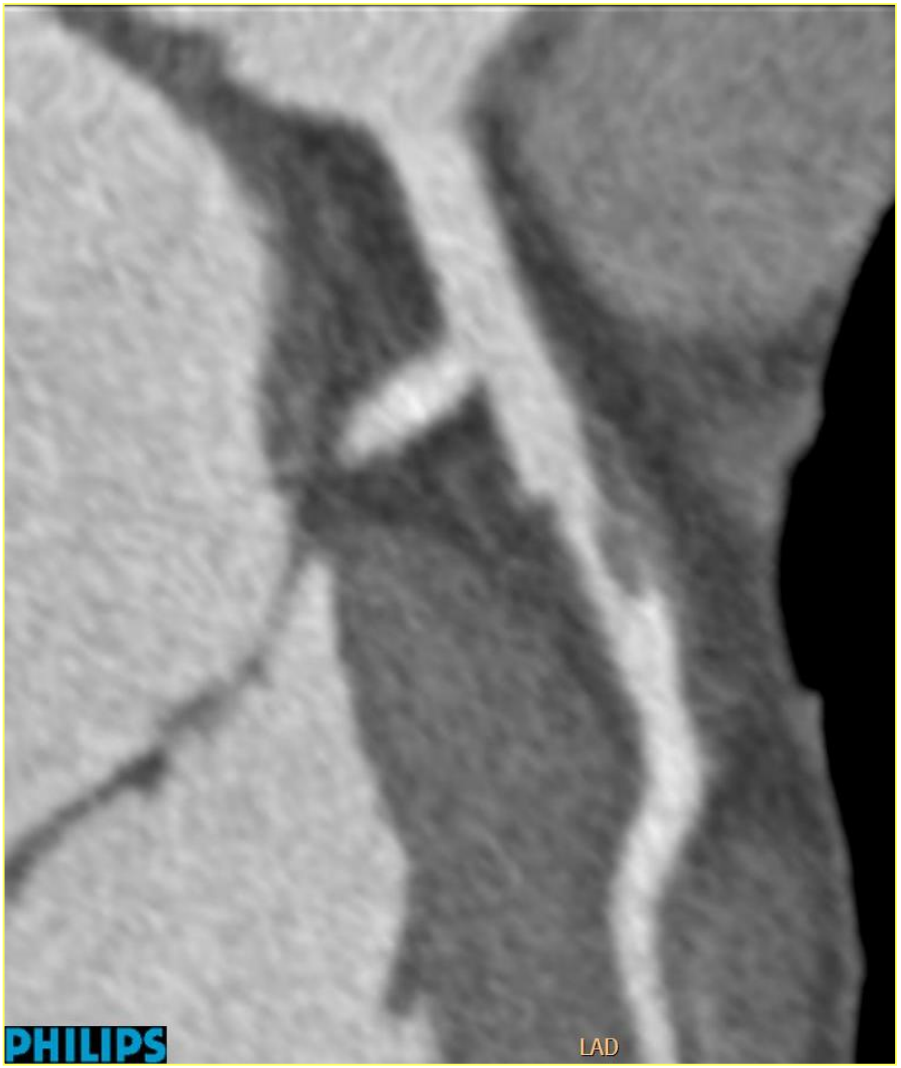
[c] $p<0.05$.

Maffei, Seitun, Guaricci, Cadematriti. Br J Radiol 2016;89

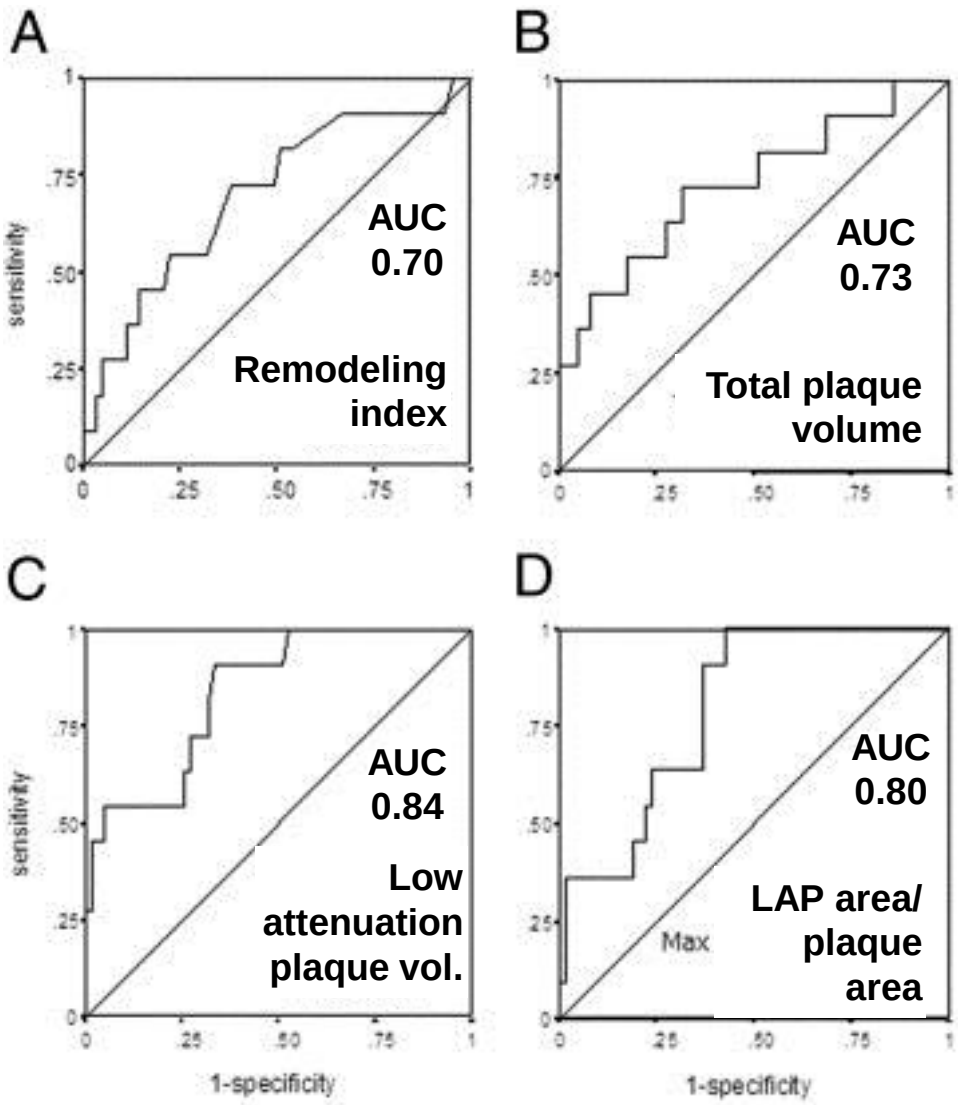
ACS – Can We Sometimes Identify the Culprit Lesion ?

- 37 y/o male,
  atypical acute chest pain.
- Ruptured plaque ?





CTA Characteristics of Atherosclerotic Plaques Subsequently Resulting in Acute Coronary Syndrome



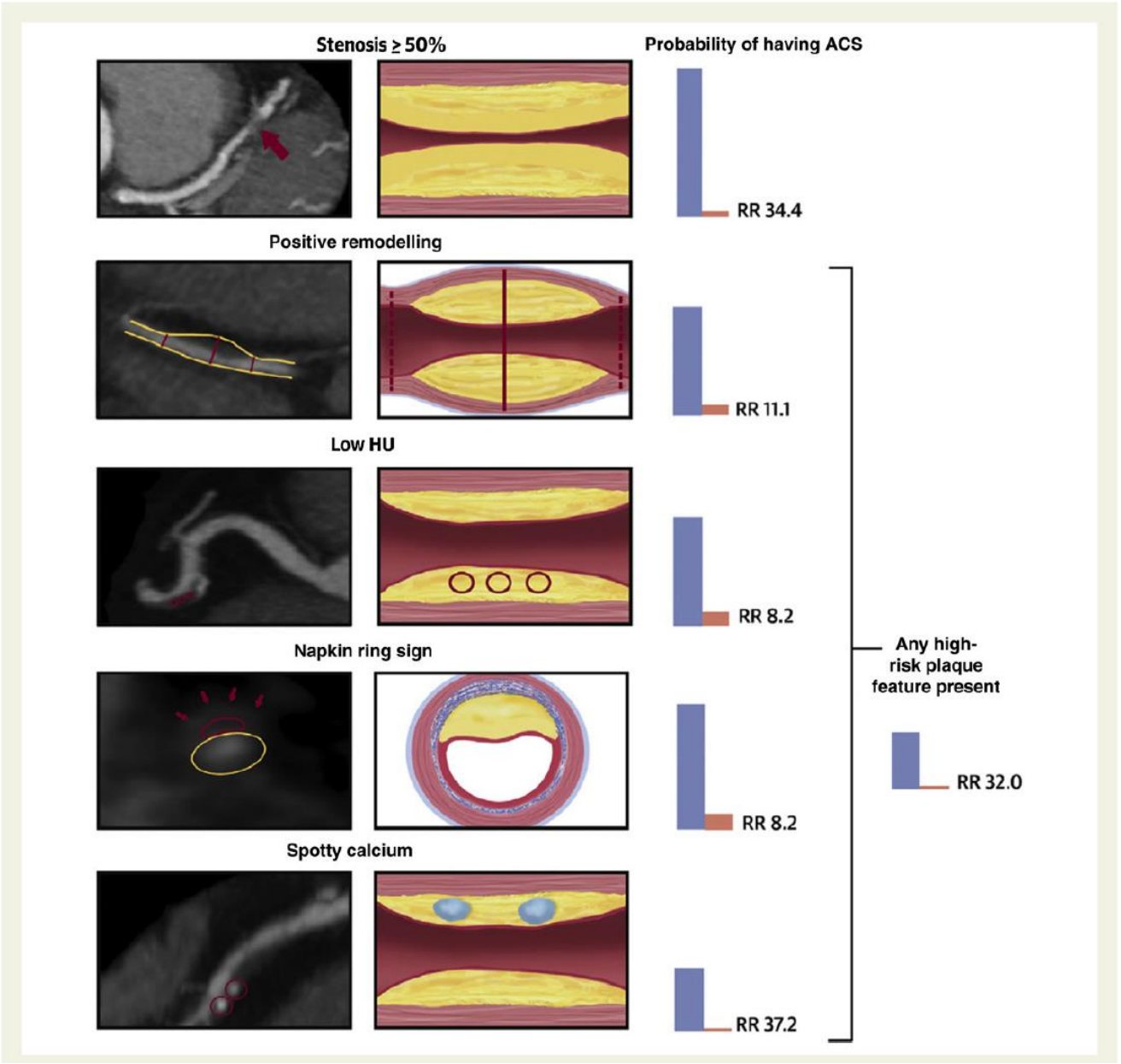
	Cutoff Value	Sens (%)	Spec (%)	PPV (%)	NPV (%)
Remodeling Index (%)	116.5	72.7	61.9	25.0	69.0
Total Plaque Volume (mm³)	63.13	72.7	68.3	28.6	93.5
LAP Volume (mm³)	0.99	90.0	66.7	32.3	97.7
Max LAP Area/ Plaque Area (%)	11.39	63.6	76.2	31.8	92.3

Low attenuation plaque volume

90%	Sensitivity
66.7%	Specificity
32.3%	PPV
97.7%	NPV

Motoyama S et al, J Am Coll Cardiol 2009;54:49–57

Stenosis and high risk plaque features in relation to ACS diagnosis (from ROMICAT 2)



Puchner et al. JACC 2014:64

ACS prevalence & MACE rate in CCTA ED studies is low (low risk patients)

Table 2 Summary of randomized, controlled, and multicentre trials comparing coronary computed tomography angiography with standard of care in patients with suspected acute coronary syndrome in the emergency department

Study	CT-STAT[40]		ACRIN[46]		ROMICAT II[51]	
Population (*n*)	699		1370		1000	
Mean age (years)	50		49		54	
Women (%)	54		53		47	
TIMI risk score	0–4		0–2		N/A	
MI during index hospitalization (%)	0.9		0.9		2.3	
Control group	Stress myocardial perfusion imaging		Standard of care		Standard of care	
Randomization	1:1		2:1		1:1	
Number of centres	16		5		9	
Conventional Tn assays and thresholds used in the study	Tn I, Bayer, thresholds not reported		Not reported		Tn T, Roche: 0.03 ng/mL Tn I, Alere: 0.40 ng/mL Tn I, Beckman: 0.07/0.04 ng/mL	
	Coronary CTA	**Controls**	**Coronary CTA**	**Controls**	**Coronary CTA**	**Controls**
ACS during index hospitalization (%)	1.2	2.7	4	2	9	6
MACE during follow-up (%)	0.8	0.4	3	1	0.4	1.2
Time to diagnosis (h)	2.9[a]	6.2[a]	–	–	–	–
Length of stay (h)	–	–	18.0[a]	24.8[a]	23.2[a]	30.8[a]
Direct ED discharges (%)	–	–	50[a]	23[a]	47[a]	12[a]
Invasive coronary angiography (%)	7	6	5	4	11	7
Coronary revascularization (%)	4	2	3	1	7	4
ED cost ($)	2137	3458	–	–	2101	2566
Radiation dose (mSv)	12	13	–	–	14[a]	5[a]

[a]Significant difference between coronary CTA and control groups ($P < 0.05$).

Puchner et al. JACC 2014;64

Halon, Rubinshtein et al Jacc Imag 2018

TABLE 3 Predictors of Culprit Plaque

	Culprit (N = 24 Subjects, 24 Plaques)	Nonculprit (N = 475 Subjects, 2,218 Plaques)	HR for Plaque Event*	
			HR*	p Value*
Entire plaque				
Plaque length, mm	18.1 (9.5-31.2)	8.3 (4.8-15.4)	7.6 (1.7-33.4)	0.007
Plaque volume, mm^3	108.5 (42.6-194.2)	44.6 (23.2-94.3)	6.9 (1.6-30.8)	0.011
Plaque burden, %†	57.3 (47.1-64.3)	48.7 (37.2-60.7)	3.4 (0.91-12.4)	0.068
Min lumen area, mm^2	1.8 (1.4-3.0)	2.9 (1.5-5.3)	0.24 (0.05-1.2)	0.079
Distance from aorta, mm‡	23.6 (13.5-46.5)	26.6 (13.3-46.8)	0.27 (0.08-0.95)	0.042
Mean plaque density, HU	184.7 (134.5-313.1)	289 (206-371)	0.31 (0.10-0.94)	0.037
Plaque <30 HU, mm^3	11.2 (3.4-23.5)	2.0 (0.66-5.7)	7.3 (1.7-32.3)	0.009
Plaque <30 HU, %	9.0 (4.1-17.5)	4.4 (2.1-8.1)	14.3 (1.9-109)	0.010
Plaque <50 HU, mm^3	16.0 (4.8-35.7)	3.2 (1.2-8.9)	7.3 (1.7-32.2)	0.010
Plaque <50 HU, %	13.6 (8.3-25.7)	6.9 (3.7-12.5)	14.2 (1.9-108)	0.010
Low density plaque, ≤50 HU ≥10% of total plaque	15 (62.5)	735 (33.1)	3.4 (1.5-7.7)	0.004
Low density plaque, ≤50 HU ≥20% of total plaque	8 (33.3)	258 (11.6)	3.9 (1.6-9.0)	0.002
Plaque <150 HU, mm^3	47.5 (21.3-102.6)	13.2 (5.7-30.4)	7.9 (1.8-34.8)	0.006
Plaque <150 HU, %	50.4 (29.1-63.3)	28.2 (18.6-43.4)	14.2 (1.9-107)	0.010
Mild plaque calcification <50%§	12 (50.0)	514 (23.2)	3.3 (1.5-7.2)	0.003
Plaque-artery relations				
Stenosis ≥50%§	11 (45.8)	330 (14.9)	5.3 (2.4-11.7)	<0.0001
Plaque facing myocardium‖	18 (75.0)	930 (41.9)	2.2 (0.89-5.7)	.090
Plaque facing pericardium‖	18 (75.0)	1137 (51.3)	2.9 (1.2-7.5)	0.023
Plaque facing myocardium and pericardium	12 (50)	583 (26.3)	3.0 (1.3-6.7)	0.008
Plaque includes inner curve of artery¶	22 (91.7)	1645 (75.4)	3.5 (0.83-15.1)	0.088
Plaque includes outer curve of artery¶	14 (58.3)	1197 (54.8)	1.2 (0.55-2.8)	0.606
plaque includes both inner and outer curves¶	12 (50)	721 (33.0)	2.2 (0.96-4.8)	0.063
True bifurcation (vs. all other plaques)#	12 (50)	473 (21.3)	3.8 (1.7-8.5)	0.001
Maximal plaque X-section				
Plaque area, mm^2	9.7 (6.2-15.5)	8.1 (5.7-11.8)	1.8 (0.52-6.1)	0.363
Plaque burden, %†	73.4 (60.3-83.0)	65.8 (50.8-79.4)	9.2 (1.2-72.9)	0.035
Lumen area at maximal plaque, mm^2	3.0 (2.2-5.2)	3.8 (2.1-6.4)	0.18 (0.02-1.5)	0.113
Distance from aorta, mm	29.8 (25.9-49.6)	32.6 (19.3-51.6)	0.56 (0.07-2.3)	0.401
Mean plaque density, HU	219 (132-387)	330 (213-433)	0.42 (0.15-1.2)	0.098
Plaque <30 HU, mm^3**	0.35 (0.07-0.89)	0.13, (0.04-0.32)	3.0 (0.98-9.5)	0.055
Plaque <30 HU, %	10.5 (1.9-19.7)	3.9 (1.4-9.0)	2.2 (0.82-5.7)	0.119
Plaque <50 HU, mm^3	0.51 (0.10-1.3)	0.21 (0.08-0.50)	4.1 (1.2-14.4)	0.028
Plaque <50 HU, %	15.4 (3.9-28.7)	6.3 (2.6-13.3)	3.3 (1.1-10.0)	0.038
Plaque <150, mm^3	1.4 (0.58-3.3)	0.80 (0.43-1.6)	3.4 (0.94-12.5)	0.062
Plaque <150 HU, %	43.1 (14.8-64.1)	24.2 (14.5-41.0)	2.0 (0.75-5.3)	0.162
Plaque circumferential extent	300 (30-360)	210 (180-300)	8.1 (1.1-61.0)	0.043
Plaque eccentricity††	0.87 (0.73-0.91)	0.90 (0.86-0.93)	0.26 (0.07-0.93)	0.038
Arterial remodeling‖‖	1.7 (1.3-2.2)	1.5 (1.2-1.8)	2.6 (0.82-8.5)	0.104

Values are median (IQR) or n (%). *For continuous variables, HRs and p values are for upper versus lower quartiles. †Calculated as percentage plaque volume/total arterial volume along length of plaque. ‡Measured to proximal border of plaque. §Visual analysis. ‖At least part of plaque facing myocardium or pericardium, respectively. ¶Not assessed for 6 nonculprit plaques in straight portion of artery. Percentages are of plaques assessed. #Medina type 3 (plaque proximal, directly opposite, and distal to side branch) versus all others. **The cross section has a patient-specific slice thickness providing a volume rather than cross-sectional area of plaque. ††Calculated as 1 - (minimal plaque thickness/maximal plaque thickness). ‖‖Cross-sectional area of artery at maximal plaque area/proximal arterial reference area.

HR = hazard ratio; HU = Hounsfield units.

Advanced Plaque Characteristics

- Positive remodeling
- Spotty calcifications
- Low attenuation plaque (<30 HU)
- “Napkin ring” sign
- Plaque volume

Incremental prognostic value of plaque components beyond CAC in patients with acute chest pain (Nance et al, Radiology 2012;264) (N=458, 2 years F/U)

Figure 2

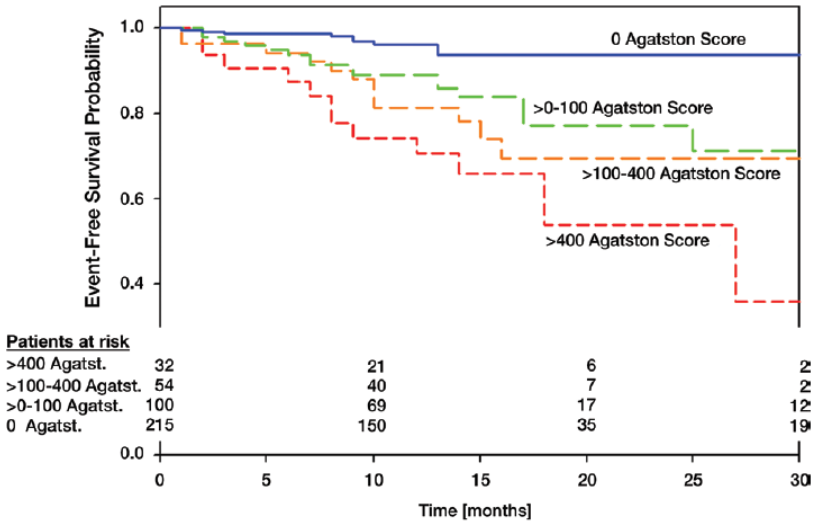
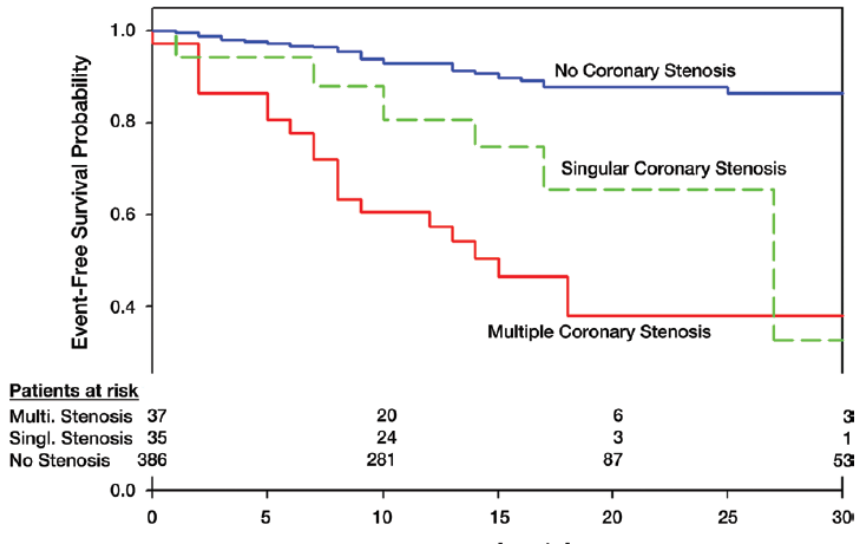
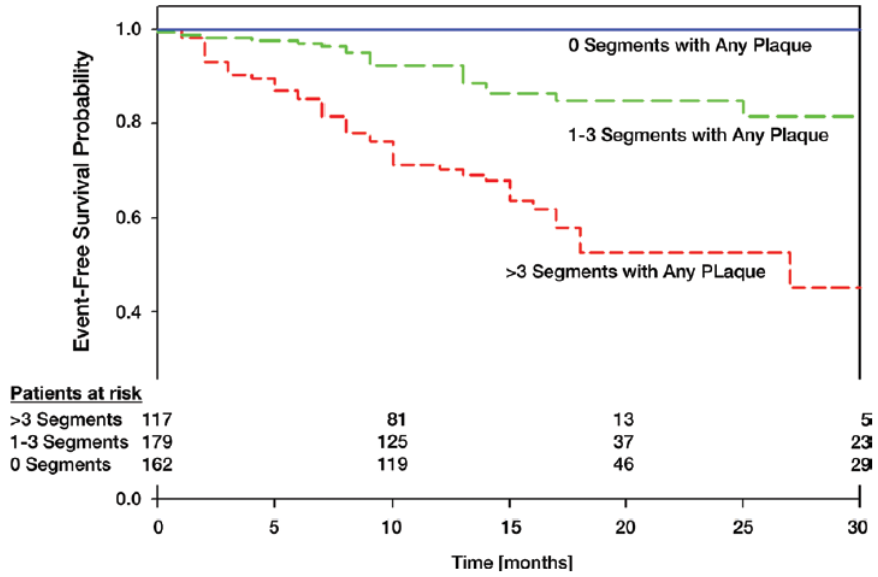


Figure 4





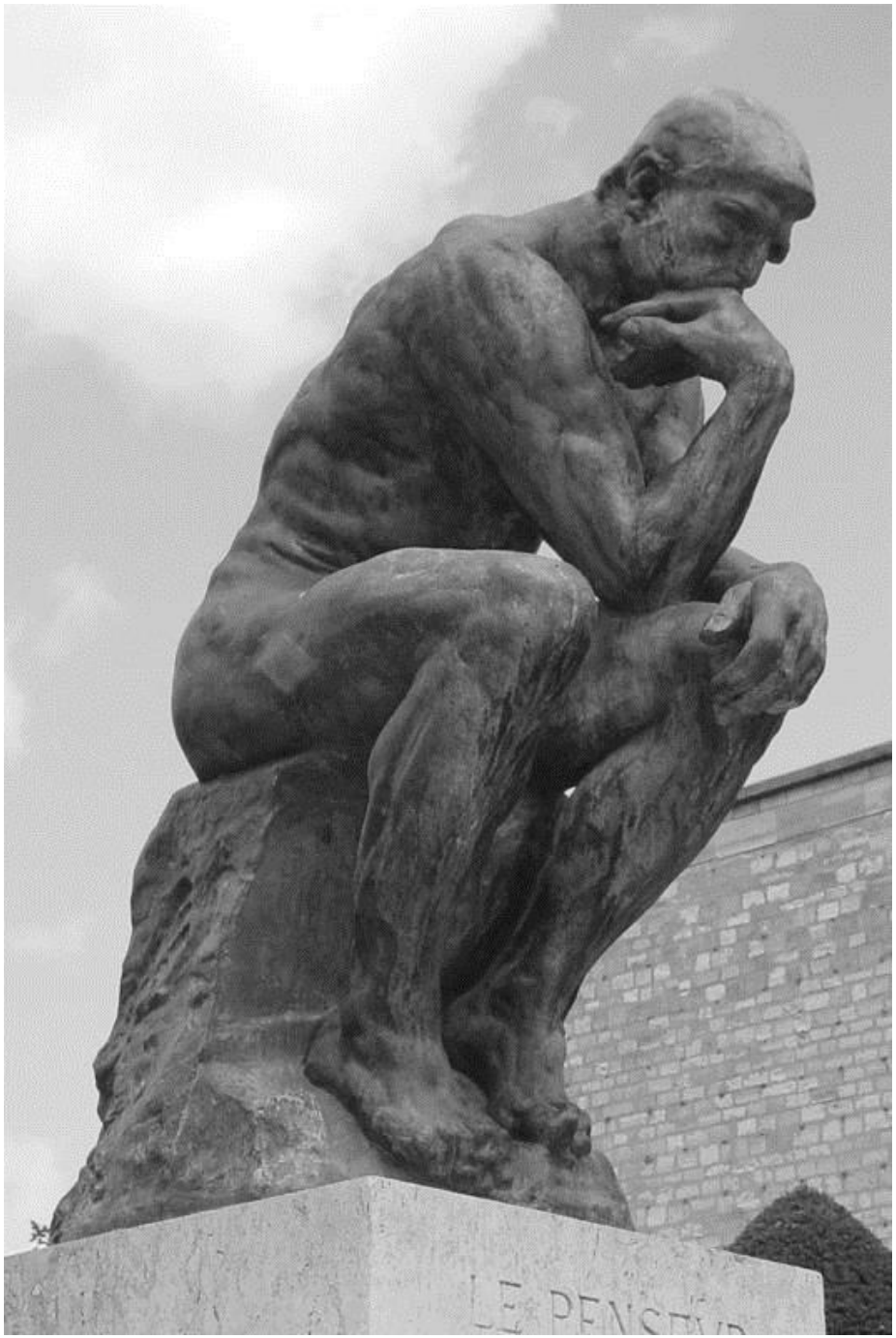
Non obstructive CAD ≠ 12 months MACE in 1000 ED patients

Prognostic Implications of Nonobstructive Coronary Artery Disease in Patients Undergoing Coronary Computed Tomographic Angiography for Acute Chest Pain

Roy Beigel, MD[a,b], Sella Brosh, MD[a], Orly Goitein, MD[b,c], Einat Guttman, BSc[b], Ilia Novikov, PhD[d], Amit Segev, MD[a,b], Yariv Gerber, PhD[b], Dan Oieru, MD[a], Eli Konen, MD[b,c], Hanoch Hod, MD[a,b], and Shlomi Matetzky, MD[a,b,*]

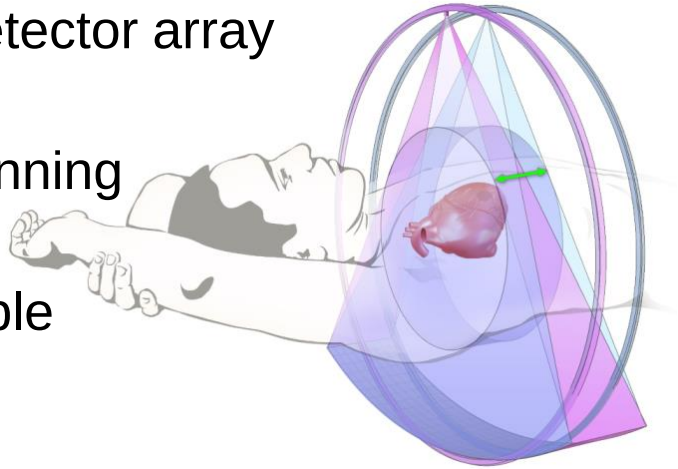
Coronary computed tomographic angiography can detect nonobstructive atherosclerotic lesions that would not otherwise have been detected with functional cardiac imaging. Currently, limited data exist regarding the clinical significance of these lesions in patients with acute chest pain. The aim of our study was to examine the prognostic significance of these nonobstructive findings in a patient population presenting with acute chest pain. We evaluated 959 consecutive patients who underwent coronary computed tomographic angiography for investigation of acute chest pain. The patients were classified as having normal (n = 545), nonobstructive coronary artery disease (CAD; defined as any narrowing <50% diameter stenosis; n = 312), or obstructive CAD (narrowing of ≥50% diameter stenosis; n = 65). Follow-up data for a minimum of 12 months (mean 27 ± 11) was obtained for any major adverse coronary events consisting of death, nonfatal acute coronary syndrome, and coronary revascularization. Compared to patients with normal coronary arteries, those with nonobstructive CAD were older and had a greater prevalence of CAD risk factors. The incidence of major adverse coronary events was equally low among both these groups (0.6% vs 1.3%, for the normal and nonobstructive groups, respectively, p = 0.2). In conclusion, patients with either nonobstructive CAD or normal findings, as evaluated by coronary computed tomographic angiography, for acute chest pain during an intermediate-term follow-up period had equally benign clinical outcomes. (Am J Cardiol 2013;111:941–945)

Is CT based plaque analysis critical in acute chest pain?

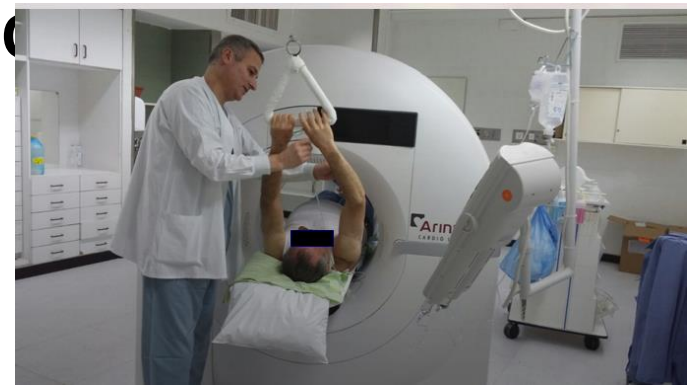


Arineta
“Stereo CT” technology

- Two overlapping cone beams facing a single detector array rotate around the patient
- Coverage (14 cm) sufficient for whole heart scanning in a single beat (acquisition time of 120 ms)
- Fastest CT gantry rotation time currently available (0.24 second)
- Small size, compatible with small rooms
- Designed for optimal spatial & temporal resolution at a lower cost



Compact, cardiac – oriented CT installed in the



Case 1: Using the Latest Version of the Arineta Scanner (GE Cardiograph)

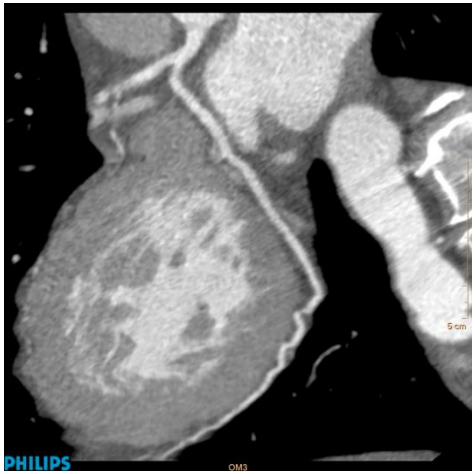
- 50 y/o female with new onset typical effort angina, negative stress test
- PMH:
  - Psoriatic Arthritis (Steroid and Biologic therapies)
  - Smoker
  - Obese (162 cm, 100 Kg)
  - Normal ECG

G.E Cardiograph, CCTA Scan 14/1/2018

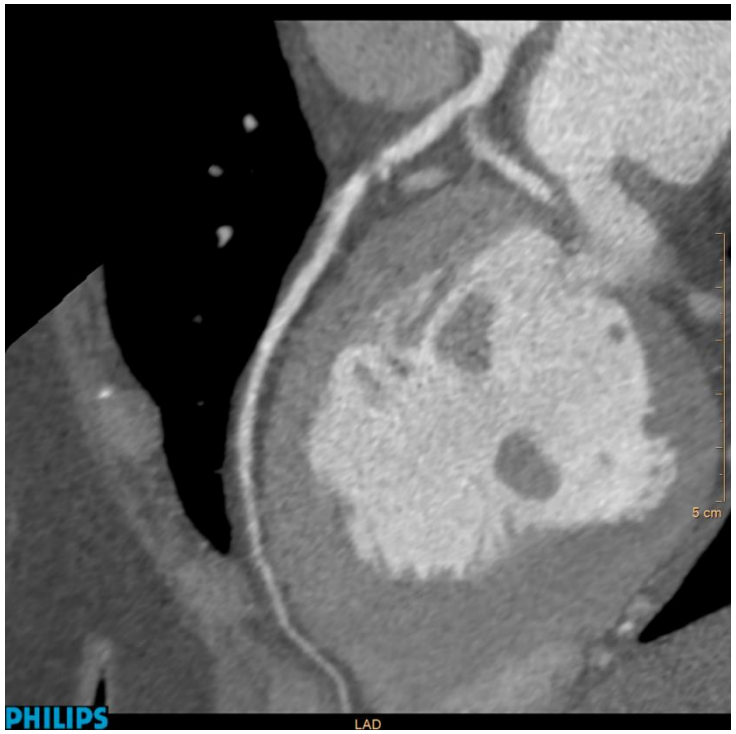
85 cc Omnipaque, HR=72 bpm

120 kV, 550 mAs, ASIR-cv 70

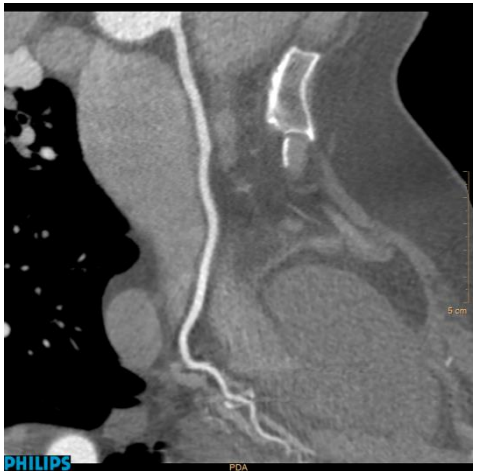
DLP = 387 mGy*cm



LCX



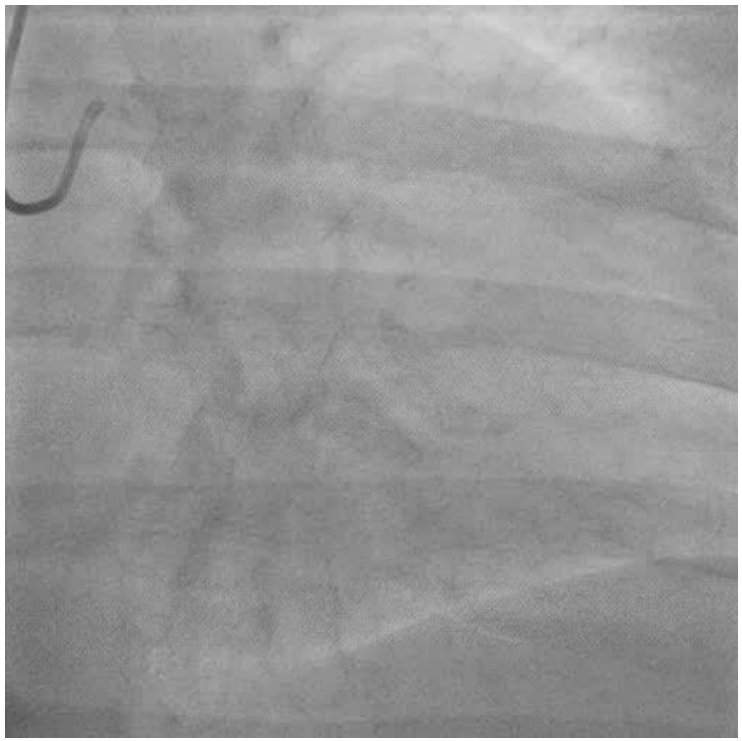
LAD

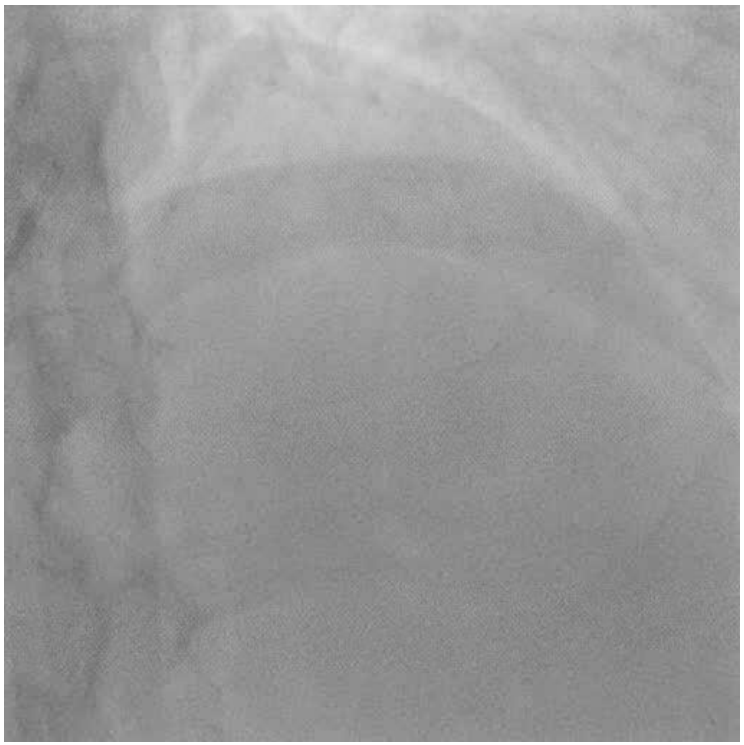


RCA

Cath

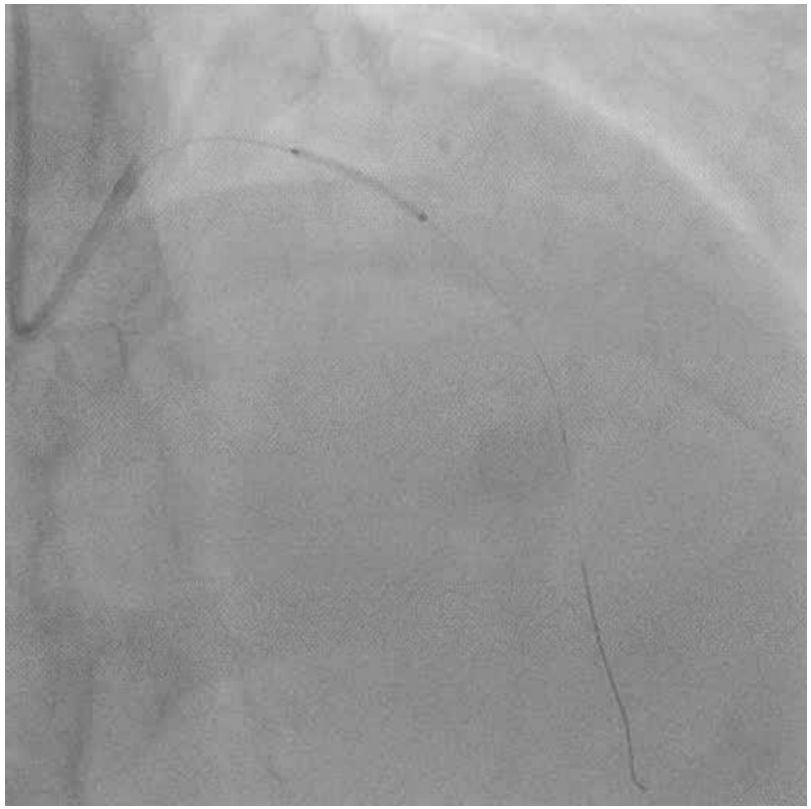
16/1/2018

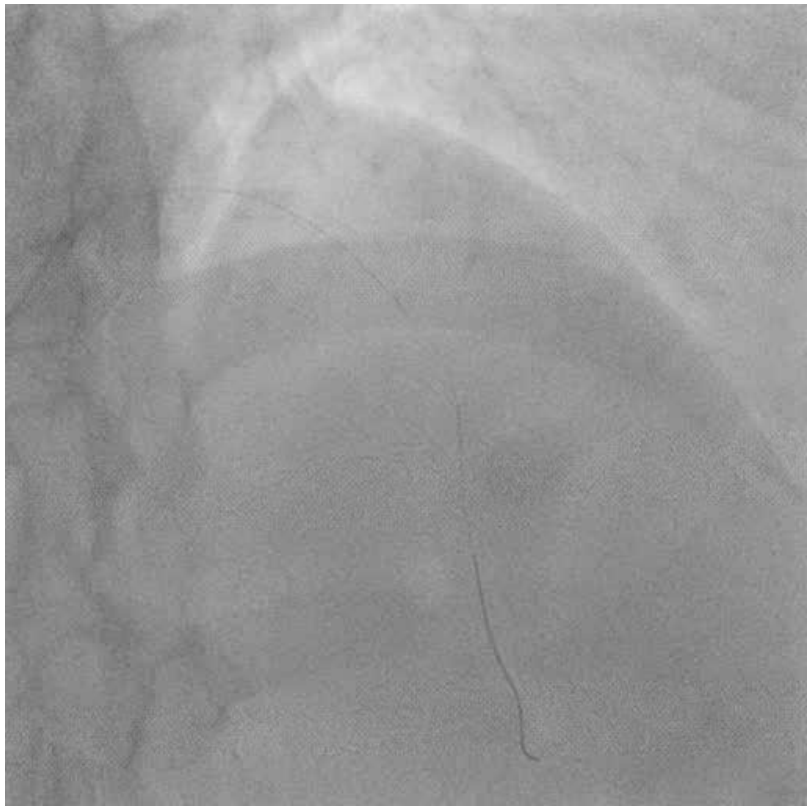




PCI

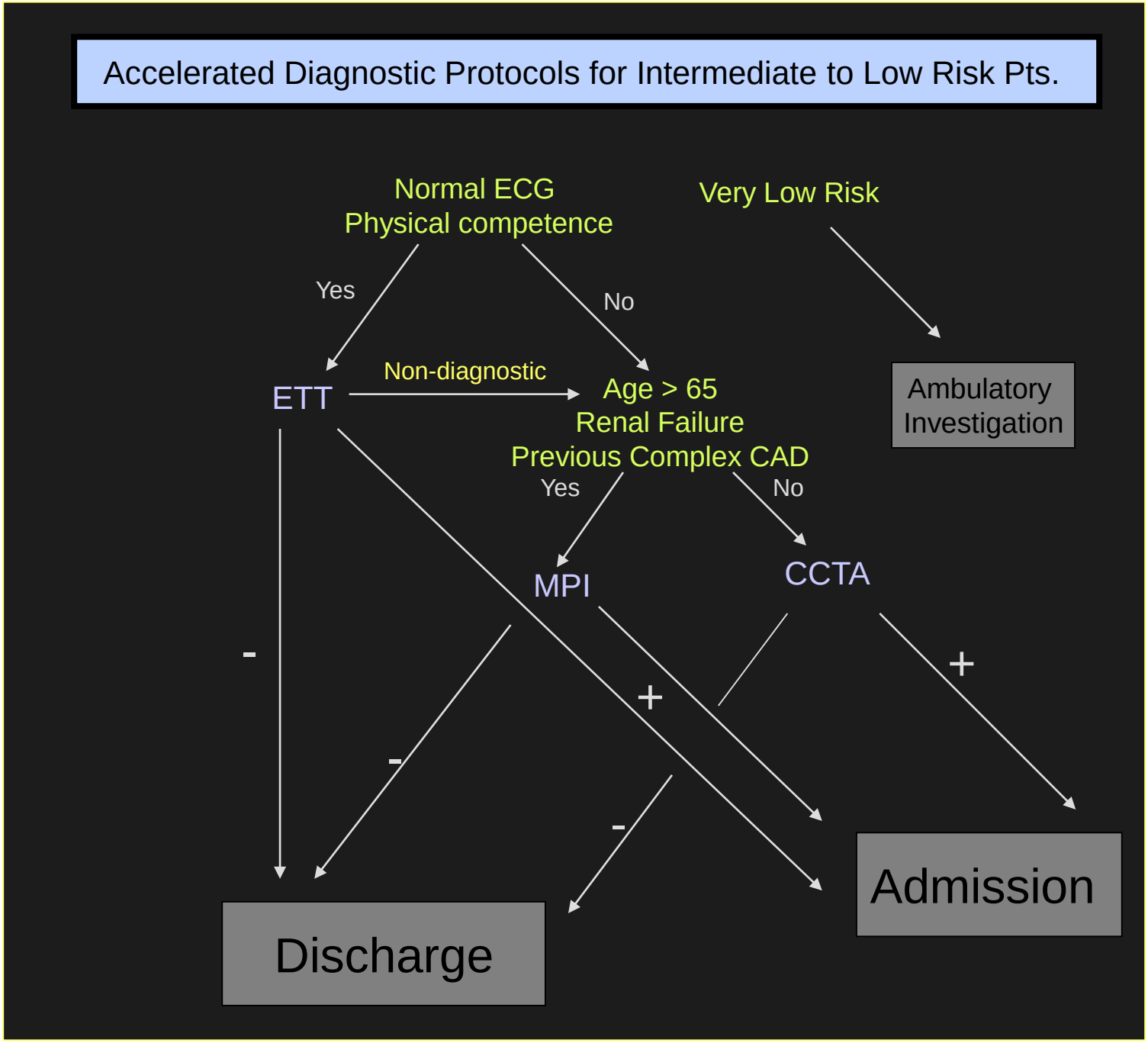
16/1/2018





Multimodality imaging of patients with chest pain of possible ischemic originacute

- ECG / Clinical syndrome / hs Troponin
- Choose a modality that is likely to make a diagnosis (CT can be the “gate keeper”)
- Remember the association (or lack of) between coronary anatomy and physiology


Accelerated Diagnostic Protocols for Intermediate to Low Risk Pts.
Normal ECG
Physical competence
Very Low Risk
Yes
No
ETT
Non-diagnostic
Age > 65
Renal Failure
Previous Complex CAD
Ambulatory Investigation
Yes
No
MPI
CCTA
-
+
-
+
-
Discharge
Admission

Summary of Non-Invasive Imaging in Chest Pain

- Acute chest pain: exercise ECG, coronary CTA, SPECT
- Stable CAD: exercise ECG, SPECT, stress Echo, coronary CTA
- Post revascularization: SPECT, early catheterization
- Unclear diagnosis: MRI

Thank-you