Turin, October 20-22, 2011

Advances in cardiovascular arrythmias and great innovations in Cardiology

3 Dimensional Left Main Reconstruction

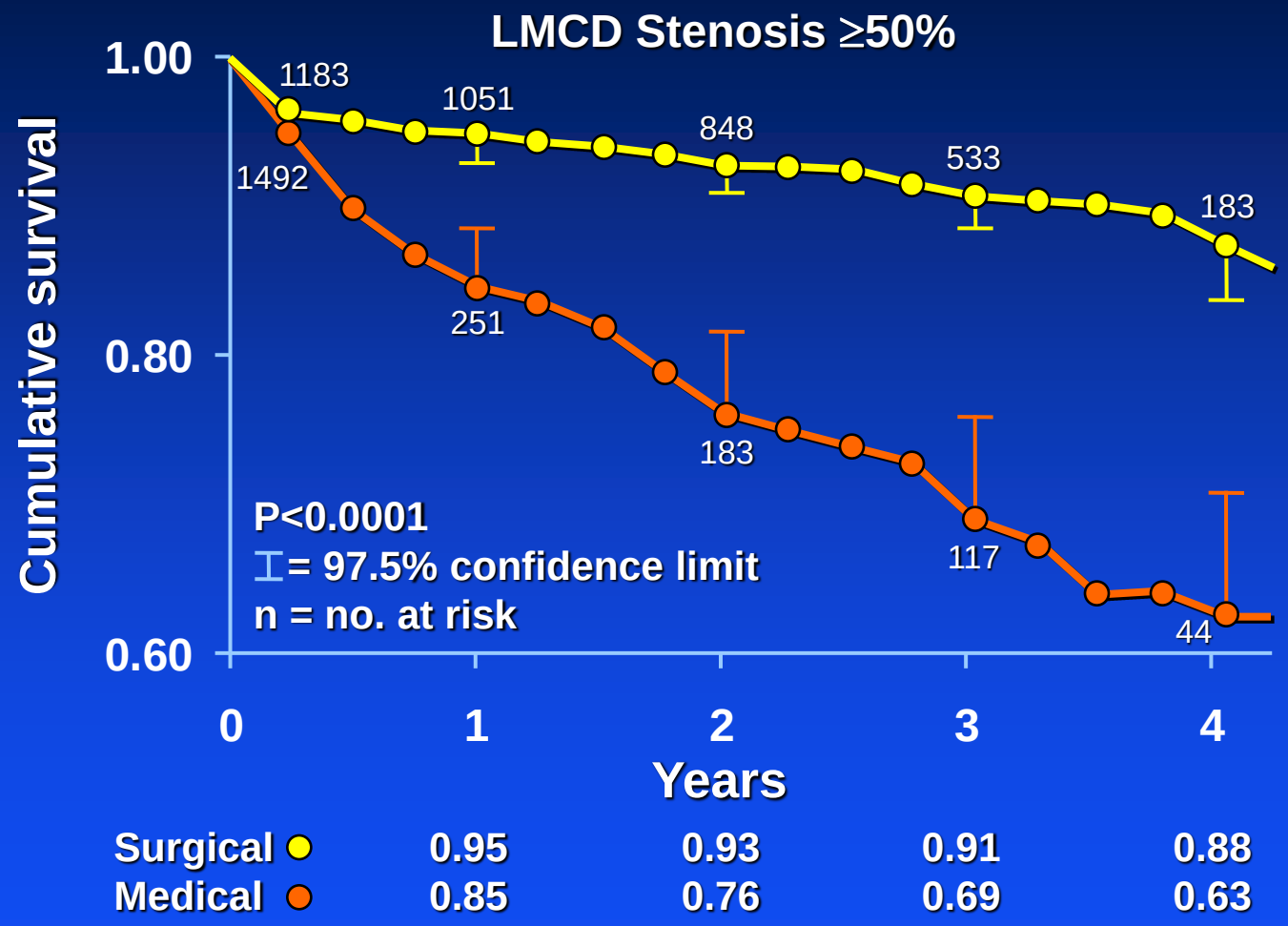
Federico Conrotto

Left Main Coronary Artery Disease Overview

- Significant, defined as greater 50% narrowing
- Found in 5-6% in patients undergoing coronary angiography
- Over 70% of the time, it is associated with MVD
- Most patients are symptomatic and at high risk
- Poor prognosis without revascularization

CASS Trial: Left Main Subset

Cumulative Survival: Actuarial Method



Chaitman BR: Am J Cardiology, 1981

CABG vs PCI: Clinical Studies

- CABG VS PTCA
  - RITA
  - ERACI
  - LAUSANNE
  - GABI
  - EAST
  - CABRI
  - BARI

- CABG VS Stents
  - ISAR
  - LE MANS
  - MAIN COMPARE
  - SYNTAX
  - PRECOMBAT

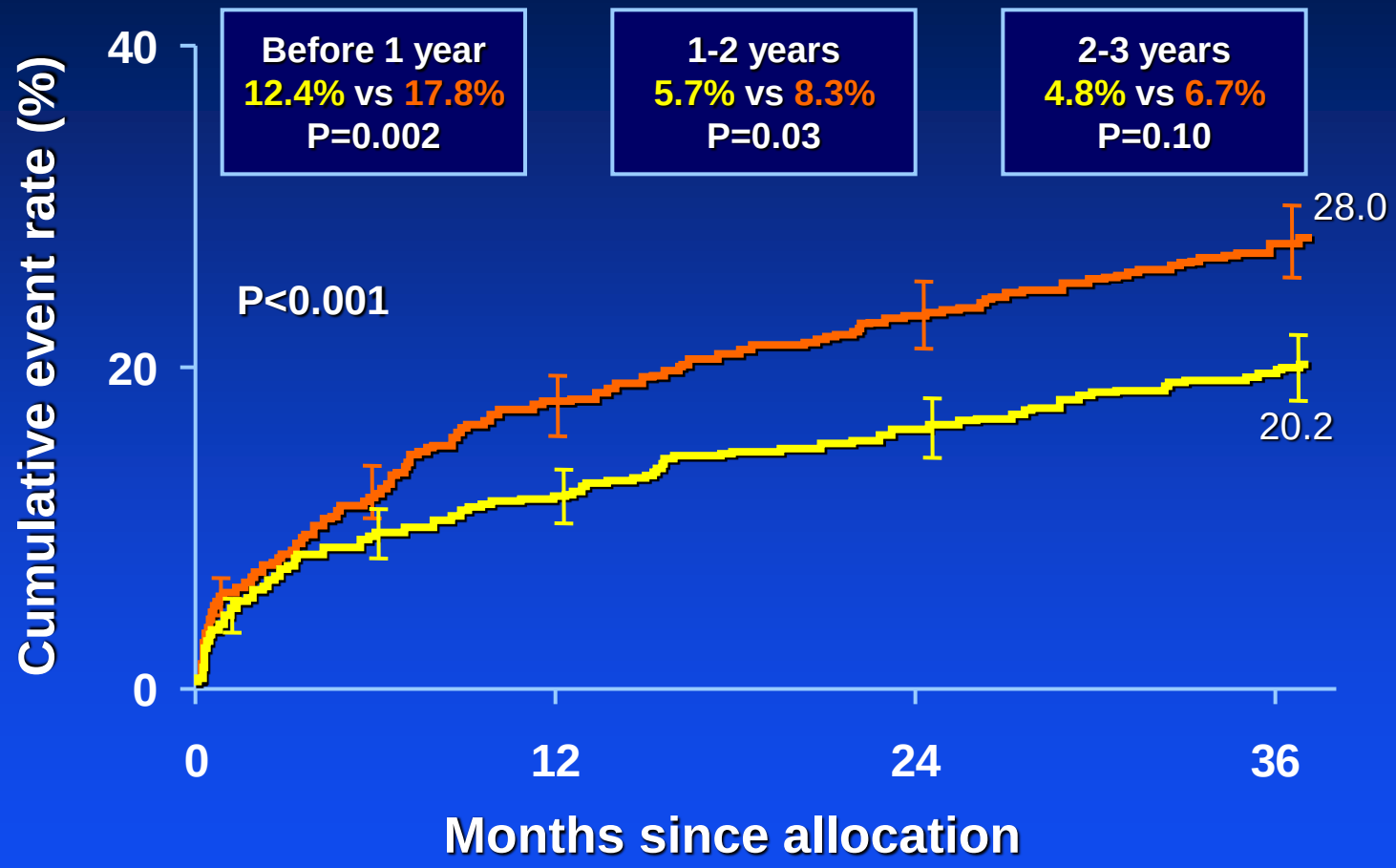
The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 MARCH 5, 2009 VOL. 360 NO. 10

Percutaneous Coronary Intervention versus Coronary-Artery Bypass Grafting for Severe Coronary Artery Disease

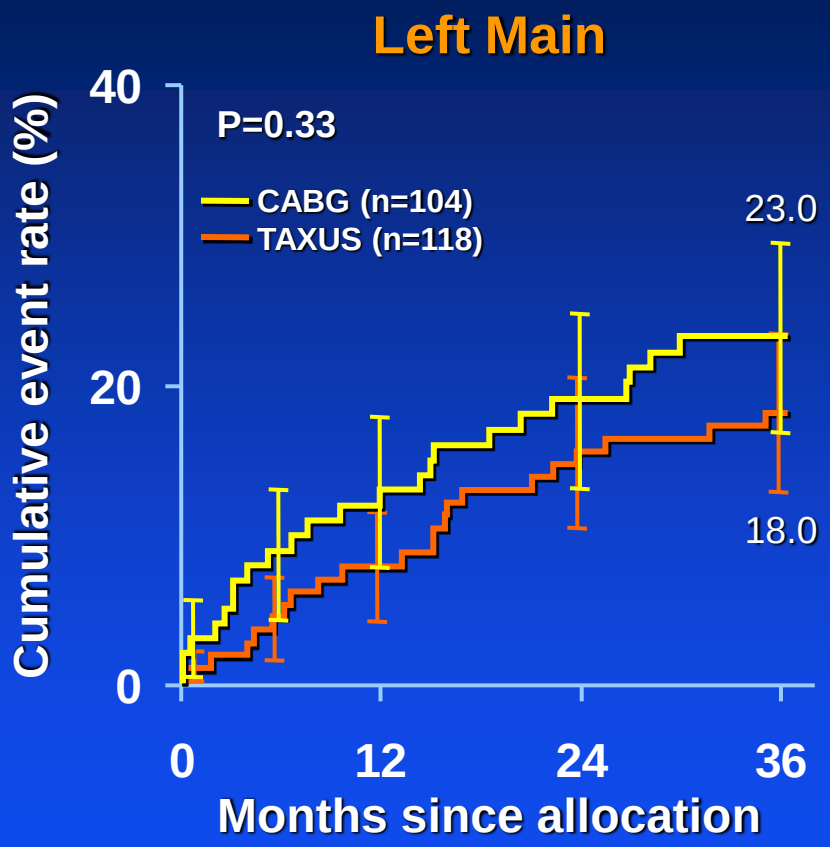
Patrick W. Serruys, M.D., Ph.D., Marie-Claude Morice, M.D., A. Pieter Kappetein, M.D., Ph.D., Antonio Colombo, M.D., David R. Holmes, M.D., Michael J. Mack, M.D., Elisabeth Ståhle, M.D., Ted E. Feldman, M.D., Marcel van den Brand, M.D., Eric J. Bass, B.A., Nic Van Dyck, R.N., Katrin Leadley, M.D., Keith D. Dawkins, M.D., and Friedrich W. Mohr, M.D., Ph.D., for the SYNTAX Investigators*

SYNTAX: 3-Year Follow-Up
MACCE

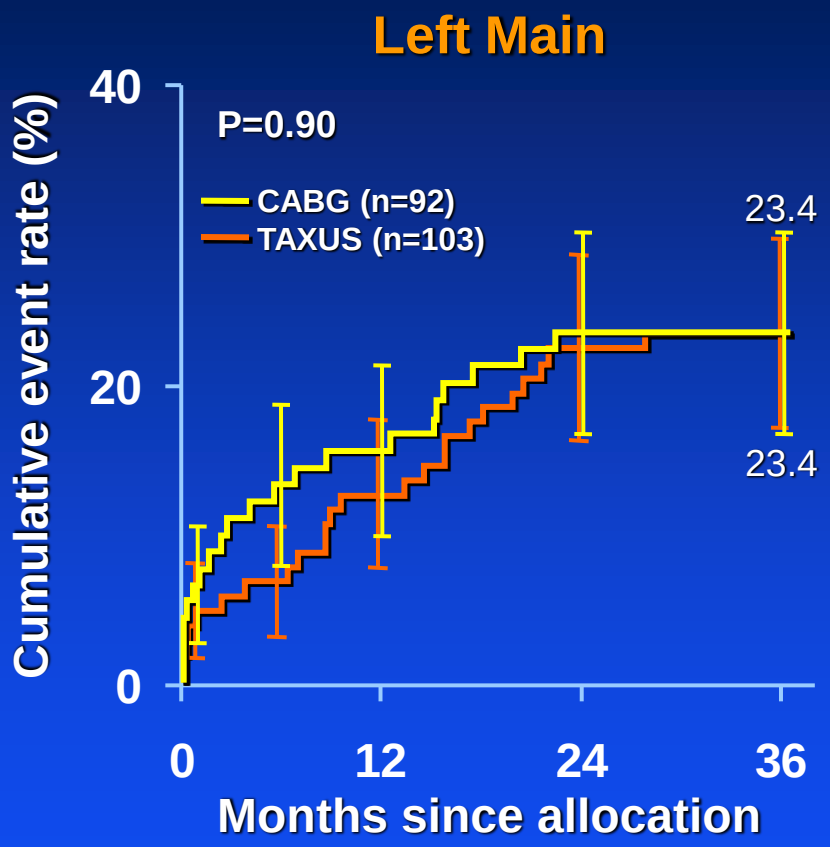


Kappetein: EACTS, 2010

SYNTAX: 3-Year Follow-Up
Left Main Subset



Syntax Score (0-22)



Syntax Score (23-32)

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Kappetein: EACTS, 2010

EDITORIAL COMMENT

Left Main Coronary Artery Stenting

Crossing the Rubicon*

Fernando Alfonso, MD, PHD

Madrid, Spain

Unprotected left main coronary artery (uLMCA) disease has major prognostic implications and remains a therapeutic challenge. Current clinical practice guidelines from both sides of the Atlantic provide a Class I recommendation (Level of Evidence: A) for coronary artery bypass grafting (CABG) in these patients. Furthermore, these guidelines state that percutaneous coronary interventions (PCIs) have a Class III indication for uLMCA patients otherwise eligible for surgery. A recent consensus document also indicates that PCI is *inappropriate* for uLMCA (1). Although the evidence supporting the value of CABG in this setting is robust, some limitations of the available information

a landmark meta-analysis (5). In the following 3 decades, all randomized trials comparing CABG with PCI specifically excluded uLMCA patients because it was considered unethical to withhold surgery from them. During that time, extensive clinical experience and data from contemporary surgical studies corroborated the excellent long-term prognosis of CABG in uLMCA patients, especially since the widespread utilization of arterial grafts.

In this issue of the *Journal*, Mehilli et al. (6) report a highly provocative trial in which uLMCA patients were systematically offered PCI with drug-eluting stents (DES). Using an elegant noninferiority study design, uLMCA patients were randomized to sirolimus-eluting stents (SES) or paclitaxel-eluting stents (PES). Results were excellent and comparable in both arms. However, are stents ready for prime time in uLMCA (7)?

From the initial steps to large observational studies. The promising results of balloon angioplasty in this location soon became overshadowed by high restenosis rates, and the interest for this approach rapidly waned. In the bare-metal stent era, most studies included many emergency cases or patients deemed inoperable, explaining the unsatisfactory results in early series. However, since the advent of DES, uLMCA patients are being increasingly considered for PCI. Initial reports warned of the potential risk of sudden death associated with uLMCA restenosis, but currently, the emphasis has shifted to the identification of patients at risk for

DO WE HAVE THE RIGHT TOOLS ?

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Left Main Coronary Artery Disease
Angiography Limitations

- Visualizing ostial area due to diagnostic catheter engagement can be difficult
- Streaming of contrast material can result impression of stenosis
- Bifurcation or trifurcation into LAD/Circumflex may conceal distal disease
- Opacification of the lumen doesn't allow imaging and study of the arterial wall

Role of IVUS

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Role of IVUS

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Intravascular Ultrasound-Guided Treatment for Angiographically Indeterminate Left Main Coronary Artery Disease

A Long-Term Follow-Up Study

Amir-Ali Fassa, MD, Kenji Wagatsuma, MD, Stuart T. Higano, MD, Verghese Mathew, MD, Gregory W. Barsness, MD, Ryan J. Lennon, MS, David R. Holmes, JR, MD, Amir Lerman, MD

Rochester, Minnesota

OBJECTIVES The purpose of this study was to evaluate the efficacy of an intravascular ultrasound (IVUS)-guided strategy for patients with angiographically indeterminate left main coronary artery (LMCA) disease.

BACKGROUND The assessment of LMCA lesions using coronary angiography is often challenging; IVUS provides useful information for assessment of coronary disease.

METHODS Intravascular ultrasound was performed on 121 patients with angiographically normal LMCAs to determine the lower range of normal minimum lumen area (MLA), defined as the mean − 2 SD. We conducted IVUS studies on 214 patients with angiographically indeterminate LMCA lesions, and deferral of revascularization was recommended when the MLA was larger than this predetermined value.

RESULTS The lower range of normal LMCA MLA was 7.5 mm^2. Of the patients with angiographically indeterminate LMCAs, 83 (38.8%) had an MLA <7.5 mm^2, and 131 (61.2%) an MLA ≥7.5 mm^2. Left main coronary artery revascularization was performed in 85.5% (71 of 83) of patients with an MLA <7.5 mm^2 and deferred in 86.9% (114 of 131) of patients with an MLA ≥7.5 mm^2. Long-term follow-up (mean 3.3 ± 2.0 years) showed no significant difference in major adverse cardiac events (target vessel revascularization, acute myocardial infarction, and death) between patients with an MLA <7.5 mm^2 who underwent revascularization and those with an MLA ≥7.5 mm^2 deferred for revascularization ($p = 0.28$). Based on outcome, the best cut-off MLA by receiver operating characteristic was 9.6 mm^2. Multivariate predictors of cardiac events were age, smoking, and number of non-LMCA vessels diseased.

CONCLUSIONS Intravascular ultrasound is an accurate method to assess angiographically indeterminate lesions of the LMCA. Furthermore, deferring revascularization for patients with a minimum lumen area ≥7.5 mm^2 appears to be safe. (J Am Coll Cardiol 2005;45:204–11) © 2005 by the American College of Cardiology Foundation

Left main coronary artery (LMCA) disease is associated with a poor prognosis when treated medically, and its presence is an indication for coronary artery bypass surgery (CABG), which significantly improves long-term outcome (1–3). Although angiography is considered as the gold standard for coronary artery disease assessment, this technique may present limitations in accurately determining the significance of LMCA lesions (4–8).

Intravascular ultrasound (IVUS) is an accurate method to determine vessel dimensions and wall characteristics, and is more sensitive than angiography in detecting early atherosclerosis (9–12). Observations at our institution and others have shown that IVUS may be helpful in assessment and treatment guidance for angiographically indeterminate LMCA disease (13–19).

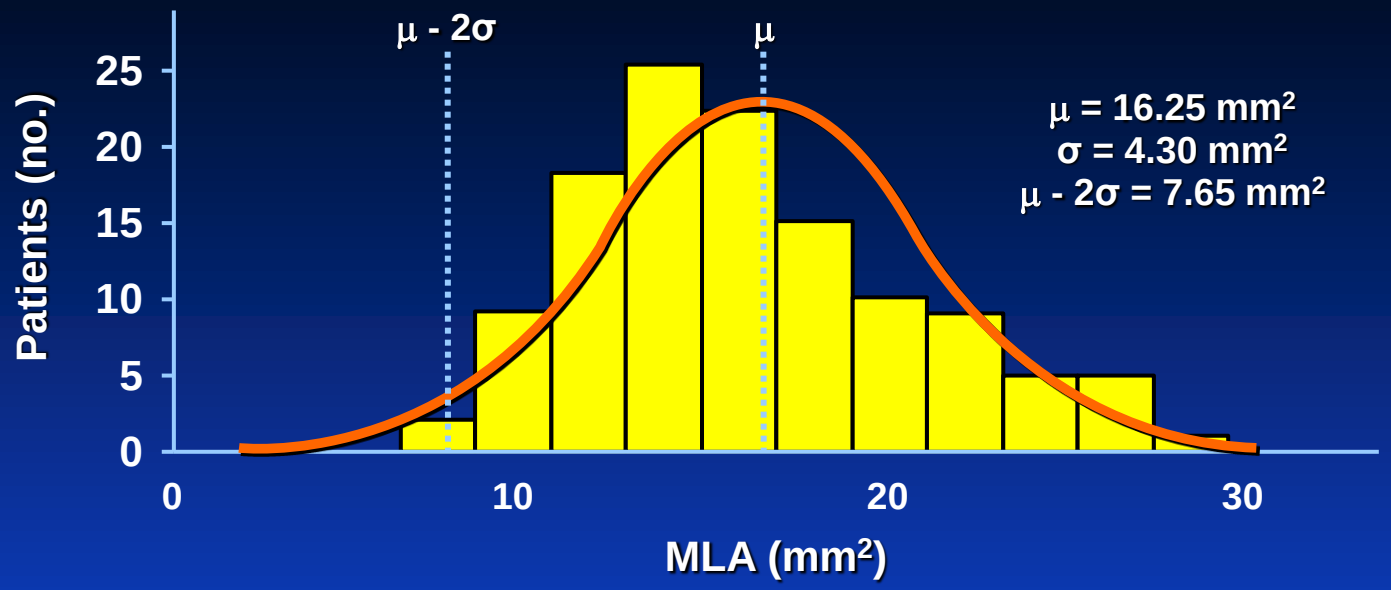
From the Center of Coronary Physiology and Imaging, Cardiac Catheterization Laboratory, Division of Cardiovascular Diseases and Internal Medicine, Mayo Clinic College of Medicine, Rochester, Minnesota. This work was supported by the National Institutes of Health (R01 HL63911, R01 HL69840) and the Miami Heart Research Institute. Dr. Fassa is the recipient of the Zahedi Family Visiting Clinician Scholarship at the Mayo Foundation.

Manuscript received May 27, 2004; revised manuscript received September 24, 2004, accepted September 28, 2004.

The purpose of this study is to evaluate the safety and efficacy of an IVUS-guided strategy for angiographically indeterminate LMCA disease, by defining a lower range of normal minimum lumen area (MLA), and deferring revascularization for patients who have an MLA larger than this value.

METHODS

Patient population. The following study protocol was approved by the Mayo Clinic Institutional Review Board. All patients included were seen from November 1994 to September 2002. A total of 121 patients who were found to have a normal or minimally diseased LMCA on angiography underwent IVUS examinations. The lower range of the normal MLA was defined as the mean MLA − 2 SDs. Based on this criterion, a recommendation was implemented that all patients with an angiographically indeterminate LMCA should undergo IVUS, and that revascularization be performed when the MLA was smaller than the predefined lower range of normal; IVUS studies were carried out at the discretion of the treating physician. All cases in which IVUS had been performed in order to clarify



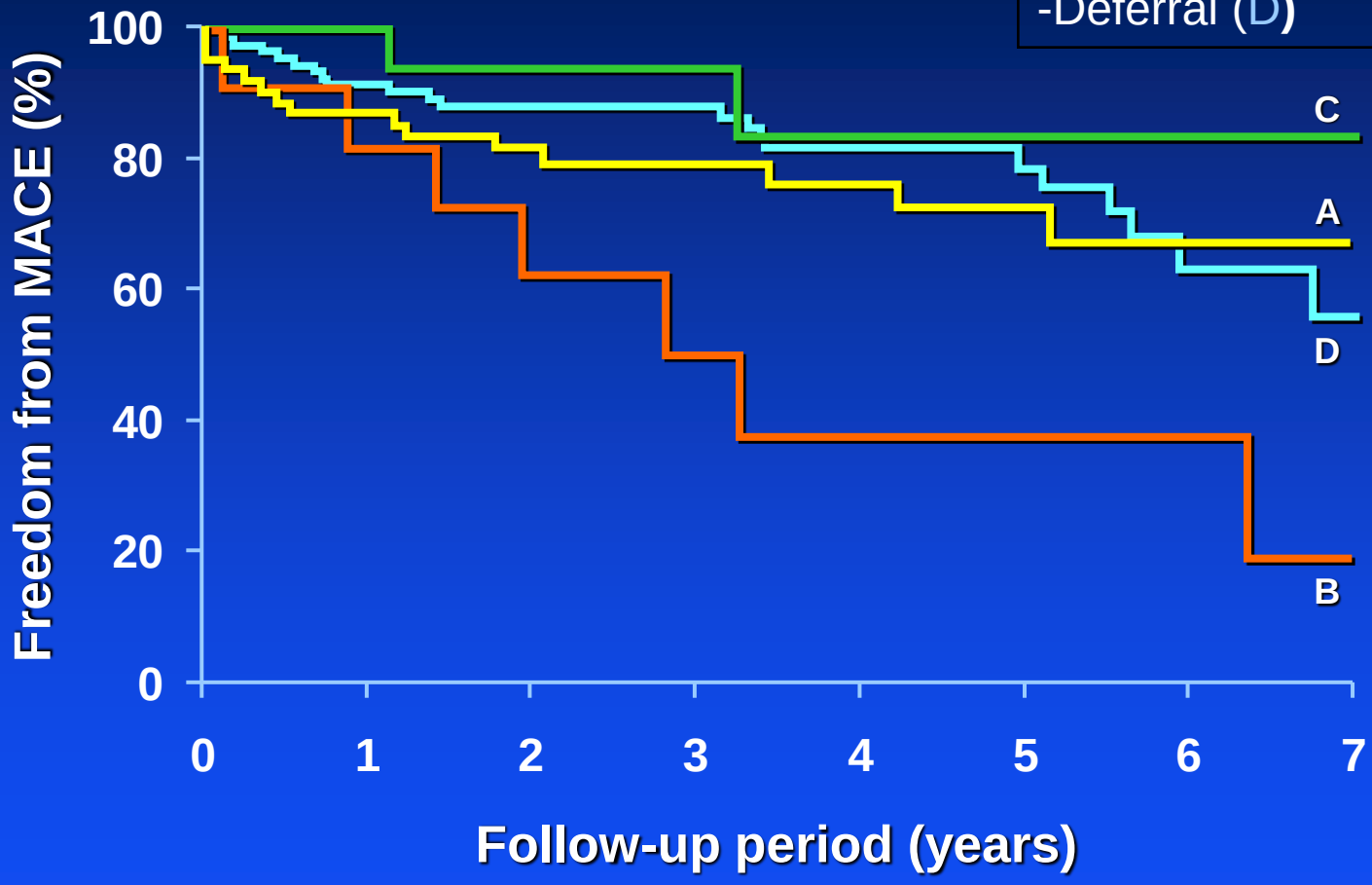
Revascularization Therapy of LMCA

	MLA <7.5 mm² (n=83)		MLA ≥7.5 mm² (n=131)	
	A (Revascularization)	B (Deferral)	C (Revascularization)	D (Deferral)
n	71 (85.5)	12 (14.5)	17 (13.0)	114 (87.0)
CABG	69 (97.2)	–	17 (100)	–
PCI of LMCA	2 (2.8)	–	0	–
Medical therapy only	–	9 (75.0)	–	79 (69.3)
PCI of non-LMCA vessels	2 (2.8)	3 (25.0)	0	35 (30.7)

Fassa/Lerman: JACC, 2005

MLA <7.5
-Revascularization (A)
-Deferral (B)

MLA >7.5
-Revascularization (C)
-Deferral (D)



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Role of IVUS

Stent optimization

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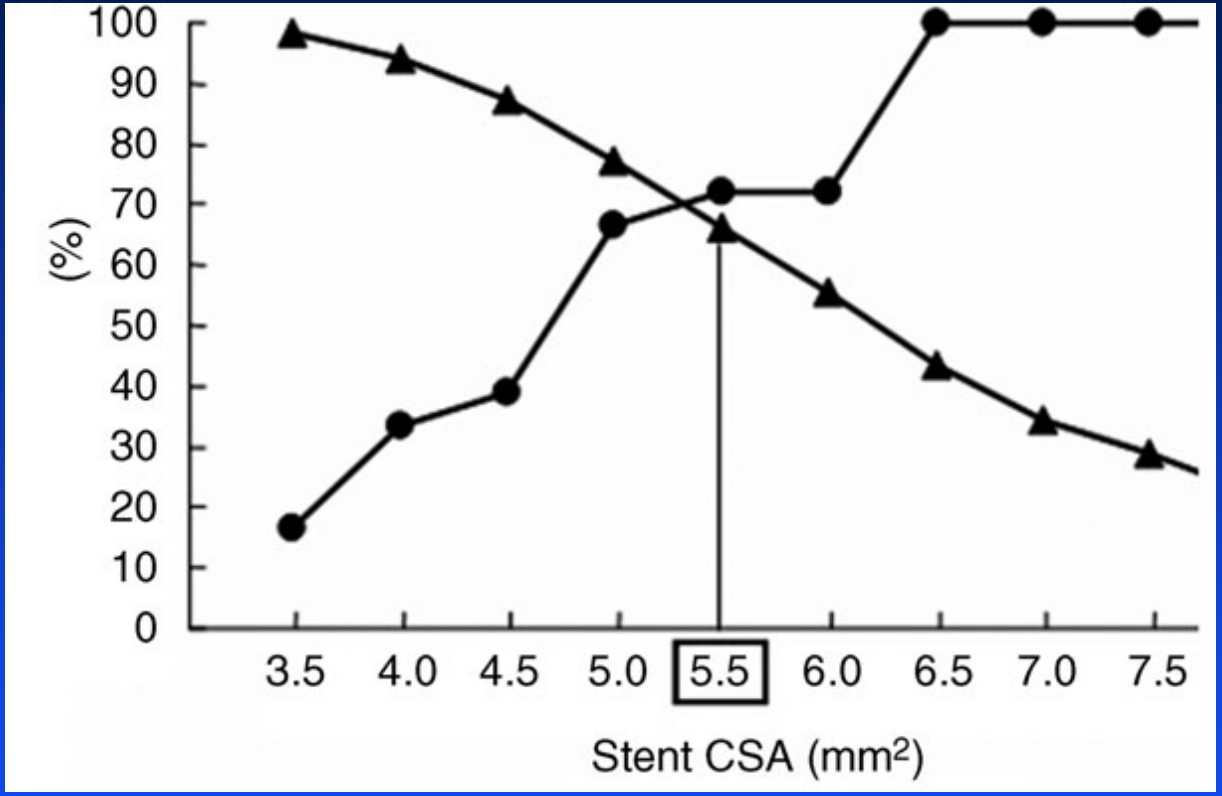
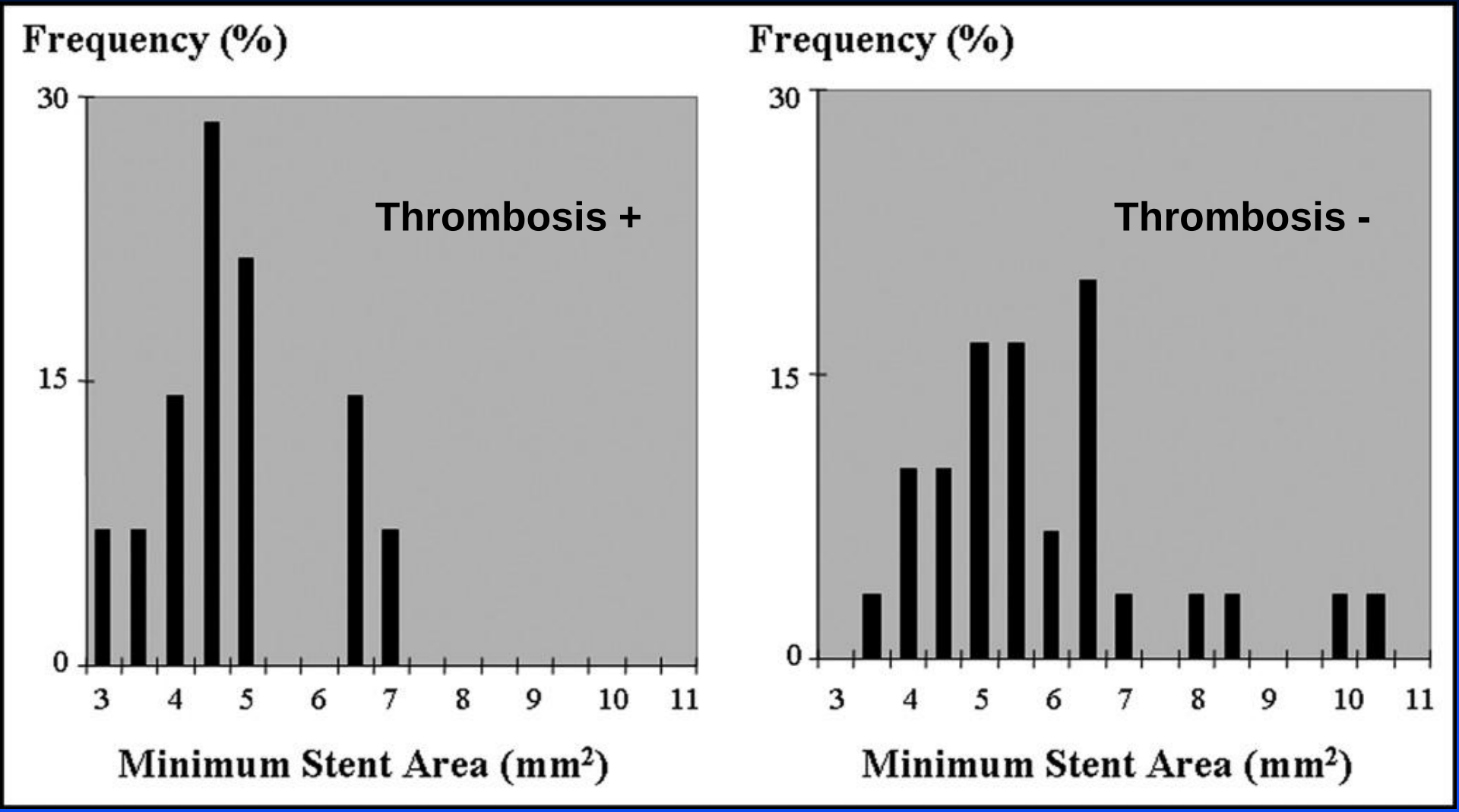
Intravascular ultrasound predictors of angiographic restenosis after sirolimus-eluting stent implantation



European Heart Journal (2006) 27, 1305–1310

Intravascular Ultrasound Parameters Associated With Stent Thrombosis After Drug-Eluting Stent Deployment



Am J Cardiol 2007;100:615– 620)

European Heart Journal (2008) **29**, 1851–1857
doi:10.1093/eurheartj/ehn249

CLINICAL RESEARCH
Interventional cardiology

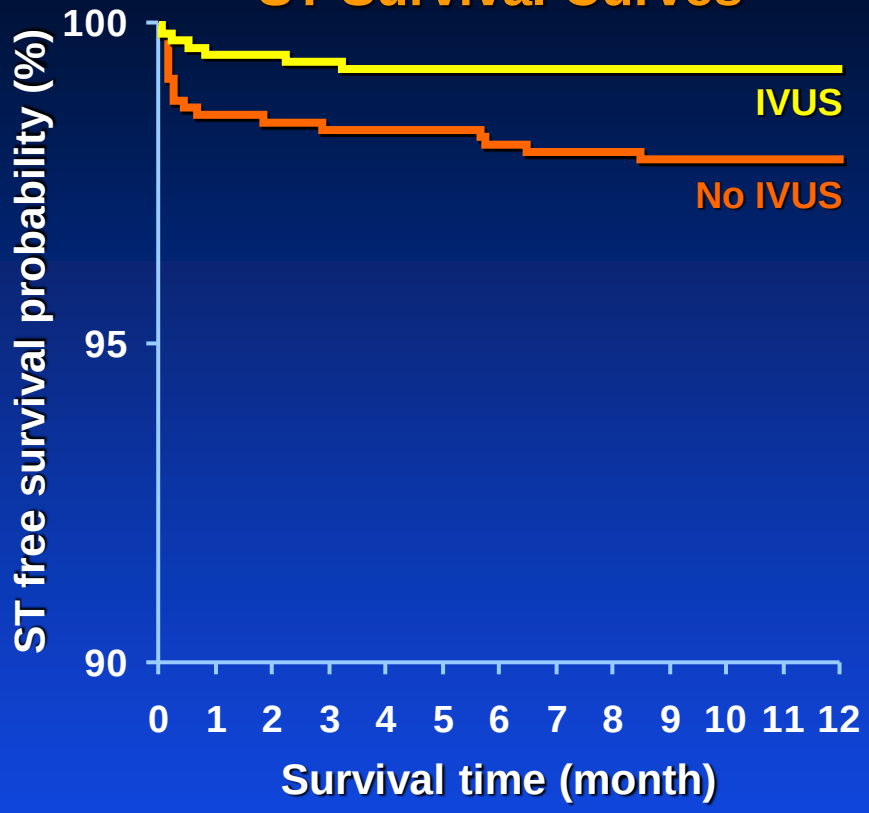
The potential clinical utility of intravascular ultrasound guidance in patients undergoing percutaneous coronary intervention with drug-eluting stents

Probal Roy, Daniel H. Steinberg, Steven J. Sushinsky, Teruo Okabe, Tina L. Pinto Slottow, Kimberly Kaneshige, Zhenyi Xue, Lowell F. Satler, Kenneth M. Kent, William O. Suddath, Augusto D. Pichard, Neil J. Weissman, Joseph Lindsay, and Ron Waksman*

Division of Cardiology, Washington Hospital Center, 110 Irving Street, NW, Suite 4B-1, Washington, DC 20010, USA

Received 25 October 2007; revised 19 May 2008; accepted 22 May 2008; online publish-ahead-of-print 11 June 2008

ST Survival Curves



Clinical Outcomes of Patients in IVUS and No IVUS Groups

	IVUS (n=884)	No IVUS (n-884)	P
In-hospital outcomes, no. (%)			
Death	11 (1.2)	20 (2.3)	0.11
Cardiac death	5 (0.6)	11 (1.2)	0.13
Q-wave MI	1 (0.1)	8 (0.9)	0.02
Peri-procedural MI	132 (14.9)	148 (16.7)	0.29
Coronary bypass surgery	4 (0.5)	7 (0.8)	0.21
Neurological event	1 (0.1)	6 (0.7)	0.06
Renal insufficiency	29 (3.7)	28 (4.0)	0.68
30-day outcomes, no. (%)			
Major adverse cardiac events	25 (2.8)	46 (5.2)	0.01
Death	15 (1.7)	29 (3.3)	0.03
Cardiac death	6 (0.7)	14 (1.6)	0.07
Q-wave MI	6 (0.7)	12 (1.4)	0.16
Target vessel revascularization	10 (1.1)	17 (2.0)	0.18
Target lesion revascularization	6 (0.7)	15 (1.7)	0.05
Cumulative stent thrombosis	4 (0.5)	12 (1.4)	0.046
12-month outcomes, no. (%)			
Major adverse cardiac events	128 (14.5)	143 (16.2)	0.33
Death	50 (5.7)	62 (7.1)	0.24
Cardiac death	16 (1.9)	24 (2.8)	0.19
Q-wave MI	18 (2.1)	26 (3.1)	0.12
Target vessel revascularization	73 (8.5)	77 (9.1)	0.67
Target lesion revascularization	43 (5.1)	61 (7.2)	0.07
Define stent thrombosis	6 (0.7)	18 (2.0)	0.014
Probable stent thrombosis	35 (4.0)	51 (5.8)	0.08
Late definite stent thrombosis	2 (0.2)	6 (0.7)	0.16

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Roy et al: European Heart Journal 29:1851, 2008

Circulation
Cardiovascular Interventions
JOURNAL OF THE AMERICAN HEART ASSOCIATION

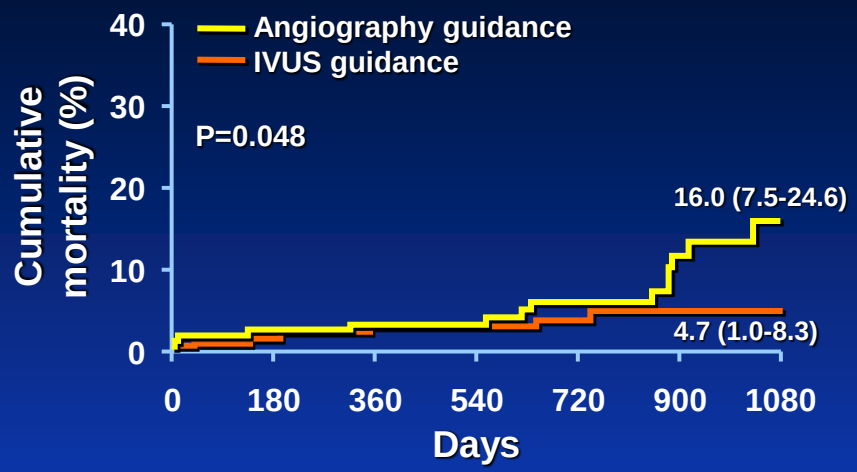
American Heart Association
Learn and Live

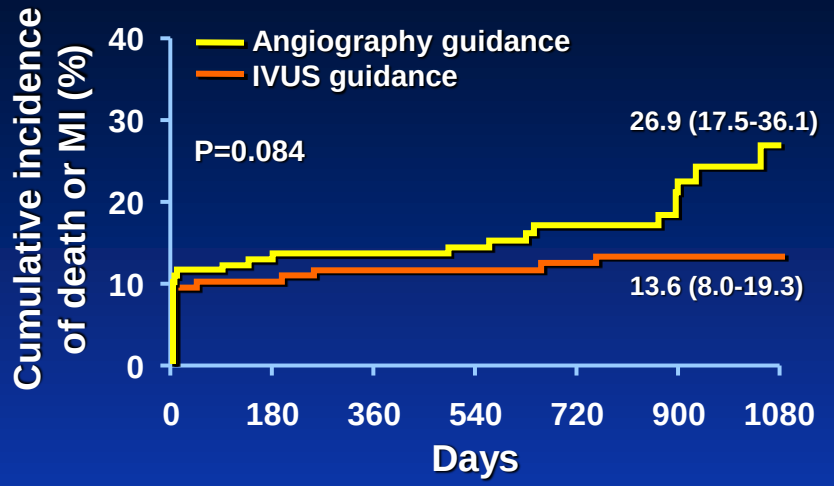
Impact of Intravascular Ultrasound Guidance on Long-Term Mortality in Stenting for Unprotected Left Main Coronary Artery Stenosis

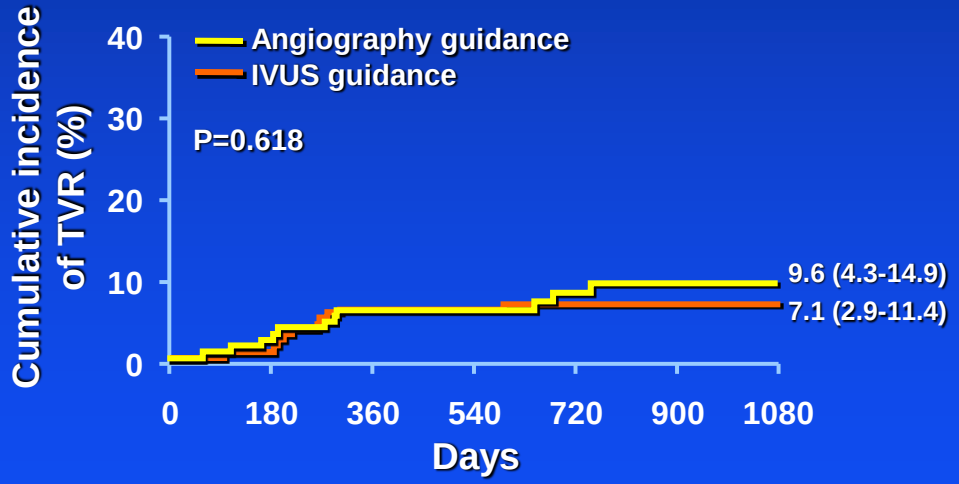
Seung-Jung Park, Young-Hak Kim, Duk-Woo Park, Seung-Whan Lee, Won-Jang Kim, Jon Suh, Sung-Cheol Yun, Cheol Whan Lee, Myeong-Ki Hong, Jae-Hwan Lee and Seong-Wook Park

Circ Cardiovasc Interv 2009;2;167-177; originally published online April 21, 2009;
DOI: 10.1161/CIRCINTERVENTIONS.108.799494
Circulation: Cardiovascular Interventions is published by the American Heart Association. 7272 Greenville Avenue, Dallas, TX 72514
 Print ISSN: 1941-7640. Online ISSN: 1941-7632

DES Patients







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Park et al: Circ Cardiovasc Intervent 2:167, 2009

The role of intravascular ultrasound in patients undergoing left main stenting with drug-eluting stents

Abdi Jama, MD, Federico Conrotto, MD, Amir Lerman, MD

Mayo Clinic Data

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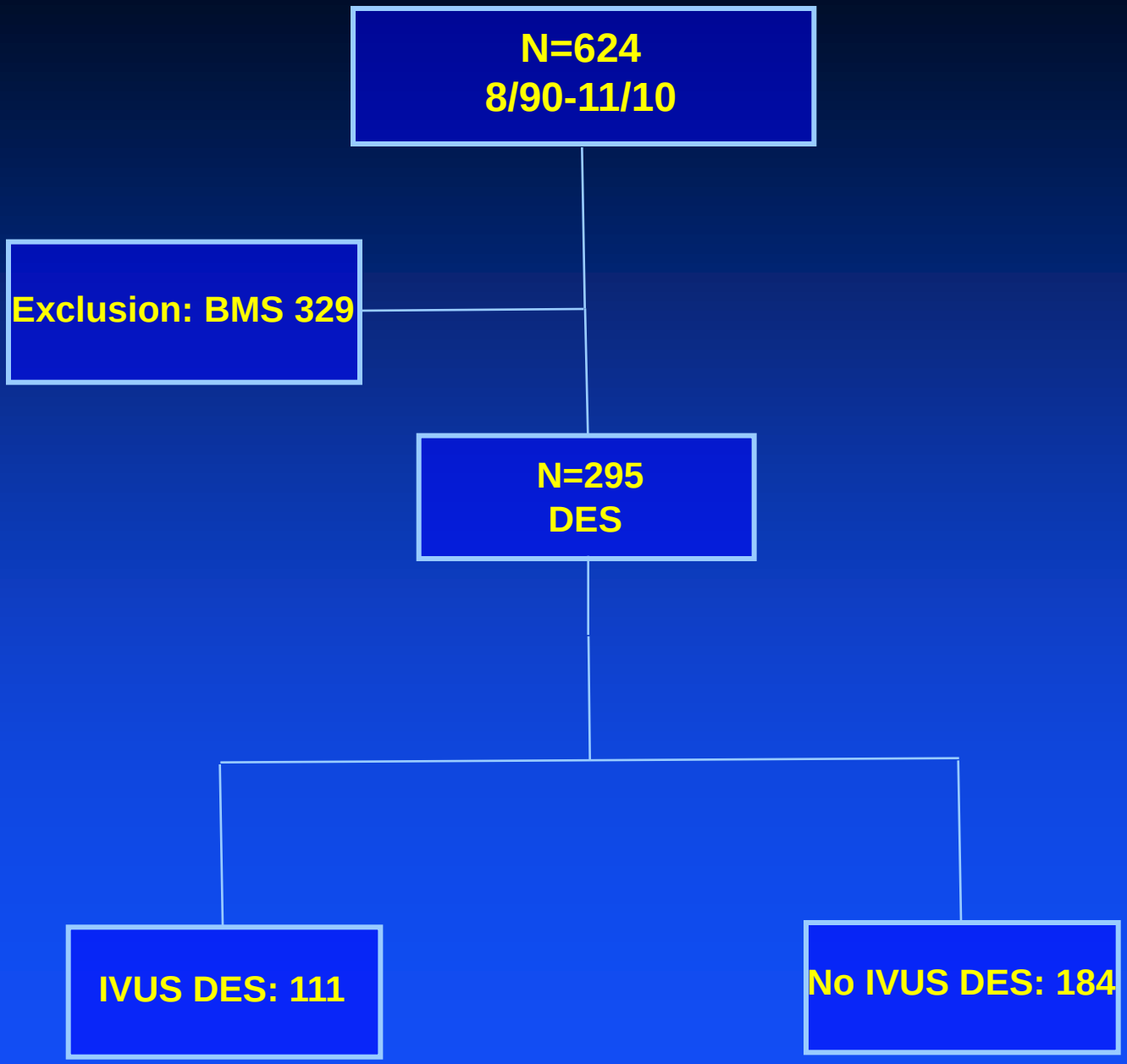
Purpose

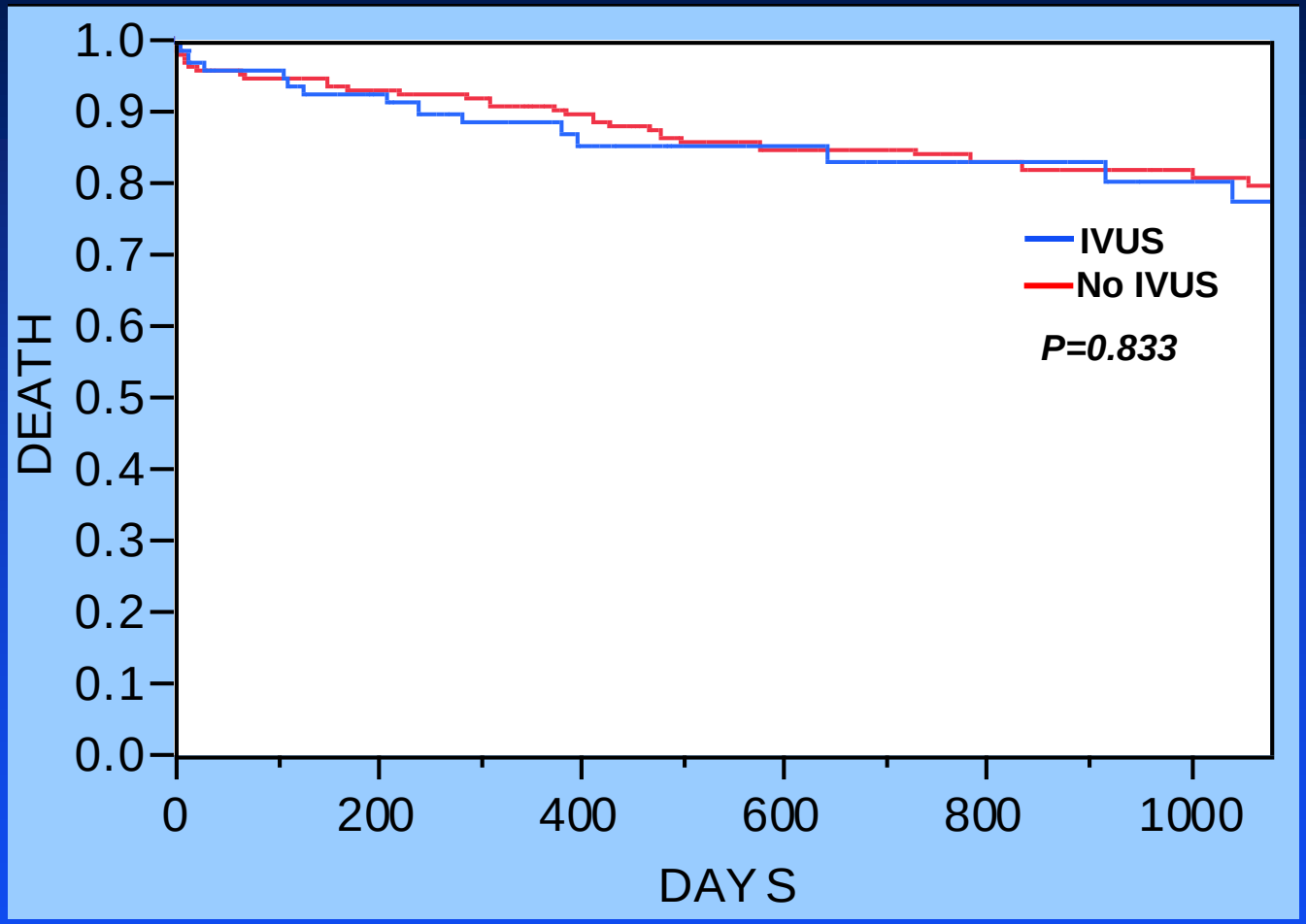
- **To examine the hypothesis that IVUS-guided left main PCI yields future clinical benefit in terms of survival, and revascularization**

Mayo Clinic Left Main PCI Database



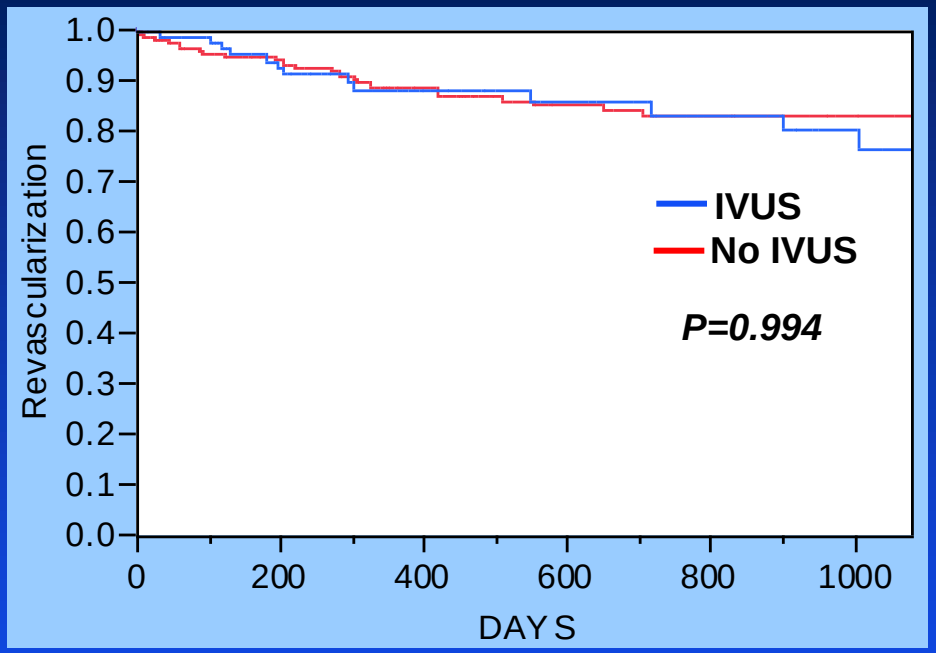
Results

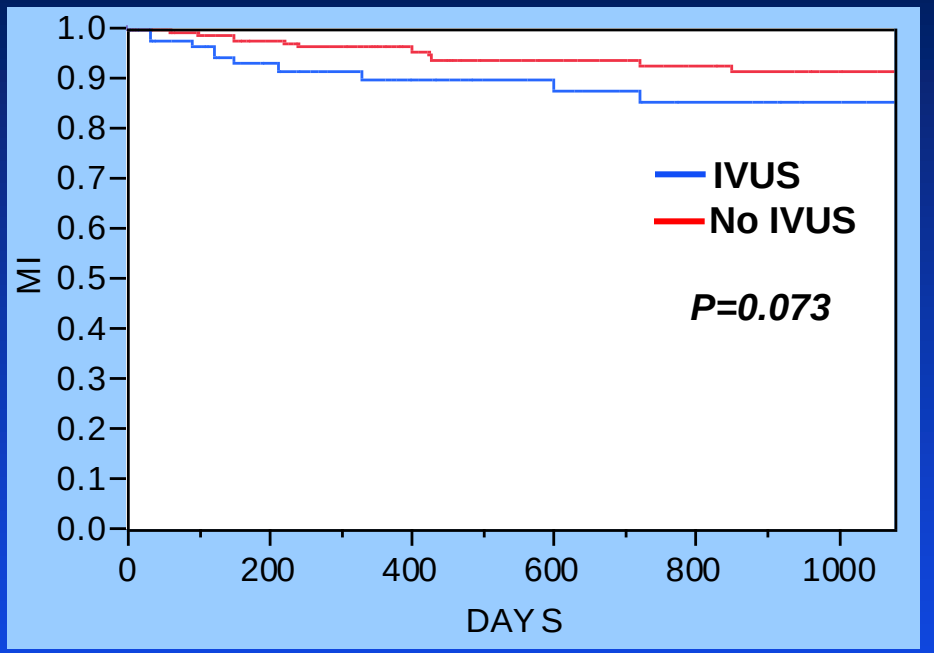
N=295



Results

N=295





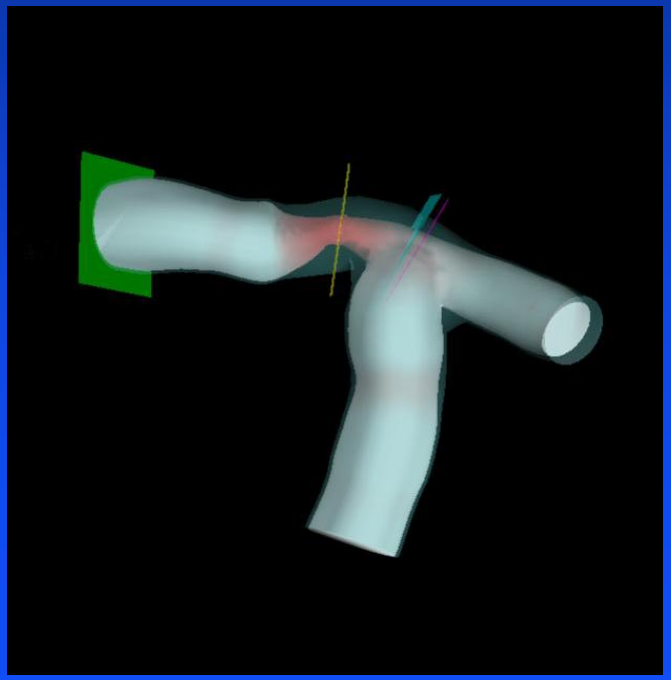
Conclusion

- **In this retrospective study, IVUS guidance during left main DES implantation did not reduce long-term mortality, risk from revascularization or recurrent myocardial infarction**

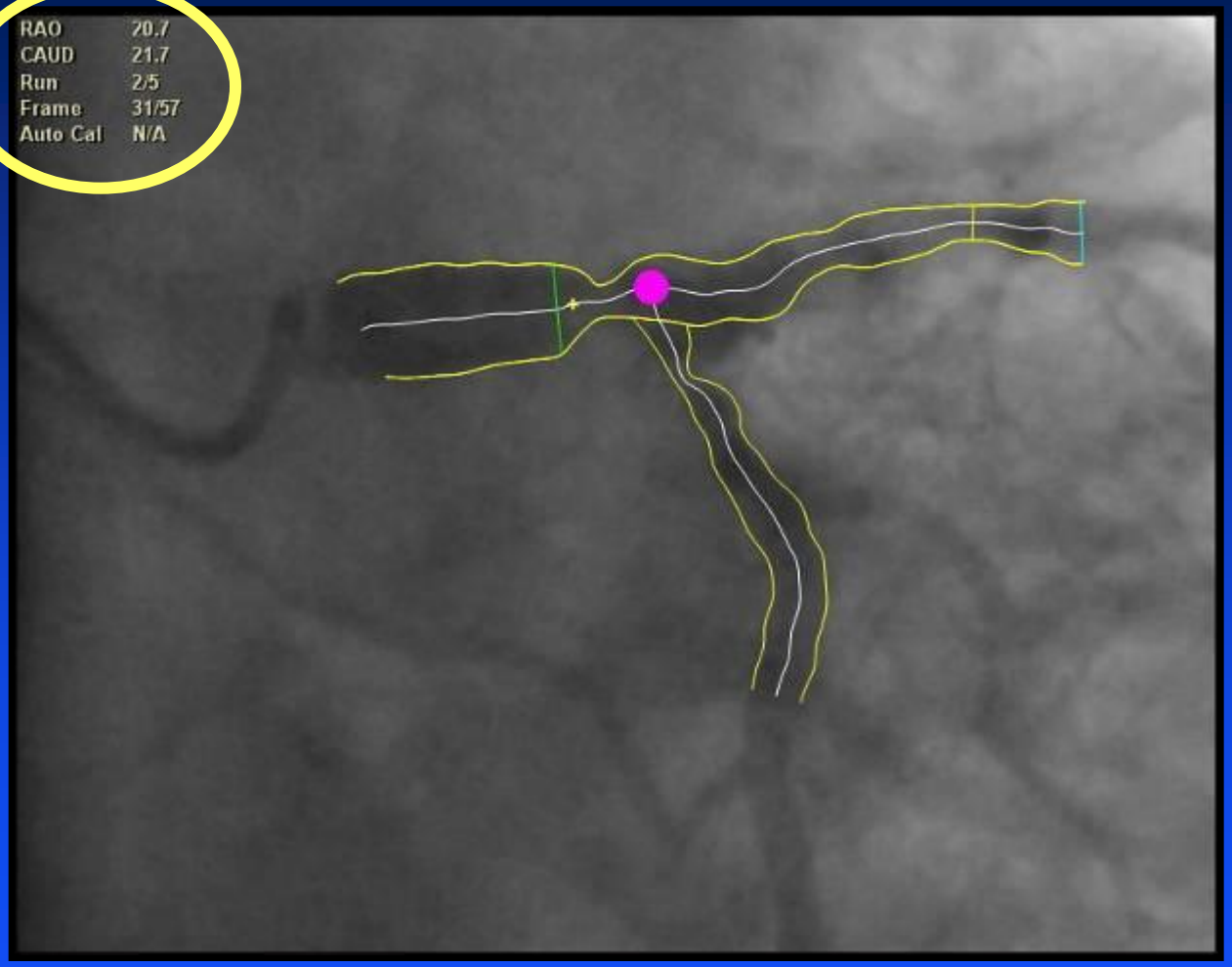
IVUS alternatives

Do we have any?

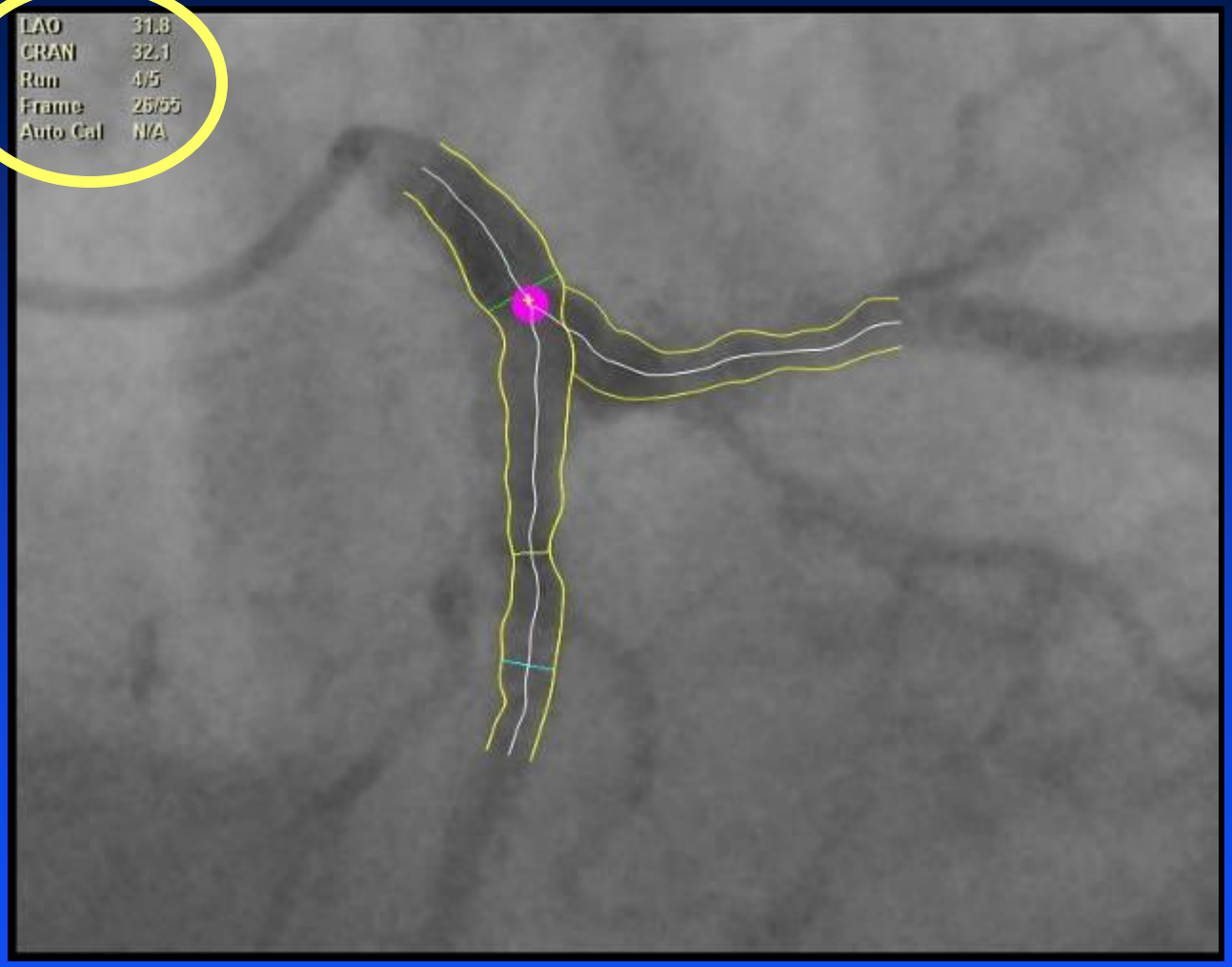
- **3D QCA reconstruction**
  - Newer technology
  - Can be obtained off line
  - Needs validation



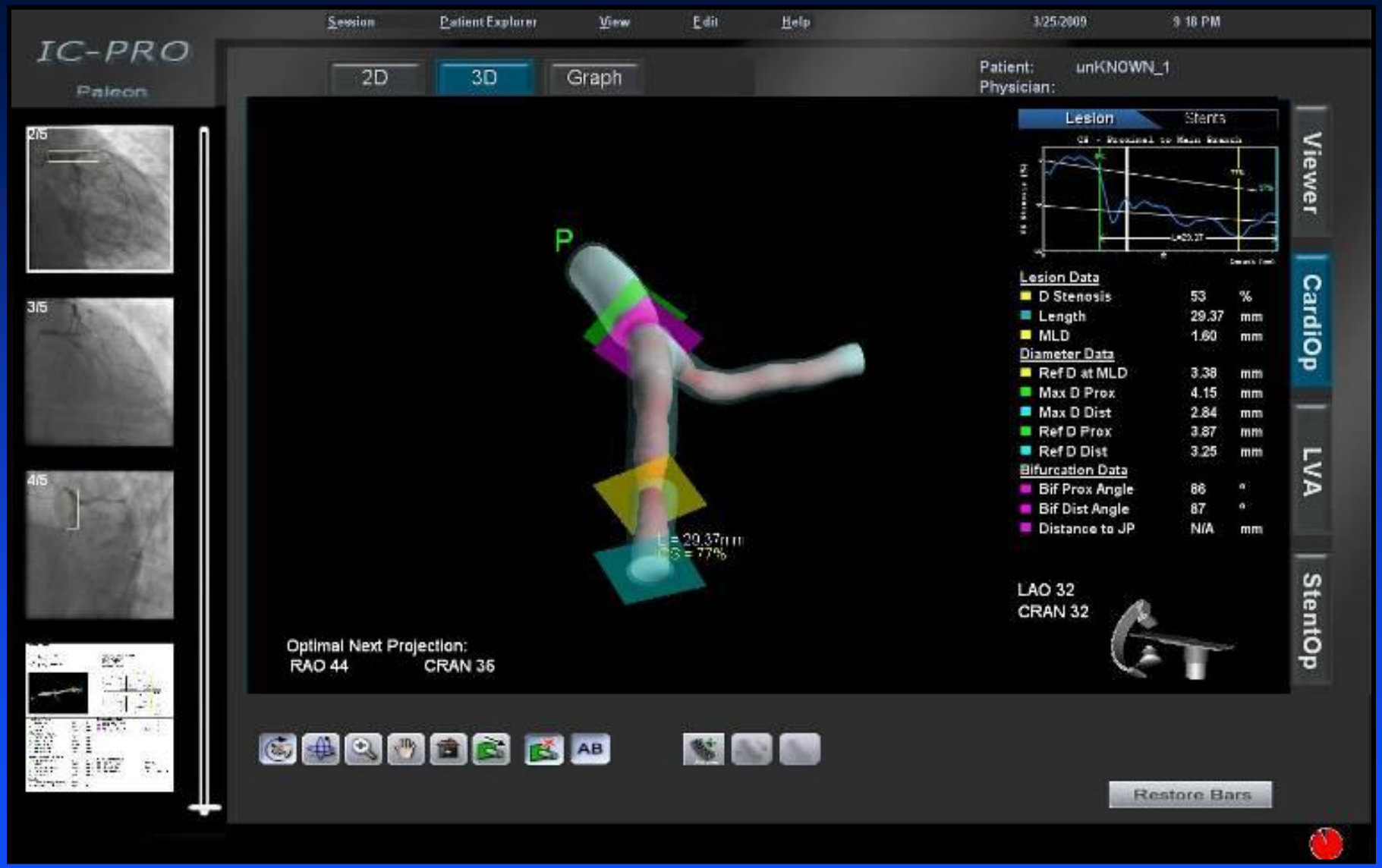
3D QCA Reconstruction
First Projection



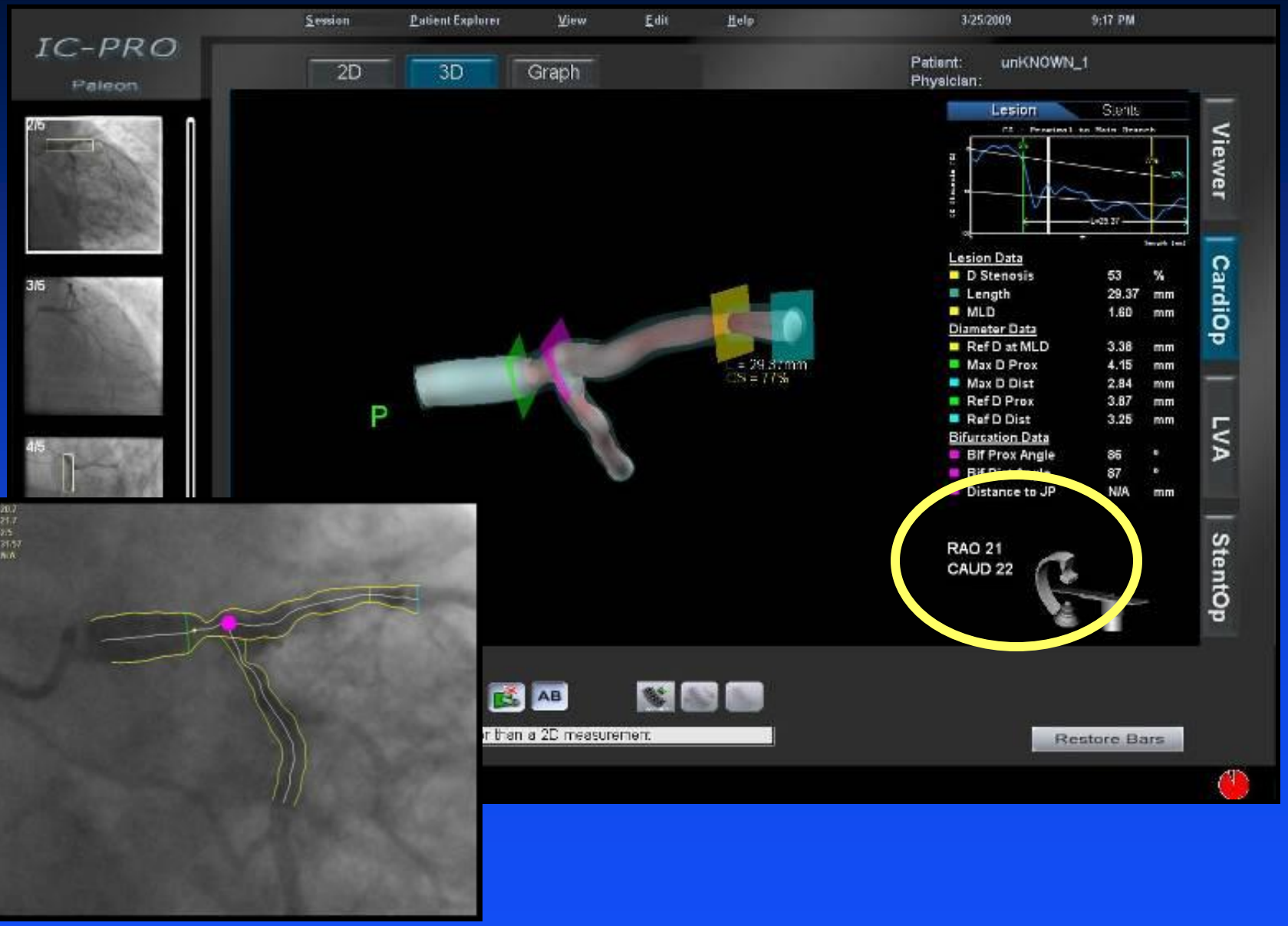
3D QCA Reconstruction
Second Projection



3D Model

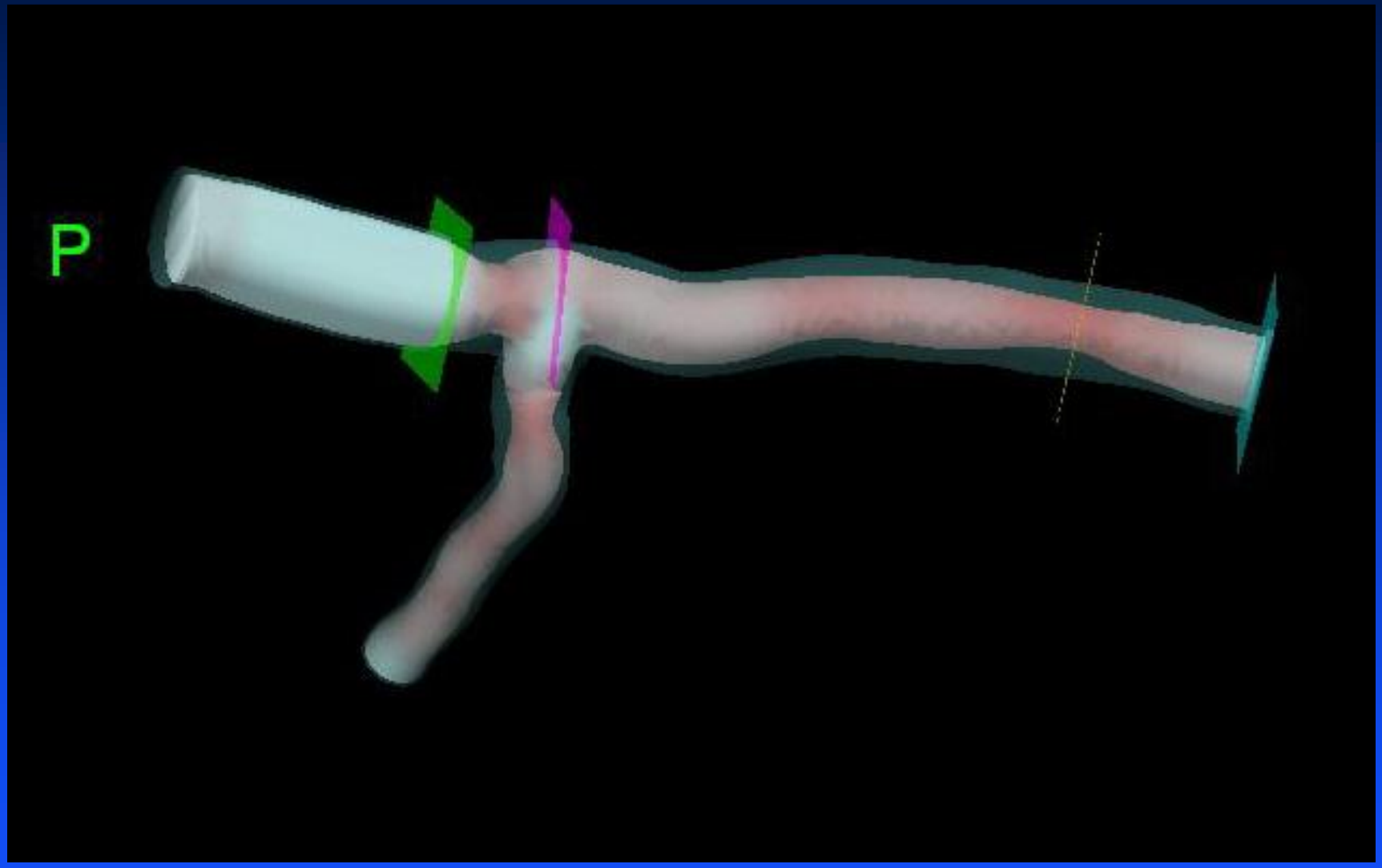

IC-PRO
Paieon
Session
Patient Explorer
View
Edit
Help
3/25/2009
9:18 PM
2D
3D
Graph
Patient: unKNOWN_1
Physician:
Lesion
Stents
Viewer
CardiOp
LVA
StentOp
Lesion Data
D Stenosis 53 %
Length 29.37 mm
MLD 1.60 mm
Diameter Data
Ref D at MLD 3.38 mm
Max D Prox 4.15 mm
Max D Dist 2.84 mm
Ref D Prox 3.87 mm
Ref D Dist 3.25 mm
Bifurcation Data
Bif Prox Angle 86 °
Bif Dist Angle 87 °
Distance to JP N/A mm
P
Optimal Next Projection:
RAO 44 CRAN 36
LAO 32
CRAN 32
AB
Restore Bars

Rotate Model to Run # 2 view

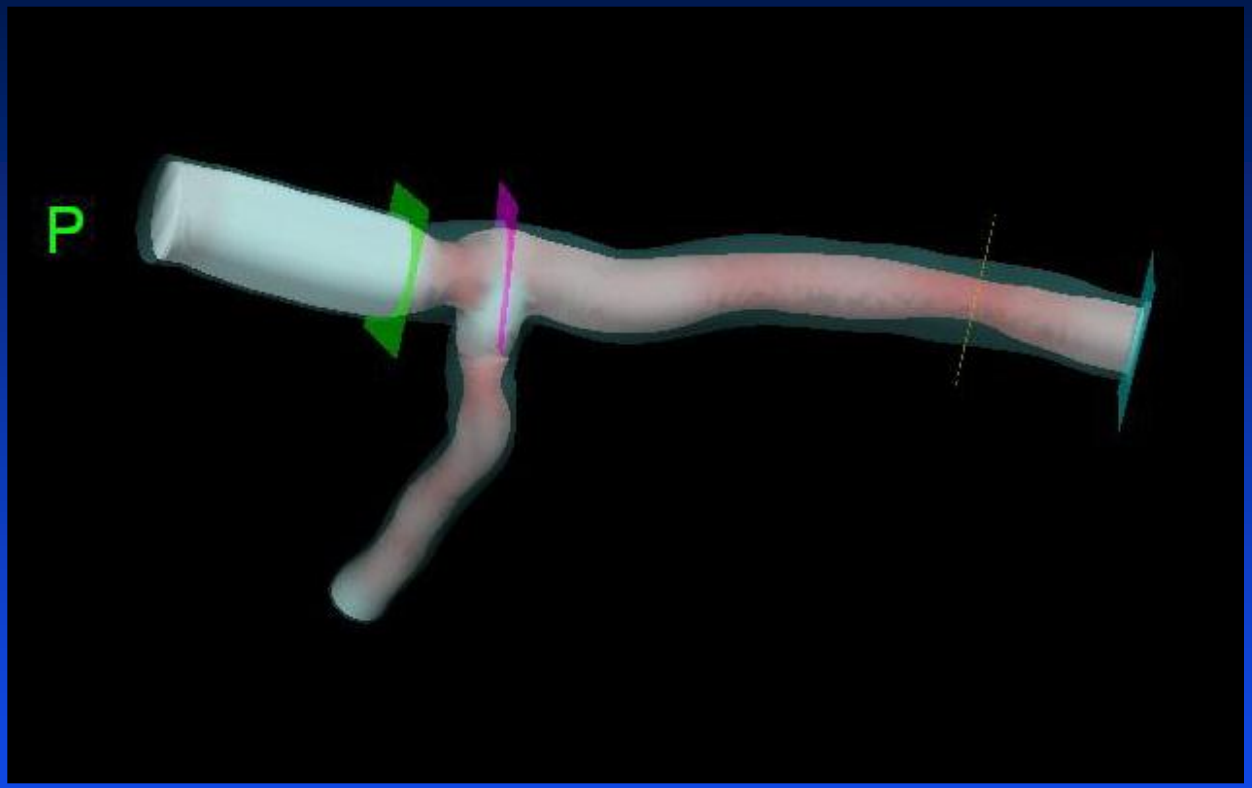


Rotate model to find the “Open View”

Closer view: bifurcation & the lesions



Quantitative Data



Lesion Data		
D Stenosis	53	%
Length	29.37	mm
MLD	1.60	mm
Diameter Data		
Ref D at MLD	3.38	mm
Max D Prox	4.15	mm
Max D Dist	2.84	mm
Ref D Prox	3.87	mm
Ref D Dist	3.25	mm
Bifurcation Data		
Bif Prox Angle	86	°
Bif Dist Angle	87	°
Distance to JP	N/A	mm

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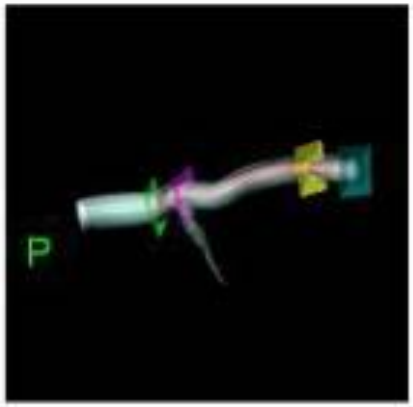
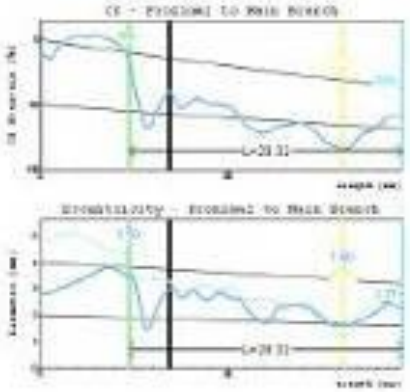
Full Report

PatientName: unknown_1
Gender: Male
PatientID: 000000
Study ID: CATH278888
Accession Number: CATH278888
Date of Birth: 2/15/1925

Institution: MAYO CLINIC
Date: 12/1/2008
Time: 4:29 PM
Physician Name:
Operator Name:





Lesion Data

D Stenosis	52	%
Length	29.32	mm
MLD	1.60	mm

Diameter Data

Ref D at MLD	3.35	mm
Max D Prox	4.11	mm
Max D Dist	2.84	mm
Ref D Prox	3.84	mm
Ref D Dist	3.22	mm

Cross Section Data

CS Stenosis	77	%
MLA	2.05	mm^2
Ref A at MLA	8.83	mm^2
Ref A Prox	11.58	mm^2
Ref A Dist	8.12	mm^2

Other

Eccentricity Index	0.01	
Plaque Volume	50	%

Bifurcation Data

Bif Prox Angle	86	°
Bif Dist Angle	86	°
Distance to JP	N/A	mm

Calibration Data

Cal. Method	Manual	
Object Size	N/A	
Cal. Factor	0.200	mm/pxl

3D quantitative coronary angiography reconstruction: Validation

Catheterization and Cardiovascular Interventions 76:291–298 (2010)

A Novel Three-Dimensional Quantitative Coronary Angiography System: In-Vivo Comparison With Intravascular Ultrasound for Assessing Arterial Segment Length

Shengxian Tu,[1,2] MSc, Zheng Huang,[3] MD, PhD, Gerhard Koning,[1,2] MSc, Kai Cui,[3] MSc, and Johan H.C. Reiber,[1,2*] PhD, FESC, FACC

International Journal of Cardiovascular Interventions. 2005; 7: 141–145

Taylor & Francis

ORIGINAL ARTICLE

Three-dimensional coronary reconstruction from routine single-plane coronary angiograms: *in vivo* quantitative validation

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European Heart Journal
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CLINICAL RESEARCH

Three-dimensional and two-dimensional quantitative coronary angiography, and their prediction of reduced fractional flow reserve

Andy S.C. Yong[1,2], Austin C.C. Ng[2], David Brieger[2], Harry C. Lowe[2], Martin K.C. Ng[3], and Leonard Kritharides[2*]

Quantitative Analysis of Reconstructed 3-D Coronary Arterial Tree and Intracoronary Devices

S.-Y. James Chen*, John D. Carroll, and John C. Messenger

Comparison between 3 Dimensional Angiographic Reconstruction and Intravascular Ultrasound – Imaging of the Left Main Coronary Artery

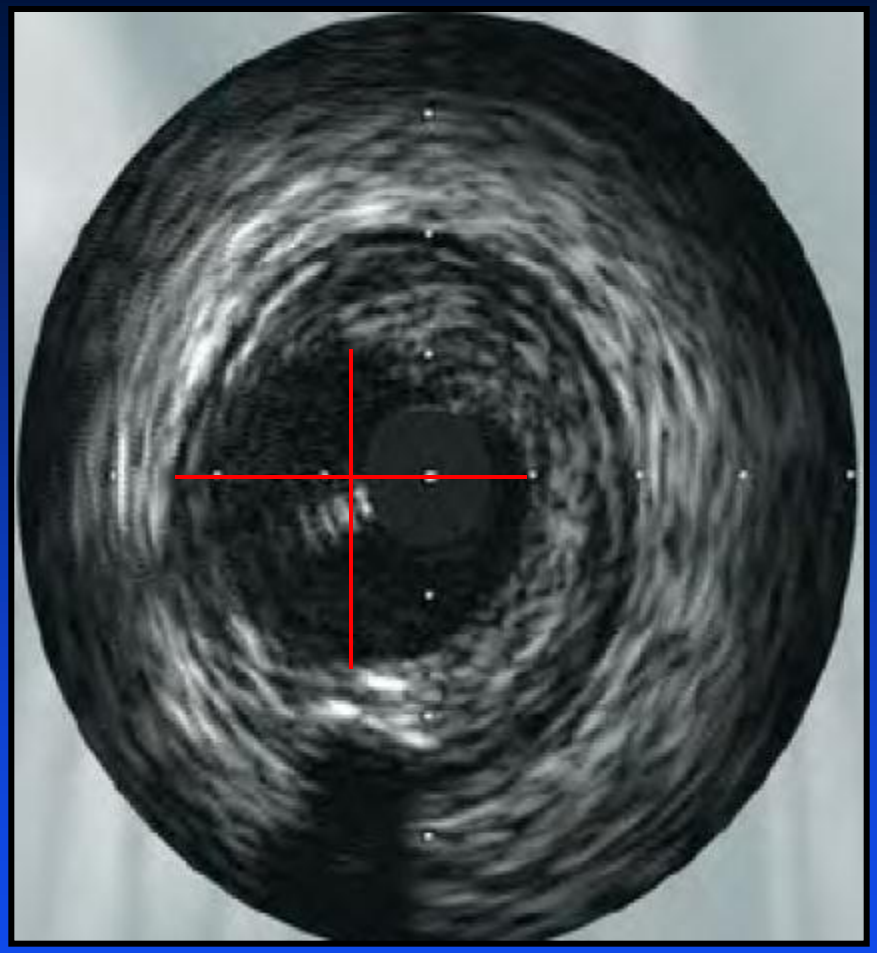
Daniel B. Spoon MD, Ronen Rubinshtein MD, Charanjit S. Rihal MD MBA, Ryan Lennon MS, Amir Lerman MD.

Mayo Clinic Data

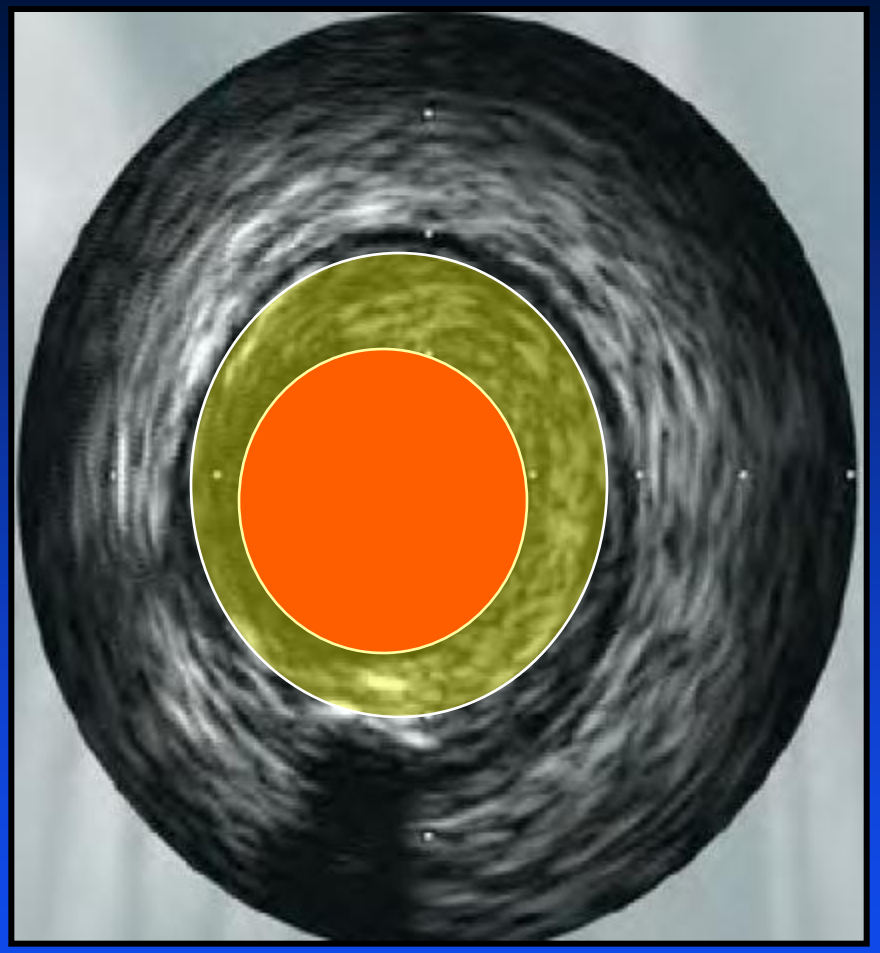
Purpose

- **To determine if left main coronary artery measurements (Diameter, and area) obtained using 3D QCA correlate with cross sectional area and luminal diameter obtained with IVUS (gold standard)**

IVUS Image Quantitation



Max and Min Diameter (mm)



- Vessel area
- Lumen area
- Plaque area
- %Plaque area

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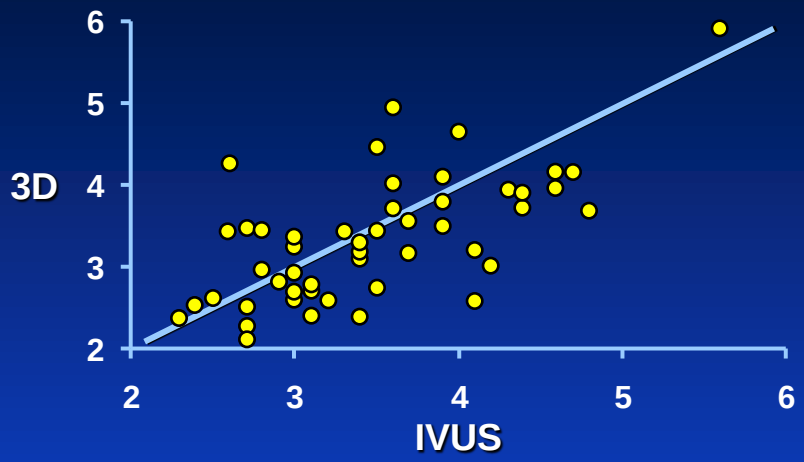
Methods

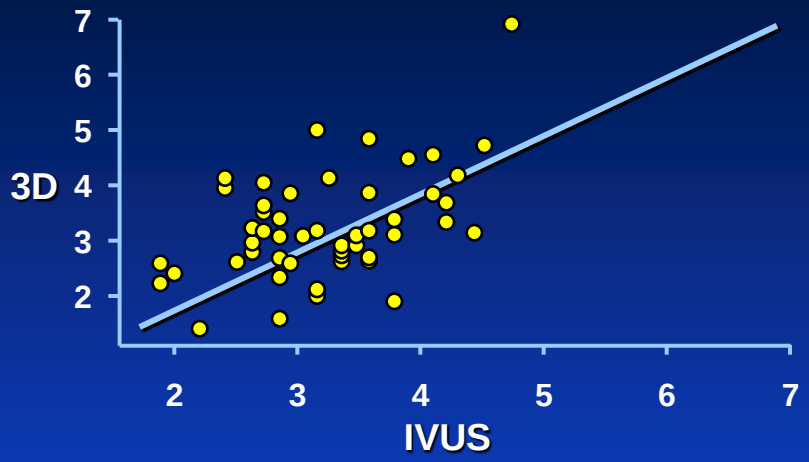
- Fifty five un-selected patients underwent both coronary angiograph and IVUS
- Left main measurements were analyzed blindly off line with 3D QCA (IC-PRO paieon) software and IVUS
- Measurements included
  - Proximal, mid and distal luminal diameter
  - Proximal, mid and distal cross sectional area
  - Plaque area

Results: LM Diameter, IVUS vs 3D QCA

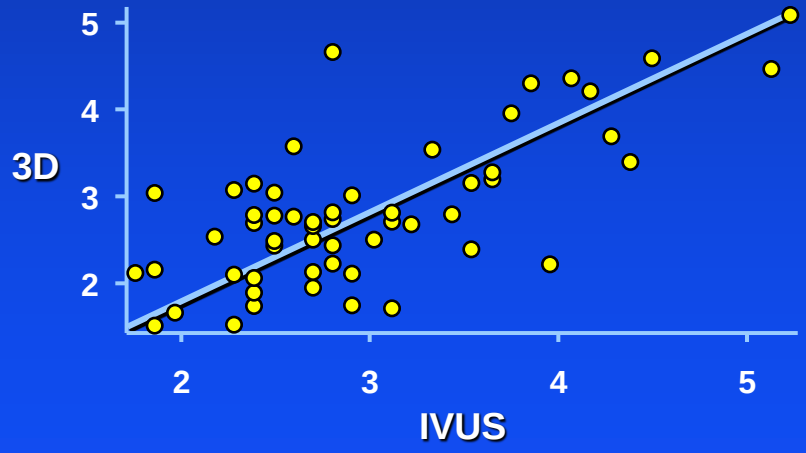
Proximal Diameter

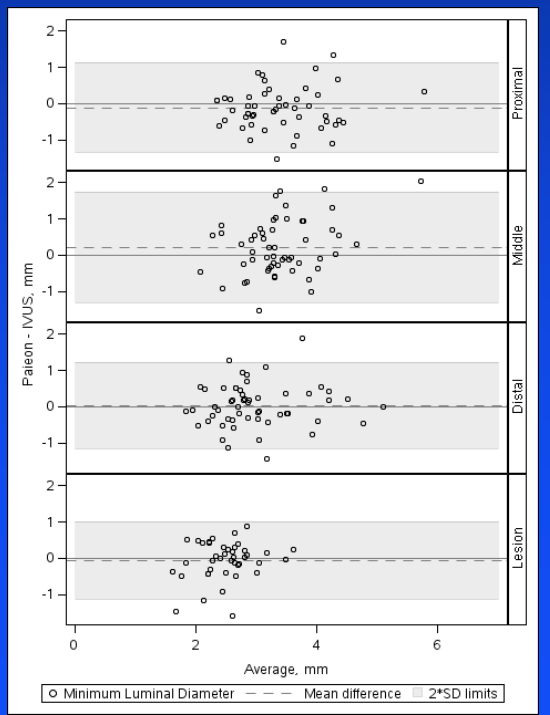


Mid Diameter



Distal Diameter





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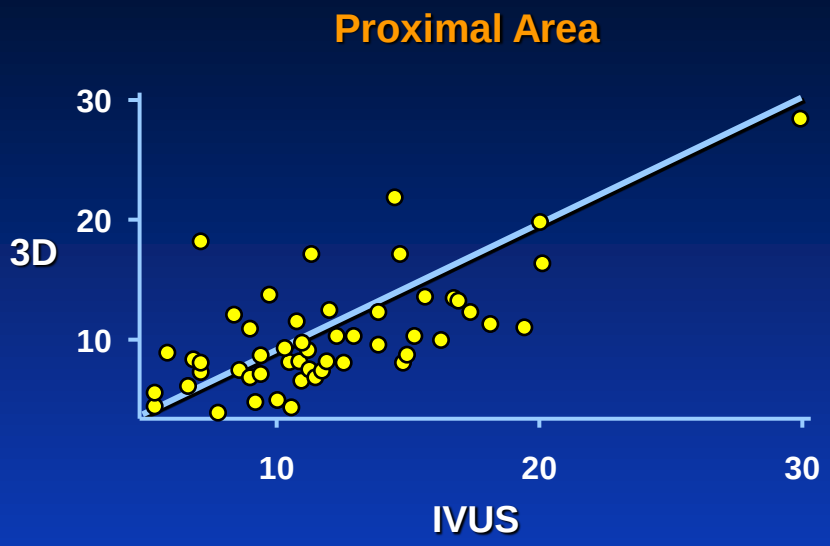
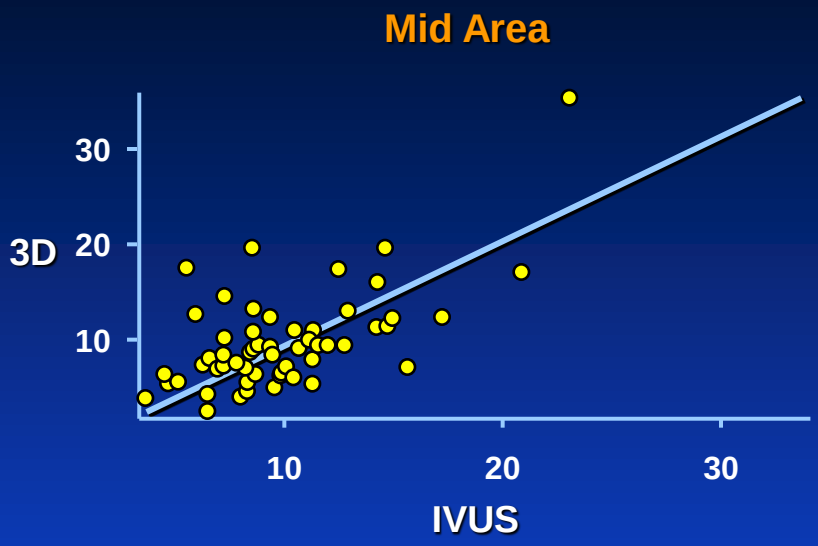
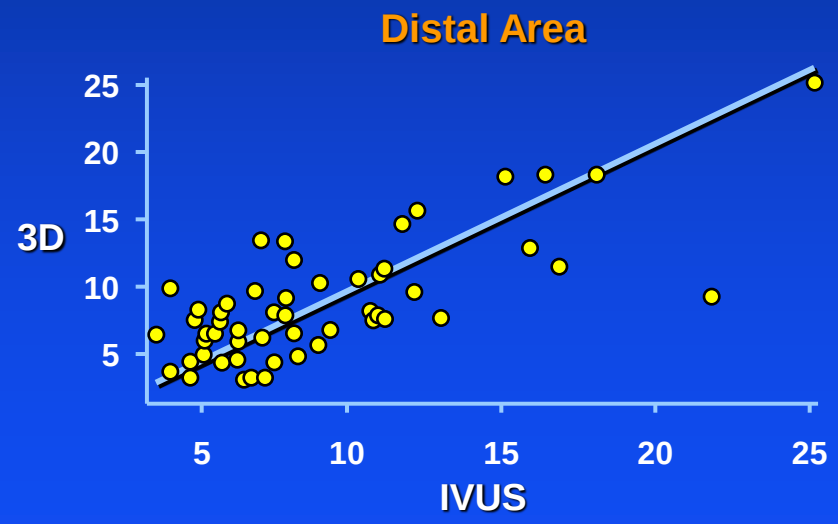
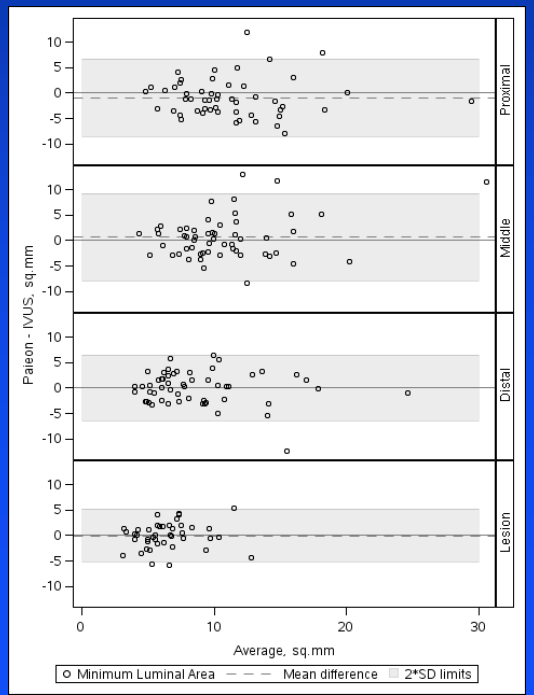
Results: LM Area, IVUS vs 3D QCA









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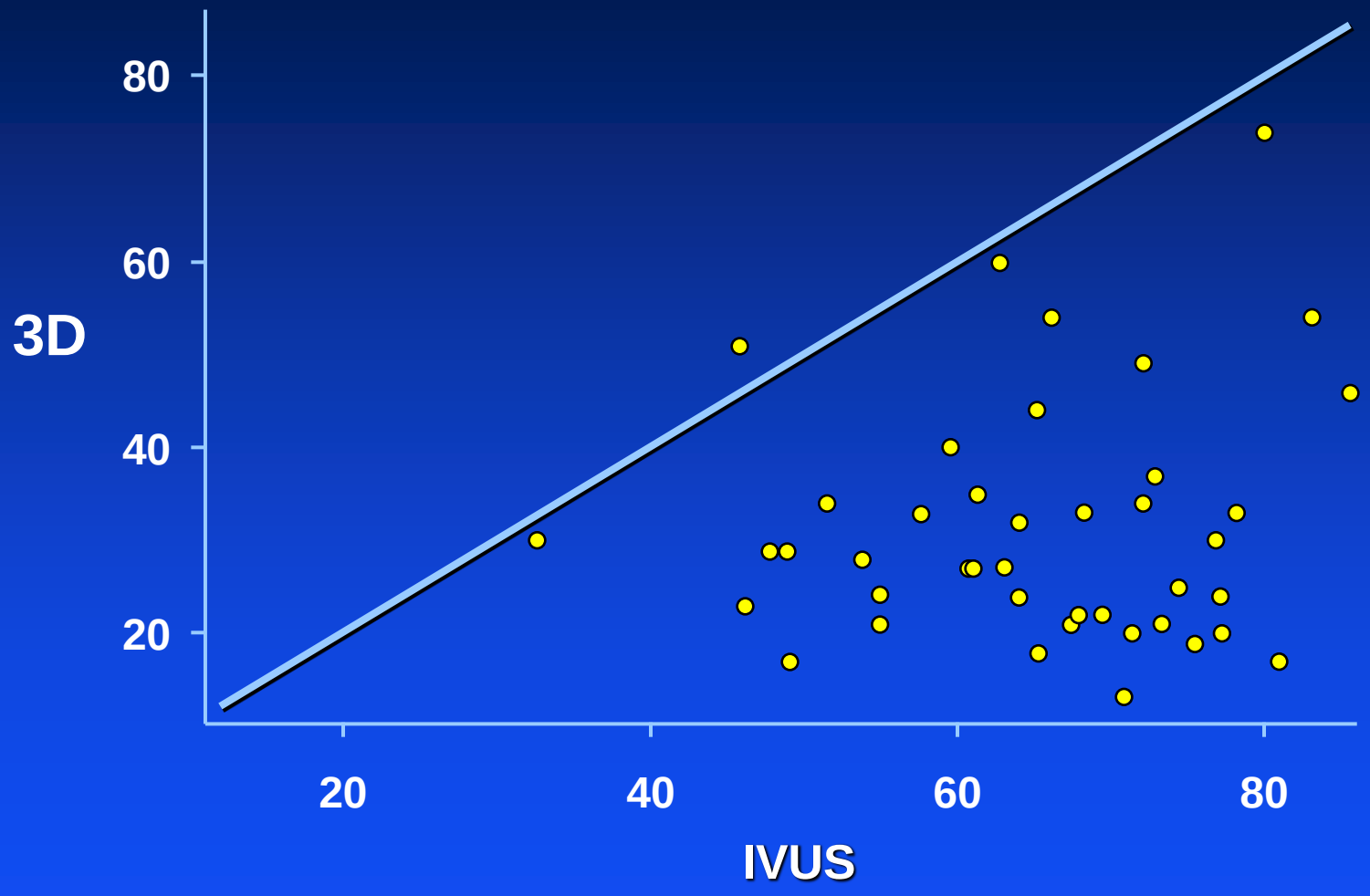
Results: Plaque Burden



Imaging of the Left Main Coronary Artery post intervention with IVUS and 3 Dimensional Angiographic Reconstruction: Comparison and Clinical follow up

Federico Conrotto, MD, Abdi Jama, MD, Amir Lerman, MD

Mayo Clinic Data

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Purpose

- To determine if measurement of left main stent diameter and area by 3D QCA reconstruction post left main stenting correlates with IVUS (gold standard)

Methods

- Sixty patients who underwent LM coronary artery intervention and IVUS
- Left main measurements were analyzed blindly off line with 3D QCA software and IVUS by two different investigators
- Measurements included
  - Minimal stent luminal diameter
  - Minimal stent cross sectional area

Results

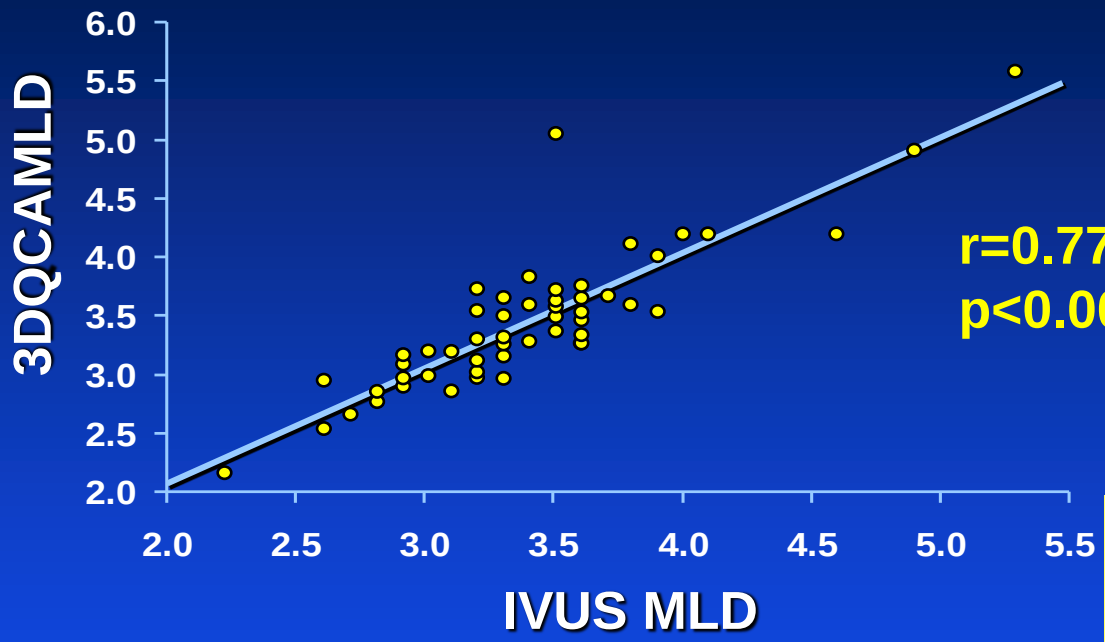
Clinical Characteristics

	N=60
Age, y	67.8 ±13.1
Male, No. (%)	48 (80)
Weight, Kg	86.9 ±20.7
BSA	1.94±0.27
Hypertension, No. (%)	43(72)
Hyperlipidemia, No. (%)	48(80)
Diabetes, No. (%)	23(38)
Smoker, No. (%)	6(10)
CVA history, No. (%)	4(6.7)
Prior PCI, No. (%)	10(16.7)
Prior CABG, No. (%)	39(65)
EF <35%, No. (%)	8(13.3)
Clinical presentation - ACS, No. (%) - Stable angina - Other	 21(35) 36(60) 3(5)

Procedural Characteristics

	N=60
DES, No. (%)	45(75)
Stent size, mm	3.8±0.55
Stent location, No. (%) -Ostial -Shaft -Distal	 19(31.7) 13(21.7) 28(46.7)
IABP, No. (%)	4(6.7)
VAD, No. (%)	5(8.3)

Results: Stent Lumen Diameter, IVUS vs 3D QCA



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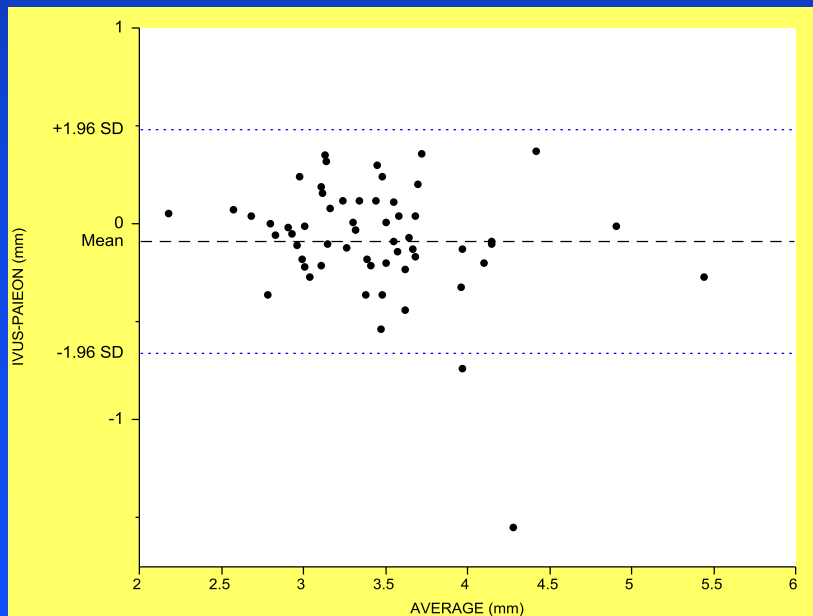

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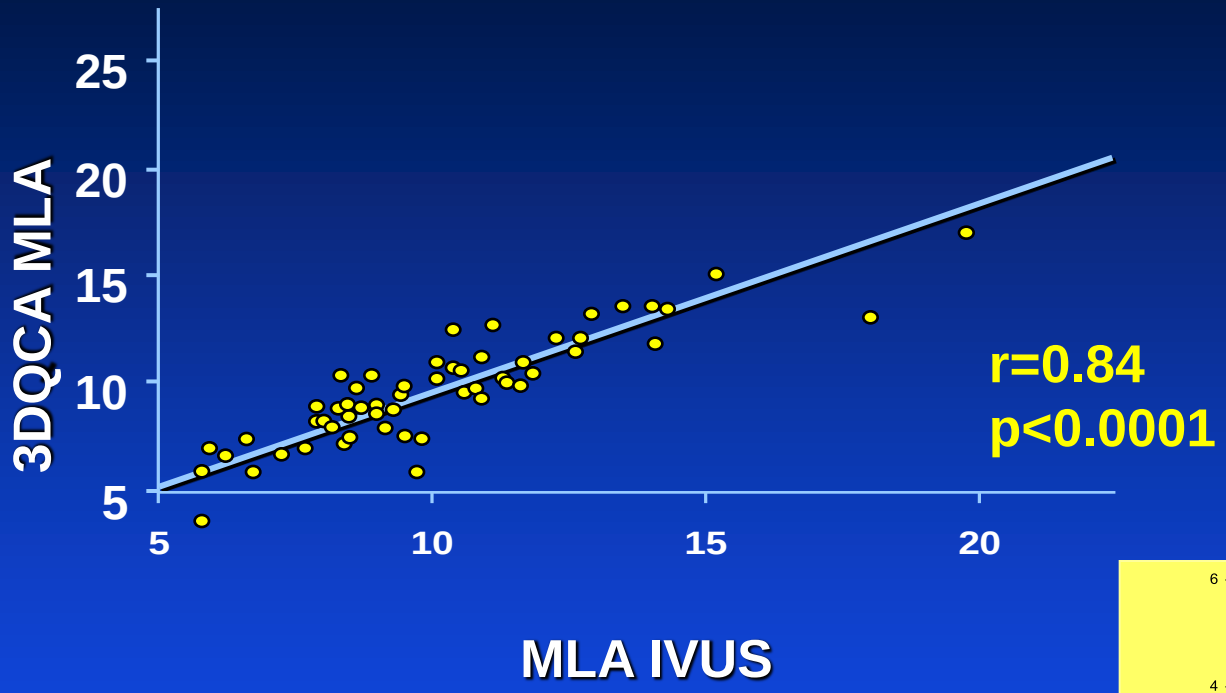
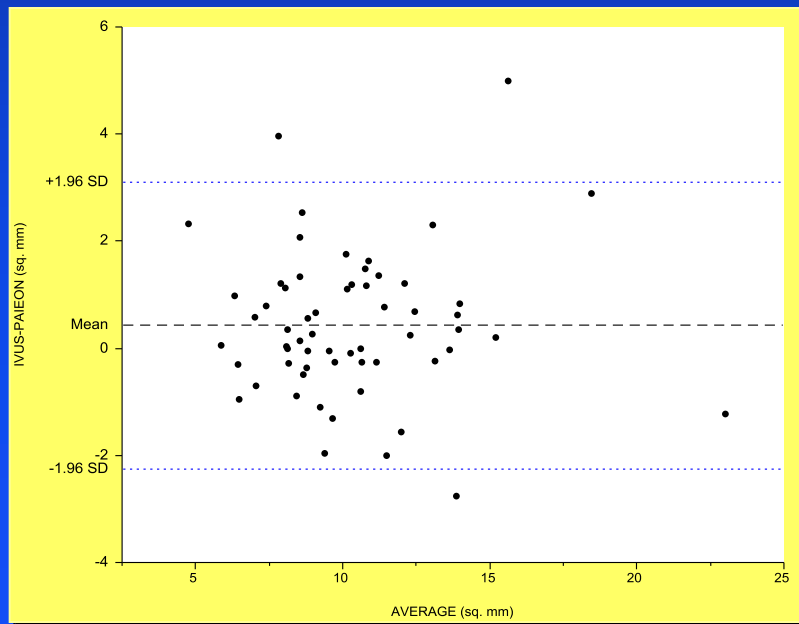
Results: Stent Lumen Area, IVUS vs 3D QCA





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Conclusions

- Intravascular ultrasound can accurately determine LM lesion significance, guide stent optimization and may improve outcome
- However, IVUS carries additional risk to the patient, is time consuming and its cost-effectiveness in the DES era have been questioned by some
- 3D quantitative coronary angiography (3D QCA) is recently validated, novel imaging tool that allows 3D coronary digital reconstruction without posing any additional risk to the patient

Conclusions

- There is a good agreement between measurement of stent/vessel diameter and area of the left main using 3D QCA reconstruction as compared to IVUS
- 3D QCA could potentially be used to determine severity of LM disease and help guide left main intervention without the additional risk or cost associated with intravascular ultrasound

Thanks for your attention