Why IVUS is my favoured modality to guide Left Main PCI ?

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Disclosure Statement of Financial Interest

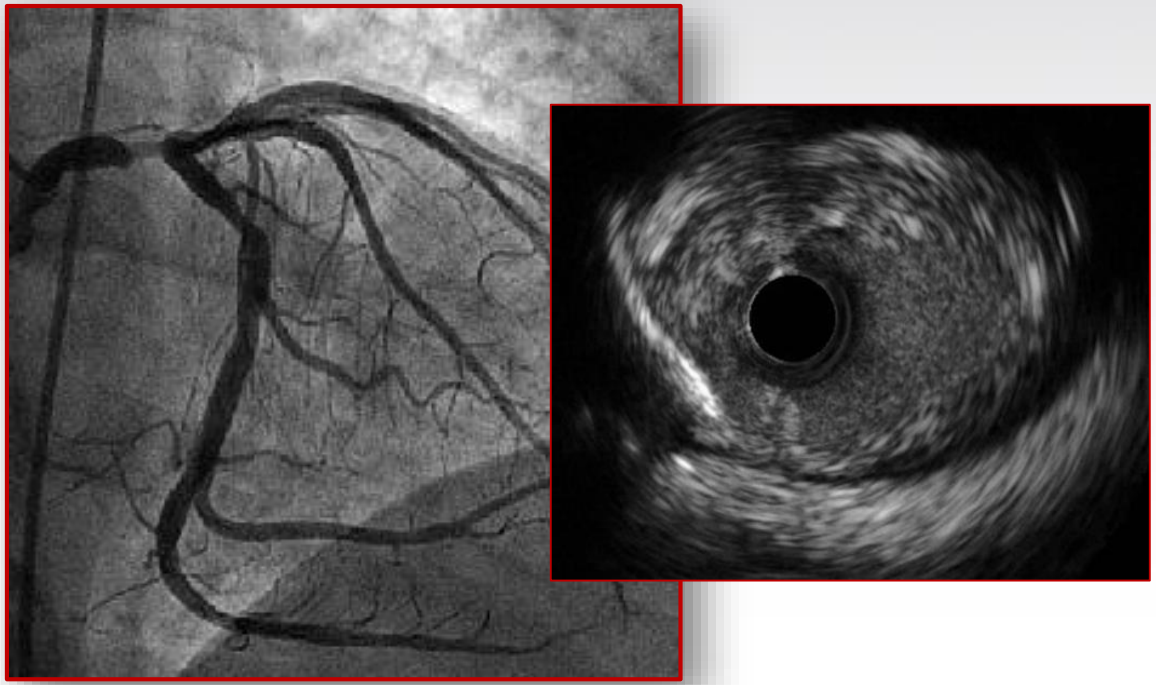
I, Jose M de la Torre Hernandez, have a financial interest/arrangement or affiliation with one or more organizations that could be perceived as a real or apparent conflict of interest in the context of the subject of this presentation:

Receipt of honoraria or consultation fees: Boston Scientific

Receipt of grants / research supports: Philips-Volcano

DIAGNOSIS INTERVENTION

Assessment	Guidance	Optimization

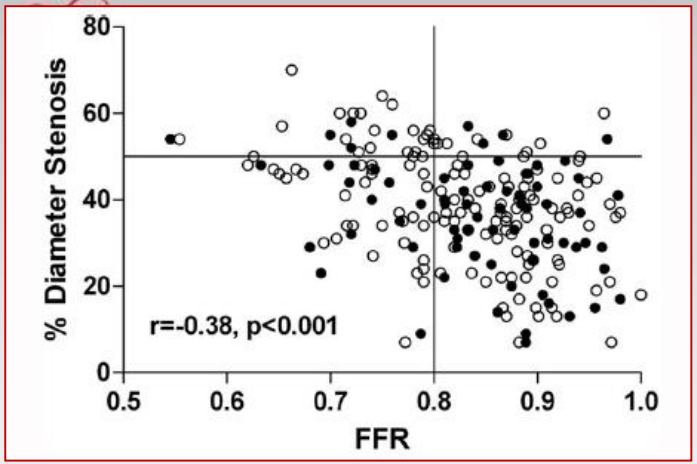


2018 ESC/EACTS Guidelines on myocardial revascularization

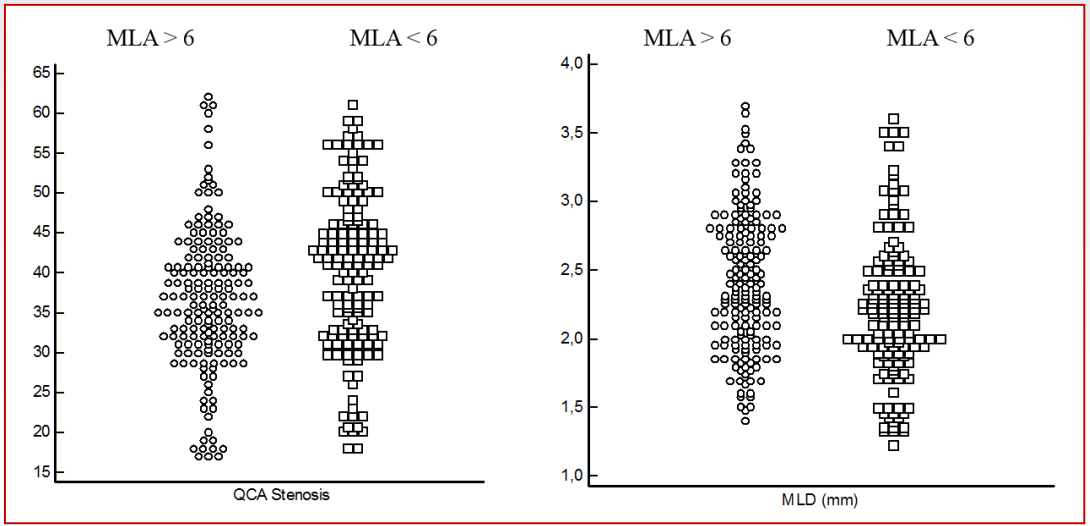
Recommendations on functional testing and intravascular imaging for lesion assessment

Recommendations	Class[a]	Level[b]
When evidence of ischaemia is not available, FFR or iwFR are recommended to assess the haemodynamic relevance of intermediate-grade stenosis.[15,17,18,39]	I	A
FFR-guided PCI should be considered in patients with multivessel disease undergoing PCI.[29,31]	IIa	B
IVUS should be considered to assess the severity of unprotected left main lesions.[35–37]	IIa	B

Ambiguity and inaccuracy of angiography for assessment of LM stenosis severity



Hamilos M, et al. Circulation 2009;120:1505-12



De la Torre Hernandez, et al.
J Am Coll Cardiol 2011; 8:351-8

LM

MLA = 6 mm²

Prospective Application of Pre-Defined Intravascular Ultrasound Criteria for Assessment of Intermediate Left Main Coronary Artery Lesions

Results From the Multicenter LITRO Study

De la Torre Hernandez, et al. J Am Coll Cardiol 2011; 58:351-8

Proximal LAD

MLA= 3 mm²

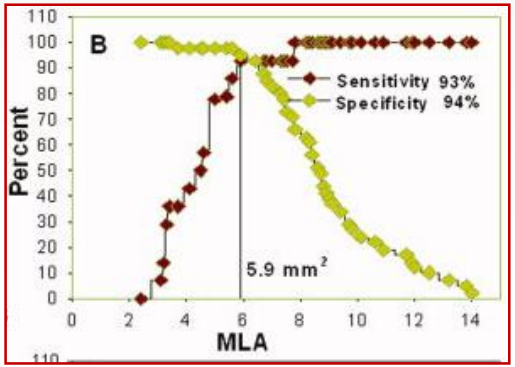
Proximal LCx

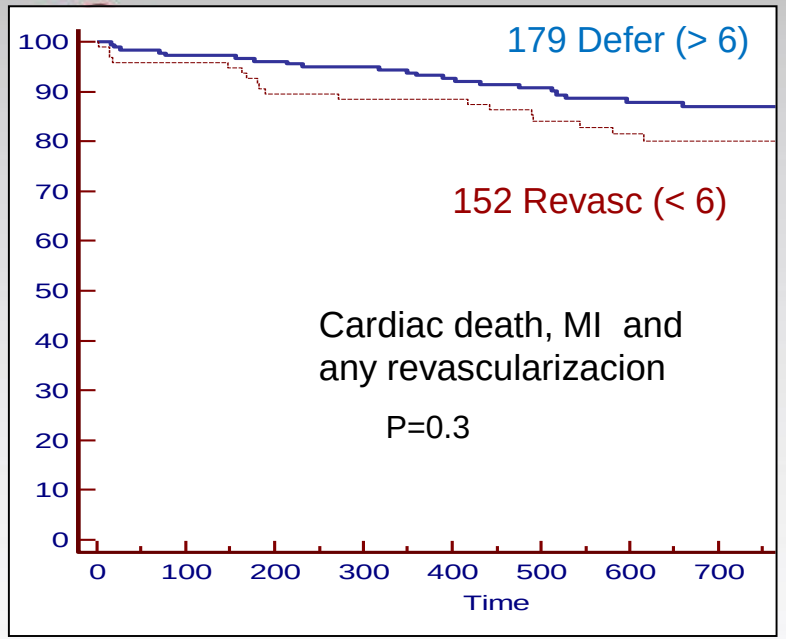
MLA= 3 mm²

Linear law (epicardial coronary artery)
Do = 0.678*(D1+D2)

Finet G et al. Eurointervention 2007;3:10-17

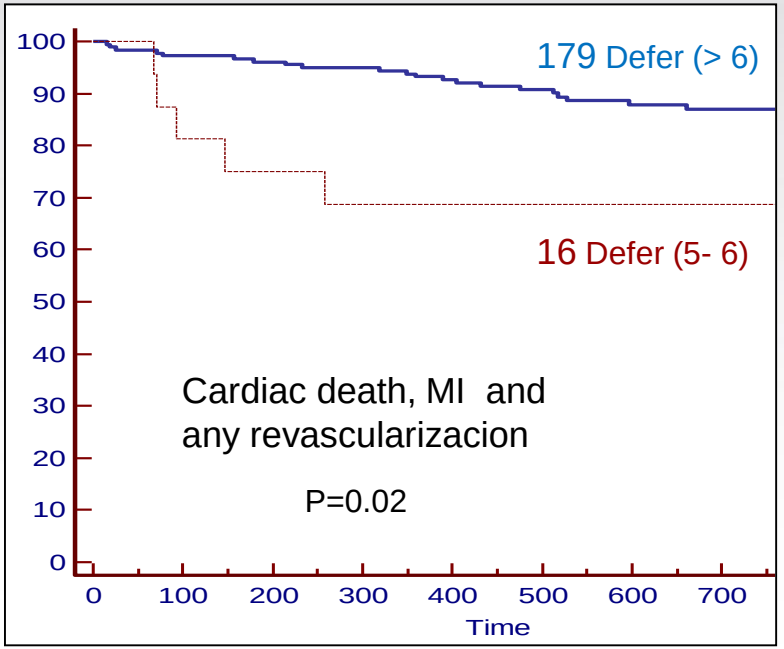
Jasti et al. Circulation 2004;110:2831-6





Prospective Application of Pre-Defined Intravascular Ultrasound Criteria for Assessment of Intermediate Left Main Coronary Artery Lesions

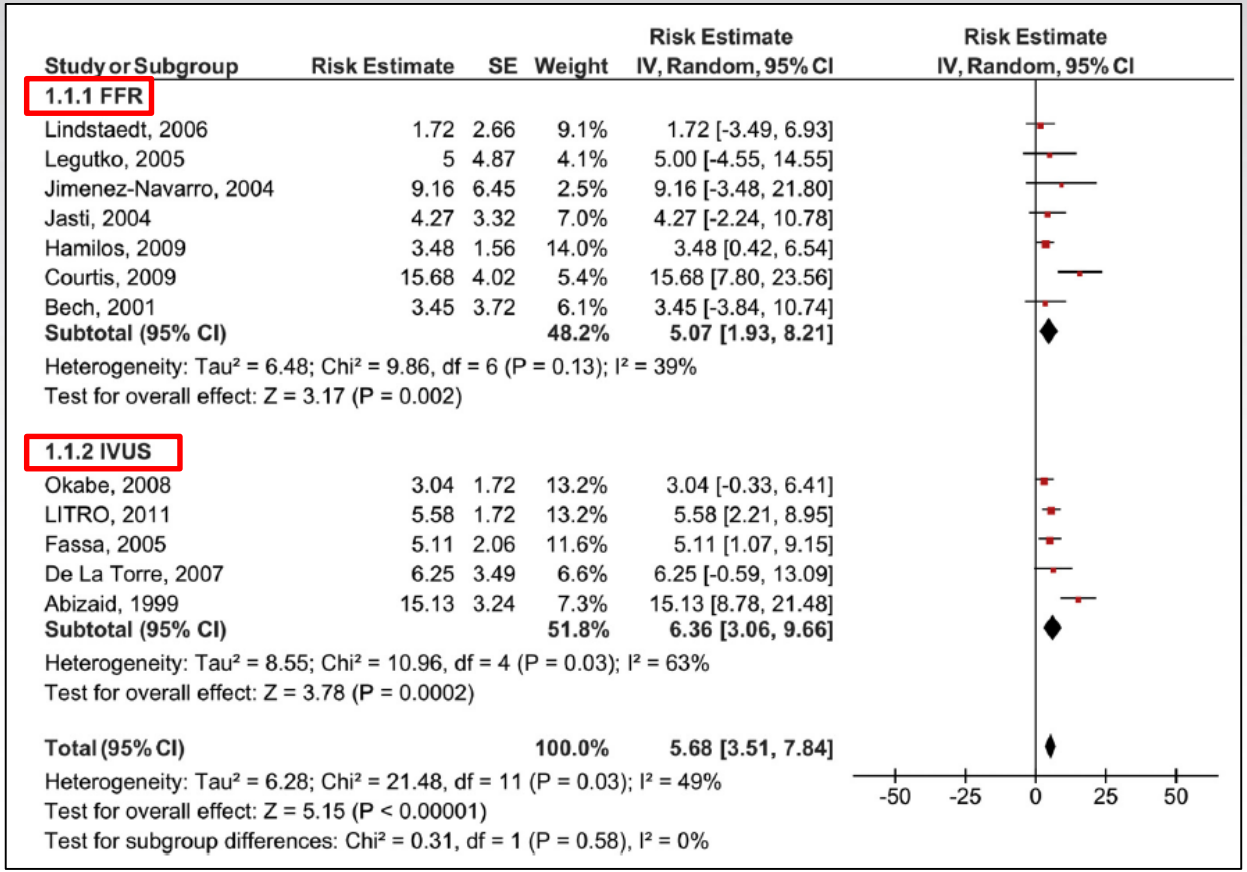
Results From the Multicenter LITRO Study



De la Torre Hernandez, et al. J Am Coll Cardiol 2011; 58:351-8

IVUS vs FFR based deferral of LM intervention

Pooling of per year follow-up occurrence of overall MACE



Cerrato E, et al
Intl J Cardiol 2018;271:42-9

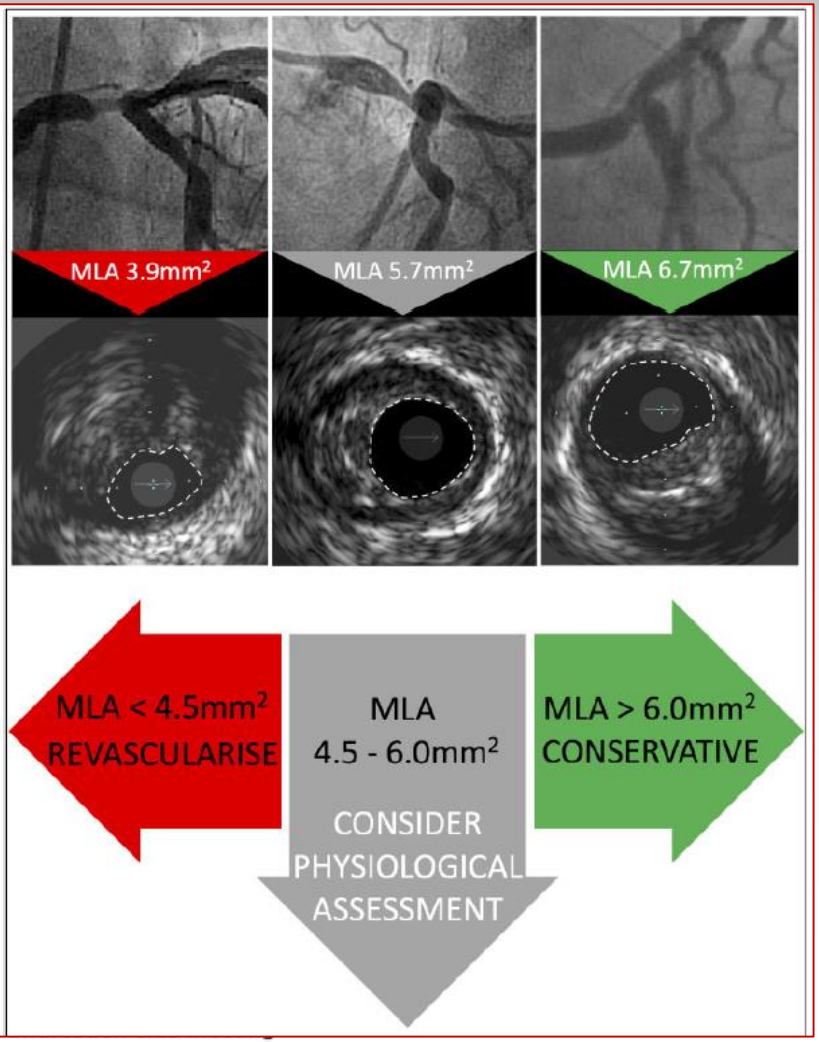
ESC European Society of Cardiology
European Heart Journal (2019) 0, 1–19
doi:10.1093/eurheartj/ehz332

FASTTRACK CLINICAL RESEARCH
Interventional cardiology

Clinical use of intracoronary imaging. Part 2: acute coronary syndromes, ambiguous coronary angiography findings, and guiding interventional decision-making: an expert consensus document of the European Association of Percutaneous Cardiovascular Interventions

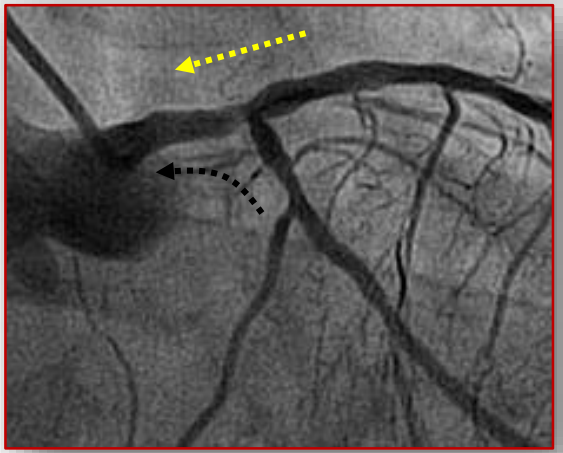
Endorsed by the Chinese Society of Cardiology, the Hong Kong Society of Transcatheter Endocardiovascular Therapeutics (HKSTENT) and the Cardiac Society of Australia and New Zealand

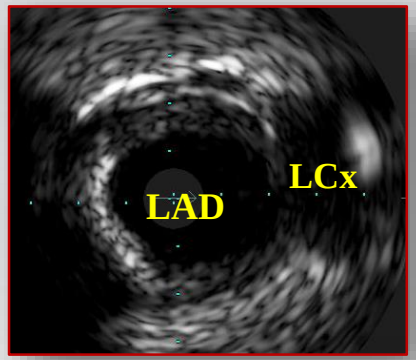
Thomas W. Johnson [1], Lorenz Räber[2], Carlo di Mario[3], Christos Bourantas[4], Haibo Jia[5], Alessio Mattesini[4], Nieves Gonzalo [6], Jose M. de la Torre Hernandez[7], Francesco Prati[8], Konstantinos Koskinas[2], Michael Joner[9], Maria D. Radu [10], David Erlinge [11], Evelyn Regar[12], Vijay Kunadian[13], Akiko Maehara[14], Robert A. Byrne [9], Davide Capodanno[15], Takashi Akasaka[16], William Wijns[17], Gary S. Mintz[14], and Giulio Guagliumi[18]*

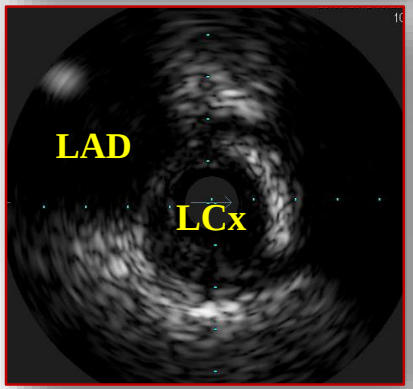


Assessment of LAD and LCx ostium in distal LM disease

MLA LAD = 7 mm^2
MLA LCx = ??



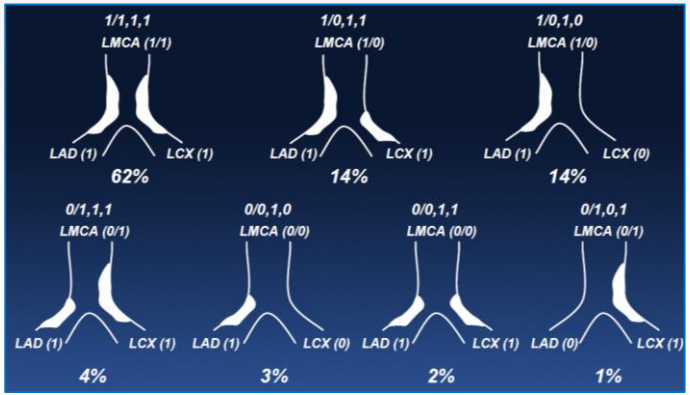




MLA LCx = 3.2 mm^2
MLA LAD = ??

ANGIO

	+PV	-PV
Ostial LAD		
Plaque burden > 70%	*41%*	*87%*
MLA < 4 mm^2	*47%*	*83%*
Ostial LCx		
Plaque burden > 70%	*14%*	*94%*
MLA < 4 mm^2	*52%*	*75%*



Oviedo et al. Circ Cardiovasc Interv. 2010;3:105-12

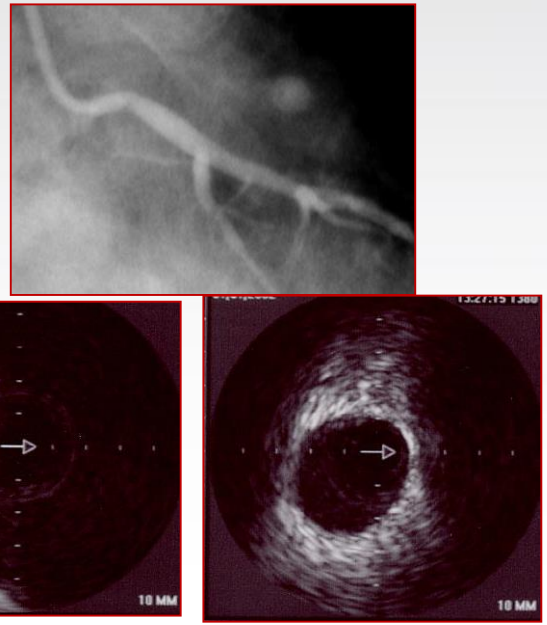
Unmasking angiographic artifacts

IVUS Free of disease

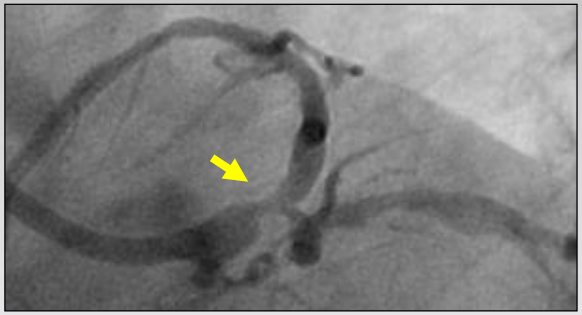
≠

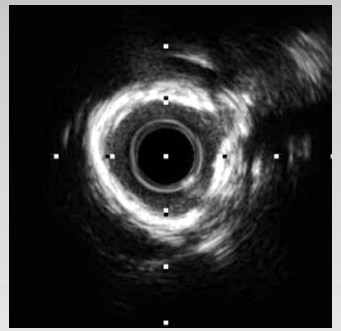
FFR > 0.8

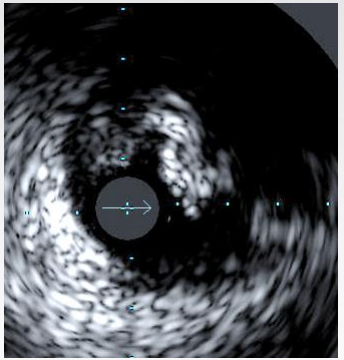
Different clinical implications

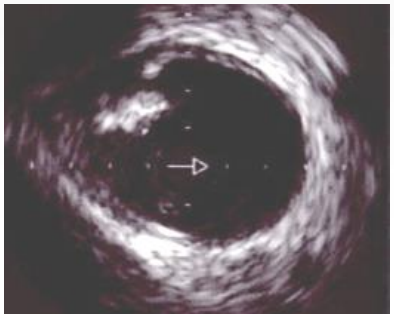


Plaque
Morphology
Composition

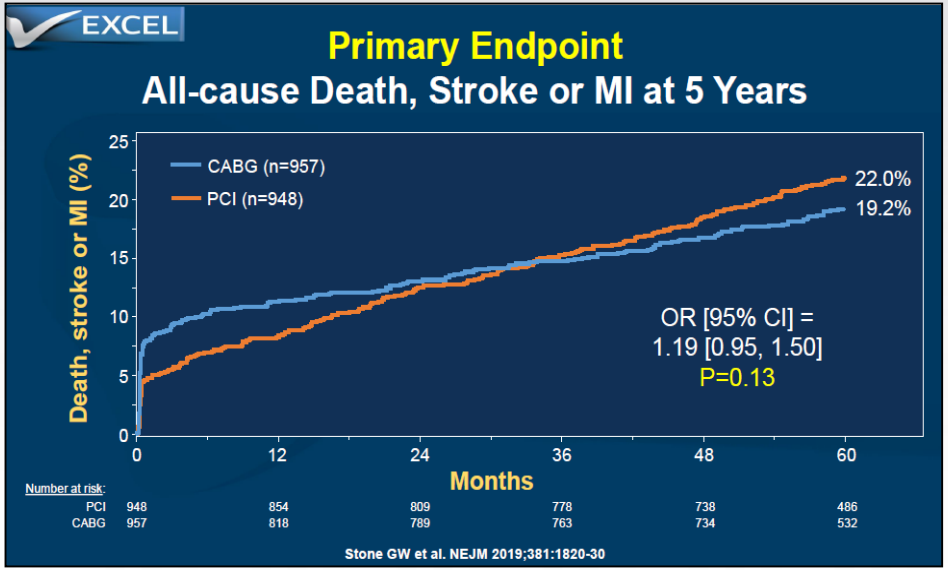


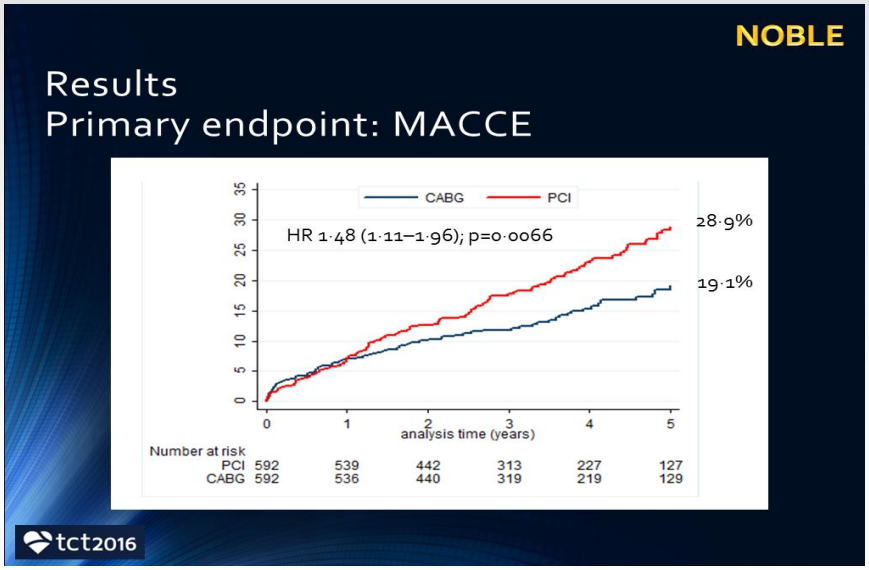






LM PCI is associated wih an accrual of hard events





We need to optimize the most the results of the PCI in the LM

Adequate clinical indication (*Heart Team, Guidelines, Evidences*)
Refined plaque modification techniques (*calcification*)
Best evidence-supported DES
Appropriate stenting approaches (*distal LM*)
Intravascular imaging (IVUS)
Optimal medical therapy after PCI

IVUS guidance for LM PCI is very helpful for:

Planning PCI strategy: -1 vs. 2 stents

Plaque preparation: -Assessment of calcification

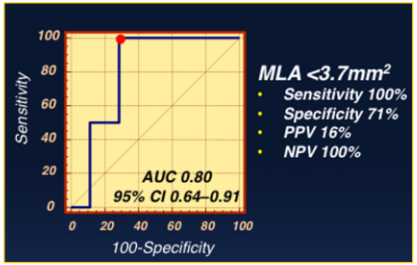
Device sizing:
-Predilatation balloon sizing
-Stent sizing
-POT balloon sizing

Optimizing results:
-Adequate stent expansión and full lesion coverage
-Complete stent apposition
-Stent edge (dissection, plaque burden)
-Stent deformation (proximal edge)

Preference for provisional stenting

LM to LAD stent

-Small LCx
-No LCx disease (< 50%) (1,0,0) (1,1,0)
-Lesion in ostial LCx extending < 5 mm
-Wide angle LAD / LCx
-No significant ostial LCx disease by IVUS (MLA > 3.5 mm^2 and PB < 50%)



Kang et al. Cath Cardiovasc Interv 2014 ;83:545-52

LM to LCx stent

LAD ostium free of disease or mildly affected by IVUS, and LCx with significant lesion in dominant or > 2.5mm vessel

De la Torre Hernandez JM. Interventional Cardiology Clinics. July 2015

Preference for 2-stents technique

No small LCx with any of the following:

-Significant and long (> 5 mm) lesion in ostial LCx (1,1,1) (0,1,1) (1,0,1)
-Complex lesion in ostial LCx
-Narrow angle LAD / LCx
-Significant ostial LCx disease by IVUS (MLA < 3.5 mm^2 and PB > 50%)

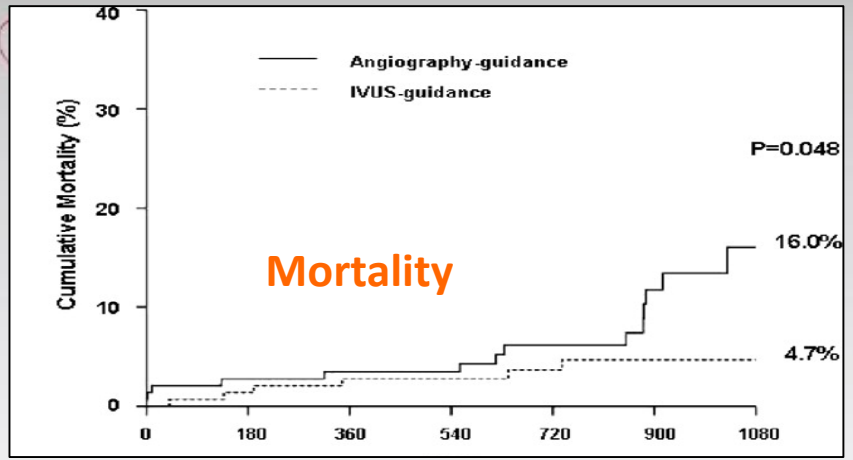
Poor result after provisional stenting:

- stenosis > 75%
- reduced flow (TIMI flow < III)
- dissection
- FFR < 0.8 / iFR < 0.9

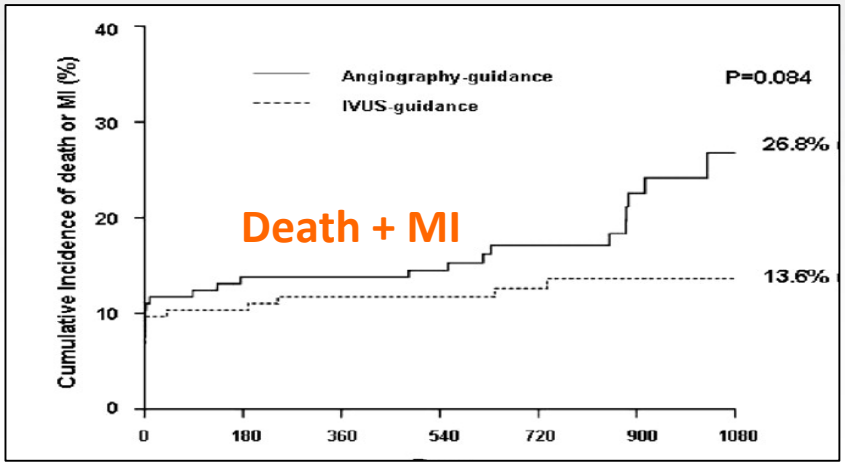
De la Torre Hernandez JM. Interventional Cardiology Clinics. July 2015

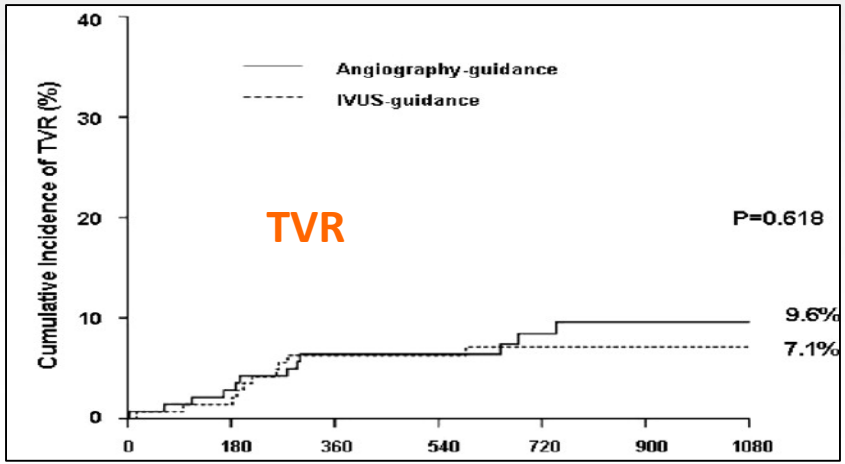
IVUS in LM PCI with DES

The Korean experience



Outcomes in 145 propensity-matched pairs of patients receiving DES with and without IVUS guidance





Park S et al. Circ Cardiovasc Interv 2009;2:167-177

Clinical Impact of Intravascular Ultrasound Guidance in Drug-Eluting Stent Implantation for Unprotected Left Main Coronary Disease

Pooled Analysis at the Patient-Level of 4 Registries

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Tamara Garcia Camarero, MD,* Federico Gimeno de Carlos, MD, PHD,‖
Gerard Roura Ferrer, MD,‡ Angel Sanchez Recalde, MD,¶
Íñigo Lozano Martínez-Luengas, MD, PHD,# Josep Gomez Lara, MD,‡
Felipe Hernandez Hernandez, MD,** María J. Pérez-Vizcayno, MD,§
Angel Cequier Fillat, MD, PHD,‡ Armando Perez de Prado, MD,††
Agustín Albarrán Gonzalez-Trevilla, MD,** Manuel F. Jimenez Navarro, MD, PHD,‡‡
Josepa Mauri Ferre, MD,§§ Jose A. Fernandez Diaz, MD,‖‖
Eduardo Pinar Bermudez, MD, PHD,¶¶ Javier Zueco Gil, MD,*
on behalf of the collaborative IVUS-TRONCO-ICP Spanish study

IVUS in LM PCI with DES

The Spanish experience

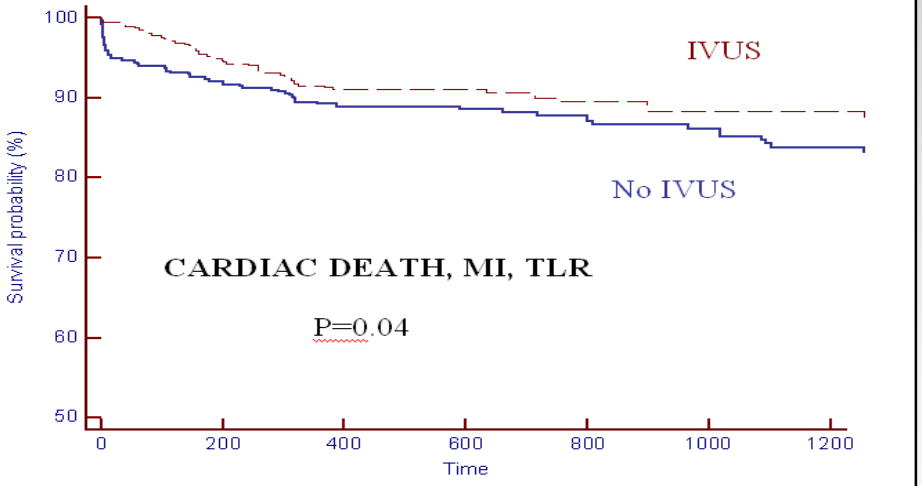
1.670 pts with DES in LM

505 pts with IVUS

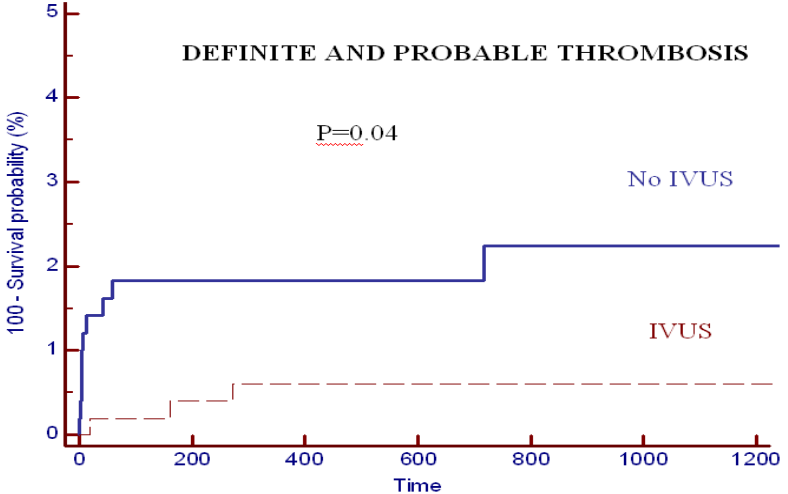
PS matched with

505 pts without IVUS

De la Torre Hernandez et al. J Am Coll Cardiol Intv 2014;7:244–54



Pts. at risk	365 days	730 days	1095 days
IVUS	485	286	203
No IVUS	470	275	201



Pts. at risk	365 days	730 days	1095 days
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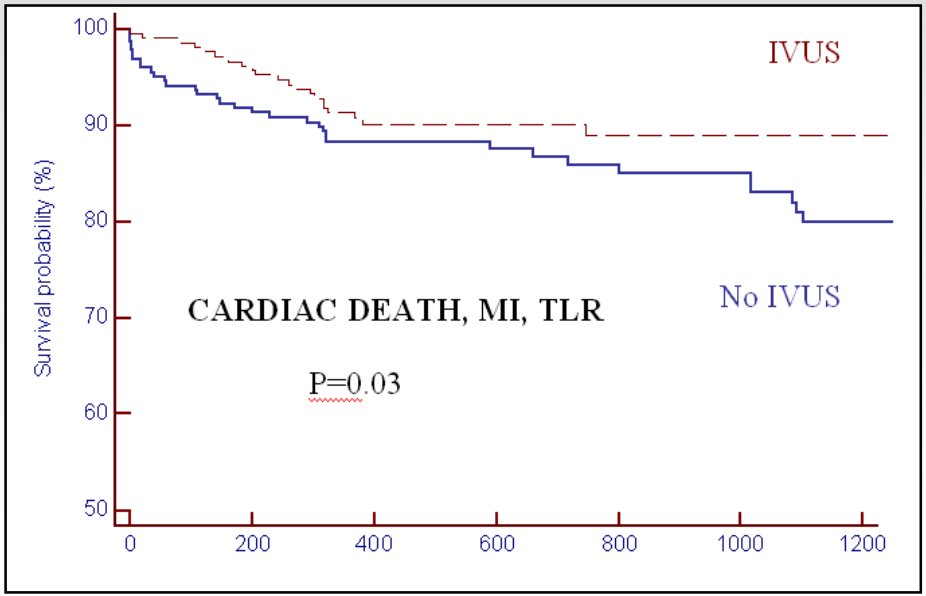
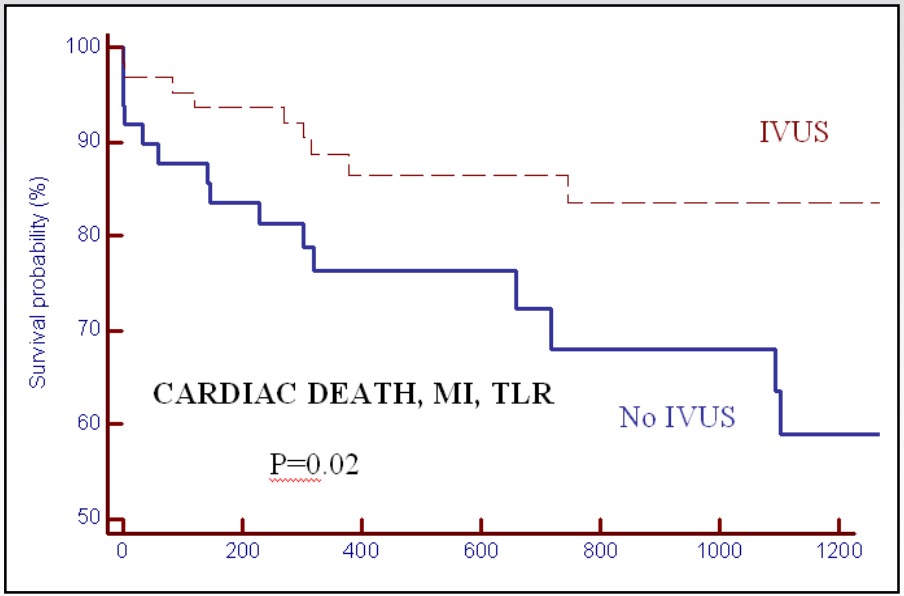
No IVUS	470	275	201

De la Torre Hernandez et al. J Am Coll Cardiol Intv 2014;7:244–54

LM distal subgroup



LM distal-2 stents subgroup



De la Torre Hernandez et al. J Am Coll Cardiol Intv 2014;7:244–54

IVUS as predictor of outcome

(Cardiac death, MI, TLR)

Overall population

	HR	95% CI	p
IVUS	**0.70**	**0.52 – 0.99**	**0.04**
Age	1.03	1.01 – 1.05	0.0001
LVEF	0.98	0.97 – 0.99	0.01
Diabetes	1.81	1.32 – 2.47	0.0002
Distal LM with 2 stents	2.23	1.44 – 3.48	0.0004
ACS	1.84	1.30 – 2.60	0.0006

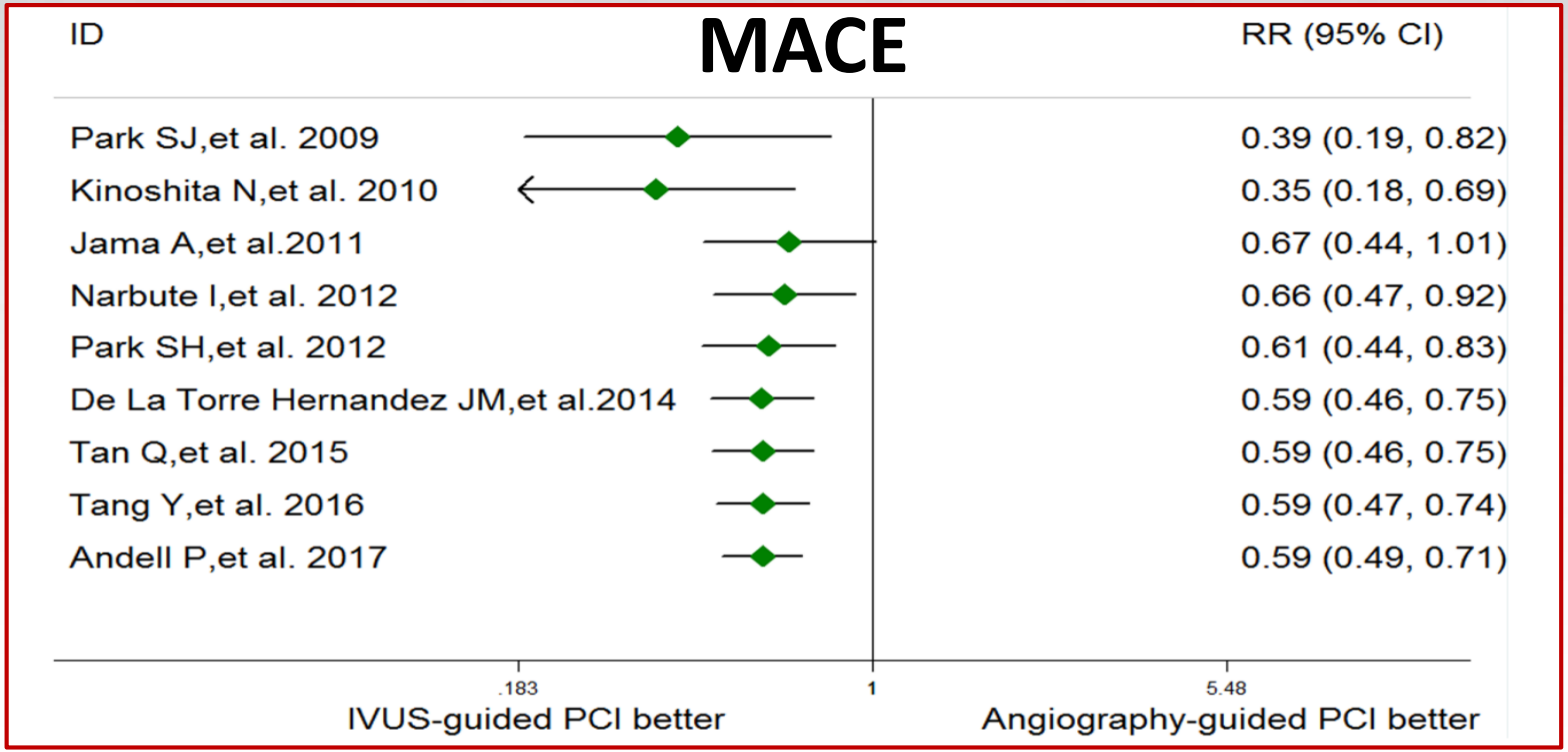
Subgroup with distal LM disease

	HR	95% CI	p
IVUS	**0.54**	**0.34 – 0.90**	**0.02**
Age	1.02	1.004 – 1.05	0.02
Diabetes	1.62	1.02 – 2.59	0.04
Distal LM with 2 stents	2.86	1.71 – 4.77	0.0001
ACS	1.95	1.14 – 3.31	0.01

IVUS makes a difference in LM stent sizing and postdilatation

Stent diameter	No IVUS *1,165 pts*	IVUS *505 pts*
4.5 mm	4%	17%
4 mm	19%	37%
3.5 mm	48%	38%
3 mm	29%	8%
Post-dilatation	**44%**	**57%** (+0.5 mm)

Meta-analysis shows consistent benefits for IVUS guided LM PCI

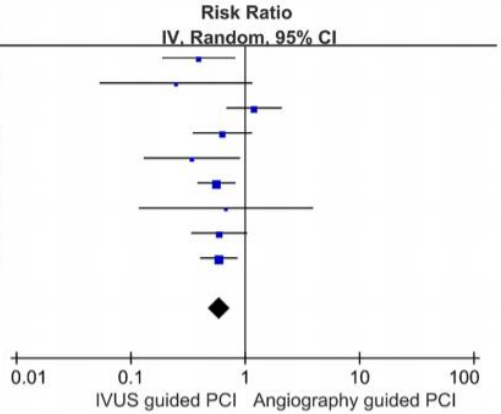


Ye Y, et al. PLoS ONE 12(6): e0179756.

Mortality

Study or Subgroup	IVUS guided PCI Events	Total	Angiography guided PCI Events	Total	Weight	Risk Ratio IV, Random, 95% CI	Year
Park SJ, et al. 2009	9	145	23	145	8.3%	0.39 [0.19, 0.82]	2009
Kinoshita N, et al. 2010	2	228	8	226	2.1%	0.25 [0.05, 1.15]	2010
Jama A, et al.2011	18	111	25	184	13.1%	1.19 [0.68, 2.09]	2011
Narbute I, et al. 2012	13	294	47	671	11.7%	0.63 [0.35, 1.15]	2012
Park SH, et al. 2012	5	90	15	92	5.1%	0.34 [0.13, 0.90]	2012
De La Torre Hernandez JM, et al.2014	37	505	66	505	22.3%	0.56 [0.38, 0.82]	2014
Tan Q, et al. 2015	2	61	3	62	1.6%	0.68 [0.12, 3.91]	2015
Tang Y, et al. 2016	16	713	45	1186	12.9%	0.59 [0.34, 1.04]	2016
Andell P, et al. 2017	37	340	63	340	22.8%	0.59 [0.40, 0.86]	2016
Total (95% CI)		**2487**		**3411**	**100.0%**	**0.60 [0.47, 0.75]**	
Total events	139		295				

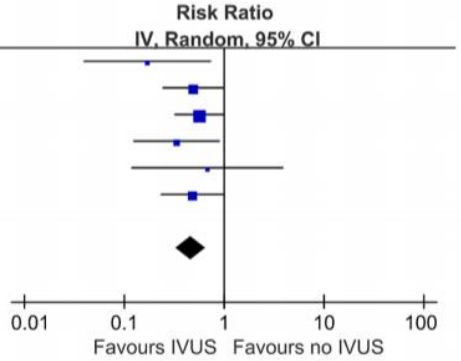
Heterogeneity: Tau² = 0.02; Chi² = 9.89, df = 8 (P = 0.27); I² = 19%
Test for overall effect: Z = 4.45 (P < 0.00001)

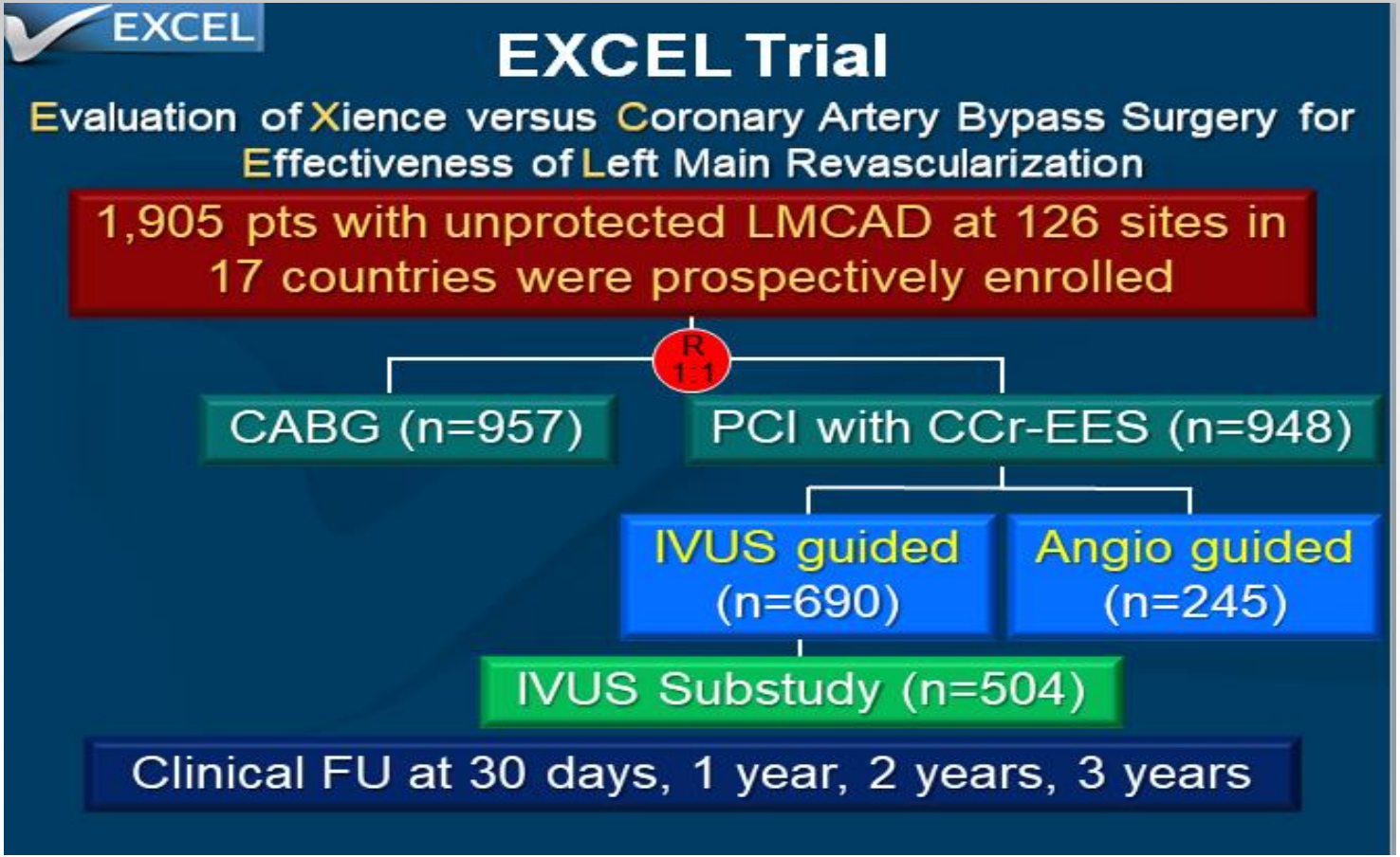


Cardiac mortality

Study or Subgroup	IVUS guided PCI Events	Total	Angiography guided PCI Events	Total	Weight	Risk Ratio IV, Random, 95% CI	Year
Park SH, et al. 2012	2	90	12	92	5.4%	0.17 [0.04, 0.74]	2012
Narbute I, et al. 2012	9	294	42	671	23.3%	0.49 [0.24, 0.99]	2012
De La Torre Hernandez JM, et al.2014	17	505	30	505	34.4%	0.57 [0.32, 1.01]	2014
Gao XF, et al. 2014	5	291	15	291	11.7%	0.33 [0.12, 0.91]	2014
Tan Q, et al. 2015	2	61	3	62	3.8%	0.68 [0.12, 3.91]	2015
Tang Y, et al. 2016	9	713	31	1186	21.5%	0.48 [0.23, 1.01]	2016
Total (95% CI)		**1954**		**2807**	**100.0%**	**0.47 [0.33, 0.66]**	
Total events	44		133				

Heterogeneity: Tau² = 0.00; Chi² = 2.87, df = 5 (P = 0.72); I² = 0%
Test for overall effect: Z = 4.35 (P < 0.0001)




EXCEL
EXCEL Trial
Evaluation of Xience versus Coronary Artery Bypass Surgery for Effectiveness of Left Main Revascularization
1,905 pts with unprotected LMCAD at 126 sites in 17 countries were prospectively enrolled
R 1:1
CABG (n=957)
PCI with CCr-EES (n=948)
IVUS guided (n=690)
Angio guided (n=245)
IVUS Substudy (n=504)
Clinical FU at 30 days, 1 year, 2 years, 3 years

3-Year Outcomes

IVUS MSA tertiles (range)	Low: 4.4-8.7 (n=172)	Inter: 8.8-10.9 (n=169)	High: 11.0-17.8 (n=163)	P L vs I	P L vs H
Death/MI/stroke	19.4% (32)	16.1% (26)	9.6% (15)	0.45	0.01
Death/MI/stroke/IDR*	26.6% (44)	23.8% (39)	18.3% (29)	0.66	0.08
All cause death	13.8% (22)	10.0% (16)	5.2% (8)	0.34	0.01
Cardiovascular death	7.4% (12)	4.8% (8)	4.0% (6)	0.39	0.16
MI	10.5% (17)	8.2% (13)	3.7% (6)	0.49	0.02
Stroke	1.8% (3)	1.2% (2)	2.1% (3)	0.66	0.98
Stent thrombosis (D/P)	3.1% (5)	1.2% (2)	0.0% (0)	0.26	0.03
Left main IDR	12.0% (19)	8.3% (13)	8.8% (14)	0.30	0.41
Non-TV IDR	1.9% (3)	3.3% (5)	1.3% (2)	0.48	0.65

CORONARY INTERVENTIONS

Intravascular ultrasound to guide left main stem intervention: a NOBLE trial substudy

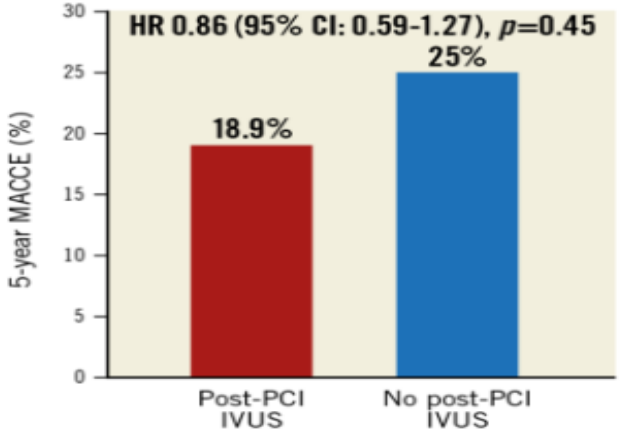
EuroIntervention 2020;16:201-209. DOI: 10.4244/EIJ-D-19-01003

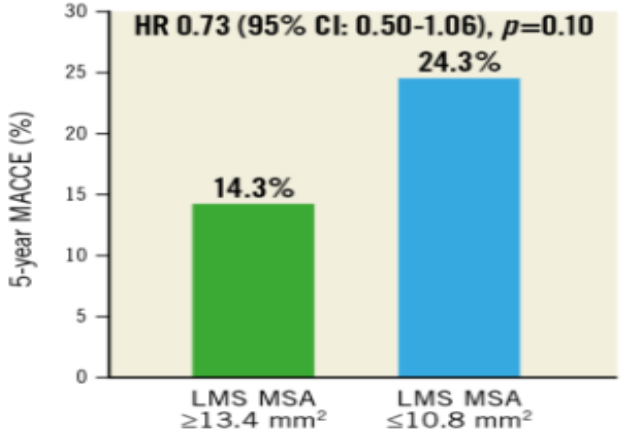
Andrew Ladwiniec[1], MD; Simon J. Walsh[2], MD; Niels Ramsing Holm[3], MD; Colm G. Hanratty[2], MD; Timo Mäkikallio[4], MD; Thomas Kellerth[5], MD; David Hildick-Smith[6], MD; Lone J.H. Mogensen[3], MStat; Juha Hartikainen[7], MD, PhD; Ian B.A. Menown[8], MD, PhD; Andrejs Erglis[9], MD, FRCP; Erlend Eriksen[10], MD, PhD; Mark S. Spence[2], MD; Leif Thuesen[11], MD, DMSc; Evald Høj Christiansen[3], MD, PhD

The NOBLE trial randomised patients with LMS disease to treatment by PCI or CABG.

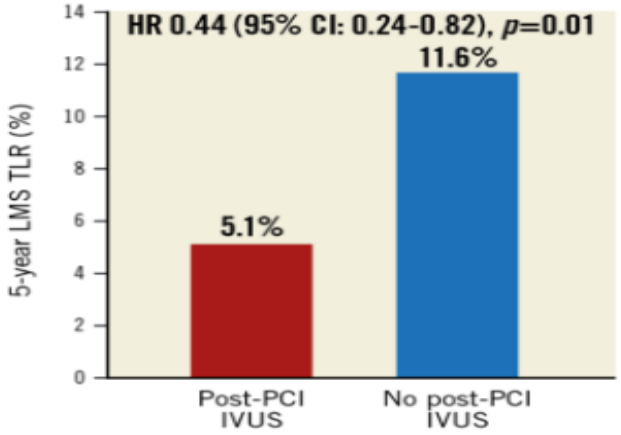
Of 603 patients treated by PCI, 435 (72%) underwent post-PCI IVUS assessment, 224 of which were analysed in a core laboratory.

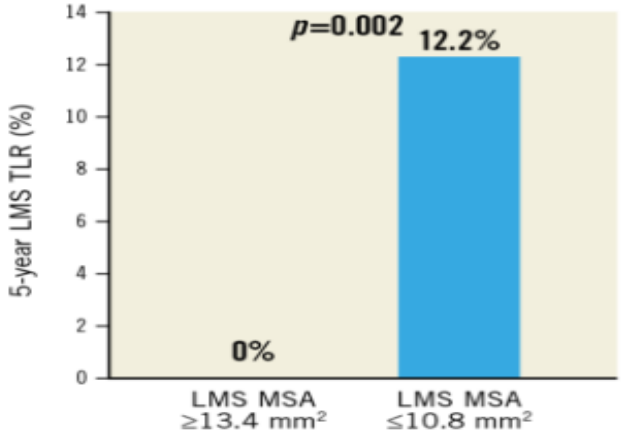
5 years MACCE





5 years LM-TLR





Intravascular Imaging and 12-Month Mortality After Unprotected Left Main Stem PCI

An Analysis From the British Cardiovascular Intervention Society Database

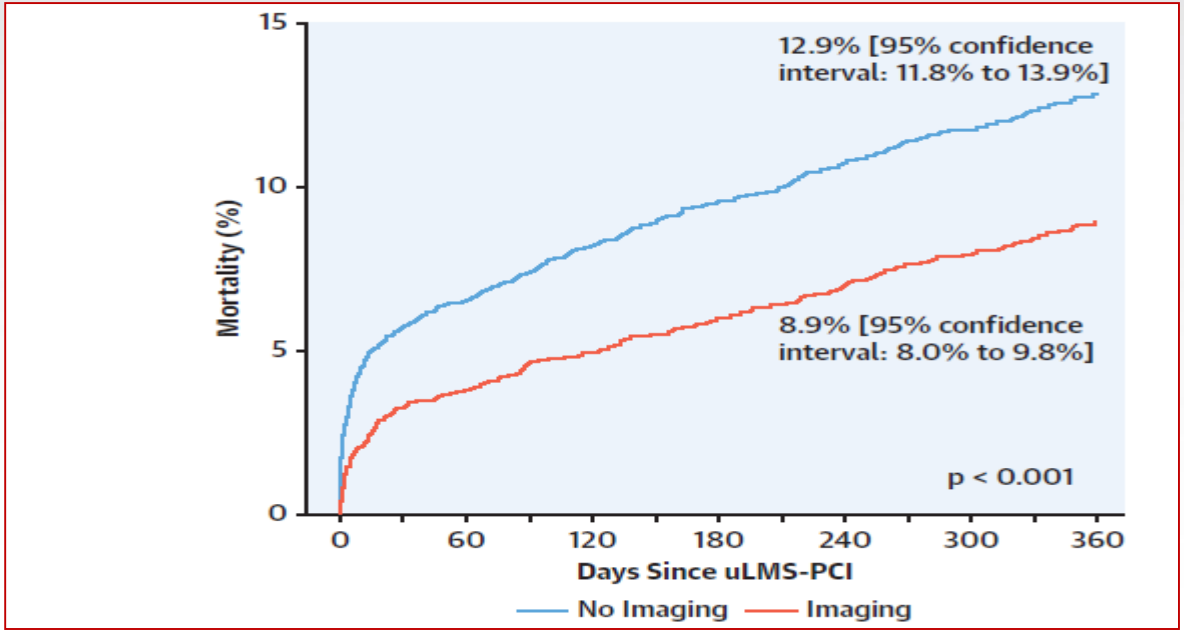
Tim Kinnaird, MD,[a,b] Thomas Johnson, PhD,[c] Richard Anderson, MD,[a] Sean Gallagher, MD,[a] Alex Sirker, PhD,[d] Peter Ludman, MD,[e] Mark de Belder, MD,[f] Samuel Copt, PhD,[g] Keith Oldroyd, MD,[h] Adrian Banning, MD,[i] Mamas Mamas, DPhil.,[a,j] Nick Curzen, PhD[k]

Kinnaird, T. et al. J Am Coll Cardiol Intv. 2020;13(3):346-57.

LM PCI
11,264

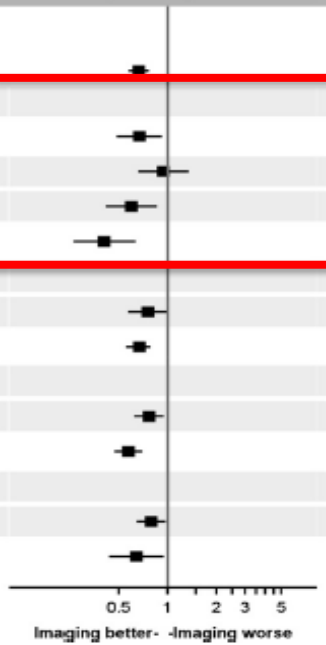
No imaging
6,208

Imaging
5,056



Subgroup Analysis of 12-Month Mortality by Imaging Use

Subgroup	Count	Imaging N (%)	No Imaging N (%)	Odds ratio (95% CI)	Interaction p-value
Overall	7,864	335 (9.01%)	538 (12.98%)	0.663 (0.574:0.766)	
Quartiles					0.0351
Q1	1,281	75 (19.41%)	103 (16.32%)	0.669 (0.485:0.921)	
Q2	1,206	60 (10.87%)	75 (11.47%)	0.941 (0.657:1.35)	
Q3	1,121	52 (9.89%)	92 (15.46%)	0.6 (0.417:0.862)	
Q4	1,192	32 (5.07%)	65 (11.59%)	0.408 (0.263:0.633)	
ACS					0.4058
No	3,516	91 (5.21%)	120 (6.78%)	0.757 (0.572:1.002)	
Yes	4,346	244 (12.35%)	418 (17.63%)	0.669 (0.555:0.781)	
Left Main + LAD					0.048
No	3,889	157 (9.33%)	261 (11.83%)	0.768 (0.623:0.946)	
Yes	3,975	178 (4.48%)	277 (14.3%)	0.574 (0.47:0.7)	
EF < 30					0.3585
No	4,471	187 (8.25%)	225 (10.2%)	0.792 (0.646:0.97)	
Yes	583	55 (20%)	83 (27.92%)	0.645 (0.439:0.95)	



Operator volume increases the IVUS-related prognostic advantage

Adjusted Clinical Outcomes by Imaging Status for uLMS PCI

	OR for Imaging vs. No Imaging	95% CI	p Value
Coronary perforation	0.920	0.590-1.420	0.689
Coronary dissection	0.820	0.690-0.980	0.028
Major side branch loss	0.810	0.540-1.200	0.282
Slow flow	0.510	0.330-0.770	0.001
Any coronary complication	0.780	0.670-0.910	0.001
Acute kidney failure	1.050	0.530-2.080	0.888
In-hospital death	0.390	0.290-0.510	<0.001
In-hospital MACCE	0.470	0.380-0.590	<0.001
In-hospital major bleed	0.890	0.590-1.340	0.565
Mortality at 30 days	0.540	0.430-0.680	<0.001
Mortality at 12 months	0.660	0.570-0.770	<0.001

OPtimizaTIon of Left MAin PCI with IntravascuLar Ultrasound. The OPTIMAL Randomized Controlled Trial

OPTIMAL

¡¡ Enrolling ¡¡

Adrian Banning **Luca Testa** Jose M de la Torre Hernandez

800 patients in approximately 30 sites (UK, Italy, Spain)

Randomized, controlled, multicenter, international, post-market strategy study in patients with indication for PCI of the Left Main coronary artery

Patients will be followed up to 2 years after the index procedure

2018 ESC/EACTS Guidelines on myocardial revascularization

IVUS should be considered to optimize treatment of unprotected left main lesions.[35]	IIa	B

ESC European Society of Cardiology
European Heart Journal (2018) 0, 1–20
doi:10.1093/eurheartj/ehy285

FASTTRACK CLINICAL RESEARCH
Coronary artery disease

Clinical use of intracoronary imaging. Part 1: guidance and optimization of coronary interventions. An expert consensus document of the European Association of Percutaneous Cardiovascular Interventions

Endorsed by the Chinese Society of Cardiology

Lorenz Räber[1], Gary S. Mintz[2], Konstantinos C. Koskinas[1], Thomas W. Johnson[3], Niels R. Holm[4], Yoshinubo Onuma[5], Maria D. Radu[6], Michael Joner[7,8], Bo Yu[9], Haibo Jia[9], Nicolas Menevau[10,11], Jose M. de la Torre Hernandez[12], Javier Escaned[13], Jonathan Hill[14], Francesco Prati[15], Antonio Colombo[16], Carlo di Mario[17], Evelyn Regar[18], Davide Capodanno[19], William Wijns[20], Robert A. Byrne[21], and Giulio Guagliumi[22]*

- **Diagnostic assessment of coronary lesions**

Consensus opinion

Angiographically unclear/ambiguous findings (e.g. dissection, thrombus, calcified nodule)

Assessment of left main stenosis

Complex bifurcation lesions

Suspected culprit lesion of ACS

- **PCI guidance and optimization**

RCT evidence

Long lesions

Chronic total occlusions

Consensus opinion

Patients with acute coronary syndromes

Left main coronary artery lesions

Two stents bifurcation

Implantation of bioresorbable scaffolds

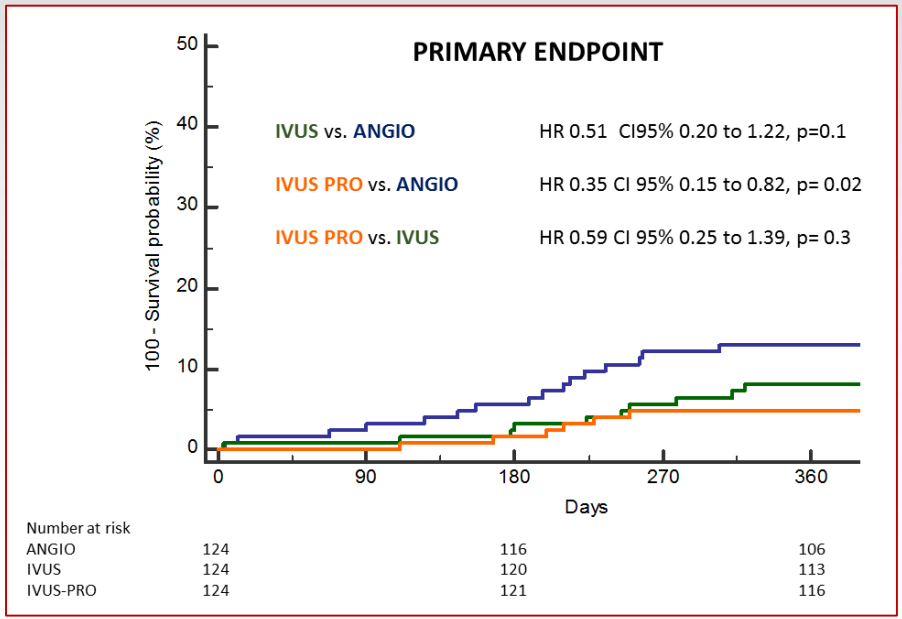
Patients with renal dysfunction (IVUS)

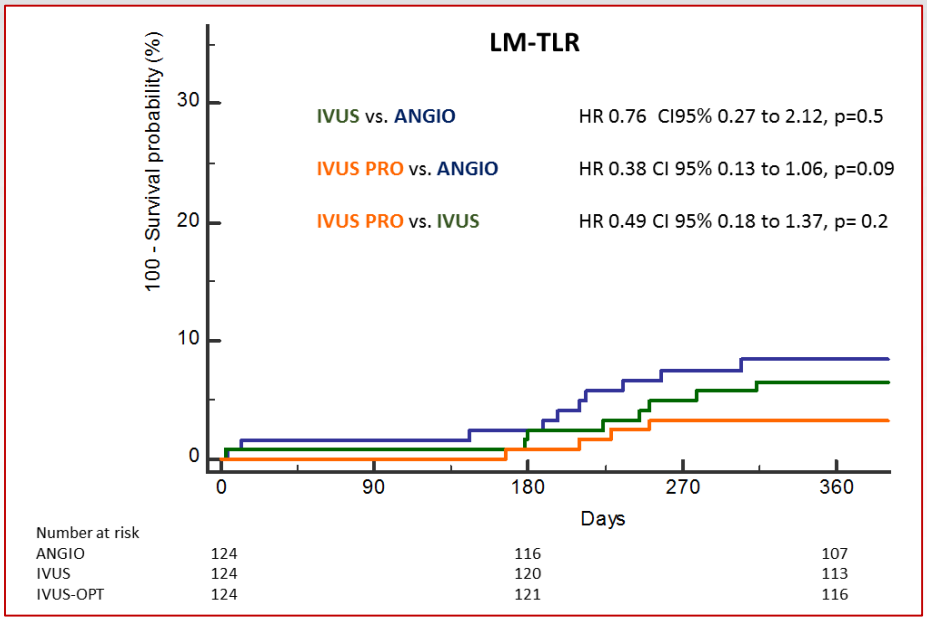
- **Identification of mechanism of stent failure**

Restenosis

Stent thrombosis

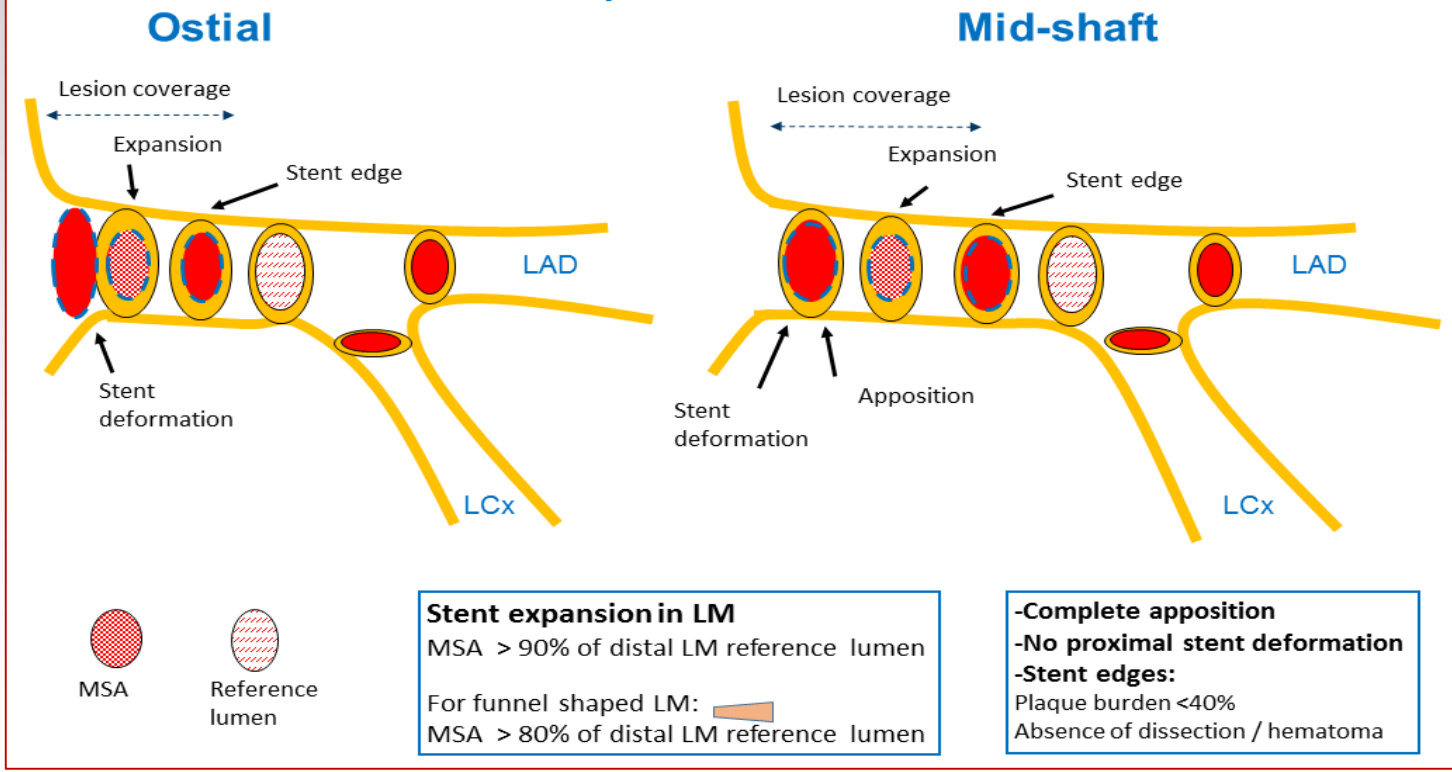
Outcomes of predefined optimisation criteria for intravascular ultrasound guidance of left main stenting





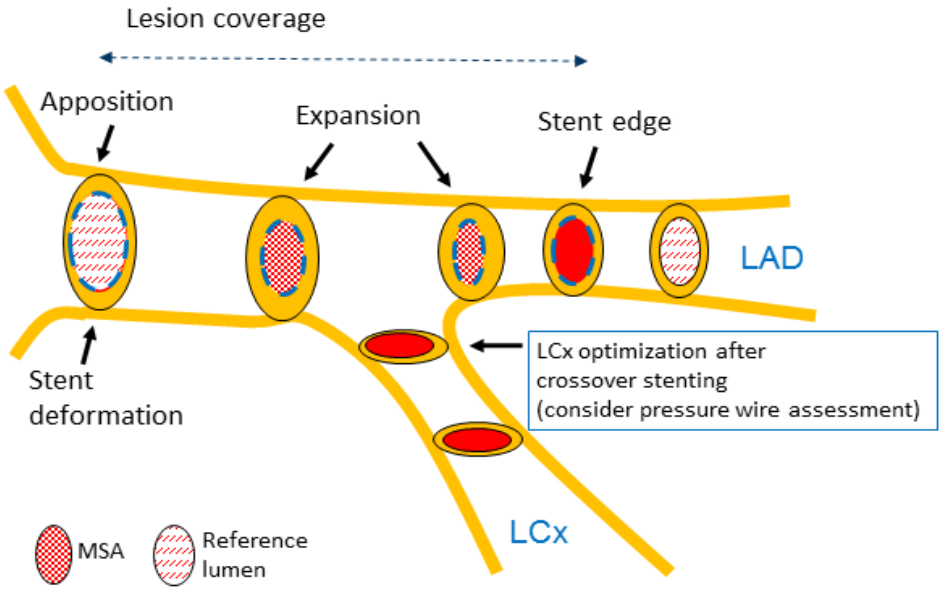
De la Torre Hernández JM et al. EuroIntervention. 2020;16:210-217

IVUS optimization

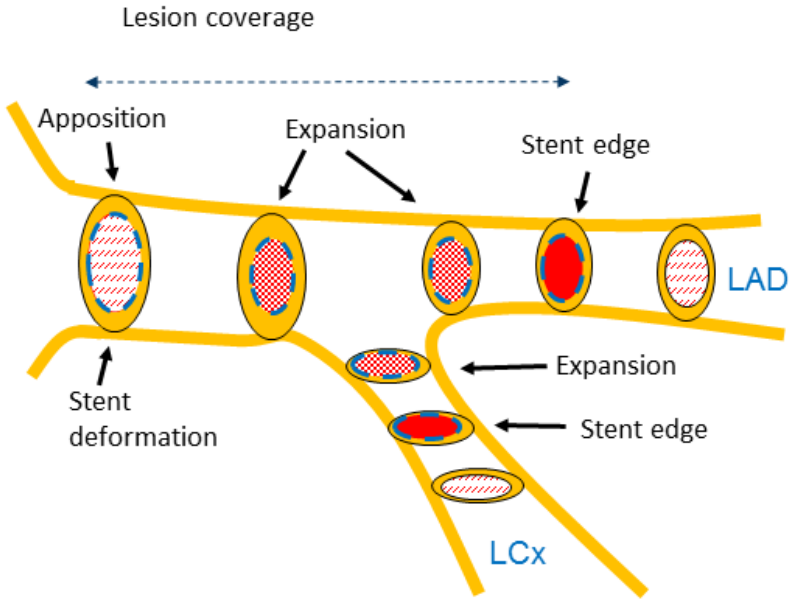


De la Torre Hernández JM et al. EuroIntervention. 2020;16:210-217

Distal (provisional stenting)



Distal (two stents techniques)



Stent expansion in LM
MSA > 90% of proximal LM reference lumen

For tapered LM:
MSA > 80% of proximal LM reference lumen

Stent expansion in LAD
MSA > 90% of proximal LAD reference lumen

Stent expansion in LCx
MSA > 90% of proximal LCx reference lumen

-Complete stent apposition
-No proximal stent deformation
-Stent edges:
Plaque burden <40%
Absence of dissection / hematoma

De la Torre Hernández JM et al. EuroIntervention. 2020;16:210-217

OCT for LM lesions

Concerns and limitations

Large vessel, frequently > 4 mm in size (poor visualization)
Ostial and mid-shaft disease (poor visualization)
Distal disease (floppy catheter, trouble to negotiate access to LCx with angulated take off)
Distal disease in very short and wide LM (poor visualization)
No validated MLA cut-off for ambiguous LM assessment (no validated treshold)
No plaque burden data (less accurate disease assessment / stent landing sites should be ideally < 40-50% PB)
No visible total vessel cross section (sizing approach limited to lumen)
Studies supporting intravascular imaging guided LM PCI are based on IVUS (no evidences with OCT)

CONCLUSIONS

IVUS imaging for LM disease is definitely helpful:

- Assess LM lesion severity if ambiguous angiography
- Evaluate disease extension to ostial LAD / LCx
- Characterization of LM plaque
- Planning PCI strategy
- Guiding plaque preparation
- Sizing of stent / POT
- Optimizing PCI results

IVUS guidance of LM stenting provides a prognostic benefit with respect to the use of angiography alone, particularly when using a protocol with predefined optimization criteria

¡¡ Get advantage from IVUS when dealing with LM disease ¡¡