Intravascular Imaging Assessment of Late Stent Failure

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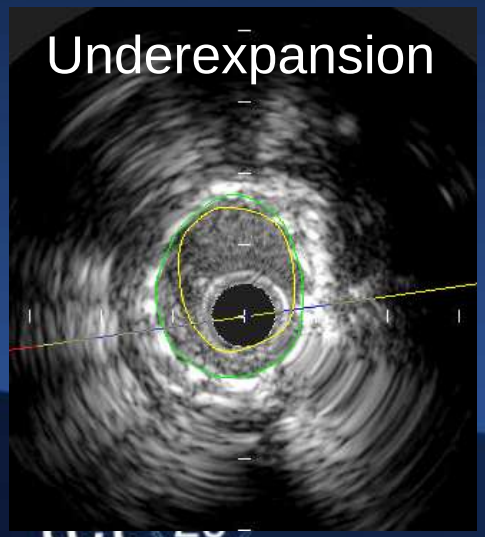
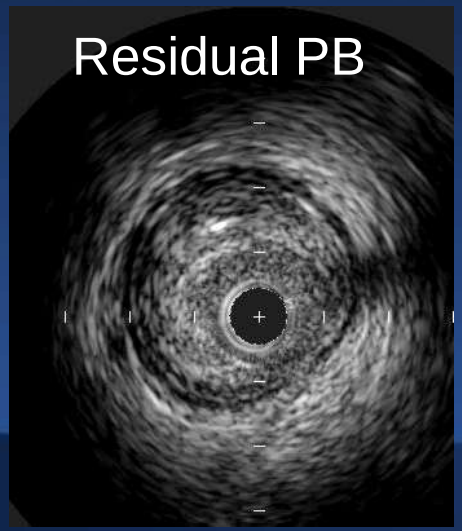
Disclosure Statement of Financial Interest

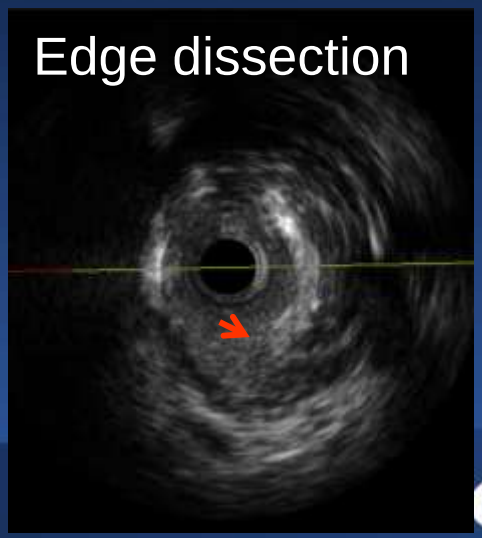
I, Soo-Jin Kang DO NOT have a financial interest/arrangement or affiliation with one or more organizations that could be perceived as a real or apparent conflict of interest in the context of the subject of this presentation

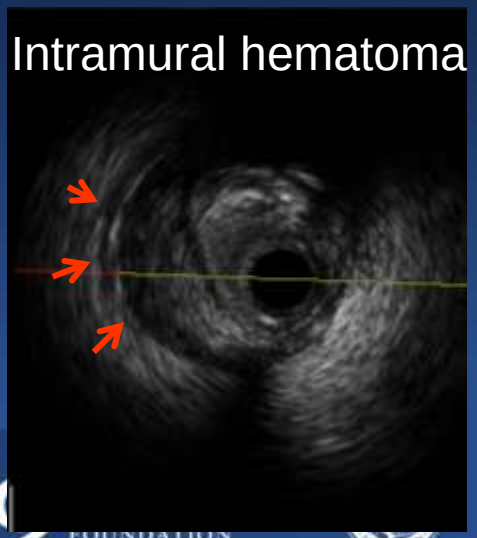
IVUS Mechanisms of DES Failure

	Early Thrombosis	Restenosis
Small MSA (Underexpansion)	•Fujii et al. JACC 2005;45:995-8 •Okabe et al., AJC 2007;100:615-20 •Liu et al. JACC Interv 2009;2:428-34 •Choi et al. Circ Interv 2011;4:239-47	•Sonoda et al. JACC 2004;43:1959-63 •Hong et al. EHJ 2006;27:1305-10 •Doi et al. JACC Interv. 2009;2:1269-75 •Fujii et al. Circulation 2004;109:1085-8 •Kang et al. Circ Interv 2011;4:9-14 •Choi et al. AJC 2012;109:455-60 •Song et al. CCI in press
Inflow/outflow tract disease	•Fujii et al. JACC 2005;45:995-8 •Okabe et al., AJC 2007;100:615-20 •Liu et al. JACC Interv 2009;2:428-34 •Choi et al. Circ Interv 2011;4:239-47	•Sakurai et al. AJC 2005;96:1251-3 •Liu et al.AJC 2009;103:501-6 •Costa et al. AJC 2008;101:1704-11

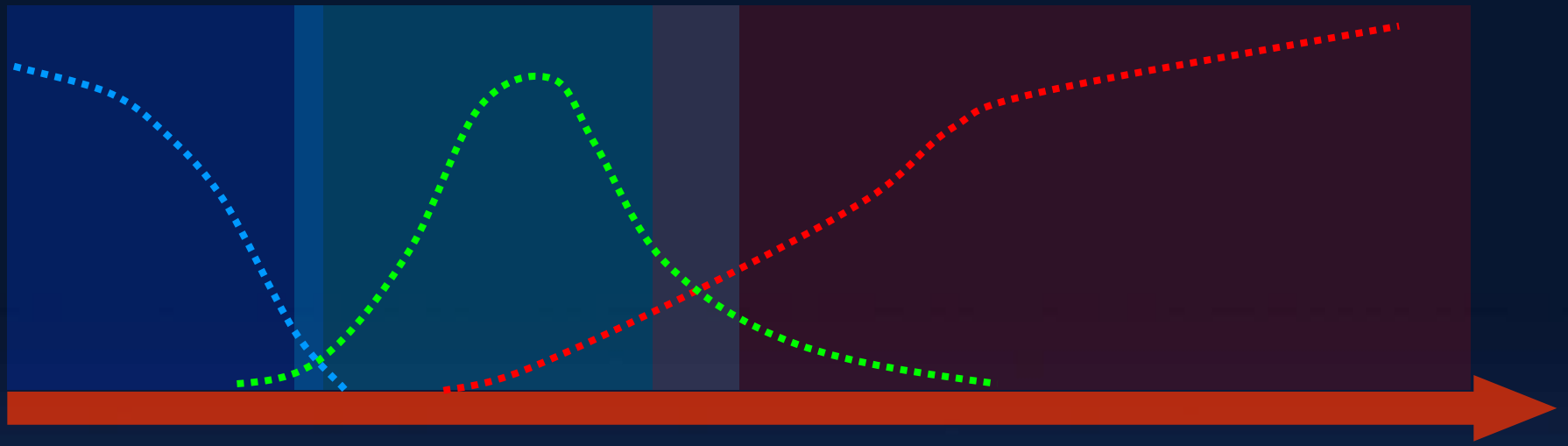






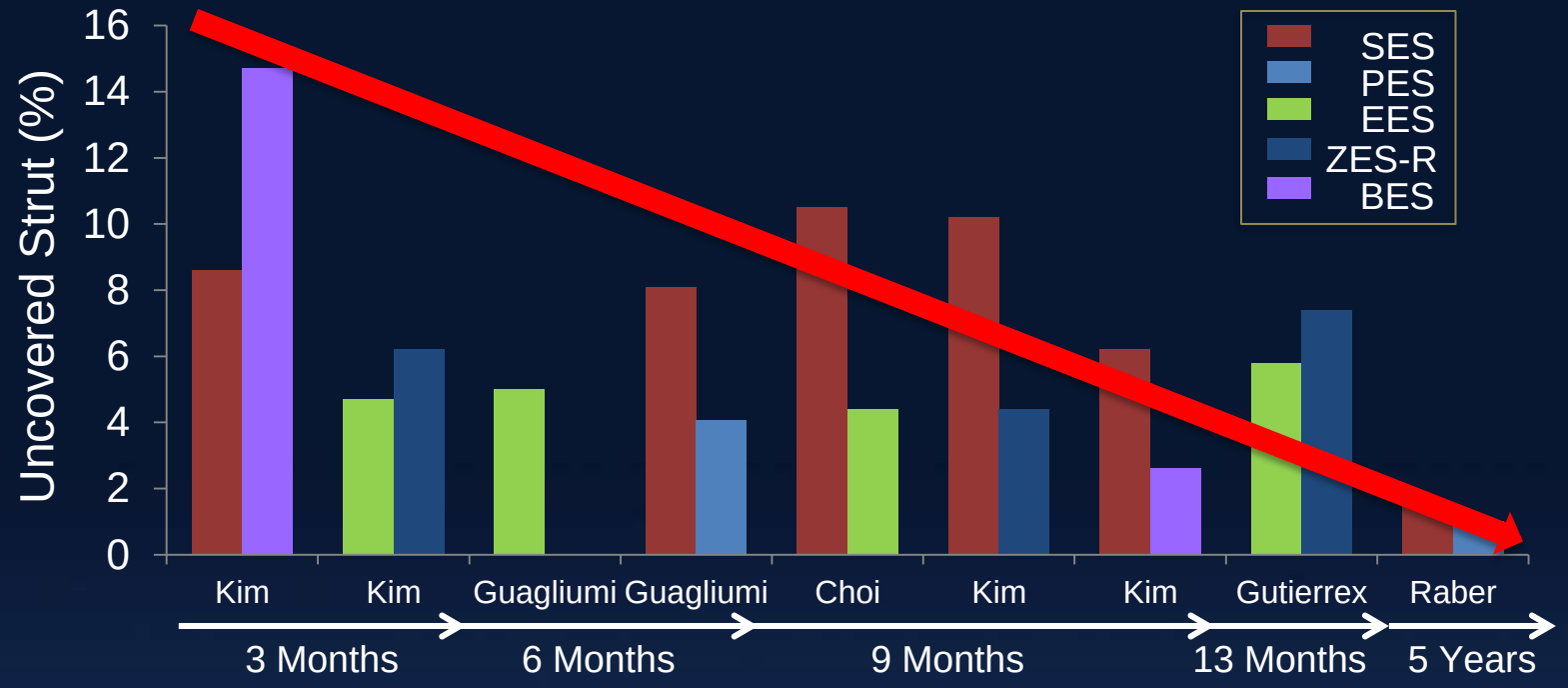


Timing and Mechanism of **DES Thrombosis**

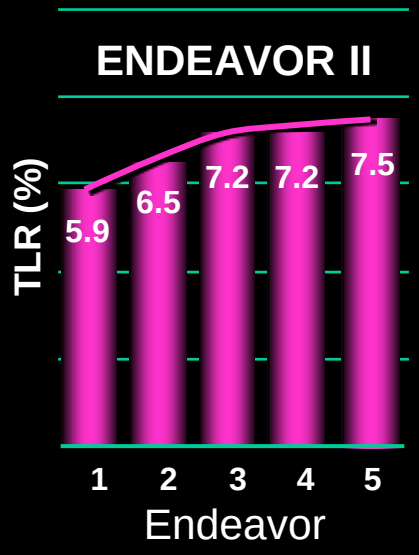


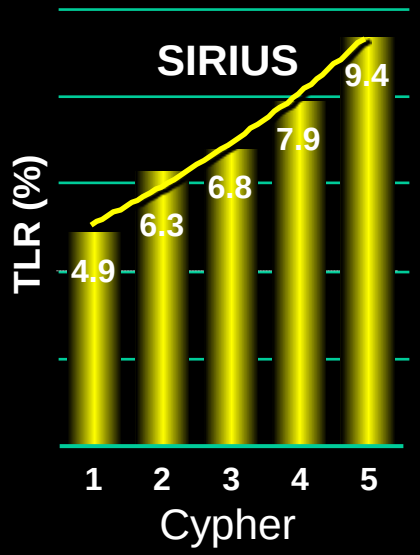
Early (<30d)	Late (1-12 Mo)	Very late (>12 Mo)
Procedural	**Delayed healing**	**Abnormal vascular response**
Underexpansion Edge dissection	Uncovered struts Fibrin deposition	Hypersensitivity Extensive fibrin deposition
Residual plaque		Late malapposition? Neoatherosclerosis

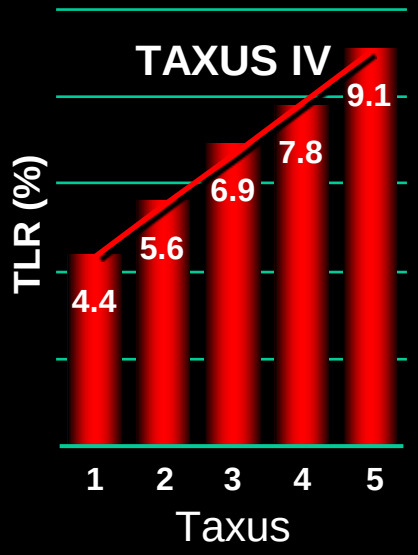
Nakazawa et al. J Cardiol 2011;58:84-91

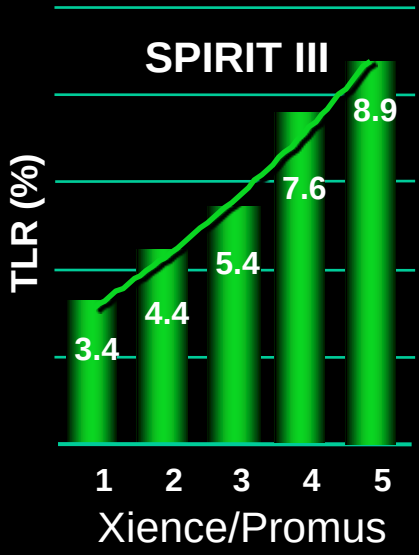


Guagliumi JACC Interv 2010;3:531-9, Guagliumi CCI 2012, Kim AJC 2013;111:1-5, Choi et al, Int J Cardiovasc Imag 2012;28:491-7, Kim Int J Cardiol 2013, Gutiérrez-Chico EHJ 2011;32:2454-63, Räber JACC Interv 2012;5:946-57



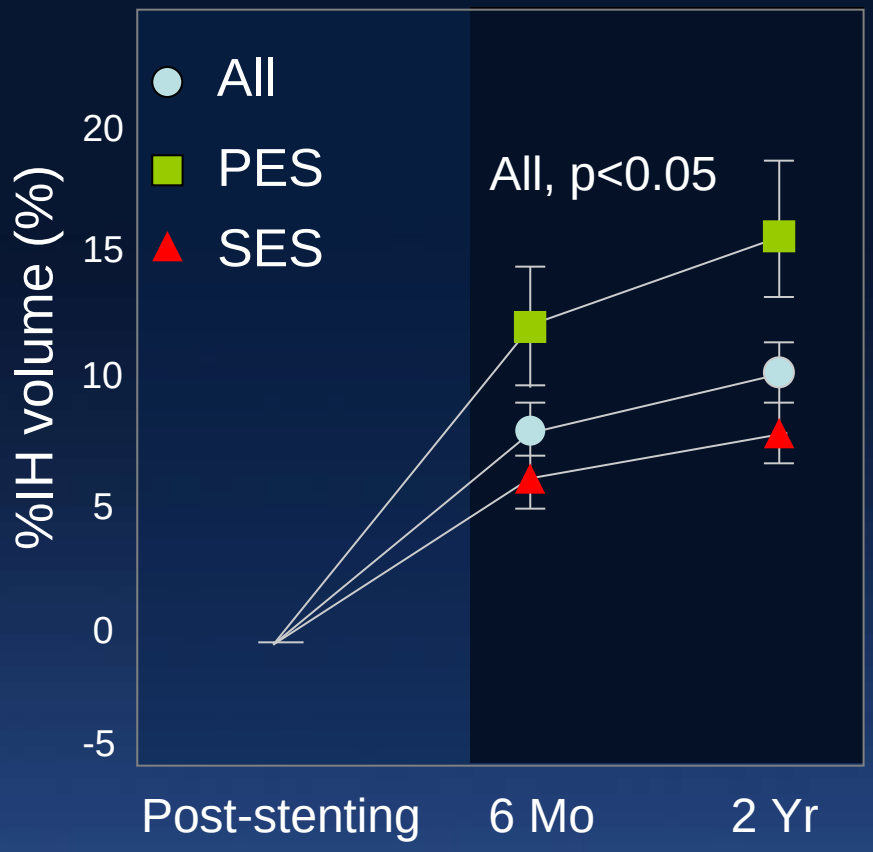






"Late Catch-up"

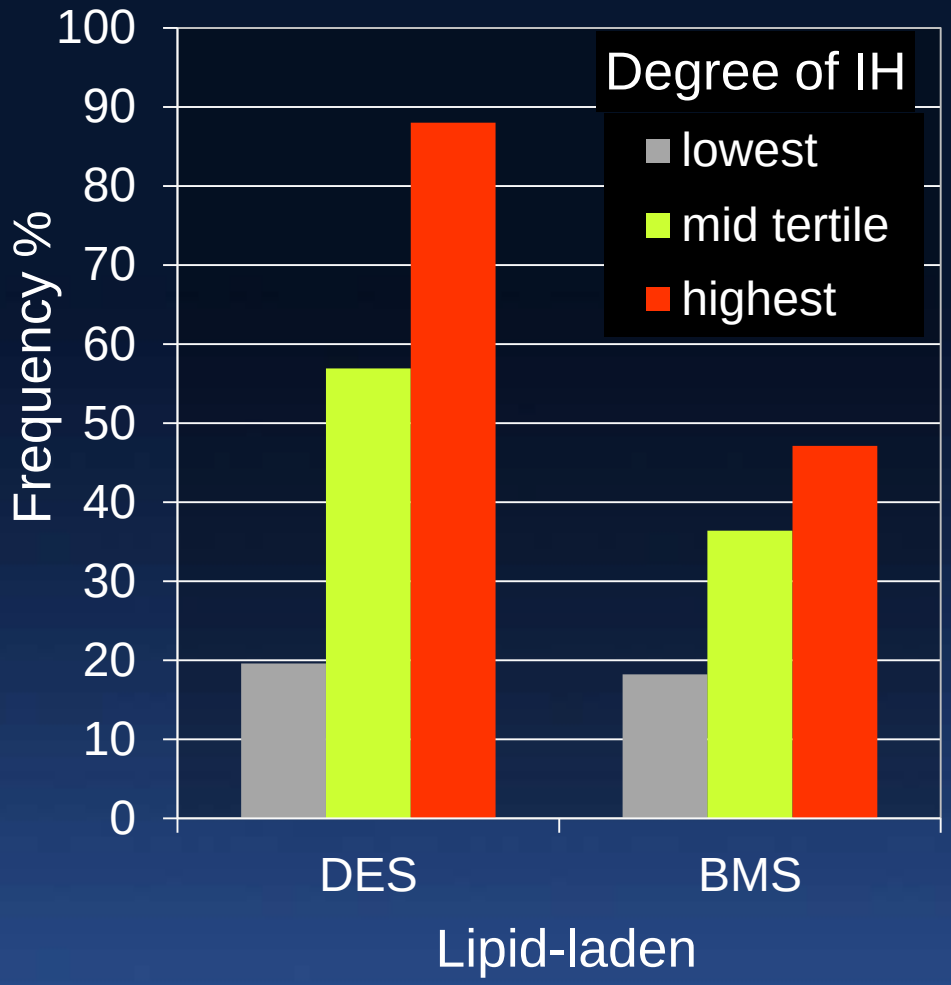
Serial %IH in DES



subsequent progression of IH

Kang et al. Am J Cardiol 2010;105:1402-8

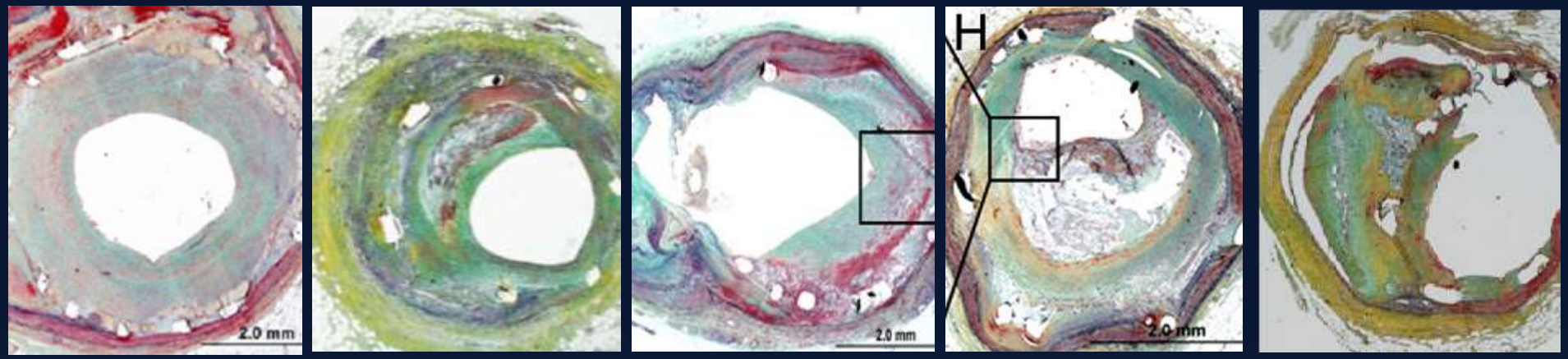
Degree of IH



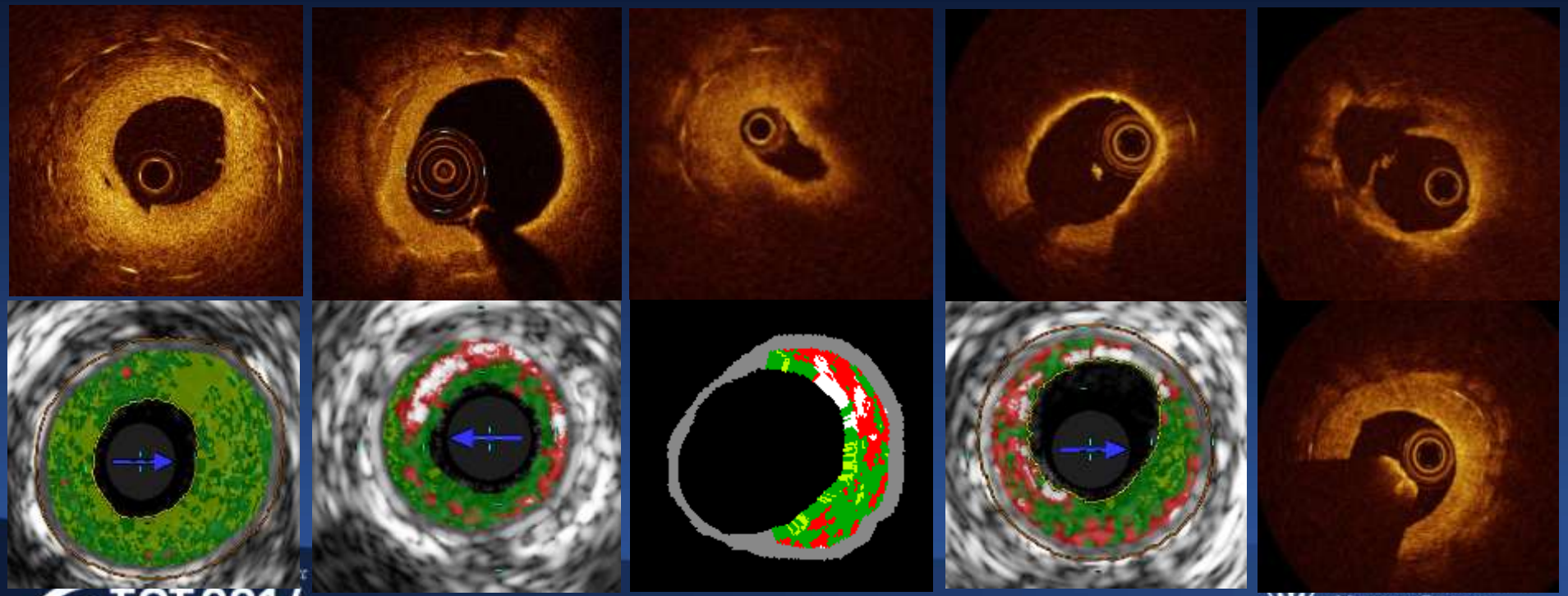
Lipid-laden

Vergallo et al. Am J Cardiol 2013;112:1315-21

Early neointima | Fibrocalcific | ThCFA | TCFA | Intimal rupture



Nakazawa et al. JACC Cariovasc Imaging 2009;2:625-8



Late ISR

63-year old male
Stable angina

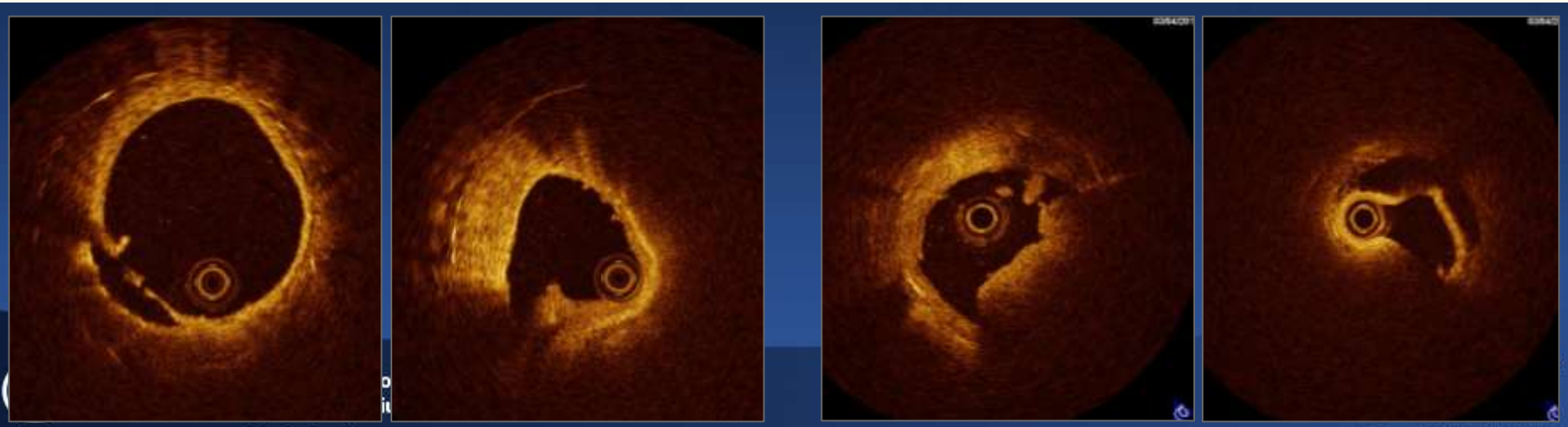
VLST

60-year old male
AMI with VLST

IMAGES IN CARDIOLOGY

Neoatherosclerosis: The Missing Link Between Very Late Stent Thrombosis and Very Late In-Stent Restenosis

Fernando Alfonso, MD, Federico Fernandez-Viña, MD, Miguel Medina, MD, Rosana Hernandez, MD
Madrid, Spain



How Frequent is Neoatherosclerosis the Mechanism of Stent Failure?

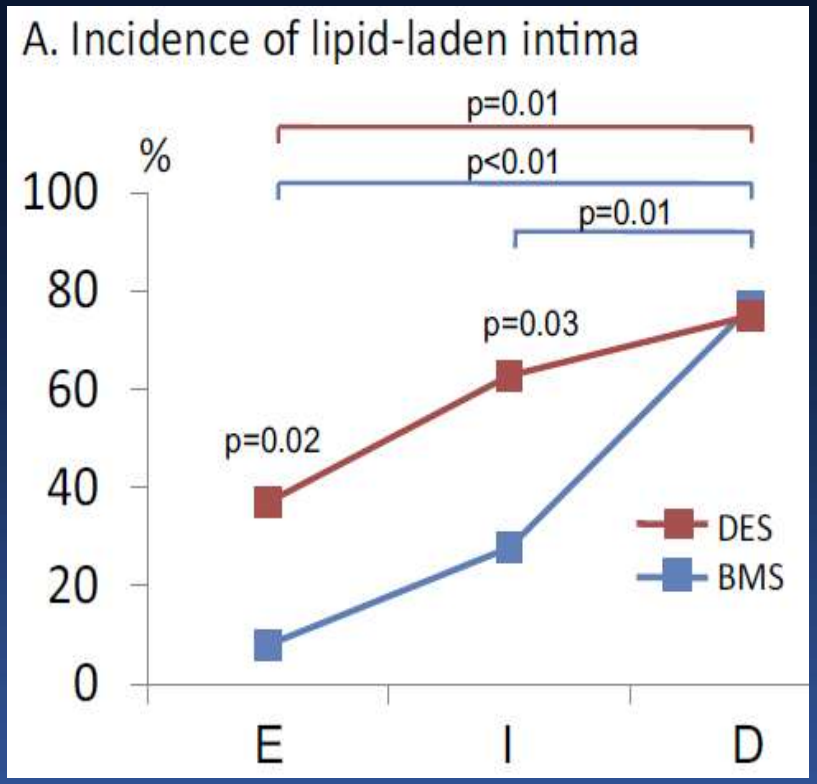
Stent failure OCT data from AMC

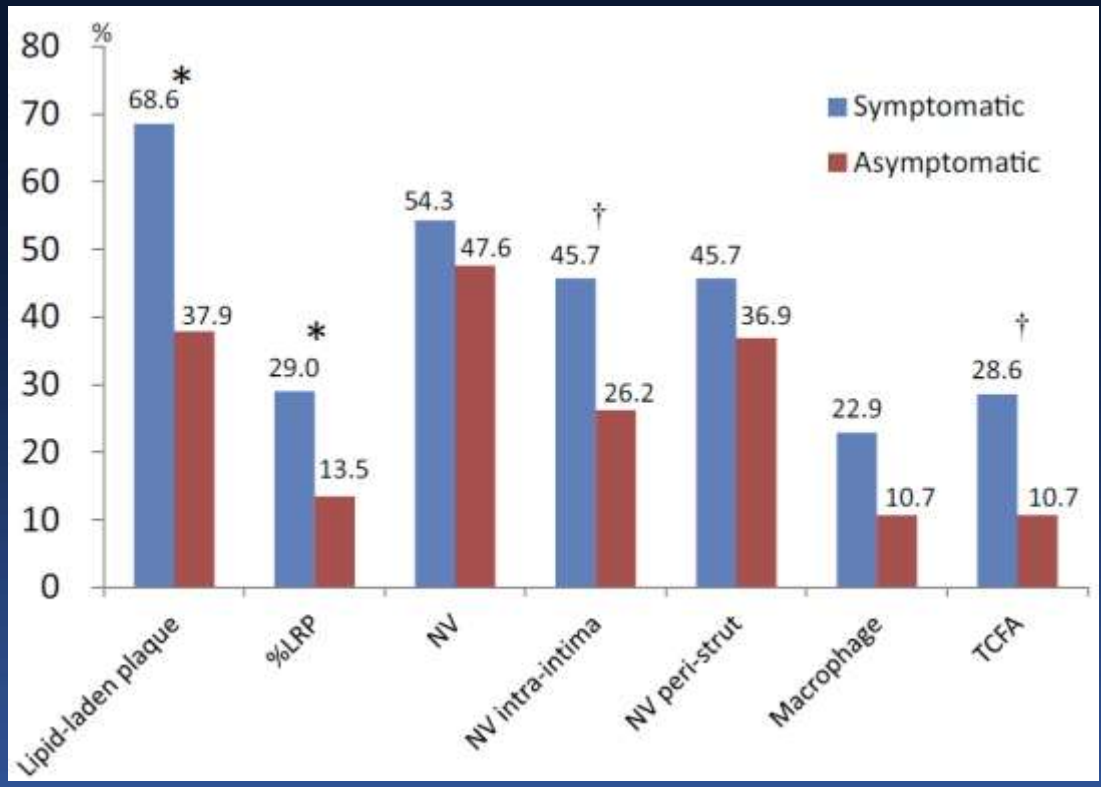
	DES-ISR[1]	BMS-ISR[2]	VLST[3]	
Lesion	50 DES	51 BMS	6 BMS	27 DES
Median F/U	32 Mo	132 Mo	109 Mo	62 Mo
Lipid or NC	90%	100%	100%	100%
OCT-TCFA	**52%**	**68%**	**100%**	**56%**
OCT-rupture	**58%**	**59%**	**100%**	**63%**
TLR	98%	all	all	all

1. *Kang et al. Circulation 2011;123:2954-63*
2. *Kang et al. JACC Cardiovasc Imaging 2012;5:1267-8*
3. *Kang et al. JACC Cardiovasc Imaging 2013;6:695-703*

Incidence and Time Course

In Vivo data from MGH OCT registry



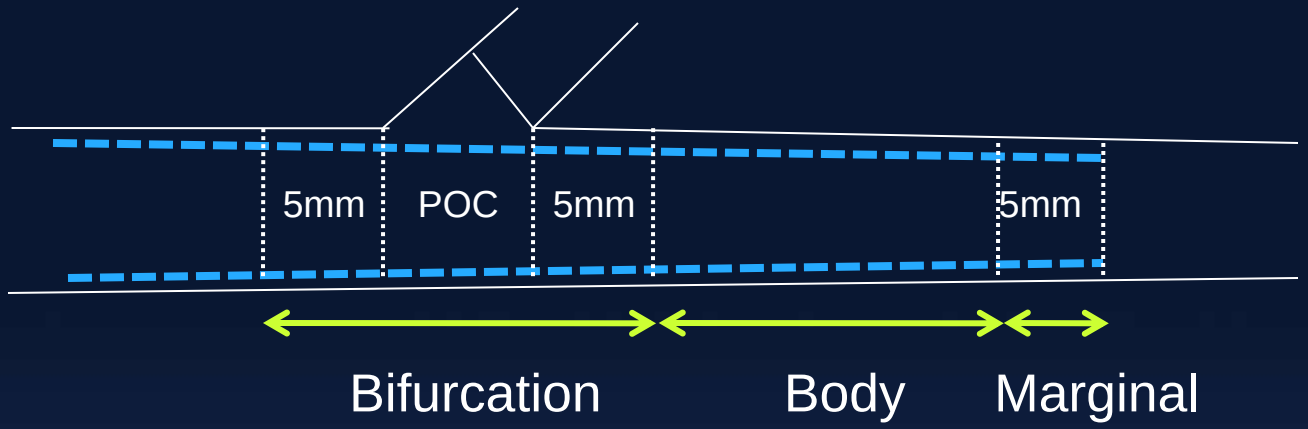


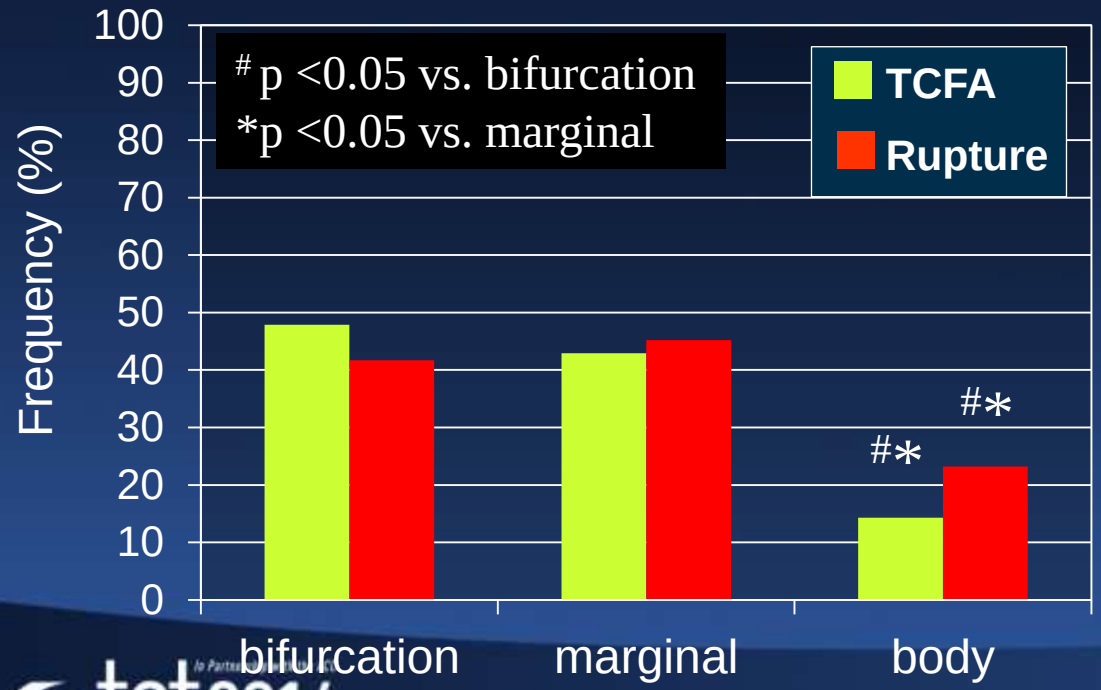
<9 mo 9–48 mo >48 mo

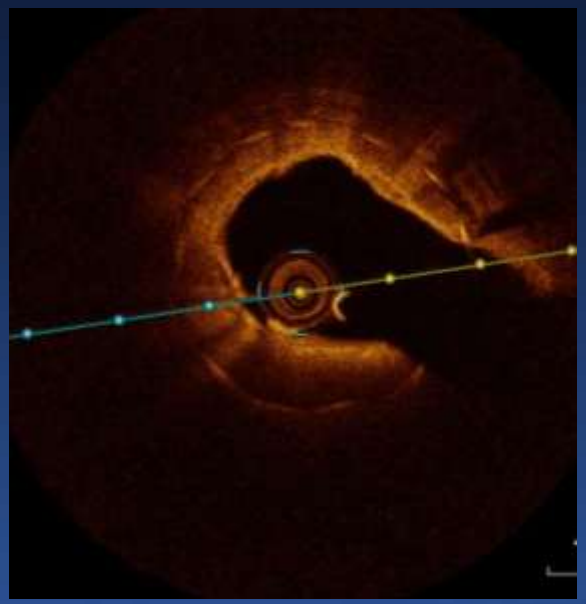
Yonetsu et al. Am J Cardiol 2012;110:933–9

Site-specific Neoatherosclerosis

Sites of in-stent MLA in 146 ISR lesions (39 BMS, 107 DES)







Kang et al. AsiaIntervention 2015 in press

Predictor of Peri-procedural MI

152 Patients with ISR, Median F/U 52.8 months

Treatment of ISR	
Balloon, N (%)	9 (6%)
Cutting, N (%)	24 (16%)
DEB, N (%)	9 (6%)
DES, N (%)	94 (62%)
Cutting+DEB, N (%)	16 (11%)

Thin-cap thickness <60um

To predict peri-procedural MI *(CK-MB>15ng/ml)*

- Sensitivity 91%
- Specificity 58%

	TCFA			Intimal rupture		
	Yes (N=68)	No (N=84)	P	Yes (N=71)	No (N=81)	P
Pre-PCI CK-MB	1.1 (0.5–2.3)	0.8 (0.5–1.5)	0.110	1.1 (0.4–2.2)	0.9 (0.6–1.7)	0.659
Post-PCI CK-MB	2.0 (1.0–5.0)	1.4 (0.8–2.2)	0.012	2.0 (0.9–4.1)	1.3 (0.9–2.4)	0.017
CK-MB>15ng/ml	9 (13%)	2 (2%)	0.010	9 (13%)	2 (3%)	0.015
MACE at 2 years	5 (7%)	5 (6%)	0.729	5 (7%)	5 (6%)	0.829

Kang et al. JACC Cardiovasc Imaging 2014 in press

Neoatherosclerosis (NA) Predicts CK-MB elevation after PCI for ISR

	CK-MB elevation		P value
	Yes (N=20)	No (N=105)	
%IH, %	44.7 (33.0 – 60.3)	33.1 (25.3 – 46.1)	0.020
Max length of NA, mm	8.8 (1.5 – 10.4)	0 (0-1.0)	<0.001
NA neointima, %	51.1 (8.1 – 74.2)	0 (0-8.0)	<0.001
Cap thickness, μm	60.0 (50.0 – 60.0)	240 (170 – 430)	<0.001
TCFA, %	11 (55%)	2 (2%)	<0.001

Predictors of post-PCI CK-MB elevation

- Maximal length of NA (OR=1.46, 95% CI=1.09-1.96)
- TCFA at MLA (OR=14.32, 95% CI=1.11-183.6)

Lee et al. Catheter Cardiovasc Interv 2014 in press

Is LSM a Cause of VLST or a Marker of Underlying Vascular Inflammation?

Study	Lesions	Duration	%LSM	Reference
Studies reporting the relationship				
Berne	221 (SES+PES)	5 years	18%	Eur Heart J 2012;33:1334-43
MISSION-AMI (combined DES/BMS)	184 (SES+BMS)	5 years	38%	Eurointervention 2012;7:1021-9
Studies reporting NO relationship				
AMC data	705 (SES+PES)	3 years	12%	J Am Coll Cardiol 2007;50:1515-6
RAVEL, SIRIUS, E-SIRIUS	180 (SES)	4 years	25%	Heart 2008;94:322-8
TAXUS IV, V, VI, Atlas Work horse, LL, Direct Stent	548 (PES)	3 years	6%	J Am Coll Cardiol Intv 2010;3:486-94
HORIZONS-AMI*	286 (PES+BMS)	4 years	45%	J Am Coll Cardiol 2012;59:A74-A75
Yonsei	356 (SES, EES, ZES, BES)	2 years	28%	Circ Cardiovasc Interv 2014;7:88-96

Predictors of DES Late/Very Late ST

In Vivo Case-Controlled Study (Median follow-up 615 days)

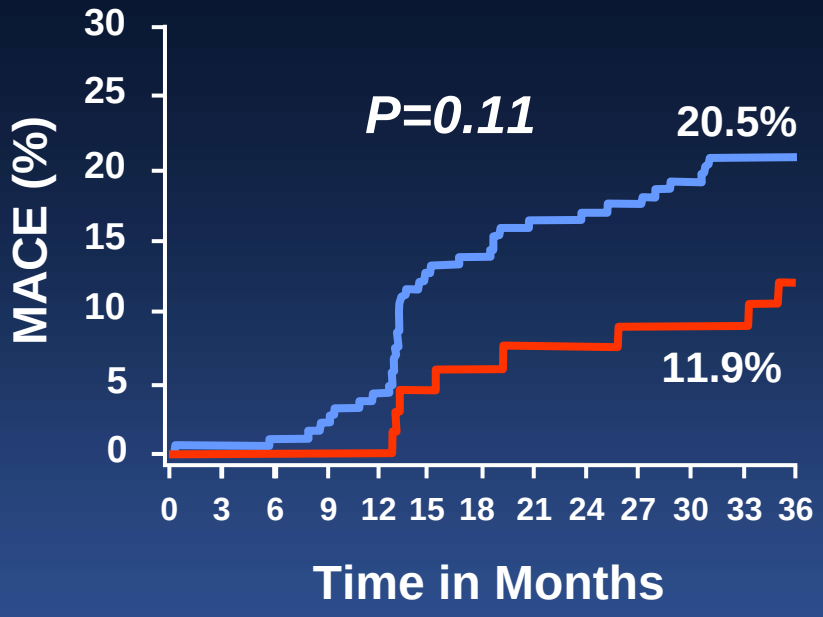
	ST	Matched controls	Univariate	Multivariate	
			P	OR	P
OCT					
Length of segments with uncovered struts	3.3 mm	0.9 mm	<0.001	2.45	0.007
Cross-sections with >30% uncovered struts	21.6 %	0	0.002		
Malapposed struts per pt.	4.6 %	1.8 %	0.001		
IVUS					
Minimum stent CSA	5.7 mm^2	5.9 mm^2	1.0		
Mean EEM CSA	19.4 mm^2	15.1 mm^2	0.003		
Remodeling index	1.24	0.99	<0.001	1.05	0.019

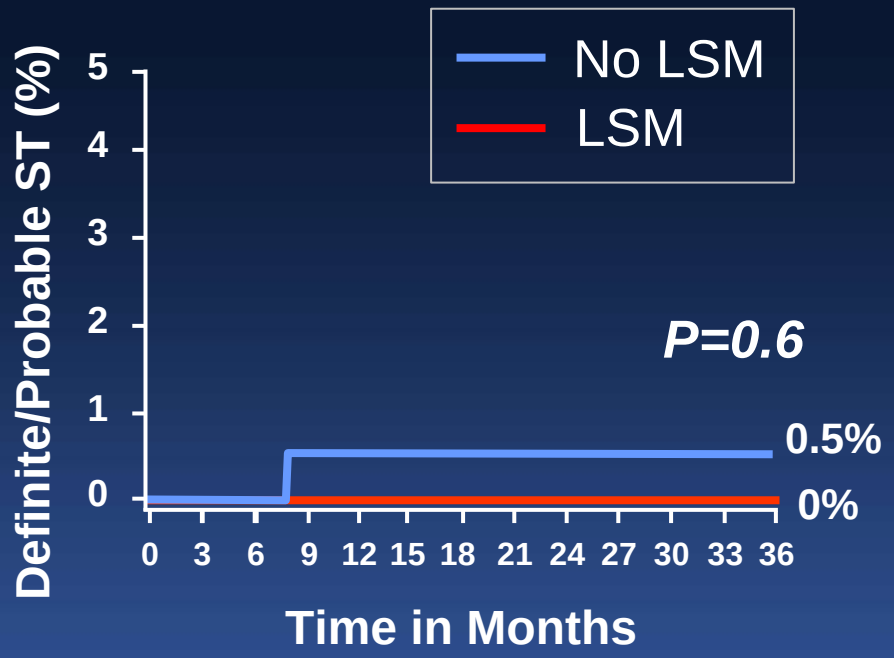
Guagliumi et al. JACC Cardiovasc Intervent 2012;5:12-20

HORIZONS-AMI

3-year Clinical Outcomes

Late Stent Malapposition (LSM)

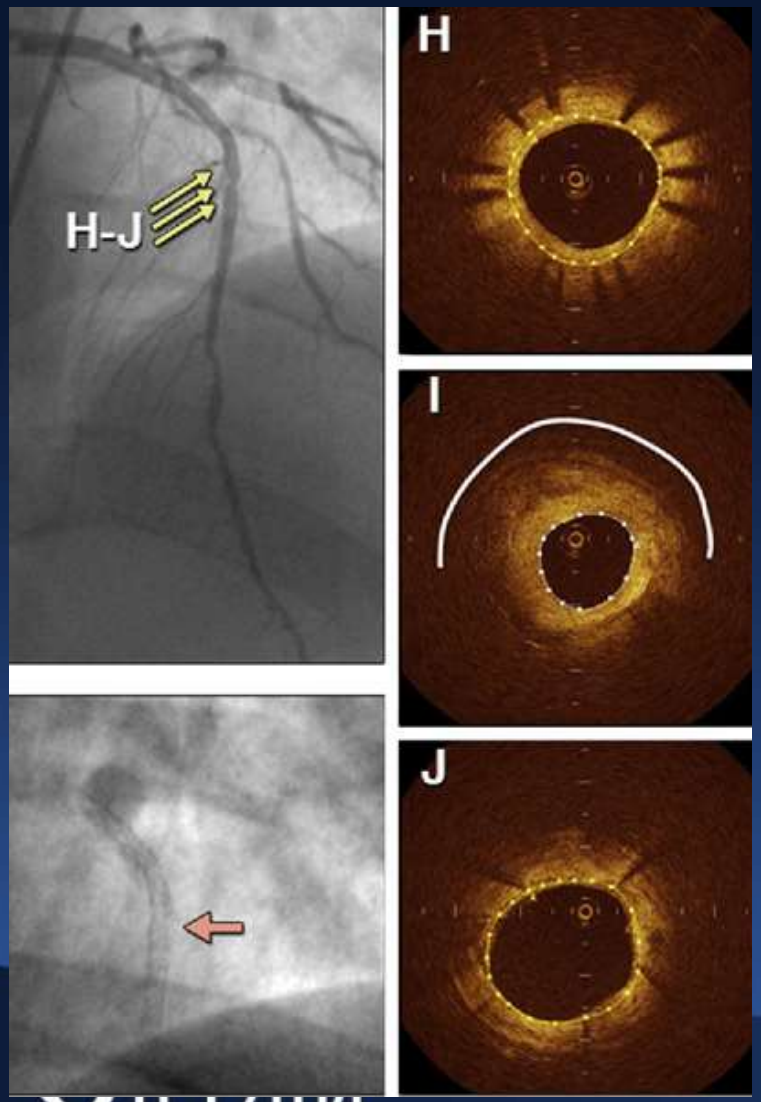


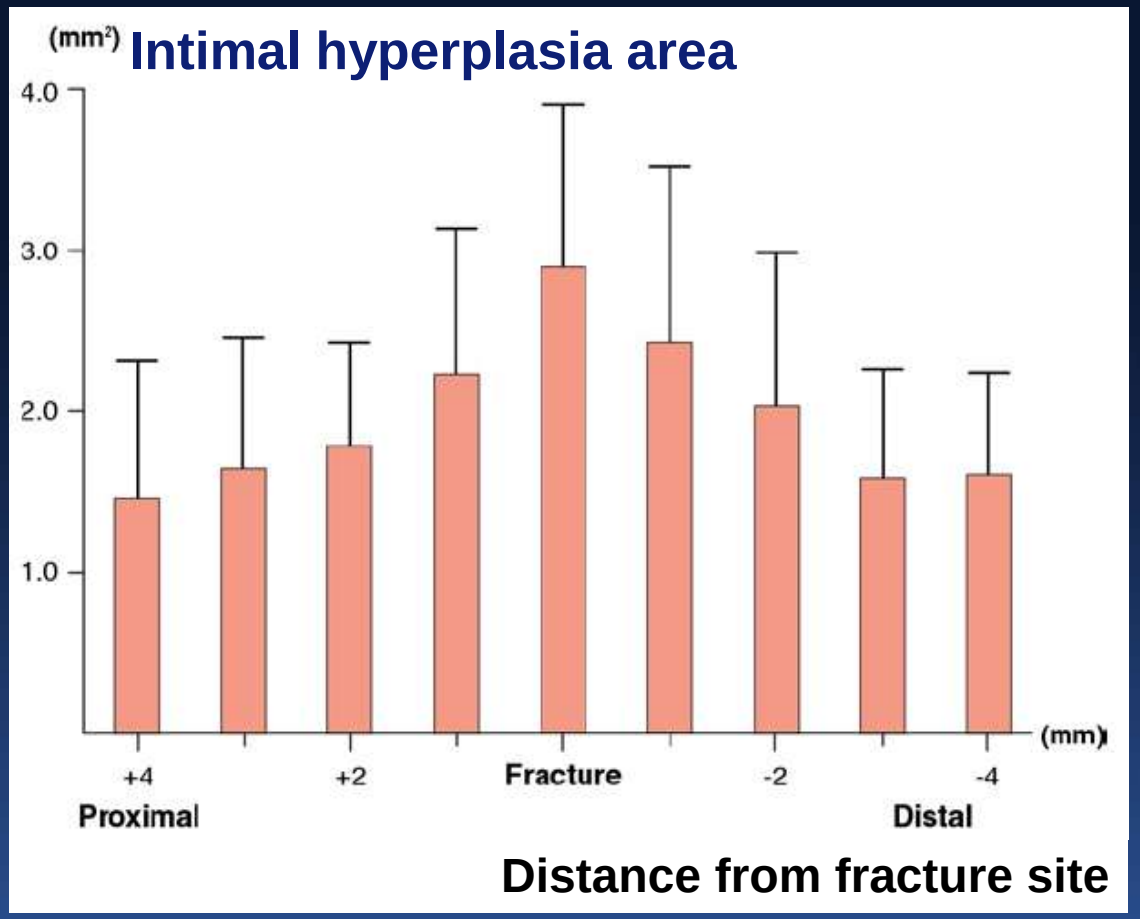


Yakushiji, Maehara et al. J Am Coll Cardiol 2012;59:A74-A75

Effect of Stent Fracture

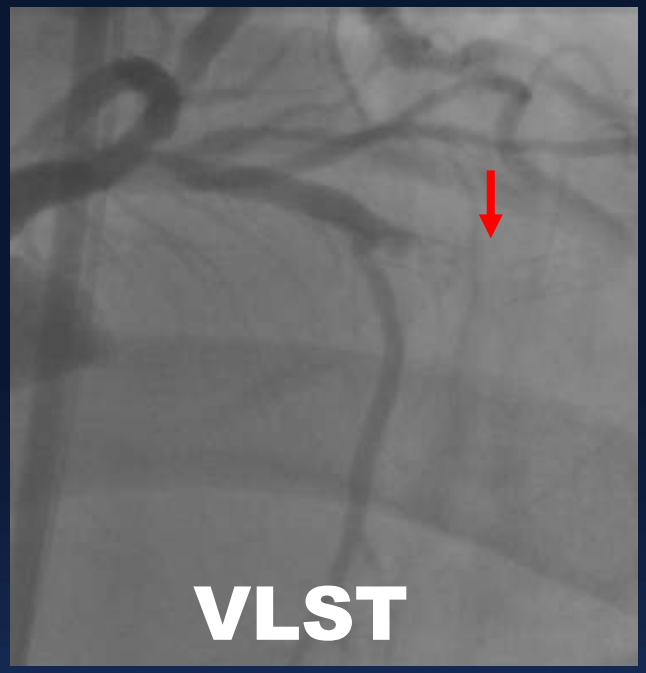
Increased intimal hyperplasia at the fracture site

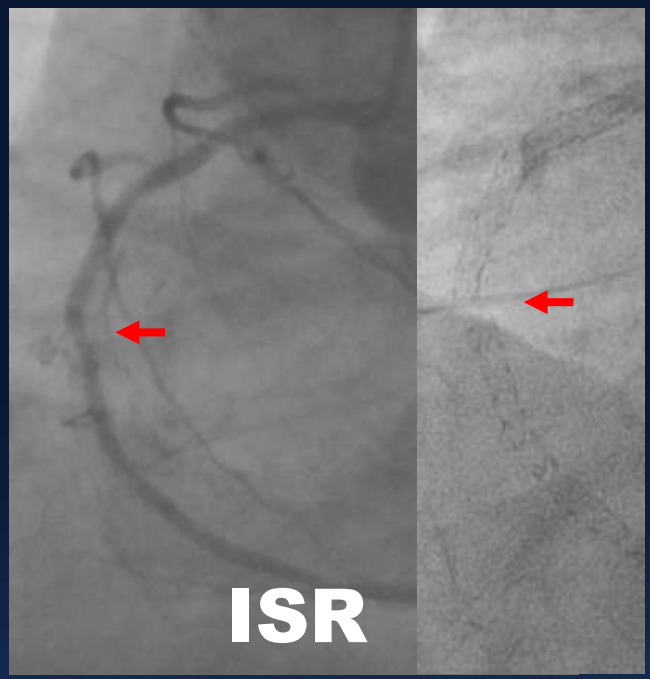


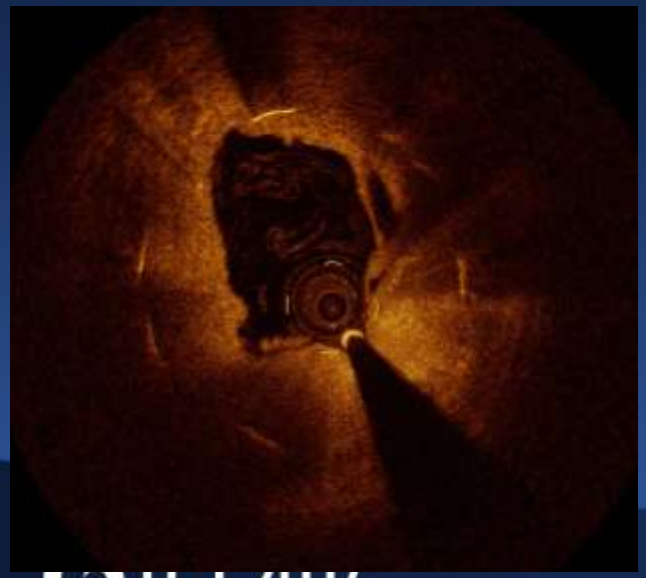


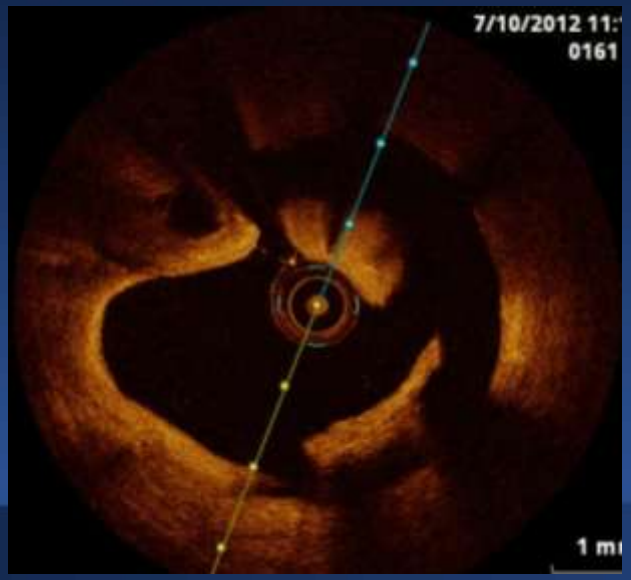
Kashiwagi et al. JACC Cardiovasc Img 2012;5:232-3

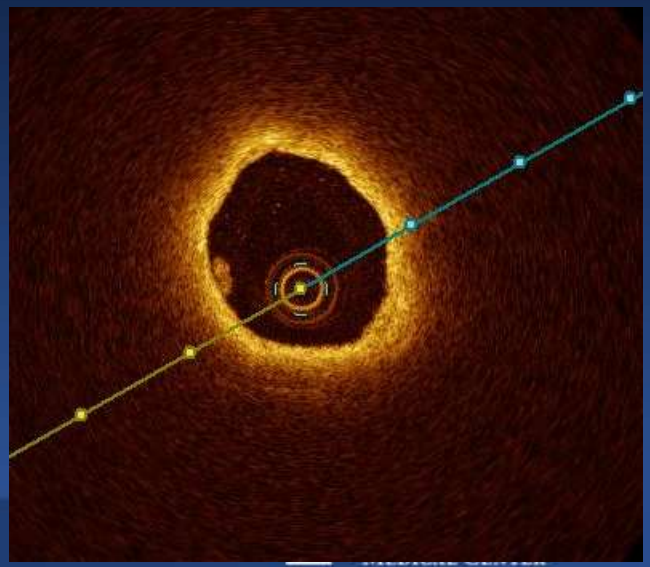
DES Failure Associated with Fracture









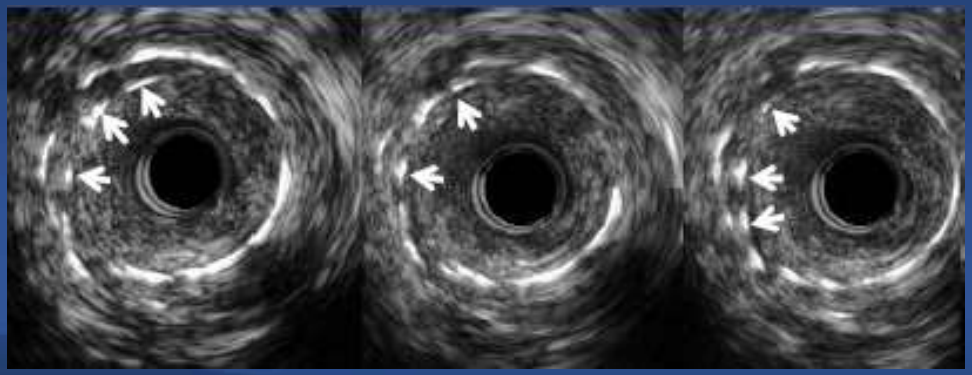


Kang et al. JACC Cardiovasc Imaging 2013 in press

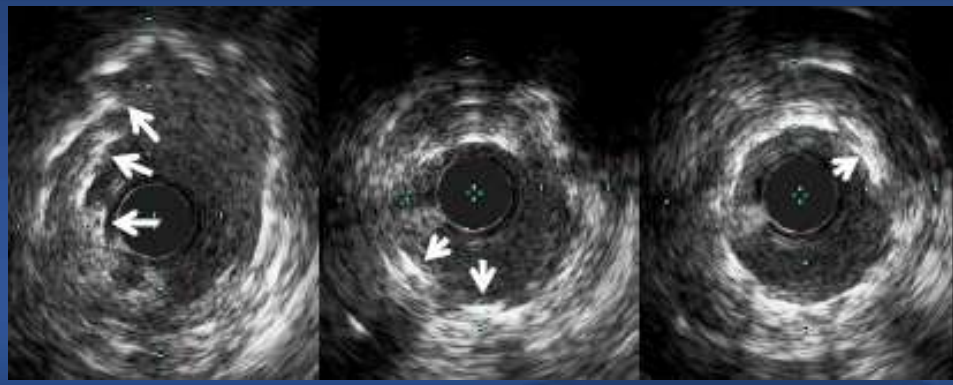
Mechanical Complication in EES-ISR

- Mechanical complication in 17 (9.6%) of 177 pts
- Focal ISR in 94%
- 13 patients: longitudinal deformation or strut fracture with overlapping of proximal and distal stent fragments
  → 35.5±12.2% smaller stent area
  → excessive IH (>50%) in 92%

Overlap EES fracture



Overlap EES deformation



Inaba, Maehara et al. EuroIntervention 2014;9:1301-8

Summary

- Intravascular imaging is useful to assess the precise mechanism of late stent failure
- Procedural factors are responsible for early ST, while delayed arterial healing and abnormal vascular responses affect in the later phase
- Neoatherosclerosis is a common mechanism of very late stent thrombosis and restenosis
- Mechanical complications - strut deformation and fracture potentially contribute to late stent failure