

IVUS Findings in DES Thrombosis

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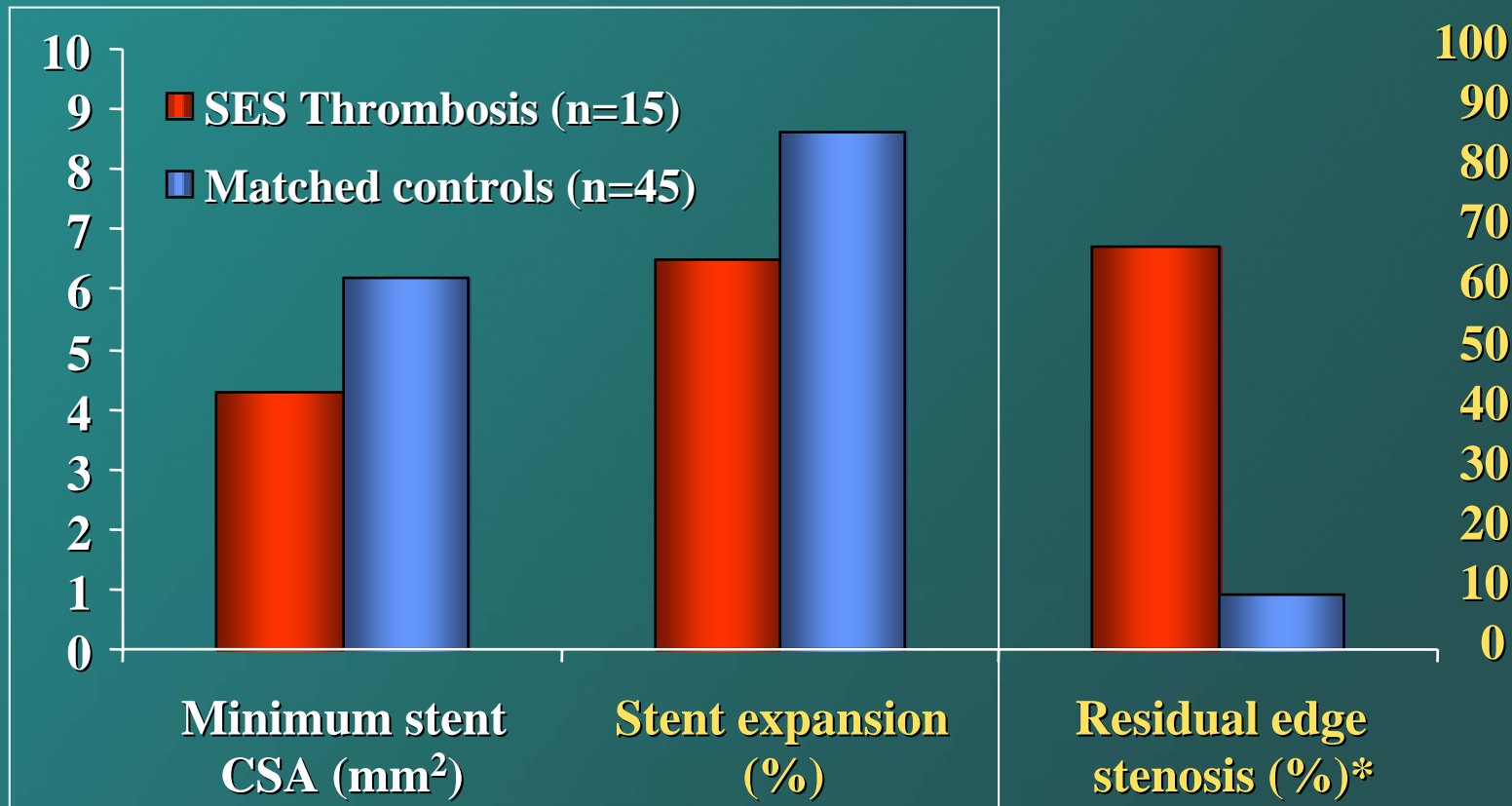
***Cardiovascular Research Foundation
New York, NY***



Stent Underexpansion



Predictors of Cypher Thrombosis @ CRF



- 2,575 patients were treated with 4,722 Cypher stents.
 - 21 (0.8%) had stent thrombosis of whom 15 had IVUS
 - 12/15 SES thrombosis lesions has stent CSA <5.0mm² (vs 13/45 controls)
- *Residual edge stenosis = edge lumen CSA <4.0mm² & plaque burden >70%.

(Fujii et al. J Am Coll Cardiol 2005;45:995-8)



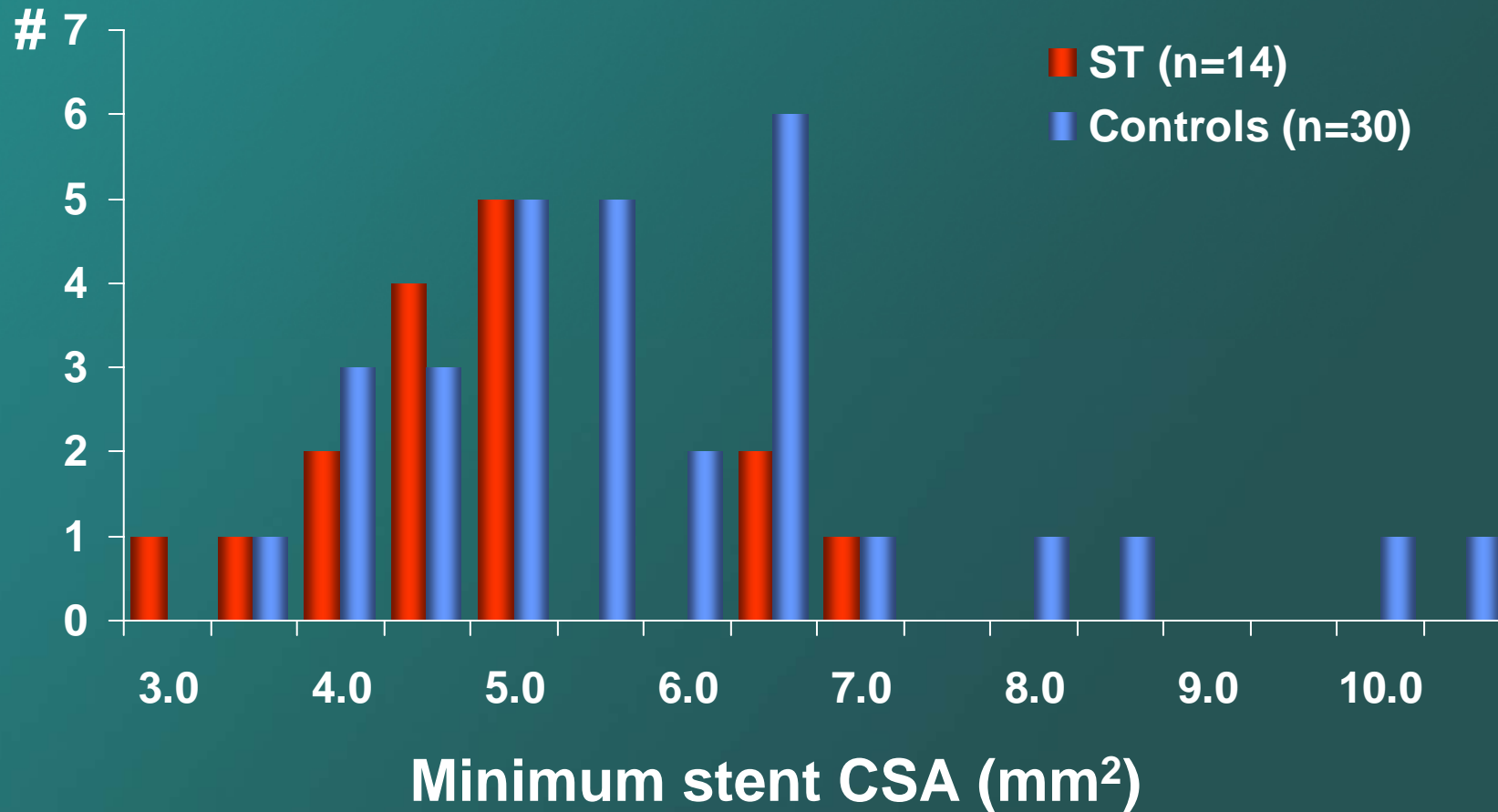
Predictors of DES Thrombosis @ WHC

	Stent Thrombosis	Matched Controls	P-value
N	14	30	
Proximal reference			
Smallest lumen CSA (mm ²)	4.7±1.1	6.0 ±2.3	0.067
Largest plaque burden (%)	66±8	56±10	0.0018
Stent			
Proximal edge CSA (mm ²)	6.1±1.7	7.0±2.1	0.17
MSA (mm ²)	4.6±1.1	5.6±1.7	0.0489
Distal edge CSA (mm ²)	5.6±1.6	6.8±2.2	0.079
Distal reference			
Smallest lumen CSA (mm ²)	4.3±1.7	5.3±2.1	0.12
Largest plaque burden (%)	53±15	45±14	0.14

(Okabe et al., Am J Cardiol. In press)

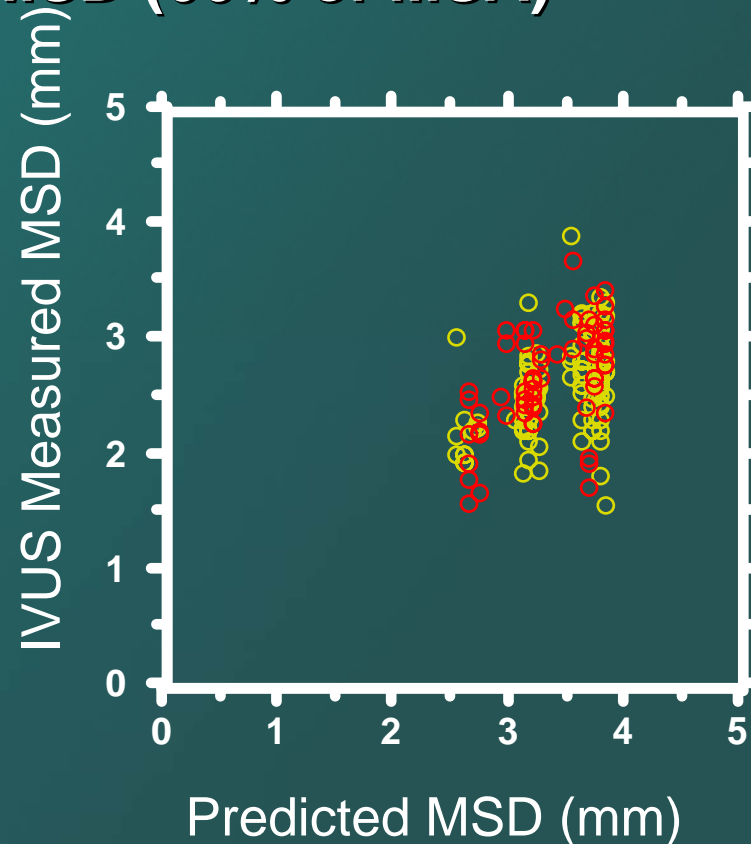
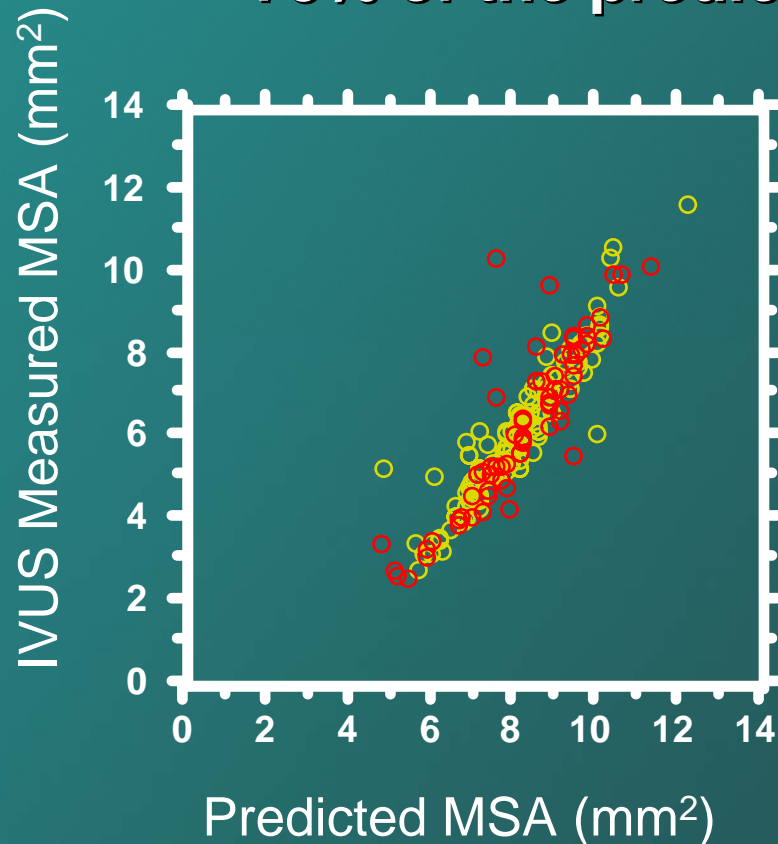


Predictors of DES Thrombosis @ WHC



(Okabe et al., Am J Cardiol. In press)

Comparison of IVUS-measured minimum stent diameter (MSD) and minimum stent area (MSA) with the predicted measurements from Cordis (Cypher in yellow, n=133) and BSC (Taxus in red, n=67). DES achieve an average of only 75% of the predicted MSD (66% of MSA)



(de Rebamar Costa et al, Am Heart J 2007;153:297-303)

Why do some underexpanded DES thrombose and some restenose?

	ST (n=15)	RS (n=45)	P-value
Cypher/Taxus	12/3	36/9	
Reference			
EEM CSA (mm²)	13.7±3.8	11.8±4.1	0.12
Lumen CSA (mm²)	7.4±2.6	6.6±1.8	0.12
Stent			
Mean stent CSA (mm²)	5.2±0.8	7.2±2.1	<0.0001
MSA (mm²)	3.7±0.8	4.9±1.8	0.01
Focal expansion (%)	55±16	75±20	0.001
Diffuse expansion (%)	77±23	110±23	<0.0001
Site of MSA (Prox/Dist)	9/6	11/34	0.01
Malapposition at F/U	40%	40%	1.0

Independent predictors of ST (vs RS) were diffuse stent expansion (OR=1.5, p=0.03) and proximal location of MSA site (OR=12.7, p=0.04)

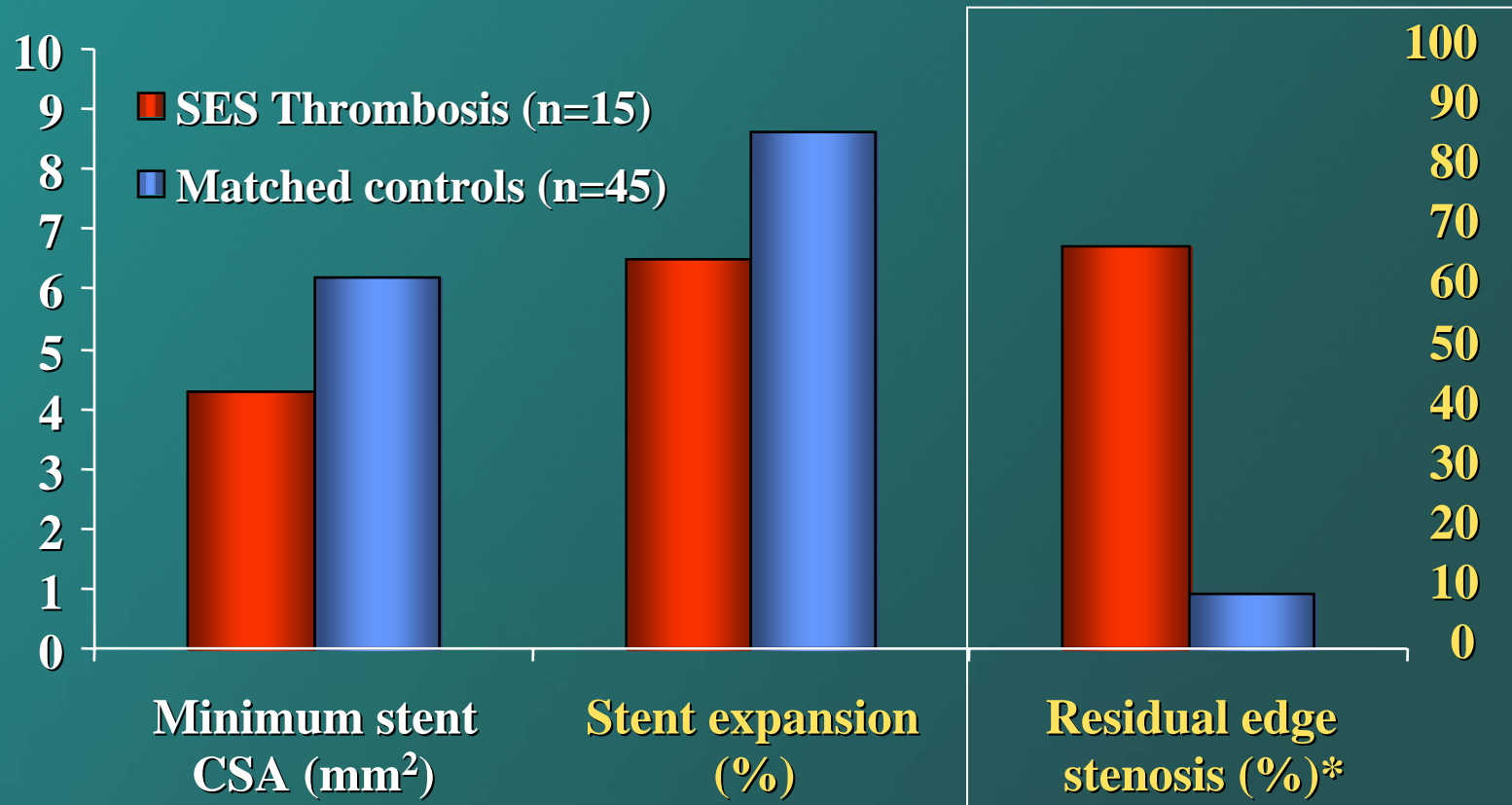
(Liu et al, unpublished)



“Uncovered” (Residual) Edge Stenoses



Predictors of Cypher Thrombosis @ CRF

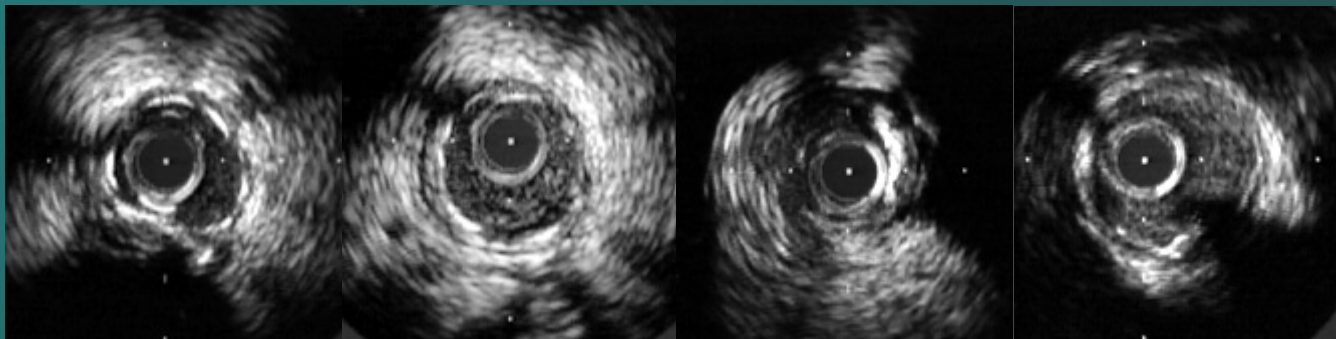
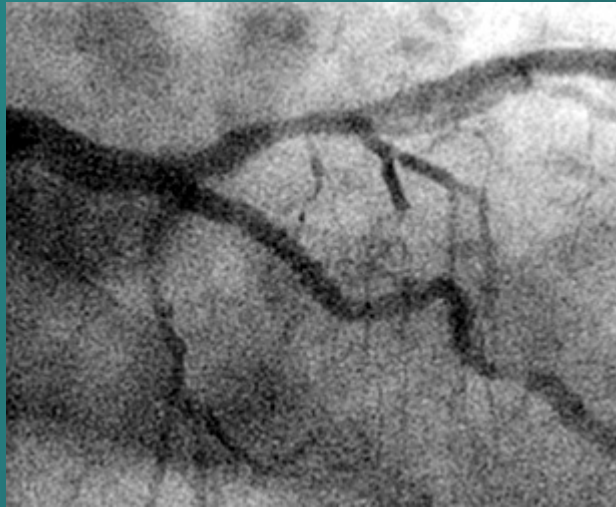


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Cypher Thrombosis



Plaque Prolapse



Intra-stent acute plaque prolapse in the DIABETES-I and DIABETES-II Trials

	Cypher		Taxus	
	Plaque prolapse	No plaque prolapse	Plaque prolapse	No plaque prolapse
N	9	60	15	65
Mean intra-stent tissue				
Post-PCI	0.72mm ²	0	0.63mm ²	0
F/U	0.55mm ²	0.77mm ²	1.71mm ²	1.49mm ²
Restenosis	0	3.3%	6.3%	7.3%
Stent thrombosis	0	0	0	0

P<0.05

(Futamatsu et al. J Am Coll Cardiol 2006;48:1139-45)



Acute Stent Malapposition



- **Most acute incomplete stent apposition is modest in size**
- **There is little or no data linking isolated acute incomplete stent apposition to adverse clinical events (thrombosis or restenosis)**



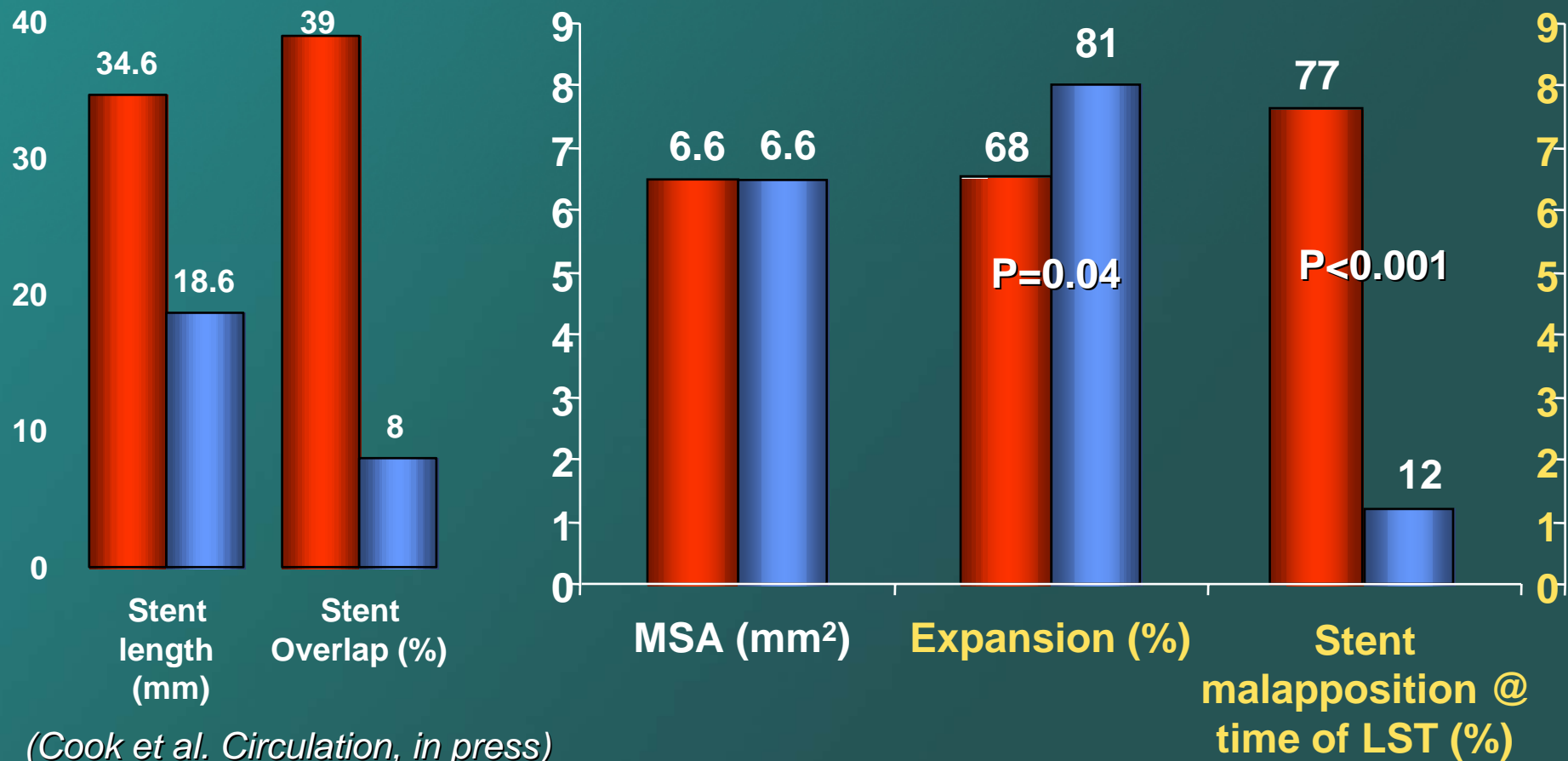
Late Stent Malapposition



IVUS Predictors of Late (>12 months) DES Thrombosis

■ Late DES Thrombosis (n=13)

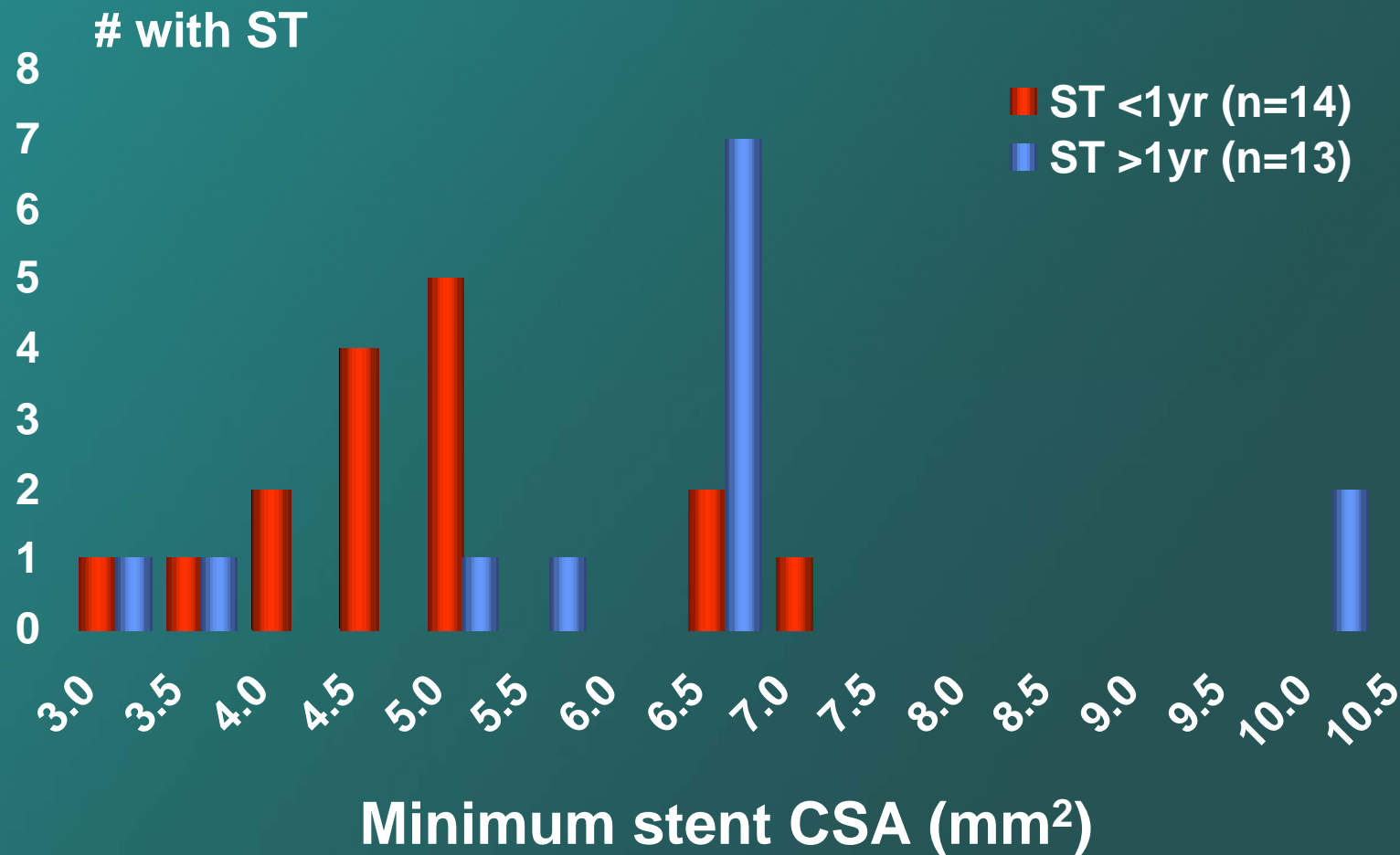
■ Controls (n=175)



(Cook et al. Circulation, in press)



Stent Underexpansion in Early vs Late DES Thrombosis (ST)

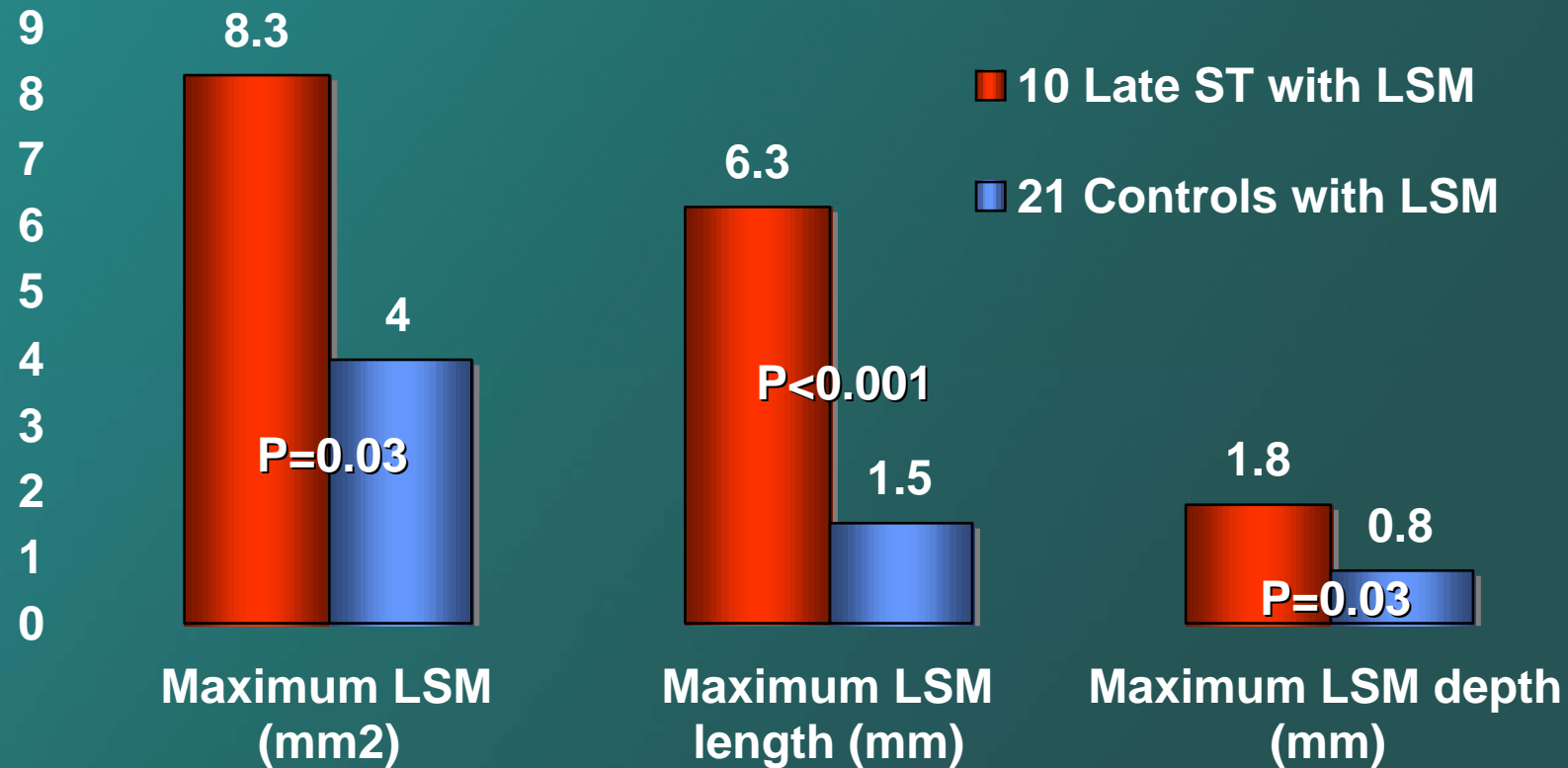


(Okabe et al., Am J Cardiol. In press)

(Cook et al. Circulation, in press)



Quantification of LSM in Patients with Late DES ST



(Cook et al. Circulation, in press)

Two Cases of Late Stent Thrombosis after DES Implantation

- LSM @ 6 months occurred in 10/195 (5.1%) lesions overall
 - 7/175 sirolimus-eluting stents
 - 3/20 paclitaxel-eluting stents
- Subsequent follow-up of 19 ± 9 months
- ***Two patients developed late stent thrombosis (331 and 1152 days). These patients had a 20% (50mm³) and a 39% (135mm³) increase in EEM volume and, presumably, severe LSM***

(Siquiera et al. J Am Coll Cardiol 2006;47:365A)

(Feres et al. Cath Cardiovasc Intervent 2006;68:83-8)

Late Stent Malapposition (LSM) and Events in IVUS Substudies

Trial	# (%) in IVUS substudy	% With LSM	LSM	Events
CYPHER				
RAVEL	48 (40%)	21% @ follow-up	3mm ² (mean area) 0.75mm (max depth)	0
SIRIUS	80 (15%)	7.5% persistent 8.7% late acquired	0.4±0.1mm (max depth) 0.7±0.3mm (max depth)	0
TAXUS	(85%)			
II-MR	116	0% persistent 9.5% late acquired	- 3.4±2.6mm ² (max area)	0
II-SR	113	4.4% persistent 8.0% late acquired	- 5.1±1.8mm ² (max area)	0
IV,V, and VI	(20%)			
MR	78	10.3% persistent 16.7% late acquired		0
SR	209	2.5% persistent 5.3% late acquired		0



Late Acquired Stent Malapposition & Events from Asan Medical Center

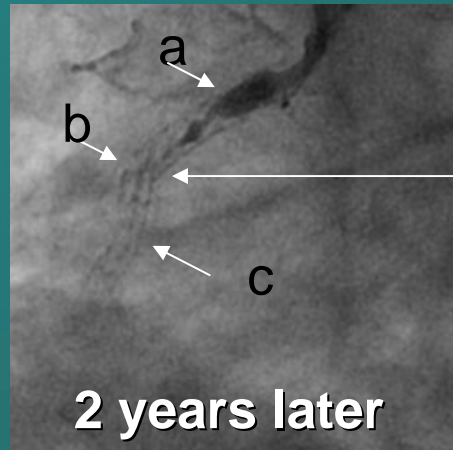
- [Persistent malapposition in 51/705 (7.2%)]
- Late acquired malapposition in 85/705 (12.1%)
 - 71/538 (13.2%) sirolimus-eluting stents
 - 14/167 (8.4%) paclitaxel-eluting stents
 - 25.0% (4/16) after DCA before stenting
 - 27.5% (14/51) in CTO lesions
 - 31.8% (7/22) after primary stenting in acute MI
- Stent-vessel wall gap
 - $1.9 \pm 1.2 \text{mm}^2$ (patients with persistent malapposition)
 - $3.0 \pm 1.9 \text{mm}^2$ (patients with acquired malapposition)
- Except for only one death in the non-LSM group, there were no MACE in either LSM or non-LSM patients during a mean 10-month follow-up after detection of LSM.

(Hong et al. Circulation 2006;113:414-9)

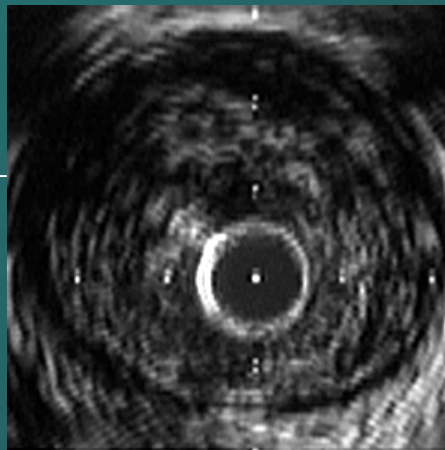
Strut Fracture and Inhomogeneous Strut Distribution



**DES after VBT failure
for Rx of BMS
Restenosis**



2 years later



Conclusions

- The most important IVUS findings in patients with stent thrombosis (especially, within 1 year) continue to be stent underexpansion and inflow/outflow stenoses. But the effect of these mechanical problems on stent thrombosis decreases over time.
- Late stent thrombosis (beyond 1 year) may be linked to late stent malapposition with large stent-vessel wall gaps, larger than have been reported routinely in prospective single and multicenter studies. However, given the high frequency of late stent malapposition in these prospective single and multicenter studies ($\approx 10-20\%$), it is likely that other pathological factors - beyond the mere presence of late malapposition - are involved.

