
بسم الله الرحمن الرحيم

Pitfalls in Coronary Angiogram Interpretation

By
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Introduction

- Coronary angiogram is currently the gold standard in diagnostic and therapeutic management of CAD
- However, several pitfalls and limitations exists
- The non recognition of those limitations may result in sub-optimal patients care (i.e over or under treatment)

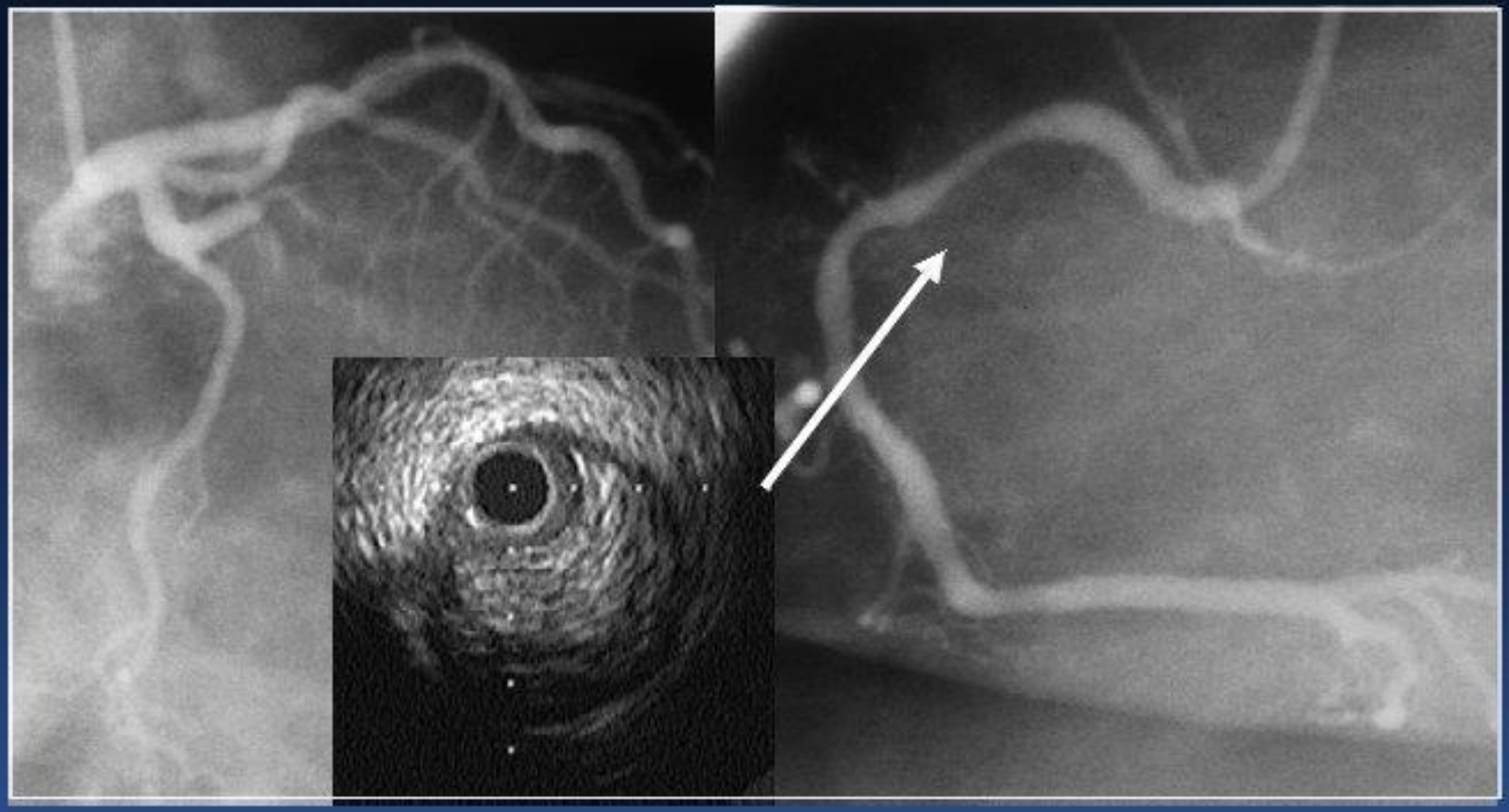
Agenda

1. Diameter stenosis severity
2. Calcification
3. Thrombus
4. Bifurcation
5. Left main
6. SYNTAX score

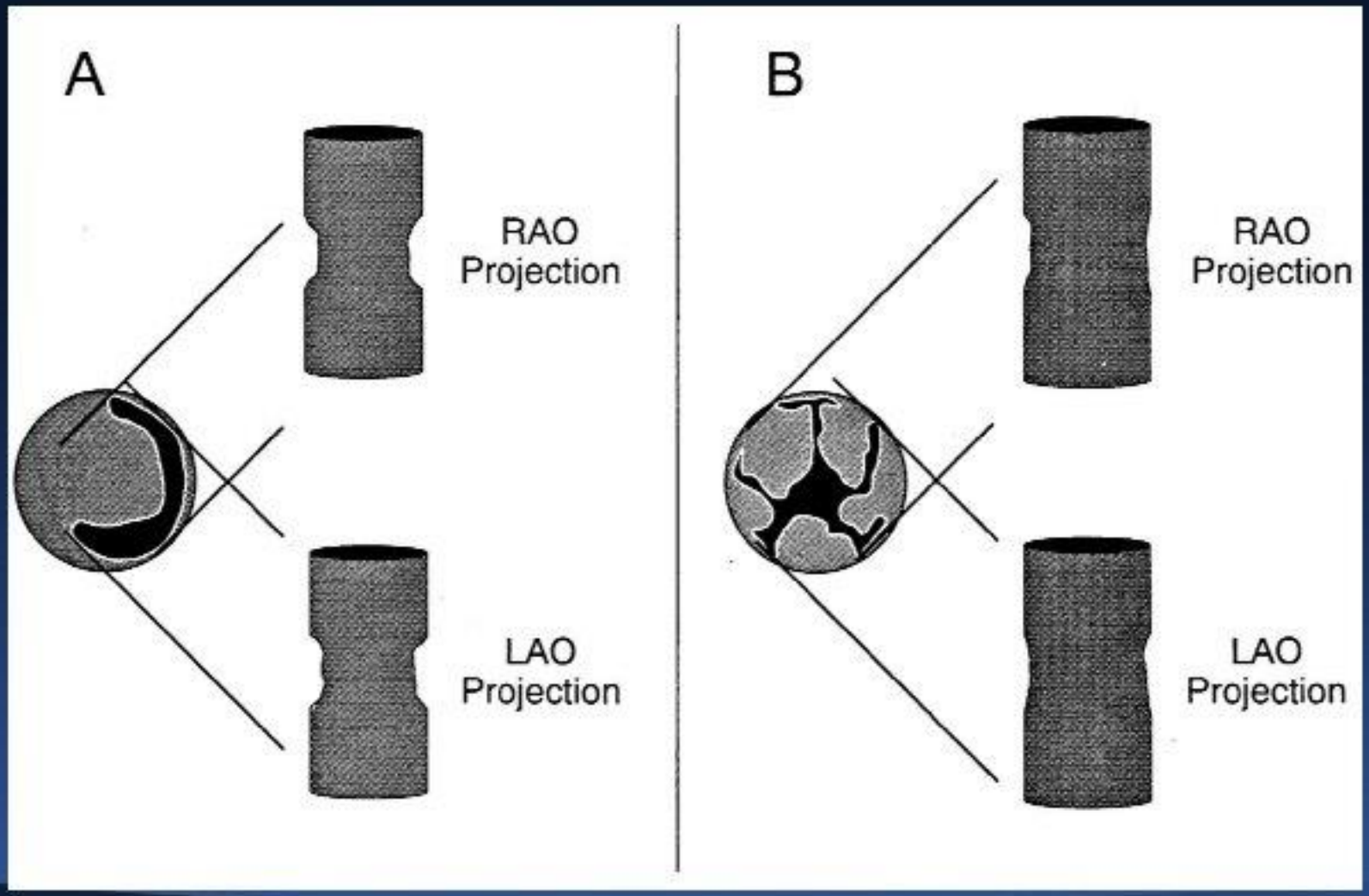
Agenda

1. Diameter stenosis severity
2. Calcification
3. Thrombus
4. Tortuosity
5. Left main
6. SYNTAX score

Lesion Severity ?

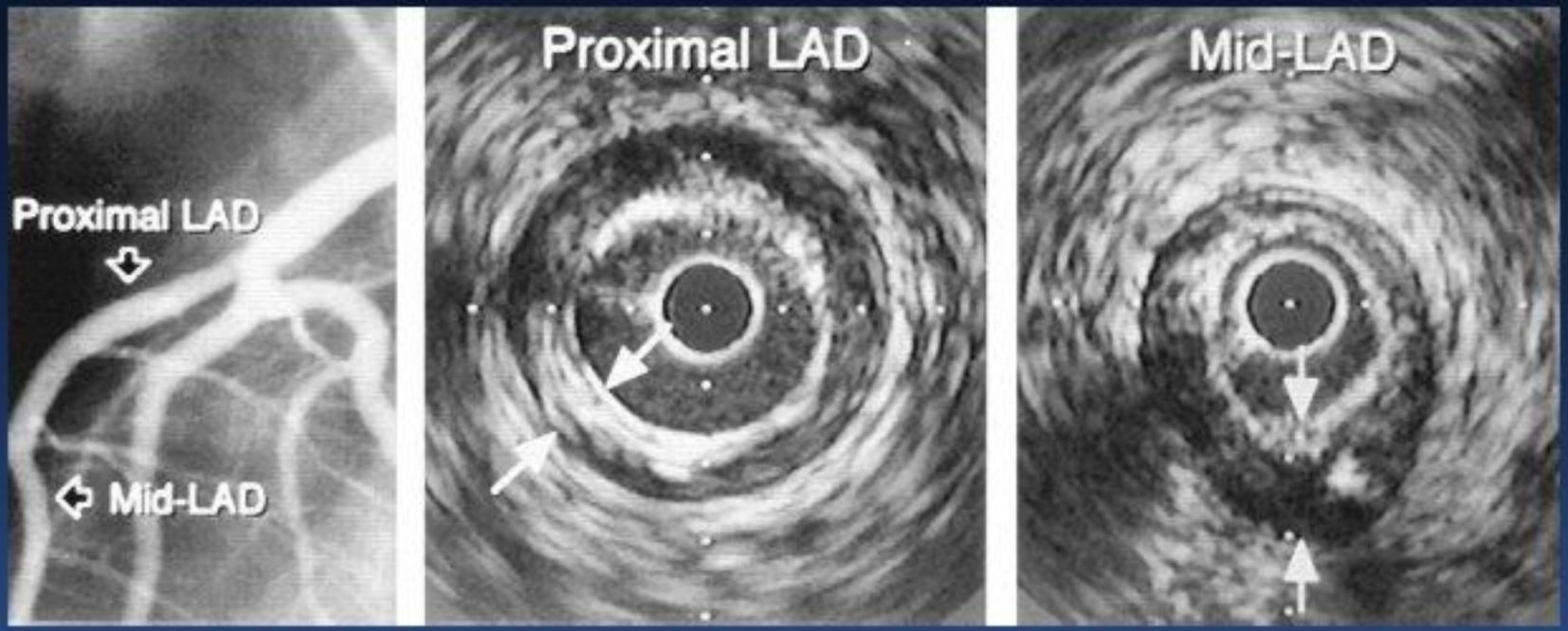


Schematic representation of an important limitation of projection imaging.



Topol E J , and Nissen S E Circulation 1995;92:2333-2342

Concealment of severe coronary disease by diffuse concentric involvement.



Topol E J , and Nissen S E Circulation 1995;92:2333-2342

QCA vs. Visual assessment?

Comparison of Clinical Interpretation with Visual Assessment and Quantitative Coronary Angiography in Patients Undergoing Percutaneous Coronary Intervention in Contemporary Practice: The Assessing Angiography (A2) Project

Brahmajee K. Nallamothu, John A. Spertus, Alexandra J. Lansky, David J. Cohen, Philip G. Jones, Faraz Kureshi, Gregory J. Dehmer, Joseph P. Drozda, Jr., Mary Norine Walsh, John E. Brush, Jr., Gerald C. Koenig, Thad F. Waites, D. Scott Gantt, George Kichura, Richard A. Chazal, Peter K. O'Brien, C. Michael Valentine, John S. Rumsfeld, Johan H.C. Reiber, Joann G. Elmore, Richard A. Krumholz, W. Douglas Weaver and Harlan M. Krumholz

175 patients; PCI of 228 lesions at 7 US sites

CathPCI Registry of the NCDR®

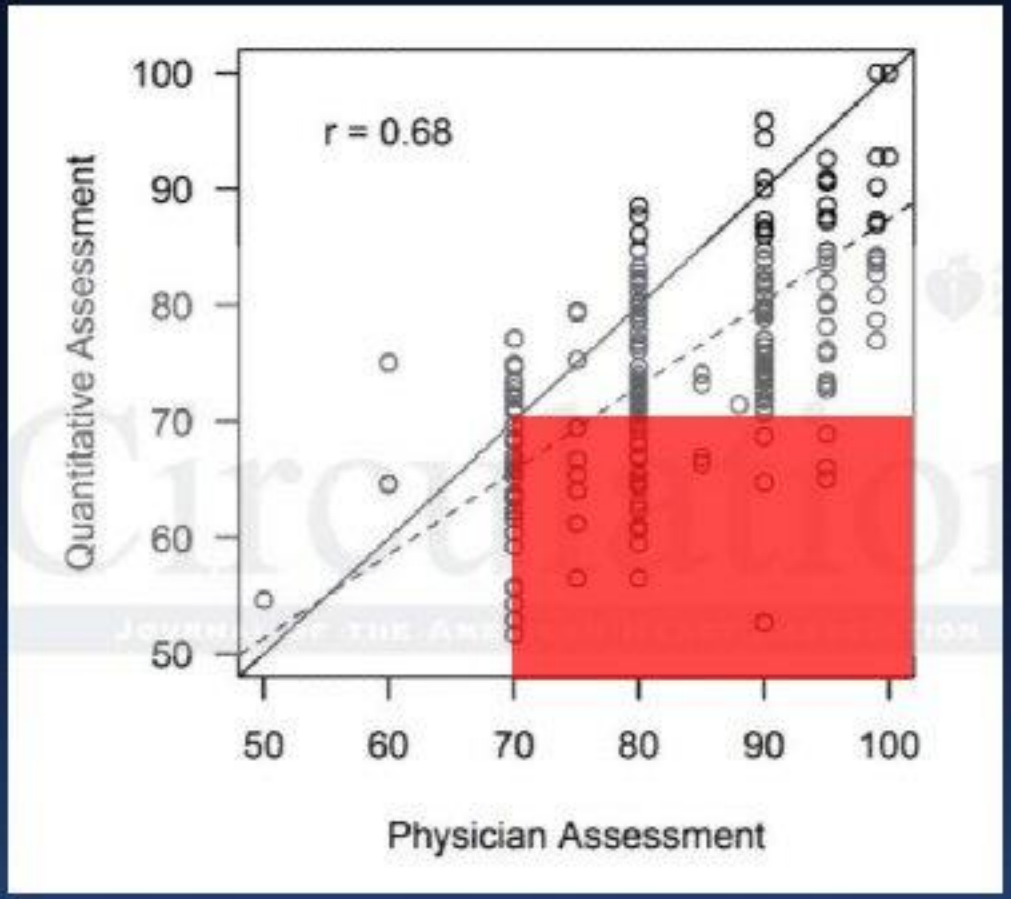
Comparison of QCA and visual assessment

Nallamothu et al. Circulation on line March 2013

The mean difference in %DS between the clinical interpretation and QCA was ***+8.2% ± 8.4%, (P<0.001)***

Of all the lesions considered 70% or greater by clinical assessment ***26.3% were measured at less than 70%***

A ***weighted kappa of 0.27*** (95% CI, 0.18 to 0.36) was found between QCA and visual assessment



Conclusions

Physicians tended to over estimated lesion severity **compared to QCA. Almost all treated lesions were >70% by clinical interpretation, while** ***approximately a quarter were <70% by QCA.***

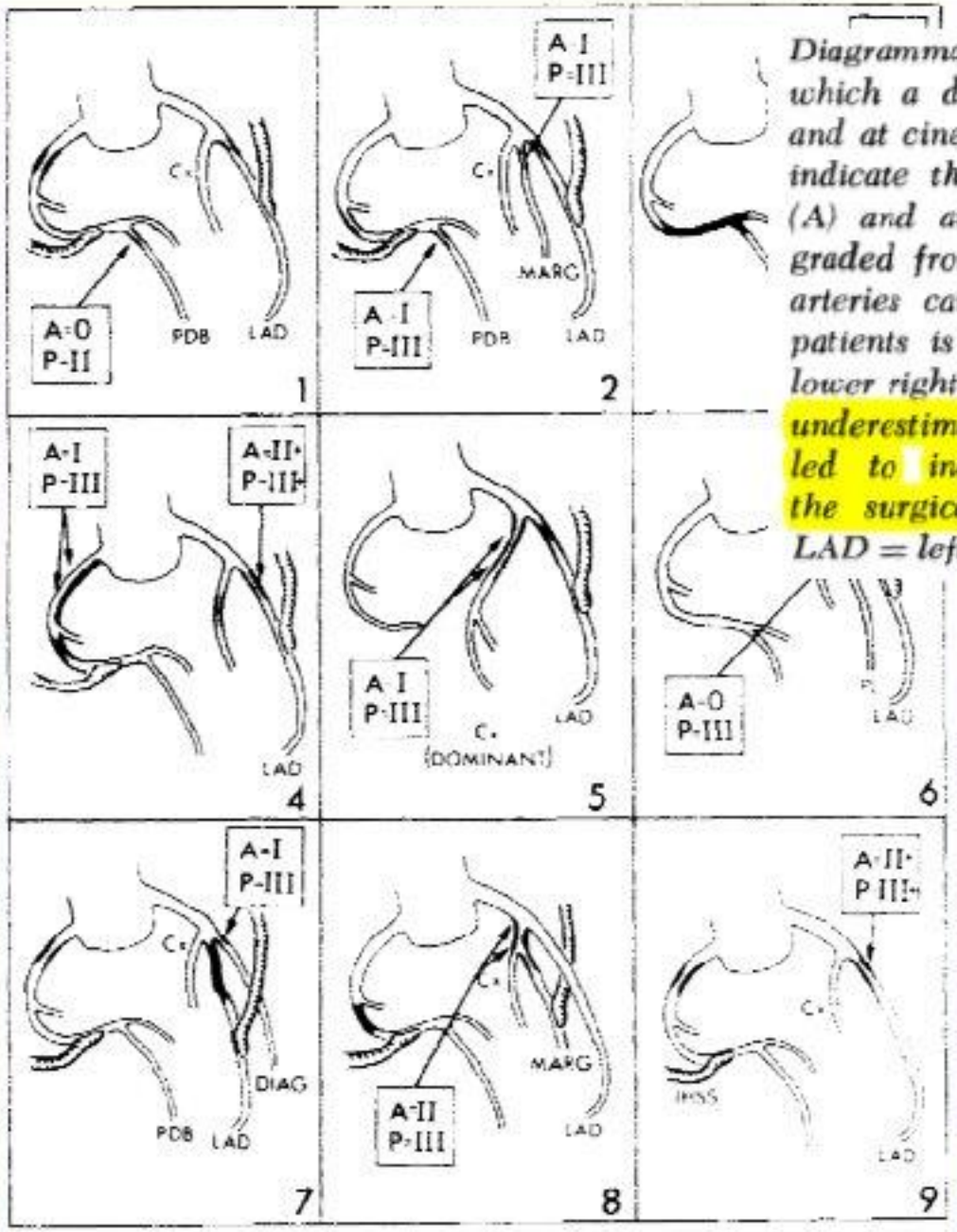
Circulation
JOURNAL OF THE AMERICAN HEART ASSOCIATION

American Heart Association

Discrepancies Between Cineangiographic and Postmortem Findings in Patients with Coronary Artery Disease and Recent Myocardial Revascularization

CLAUDE M. GRÖNDIN, IHOR DYRDA, ANDRÉ PASTERNAC, LUCIEN CAMPEAU, MARTIAL G. BOURASSA and JACQUES LESPÉRANCE

23 patients died inside 30 days post CABG
Autopsies were performed to compared pathological findings to pre CABG lesion severity performed by QCA analysis



Diagrammatic portrayal of coronary arterial lesions for which a discrepancy existed between findings at autopsy and at cineangiography. The roman numbers in the squares indicate the degree of narrowing as seen at angiography (A) and at pathological (P) examination. Narrowings are graded from 0 to IV (0% to 100%). Vein grafts to various arteries can be recognized by the hash marks. Order of patients is same as in table 1 and in arabic numbers in lower right hand corner. In cases 2, 5, 6 and 7, angiographic underestimation of the severity of coronary arterial lesions led to incomplete revascularization and contributed to the surgical failure. PDB = posterior descending branch; LAD = left anterior descending artery; Cx = circumflex

*"…it is recommended **that additional projections in the sagittal plane be included to eliminate angiographic superimposition** of multiple branches, which often cannot be properly separated in the standard transverse plane…"*

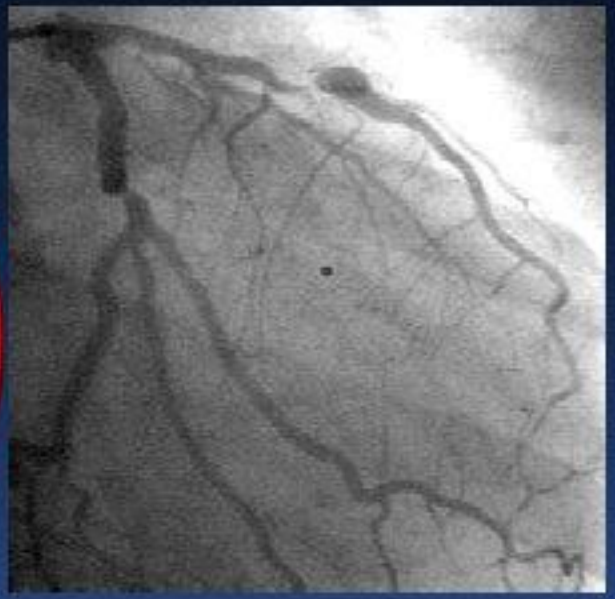
Grondin et al. Circulation. 1974;49:703-708

Not identifying/treating a significant lesion may have similar (or even worse…) detrimental consequence than over-treating non significant lesion…

Angio vs. Physiology?

Angiography versus FFR in the FAME study

Proportions of functionally diseased coronary arteries
in patients with angiographic 3-vessel disease



Angiographic 3-VD (n=115)

Tonino et al. J Am Coll Cardiol. 2010;55(25):2816-2821

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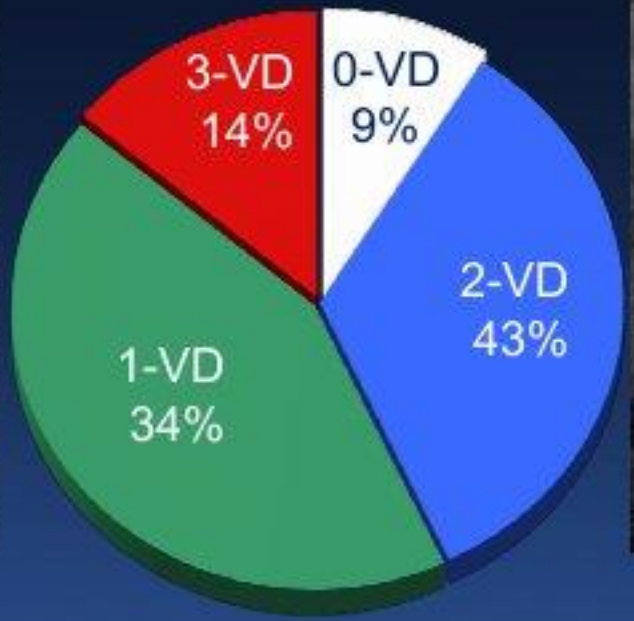
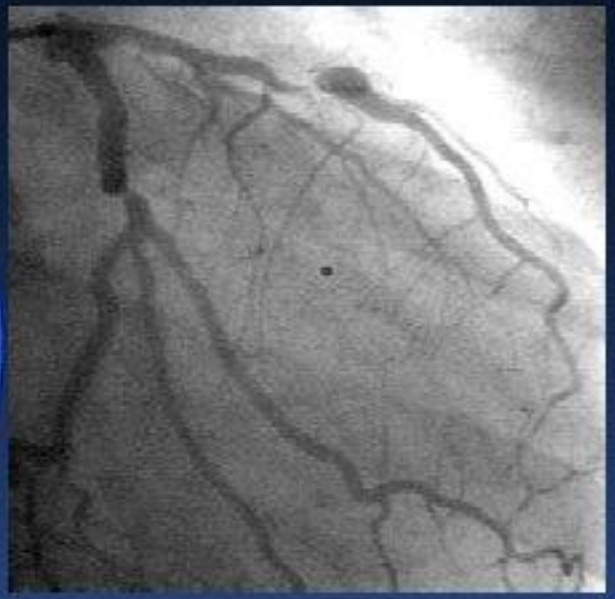




Angiographic 3-VD (n=115)

Tonino et al. J Am Coll Cardiol. 2010;55(25):2816-2821

Angio vs. IVUS?

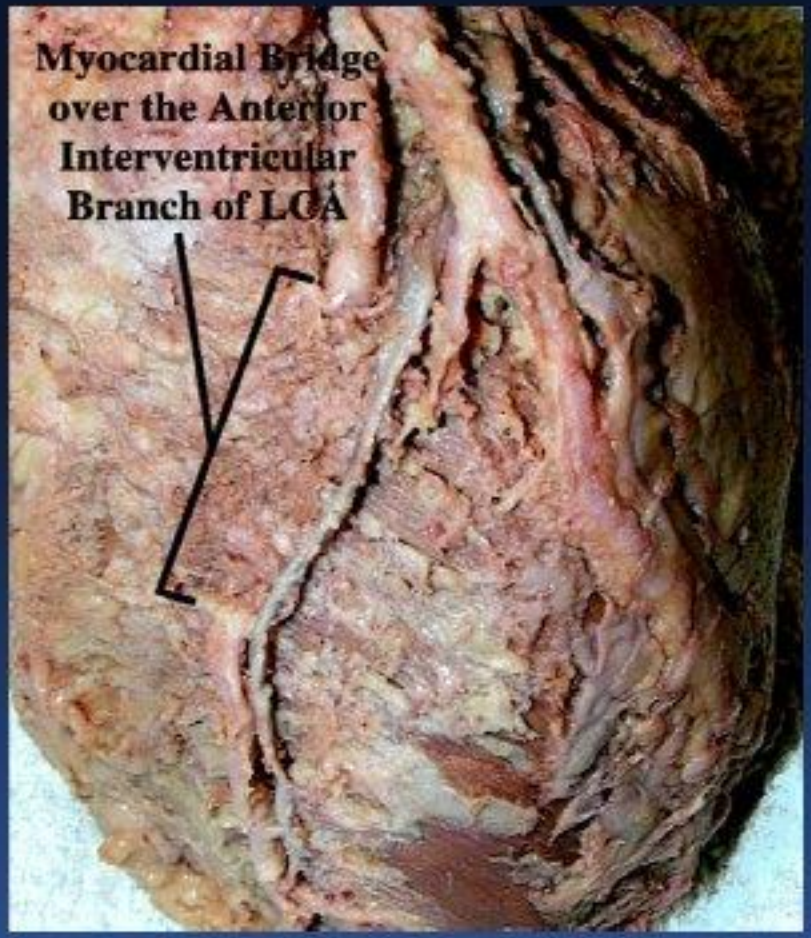
IVUS vs. QCA at Baseline
Total plaque volume (mm^3)
n=525 pts

	Correlation (95% CI)	p
Coronary artery score, mm	*0.22* (0.14 to 0.30)	<0.0001
Cumulative coronary stenosis score	*0.25* (0.16 to 0.32)	<0.0001
Mean lesion diameter, mm	***0.22 (0.12 to 0.32)***	***<0.0001***
Mean plaque area, mm^2	*0.14* (0.06 to 0.23)	0.0013

Berry et al. Circulation. 2007;115:1851-1857

Myocardial Bridge

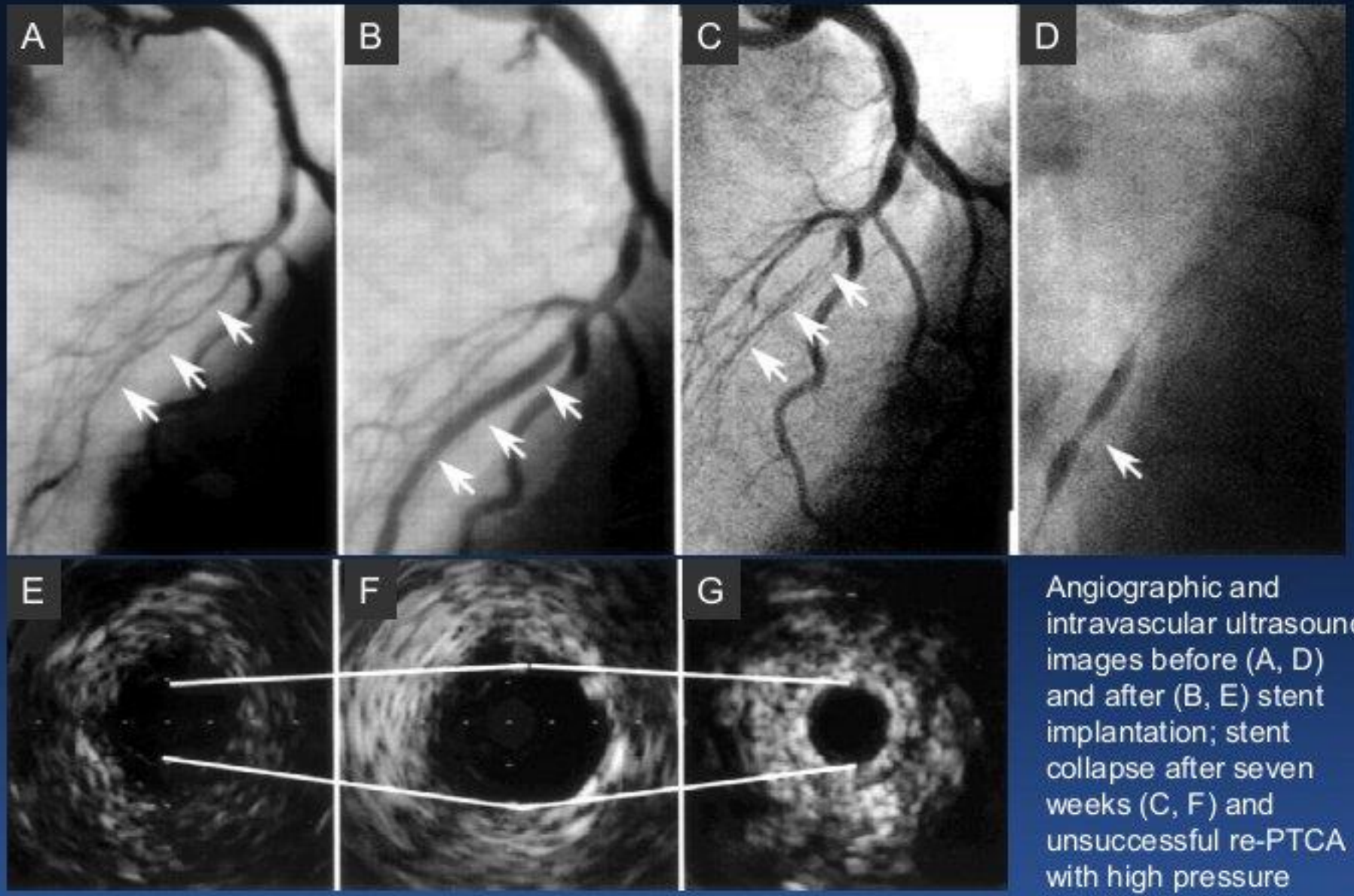
- Segment of a major coronary epicardial coronary artery that *dives intramurally* through the myocardium beneath the muscle bridge.[1]
- Generally involving ***LAD*** and its diagonal branches
- Frequency
  - Coronary angiographic series: ***0.5-16%***
  - Pathological series up to 85%. [1,2]
- Superficial and deep variants



Loukas et al Journal of Anatomy 2006; 209(1): 43-50.

[1] Alegria et al Eur Heart Journal 2005; 26:1159-1168

[2] Ge et al Eur Heart Journal 1999; 20:1707-1716



Angiographic and intravascular ultrasound images before (A, D) and after (B, E) stent implantation; stent collapse after seven weeks (C, F) and unsuccessful re-PTCA with high pressure insufflation (G).

Haager et al Heart 2000; 84:403-408

Why is it so important to appropriately assess %DS and lesion severity?

- Avoid unnecessary stenting
- Avoid under revascularization
- Offer the most appropriate revascularization strategy for every given patients

For intermediate lesions…use FFR

Agenda

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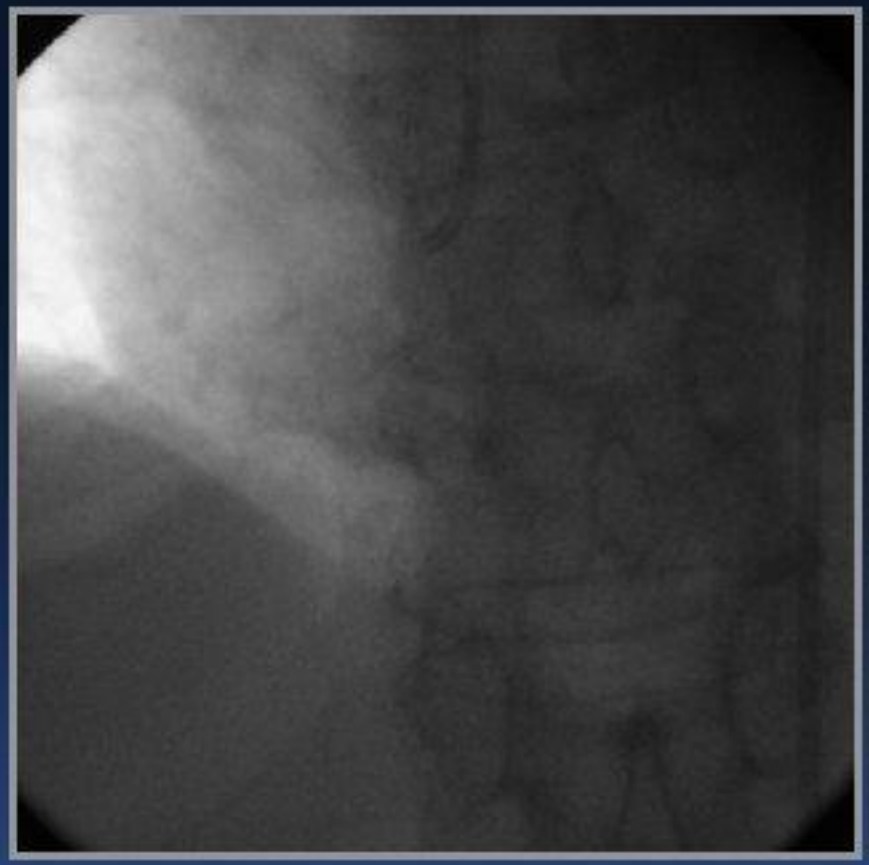
2. Calcification
3. Thrombus
4. Bifurcations
5. Left main
6. SYNTAX score

Calcificications

Moderate

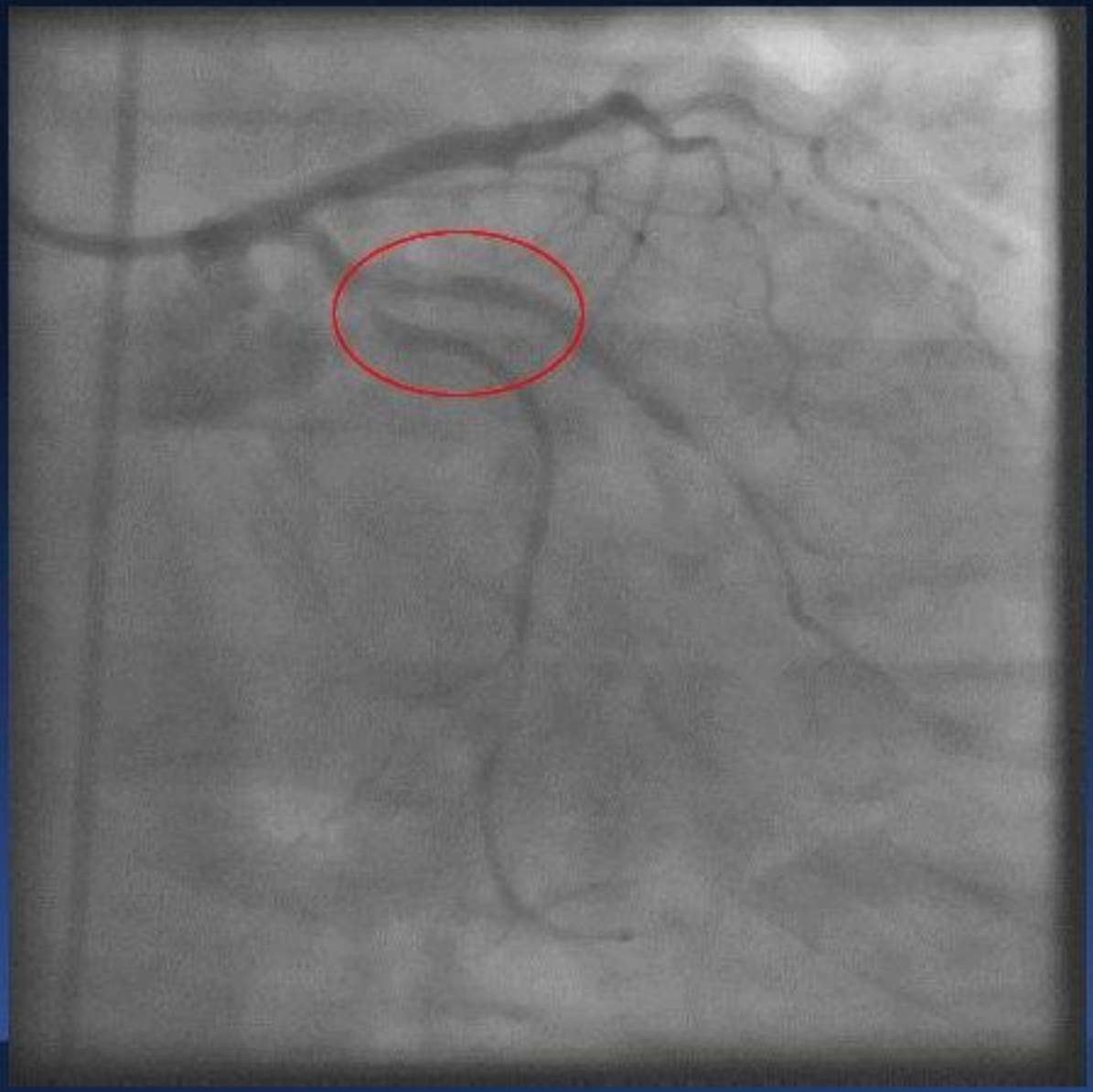


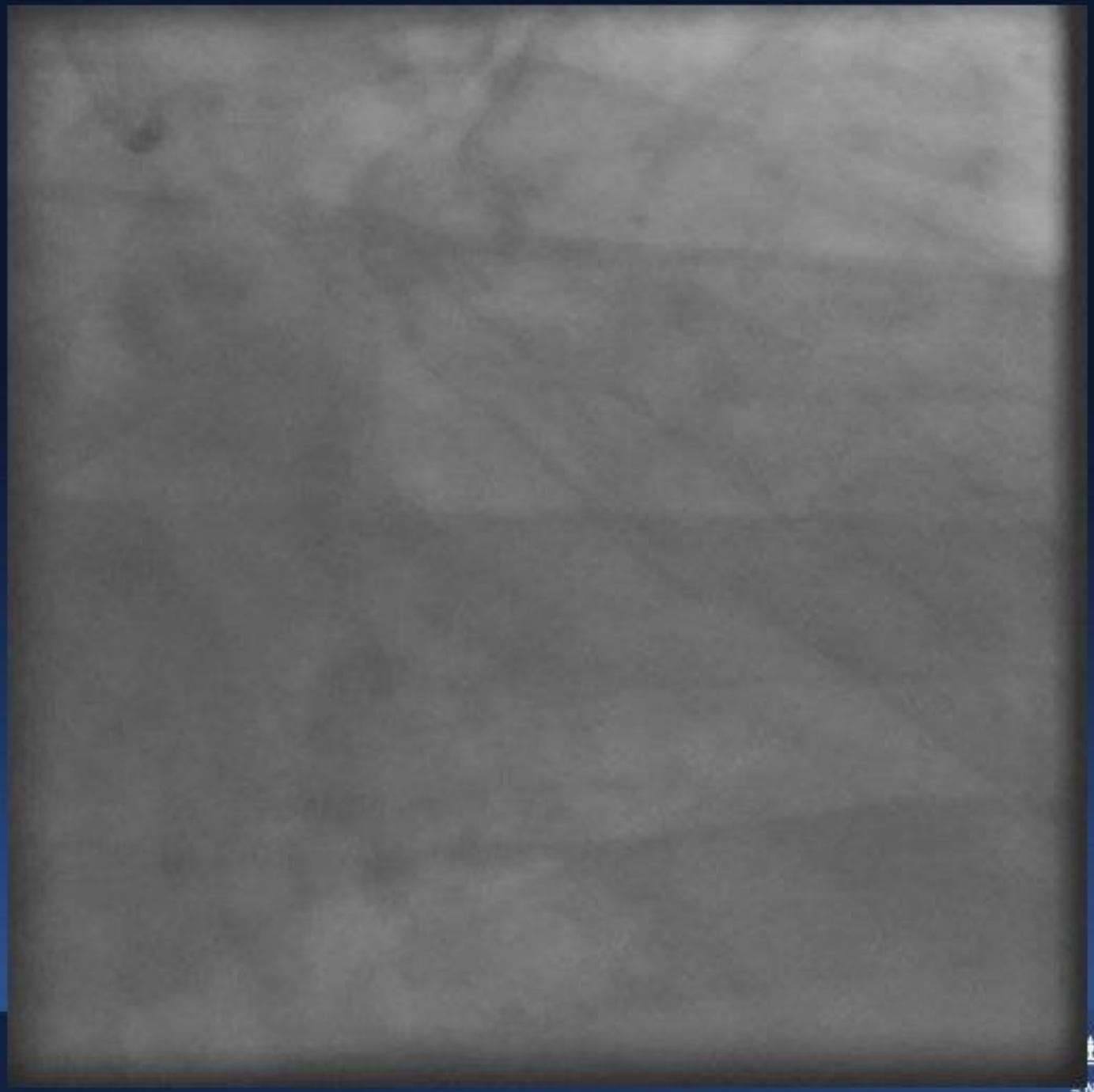
Severe

Readily apparent densities noted within the apparent vascular wall at the stenosis

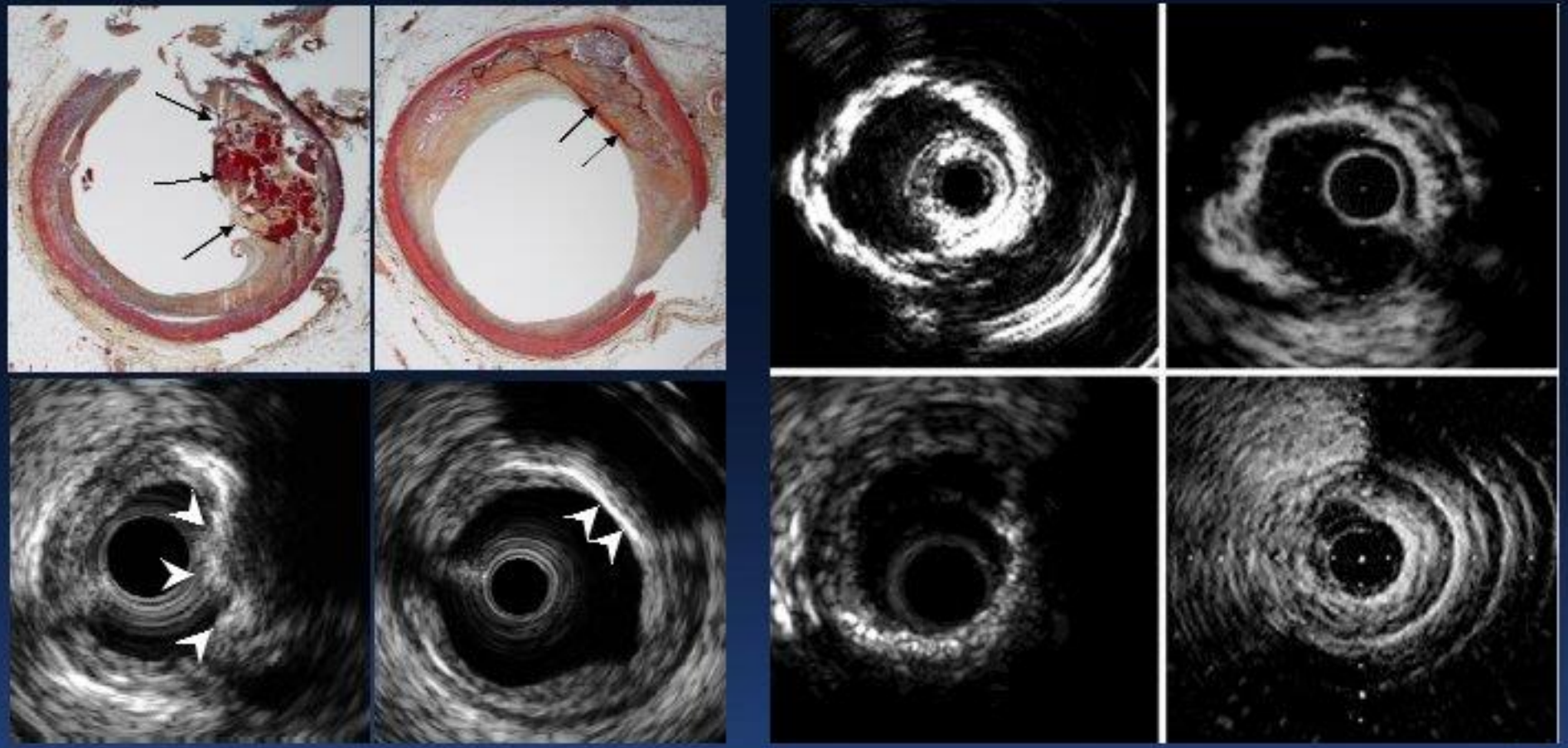
Moderate: Densities noted only during the cardiac cycle prior to contrast injection
Severe: Radiooppacities noted without cardiac motion prior to contrast injection generally involving ***both sides of the arterial wall***

Thrombus vs. Calcium?





IVUS Detection of Calcium

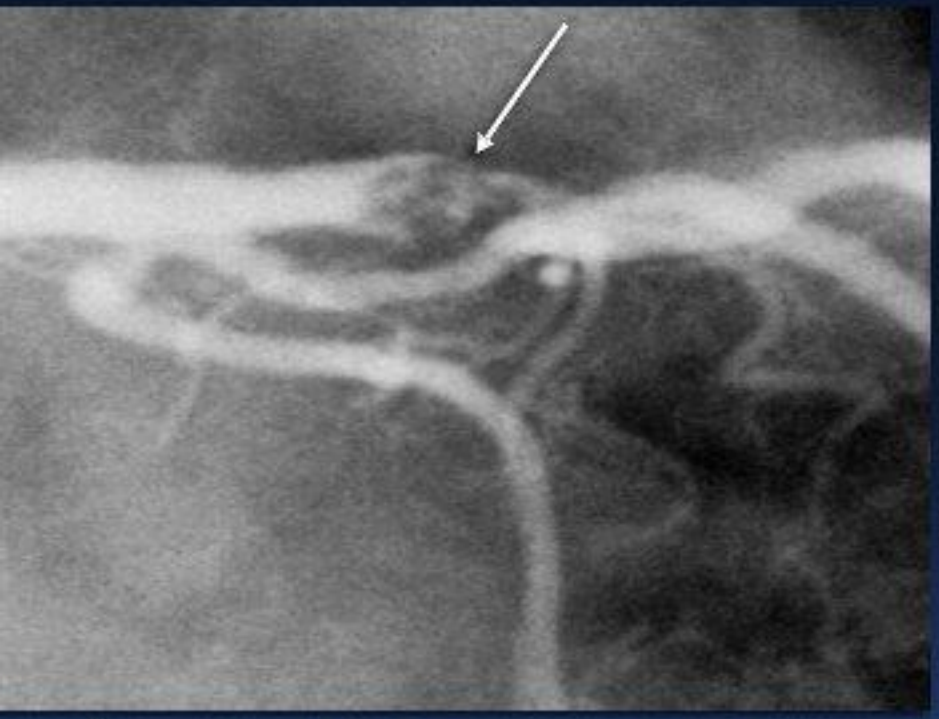


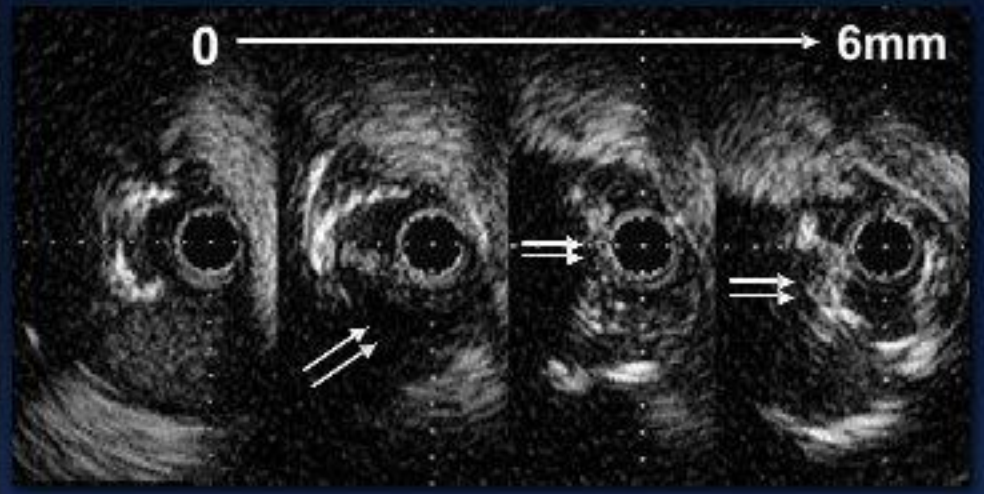
Because IVUS does not penetrate into calcium. . .

1) it cannot measure thickness or mass, only arc and length
2) we assume that superficial calcium is thicker than deep calcium

Potkin et al. Circulation 2001;81:1575-85
Lee et al. Am J Cardiol 2011;108:1547-51

Calcified Nodules in PROSPECT





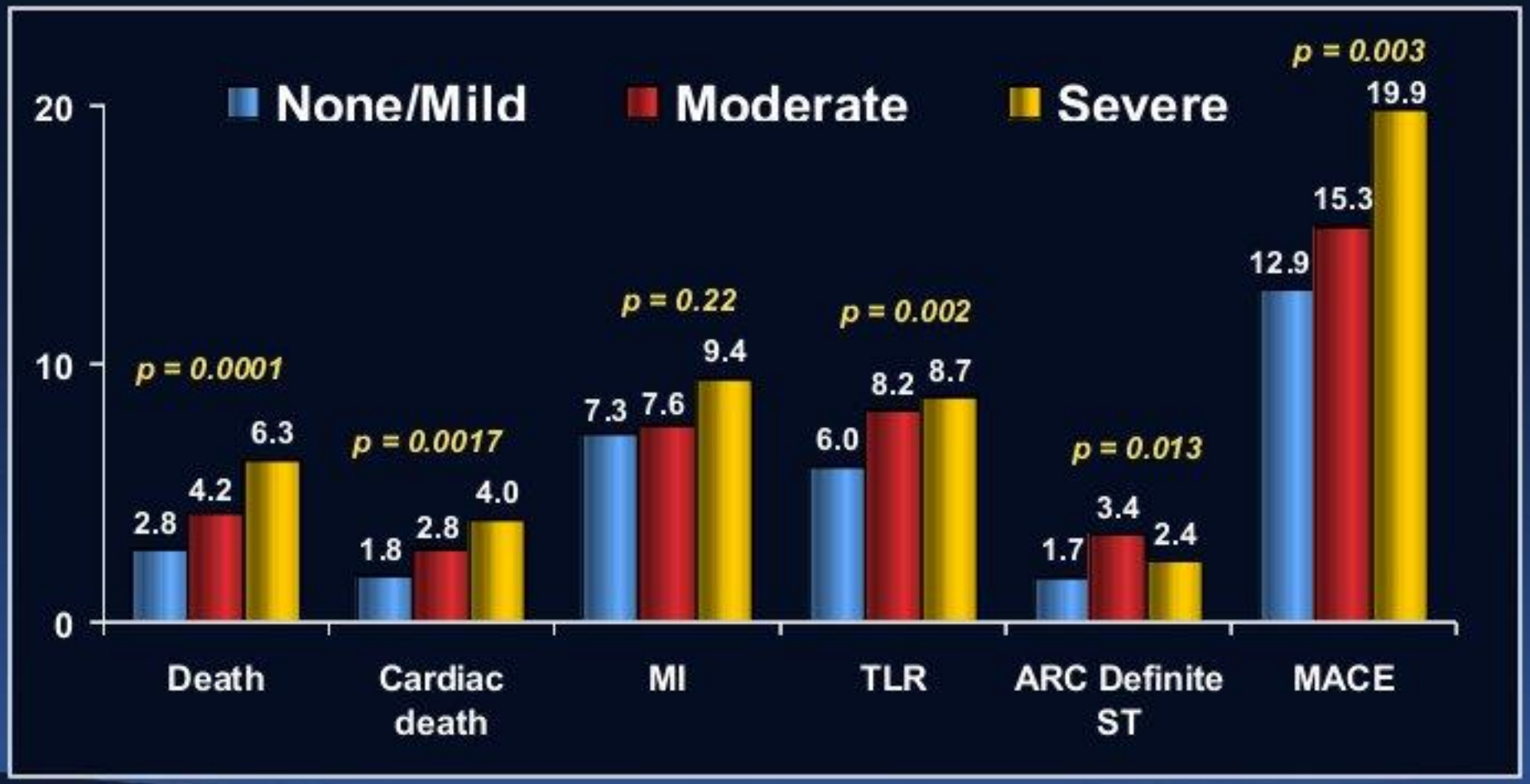
Angio interpretation/appearance of Calcified Nodule n=314

1) Severe calcification in 1%
2) Moderate calcificaton in 11%
3) ***Hazy/thrombus in 6%***
4) ***Normal in 82%***

Xu et al. Circulation 2012;126:537-45

Why is it so important to assess appropriately calcification severity?

1-Year Ischemic Outcomes: ACS Population-6,855 pts



Généreux, P. et al. J Am Coll Cardiol 2014

Columbia University Medical Center
NewYork-Presbyterian

IVUS stent expansion is the strongest predictor of early ST or restenosis after BMS or DES

	Early Stent Thrombosis	Restenosis
BMS	•Cheneau et al. Circulation 2003;108:43-7	•Kasaoka et al. J Am Coll Cardiol 1998;32:1630-5 •Castagna et al. AHJ 2001;142:970-4 •de Feyter et al. Circulation 1999;100:1777-83 •Sonoda et al. J Am Coll Cardiol 2004;43:1959-63 •Morino et al. Am J Cardiol 2001;88:301-3 •Ziada et al. Am Heart J 2001;141:823-31 •Doi et al. JACC Cardiovasc Interv. 2009;2:1269-75
DES	•Fujii et al. J Am Coll Cardiol 2005;45:995-8) •Okabe et al., Am J Cardiol. 2007;100:615-20 •Liu et al. JACC Cardiovasc Interv. 2009;2:428-34 •Choi et al. Circulation Cardiovasc Interv. 20011;4:239-47	•Sonoda et al. J Am Coll Cardiol 2004;43:1959-63 •Hong et al. Eur Heart J 2006;27:1305-10 •Doi et al JACC Cardiovasc Interv. 2009;2:1269-75 •Fujii et al. Circulation 2004;109:1085-1088 •Hahn et al. J Am Coll Cardiol 2009;54:110-7 •Kang et al. Circ Cardiovasc Interv 2011;4:9-14 •Kang et al. Circ Cardiovasc Interv 2011;4:562-9 •Choi et al. Am J Cardiol 2012;109:455-60 •Song et al. Catheter Cardiovasc Interv, in press

Agenda

1. Diameter stenosis severity
2. Calcification
3. Thrombus
4. Bifurcations
5. Left main
6. SYNTAX score

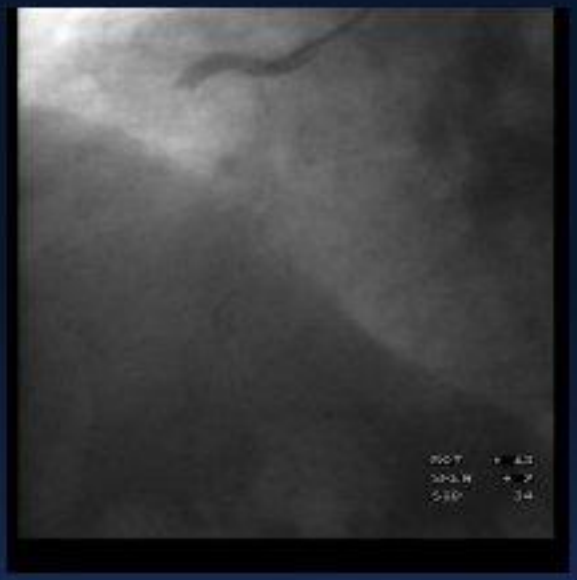
Thrombus Containing Lesions

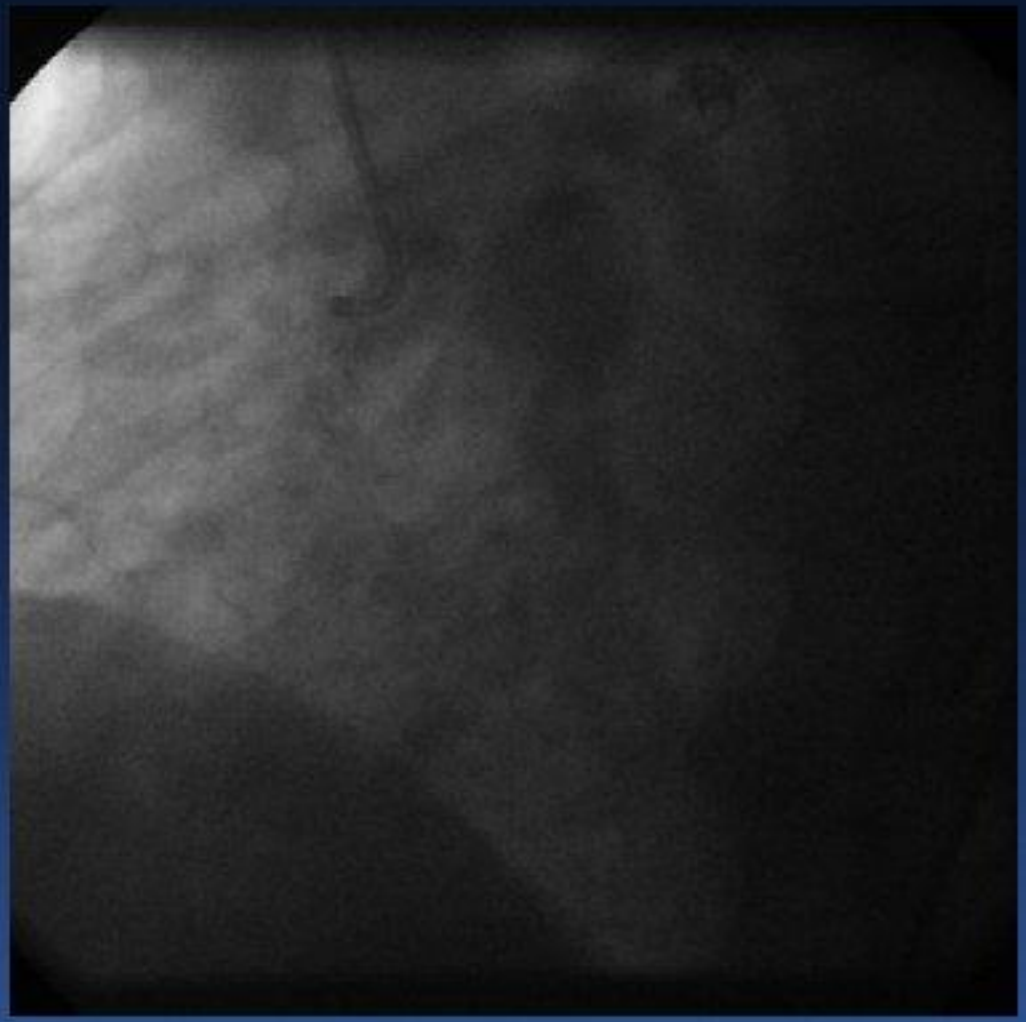
Large thrombus: filling defect with contrast staining

Thrombus
Diagnostic Considerations

- ***Angiography:***
  - Low sensitivity, high specificity
- Thrombus can form/embolize during procedure (IPST, IPTE)…be vigilant
- ***Angioscopy*** is best diagnostic tool
- Be careful: can looks like ***calcium or dissection***

Type of Thrombus





Agenda

1. Diameter stenosis severity
2. Calcification
3. Thrombus
4. **Bifurcation**
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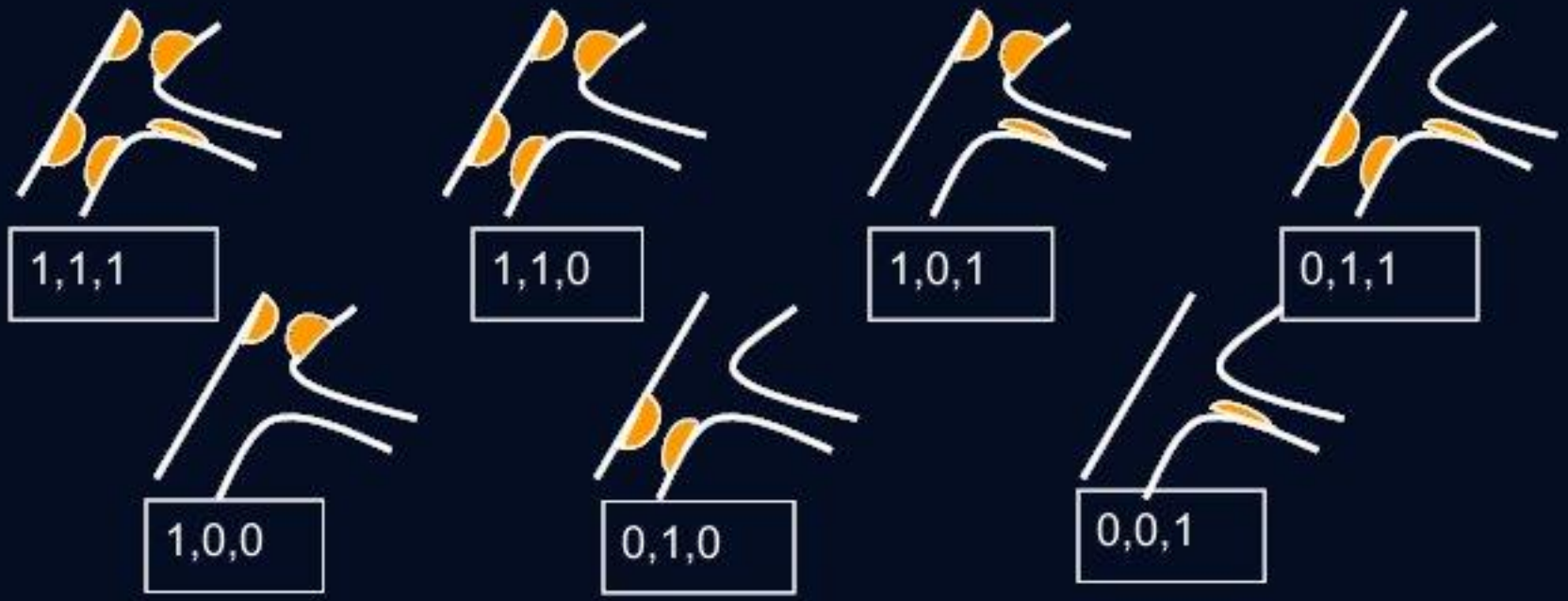
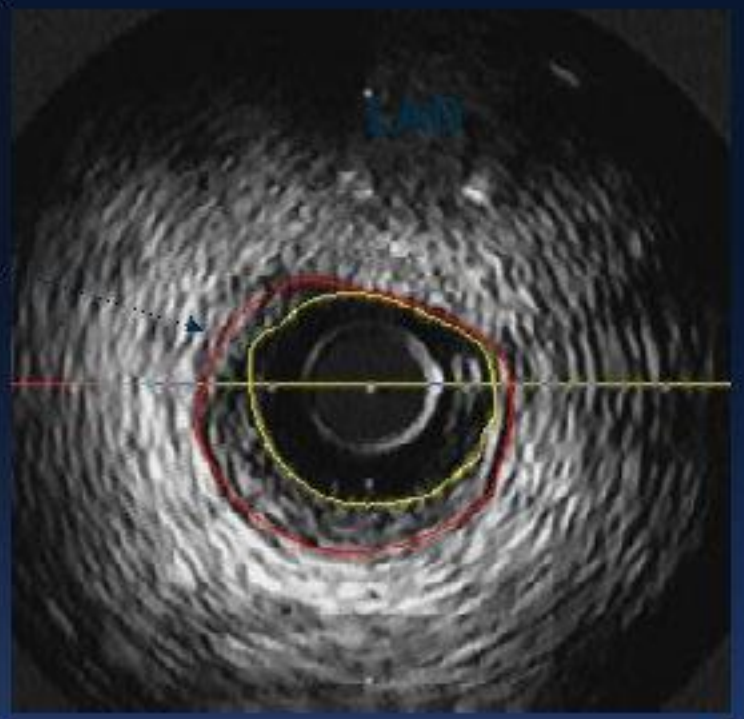
The MEDINA Classification

1. Prox PV > 50%: 0 or 1
2. Distal PV > 50%: 0 or 1
3. SB > 50%: 0 or 1



Medina A.Rev Esp Cardiol. 2006 Feb;59(2):183

Ostial SB Lesion Severity at Baseline



Measurements On Current Frame

	Area (mm^2)	Diameter (mm)			
		Mean	Min	Max	Min/Max
Lumen	3.83	2.23	2.03	2.45	0.82
Vessel	6.31	2.65	2.57	3.10	0.83
Stent					
Plaque	2.48 (39.2% of Vessel)	Comparative Lumen Area			
NIH					

Relationship Between Fractional Flow Reserve and Angiographic and Intravascular Ultrasound Parameters in Ostial Lesions

Major Epicardial Vessel Versus Side Branch Ostial Lesions

Jin-Sin Koh, MD,*† Bon-Kwon Koo, MD, PHD,* Ji-Hyun Kim, MD,* Han-Mo Yang, MD, PHD,* Kyung-Woo Park, MD, PHD,* Hyun-Jae Kang, MD, PHD,* Hyo-Soo Kim, MD, PHD,* Byung-Hee Oh, MD, PHD,* Young-Bae Park, MD, PHD*

Seoul and Jinju, Korea

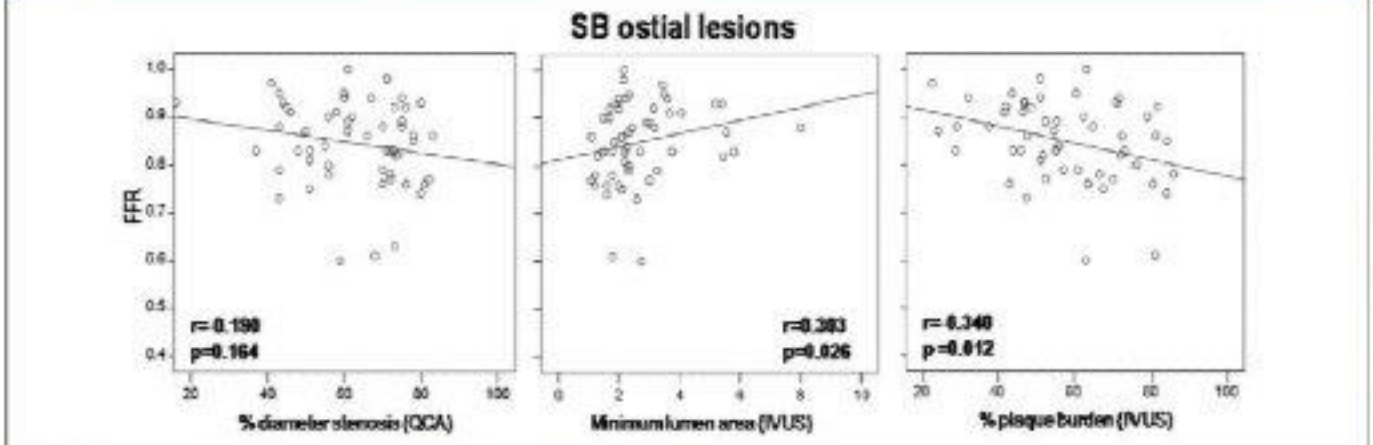


Figure 1. Relationships Among FFR and Angiographic and IVUS Parameters

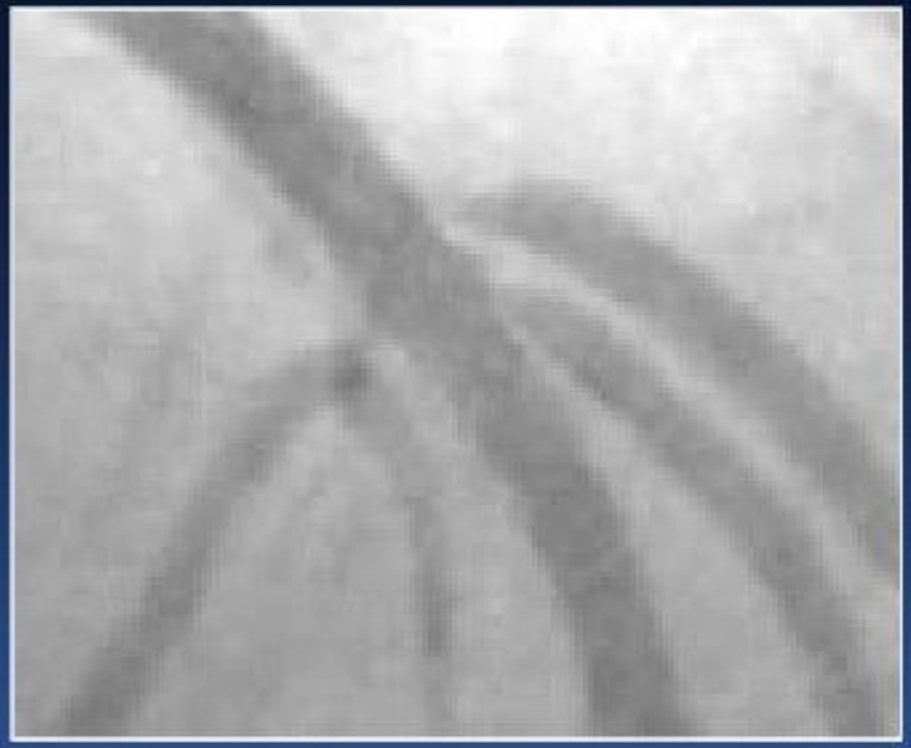
Relationships among fractional flow reserve (FFR) and angiographic and intravascular ultrasound (IVUS) parameters in major epicardial vessel (MV) and side branch (SB) ostial lesions. QCA = quantitative coronary angiography.

Angiographic and IVUS parameters had poor diagnostic accuracy in predicting the functional significance of SB ostial lesions.

Koh et al. J Am Coll Cardiol Intv 2012;5:409-15

Diagnostic Considerations
Ostial SB Lesion Severity after SB Jailing

Angiography vs FFR: N=94

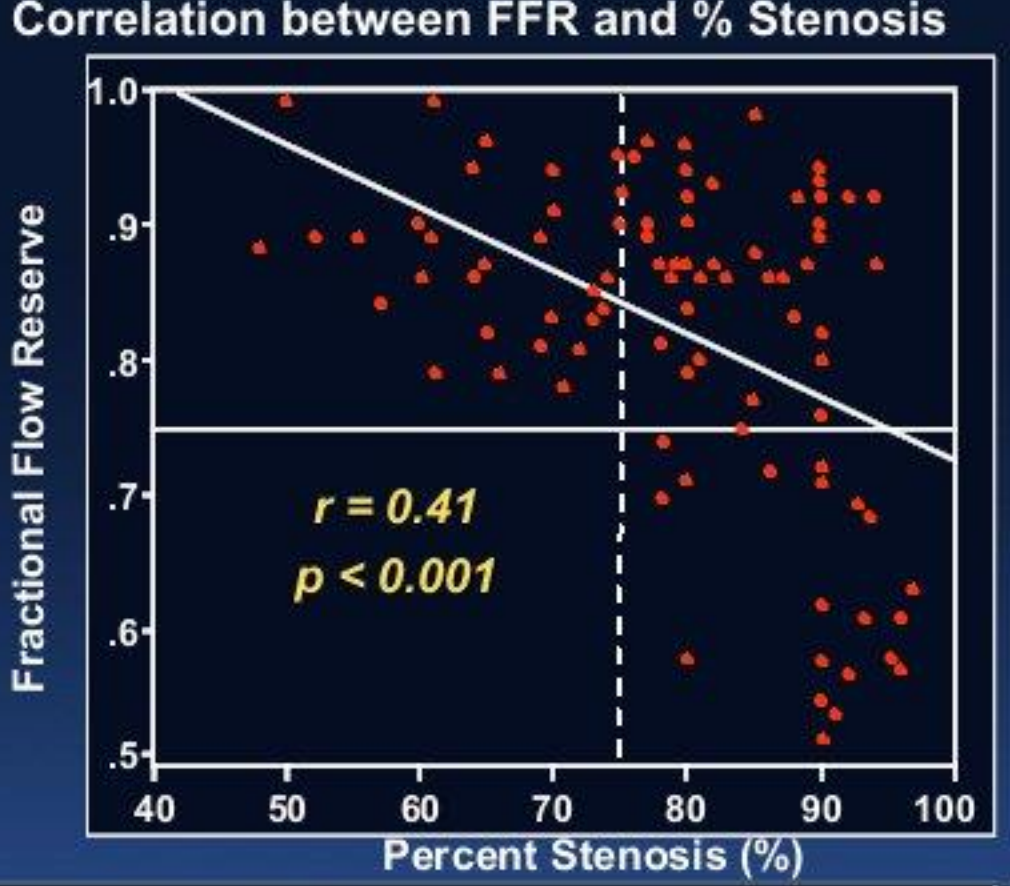


Koo, B.-K. et al. *JACC* 2005;46:633-637

Physiologic Assessment of Jailed Side Branch Lesions Using Fractional Flow Reserve (FFR)

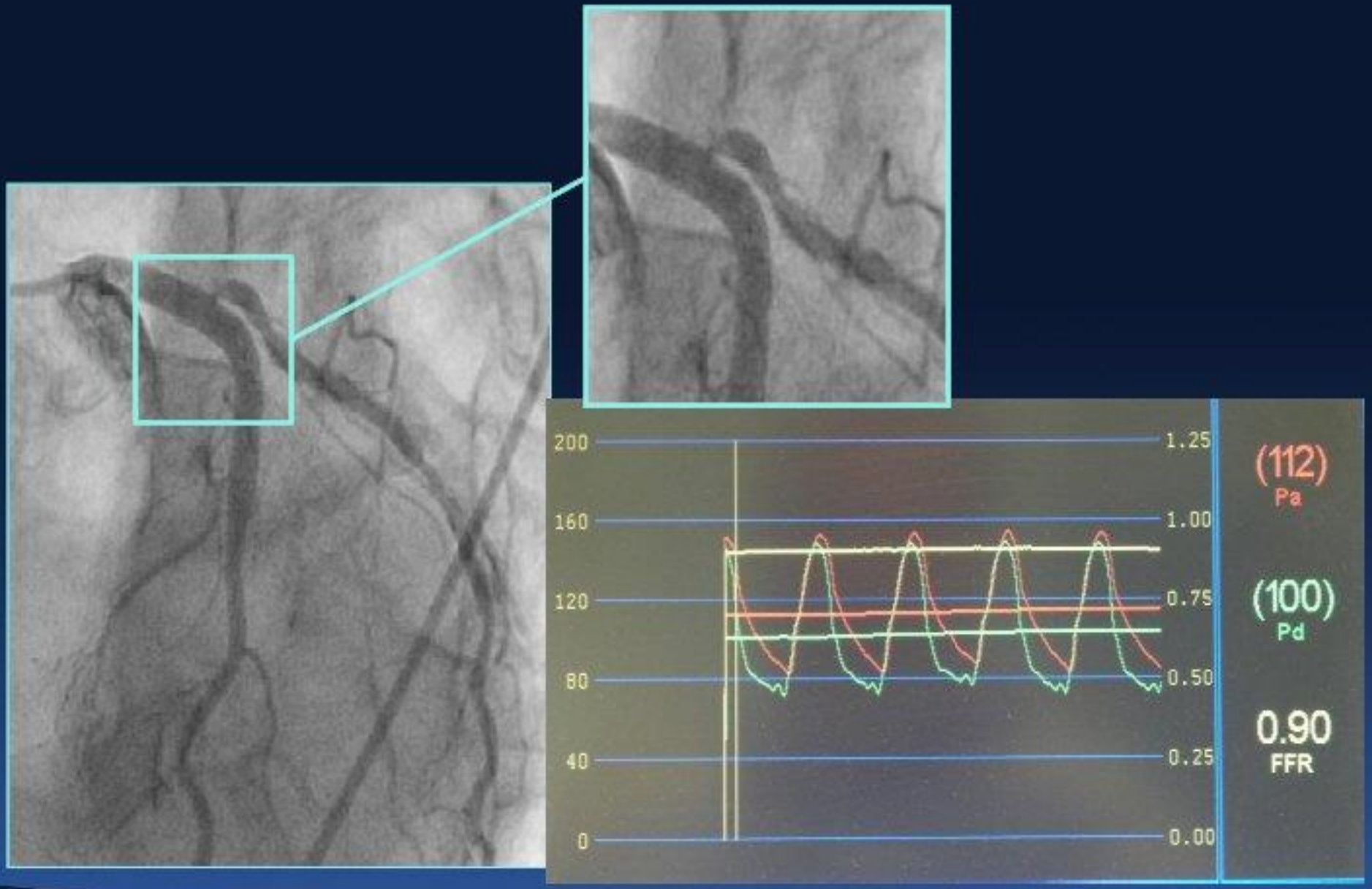
The optimal cutoff value for percent stenosis to predict functionally ***significant stenosis was %DS of 85%***

(Sensitivity: 0.80, Specificity: 0.76)



Conclusions: ***QCA*** is unreliable in the "functional" assessment of stenosis severity in jailed SBs. Conversely, ***FFR*** measurements demonstrate that most of stenotic SBs do not have functional significance

Koo, B.-K. et al. *JACC* 2005;46:633-637



Why appropriate bifurcation assessment important?

- Avoiding unnecessary stenting/treatment of SB lesions when not physiologicaly significant
- Stent failure is high in this sub-set of lesion

In doubt…use FFR

Agenda

1. Diameter stenosis severity
2. Calcification
3. Thrombus
4. Bifurcation
5. **Left main**
6. SYNTAX score

Pitfalls of QCA LM assessment

- Diffuse atherosclerotic involvement affects the %DS calculation because of ***the lack of a normal reference segment***
- ***Short LMCA*** also makes identification of a normal reference segment difficult
- Ostial lesion can be miss
  - Guiding engagement; damping of pressure
- Positive remodeling

Abizaid et al. J Am Coll Cardiol 1999;34:707–15

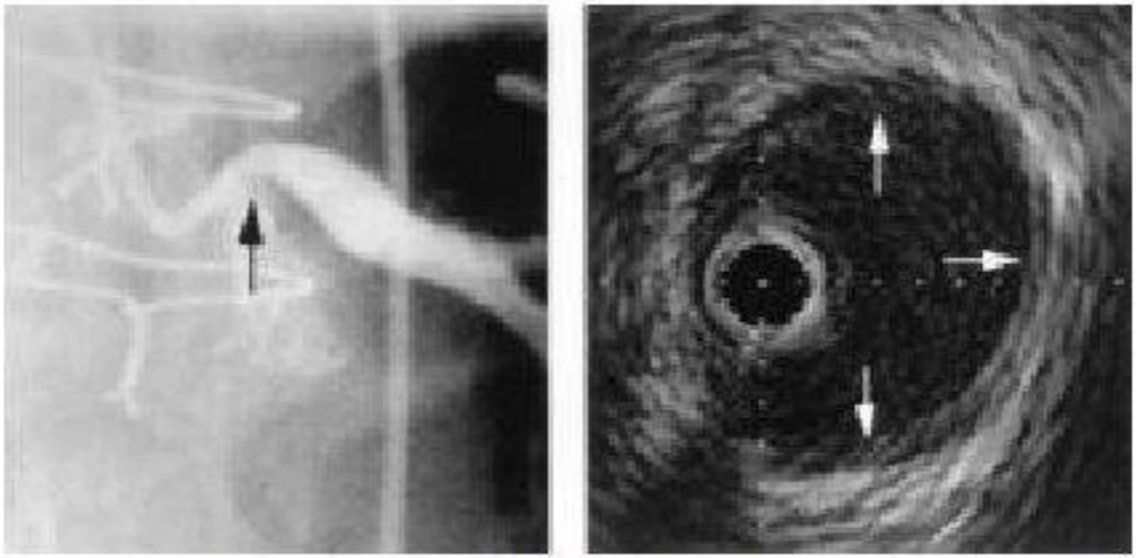
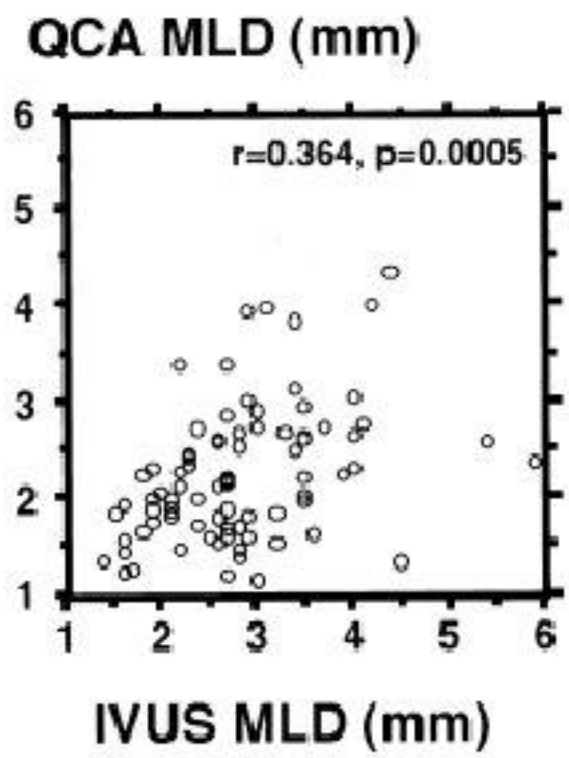


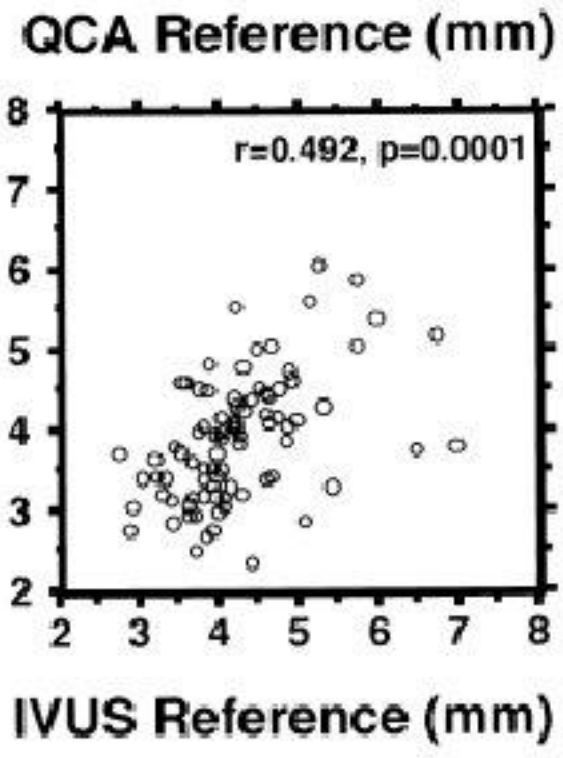
Figure 2. This case example illustrates the discrepancy between angiographic and IVUS evaluation of LMCA disease. This patient underwent bypass surgery for ostial LMCA disease **(black arrow).** After the bypass grafts closed, he was referred for IVUS study. By QCA, the ostial LMCA stenosis MLD measured 1.32 mm. By IVUS, there was mild diffuse atherosclerosis **(white arrows),** no significant plaque burden and an MLD of 3.5 mm. LMCA = left main coronary artery. Other abbreviations as in Figure 1.

One-Year Follow-up After Intravascular Ultrasound Assessment of Moderate Left Main Coronary Artery Disease in Patients With Ambiguous Angiograms

Andrea S. Abizaid, MD, Gary S. Mintz, MD, FACC, Alexandre Abizaid, MD, Roxana Mehran, MD, FACC, Alexandra J. Lansky, MD, Augusto D. Pichard, MD, FACC, Lowell F. Satler, MD, FACC, Hongsheng Wu, PhD, Kenneth M. Kent, MD, FACC, Martin B. Leon, MD, FACC

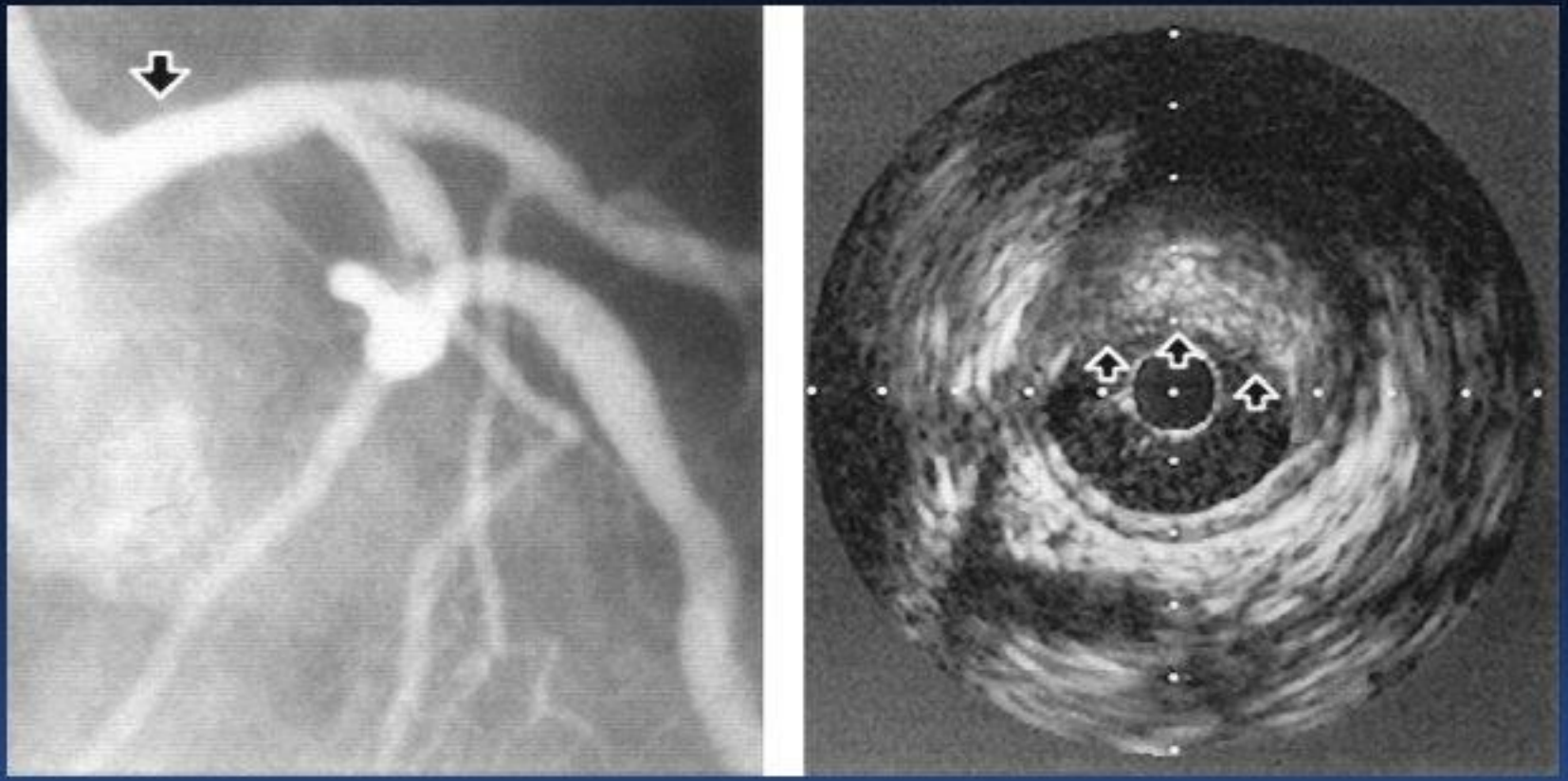
Washington, DC





Abizaid et al. J Am Coll Cardiol 1999;34:707–15

Angiographically unrecognized left main coronary artery disease.



Topol E J , and Nissen S E Circulation 1995;92:2333-2342

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The SYNTAX score

- SYNTAX score is *a powerful tool to risk stratify and discriminate outcomes* of patients with complex CAD undergoing PCI compared to coronary artery bypass graft surgery
- SYNTAX score has been *validated in different cohorts of patients* undergoing PCI and for different subsets of lesions

Nothing is perfect…

- Assessment of the SYNTAX score relies on *visual interpretation*
- Time consuming…
- Reproducibility and variability issues

Syntax Score How Much Training Is Necessary?

Is the current "recommended training" enough?

- Online tutorial www.syntaxscore.org
- Variable definitions
- 13 schematic case examples
- Self-evaluation, including 7 real cases with online angiograms

Circulation
Cardiovascular Interventions
JOURNAL OF THE AMERICAN HEART ASSOCIATION

American Heart Association
Learn and Live

SYNTAX Score Reproducibility and Variability Between Interventional Cardiologists, Core Laboratory Technicians, and Quantitative Coronary Measurements

Philippe Généreux, Tullio Palmerini, Adriano Caixeta, Ecaterina Cristea, Roxana Mehran, Raquel Sanchez, Dana Lazar, Ivana Jankovic, Maria D. Corral, Ovidiu Dressler, Martin P. Fahy, Helen Parise, Alexandra J. Lansky and Gregg W. Stone

Circ Cardiovasc Interv 2011;4;553-561; originally published online October 25, 2011;
DOI: 10.1161/CIRCINTERVENTIONS.111.961862
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 Print ISSN: 1941-7640. Online ISSN: 1941-7632

SYNTAX score assessment: 80 angiograms

Généreux et al, Circulation Intervention, 2011 Dec 1;4(6):553-61.

Table 2. SYNTAX Score Inter-observer Variability Before and After an Advanced Training Session

Angiographic Core Laboratory Technicians		
	30 cases after basic training*	50 cases after advanced training†
	Kappa [95% CI]	Kappa [95% CI]
SYNTAX score (tertile)	*0.82 [0.72,1.00]*	*0.84 [0.76,1.00]*
Number of lesions	0.70 [0.64,1.00]	0.78 [0.73,1.00]
Severe calcification	0.86 [0.72,1.00]	0.84 [0.73,1.00]
Length >20 cm	0.61 [0.46,0.99]	0.84 [0.72,1.00]
Bifurcation/trifurcation	0.47 [0.41,0.84]	0.56 [0.51,1.00]
Sum of lesions	0.77 [0.67,1.00]	0.82 [0.73,1.00]
Small vessel disease	0.56 [0.49,1.00]	0.60 [0.54,1.00]
Total occlusion present	0.96 [0.81,1.00]	1.00 [0.89,1.00]

* Basic training consisted of completion of the tutorial available on the SYNTAX score website (www.syntaxscore.com).

† Advanced training consisted of a 6 hour extensive review of the initial 30 reads with a highly experienced angiographic core laboratory team

Généreux et al, Circulation Intervention, 2011 Dec 1;4(6):553-61.

Table 2. SYNTAX Score Inter-observer Variability Before and After an Advanced Training Session (Cont.)

	Interventional Cardiologist Group	
	30 cases after basic training*	50 cases after advanced training†
	Kappa [95% CI]	Kappa [95% CI]
SYNTAX score (tertile)	*0.33 [0.18,0.44]*	*0.76 [0.64,1.00]*
Number of lesions	0.26 [0.17,0.38]	0.65 [0.55,1.00]
Severe calcification	0.23 [0.02,0.34]	0.57 [0.41,0.89]
Length >20 cm	0.48 [0.27,0.64]	0.65 [0.49,1.00]
Bifurcation/trifurcation	0.13 [0.04,0.22]	0.49 [0.39,0.81]
Sum of lesions	0.38 [0.23,0.53]	0.70 [0.58,1.00]
Small vessel disease	0.20 [0.09,0.24]	0.30 [0.20,0.45]
Total occlusion present	0.81 [0.60,1.00]	0.96 [0.80,1.00]

* Basic training consisted of completion of the tutorial available on the SYNTAX score website (www.syntaxscore.com).

† Advanced training consisted of a 6 hour extensive review of the initial 30 reads with a highly experienced angiographic core laboratory team

Généreux et al, Circulation Intervention, 2011 Dec 1;4(6):553-61.

Bifurcation and small vessel…

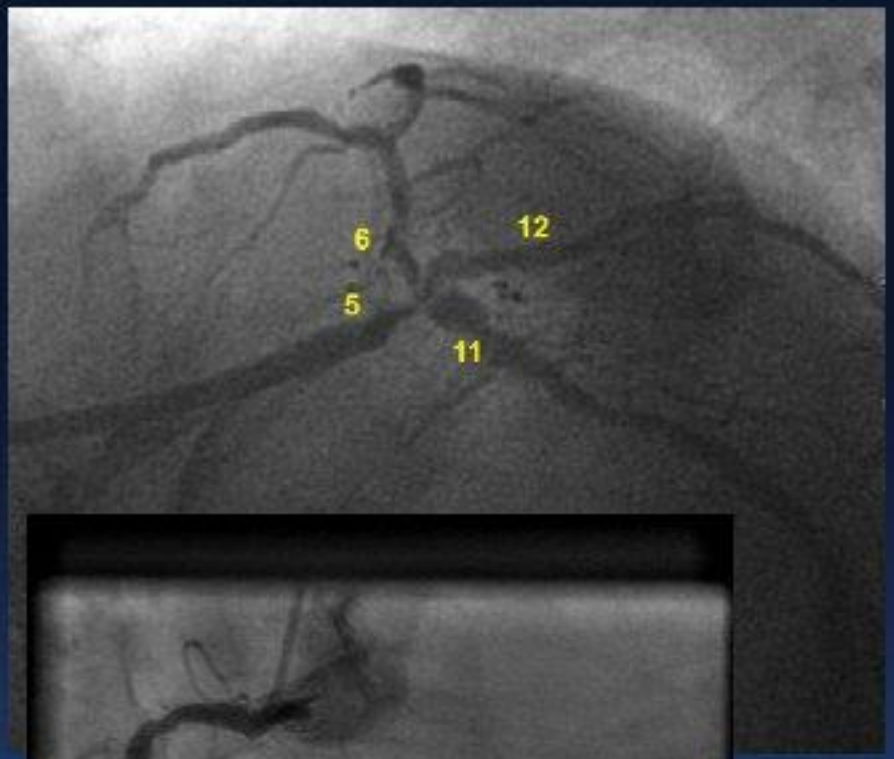


Table 4. Difference in Quantitative Components of the SYNTAX Score Between Interventional Cardiologists, Core Laboratory Technicians and Quantitative Coronary Analysis

	Core lab technicians vs. QCA analysis	Interventional cardiologists vs. QCA analysis	Core lab technicians vs. Interventional cardiologists	p-value (3-way)
	Mean difference [95% CI]	Mean difference [95% CI]	Mean difference [95% CI]	
SYNTAX Score	1.1 [0.4, 1.8]	-6.4 [-8.5, -4.3]	7.5 [5.5, 9.5]	<0.001
Number of lesions	0.2 [0.1, 0.3]	-0.8 [-1.1, -0.5]	0.99 [0.7, 1.3]	<0.001
Bifurcation/trifurcation	0.18 [-0.2, 0.5]	-1.9 [-2.5, -1.2]	2.04 [1.5, 2.6]	<0.0001
Small vessels disease	0.3 [0.1, 0.4]	-1.1 [-1.5, -0.7]	1.37 [0.9, 1.8]	<0.0001

There were no statistically significant differences between QCA analysis and Core lab technicians analysis

2 interventional cardiologists: <50%
1 Interventional cardiologist: >50%

QCA=52%

Table 6. Distribution of SYNTAX Score Tertiles Among four ACL Technicians and Three ICs Readings Before and after Advanced Training

30 cases after basic training				
SYNTAX tertile	Core lab technicians readings n=120	Interventional Cardiologists readings n=90	Difference [95% CI]	p-value*
Low score ≤22; % [95% CI]	46.7% (56/120) [37.5%, 56.0%]	63.3% (57/90) [52.5%, 73.3%]	16.7% [2.3, 31.1]	
Intermediate score 23-32; % [95% CI]	26.7% (32/120) [19.0%, 35.5%]	27.8% (25/90) 18.9%, 38.2%]	1.1% [-12.1, 14.3]	p=0.004
High Score >32; % [95% CI]	26.7% (32/120) [19.0%, 35.5%]	8.9% (8/90) [3.9%, 16.8%]	-17.8% [-28.7, -6.9]	
50 cases after advanced training				
SYNTAX tertile	Core lab technicians n=200	Interventional Cardiologists n=150	Difference [95% CI]	p-value*
Low score ≤22; % [95% CI]	67.5% (135/200) [60.5%, 73.9%]	92.7% (139/150) [87.3%, 96.3%]	25.2% [16.8, 33.5]	
Intermediate score 23-32; % [95% CI]	19.5% (39/200) [14.3%, 25.7%]	4.7% (7/150) [1.9%, 9.4%]	-14.8% [-21.9, -7.8]	p<0.0001
High Score >32; % [95% CI]	13.0% (26/200) [8.7%, 18.5%]	2.7% (4/150) [0.7%, 6.7%]	-10.3% [-16.3, -4.4]	

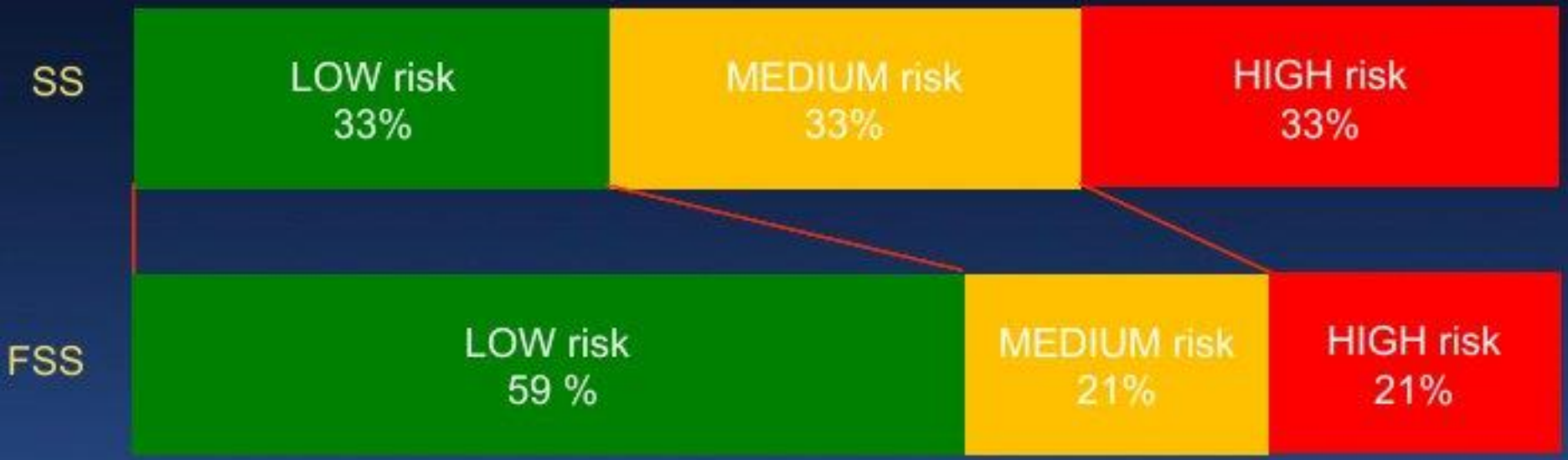
* p value derived from the generalized estimated equations method

Conclusion

- **Training beyond the standard on-line tutorial is warranted if the full clinical potential of the SYNTAX score is to be realized.**

FFR-guided SYNTAX Score (FSS) versus Conventional SYNTAX Score (SS) and Clinical Outcome

497 patients of the FFR-arm of FAME I
Syntax scored re-calculated by 3 independent reviewers
3 tertiles based on SS



32% of patients moved to a lower-risk group

Nam, C.W. et al. JACC 2011

Conclusions

- Coronary angiogram remains the gold standard in CAD assessment
- Acknowledgement and understanding of its limitations will ensure its appropriate use/interpretation
- ***IVUS guidance*** is important for assessing ambiguous lesions and procedure optimization (ca+, thrombus, LM)
- ***FFR*** is an important tool to help in assessment of angiographic intermediate lesion
- ***SYNTAX score*** is a complex score for which training beyond the proposed online tutorial is needed to achieve its full potential

References

Pitfalls in Coronary Angiogram Interpretation :

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Thank
You