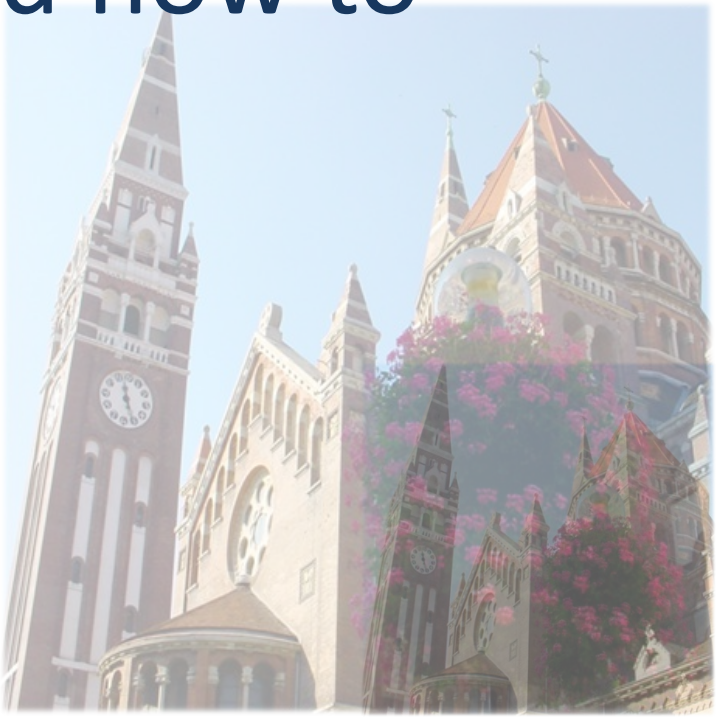
FFR assessment for complex lesions (LM, Bifurcation, Tandem lesions) - validity and how to evaluate.

Ferenc Nagy MD,PhD
University of Szeged, Hungary

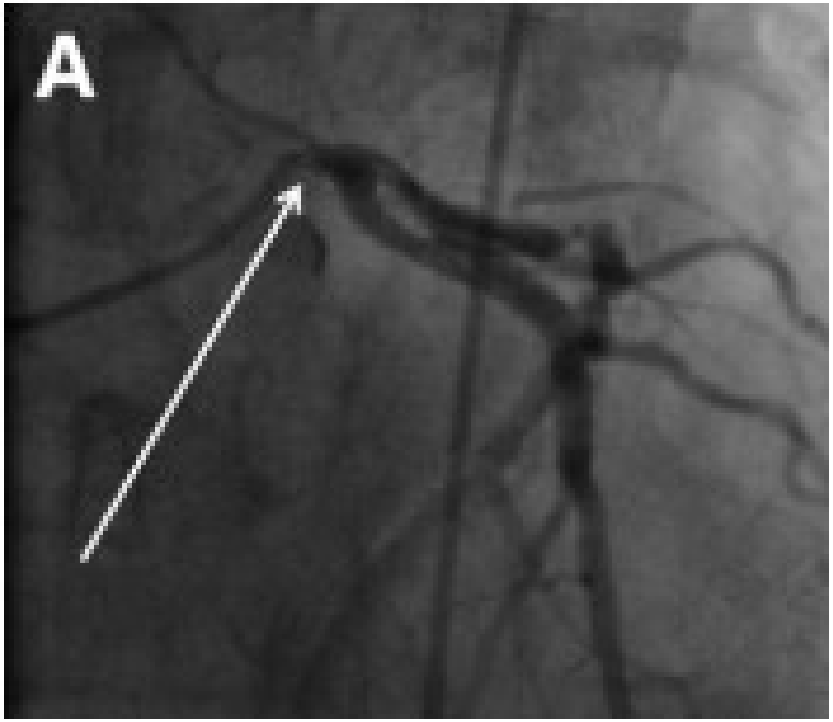


Bulgarian Bifurcation and Complex Coronary Interventions Course
22-23 January 2016 Tokuda Hospital, Sofia

Intermediate (40-70%) left main stenosis: angiographic interpretation

Challenges of angiographic assessment:

- Short segment, lack of clear reference segment, overlapping side branches

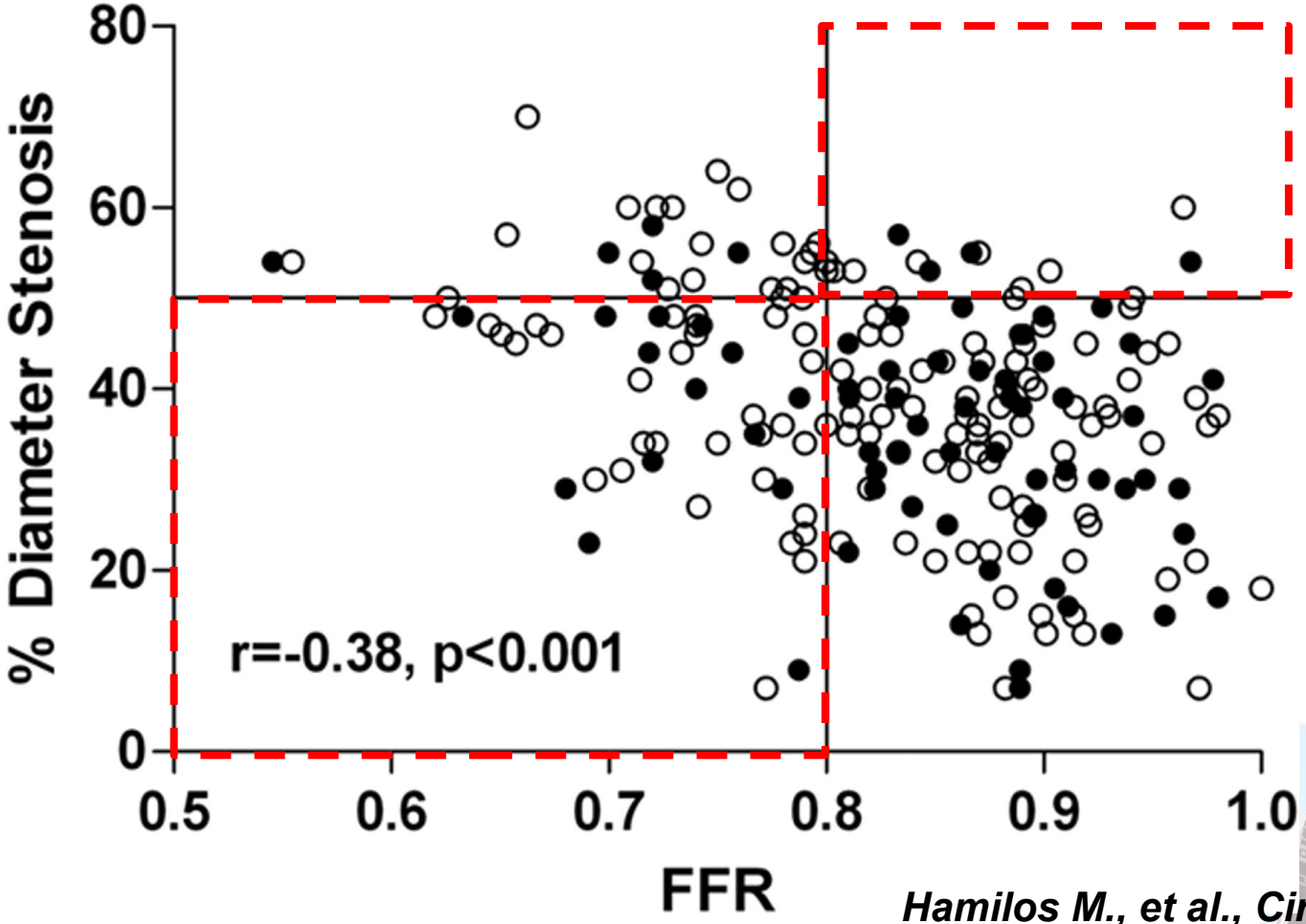


Ragosta M. JACC Cardiovasc Interv. 2012

Especially difficult in:

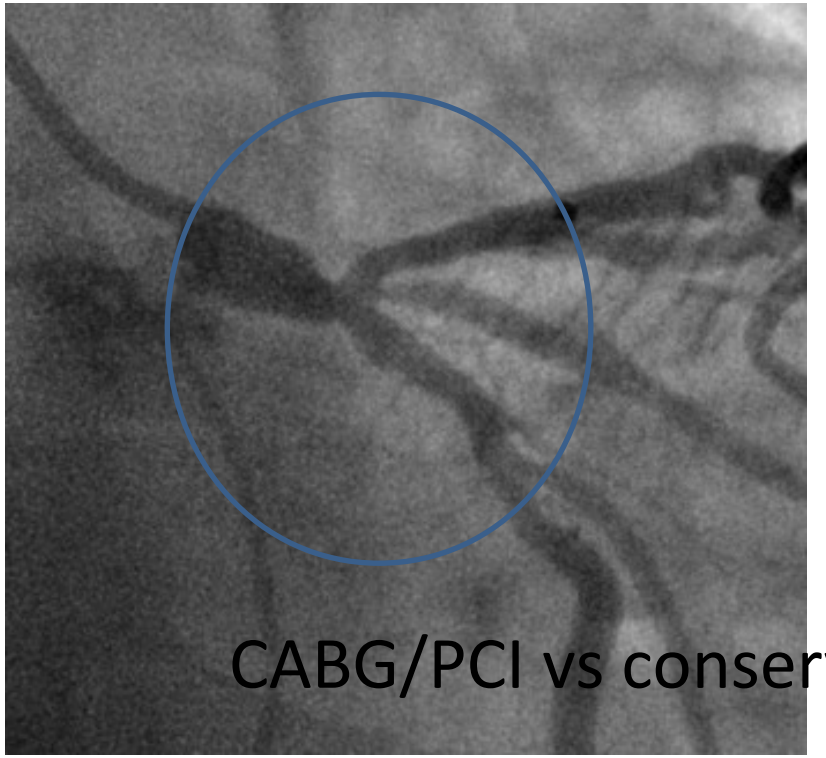
- Ostial lesions

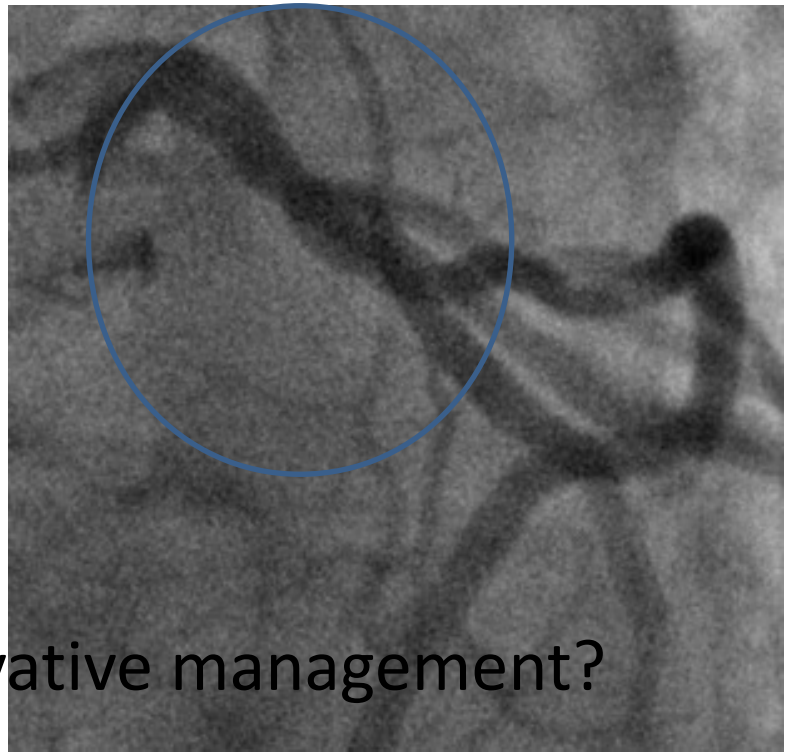
FFR vs %DS in LMCA disease



Hamilos M., et al., Circulation. 2009

Intermediate (40-70%) left main stenosis
The importance of making the right call



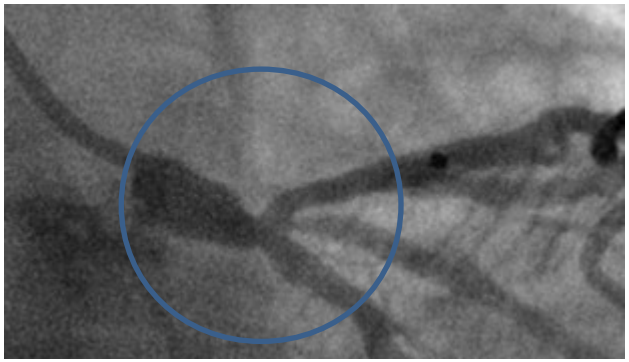


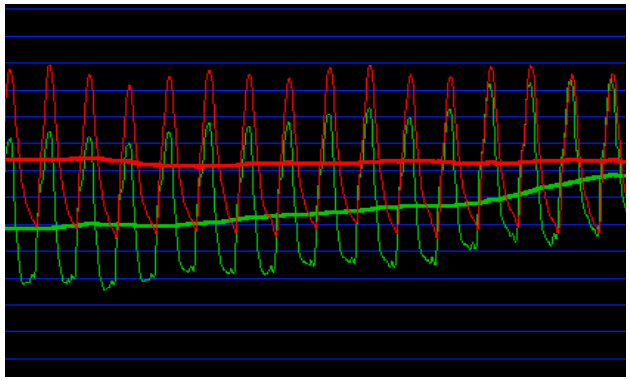
CABG/PCI vs conservative management?

1. Conservative management of otherwise significant LM disease leads to a rise in mortality
2. Conversely premature invasive treatment leads to unnecessary perioperative risk and potential grapht failure in the long run

Intermediate (40-70%) left main stenosis: additional modalities for evaluation

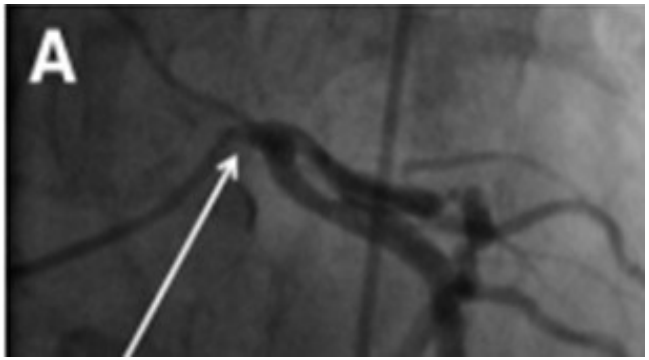
- FFR

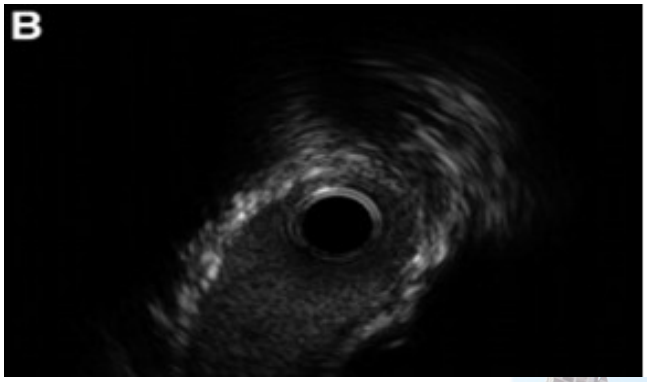




FFR=0.83 (NS lesion)

- IVUS



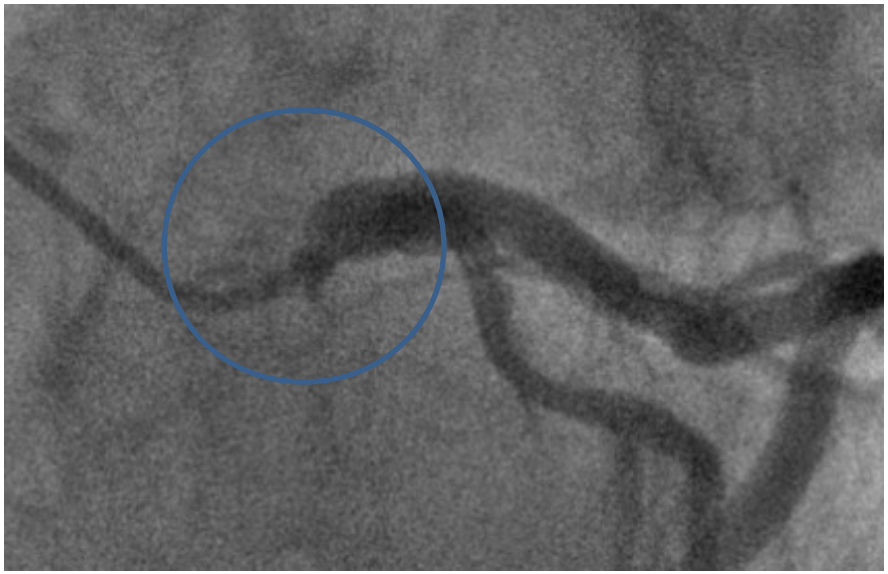


MLA=10.08 mm2 (NS lesion)

Ragosta M. JACC Cardiovasc Interv. 2012

Left main FFR technical aspects

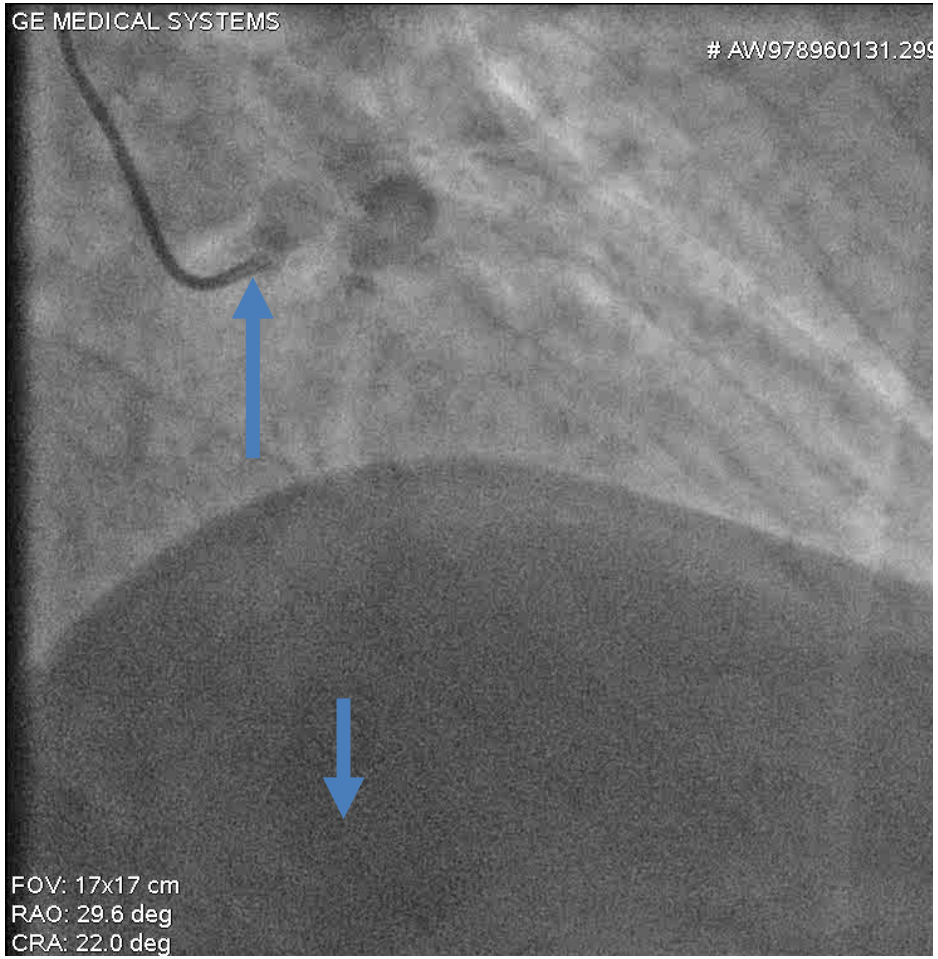
Ostial left main stenosis



FFR=0,9 with guide catheter in the ostium, 0.83 after removal

- Guide catheter should not be in wedge position potentially to leading false negative FFR values (FFRtrue<FFRapp)
- Continuous venous adenosine administration is

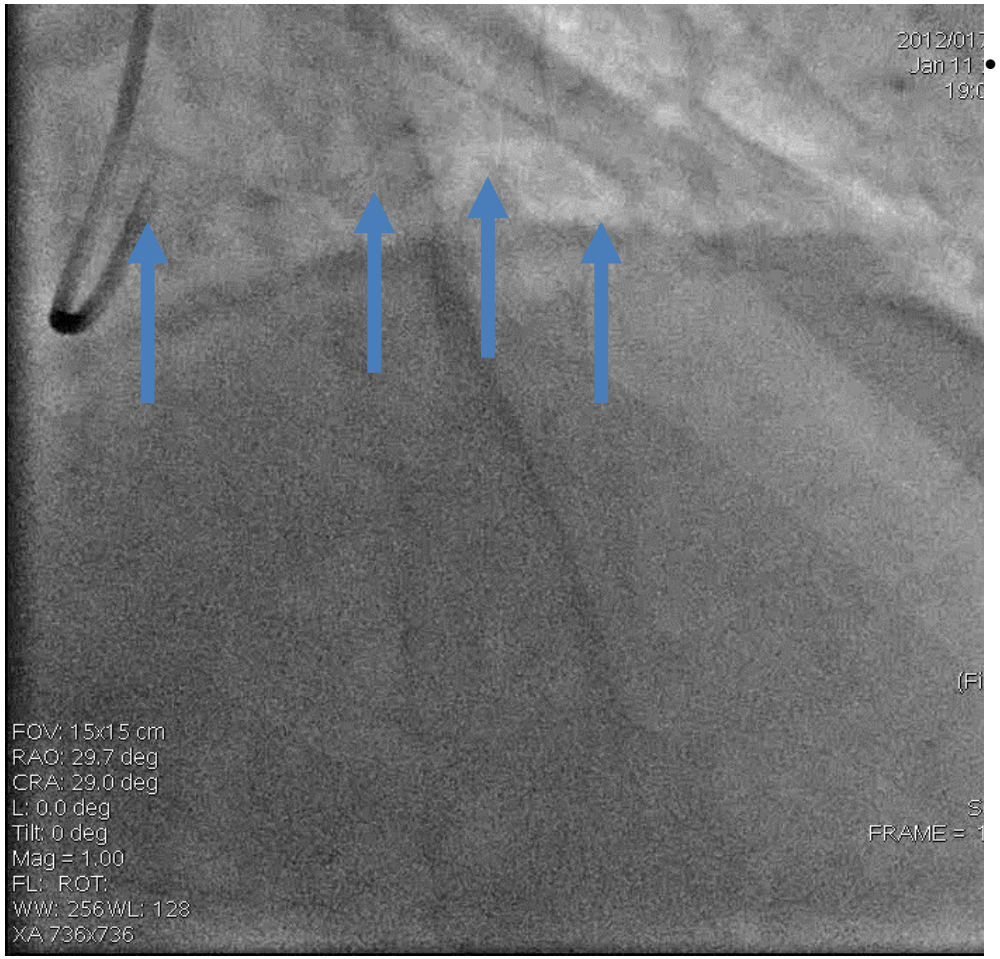
Left main FFR technical aspects



Intermediate LM lesion and concomitant flow limiting stenosis /CTO of the RCA.

- Possibility of false positive results (FFRtrue>FFRapp) due the enlarged area of myocardium supplied.

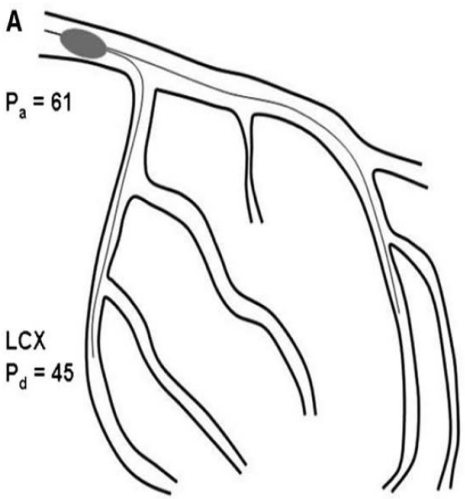
Left main FFR technical aspects



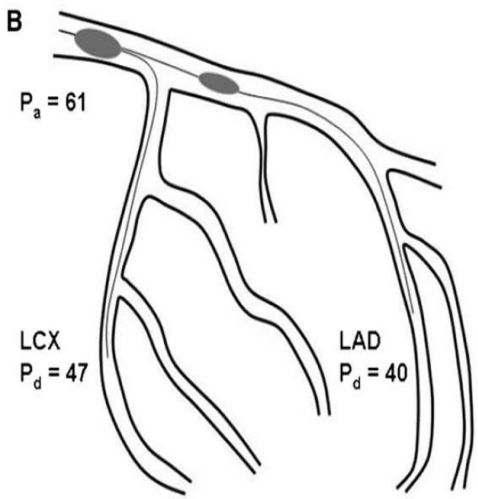
- Intermediate LM lesion and concomitant distal run off disease: a common problem (2.5/3 major arteries effected*)
  - Is it appropriate to measure in the unaffected

***Bulkley BH et al. Circulation. 1976**
***Roberts WC.**

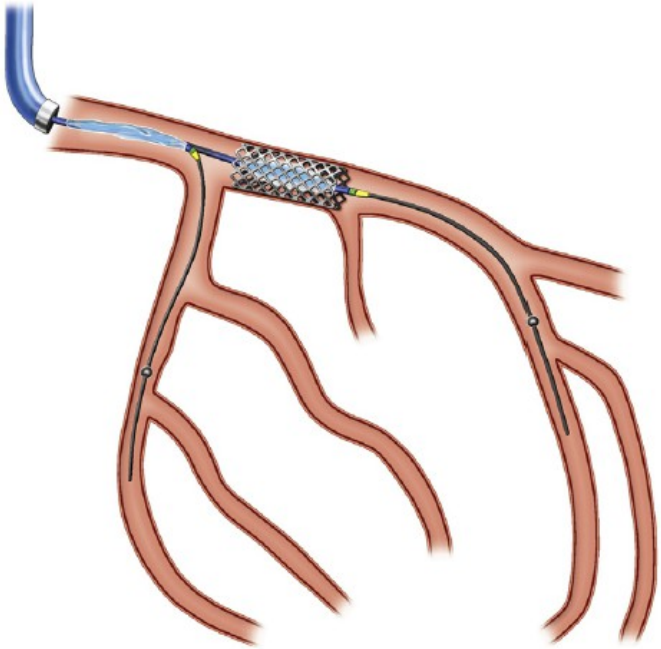
Downstream coronary stenosis: impact on FFR measurement in the non effected vessel for intermediate LM disease



FFRtrue



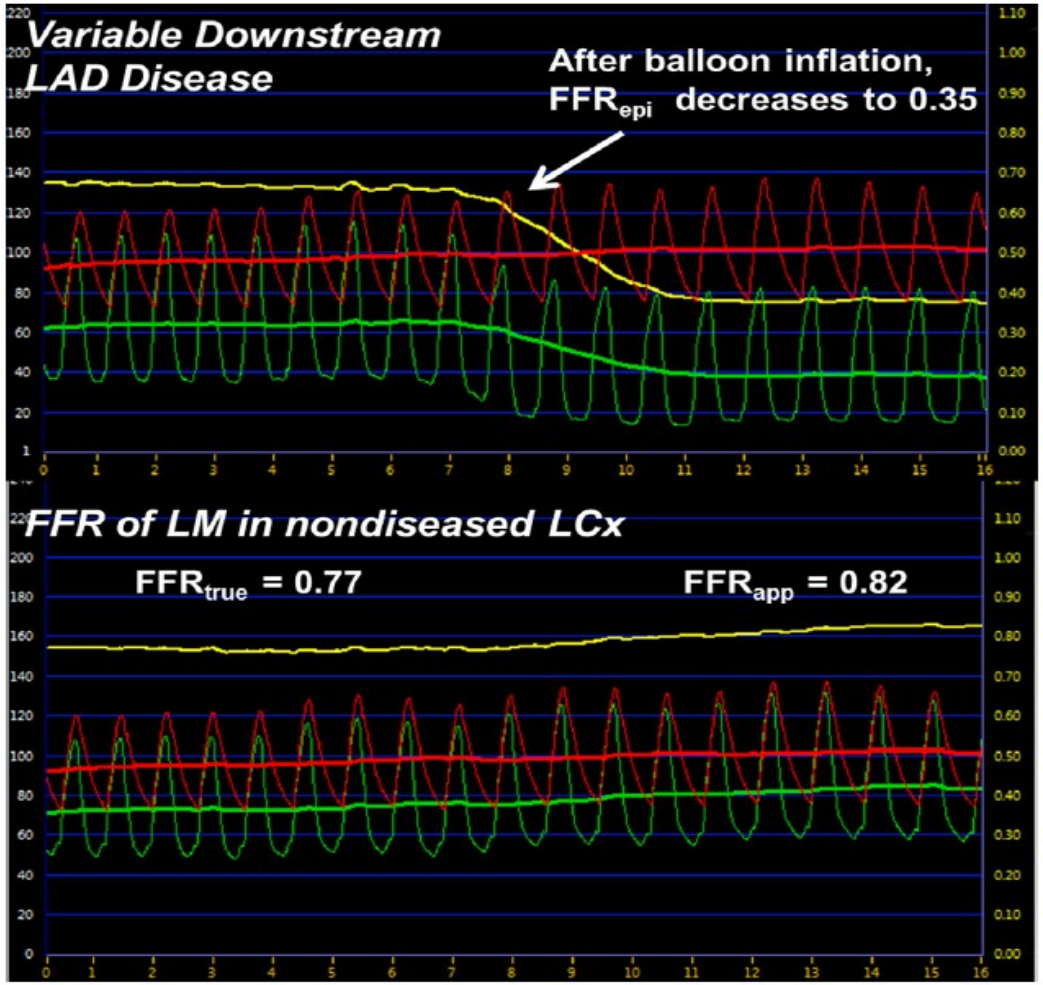
FFRapp



Yong AS., et al., Circ Cardiovasc Interv. 2013

Fearon WF., et al., JACC Cardiovasc Interv. 2015

Downstream coronary stenosis: impact on FFR measurement in the non effected vessel for intermediate LM disease



Fearon WF., et al., JACC Cardiovasc Interv. 2015

Downstream coronary stenosis: impact on FFR measurement in the non effected vessel for intermediate LM disease

Major findings:

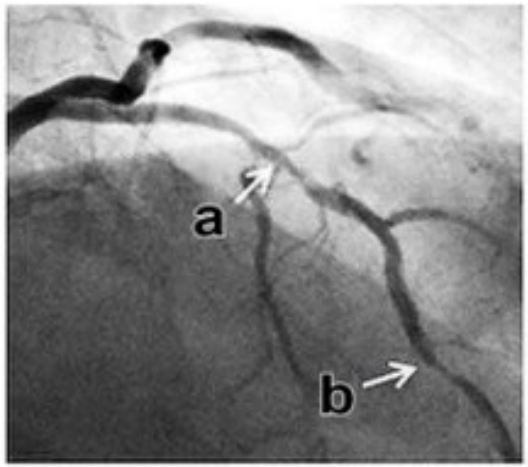
- Statistically significant, however in most cases clinically irrelevant effect (ΔFFR≈0,02)
- Most prominent in case of severe LAD disease (FFRepi<0,45), (ΔFFR≈0,05)

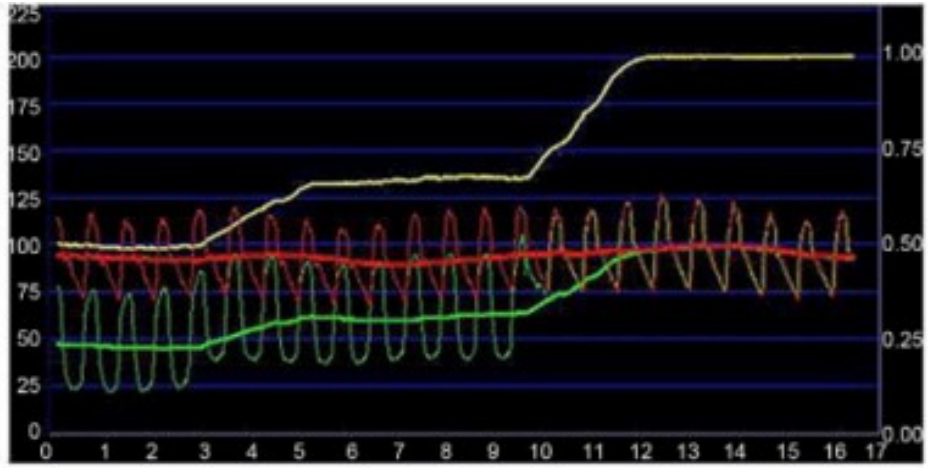
Clinical implications:

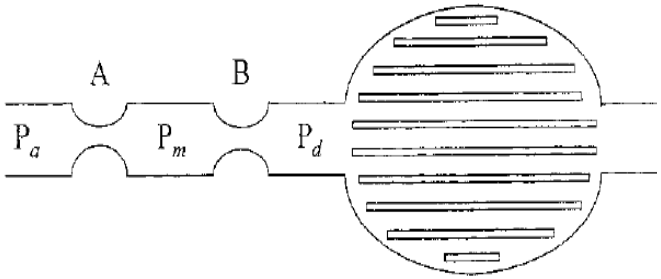
- Referral for revascularization FFR<0,8
- Deferral if FFR>0,85
- 0,8<FFR<0,85 and FFRepi<0,45 further

Fearon WF., et al., JACC Cardiovasc Interv. 2015

FFR assessment in tandem lesions







$FFR(A)_{app} = P_m/P_a$

$FFR(B)_{app} = P_d/P_m.$

=?

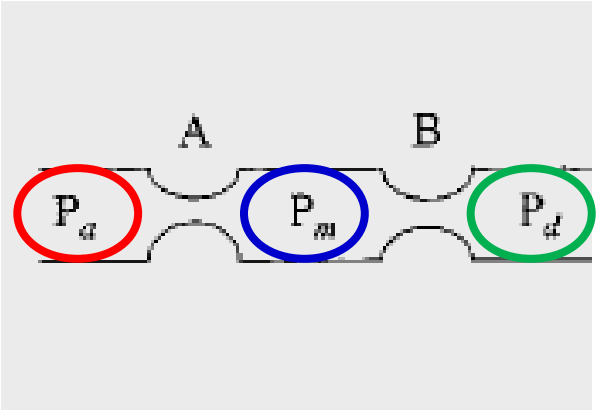
$FFR(A)_{true} = P_d/P_a$

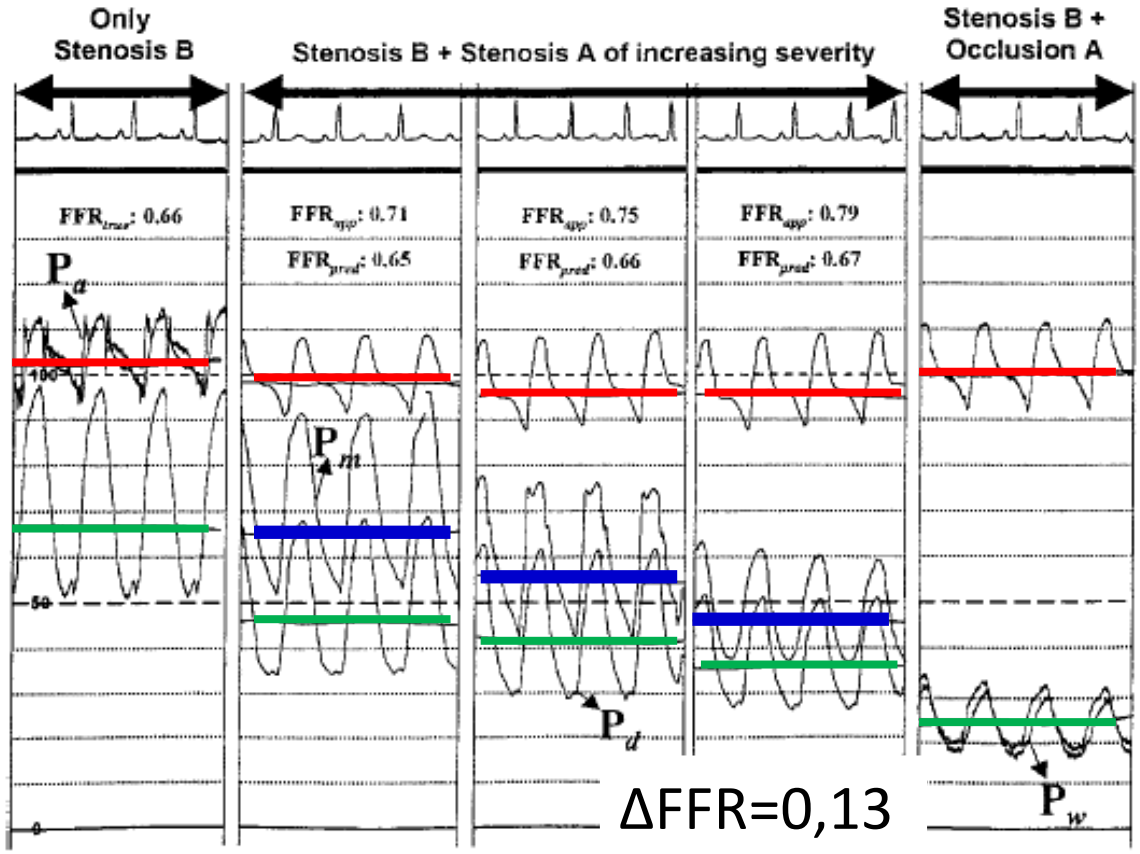
$FFR(B)_{true} = P_d/P_a.$

De Bruyne B., et al., Circulation. 2000

Is FFR suitable for lesion specific assessment of CHD with serial stenoses?

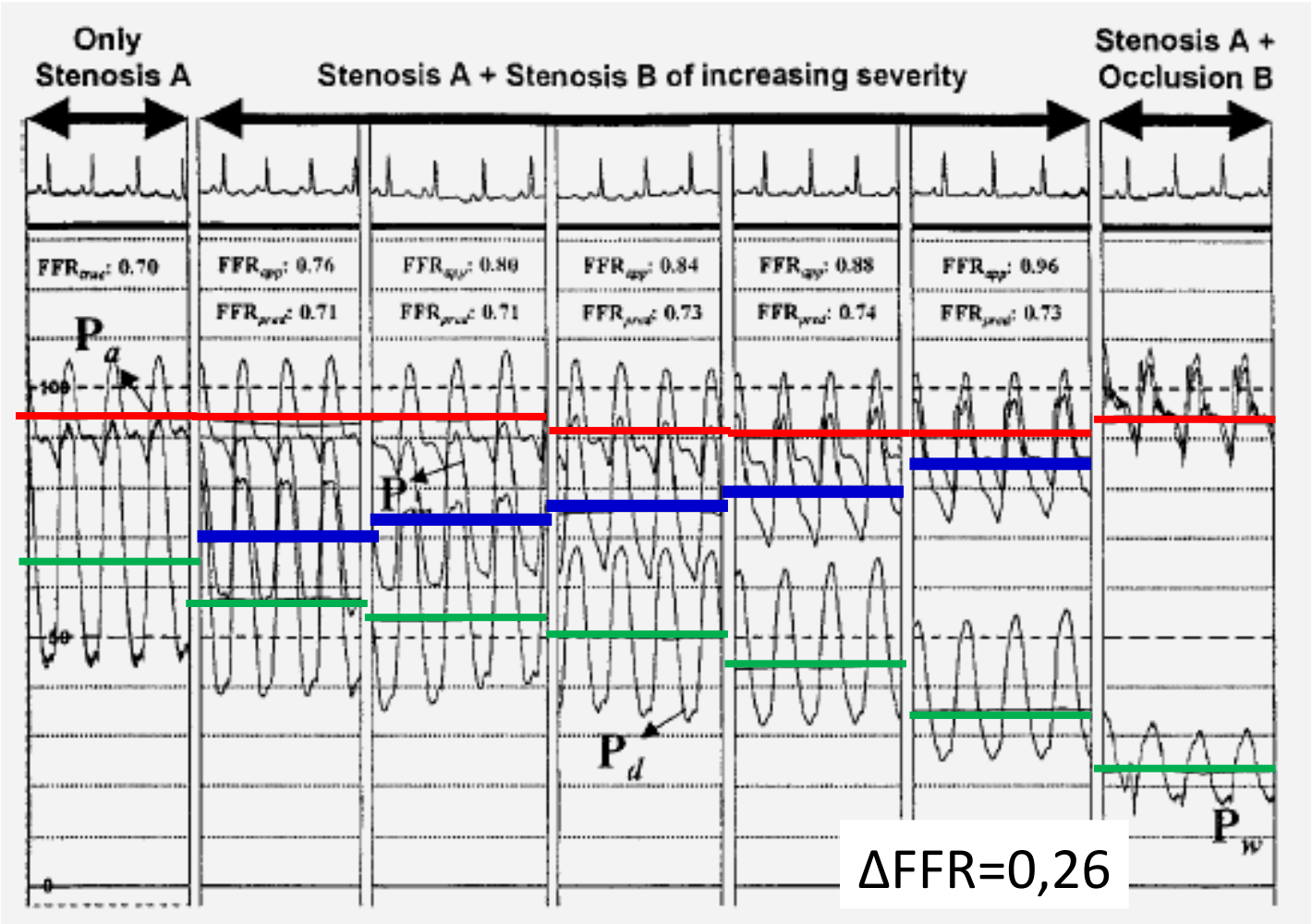
De Bruyne B, Pijls NHJ, et al. Pressure-Derived Fractional Flow Reserve to Assess Serial Epicardial Stenoses Theoretical Basis and Animal Validation. Circulation. 2000;101:1840-1847





ΔFFR=0,13

Is FFR suitable for lesion specific assessment of CHD with serial stenoses?



De Bruyne B, Pijls NHJ, et al. Circulation. 2000;101:1840

Conclusion

- The interaction between 2 stenoses is such that FFR of each lesion separately cannot be calculated by the equation for isolated stenoses (Pd/Pa during hyperemia) applied to each separately but can be predicted by more complete equations taking into account Pa, Pm, Pd, and Pw.

$$FFR(A)_{pred} = \frac{P_d - (P_m/P_a)\,P_w}{P_a - P_m + P_d - P_w}$$

$$FFR(B)_{pred} = 1 - \frac{(P_a - P_w)(P_m - P_d)}{P_a(P_m - P_w)}$$

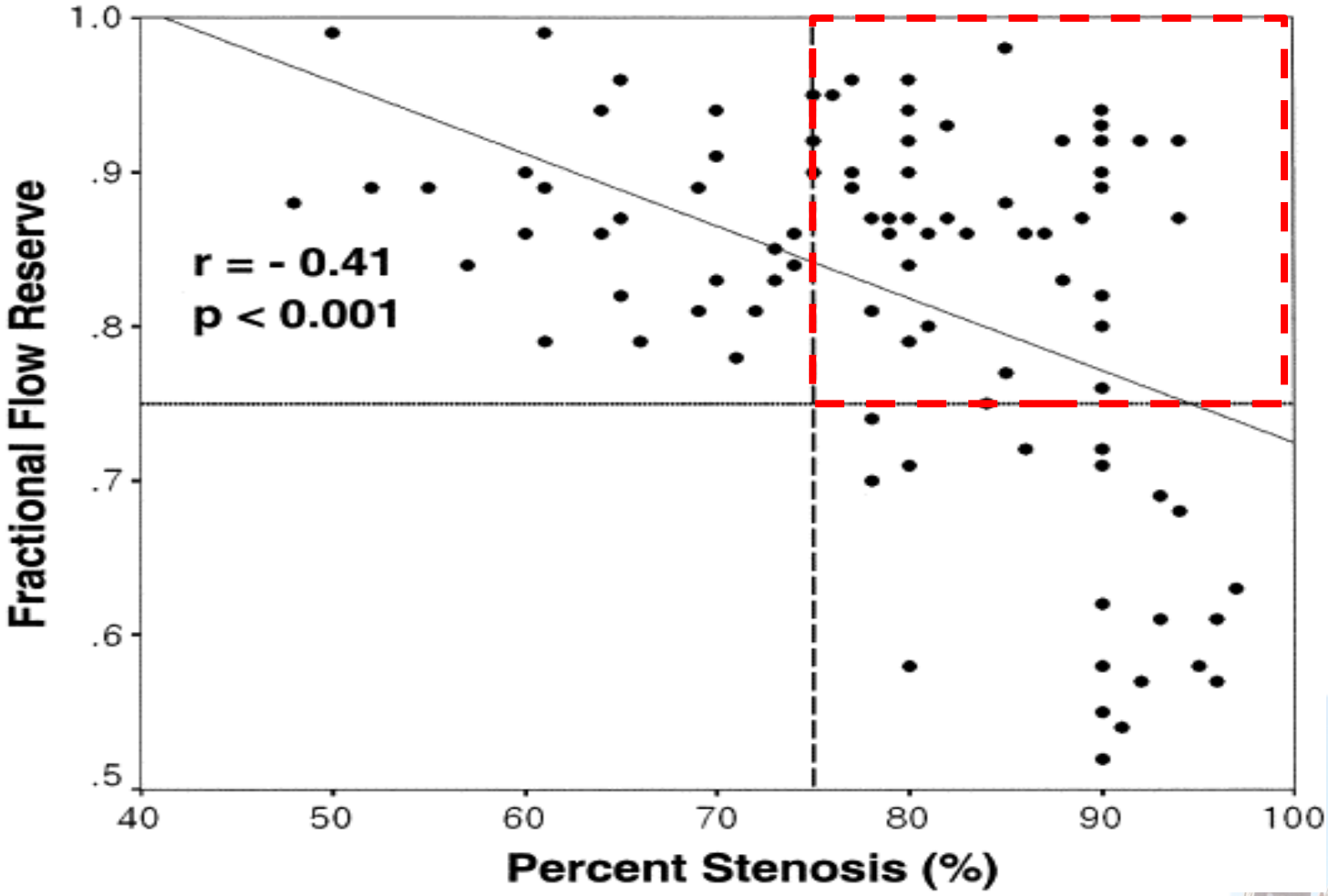
De Bruyne B., et al. Circulation. 2000

FFR assessment of tandem/serial lesions clinical practice

- Start measurement distal to the most distal lesion;
- Measure with 140 µg/kg/min i.v. adenosine, if <0.80 – PCI is appropriate;
- Pull-back recording under fluoroscopy;

Jailed side branch severity: Is angiographic assessment

Jailed side branch severity assessment: FFR vs %DS



Koo BK et al. J Am Coll Cardiol 2005

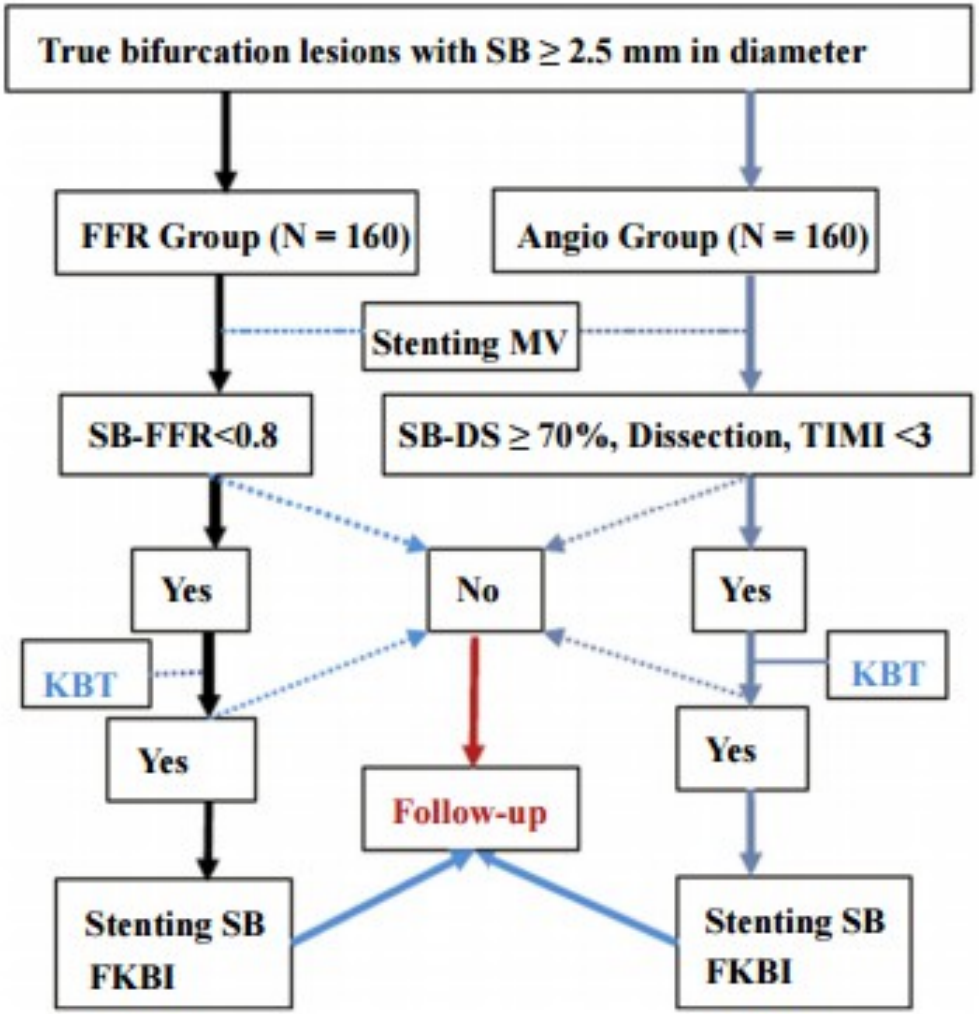
Concerns regarding use of FFR in sidebranch jail severity assessment

- Validity of SB FFR after MV stenting may be controversial due to local edema, thrombus and debris in the ostium, and distal

Routine FFR evaluation of the jailed side branch is not advised (BBC consensus 2014)

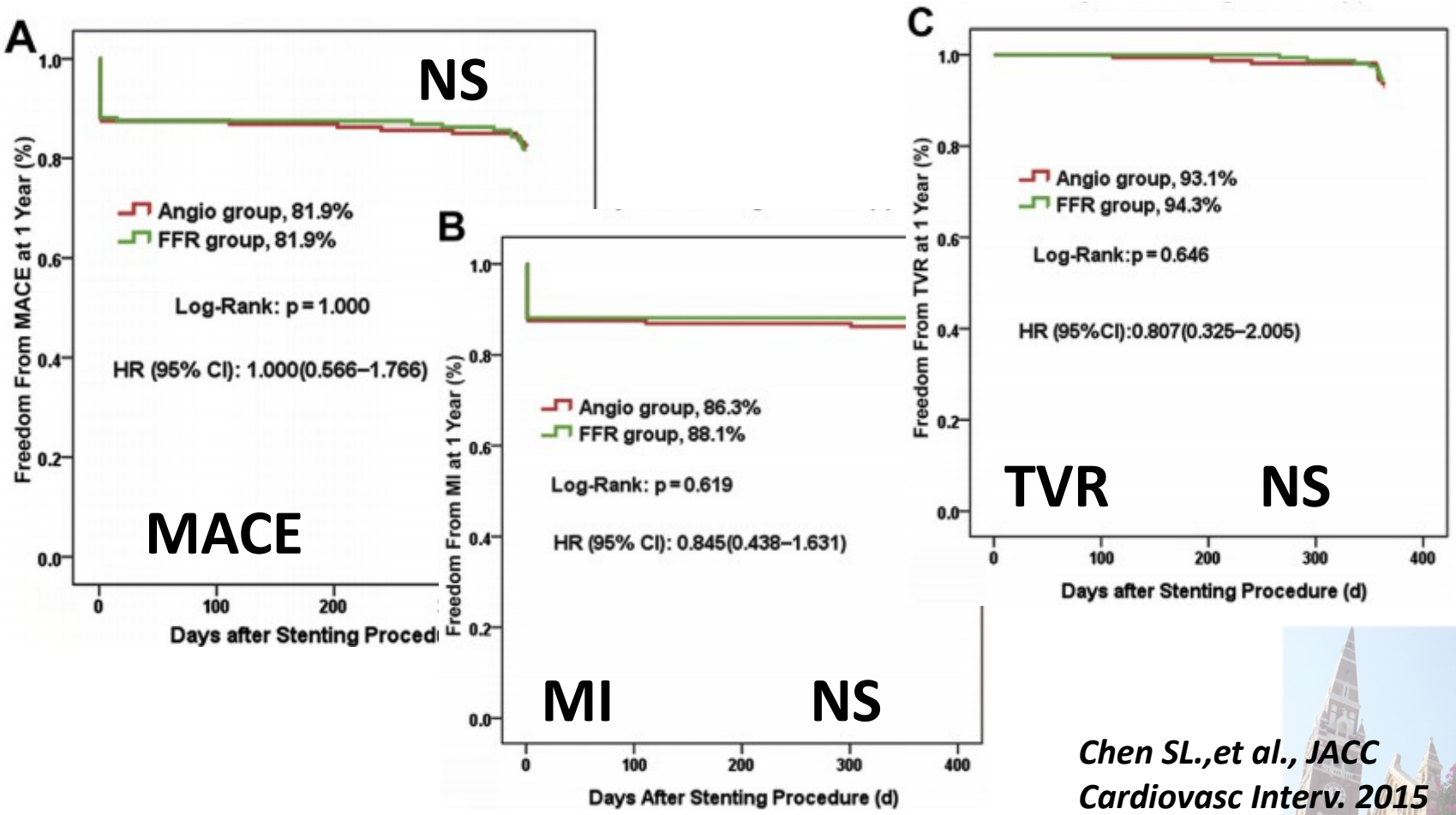
- Failure to recross to the side branch and preform FFR (10%)

FFR vs angiography guided provisional T stenting



Chen SL., et al., JACC Cardiovasc Interv. 2015

FFR vs angiography guided provisional T stenting



Chen SL.,et al., JACC Cardiovasc Interv. 2015

FFR vs angiography guided provisional T stenting

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- Formal cost analysis was not preformed, but the cost of more stents in the angiography group is offset by the cost of upfront FFR wire use in the FFR group.

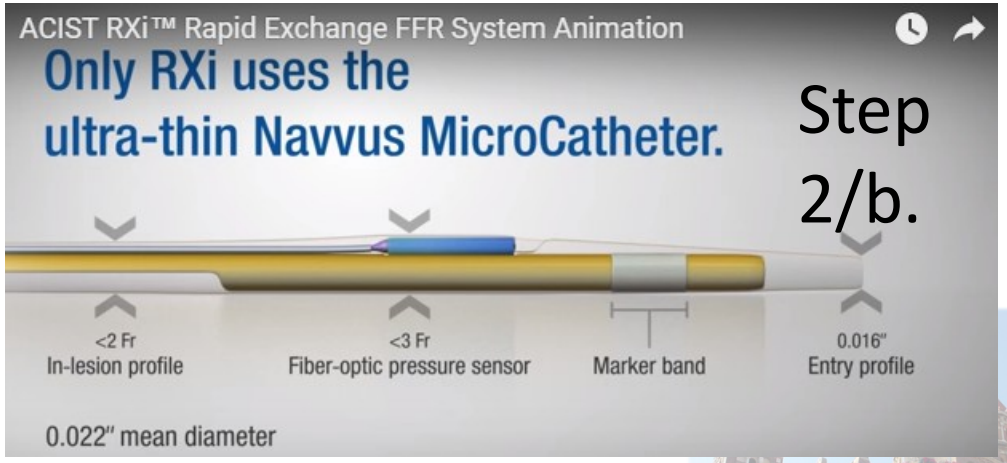
Routine FFR evaluation of the jailed side branch is not advised (BBC consensus 2014)

Tips and tricks to facilitate safe rewiring for FFR in difficult anatomy

Step 1. Rewiring upfront using (floppy/hydrophilic) wires of choice.

Step 2/a.

Change to FFR wire over microcatheter or OTW balloon



Step 2/b.

Conclusion

- LM disease, serial lesions and bifurcation disease can be challenging cases for the assessment of lesion significance by FFR

- The difficulties of interpretation and potential pitfalls of these lesion subsets do not mean a real limitation for FFR measurement


Thank you for
your attention!

FFR assessment in tandem lesions

- The presence of a second stenosis hinders maximum transtenotic flow through the first stenosis even after achieving maximal hyperemia.
- This phenomenon is more pronounced if the second lesion is distal to the first.
- Pw also has to be measured to account for increasing collateral flow

$$FFR(A)_{pred} = \frac{P_d - (P_m/P_a)\,P_w}{P_a - P_m + P_d - P_w}$$

$$FFR(B)_{pred} = 1 - \frac{(P_a - P_w)(P_m - P_d)}{P_a(P_m - P_w)}.$$

Pressure-derived fractional flow reserve to assess serial epicardial stenoses: theoretical basis and animal validation.De Bruyne B et al. Circulation. 2000

Is decision making based on FFR evaluation in intermediate left main stenosis evidence based?

2014 ESC/EACTS Guidelines on myocardial revascularization

The Task Force on Myocardial Revascularization of the European Society of Cardiology (ESC) and the European Association for Cardio-Thoracic Surgery (EACTS)

Based on the DEFER, FAME and FAME 2 trials
„Fractional flow reserve measurement is indicated for the assessment of the functional consequences of moderate coronary stenosis".

Patients with LM stenosis excluded form these trials.

Meta-analysis of prospective cohort studies in FFR guided LM revascularization for intermediate lesions

Table 1. Baseline Characteristics of Six Studies Included in the Meta-analysis

Study	Year of publication	Definition of intermediate LMCA stenosis	FFR cutoff value	Total number of patients			Mean FU (months)
				Total	Deferred	Revascularization	
Bech et al.[7]	2001	40–60%	<0.75	54	24	30 (CABG)	29 ± 15
Jiménez-Navarro et al [9]	2004	30–50%	<0.75	27	20	7 (6 CABG, 1 PCI)	26 ± 12
Legutko et al.[10]	2005	30–60%	<0.75	38	20	18 (12 CABG, 5 PCI, 1 OMT)	24 ± 12
Lindstaedt et al.[12]	2006	40–80%	<0.75[a]	51	24[b]	27[c] (CABG)	29 ± 16
Courtis et al.[13]	2009	30–60%	<0.75[a]	142	82	60 (54 CABG, 6 PCI)	14± 11
Hamilos et al.[14]	2009	30–70%	<0.80	213	138	75 (CABG)	36 (6-99)
Total		–	–	525	308	217	–

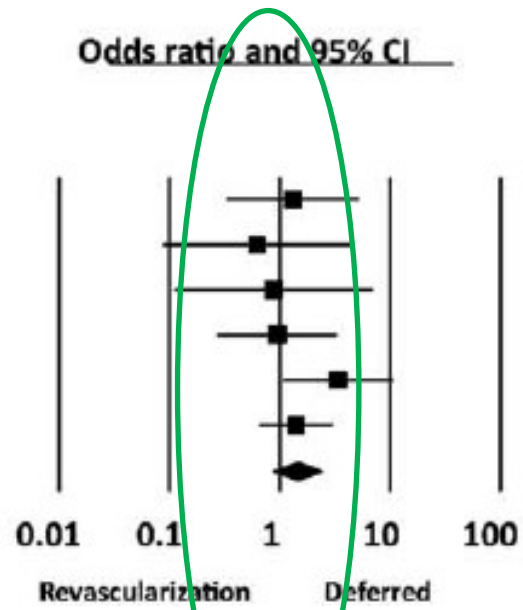
Mallidi J et al. Catheter Cardiovasc Interv. 2015

Meta-analysis of prospective cohort studies in FFR guided LM revascularization for intermediate lesions

A

Study name	Odds ratio	Lower limit	Upper limit	Z-Value	p-Value
Bech	1.316	0.332	5.207	0.391	0.696
Jimenez-Navarro	0.625	0.087	4.491	-0.467	0.640
Legutko	0.889	0.112	7.061	-0.111	0.911
Lindstaedt	0.952	0.269	3.367	-0.076	0.940
Courtis	3.394	1.072	10.741	2.079	0.038
Hamilos	1.415	0.658	3.043	0.889	0.374
	1.434	0.875	2.349	1.431	0.152

Statistics for each study



Composite endpoint of death, revascularisation and MI: NS

3 year mortality (4.5%) in the defer group vs (50%) historical data in significant untreated LMCA disease

Mallidi J et al. Catheter Cardiovasc Interv. 2015

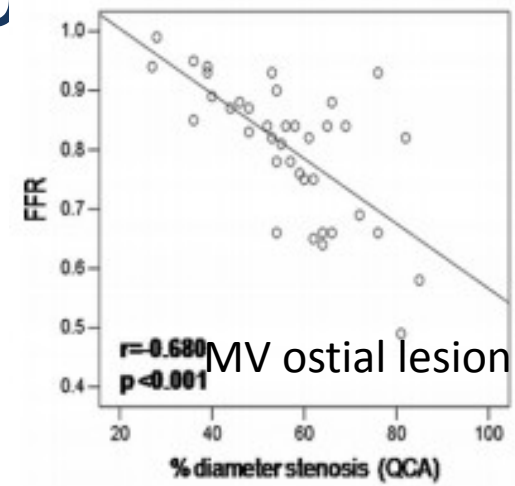
Is decision making based on FFR evaluation in intermediate left main stenosis good clinical practice?

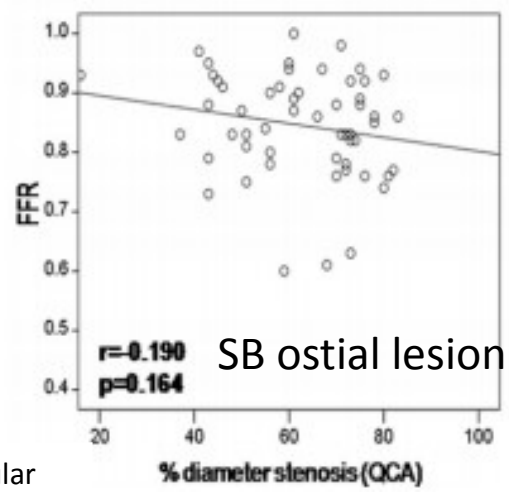
„in ambiguous LMCA disease, deferral of revascularization based on FFR results is safe in terms of overall mortality and myocardial infarction" and „FFR can be used to identify patients who are likely to benefit from revascularization"

Mallidi J et al. Catheter Cardiovasc Interv. 2015

FFR assessment of bifurcation lesions: indication for stenting

„MV FFR is recommended in stable patients when no other objective evidence of ischaemia is available"





Relationship between fractional flow reserve and angiographic and intravascular ultrasound parameters in ostial lesions: major epicardial vessel versus side branch ostial lesions. Koh JS et al. JACC Cardiovasc Interv. 2012

FFR vs angiography guided provisional T stenting

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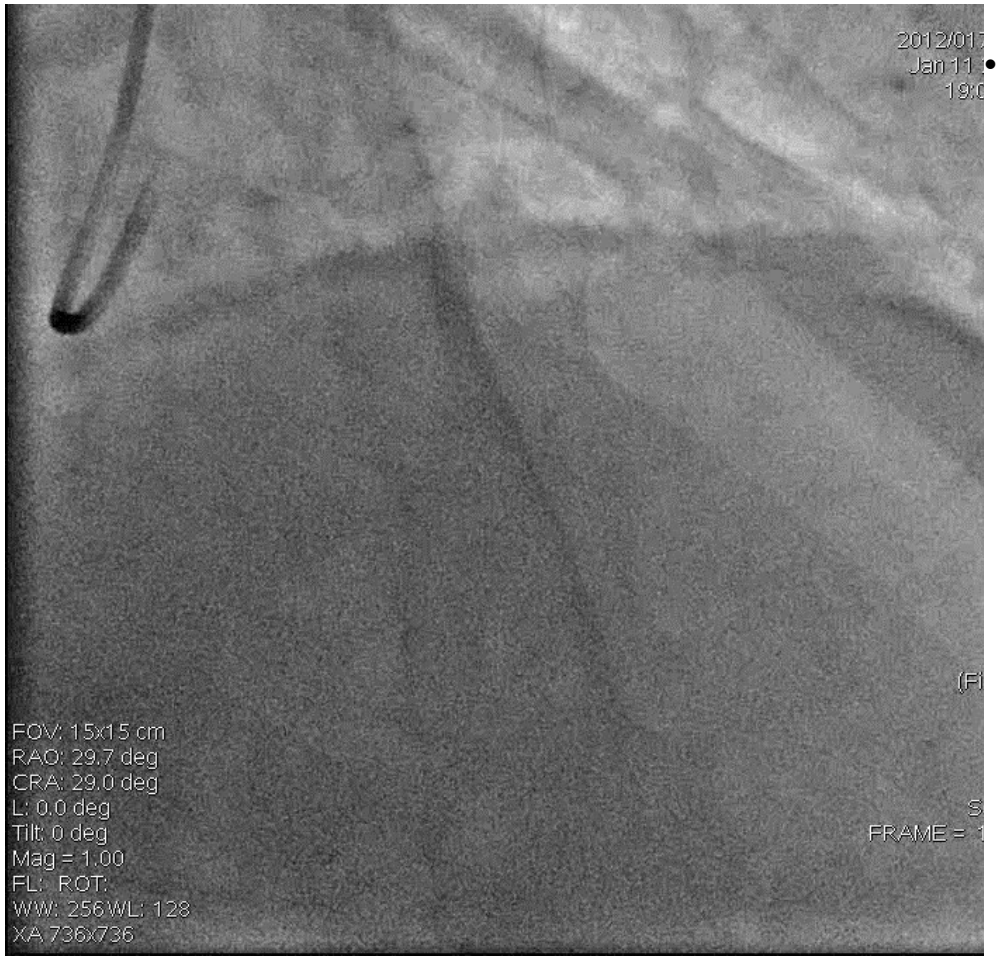
Left main FFR technical aspects



- Intermediate LM lesion and concomittant distal run off disease(LAD)
  - FFRproxLAD=0,92
  - FFRmidLAD=0,74
  - FFRproxCX=0,90
- NS LM disease, significant LAD