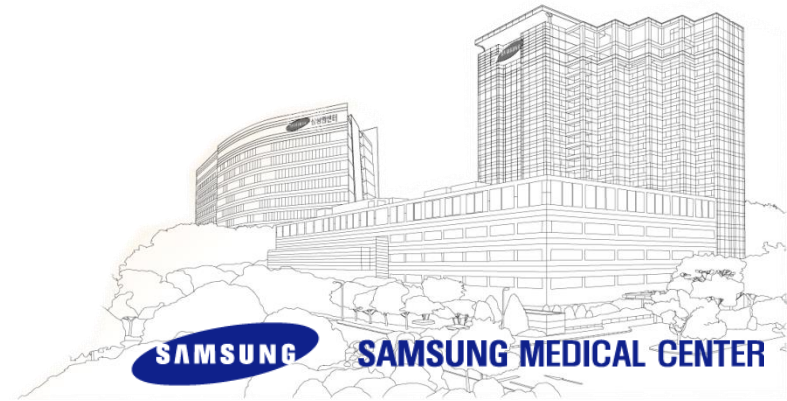


QFR : Current Evidences and Future Perspectives

Ki Hong Choi, MD

**Heart Vascular Stroke Institute,
Samsung Medical Center, Seoul, Republic of Korea**



What is QFR?

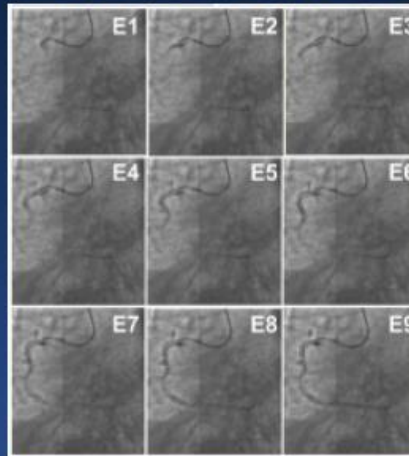
Quantitative Flow Ratio (QFR)

- Computed FFR based on two angiographic projections
- 3-dimensional QCA derived FFR
- No need of pressure wire or hyperemic agent

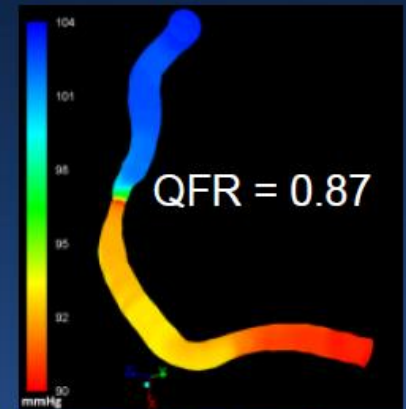
3D Reconstruction



Modified Frame Count



QFR



Without Inducing Hyperemia

3D model reconstructed from 2 angiographic projections with **angles $\geq 25^\circ$** apart.

Patient-specific volumetric flow rate calculated using the combination of contrast bolus front **TIMI frame count** and 3D QCA

In-procedure time: < 5 min

Evidences of QFR

- First-in-Man Study of FFR_{QCA} -

JACC: CARDIOVASCULAR INTERVENTIONS
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 PUBLISHED BY ELSEVIER INC.

VOL. 7, NO. 7, 2014
 ISSN 1936-8798/536.00
<http://dx.doi.org/10.1016/j.jcin.2014.03.004>

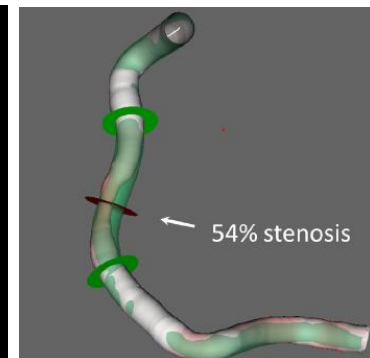
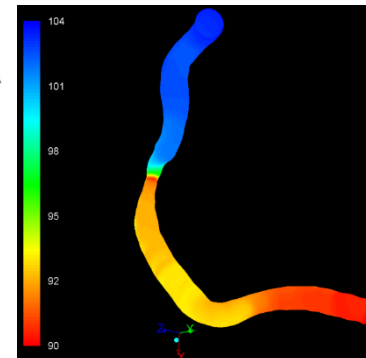
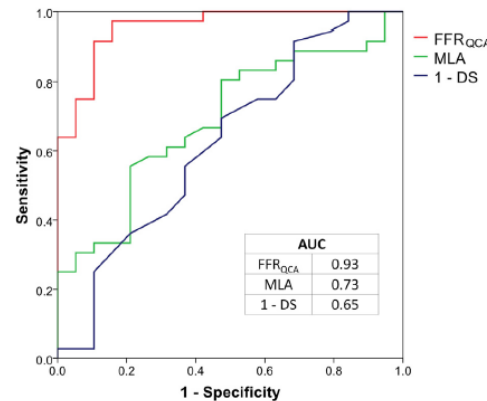
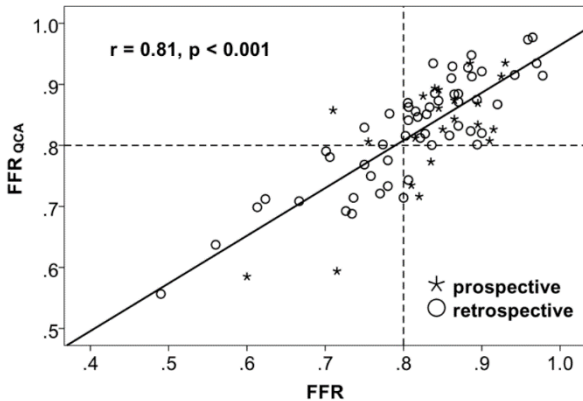
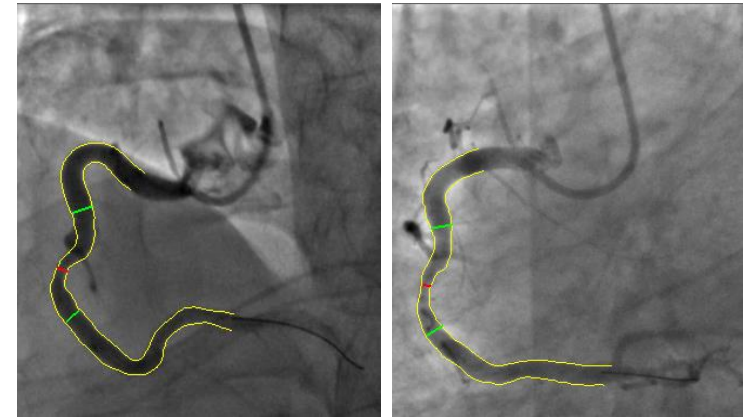
Stable patients with intermediate (40-70%) de novo stenosis and underwent FFR

Fractional Flow Reserve Calculation From 3-Dimensional Quantitative Coronary Angiography and TIMI Frame Count

A Fast Computer Model to Quantify the Functional Significance of Moderately Obstructed Coronary Arteries

Shengxian Tu, PhD,* Emanuele Barbato, MD, PhD,† Zsolt Kőszegi, MD, PhD,‡
 Junqing Yang, MD,§ Zhonghua Sun, MD,|| Niels R. Holm, MD,¶ Balázs Tar, MD,‡
 Yingguang Li, MSC,* Dan Rusinaru, MD,† William Wijns, MD, PhD,‡
 Johan H.C. Reiber, PhD*

Leiden, the Netherlands; Aalst, Belgium; Nyiregyhaza, Hungary; Guangzhou and Tianjin, China; and Skejby, Denmark



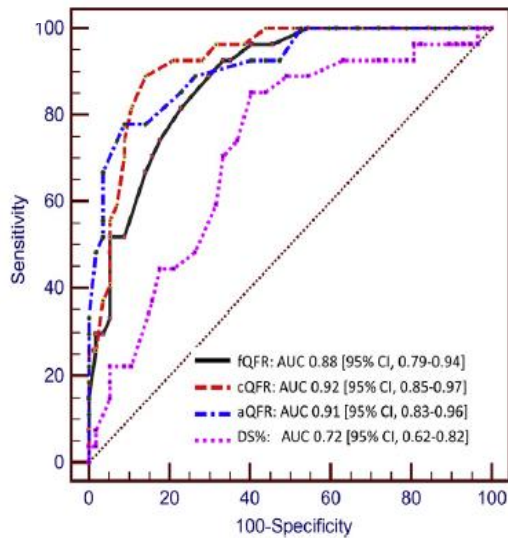
SAMSUNG MEDICAL CENTER

Evidences of QFR

- FAVOR Series -

Favor Pilot Trial

73 Stable angina with FFR assessment (30-80% stenosis)



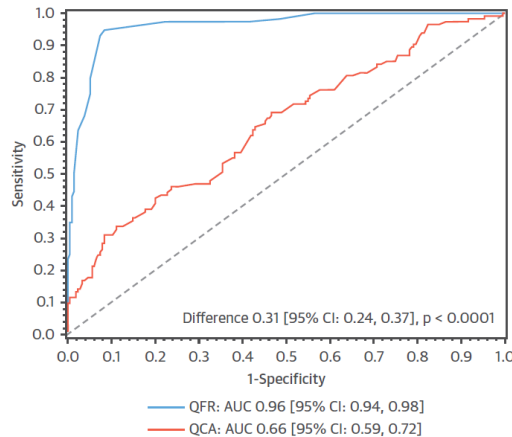
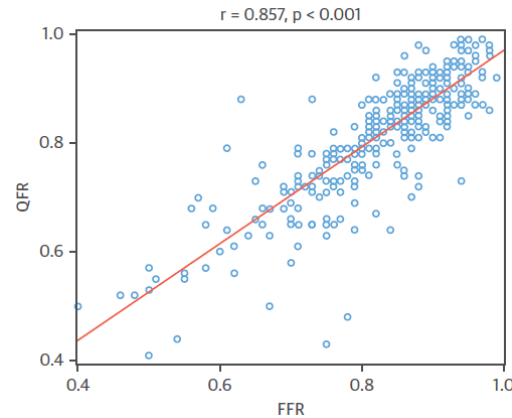
fQFR = fixed QFR
cQFR = contrast QFR
aQFR = adenosine-flow QFR

Contrast QFR shows most favorable results

Tu et al. JACC Cardiovasc Interv 2016

Favor II China

308 coronary artery disease with FFR assessment (30-90% stenosis)

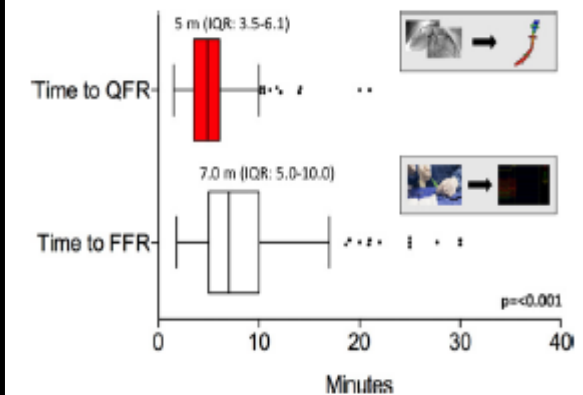


Xu et al. JACC 2017

Favor II Europe-Japan

272 Stable angina with FFR assessment (30-90% stenosis)

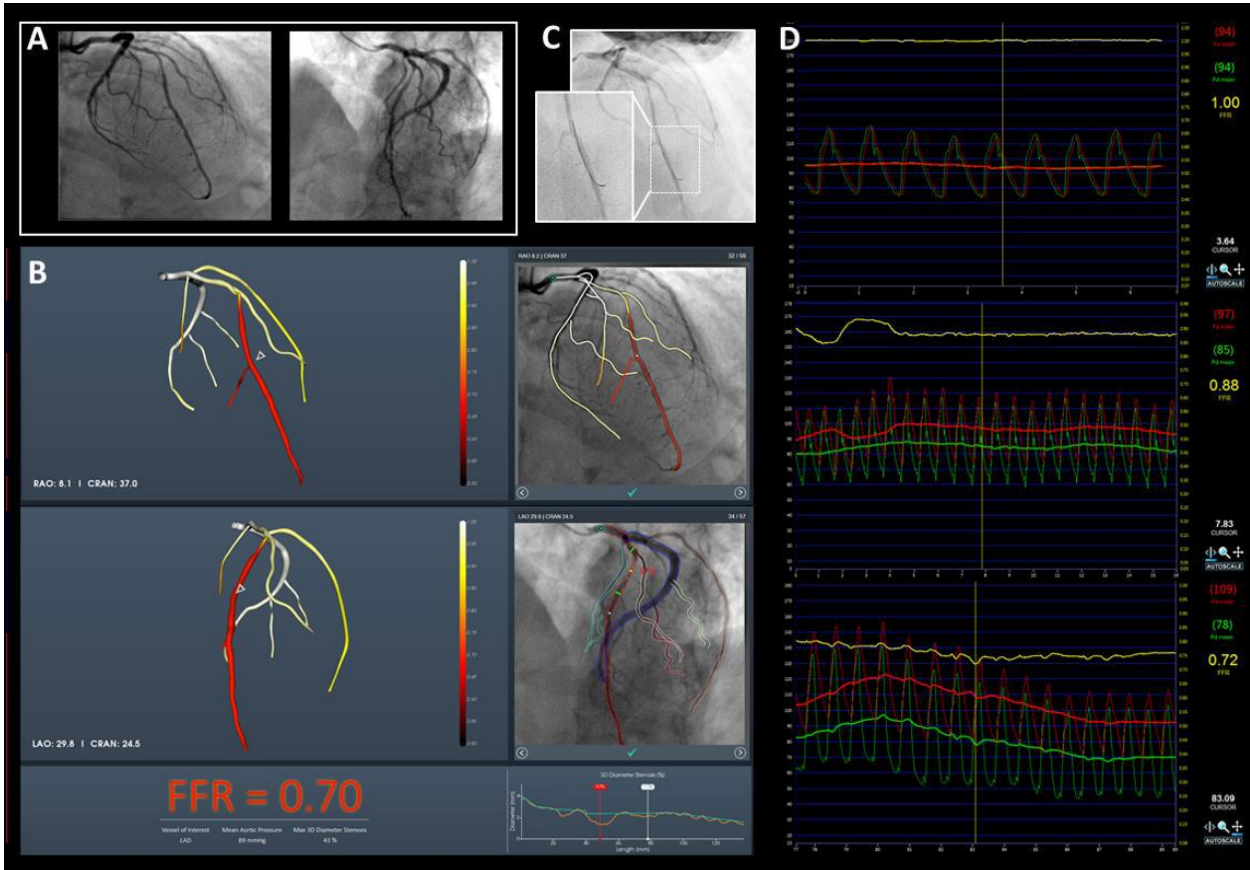
	QFR	2D-QCA	P Value
Accuracy	86.8%	65.9%	<0.001
AUC	0.92 (0.89-0.96)	0.64 (0.57-0.70)	<0.001
Sensitivity	86.5 (78.4-92.4)	44.2 (34.5-54.3)	<0.001
Specificity	86.9 (81.6-91.1)	76.5 (70.3-82.0)	0.002
PPV	76.3 (67.6-83.6)	47.9 (37.6-58.4)	<0.001
NPV	93.0 (88.5-96.1)	73.8 (67.4-79.4)	0.001
LR (+)	6.58 (4.62-9.37)	1.88 (1.36-2.61)	<0.001
LR (-)	0.16 (0.09-0.25)	0.73 (0.61-0.88)	0.001



Westra et al. JAMA 2018

Another Method of Angiography-Derived FFR

- FAST FFR Study -



FFR_{angio} from CathWorks Ltd.



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Evidences of QFR

- Study-Level Meta-Analysis -

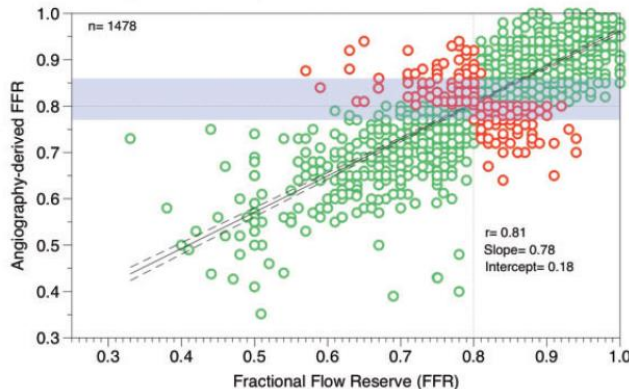
Diagnostic performance of angiography-derived fractional flow reserve: a systematic review and Bayesian meta-analysis

Carlos Collet^{1,2}, Yoshinobu Onuma^{3,4}, Jeroen Sonck², Taku Asano¹, Bert Vandeloo², Ran Kornowski⁵, Shengxian Tu⁶, Jelmer Westra⁷, Niels R. Holm⁷, Xu Bo⁸, Robbert J. de Winter¹, Jan G. Tijssen¹, Yosuke Miyazaki⁴, Yuki Katagiri¹, Erhan Tenekecioglu⁴, Rodrigo Modolo¹, Ply Chichareon¹, Bernard Cosyns², Daniel Schoors², Bram Roosens², Stijn Lochy², Jean-Francois Argacha², Alexandre van Rosendael⁹, Jeroen Bax⁹, Johan H.C. Reiber^{10,11}, Javier Escaned¹², Bernard De Bruyne¹³, William Wijns¹⁴, and Patrick W. Serruys^{15*}

The accuracy of angiography derived FFR was good to detect hemodynamically significant lesions with pressure-wire measured FFR as a reference.

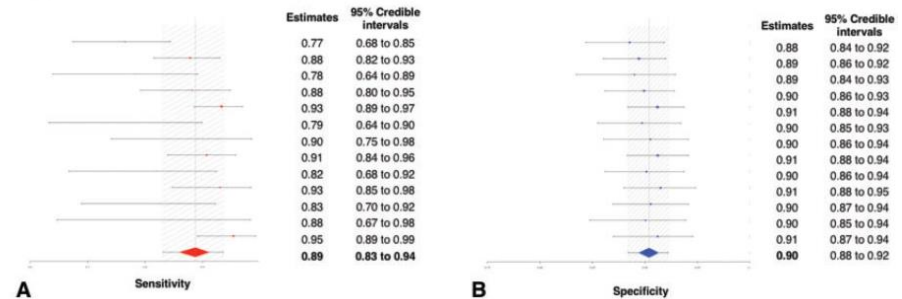
*** No difference according to different software and different computational methods**

A Linear regression analysis



Forest plots for sensitivity and specificity

Studies	TP	FP	TN	FN
WIFI Study	66	20	132	22
FAVOR II Europe & Japan	92	26	187	12
Tar et al.	24	4	21	8
Yazaki et al.	41	12	93	5
FAVOR II China	106	18	198	6
FAVOR Pilot	20	5	52	7
Morris et al.	6	3	27	0
Pellicano et al.	64	9	124	6
Tu et al.	18	4	50	5
Kornowski et al.	30	4	66	1
Trobs et al.	23	4	67	6
van Rosendael et al.	2	2	11	0
Legutko et al.	49	7	67	0
Summary				



QFR in Real World Practice

- Advantages & Disadvantages -

Advantages

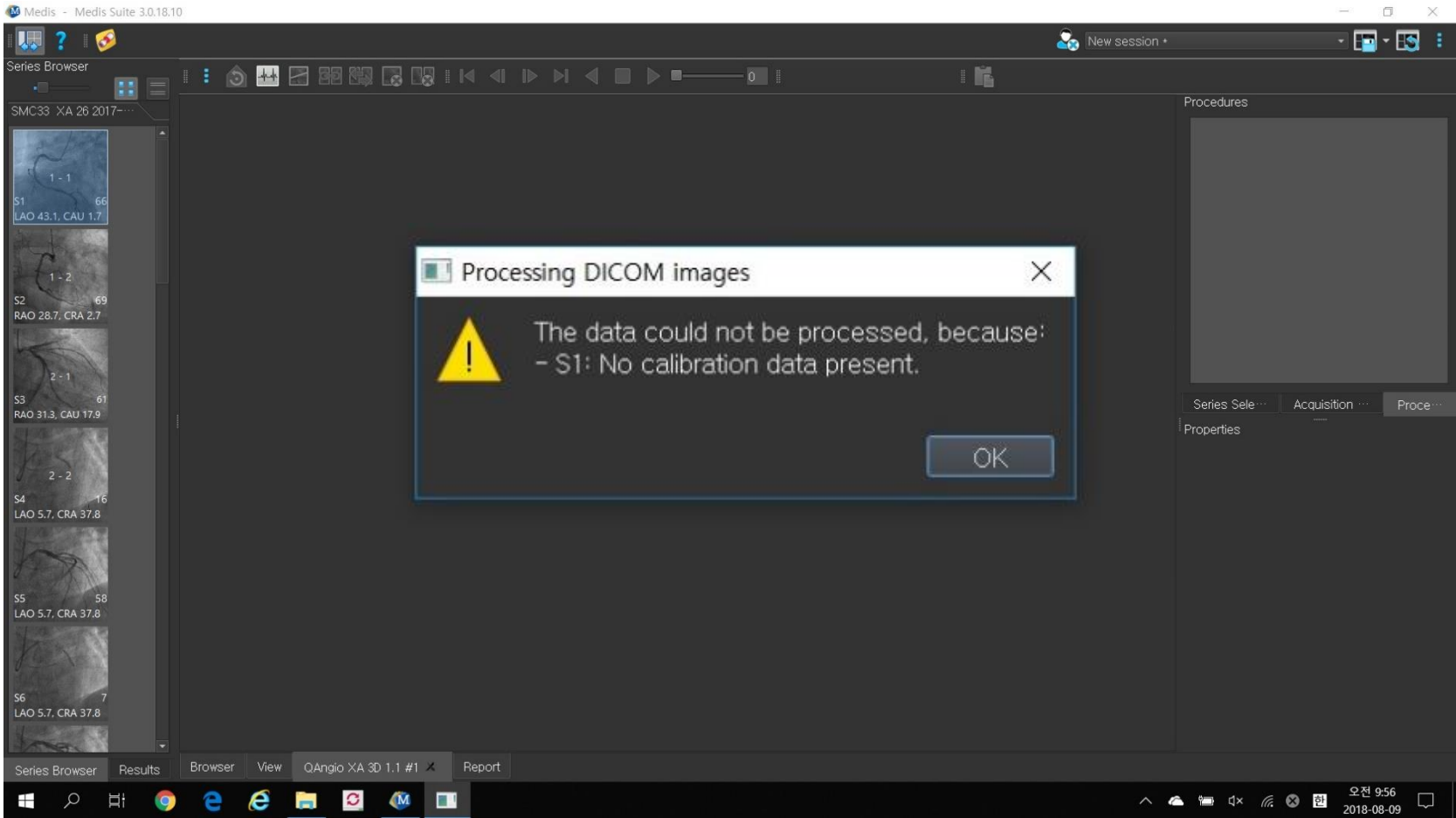
- 1. Non-invasive procedure**
- 2. No need of pressure wire or hyperemic agent**
- 3. Real-time online measure**
- 4. Easy to measure in all 3 vessels**
- 5. Easy to perform the retrospective analysis**
- 6. Per-stenosis QFR Is possible**

Disadvantages

- 1. Calibration failure (We don't know how to prevent)**
- 2. Cannot measure if the image quality is poor (Overlap, Tortuous lesion, Poor contrast filling, No optimal projections > 25 degree)**
- 3. Angiographic limitation (LM ostial lesion, RCA ostial lesion, myocardial bridging)**
- 4. Limited Outcome Data**

Pitfalls of QFR

- Calibration Failure -



In SMC database, 10.1% (49/483 vessels) of lesions cannot assess due to calibration failure.

Pitfalls of QFR

- QFR do not reflect the status of coronary microcirculation -

Microvascular Dysfunction

248 Stable angina with FFR, CFR, and IMR assessment
(Including Samsung Medical Center Data)

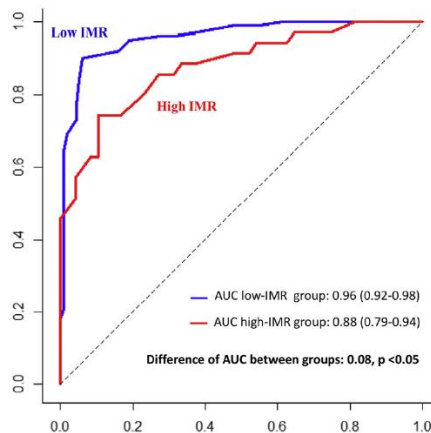


TABLE 5 Predictors of Disagreement Between QFR and FFR

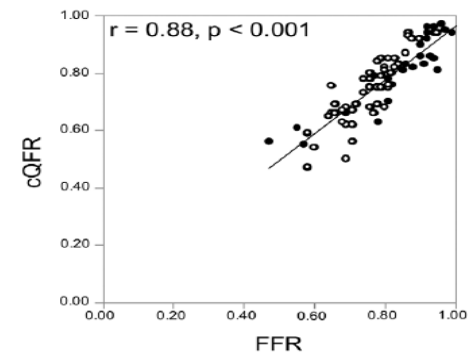
	Univariate Analysis			Multivariate Analysis		
	OR	95% CI	p Value	OR	95% CI	p Value
ACS	2.61	1.24-5.48	0.01	3.97	1.78-8.86	0.001
Smoker	1.99	0.96-4.16	0.06	-	-	-
Multivessel disease	2.18	0.96-4.94	0.06	-	-	-
Proximal or mid segment*	0.45	0.20-1.00	0.05	-	-	-
%DS	1.02	0.99-1.05	0.19	-	-	-
MLD	0.51	0.23-1.14	0.10	-	-	-
IMR†	1.04	1.02-1.07	0.01	1.05	1.02-1.08	0.001
Pa‡	0.98	0.95-0.99	0.04	-	-	-

Hernan, Lee JM et al. JACC: Cardiovascular Intervention 2018

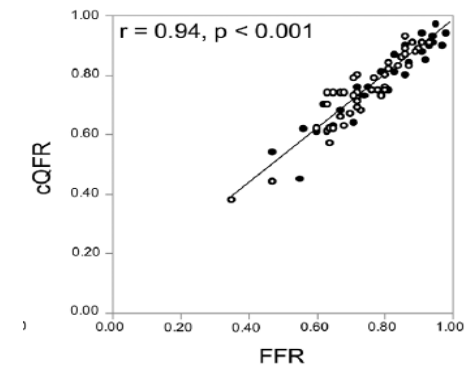
Previous MI Related Artery

150 intermediate coronary artery disease with FFR assessment (40-70% stenosis)

A. Prior-MI-related coronary arteries



B. Non-prior-MI-related coronary arteries



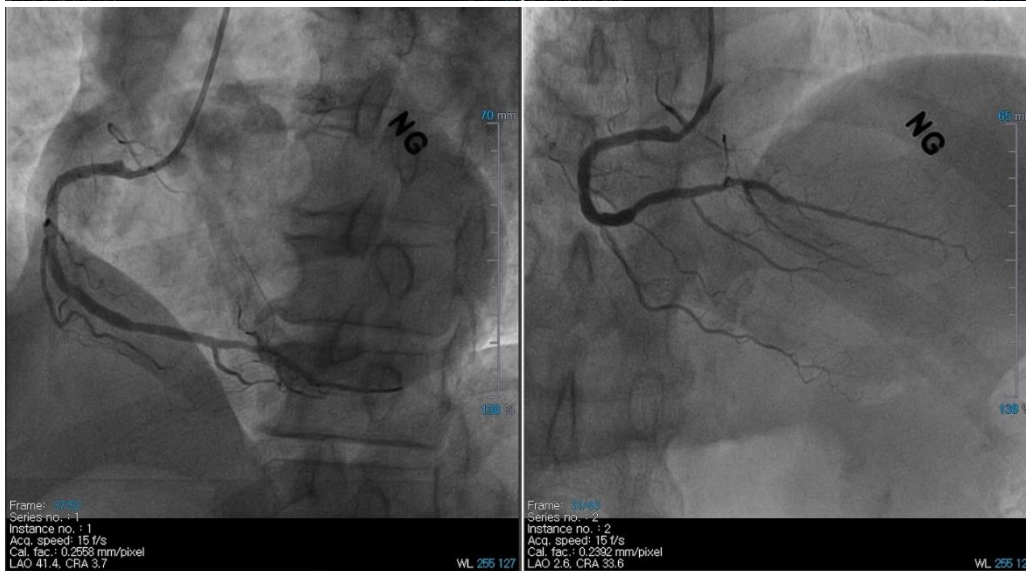
Asano et al. Eurointervention 2018

Pitfalls of QFR

- Ostial Lesion -



**LM Ostial lesion cannot be analyzed.
(No proximal reference segment)**

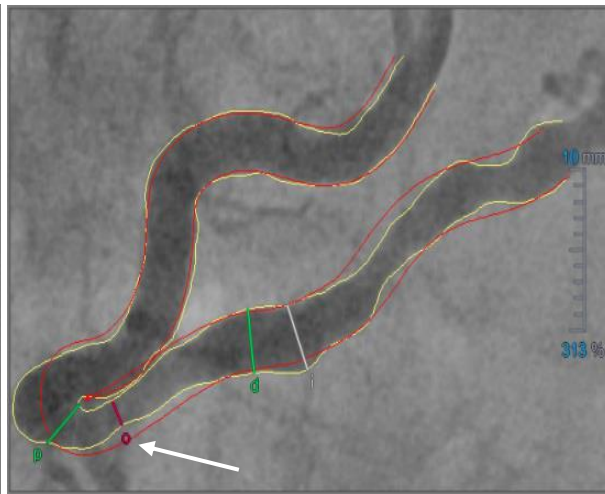
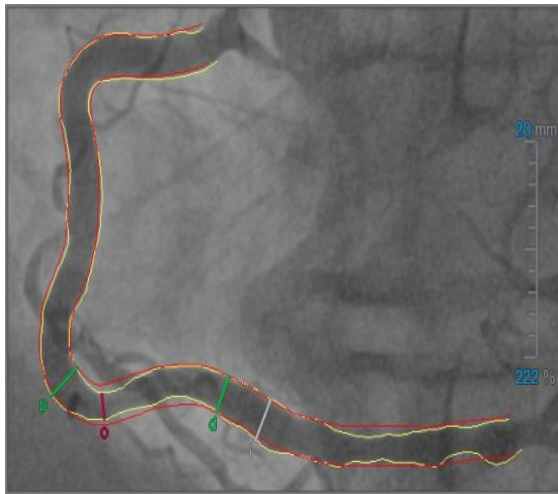
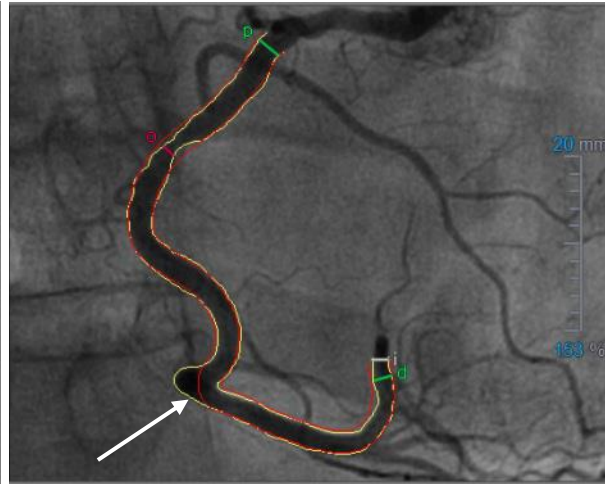
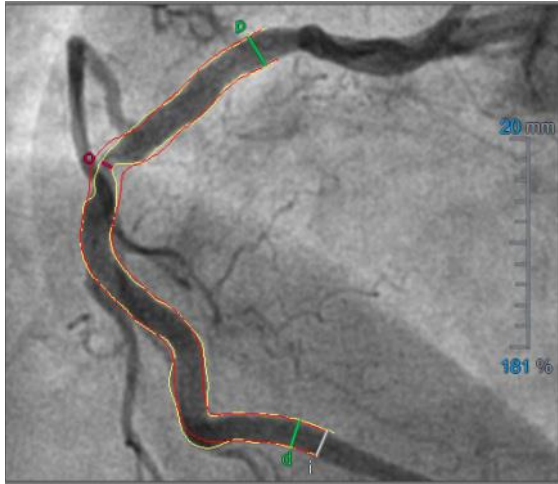


**RCA Ostial lesion cannot be analyzed.
(No proximal reference segment)**

**In SMC database, 7.2% (35/483 vessels)
of lesions cannot assess due to LM or
RCA ostial lesion.**

Pitfalls of QFR

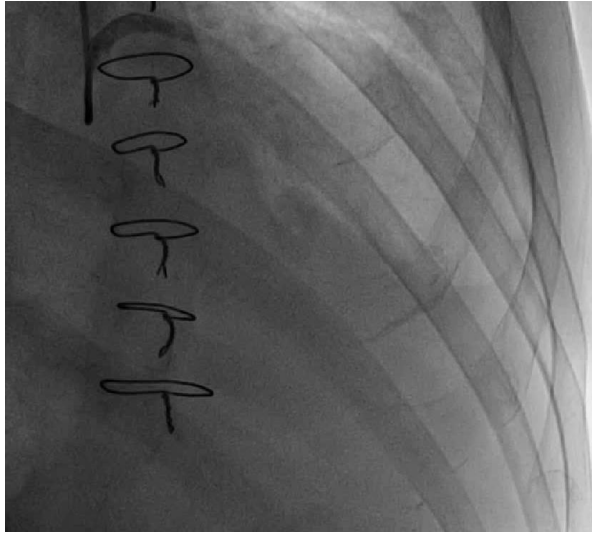
- Tortuous Lesion -



In SMC database, 1.5% (7/483 vessels) cannot be assessed due to severe tortuosity.

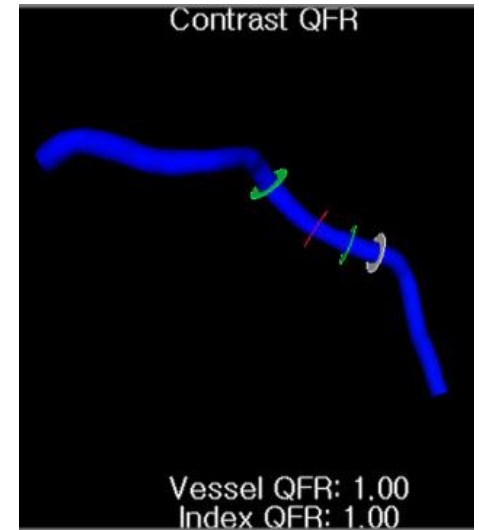
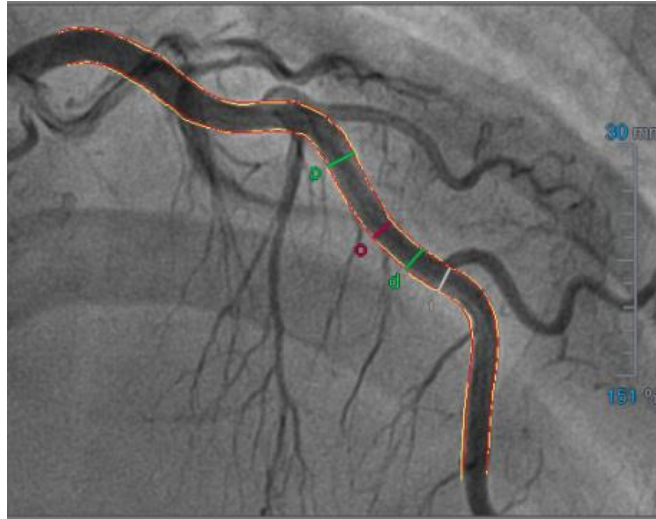
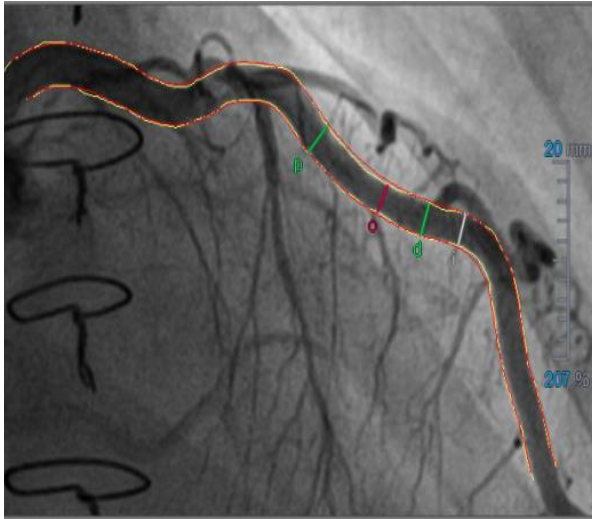
Pitfalls of QFR

- Myocardial Bridging -



Physiologic evaluation for LAD

Resting Pd/Pa : 0.98
FFR : 0.94



Technical Limitation of QFR

QFR analysis is unreliable or impossible in following conditions

<SMC database, 25.7% (124/483) of lesions cannot be assessed QFR>

- **Too much overlap** of target vessel
- **Too much foreshortening** of the target coronary artery
- **Ostial lesions**
- **Tortuous lesions**
- **Very severe lesions** might lead to very low QFR value, much lower than the corresponding FFR. Clinical decision will be the same.

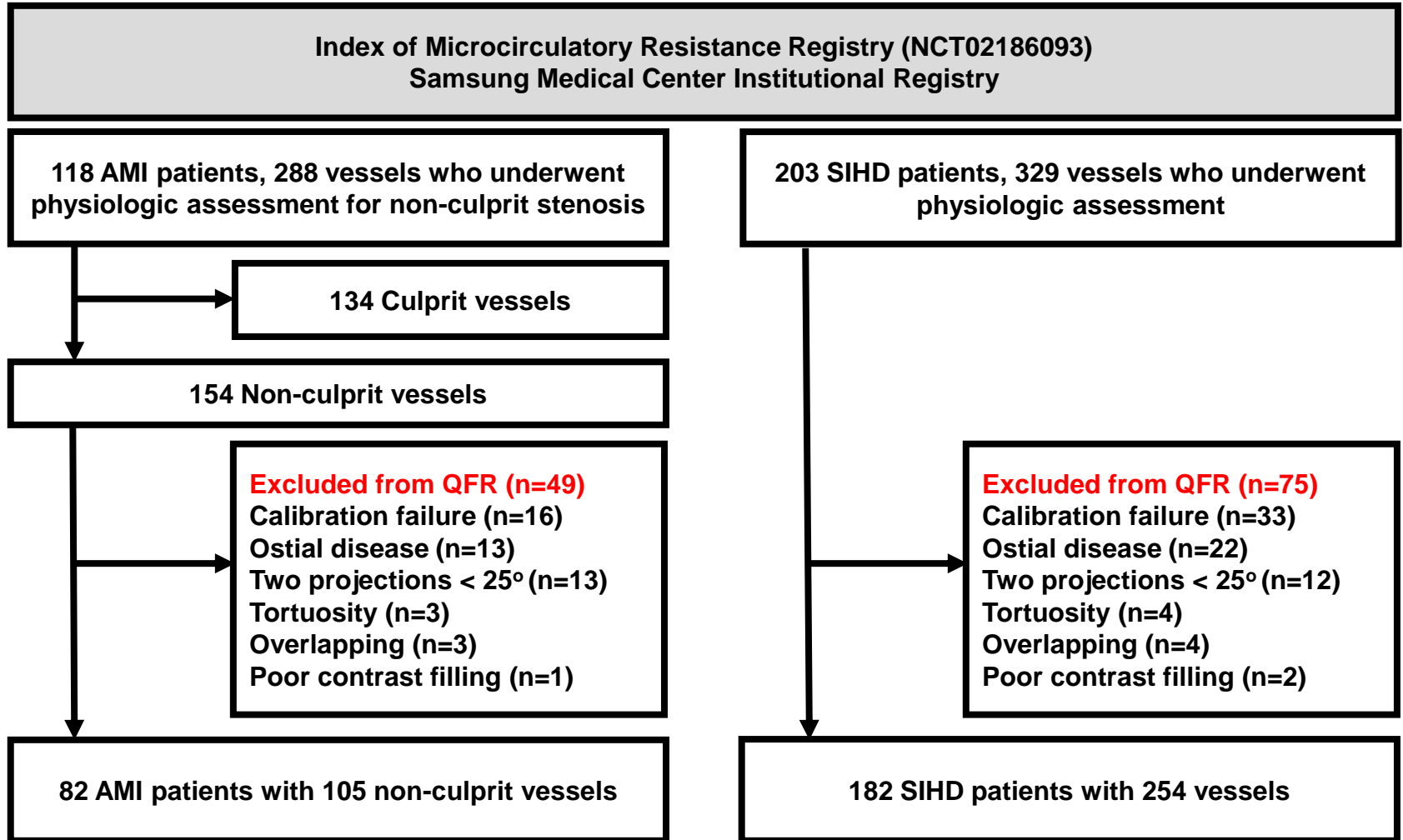
Unclarified Reliability of QFR to date

The safety and effectiveness of the QFR has not been evaluated for patients with the following conditions

- **Unstable angina (ongoing researches)**
- **Acute myocardial infarction (ongoing researches)**
- **Hyper-dynamic heart**
- **Atrial fibrillation**
- **Ostial lesions**
- **True bifurcation lesions (1,1,1 Medina classification)**
- **Jailed side branch**
- **Vessels with retrograde fillings**
- **Grafted coronary arteries**
- **Non-coronary arteries (ex> LIMA-LAD, Saphenous graft)**

Ongoing Research of QFR

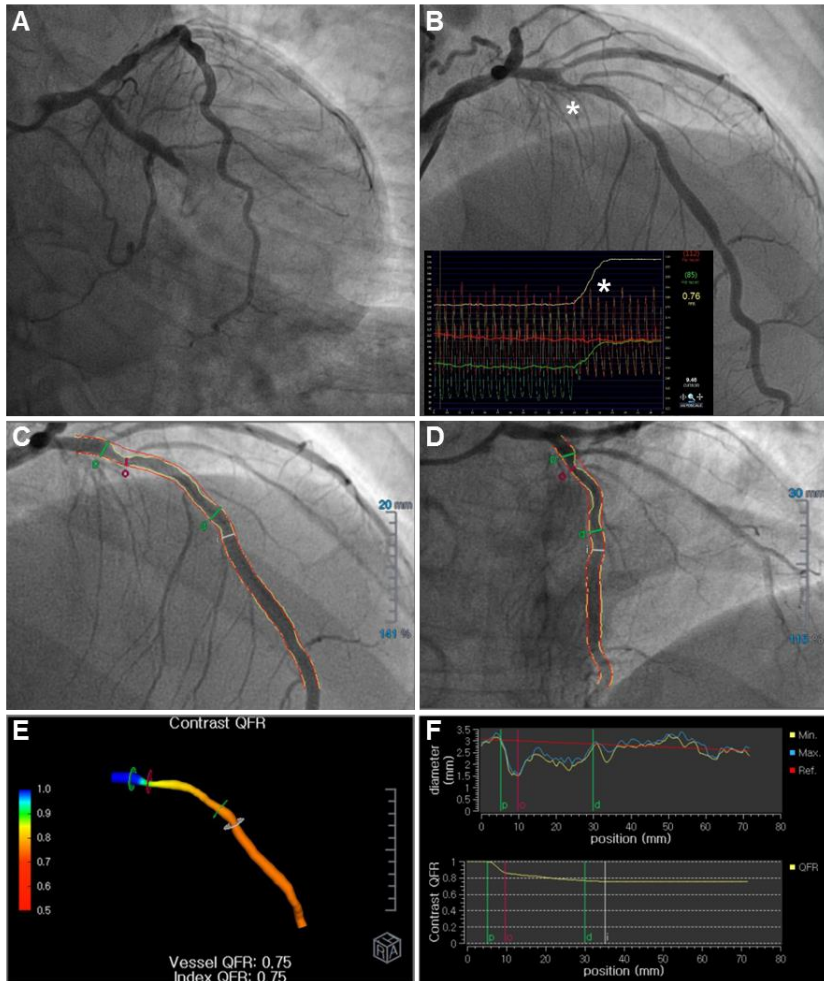
<QFR for Non-culprit Lesion in AMI Patients>



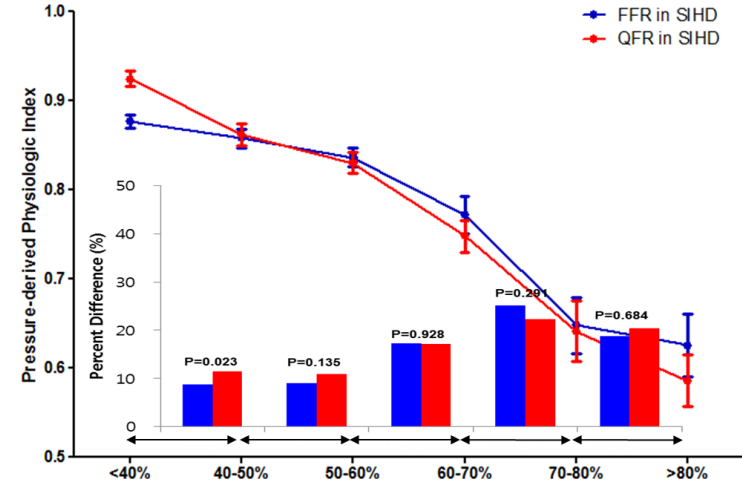
Ongoing Research of QFR

<QFR for Non-culprit Lesion in AMI Patients>

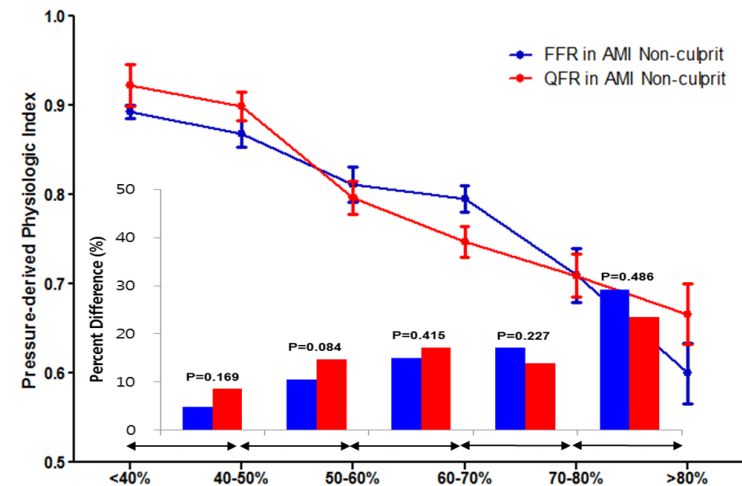
<AMI Non-culprit Intermediate Stenosis>



A. Stable Ischemic Heart Disease



B. Acute Myocardial Infarction (Non-Culprit Vessel)

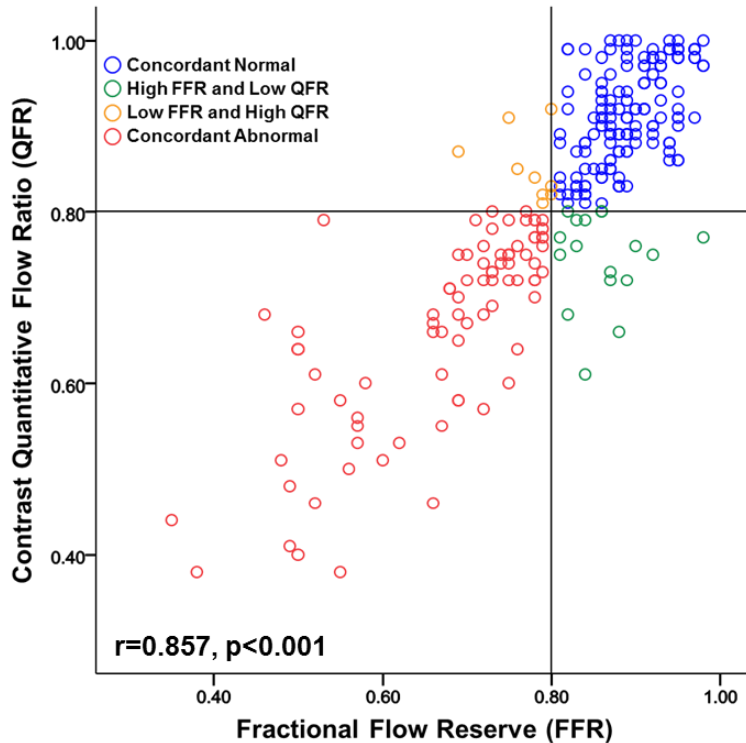


Ongoing Research of QFR

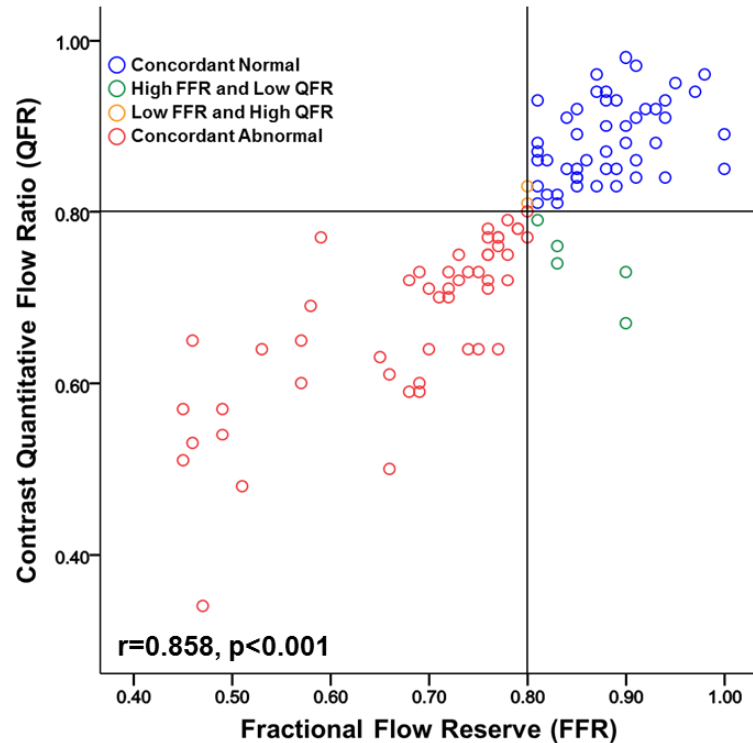
<QFR for Non-culprit Lesion in AMI Patients>

- Correlation Between QFR and FFR According to Clinical Presentation -

A. Stable Ischemic Heart Disease



B. Acute Myocardial Infarction (Non-culprit Vessel)



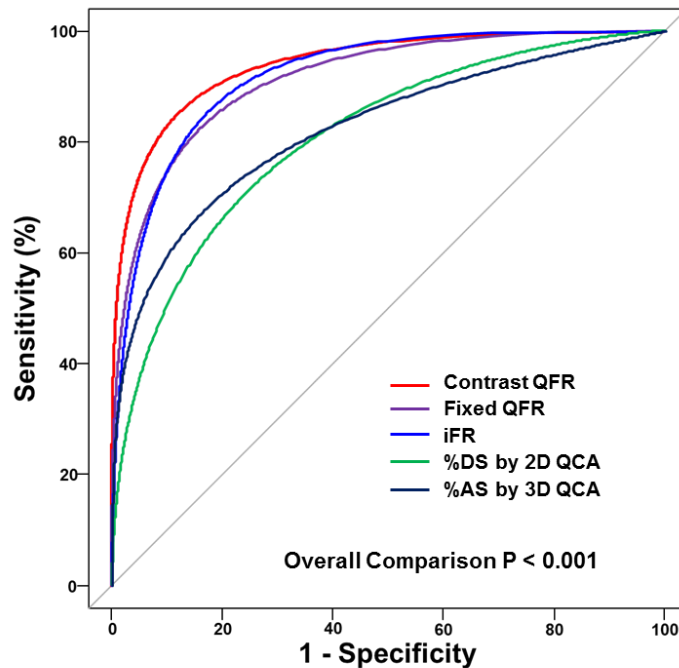
P value = 0.974 for comparison of correlation coefficients between SIHD and AMI non-culprit vessel.

Ongoing Research of QFR

<QFR for Non-culprit Lesion in AMI Patients>

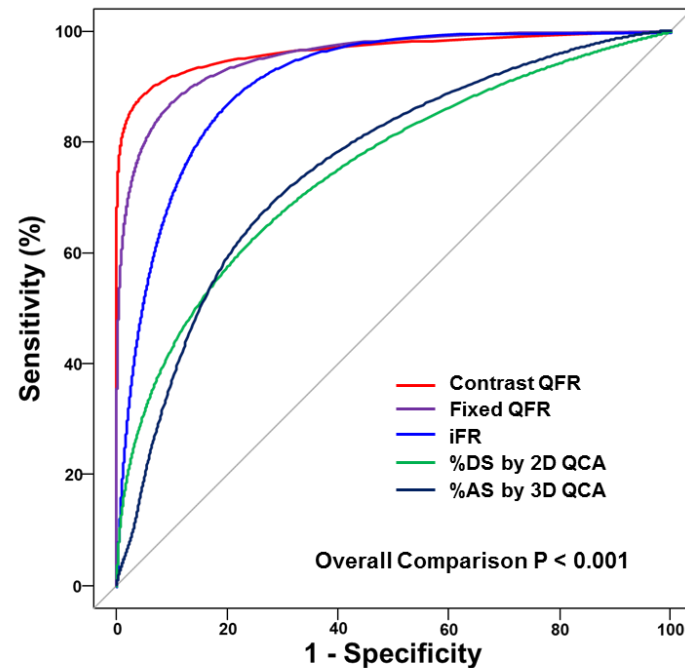
- Predicting Ability for Functional Significance -

A. Stable Ischemic Heart Disease



Model	AUC	95% CI	P value*
%DS by 2D QCA	0.812	0.757-0.866	NA
%AS by 3D QCA	0.819	0.768-0.870	0.293
iFR	0.914	0.880-0.949	0.001
Fixed QFR	0.918	0.884-0.952	<0.001
Contrast QFR	0.946	0.919-0.974	<0.001

B. Acute Myocardial Infarction (Non-culprit Vessel)



Model	AUC	95% CI	P value*
%DS by 2D QCA	0.759	0.668-0.851	NA
%AS by 3D QCA	0.774	0.684-0.864	0.134
iFR	0.924	0.870-0.979	0.002
Fixed QFR	0.957	0.920-0.994	<0.001
Contrast QFR	0.967	0.936-0.999	<0.001

Summary & Future Perspectives

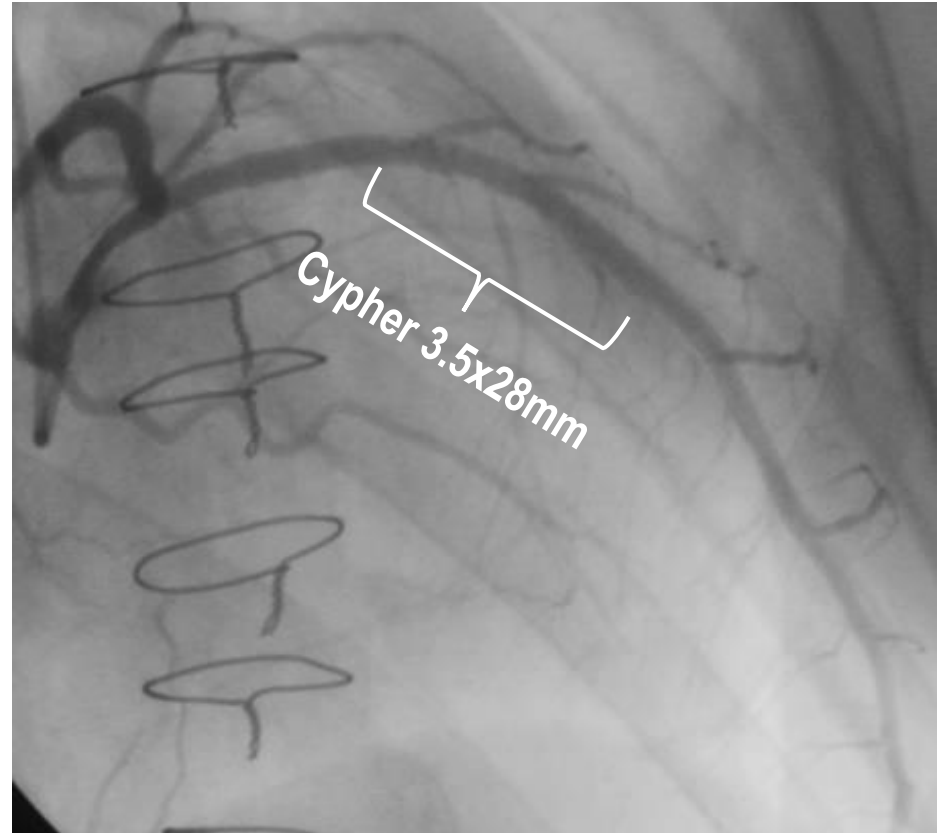
- **Fast computation of FFR from coronary angiography (QFR) without pressure wire or hyperemic agents is feasible and reliable.**
- **Contrast-flow QFR (cQFR) showed similar diagnostic performance with adenosine-QFR, and showed superior diagnostic performance than fixed-QFR.**
- **QFR has been validated only in patients with Stable Ischemic Heart Disease.**
- **Currently, the reliability of QFR for patients with AMI (non-culprit), or specific lesion subsets (such as bifurcation, and diffuse disease) are ongoing.**
- **Our group is planning to identify the association between post-PCI 3-vessel QFR and increase of exercise performance after PCI.**
- **Validation of clinical outcomes of QFR-guided PCI is needed (FAVOR III China)**

Future Research Perspective Using QFR

63 years old male

2006.07.18 s/p Heart Transplantation d/t ICMP

2006.09.28 CAG : proximal LAD 70% stenosis s/p PCI (Cypher 3.5x28mm)

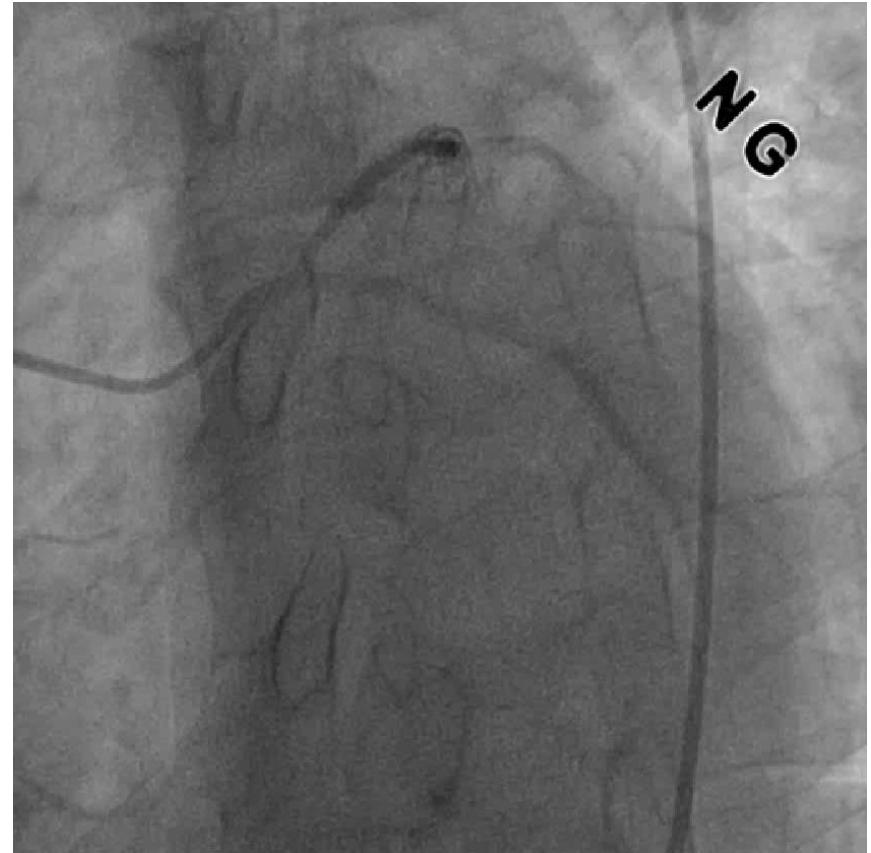
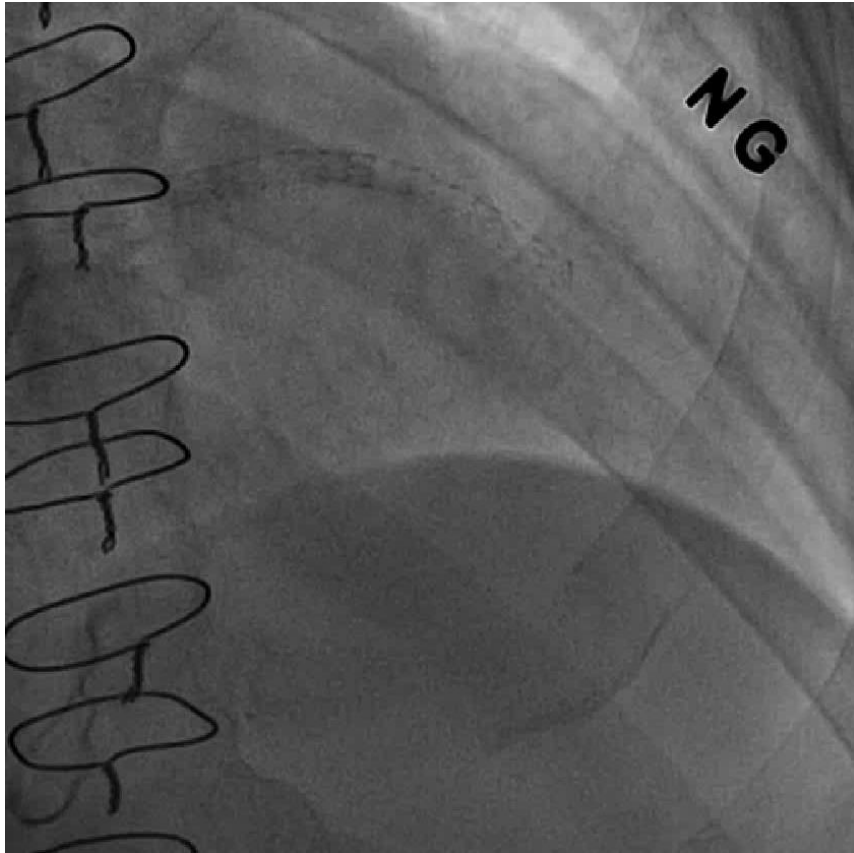


Future Research Perspective Using QFR

2018.11.06 CAG was performed d/t newly developed RWMA (LAD territory)

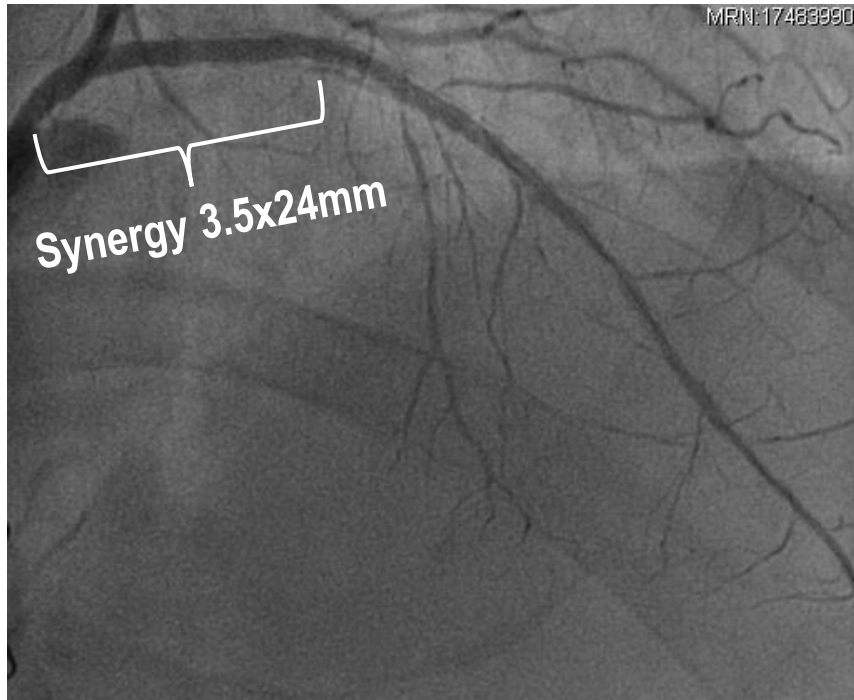
CAG: ostium to proximal LAD - diffuse stenosis up to 70%

Mid LAD - ISR CTO



Future Research Perspective Using QFR

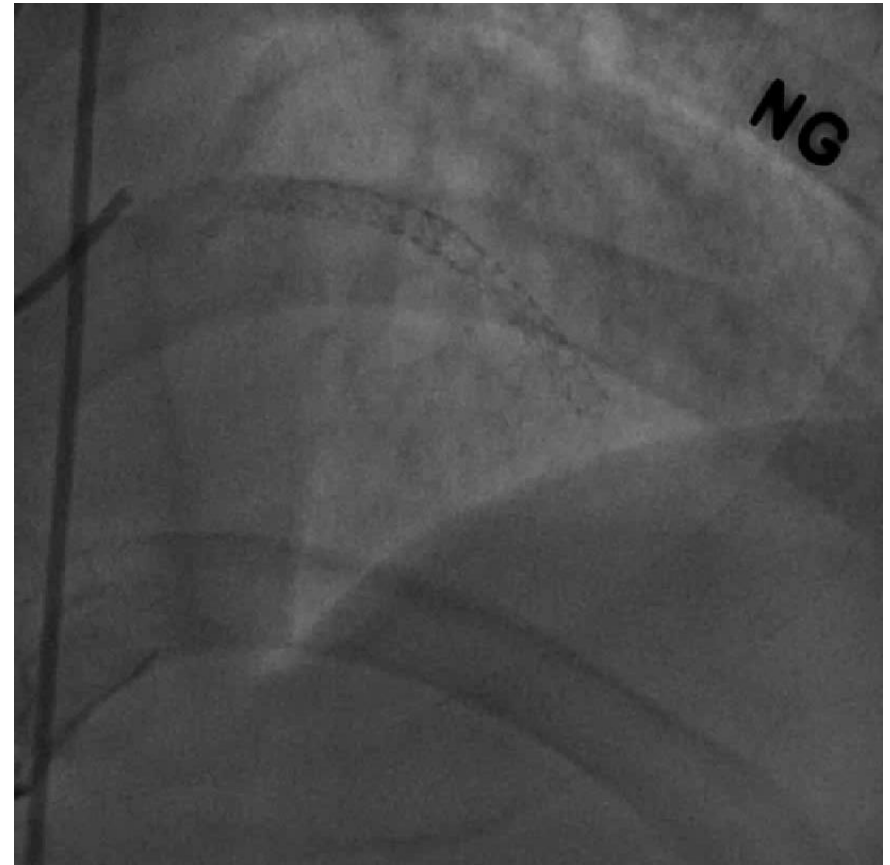
PCI was performed
LM to proximal LAD – 3.5x24mm Synergy
mLAD – 3.0x30mm DEB x2EA



Future Research Perspective Using QFR

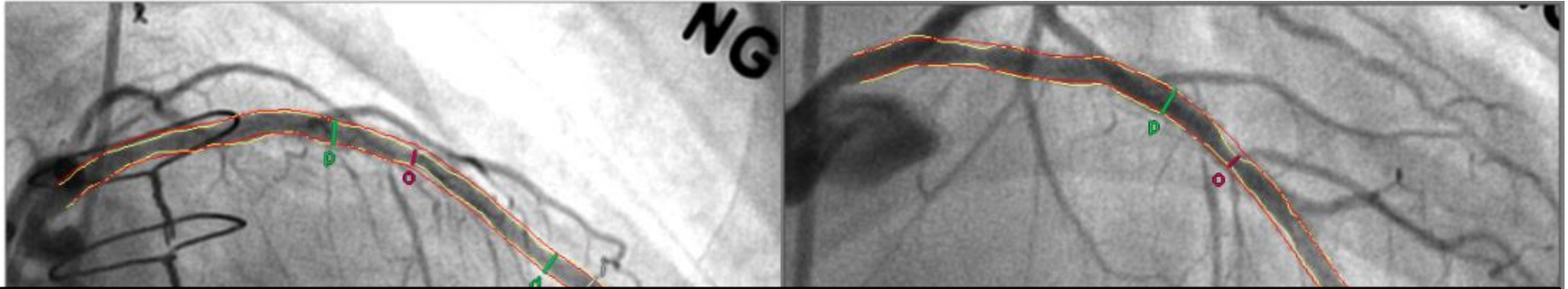
Why did this lesion progress?

We can find the clue in the past CAG (2012.09.11)



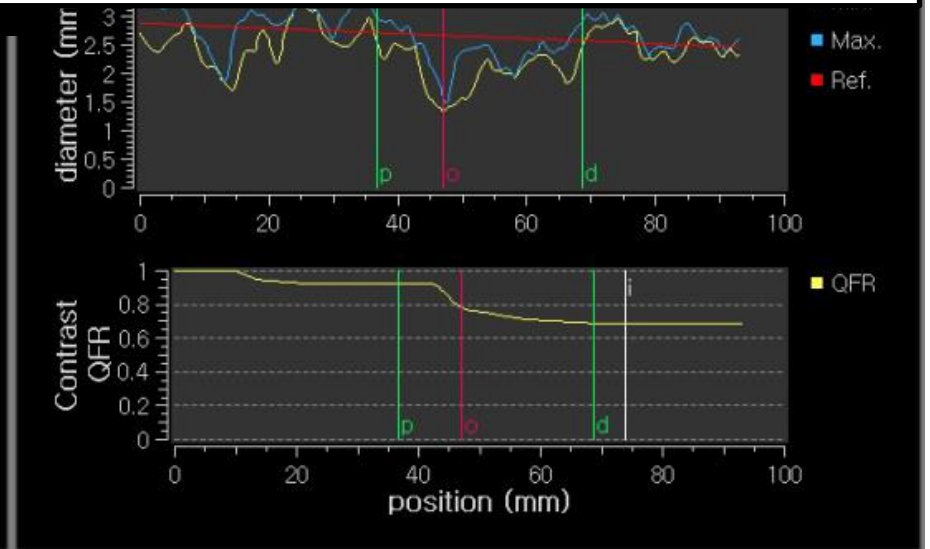
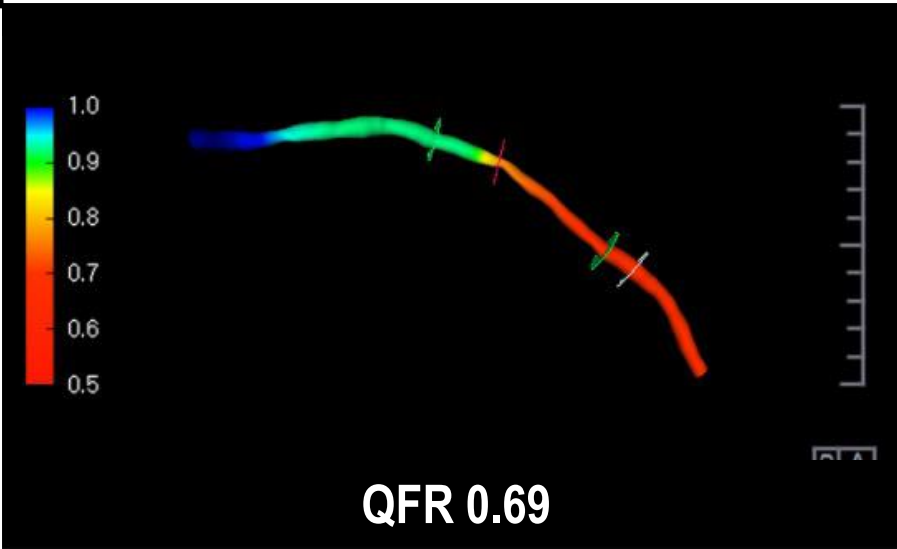
What do you think about the functional significance of this lesion?

Future Research Perspective Using QFR



**This lesion might be a functionally significant lesion in 2012.
Hemodynamic significance of the lesion might have affected the lesion progression.**

**This is one of the advantages of functional coronary angiography for
understanding the lesion progression and subsequent outcomes**



Thank You For Your Attention !

Ki Hong Choi, MD

**Clinical Fellow,
Heart Vascular Stroke Institute,
Samsung Medical Center, Seoul, Republic of Korea**



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