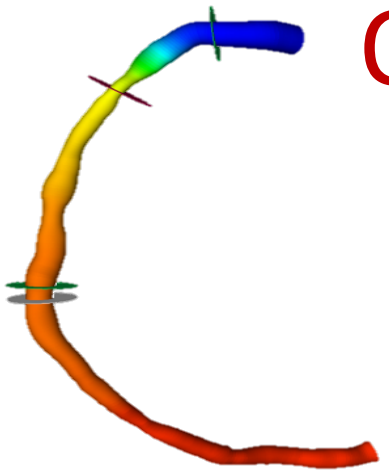
13ÈME CARDIO RUN 2021

CONGRÈS DE PATHOLOGIE CARDIO-VASCULAIRE

29-30 SEPTEMBRE & 1 OCTOBRE 2021

HÔTEL SAINT ALEXIS - ÎLE DE LA RÉUNION, FRANCE



Quantitative Flow Ratio (QFR®)

How friendly use FFR ?

Have you ever tested QFR ?

Luc Maillard, MD, PhD

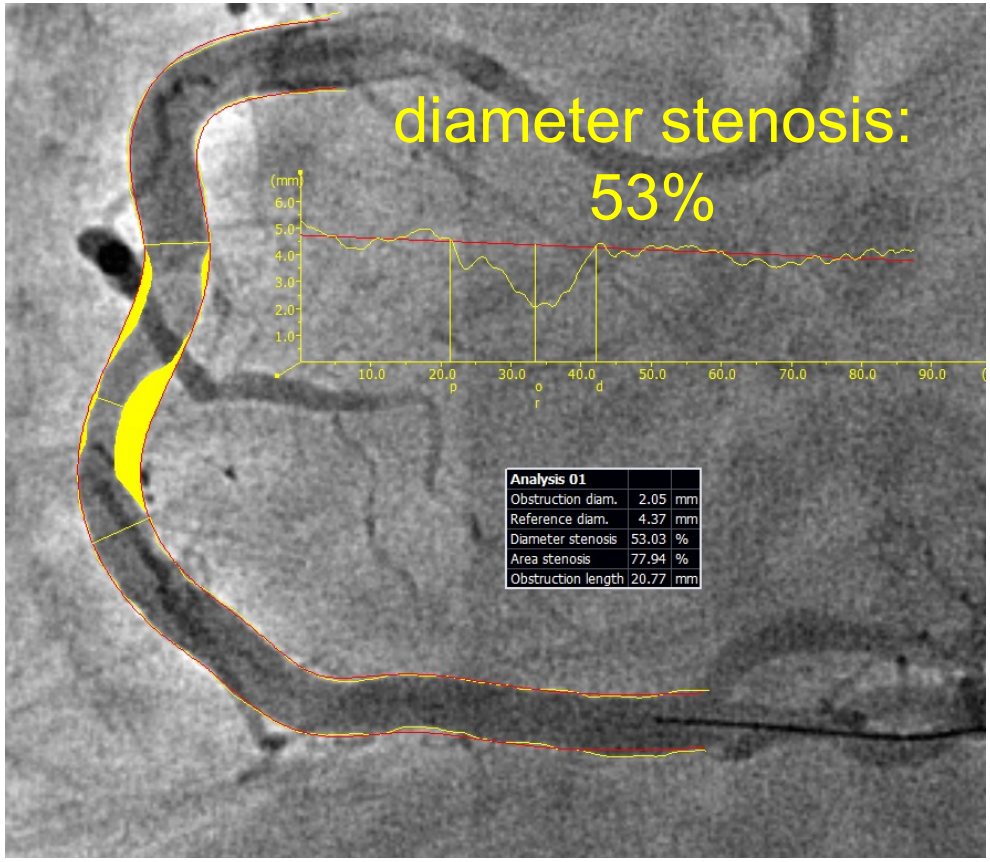
CARDIOVISTA

AIX-EN-PROVENCE / AUBAGNE / MARSEILLE

Centre de Cardiologie Interventionnelle

G.C.S AXIUM - RAMBOT

Can we improve the capacity of ‘luminography’ for the detection of ischaemia?



quantitative coronary angiography (QCA)

Anatomy: diameter stenosis = 53%

vs.

Physiology: FFR = 0.85

Wire based FFR

FFR is a quantitative measurement of the functional severity of the coronary stenosis and measured by a pressure wire

$$\textbf{FFR} = \frac{Distal\ Coronary\ Pressure\ (Pd)}{Proximal\ Coronary\ Pressure\ (Pa)}$$

During maximum hyperemia

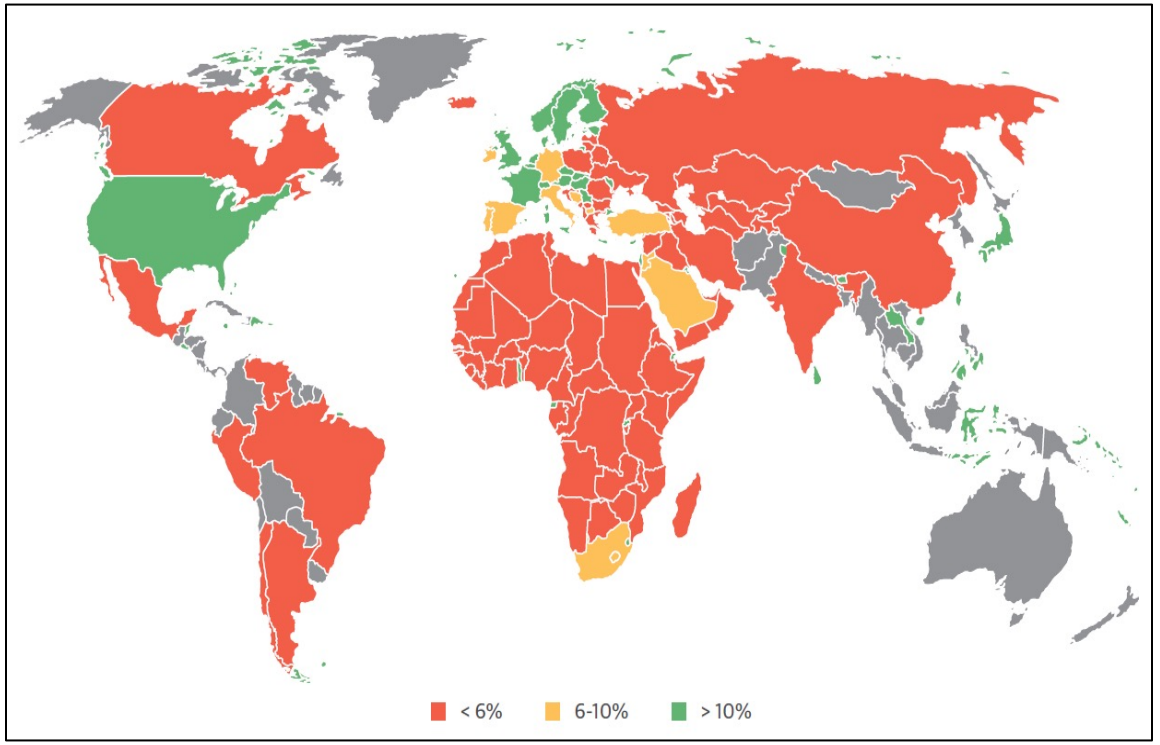
Intervention Yes/No is based on:

FFR ≤ or > 0.80

Fractional Flow Reserve

Recommendations	Class[a]	Level[b]	Ref.[c]
FFR to identify haemodynamically relevant coronary lesion(s) in stable patients when evidence of ischaemia is not available.	I	A	50,51,713
FFR-guided PCI in patients with multivessel disease.	IIa	B	54
IVUS in selected patients to optimize stent implantation.	IIa	B	702,703,706
IVUS to assess severity and optimize treatment of unprotected left main lesions.	IIa	B	705
IVUS or OCT to assess mechanisms of stent failure.	IIa	C	
OCT in selected patients to optimize stent implantation.	IIb	C	

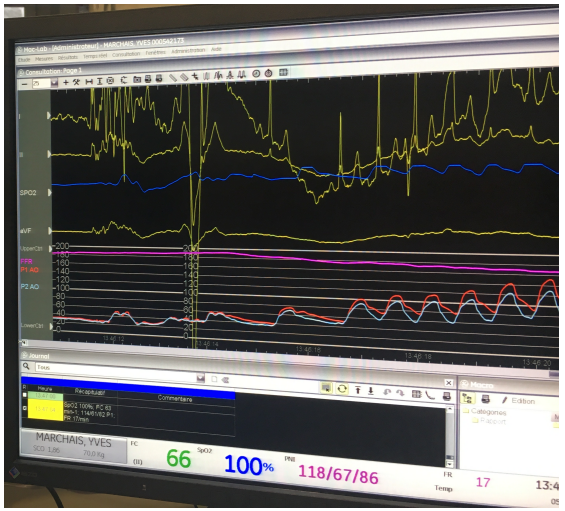
European Heart Journal, October 2014



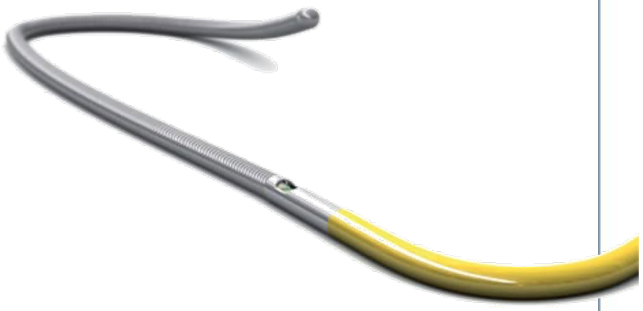
Götberg et al., JACC 2017

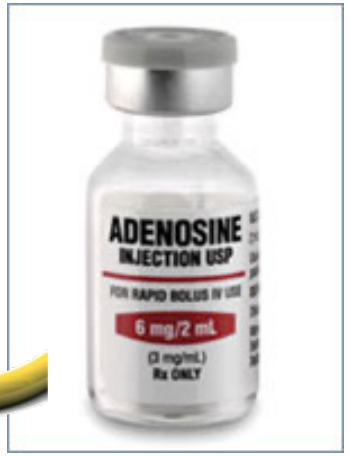
Very poor utilization of pressure wire based functional stenosis evaluation world-wide with few exceptions

FFR Limitations

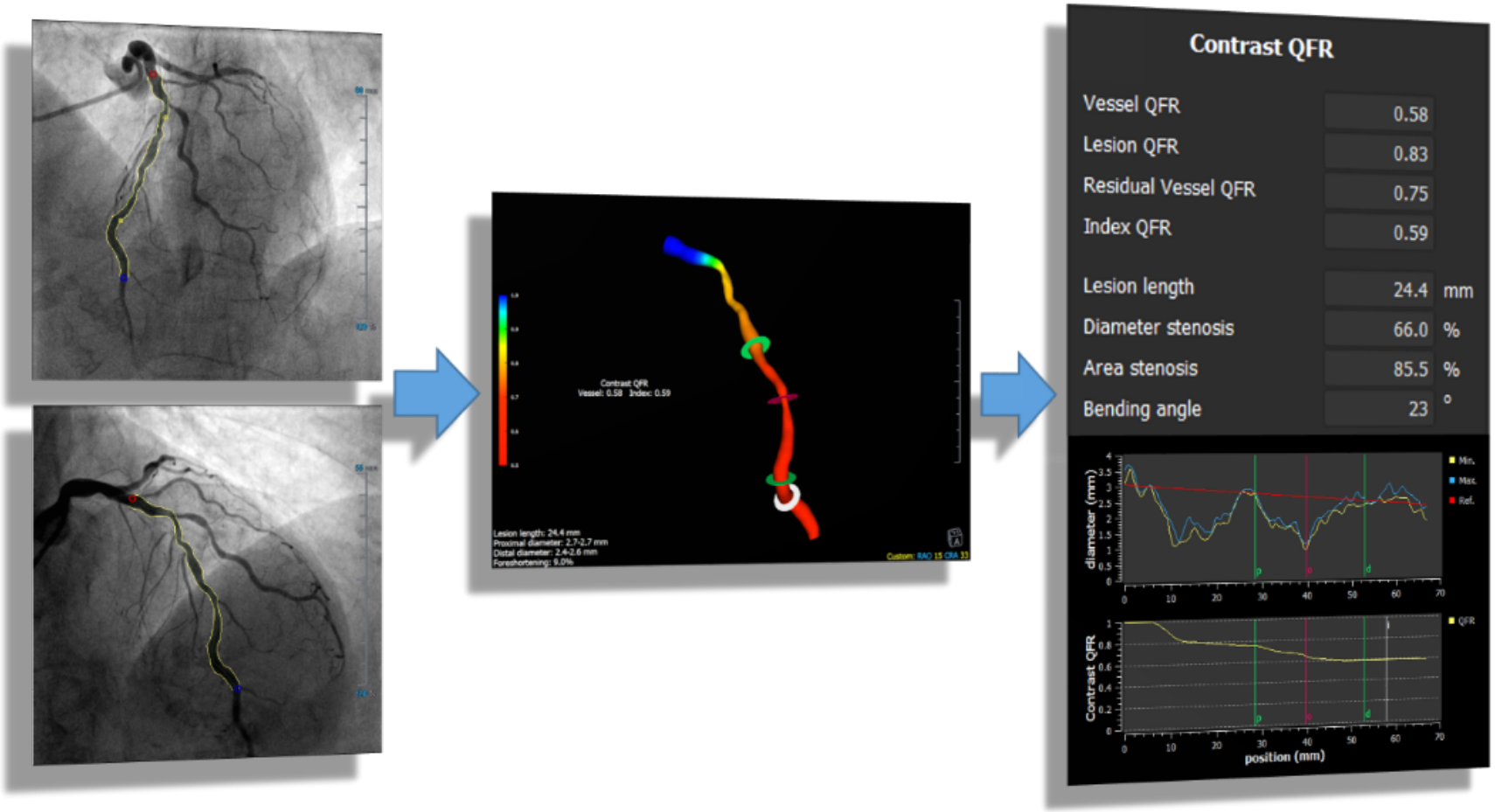


- Invasive
- Need for adenosine
- Time for preparation (consuming)
- Egalization Pressure in the aorta
- Wiring (sometime complex)
- Extubation
- Pullback device not available
- Suboptimal FFR measurements occur in about 1/3 of tracings; JACC Interv 2017; 10:1392
- Expensive for operator or hospital
- Derivation
- Adenosine AV Block
- Worldwide acceptance 7-10%





What if there was another way……..



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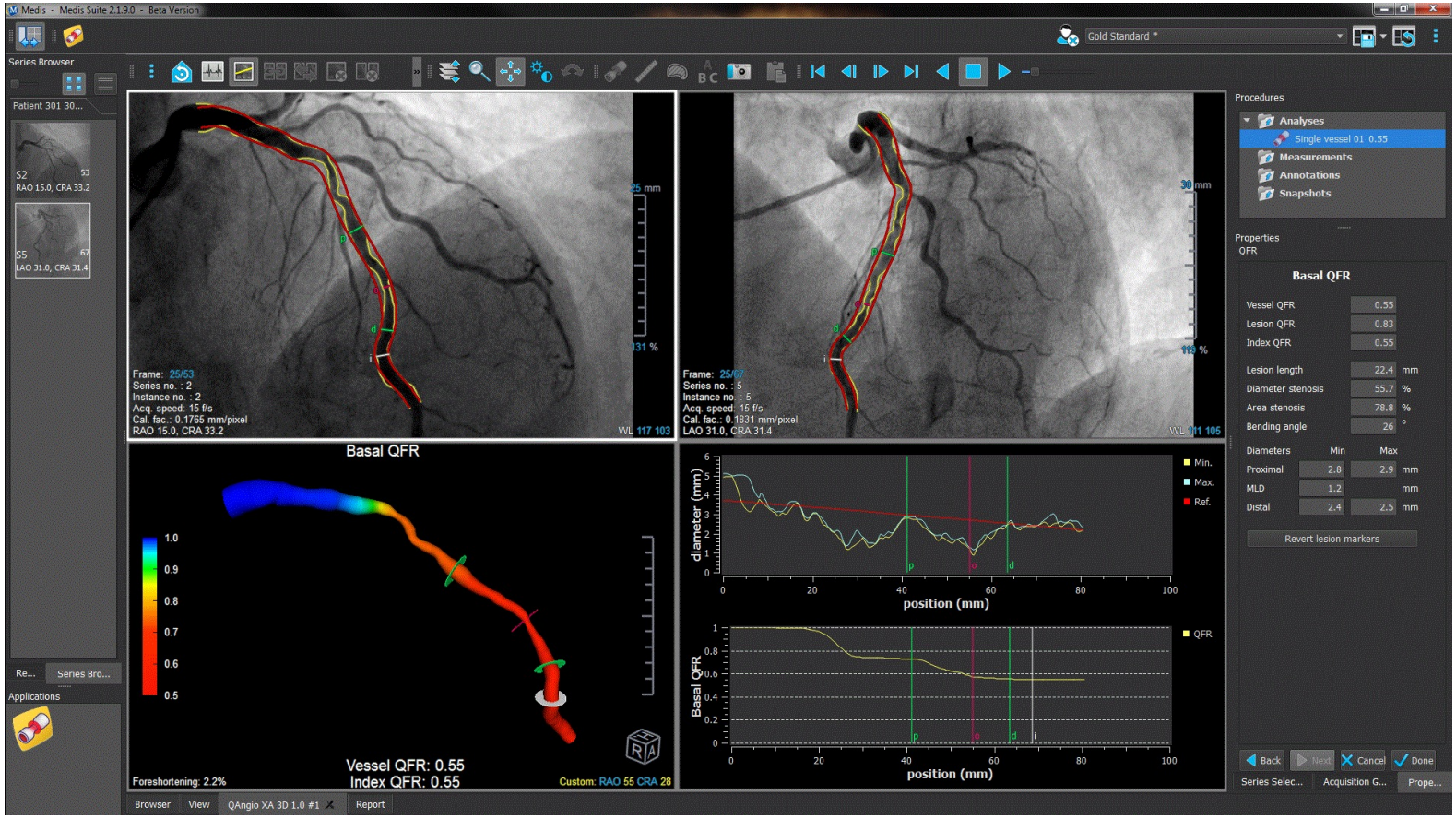
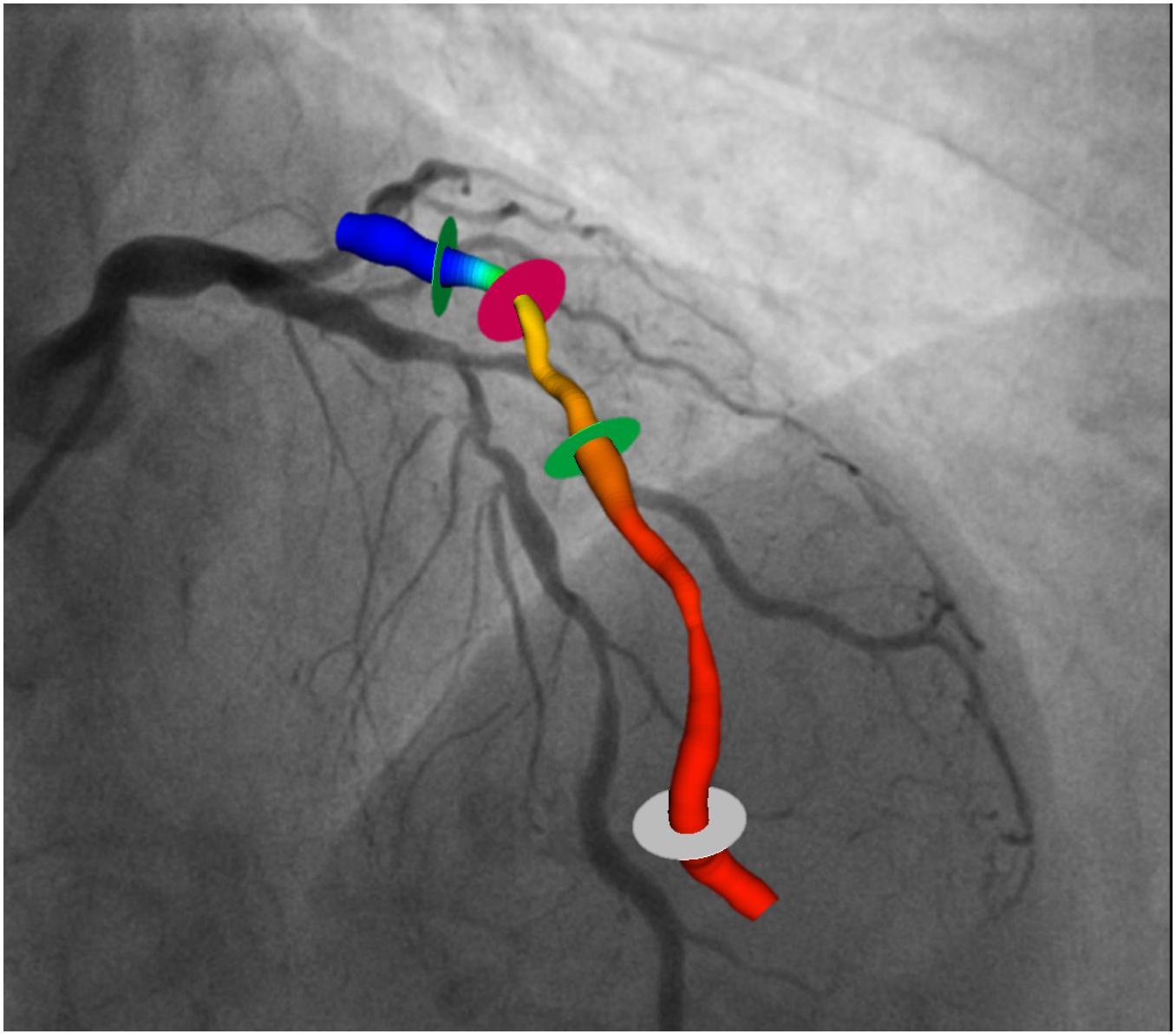
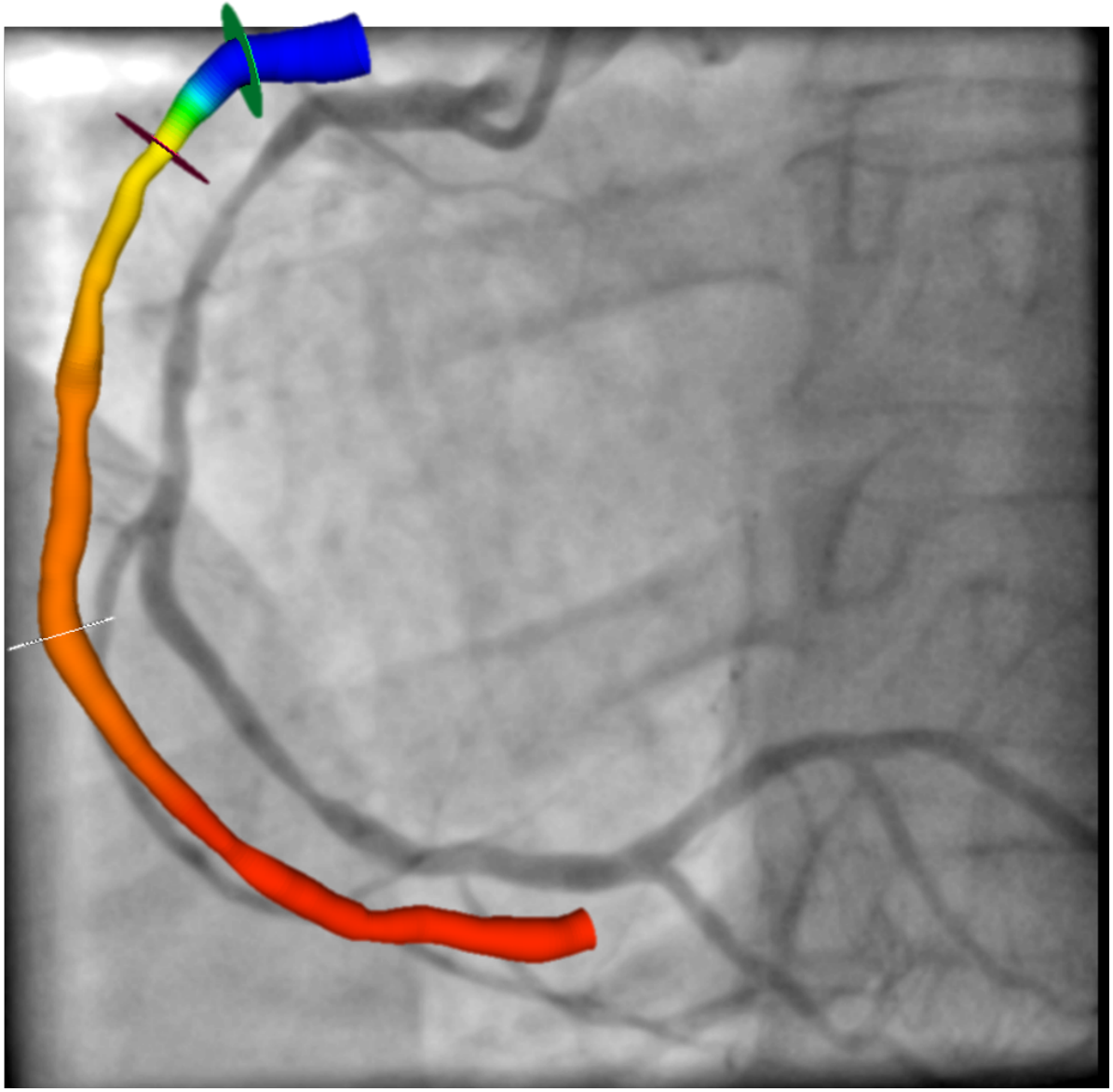


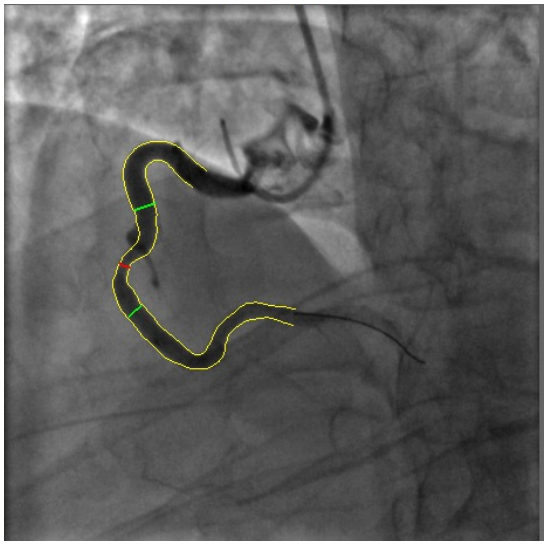
3D QCA model, color coded with the QFR values, as assessed by QAngio XA 3D 1.0 (Medis, Leiden, The Netherlands)

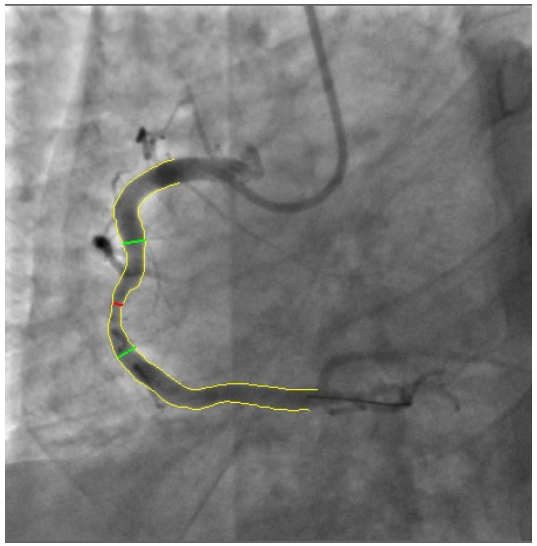


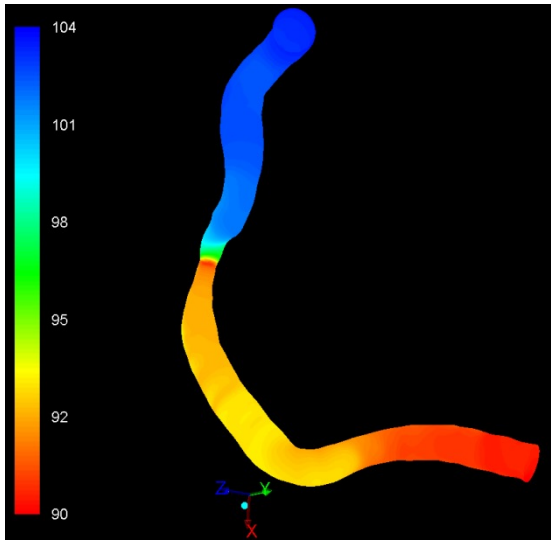


QFR

(Quantitative Flow Ratio = Medis' QCA derived FFR)







3D model reconstructed from 2 angiographic projections with angles ≥ 25º apart, acquired by monoplane or biplane systems.

Patient-specific **volumetric flow rate** (at hyperaemia) calculated using the combination of contrast bolus front **frame count** and **3D QCA**;

In-procedure time: < 5 min

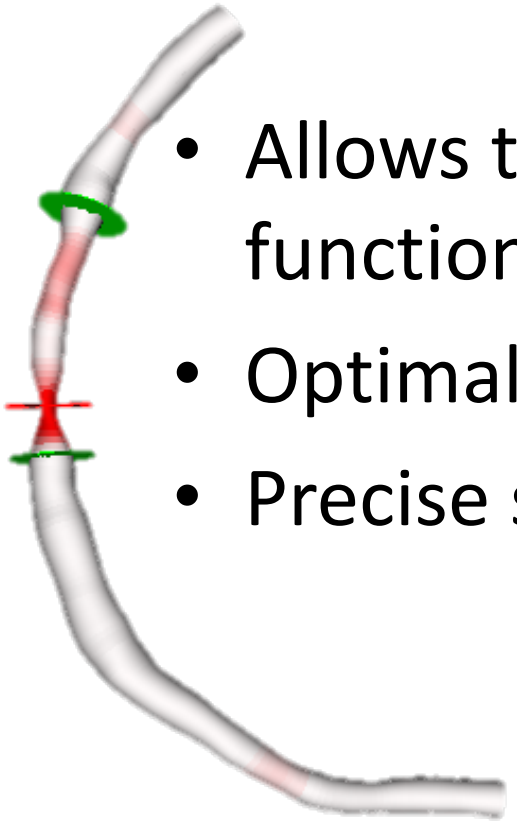
QFR = 0.87

FFR = 0.85

Based on EuroPCR 2014 presentation by
Niels Holm, Aarhus University Hospital, Skejby, Denmark

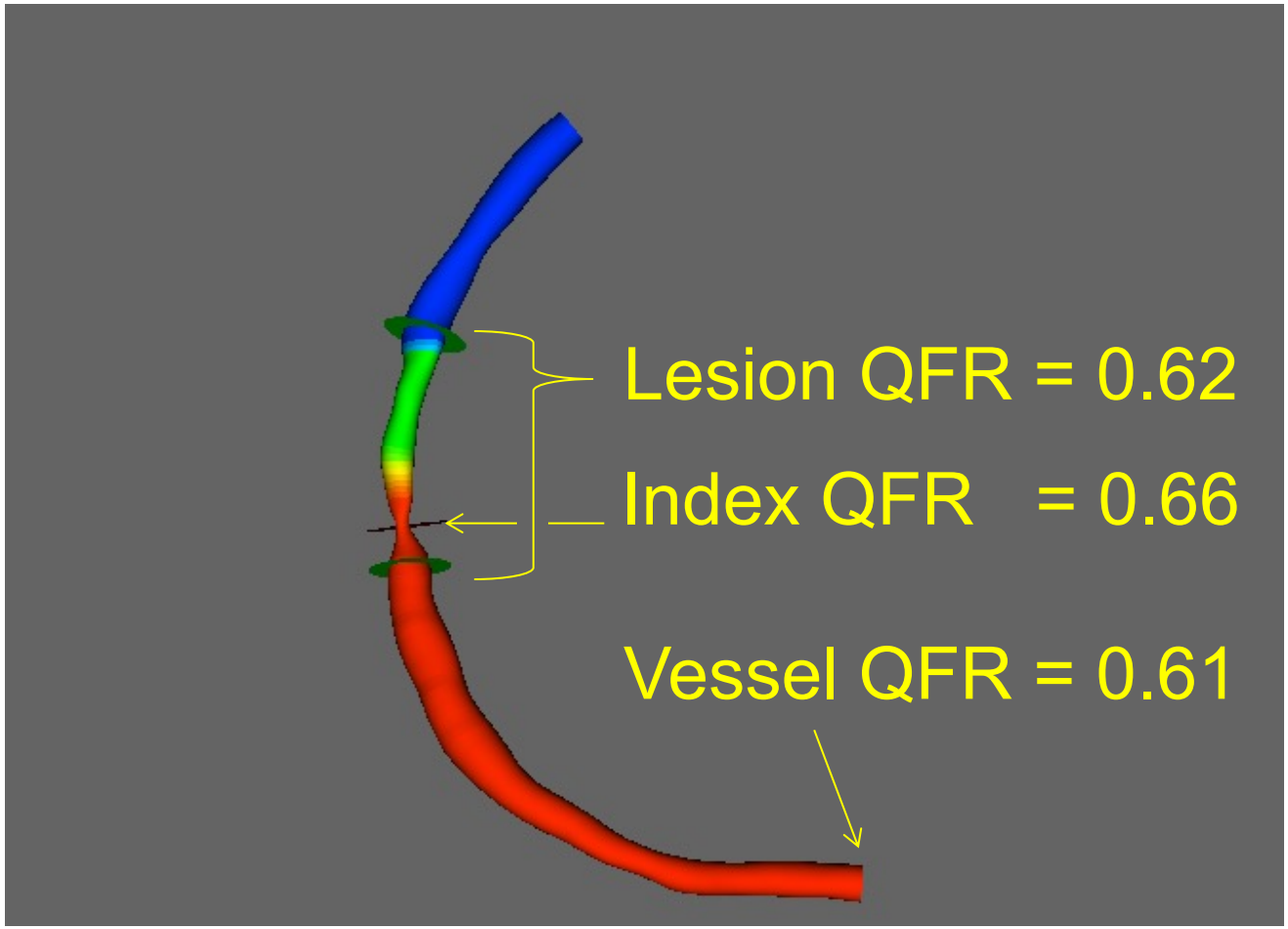
3D QCA

3D vessel modelling by Qangio XA 3D is the backbone for the PCI procedure:

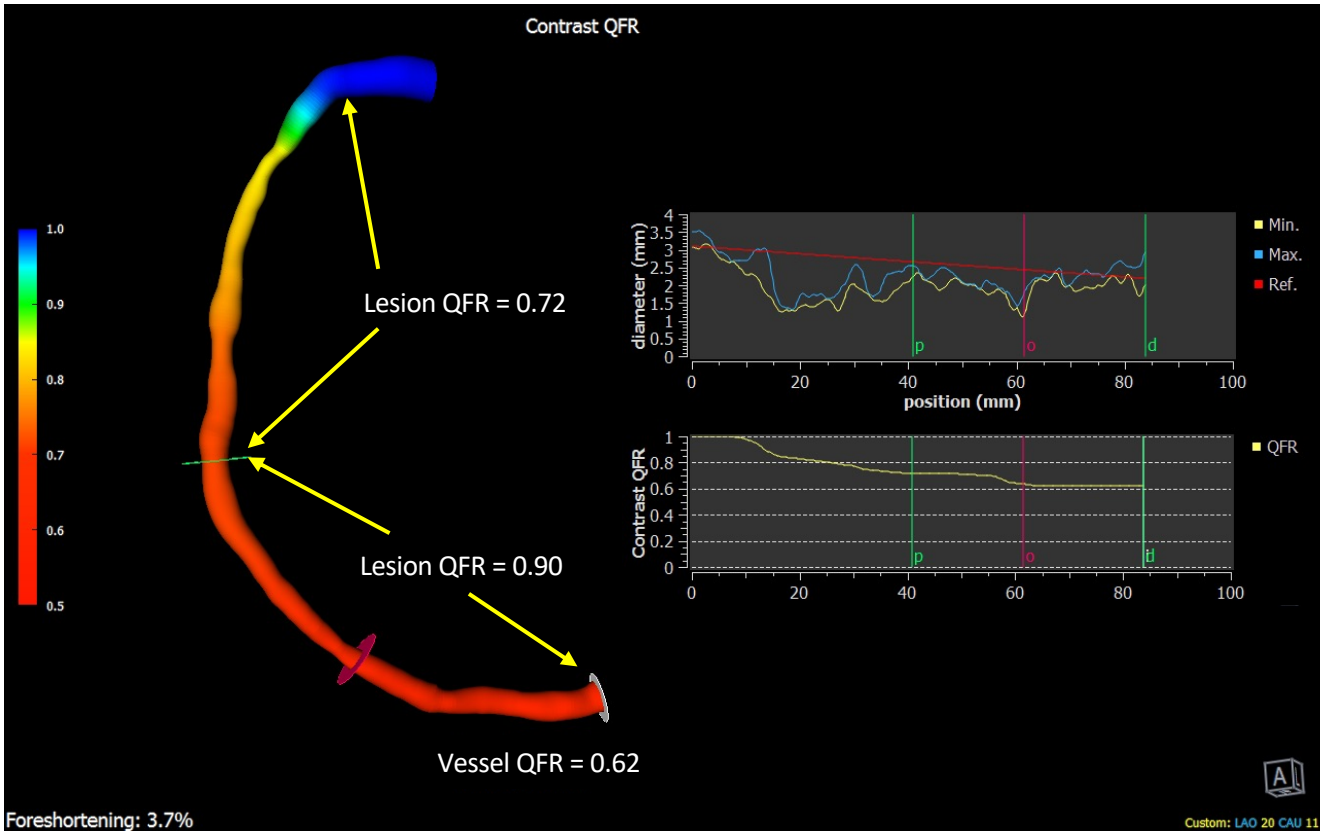


- Allows the calculation of the functional significance parameter QFR
- Optimal viewing angle for PCI
- Precise stent sizing

QFR (Medis' QCA derived FFR)



Several QFR parameters



QFR pullback curve synchronized with diameter curve

Vessel QFR = QFR value at distal vessel segment location
Lesion QFR = significance of that lesion only
Residual vessel QFR = significance of all other parts of the target vessel

(in case of the first lesion (lesion QFR = 0.72; residual QFR is 0.90)

First Clinical Trial

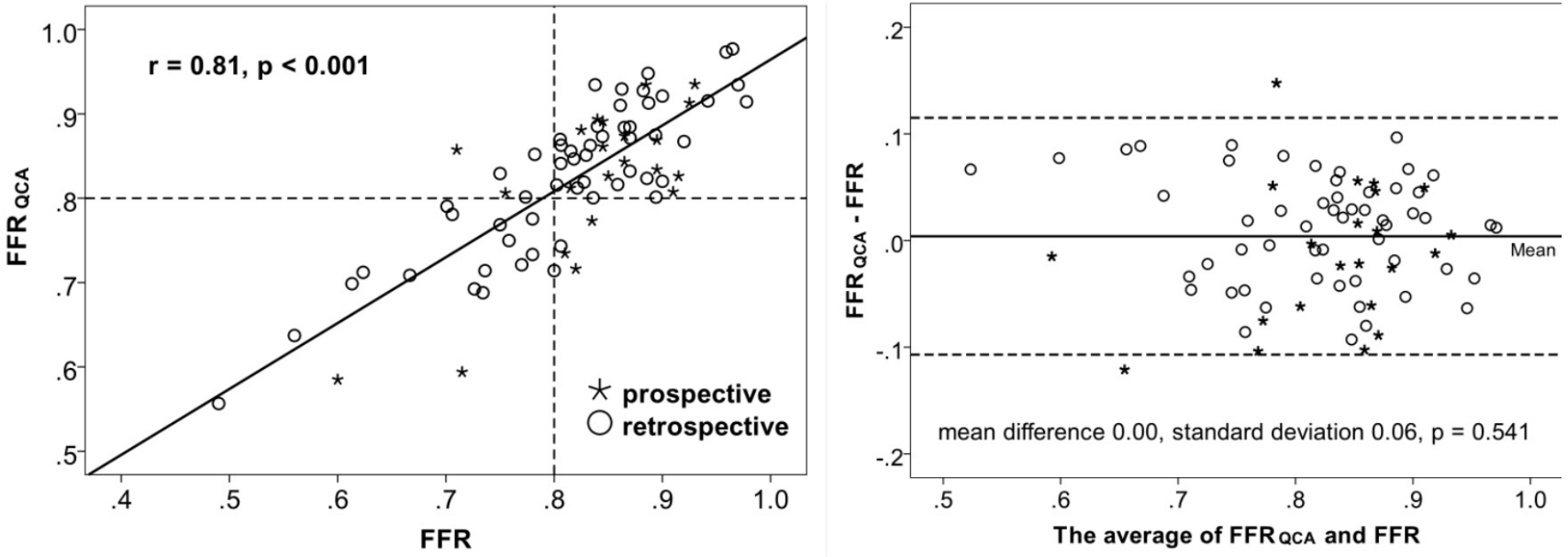
2014

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 Köszegi, 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*

FFR_{QCA} versus FFR

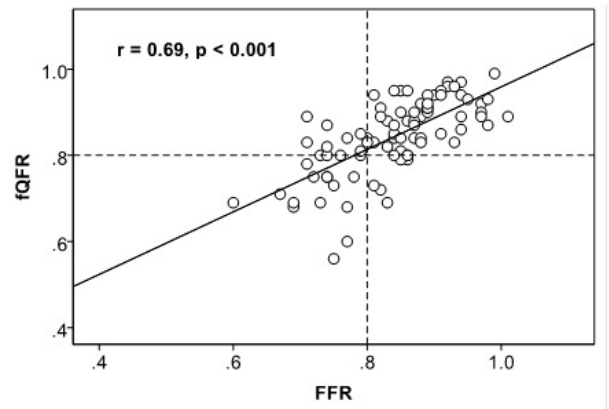


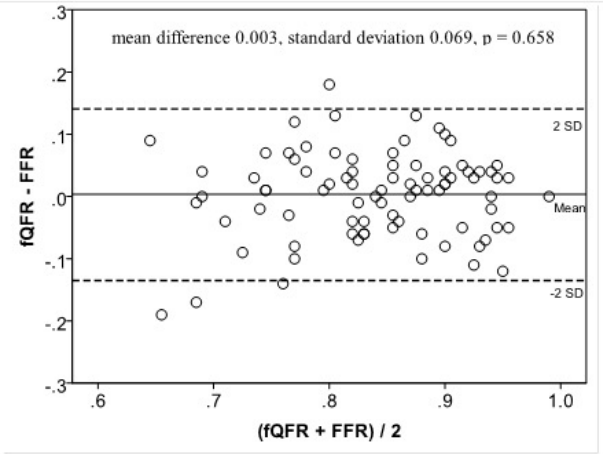
Difference: 0.00 ± 0.06 (p = 0.541)

Tu et al. JACC Cardiovasc Interv 2014, 7:768-777

Results – Correlation and Agreement

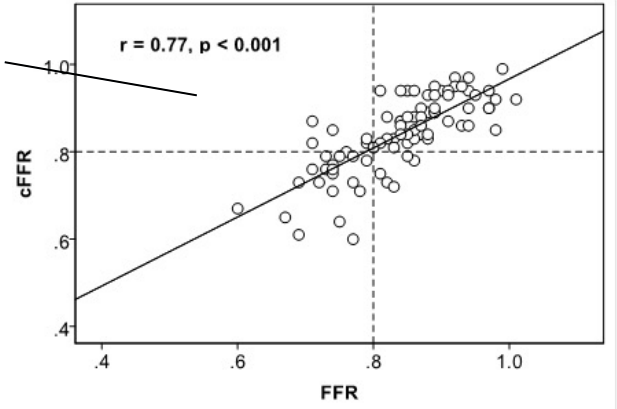
Fixed-flow

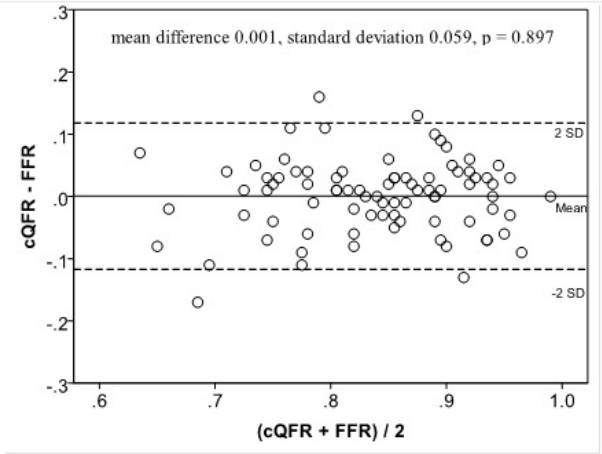




Difference: 0.003±0.069

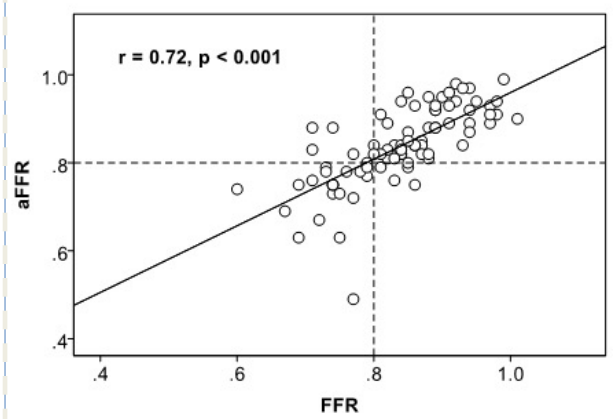
Contrast-flow

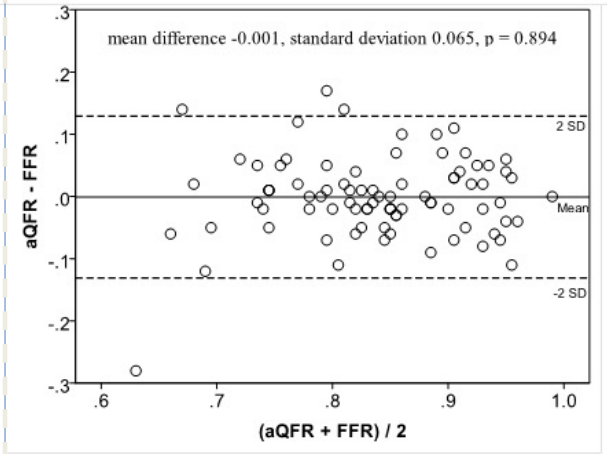




0.001±0.059

Adenosine-flow





-0.001±0.065

Clinical Trial [1] Publications

Medis QFR

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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 Köszegi, 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; Nyiregyyhaza, Hungary; Guangzhou and Tianjin, China; and Skejby, Denmark

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EDITORIAL COMMENT

Fractional Flow Reserve From 3-Dimensional Quantitative Coronary Angiography

Fresh Light Through an Old Window*

Alexandra J. Lansky, MD, Cody Pietras, BSc

New Haven, Connecticut

In this issue of *JACC: Cardiovascular Interventions*, Tu et al. (1) report on an initial validation study for a less-invasive approach to derive fractional flow reserve (FFR) based on the coronary angiogram. The investigators should be congratulated on developing an innovative means to expand the diagnostic value of angiography by including physiological ischemic assessment, potentially broadening access FFR data to every patient undergoing cardiac catheterization.

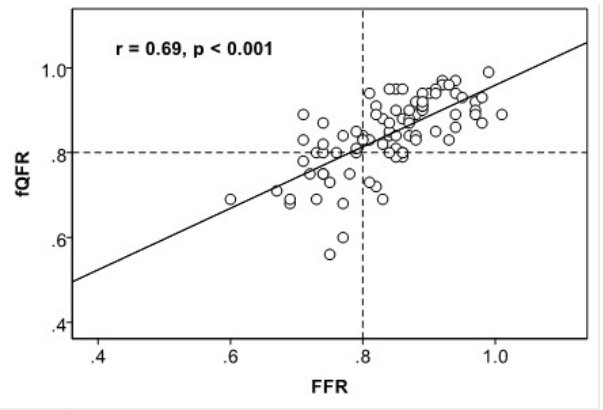
FAVOR II

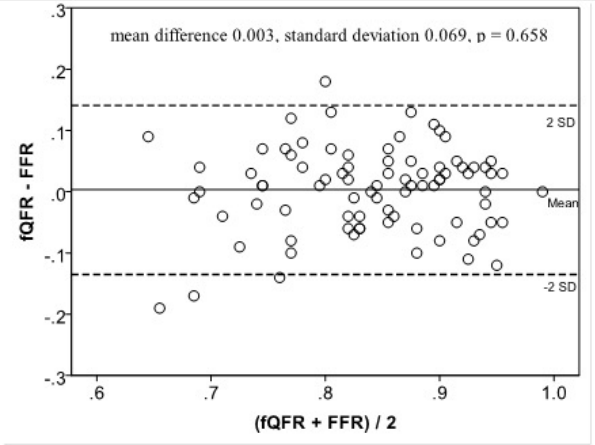
- Finalized recruitment and analyses of 73 patients in multi-center setting for optimizing algorithms;
- Tested 3 different scenarios:
  - 1) with adenosine;
  - 2) without adenosine; and
  - 3) fixed flow velocity.
- Manuscript submitted to JACC Interventions

FAVOR II confirmed results of FAVOR I

Results – Correlation and Agreement

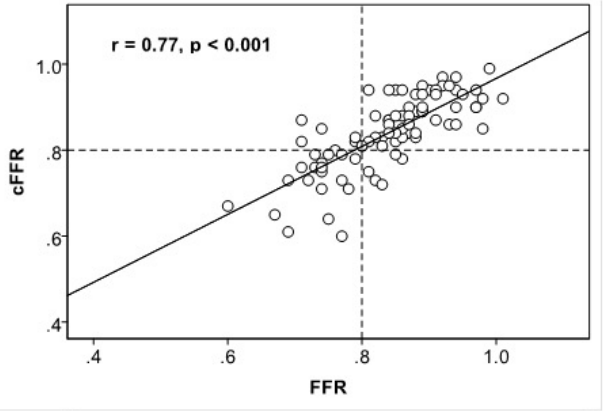
Fixed-flow

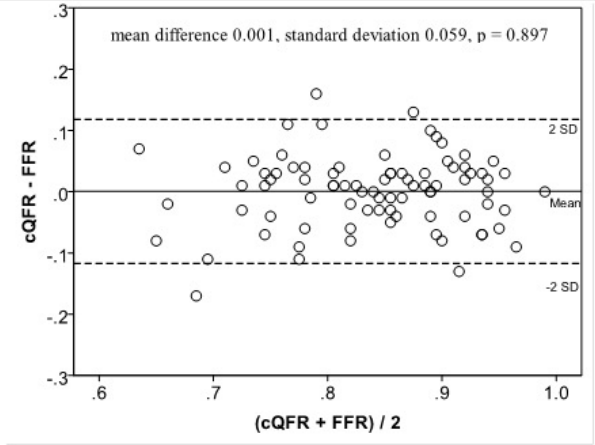




Difference: 0.003±0.069

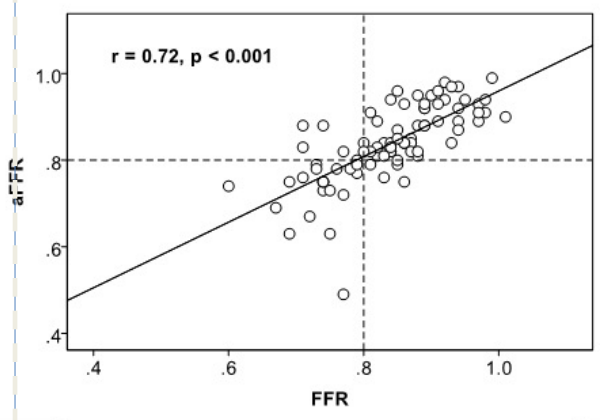
Contrast-flow

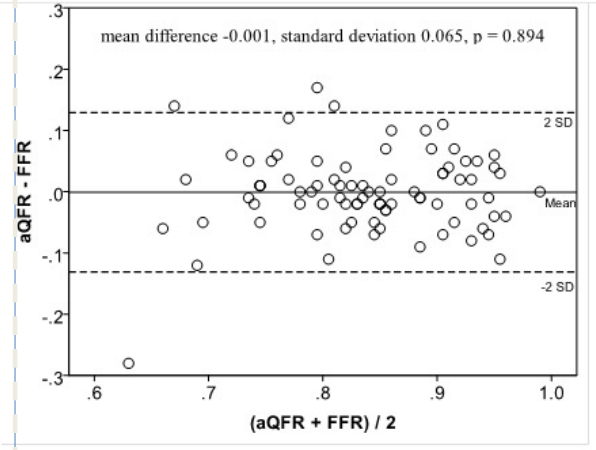




0.001±0.059

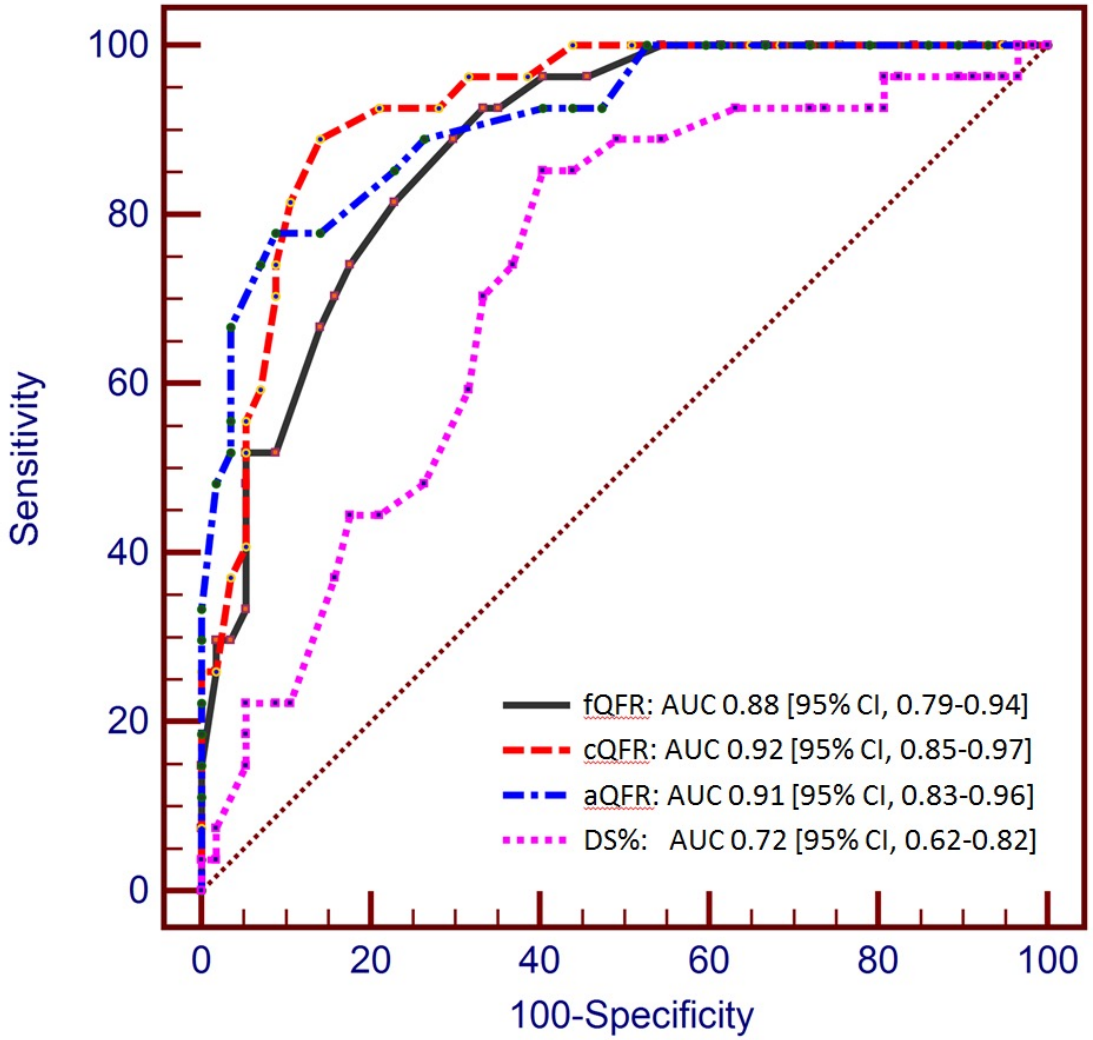
Adenosine-flow





-0.001±0.065

Results – Diagnostic Performance



Increase in AUC

fQFR – DS%: 0.16 ($p = 0.003$)

cQFR – DS%: 0.20 ($p < 0.001$)

aQFR – DS%: 0.19 ($p < 0.001$)

cQFR – fQFR: 0.04 ($p = 0.006$)

cQFR – aQFR: 0.01 ($p = 0.646$)

Presented CIT 2016

Results – Diagnostic Performance

Clinical population requiring FFR.
Consistent with previous studies[1,2,3]

	fQFR ≤ 0.8	cQFR ≤ 0.8	aQFR ≤ 0.8	DS% ≥ 50%
Accuracy	80 (71-89)	86 (78-93)	87 (80-94)	65 (55-76)
Sensitivity	67 (46-84)	74 (54-89)	78 (58-91)	44 (26-65)
Specificity	86 (74-94)	91 (81-97)	91 (81-97)	79 (66-89)
PPV	69 (48-86)	80 (59-93)	81 (61-93)	50 (29-71)
NPV	85 (73-93)	88 (77-95)	90 (79-96)	75 (62-85)
LR+	4.8 (2.4-9.5)	8.4 (3.6-20.1)	8.9 (3.7-21.0)	2.1(1.1-4.1)
LR-	0.4 (0.2-0.7)	0.3 (0.1-0.5)	0.2 (0.1-0.5)	0.7 (0.5-1.0)
AUC	0.88 (0.79-0.94)	0.92 (0.85-0.97)	0.91 (0.83-0.96)	0.72 (0.62-0.82)

Good diagnostic accuracy

1. Toth et al. Eur Heart J 2014; 35:2831-8.
2. Tu et al. JACC Cardiovasc Interv1.
3. Tu et al. JACC Cardiovasc Interv 2015, 8:564-74.

CE MARK

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Diagnostic Accuracy of Fast Computational Approaches to Derive Fractional Flow Reserve From Diagnostic Coronary Angiography

The International Multicenter FAVOR Pilot Study

Shengxian Tu, PhD,[a] Jelmer Westra, MS,[b] Junqing Yang, MD,[c] Clemens von Birgelen, MD, PhD,[d] Angela Ferrara, MD,[e] Mariano Pellicano, MD,[e,f] Holger Nef, MD,[g] Matteo Tebaldi, MD,[h] Yoshinobu Murasato, MD, PhD,[i] Alexandra Lansky, MD, PhD,[j] Emanuele Barbato, MD, PhD,[e,f] Liefke C. van der Heijden, MD,[d] Johan H.C. Reiber, PhD,[k] Niels R. Holm, MD,[b] William Wijns, MD, PhD,[e,l]
on behalf of the FAVOR Pilot Trial Study Group

How does it integrate into my practice ?

Examination Room

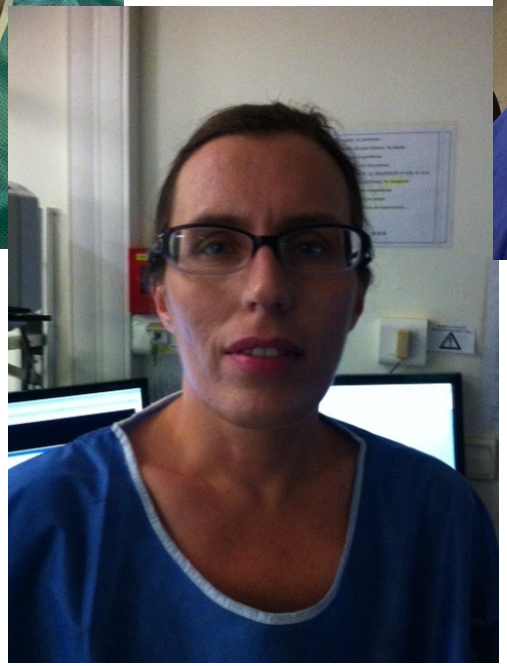
Display

Images,
ECG and
Gantry angles

Control Room

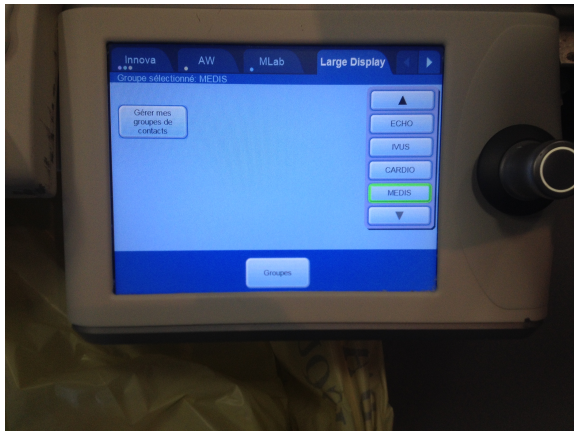
- Images are automatically pushed by GE X-ray system to the Medis Suite workstation, for optimal work flow during examination
- Viewing angles are pushed as well for optimal and fast selection of good second view of target vessel
- Analysis performed in the control room
- Result can be displayed in the cathlab on the Large Display Monitor (LDM)

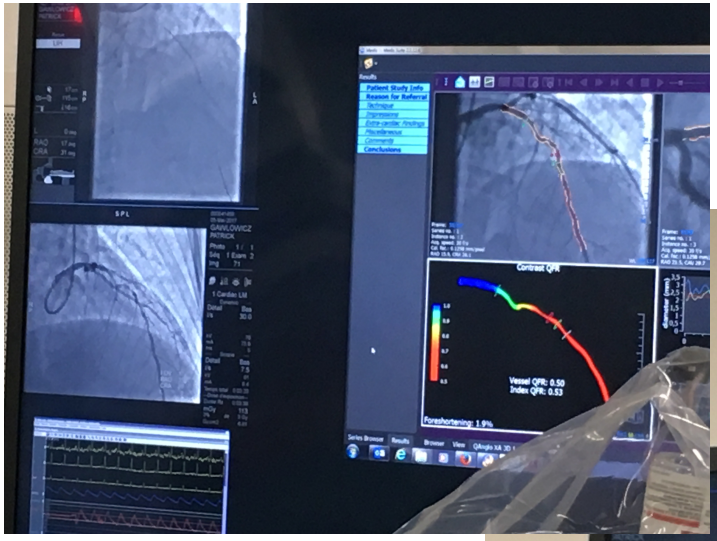
Who is working behind the screen?

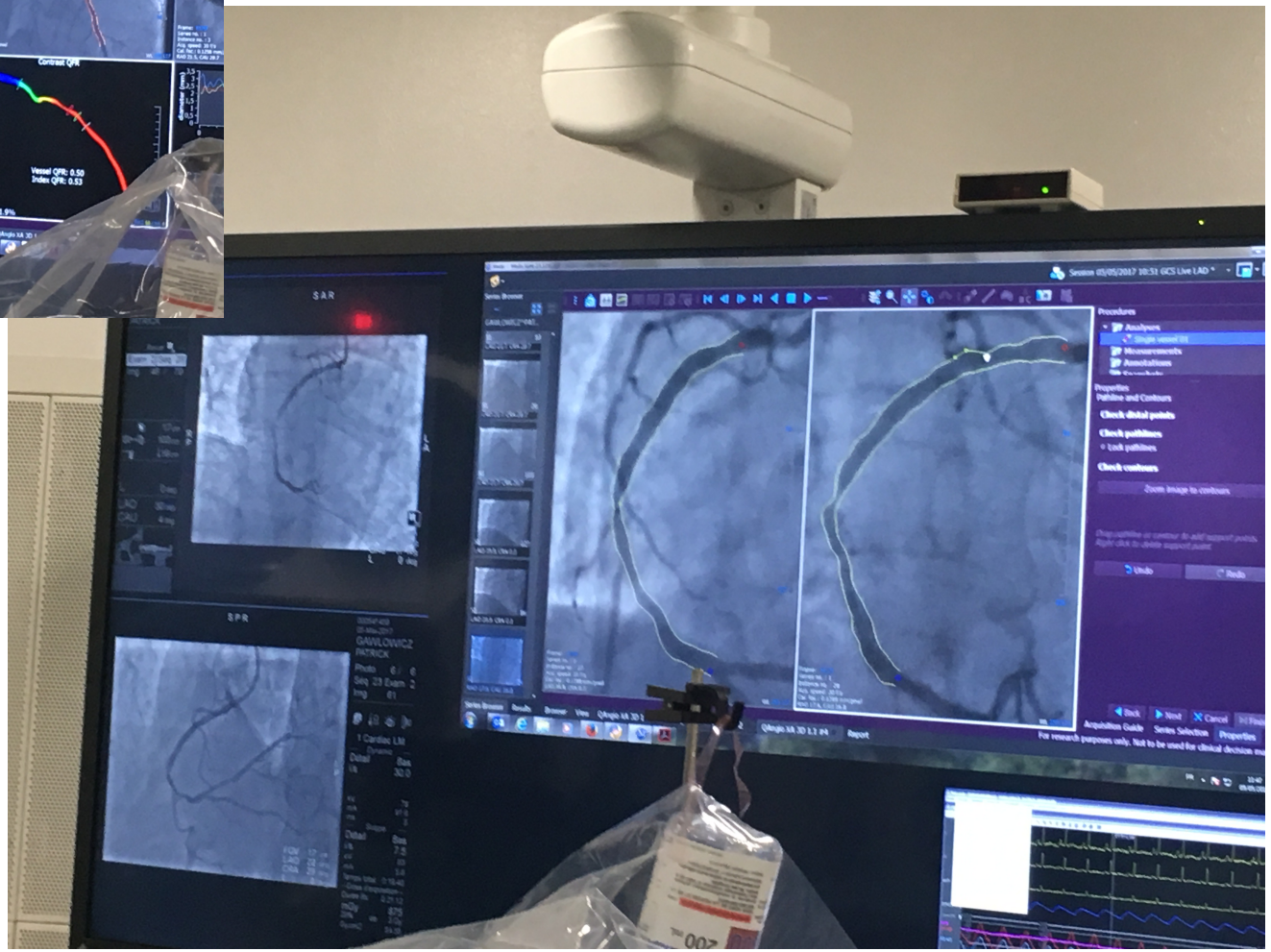


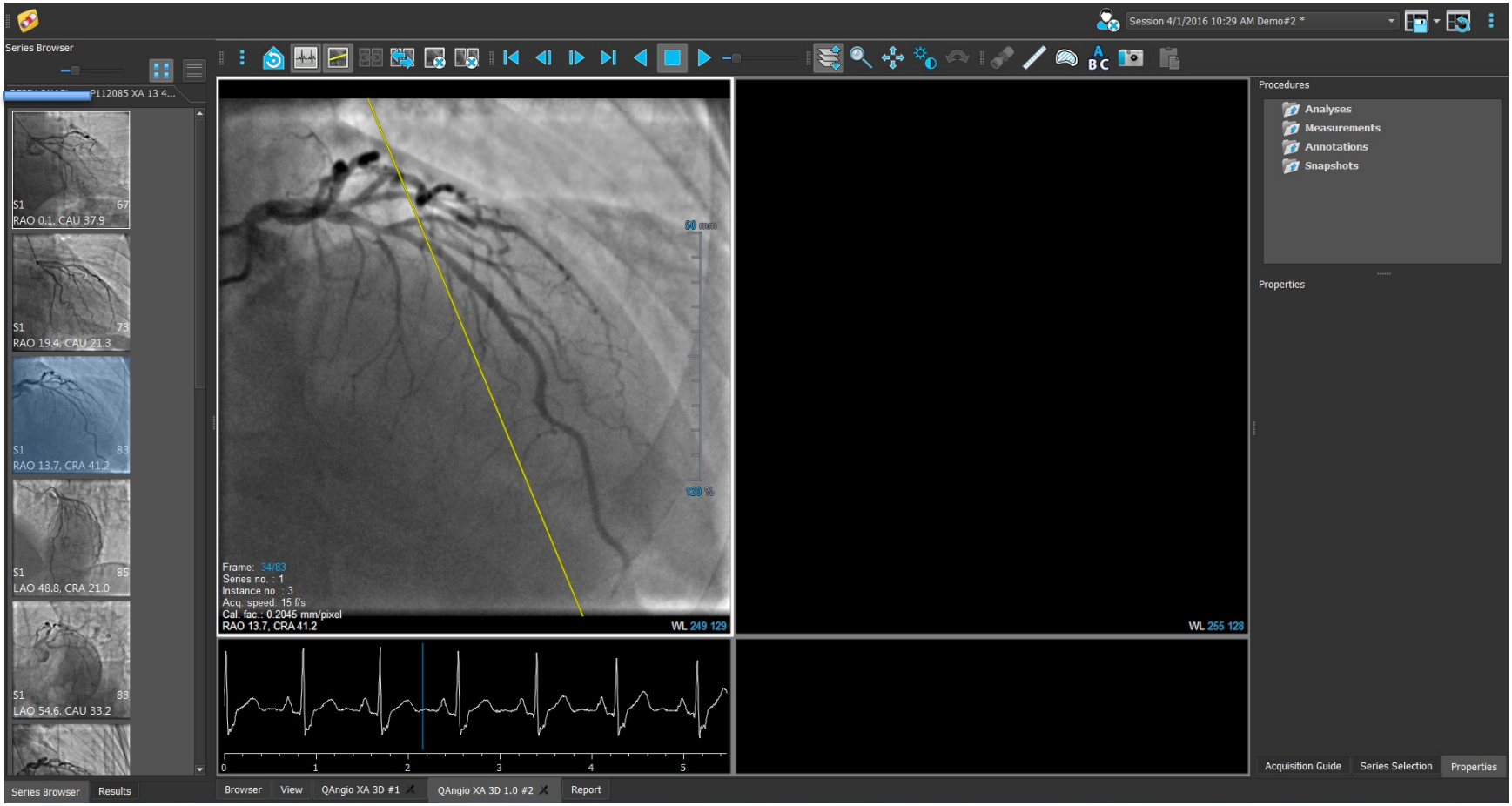
MY STARS

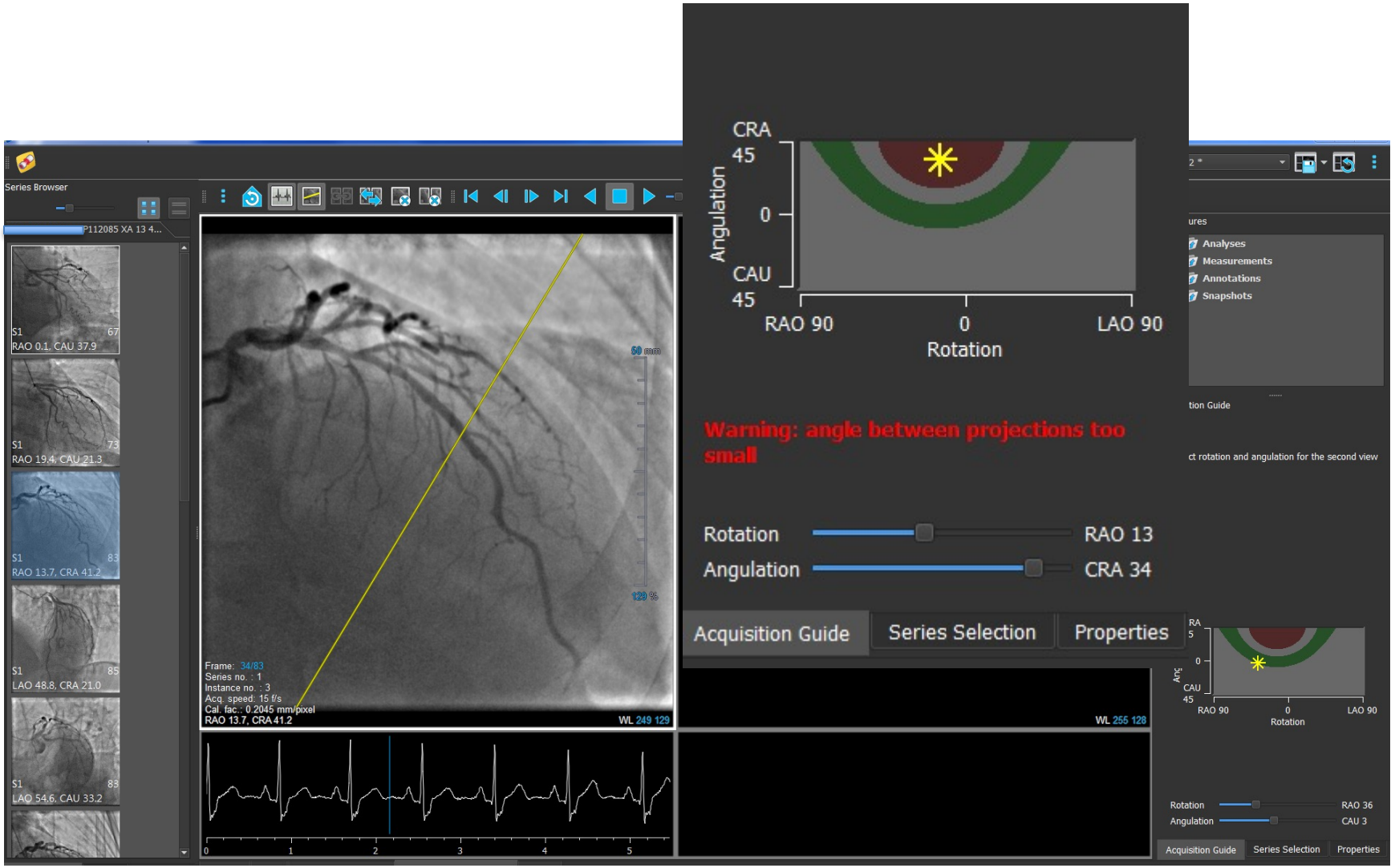
Special options for Medis connection for the LDM

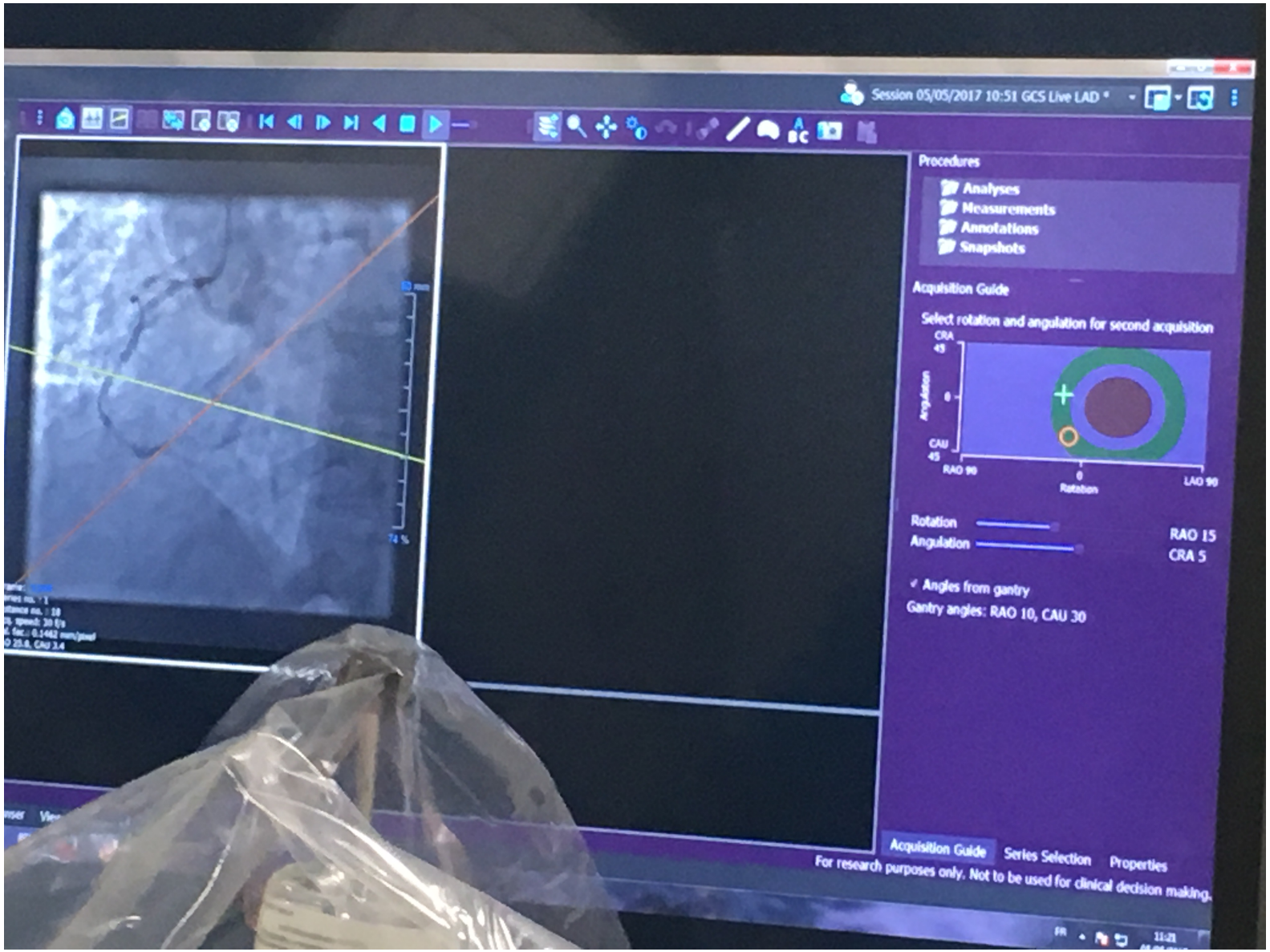



Contrast QFR
Vessel QFR: 0.50
Index QFR: 0.53
Foreshortening: 1.9%


SAR
SPR


Session 4/1/2016 10:29 AM Demo#2 *
Series Browser
P112085 XA 13 4...
S1 67
RAO 0.1, CAU 37.9
S1 73
RAO 19.4, CAU 21.3
S1 83
RAO 13.7, CRA 41.2
S1 85
LAO 48.8, CRA 21.0
S1 83
LAO 54.6, CAU 33.2
60 mm
120 %
Frame: 34/83
Series no. : 1
Instance no. : 3
Acq. speed: 15 f/s
Cal. fac.: 0.2045 mm/pixel
RAO 13.7, CRA 41.2
WL 249 129
WL 255 128
0
1
2
3
4
5
Procedures
Analyses
Measurements
Annotations
Snapshots
Properties
Acquisition Guide
Series Selection
Properties
Series Browser
Results
Browser
View
QAngio XA 3D #1
QAngio XA 3D 1.0 #2
Report

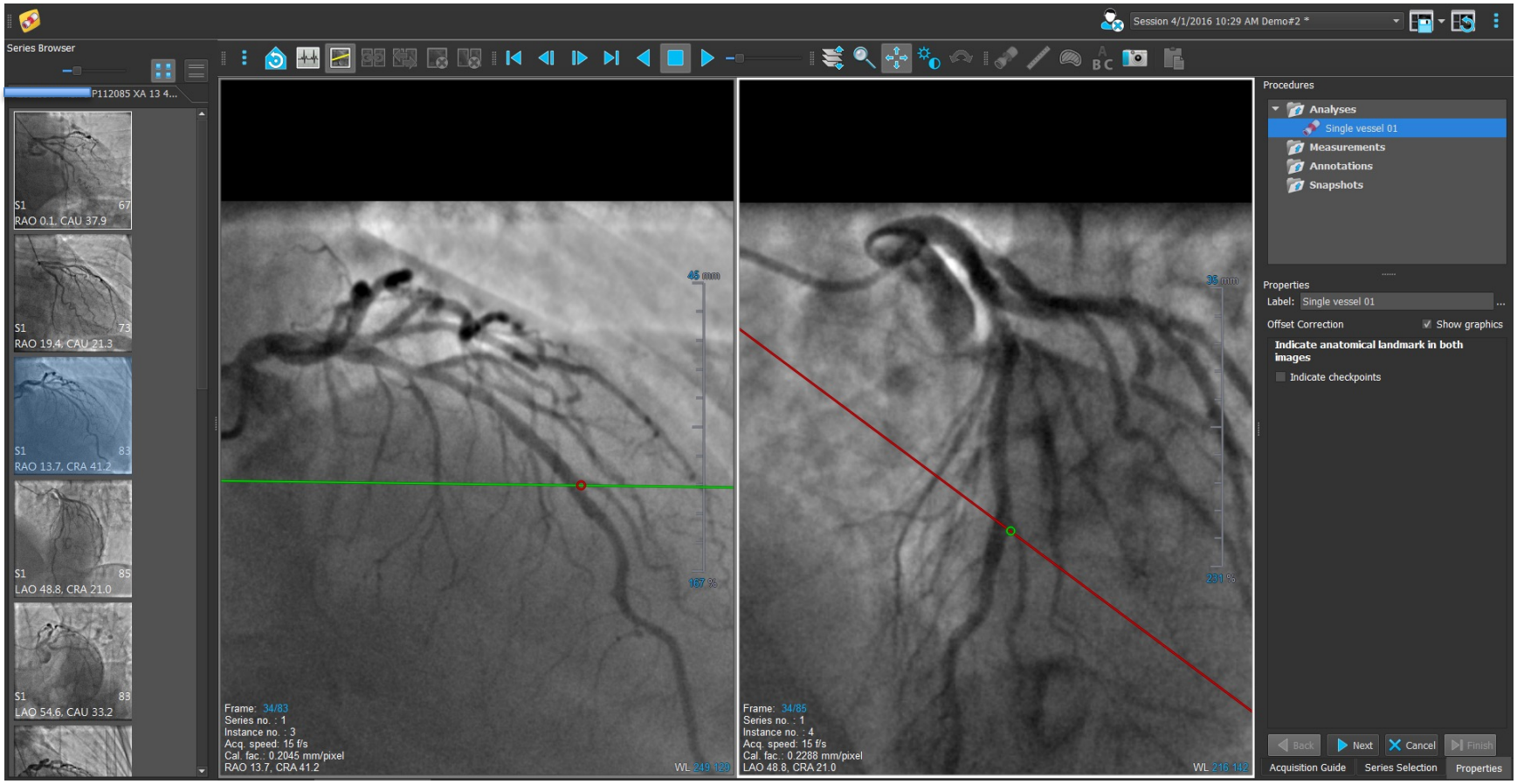

Series Browser
P112085 XA 13 4...
S1 67
RAO 0.1, CAU 37.9
S1 73
RAO 19.4, CAU 21.3
S1 83
RAO 13.7, CRA 41.2
S1 85
LAO 48.8, CRA 21.0
S1 83
LAO 54.6, CAU 33.2
50 mm
129 %
Frame: 34/83
Series no. : 1
Instance no. : 3
Acq. speed: 15 f/s
Cal. fac.: 0.2045 mm/pixel
RAO 13.7, CRA 41.2
WL 249 129
0 1 2 3 4 5
CRA
45
Angulation
0
CAU
45
RAO 90
0
LAO 90
Rotation
Warning: angle between projections too small
Rotation
RAO 13
Angulation
CRA 34
Acquisition Guide
Series Selection
Properties
WL 255 128
ures
Analyses
Measurements
Annotations
Snapshots
tion Guide
ct rotation and angulation for the second view
RA
5
0
CAU
45
RAO 90
0
LAO 90
Rotation
Rotation
RAO 36
Angulation
CAU 3
Acquisition Guide
Series Selection
Properties

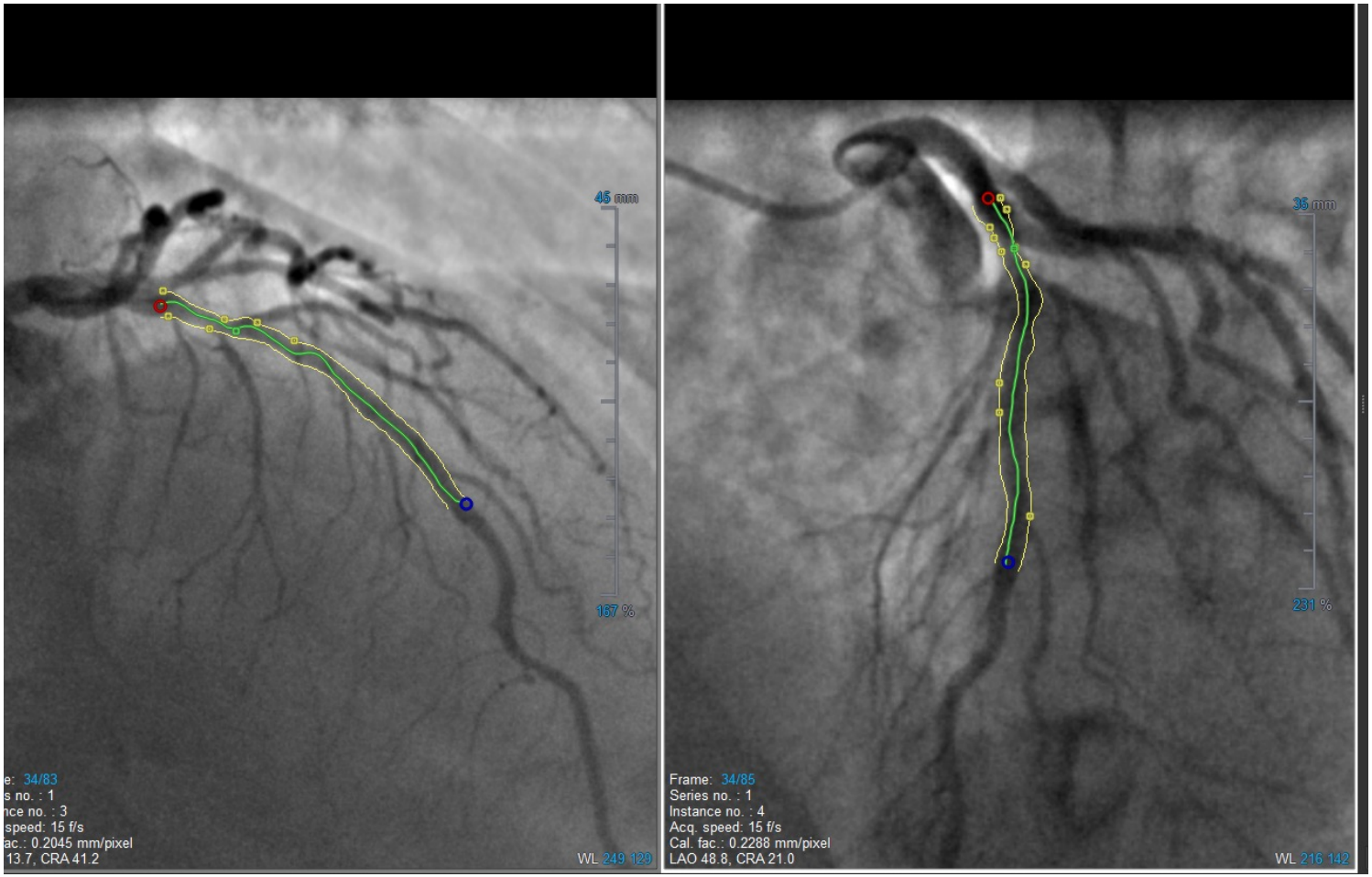

Session 05/05/2017 10:51 GCS Live LAD *
Procedures
Analyses
Measurements
Annotations
Snapshots
Acquisition Guide
Select rotation and angulation for second acquisition
CRA
45
Angulation
0
CAU
45
RAO 90
0
LAO 90
Rotation
Rotation
Angulation
RAO 15
CRA 5
Angles from gantry
Gantry angles: RAO 10, CAU 30
Acquisition Guide
Series Selection
Properties
For research purposes only. Not to be used for clinical decision making.

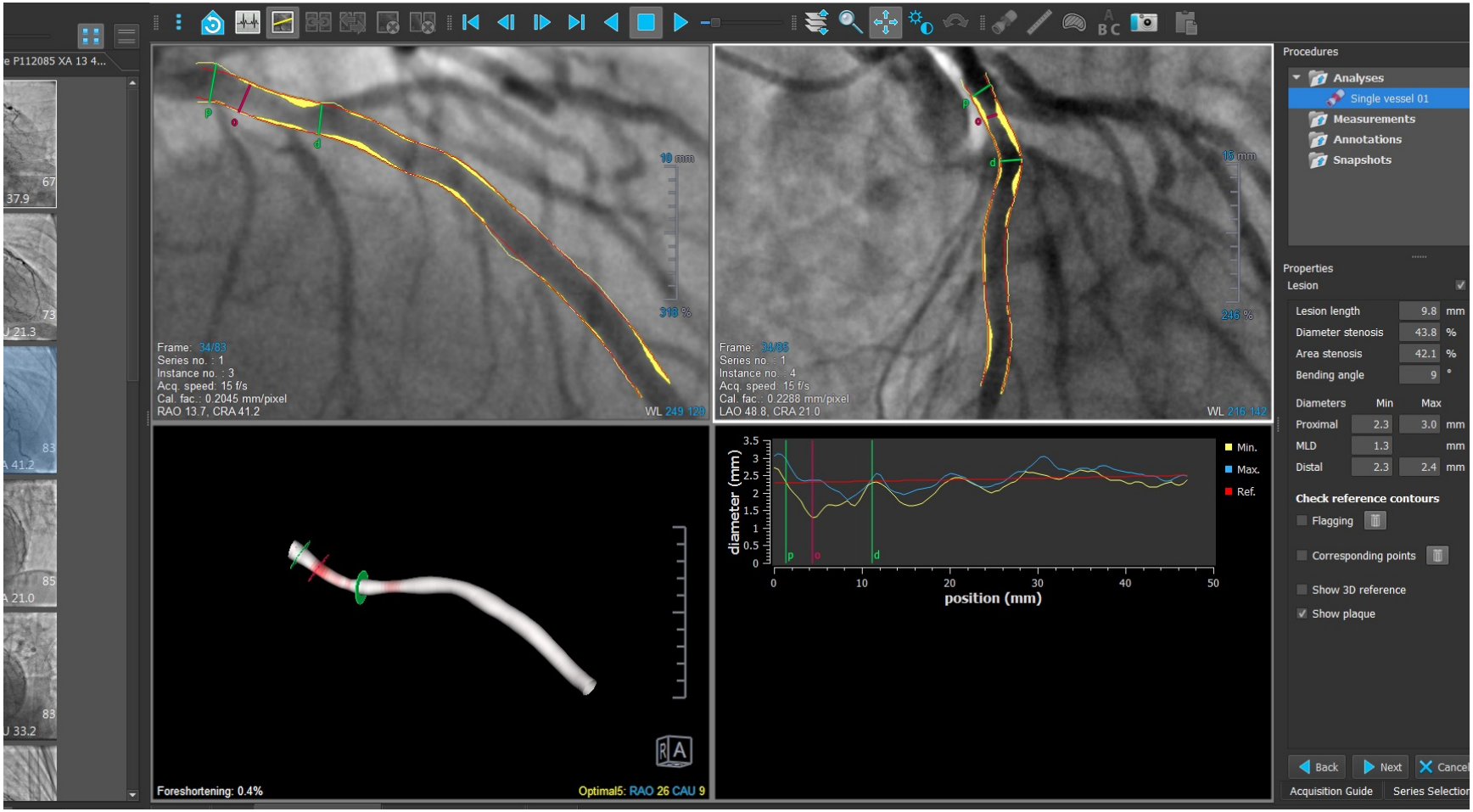
Acquisition Aid for QFR®

Target Vessel	1st XA		2nd XA	
LM + LAD/LCX	RAO 20,	CAU 45	AP,	CAU 10
LAD/Diag	AP,	CRA 45	RAO 30,	CRA 20
LCX/OM	LAO 10,	CAU 25	RAO 25,	CAU 25
RCA	LAO 45,	CAU 10	LAO 20,	CRA 20

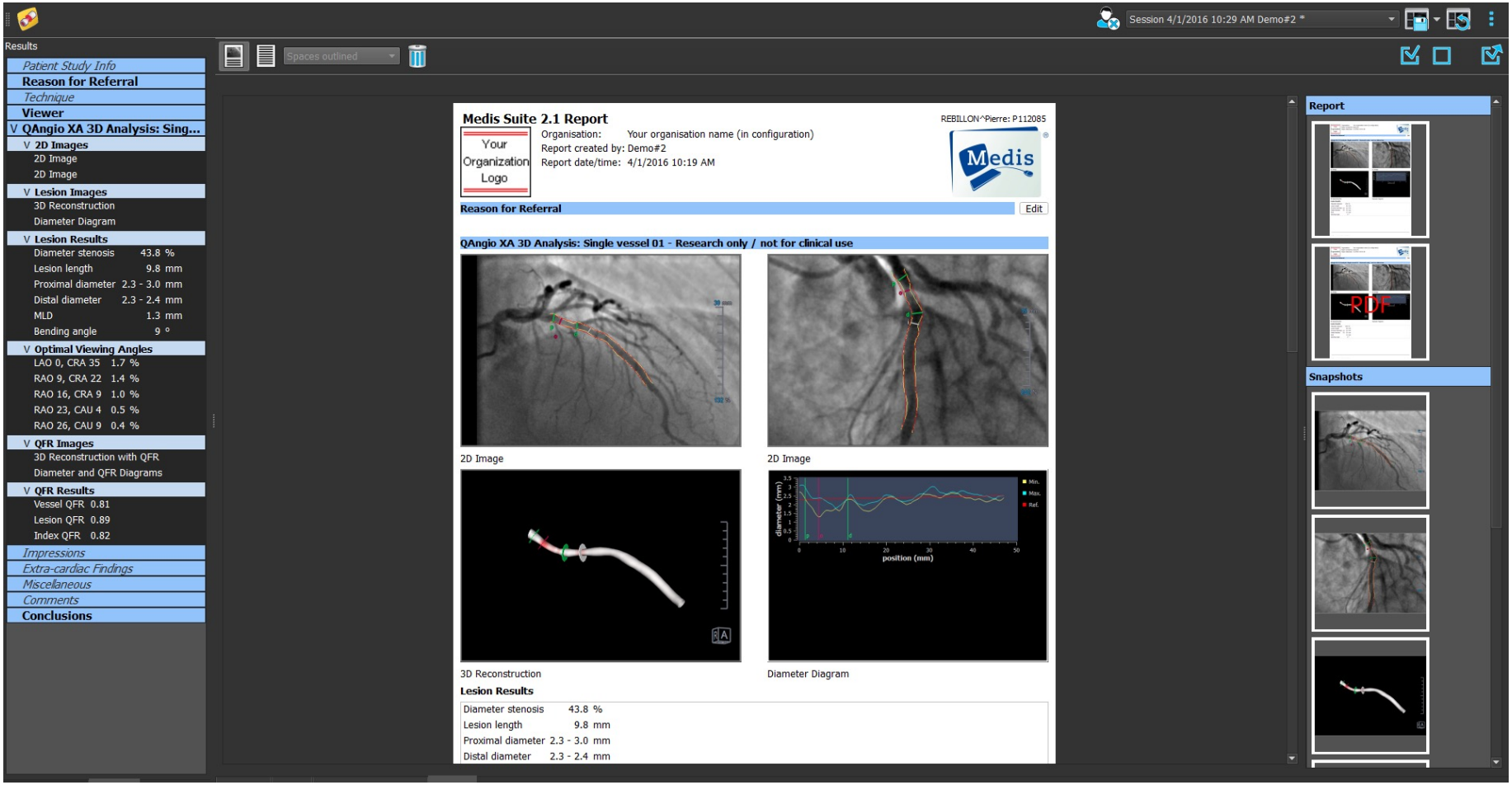
- ✓ Imaging shortly after Nitroglycerin
- ✓ ≥ 12,5 Fr/s Acquisition
- ✓ Δ Angulation ≥ 25° & perpendicular on lesion
- ✓ Brisk contrast fluid injection for 3 cardiac cycles
- ✓ Prevent: Vessel overlap & Patient movement


Session 4/1/2016 10:29 AM Demo#2 *
Series Browser
P112085 XA 13 4...
S1 67
RAO 0.1, CAU 37.9
S1 73
RAO 19.4, CAU 21.3
S1 83
RAO 13.7, CRA 41.2
S1 85
LAO 48.8, CRA 21.0
S1 83
LAO 54.6, CAU 33.2
45 mm
167 %
Frame: 34/83
Series no. : 1
Instance no. : 3
Acq. speed: 15 f/s
Cal. fac.: 0.2045 mm/pixel
RAO 13.7, CRA 41.2
WL 249 129
39 mm
231 %
Frame: 34/85
Series no. : 1
Instance no. : 4
Acq. speed: 15 f/s
Cal. fac.: 0.2288 mm/pixel
LAO 48.8, CRA 21.0
WL 216 142
Procedures
Analyses
Single vessel 01
Measurements
Annotations
Snapshots
Properties
Label: Single vessel 01
Offset Correction
Show graphics
Indicate anatomical landmark in both images
Indicate checkpoints
Back
Next
Cancel
Finish
Acquisition Guide
Series Selection
Properties

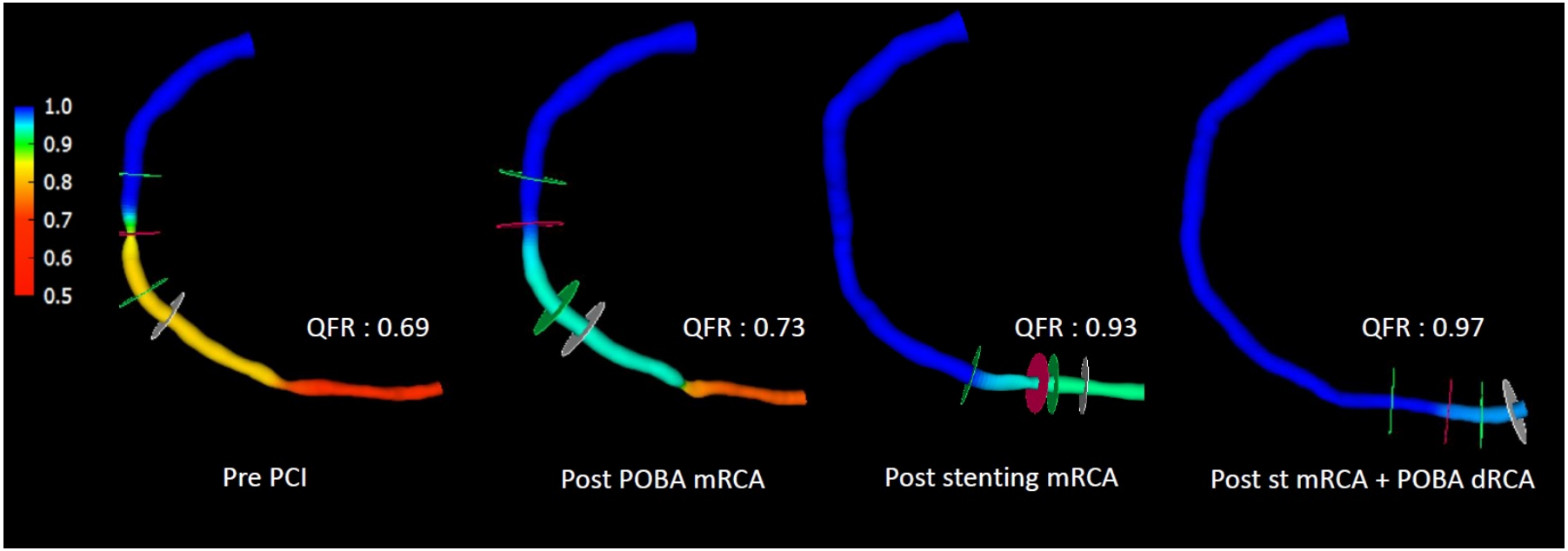

45 mm
167 %
e: 34/83
s no. : 1
nce no. : 3
speed: 15 f/s
ac.: 0.2045 mm/pixel
13.7, CRA 41.2
WL 249 129
35 mm
231 %
Frame: 34/85
Series no. : 1
Instance no. : 4
Acq. speed: 15 f/s
Cal. fac.: 0.2288 mm/pixel
LAO 48.8, CRA 21.0
WL 216 142

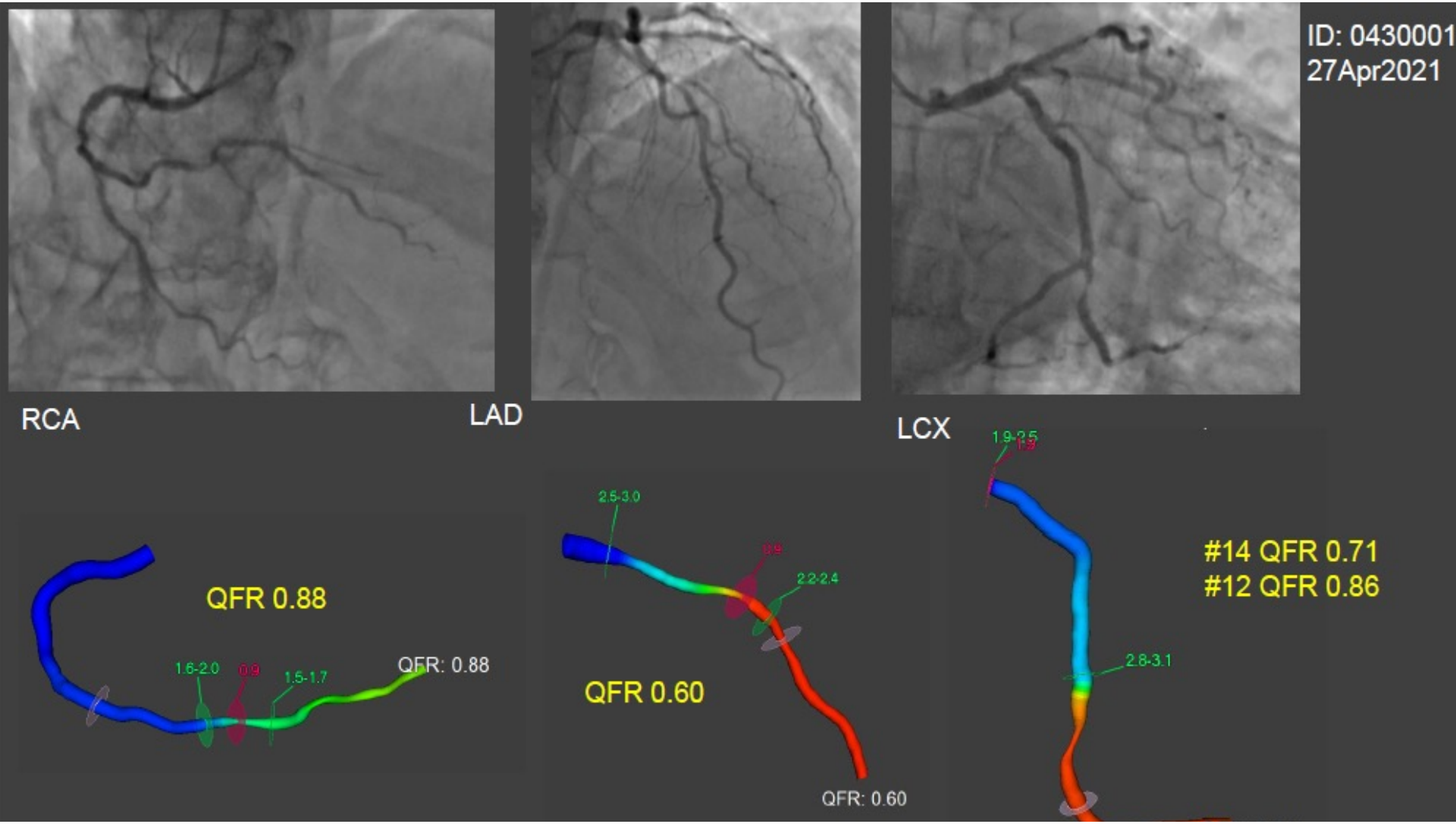

Procedures
Analyses
Single vessel 01
Measurements
Annotations
Snapshots
Properties
Lesion
Lesion length 9.8 mm
Diameter stenosis 43.8 %
Area stenosis 42.1 %
Bending angle 9 °
Diameters Min Max
Proximal 2.3 3.0 mm
MLD 1.3 mm
Distal 2.3 2.4 mm
Check reference contours
Flagging
Corresponding points
Show 3D reference
Show plaque
Back
Next
Cancel
Acquisition Guide
Series Selection
Frame: 34/83
Series no. : 1
Instance no. : 3
Acq. speed: 15 f/s
Cal. fac.: 0.2045 mm/pixel
RAO 13.7, CRA 41.2
WL 249 129
Frame: 34/85
Series no. : 1
Instance no. : 4
Acq. speed: 15 f/s
Cal. fac.: 0.2288 mm/pixel
LAO 48.8, CRA 21.0
WL 216 142
Foreshortening: 0.4%
Optimal5: RAO 26 CAU 9
diameter (mm)
position (mm)
Min.
Max.
Ref.

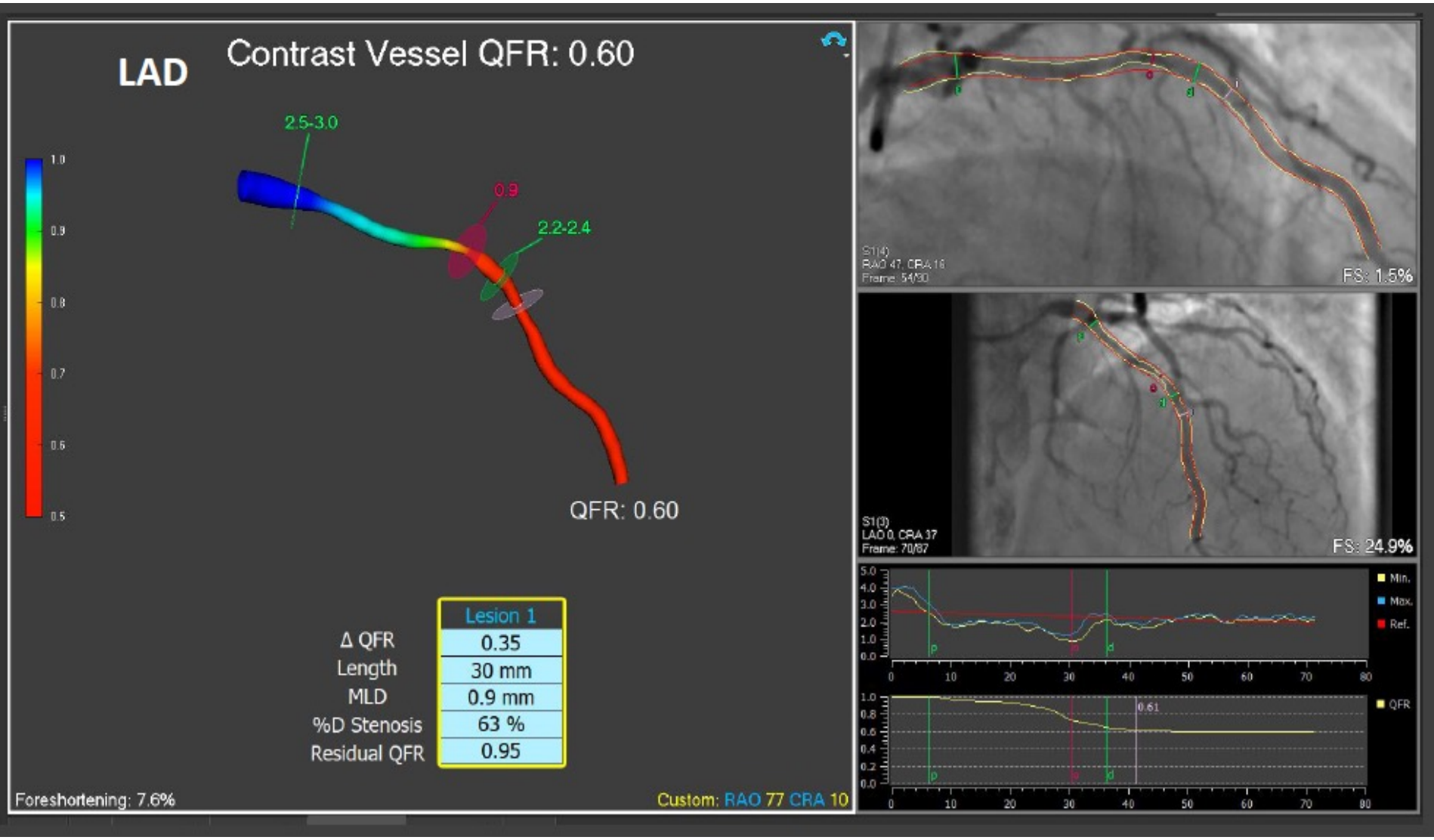
Session 4/1/2016 10:29 AM Demo#2 *
Procedures
Analyses
Single vessel 01
Measurements
Annotations
Snapshots
Properties
QFR
Basal QFR
Vessel QFR 0.85
Lesion QFR 0.87
Index QFR 0.86
Lesion length 19.1 mm
Diameter stenosis 48.4 %
Area stenosis 51.2 %
Bending angle 22 °
Diameters Min Max
Proximal 2.5 3.1 mm
MLD 1.3 mm
Distal 2.4 2.5 mm
Revert lesion markers
Frame: 34/83
Series no. : 1
Instance no. : 3
Acq. speed: 15 f/s
Cal. fac.: 0.2045 mm/pixel
RAO 13.7, CRA 41.2
Frame: 34/85
Series no. : 1
Instance no. : 4
Acq. speed: 15 f/s
Cal. fac.: 0.2288 mm/pixel
LAO 48.8, CRA 21.0
Basal QFR
Foreshortening: 3.3%
Optimal5: RAO 26 CAU 9
diameter (mm)
position (mm)
Min.
Max.
Ref.
Basal QFR
QFR
Back
Next
Cancel
Acquisition Guide
Series Selection

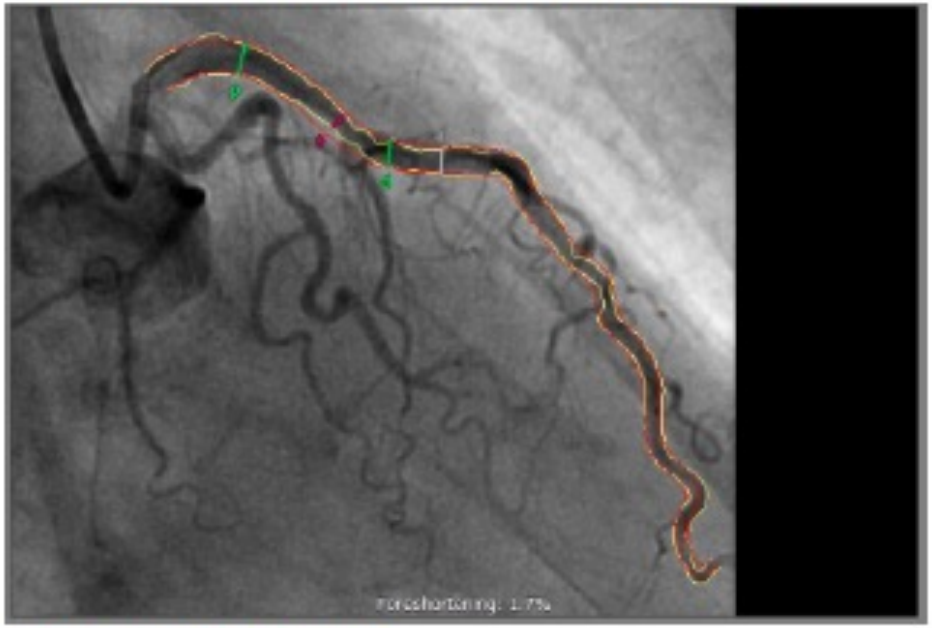

Session 4/1/2016 10:29 AM Demo#2 *
Results
Spaces outlined
Patient Study Info
Reason for Referral
Technique
Viewer
V QAngio XA 3D Analysis: Sing...
V 2D Images
2D Image
2D Image
V Lesion Images
3D Reconstruction
Diameter Diagram
V Lesion Results
Diameter stenosis 43.8 %
Lesion length 9.8 mm
Proximal diameter 2.3 - 3.0 mm
Distal diameter 2.3 - 2.4 mm
MLD 1.3 mm
Bending angle 9 °
V Optimal Viewing Angles
LAO 0, CRA 35 1.7 %
RAO 9, CRA 22 1.4 %
RAO 16, CRA 9 1.0 %
RAO 23, CAU 4 0.5 %
RAO 26, CAU 9 0.4 %
V QFR Images
3D Reconstruction with QFR
Diameter and QFR Diagrams
V QFR Results
Vessel QFR 0.81
Lesion QFR 0.89
Index QFR 0.82
Impressions
Extra-cardiac Findings
Miscellaneous
Comments
Conclusions
Medis Suite 2.1 Report
Your Organization Logo
Organisation: Your organisation name (in configuration)
Report created by: Demo#2
Report date/time: 4/1/2016 10:19 AM
REBILLON^Pierre: P112085
Medis
Reason for Referral
Edit
QAngio XA 3D Analysis: Single vessel 01 - Research only / not for clinical use
2D Image
2D Image
3D Reconstruction
Diameter Diagram
Lesion Results
Diameter stenosis 43.8 %
Lesion length 9.8 mm
Proximal diameter 2.3 - 3.0 mm
Distal diameter 2.3 - 2.4 mm
Report
RDF
Snapshots

QFR can be used pre-, during, and post-PCI

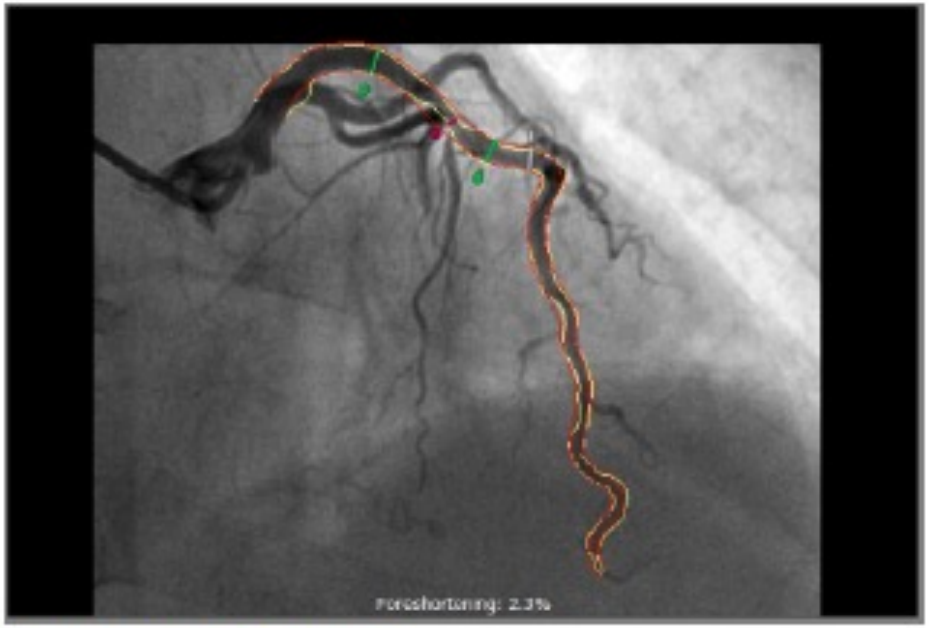



ID: 0430001
27Apr2021
RCA
LAD
LCX
QFR 0.88
1.6-2.0
0.9
1.5-1.7
QFR: 0.88
2.5-3.0
0.9
2.2-2.4
QFR 0.60
QFR: 0.60
1.9-2.5
2.8-3.1
#14 QFR 0.71
#12 QFR 0.86

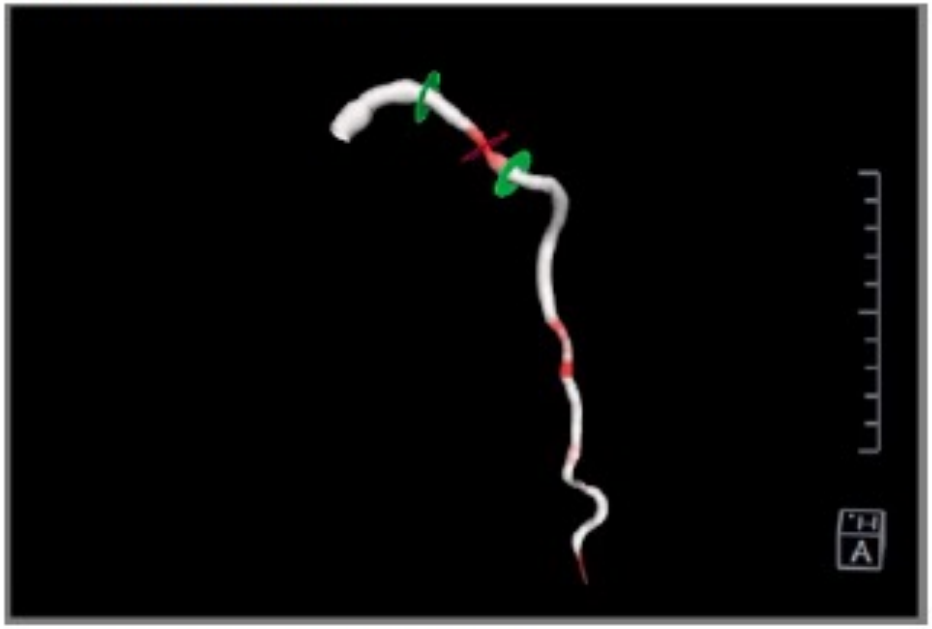

LAD
Contrast Vessel QFR: 0.60
2.5-3.0
0.9
2.2-2.4
QFR: 0.60
1.0
0.9
0.8
0.7
0.6
0.5
Lesion 1
Δ QFR 0.35
Length 30 mm
MLD 0.9 mm
%D Stenosis 63 %
Residual QFR 0.95
Foreshortening: 7.6%
Custom: RAO 77 CRA 10
S1(4)
RAO 47, CRA 16
Frame: 54/90
FS: 1.5%
S1(3)
LAO 0, CRA 37
Frame: 70/87
FS: 24.9%
Min.
Max.
Ref.
QFR
0.61

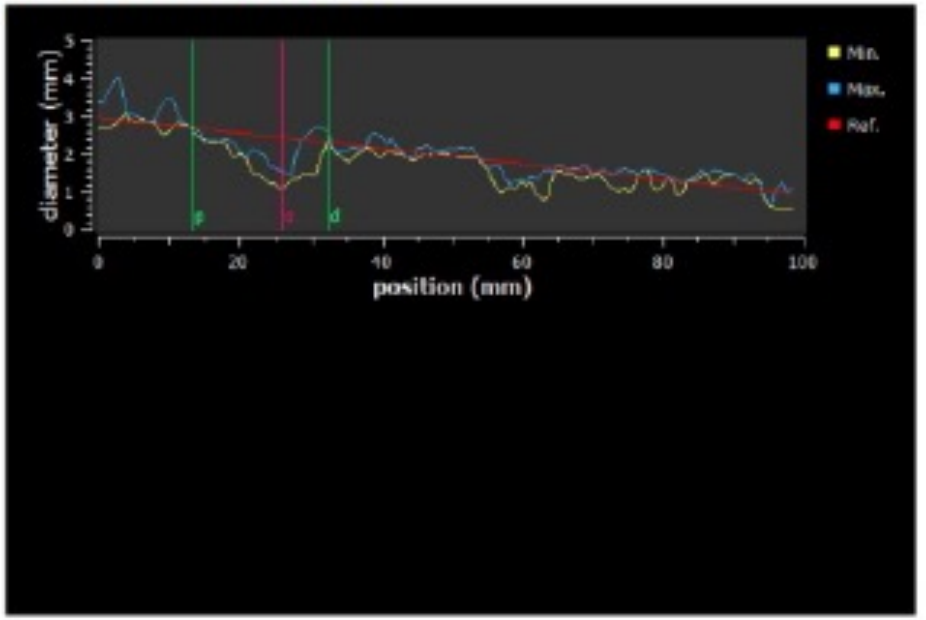


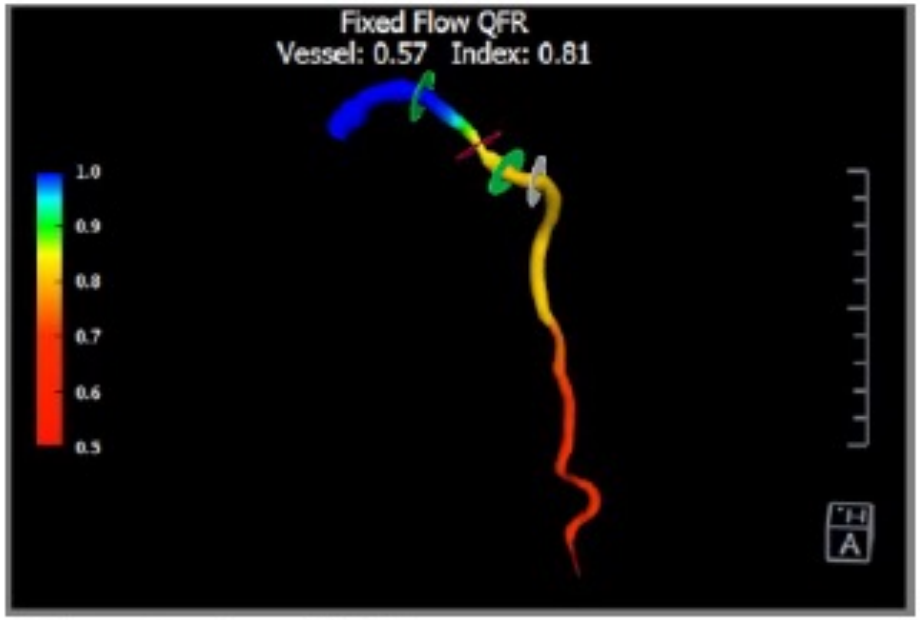
Left 2D Image: frame 26



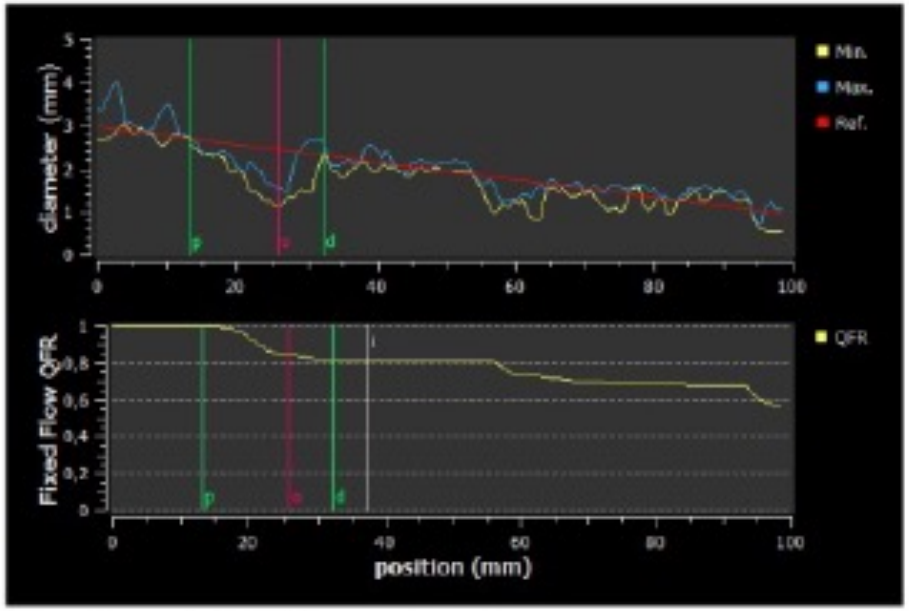
Right 2D Image: frame 15



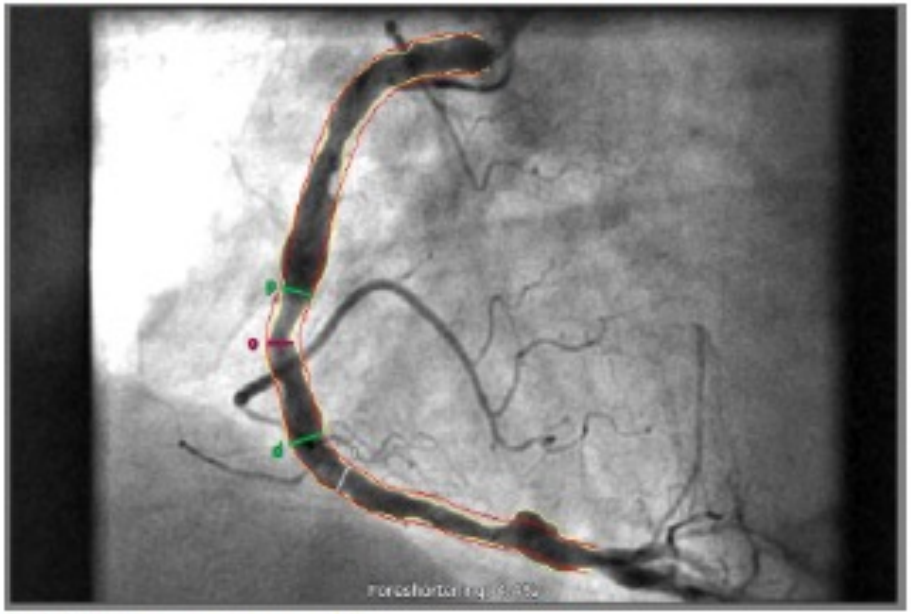




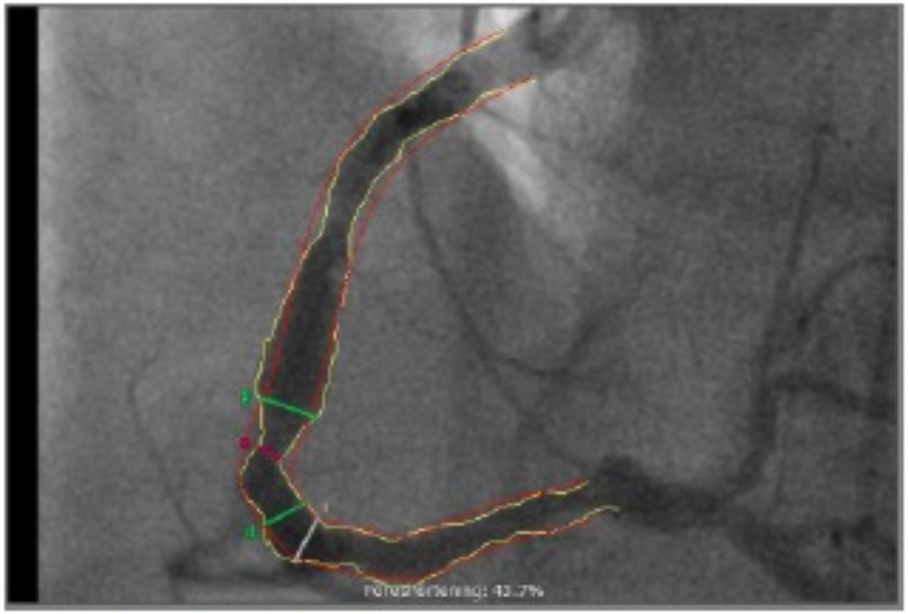
3D Reconstruction with QFR



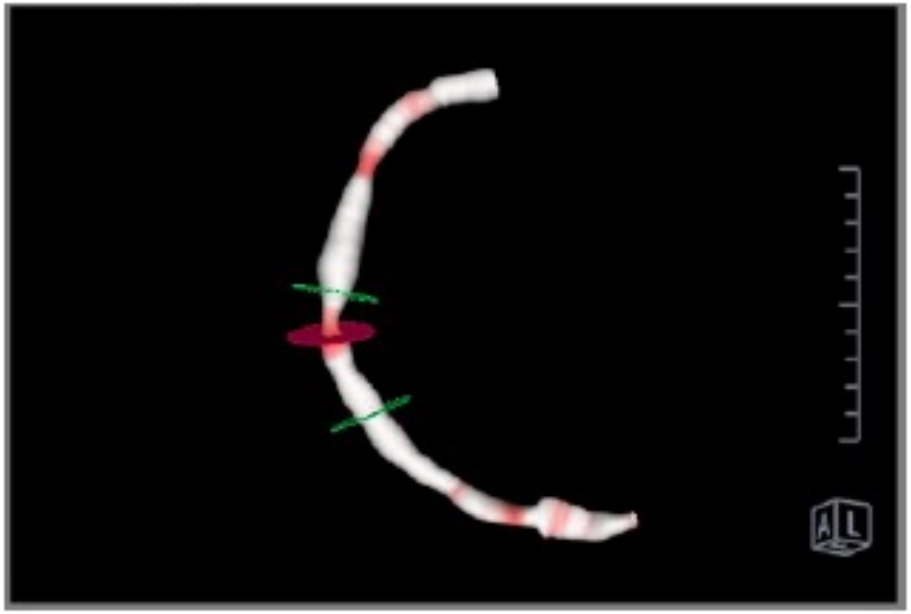
Diameter and QFR Diagrams



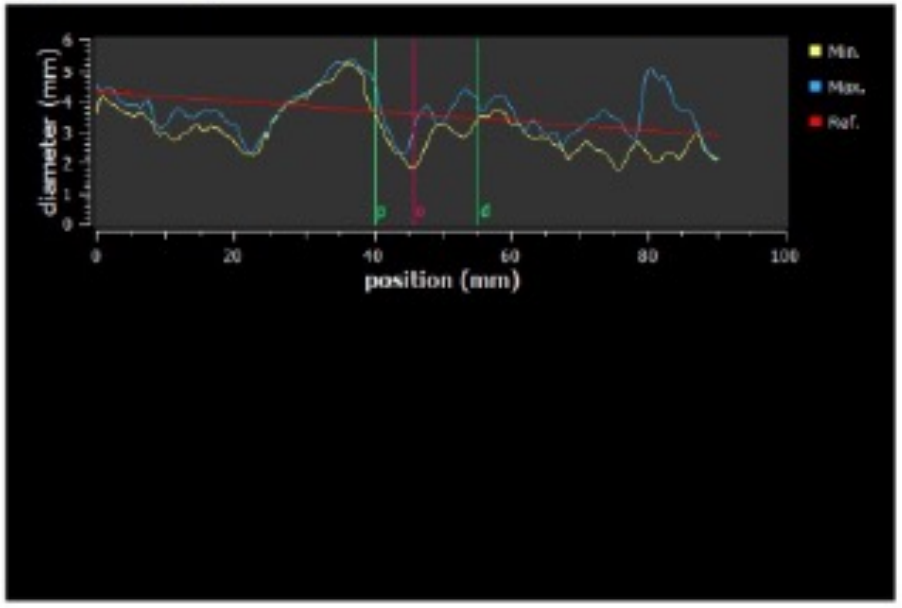
Left 2D Image: frame 29



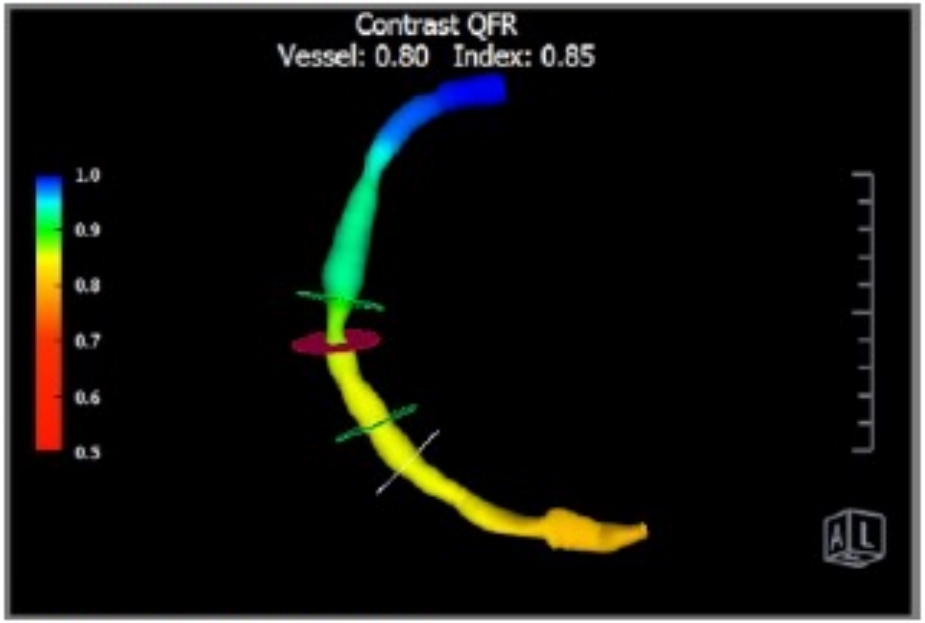
Right 2D Image: frame 33



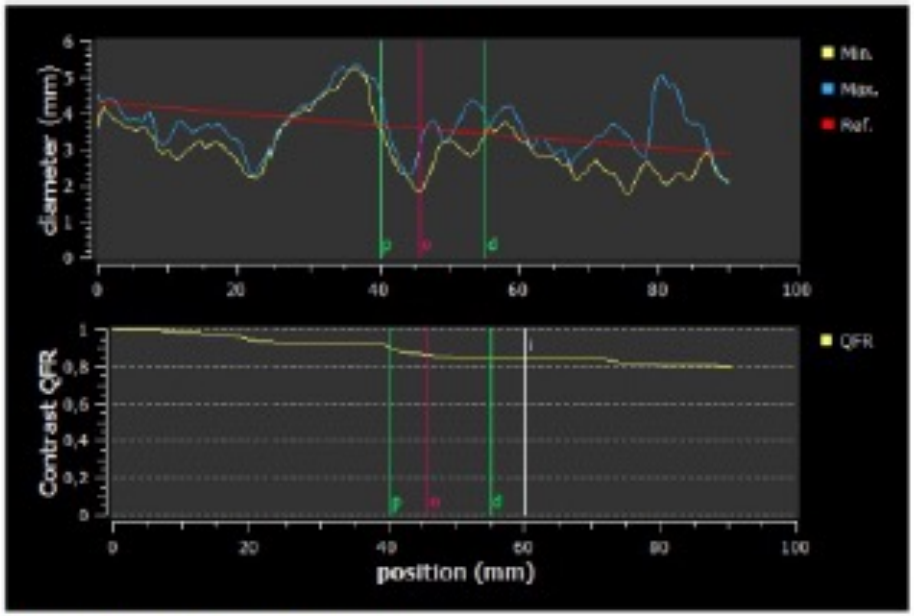
3D Reconstruction: LAO 56, CAU 16



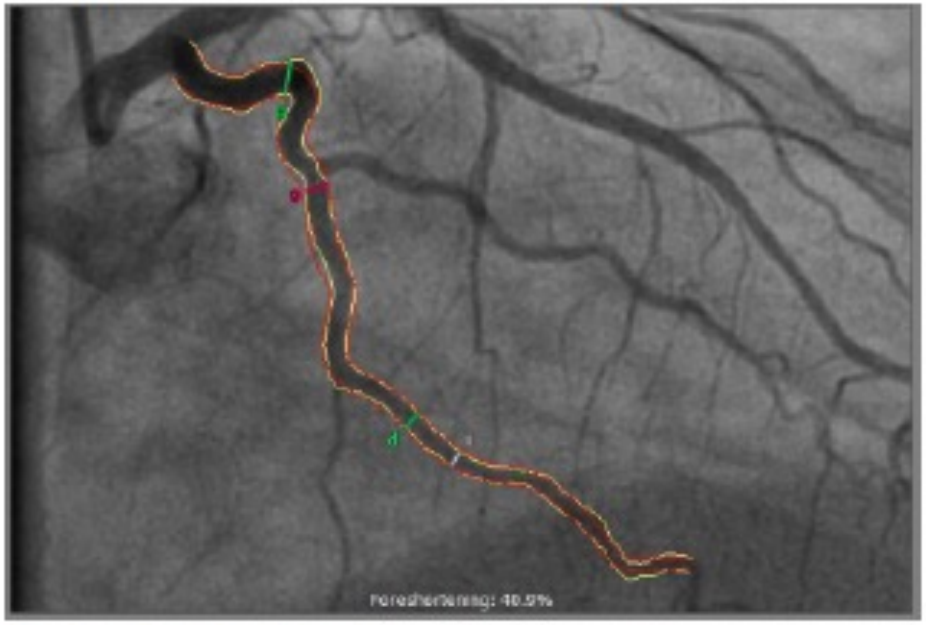
Diameter Diagram



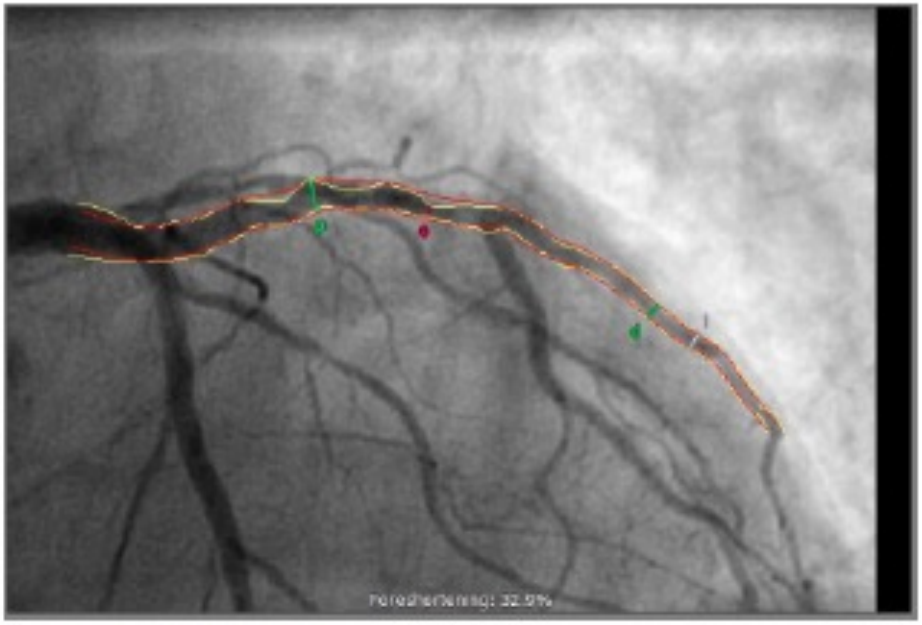
3D Reconstruction with QFR



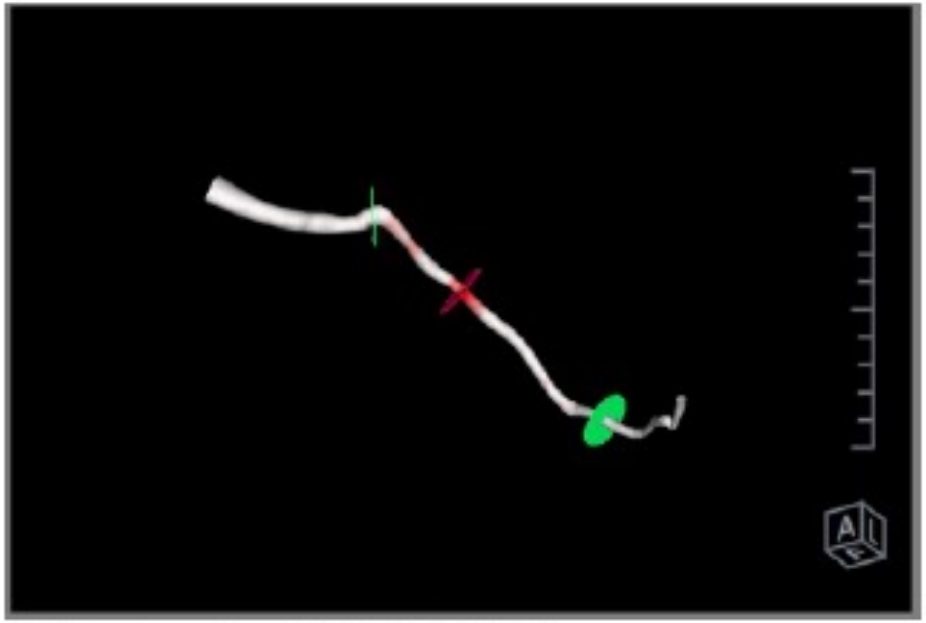
Diameter and QFR Diagrams



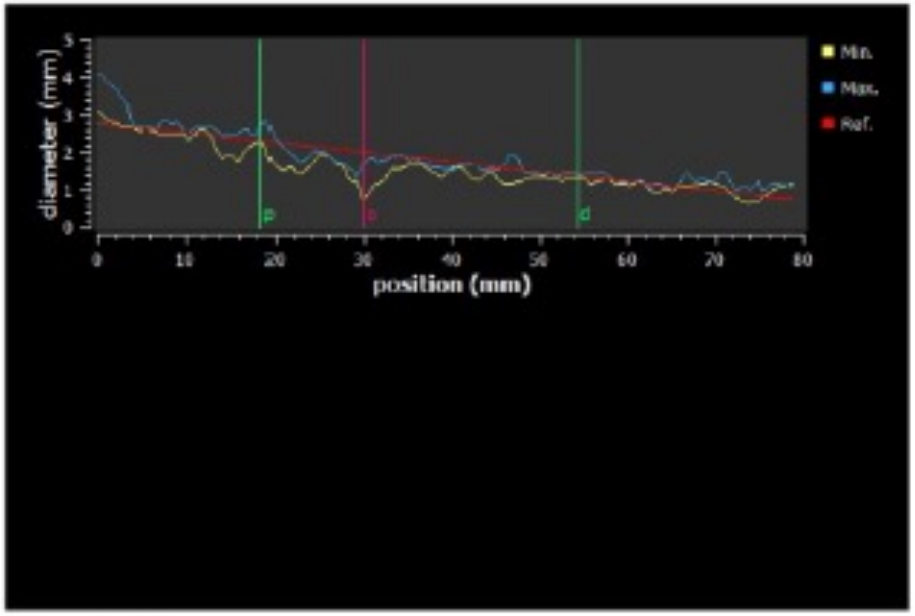
Left 2D Image: frame 46



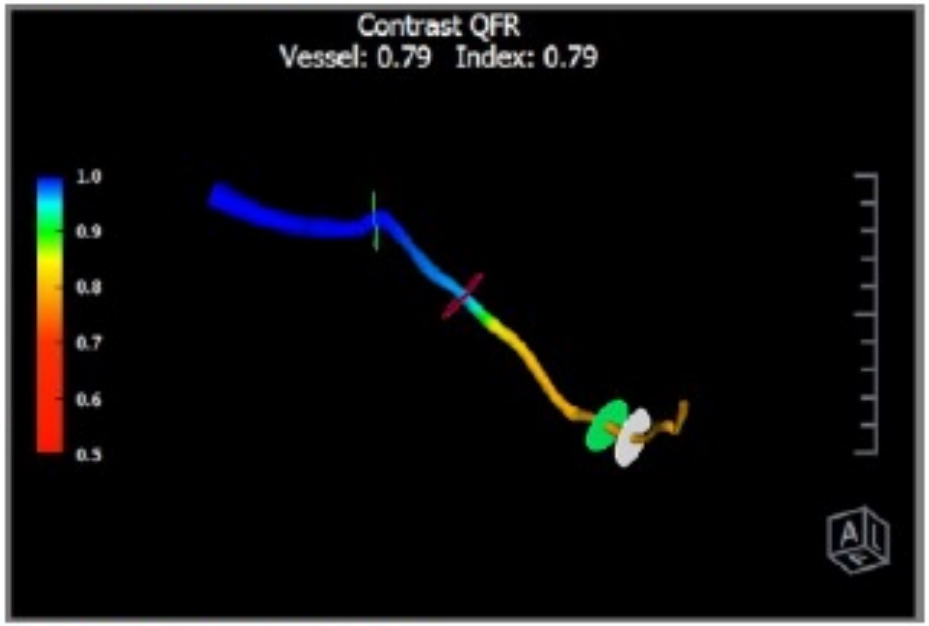
Right 2D Image: frame 38



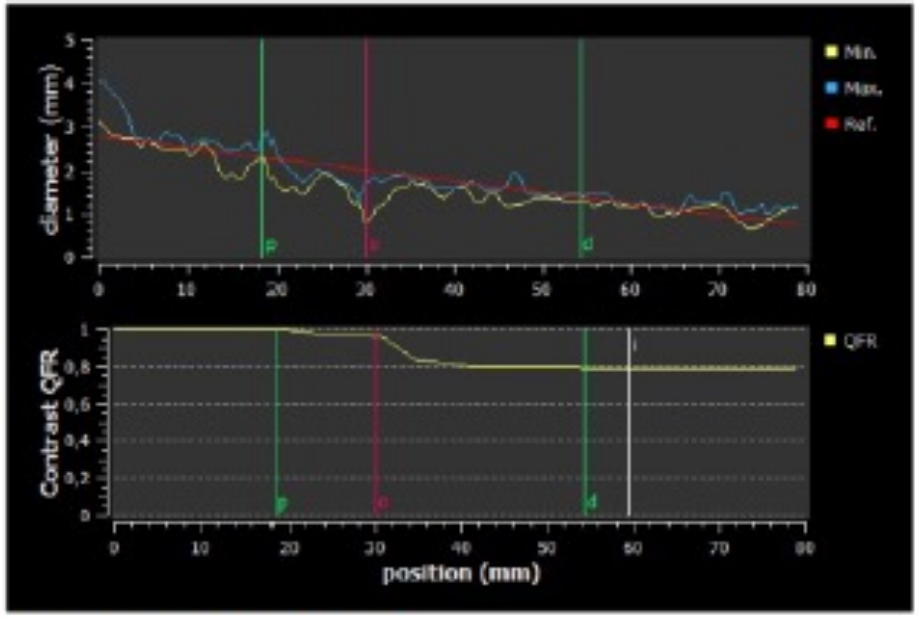
3D Reconstruction: LAO 30, CAU 28



Diameter Diagram



3D Reconstruction with QFR



Diameter and QFR Diagrams

Benefits

- For patients:
  - No adenosine with side-effects
  - No extra radiation
  - Less chances on complications due to wire insertion
- For (interventional) cardiologist:
  - Applicable in diagnostic cases, and pre-, during-, and post-PCI
  - Applicable in all coronary vessels without repeat insertions of wire
  - Fast and easy, embedded in diagnostic on-line workflow
- For hospitals:
  - Cost-effective

Tips and Tricks

Do not forget Nitro

PA > 100 mm Hg

Get good pictures,

increase frequency if needed

5F

Avoid superposition

Look at the curves

Ostial lesion

Acquisition Aid for QFR®

Target Vessel	1st XA		2nd XA	
LM + LAD/LCX	RAO 20,	CAU 45	AP,	CAU 10
LAD/Diag	AP,	CRA 45	RAO 30,	CRA 20
LCX/OM	LAO 10,	CAU 25	RAO 25,	CAU 25
RCA	LAO 45,	CAU 10	LAO 20,	CRA 20

- ✓ Imaging shortly after Nitroglycerin
- ✓ ≥ 12,5 Fr/s Acquisition
- ✓ Δ Angulation ≥ 25° & perpendicular on lesion
- ✓ Brisk contrast fluid injection for 3 cardiac cycles
- ✓ Prevent: Vessel overlap & Patient movement

Evaluation

	Target lesion	Non Target lesion
ST +	No	Yes
ST -	Yes (> 5 Days)	Yes
Stable Angina	Yes	Yes

PA > 100 mm Hg - Nitro

Conclusions

- **Research tool**
- **Learning tool**
- **Clinical application**

Ischémia with Courage