

PHYSIO DAY

JOURNÉES DE PHYSIOLOGIE EN CARDIOLOGIE INTERVENTIONNELLE

5 & 6 AVRIL – 2024 – NICE

Symposium Microport
La μ FR d'aujourd'hui et de demain

Radwan HAKIM

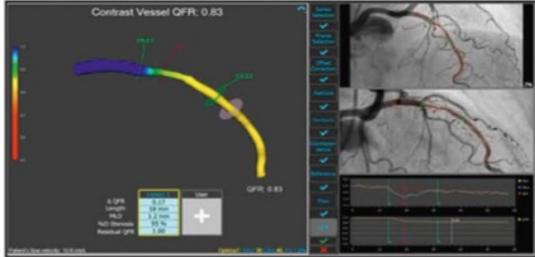
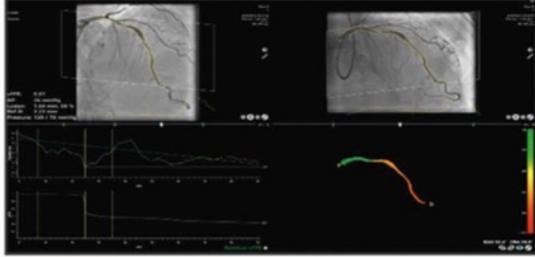
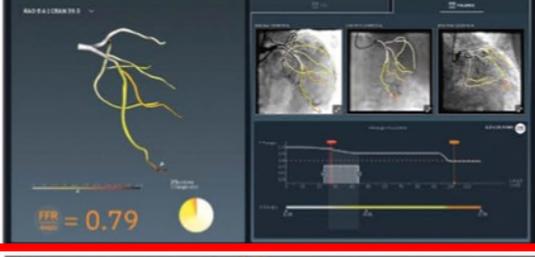
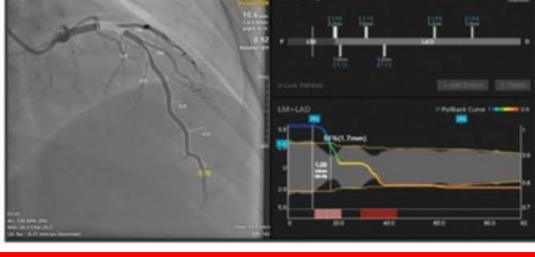
Chartres, France

Liens d'intérêt

- Consultant : Abbott

La μ FR d'aujourd'hui

FFR non invasives basées sur l'angiographie

	User display	Projections needed	Pressure sensor	Microcirculation	Side branches	Available data
QFR		2	No	Yes	No	
CAAS vFFR		2	No	No	No	
caFFR		2	Yes	Yes	No	
FFR angio		3	Yes	No	Yes	
μQFR		1	No	Yes	Yes	

QFR ? μ FR ?

Inventeur des techniques
QFR/UFR/OFR/CT-QFR



Shengxian Tu

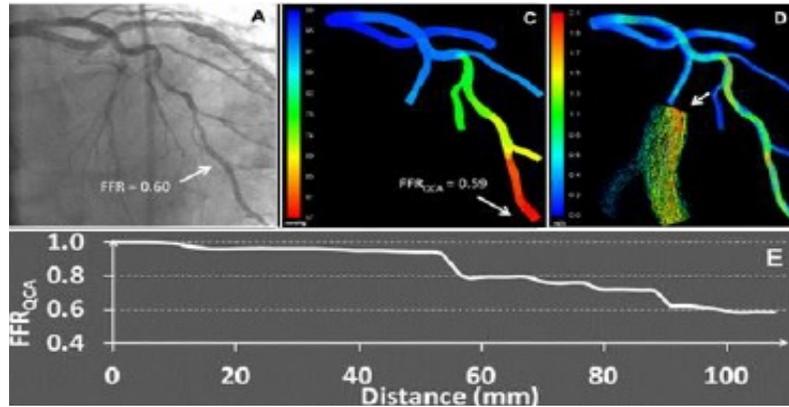


excellence for life



1^{ère} Gen

2016 QFR



2 incidences



2nd Gen

2021 μ FR

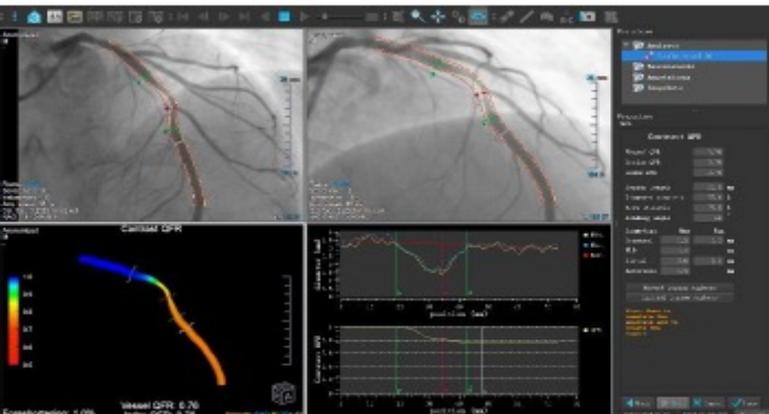


1 Seule incidence
Basée sur la loi de Murray
AMR



Prototype

2014 FFR_{QCA}



Concordance μ FR / FFR

Diagnostic accuracy of quantitative flow ratio for assessment of coronary stenosis significance from a single angiographic view: A novel method based on bifurcation fractal law

Shengxian Tu PhD^{1,2} | Daixin Ding MSc^{1,3} | Yunxiao Chang MSc⁴ |
Chunming Li BSc¹ | William Wijns MD, PhD³ | Bo Xu MBBS⁵
[Catheter Cardiovasc Interv 2021;97:1040-7](#)

Concordance μ FR / FFR : 93%

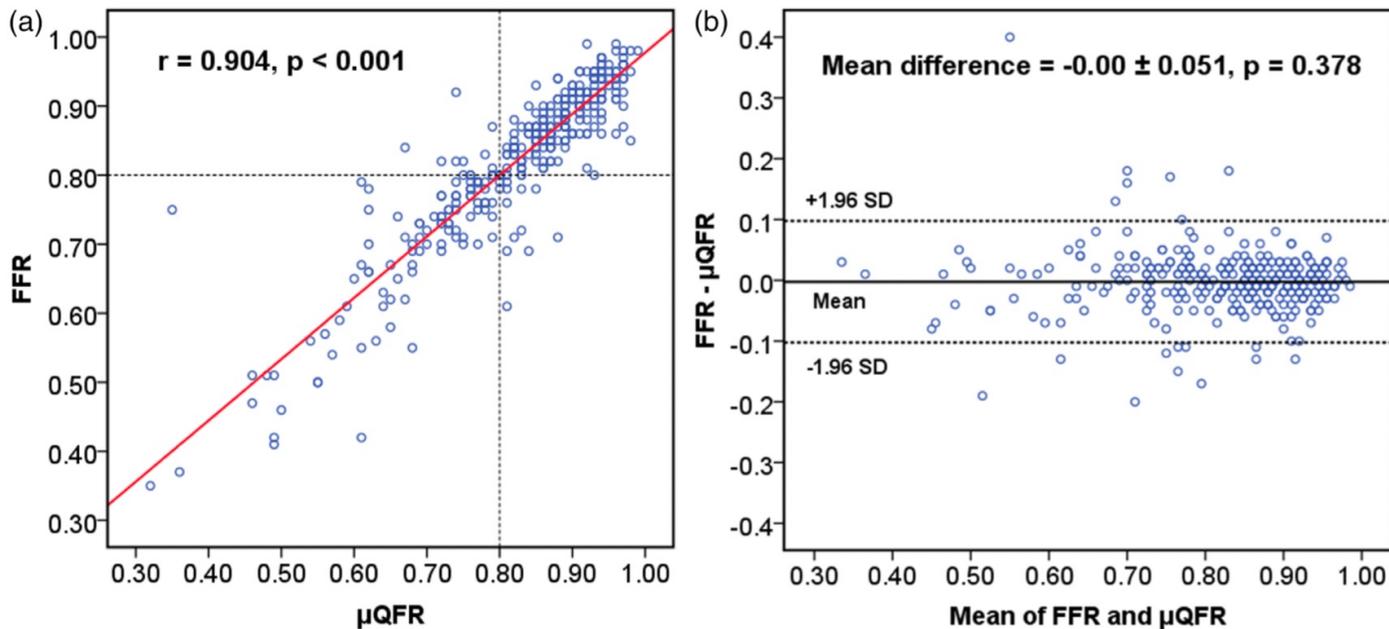
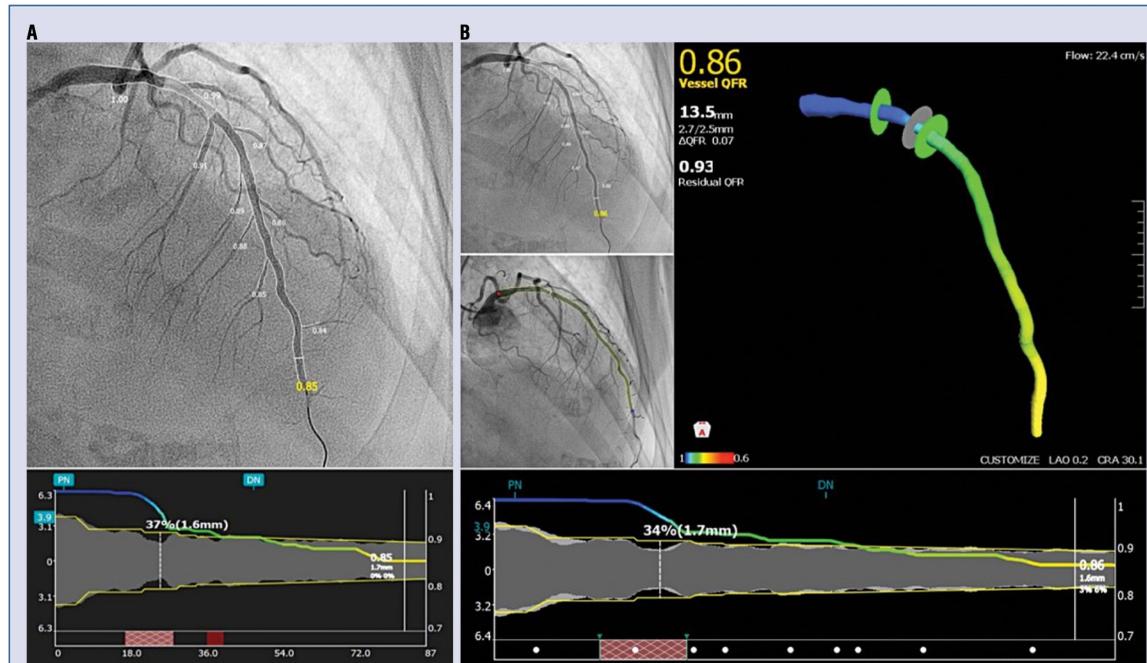


TABLE 1 Diagnostic performance of μ QFR and QCA-derived DS% in predicting FFR ≤ 0.80

	μ QFR ≤ 0.80	DS% $\geq 50\%$
Accuracy, % (95% CI)	93.0 (90.2, 95.8)	76.1 (71.4, 80.7)
Sensitivity, % (95% CI)	87.5 (80.2, 92.8)	57.5 (48.1, 66.5)
Specificity, % (95% CI)	96.2 (92.6, 98.3)	86.7 (81.3, 91.0)
PPV, % (95% CI)	92.9 (86.5, 96.9)	71.1 (61.0, 79.9)
NPV, % (95% CI)	93.1 (88.9, 96.1)	78.1 (72.2, 83.2)
+LR (95% CI)	23.0 (11.6, 45.5)	4.3 (3.0, 6.3)
-LR (95% CI)	0.13 (0.08, 0.20)	0.49 (0.40, 0.60)

Comparaison μ FR / 3D-QFR



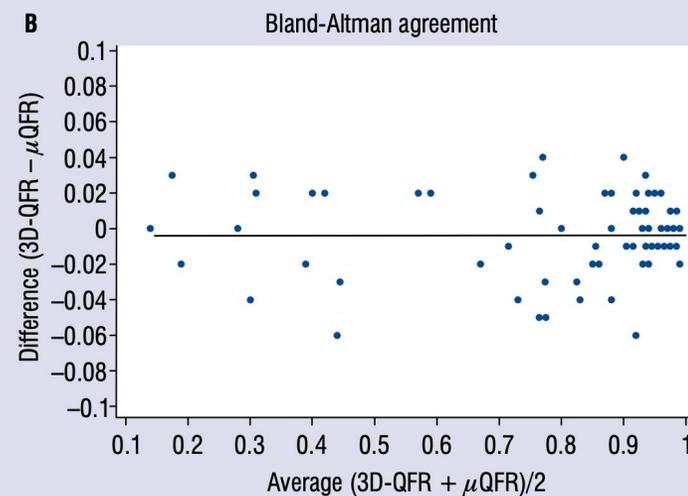
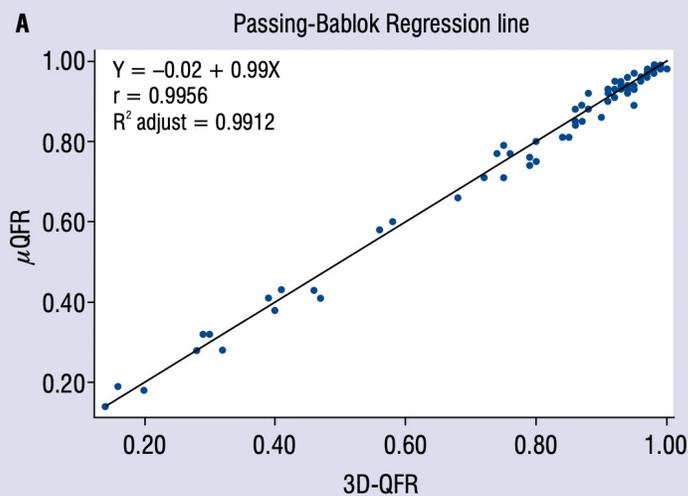
Agreement between Murray law-based quantitative flow ratio (μ QFR) and three-dimensional quantitative flow ratio (3D-QFR) in non-selected angiographic stenosis: A multicenter study

Cardiol J 2022;29:388-95

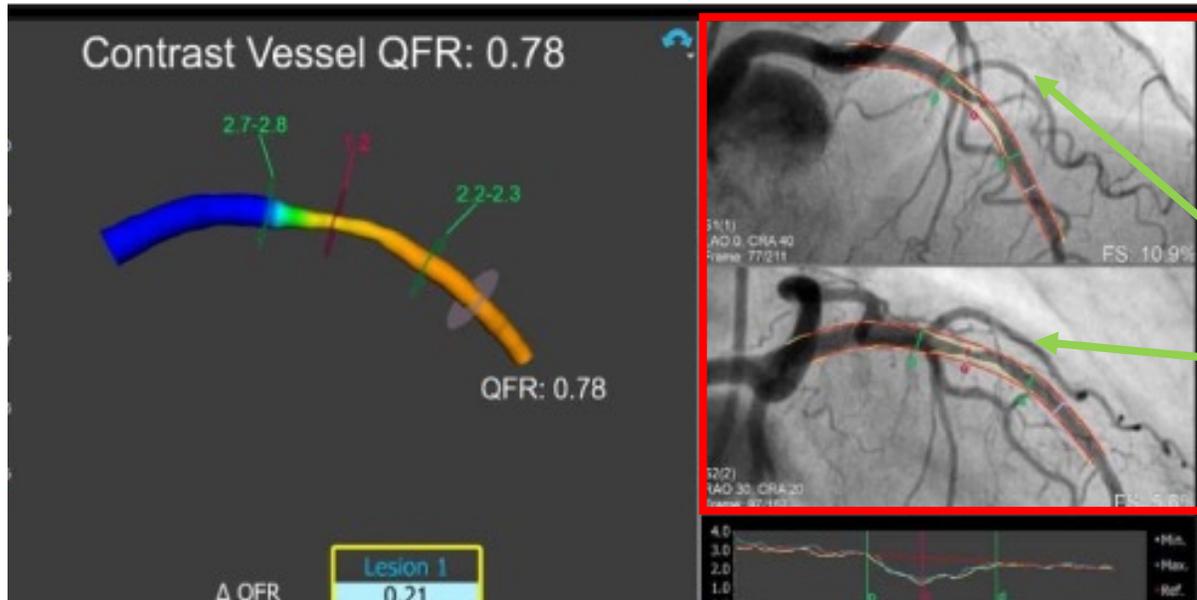
Corrélation μ FR / 3D-QFR \approx 100%

Faisabilité :

- μ FR = 100%
- 3D-QFR = 88%



μ FR et limites de la QFR



2 incidences

Branches filles exclues de l'analyse

Analyse rétrospective QFR de l'étude SYNTAX II : possible dans 71% des cas

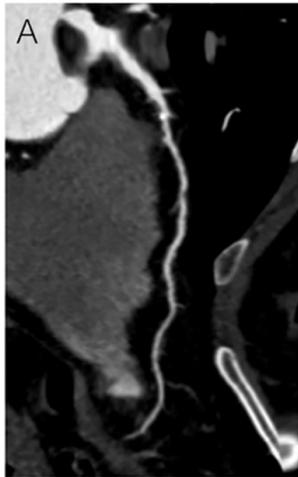
Facteurs prédictifs indépendants de discordance avec la FFR :

- Présence de branches filles (bifurcation et trifurcation) (faux négatifs)
- Petits vaisseaux (faux négatifs),
- Lésions branches filles (faux positifs)

Comparison μ FR / CT-QFR

Comparison of coronary CT angiography-based and invasive coronary angiography-based quantitative flow ratio for functional assessment of coronary stenosis: A multicenter retrospective analysis

J Cardiovasc Comput Tomogr 2022;16:509-16



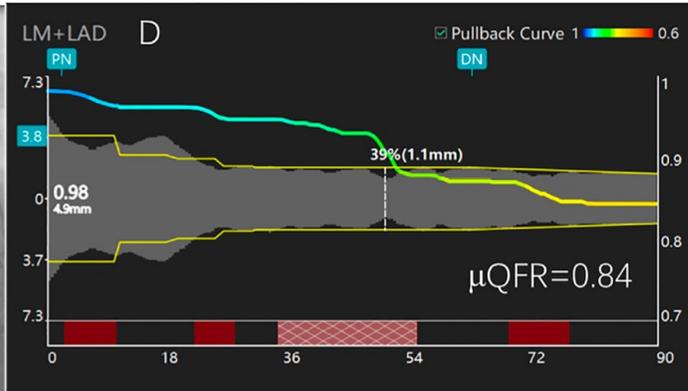
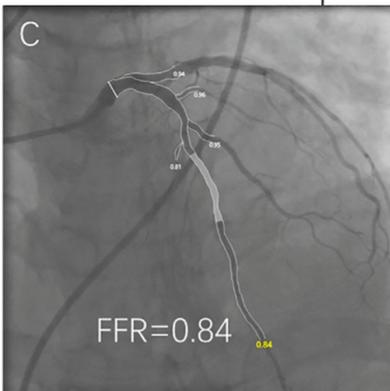
B



CT-QFR=0.83

Diagnostic Performance of CT-QFR, μ QFR and CTA-derived DS% in predicting $FFR \leq 0.80$

	Patient-level (n = 167)		Vessel-level (n = 191)	
	CT-QFR ≤ 0.80		CT-QFR ≤ 0.80	μ QFR ≤ 0.80
Accuracy (%)	88 (83, 93)		89 (85, 93)	93 (90, 97)
Sensitivity (%)	90 (81, 96)		90 (82, 96)	91 (83, 97)
Specificity (%)	86 (77, 93)		88 (81, 94)	95 (89, 98)
PPV (%)	86 (76, 92)		85 (76, 92)	93 (84, 97)
NPV (%)	91 (82, 96)		92 (86, 97)	94 (87, 97)
+LR	6.59 (3.9, 11.2)		7.6 (4.6, 12.8)	16.8 (7.7, 36.6)
-LR	0.12 (0.06, 0.2)		0.11 (0.06, 0.2)	0.09 (0.04, 0.2)
AUC	0.94 (0.89, 0.97)		0.94 (0.90, 0.97)	0.97 (0.93, 0.99)

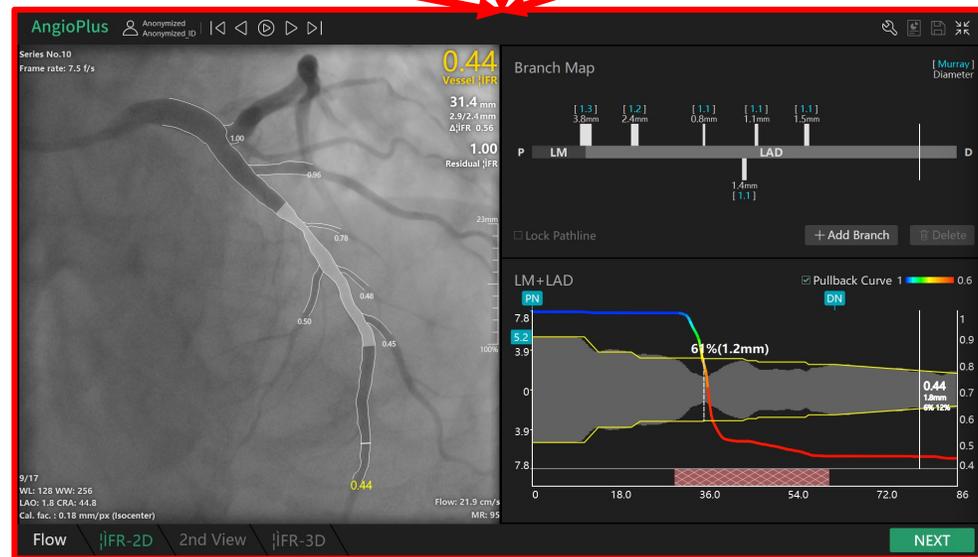


Conclusions: Performance in diagnosis of hemodynamically significant coronary stenosis by CT-QFR was slightly lower but without statistical significance than μ QFR, and substantially higher than CTA-derived diameter stenosis. Extensively calcified lesions reduced the diagnostic accuracy of CT-QFR.

μ FR : comment ça marche ?



- 1 seule incidence
- Loi de Murray
- Prend en compte les branches filles
- « Contourage » fiable
- Rapide (< 1min)



Comment ça marche ?

1

Sélection vue angiographique optimale

2

- Contours automatiquement délimités
- Vitesse de flux dérivée de la longueur du vaisseau divisée par le temps de remplissage puis convertie en vitesse de flux hyperhémique

The screenshot displays the AngioPlus software interface. At the top, there's a 'Patient/Study Information' table with columns for No., Patient ID, Patient Name, Gender, Birthdate, Modality, Study Date, Study ID, Accession Number, Description, and File Path. Below it is a 'Series Information' table with columns for No., Series No., Frames, Modality, Series Date/Time, Projection Angle, File Name, Description, and Notes. A preview window on the left shows various angiographic views (RAO 37.4 CRA 23.1, RAO 1.2 CRA 32.6, RAO 1.1 CRA 32.4, LAO 25.5 CRA 32.2, RAO 26.7 CRA 30.8). A small thumbnail of the selected series is shown on the right.

No.	Patient ID	Patient Name	Gender	Birthdate	Modality	Study Date	Study ID	Accession Number	Description	File Path
83	100030929795			1939-03-02	XA	2023-11-28	452124	C452124	Angioplastie	D:\PStationData\Import\1.2.2
82	100024960053			1973-08-09	XA/OT	2023-11-28	452045	C452045	Coronarographie	D:\PStationData\Import\1.2.2
81	100016299872			1953-01-27	OT/XA	2023-11-28	452017	C452017	Coronarographie	D:\PStationData\Import\1.2.2
80	900000013994			1974-11-01	XA/OT	2023-11-22	451421	D:\PStationData\Import\1.2.2		D:\PStationData\Import\1.2.2
79	100035568520			1947-01-24	XA/OT	2023-11-22	451378	C451378		D:\PStationData\Import\1.2.2
78	100021593345			1940-09-18	XA	2023-11-14	450115	C450115	Coronarographie	D:\PStationData\Import\1.2.2
77	900000013652			1939-04-26	OT/XA	2023-11-13	449953	C449953	Coronarographie	D:\PStationData\Import\1.2.2
76	100030929795			1939-03-02	OT/XA	2023-11-13	449941	C449941	Coronarographie	D:\PStationData\Import\1.2.2
75	100023499595			1954-09-23	OT/XA	2023-11-13	449932	C449932	Coronarographie	D:\PStationData\Import\1.2.2
74	062615118079			1946-07-18	OT/XA	2023-11-08	449442	C449442	Coronarographie	D:\PStationData\Import\1.2.2
73	900000005667			1944-04-07	OT/XA	2023-10-17	446553	C446553	Coronarographie	D:\PStationData\Import\1.2.2
72	900000013456			1955-11-17	OT/XA	2023-11-07	449143	C449143	Coronarographie	D:\PStationData\Import\1.2.2

No.	Series No.	Frames	Modality	Series Date/Time	Projection Angle	File Name	Description	Notes
5	5	57	XA	2023-11-28 11:50:19	RAO 29.2 CRA 21.6	XA1.3.46.670589.28.68172...	Coro 15 V/s Moyen	
6	6	58	XA	2023-11-28 11:50:35	LAO 20.6 CRA 28.7	XA1.3.46.670589.28.68172...	Coro 15 V/s Moyen	
7	7	41	XA	2023-11-28 11:51:07	RAO 37.4 CRA 23.1	XA1.3.46.670589.28.68172...	Coro 25 V/s Moyen	
8	8	103	XA	2023-11-28 11:51:11	RAO 37.4 CRA 23.1	XA1.3.46.670589.28.68172...	Coro 25 V/s Moyen	
9	9	117	XA	2023-11-28 11:51:23	RAO 1.2 CRA 32.6	XA1.3.46.670589.28.68172...	Coro 25 V/s Moyen	
10	10	75	XA	2023-11-28 11:51:53	RAO 1.1 CRA 32.4	XA1.3.46.670589.28.68172...	Coro 15 V/s Normal	
11	11	55	XA	2023-11-28 11:52:26	LAO 2.5 CRA 30.8	XA1.3.46.670589.28.68172...	Coro 15 V/s Normal	
12	12	104	XA	2023-11-28 11:56:10	RAO 26.7 CRA 30.8	XA1.3.46.670589.28.68172...	Coro 25 V/s Moyen	

The screenshot shows the AngioPlus software interface with a coronary artery image. A yellow contour is drawn along the vessel. To the right, there's a graph showing flow velocity in cm/s over time. The graph has a y-axis from 0 to 10 cm/s and an x-axis from 0s to 3s. A green vertical line labeled 'K' is at approximately 1.8s. Below the graph, the text reads 'Flow Velocity: 25.8 cm/s (Confidence: 97%)'. There are also checkboxes for 'Use Fixed Flow for μFR' and 'Check Contour'. Below that are buttons for 'Zoom Image to Contour', 'Lock Pathline', 'Include LM', 'Undo', and 'Redo'. At the bottom, there's a 'Flow μFR-2D' label and a 'NEXT' button.

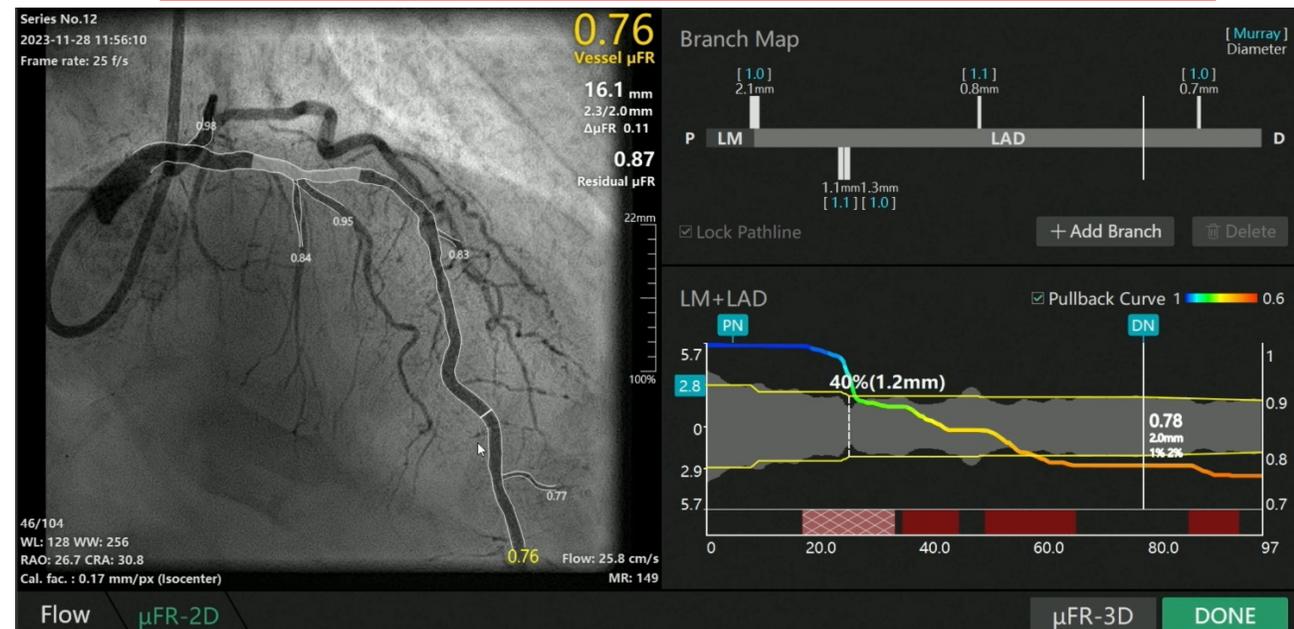
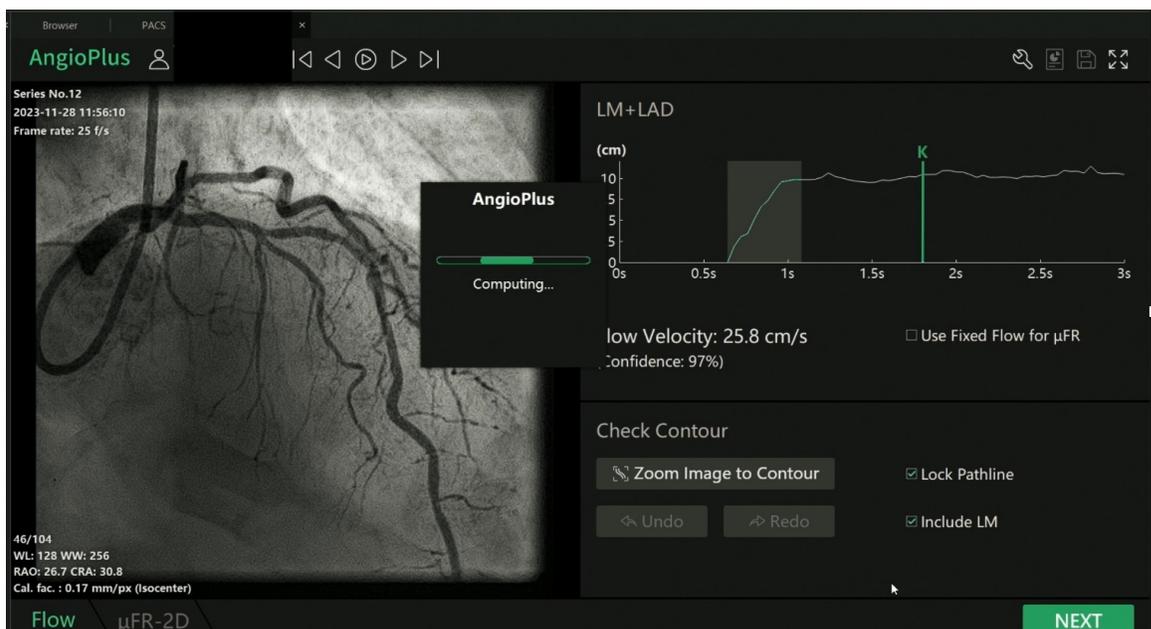
Comment ça marche ?

3

Analyse < 1 minute

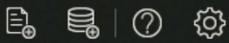
4

- Reconstruction diamètre vaisseau de référence (Loi de Murray)
- Chute de pression calculée (Pd) / équations de dynamique des fluides
 - Pa hyperhémique supposée 86 mmHg
 - $\mu\text{FR} = Pd / Pa$
 - $\text{AMR} = Pd / \text{vitesse flux hyperhémique}$

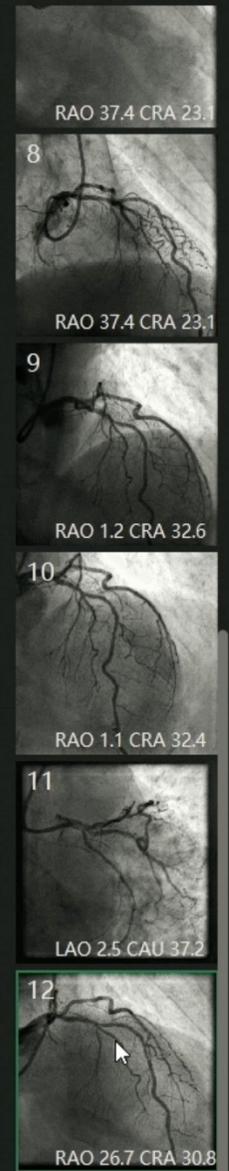


Recette pour une bonne μ FR

- Injection de nitrés
- Bonne angiographie
 - ✓ 15 images/s (possible 7,5 images/s)
 - ✓ Quantité suffisante de contraste (≥ 8 cc)
- Le moins de superposition possible
- Incidence qui déroule bien l'artère (pas de raccourcissement)
- Pas de « travelling »



Preview



Browser

PACS

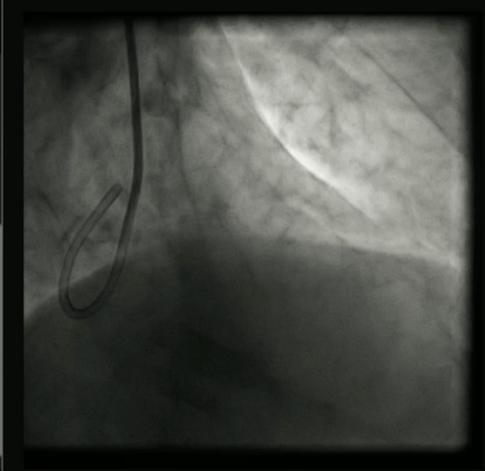
Patient/Study Information

Please input search content | All | All Study Date | 14/09/1752 - 28/11/2023

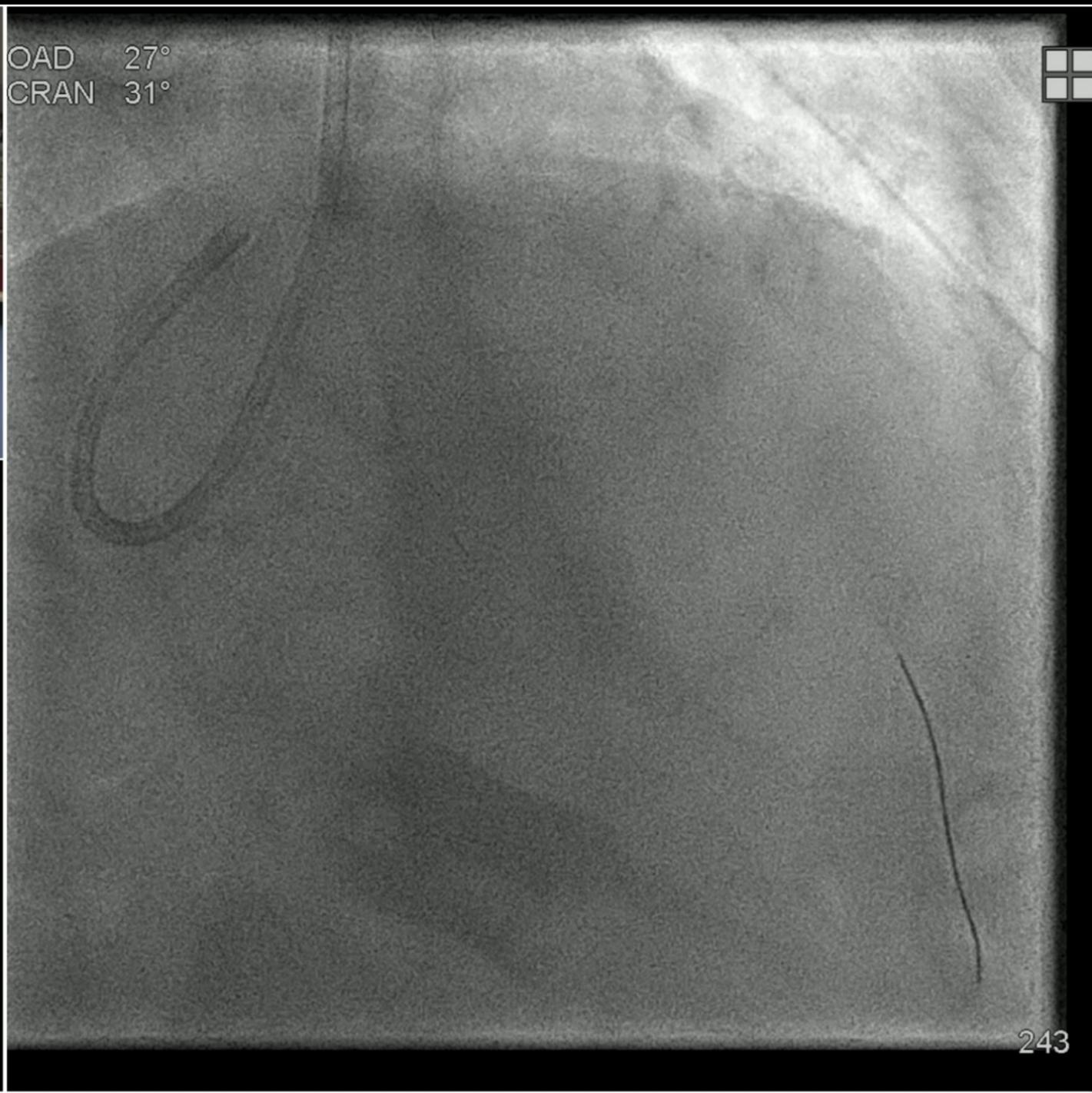
No.	Patient ID	Patient Name	Gender	Birthday	Modality	Study Date	Study ID	Accession Number	Description	File Path
83	100030929795			1939-03-02	XA	2023-11-28	452124	C452124	Angioplastie	D:\PStationData\Import\1.2.2
82	100024960053			1973-08-09	XA/OT	2023-11-28	452045	C452045	Coronarographie	D:\PStationData\Import\1.2.2
81	100016299872			1953-01-27	OT/XA	2023-11-28	452017	C452017	Coronarographie	D:\PStationData\Import\1.2.2
80	900000013994			1974-11-01	XA/OT	2023-11-22	451421	C451421		D:\PStationData\Import\1.2.2
79	100035568520			1947-01-24	XA/OT	2023-11-22	451378	C451378		D:\PStationData\Import\1.2.2
78	100021593345			1940-09-18	XA	2023-11-14	450115	C450115	Coronarographie	D:\PStationData\Import\1.2.2
77	900000013652			1939-04-26	OT/XA	2023-11-13	449953	C449953	Coronarographie	D:\PStationData\Import\1.2.2
76	100030929795			1939-03-02	OT/XA	2023-11-13	449941	C449941	Coronarographie	D:\PStationData\Import\1.2.2
75	100023499595			1954-09-23	OT/XA	2023-11-13	449932	C449932	Coronarographie	D:\PStationData\Import\1.2.2
74	062615118079			1946-07-18	OT/XA	2023-11-08	449442	C449442	Coronarographie	D:\PStationData\Import\1.2.2
73	900000005667			1944-04-07	OT/XA	2023-10-17	446553	C446553	Coronarographie	D:\PStationData\Import\1.2.2
72	900000013456			1955-11-17	OT/XA	2023-11-07	449143	C449143	Coronarographie	D:\PStationData\Import\1.2.2

Series Information

No.	Series No.	Frames	Modality	Series Date/Time	Projection Angle	File Name	Description	Notes
5	5	57	XA	2023-11-28 11:50:19	RAO 29.2 CRA 21.6	XA1.3.46.670589.28.68172...	Coro 15 i/s Moyen	
6	6	58	XA	2023-11-28 11:50:35	LAO 20.6 CRA 28.7	XA1.3.46.670589.28.68172...	Coro 15 i/s Moyen	
7	7	41	XA	2023-11-28 11:51:07	RAO 37.4 CRA 23.1	XA1.3.46.670589.28.68172...	Coro 25 i/s Moyen	
8	8	103	XA	2023-11-28 11:51:11	RAO 37.4 CRA 23.1	XA1.3.46.670589.28.68172...	Coro 25 i/s Moyen	
9	9	117	XA	2023-11-28 11:51:23	RAO 1.2 CRA 32.6	XA1.3.46.670589.28.68172...	Coro 25 i/s Moyen	
10	10	75	XA	2023-11-28 11:51:53	RAO 1.1 CRA 32.4	XA1.3.46.670589.28.68172...	Coro 15 i/s Normal	
11	11	55	XA	2023-11-28 11:52:26	LAO 2.5 CAU 37.2	XA1.3.46.670589.28.68172...	Coro 15 i/s Normal	
12	12	104	XA	2023-11-28 11:56:10	RAO 26.7 CRA 30.8	XA1.3.46.670589.28.68172...	Coro 25 i/s Moyen	



OAD 27°
CRAN 31°



← Configuration **FFR** RFR Abbott ∅ EQ ≡

Examen FFR



Pa **95**

Pd **73**

EQ --

FFR **0,77**

Direct →

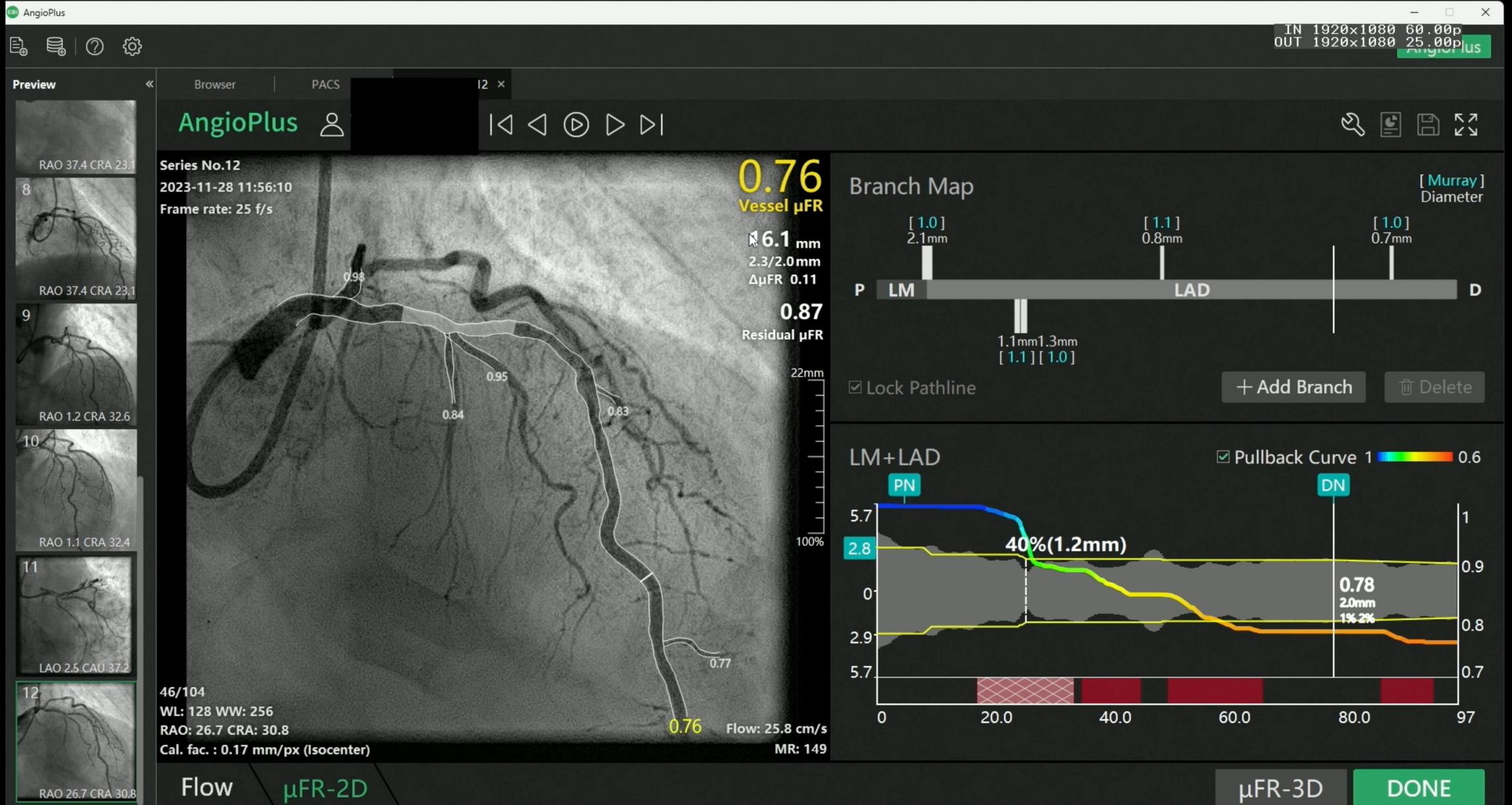
Enregistrement ●

01:18 FFR 0,77 ---

Site

Procédure

Choix du stent guidé par μ FR



Corrélation FFR / μ FR post angioplastie

AngioPlus Series No.12
2023-11-28 11:56:10
Frame rate: 25 f/s

0.76
Vessel μ FR
28.6 mm
2.3/2.6 mm
 $\Delta\mu$ FR 0.16
0.92
Residual μ FR

Branch Map
[Murray] Diameter
LM 2.1mm [1.0]
LAD 0.8mm [1.1]
D 0.7mm [1.0]
1.1mm 1.3mm [1.1] [1.0]
+ Add Branch Delete

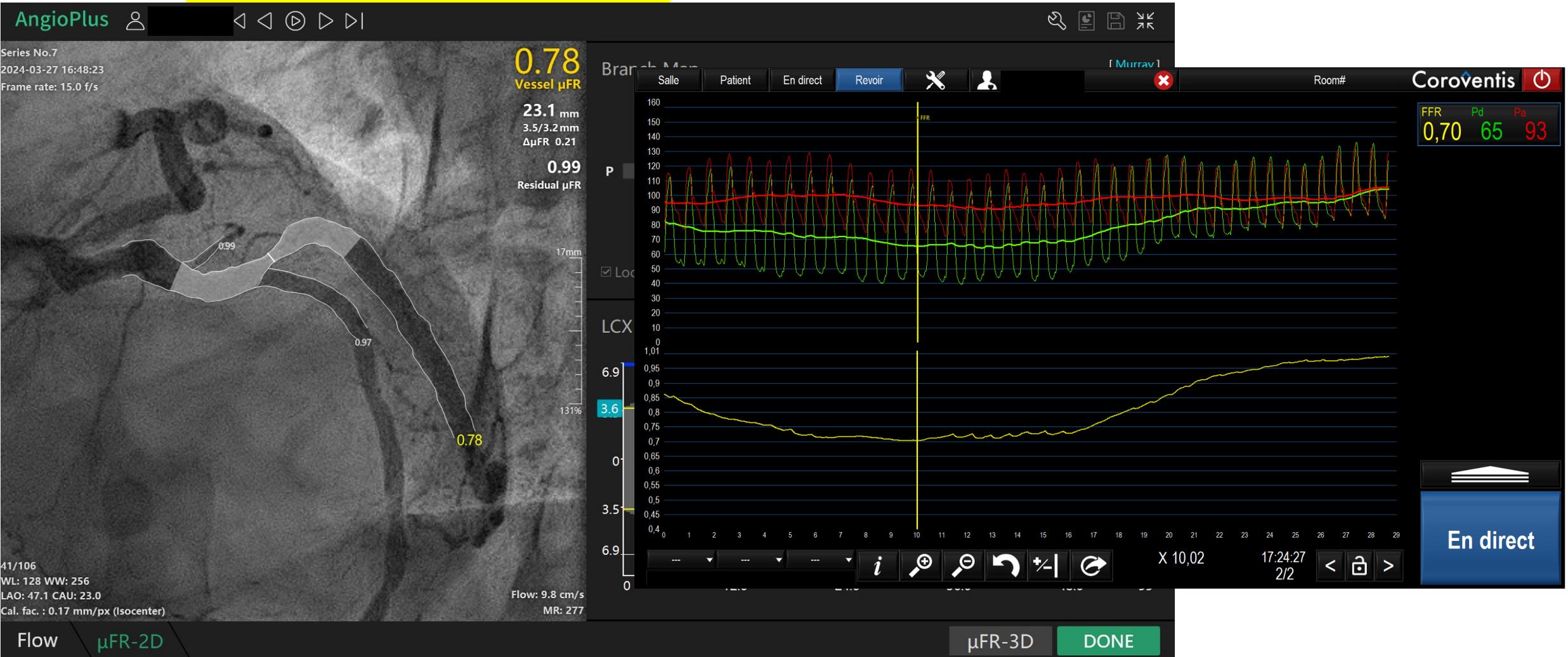
LM+LAD Pullback Curve 1 0.6
PN DN
40% (1.2mm)
0.78
2.0mm
1% 2%

46/104
WL: 128 WW: 256
RAO: 26.7 CRA: 30.8
Flow: 25.8 cm/s

18
11

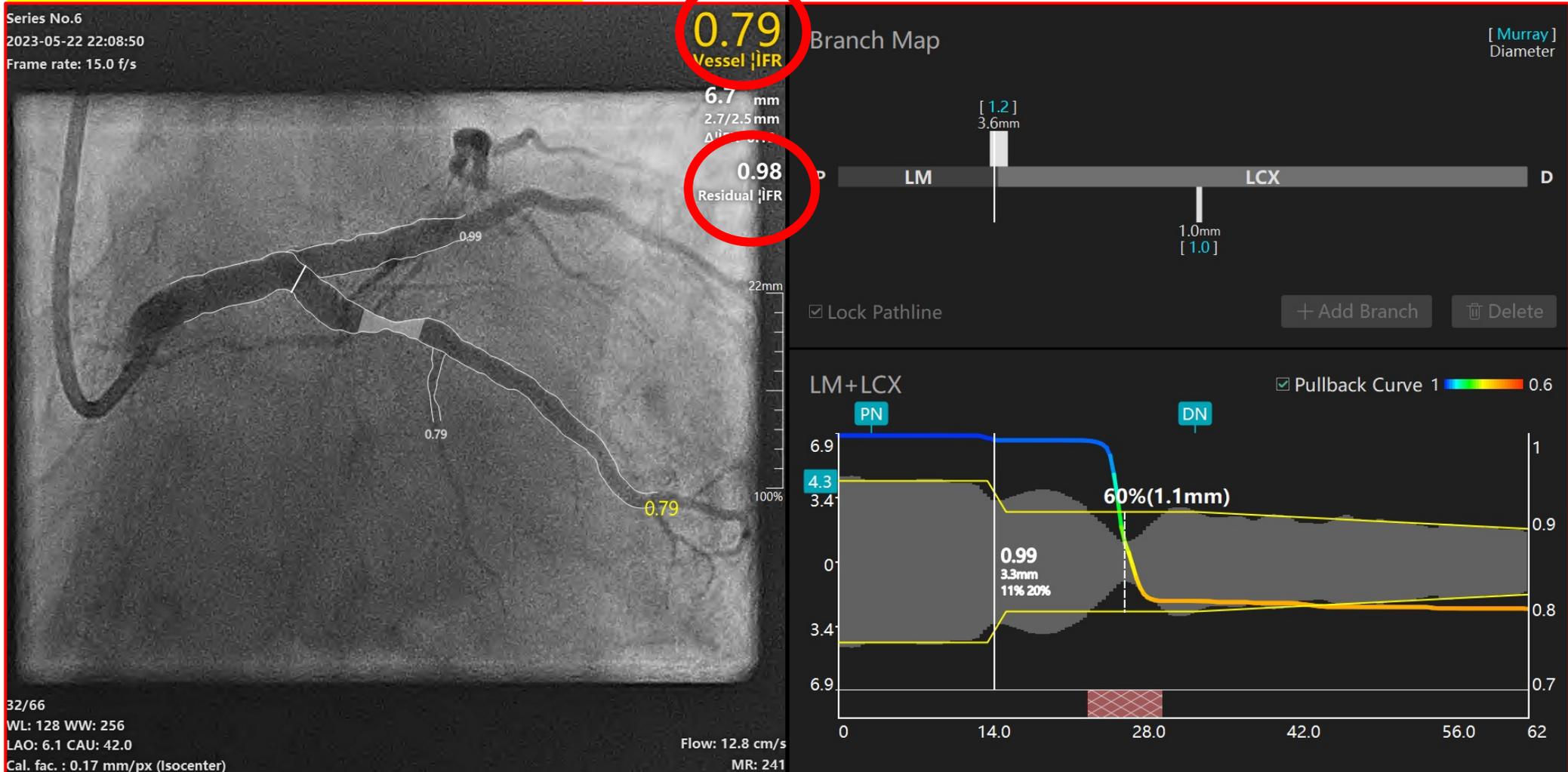
Cas n°1

Angor
Coroscanner +



Cas n°2

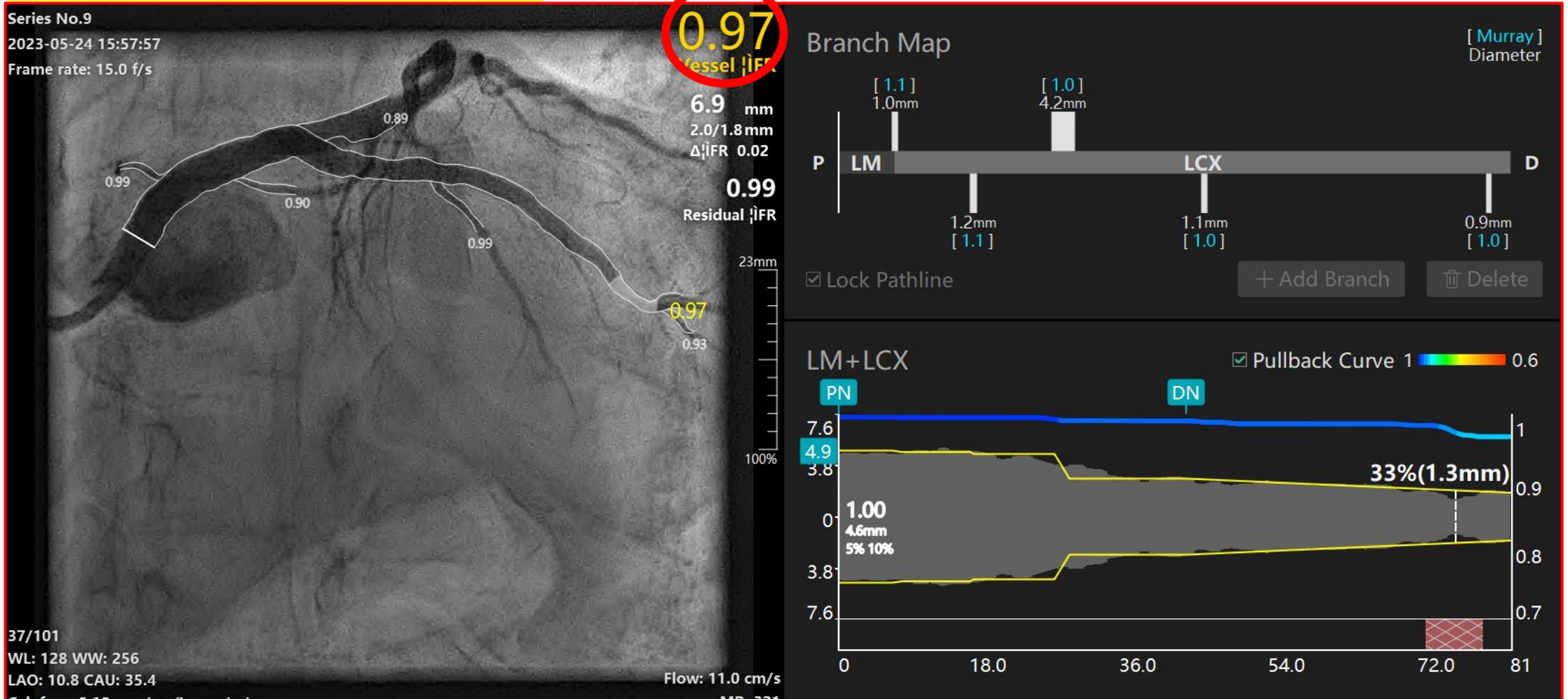
STEMI antérieur reperfusé
ATL programmé de la Cx



Cas n°2

STEMI antérieur reperfusé
ATL programmé de la Cx

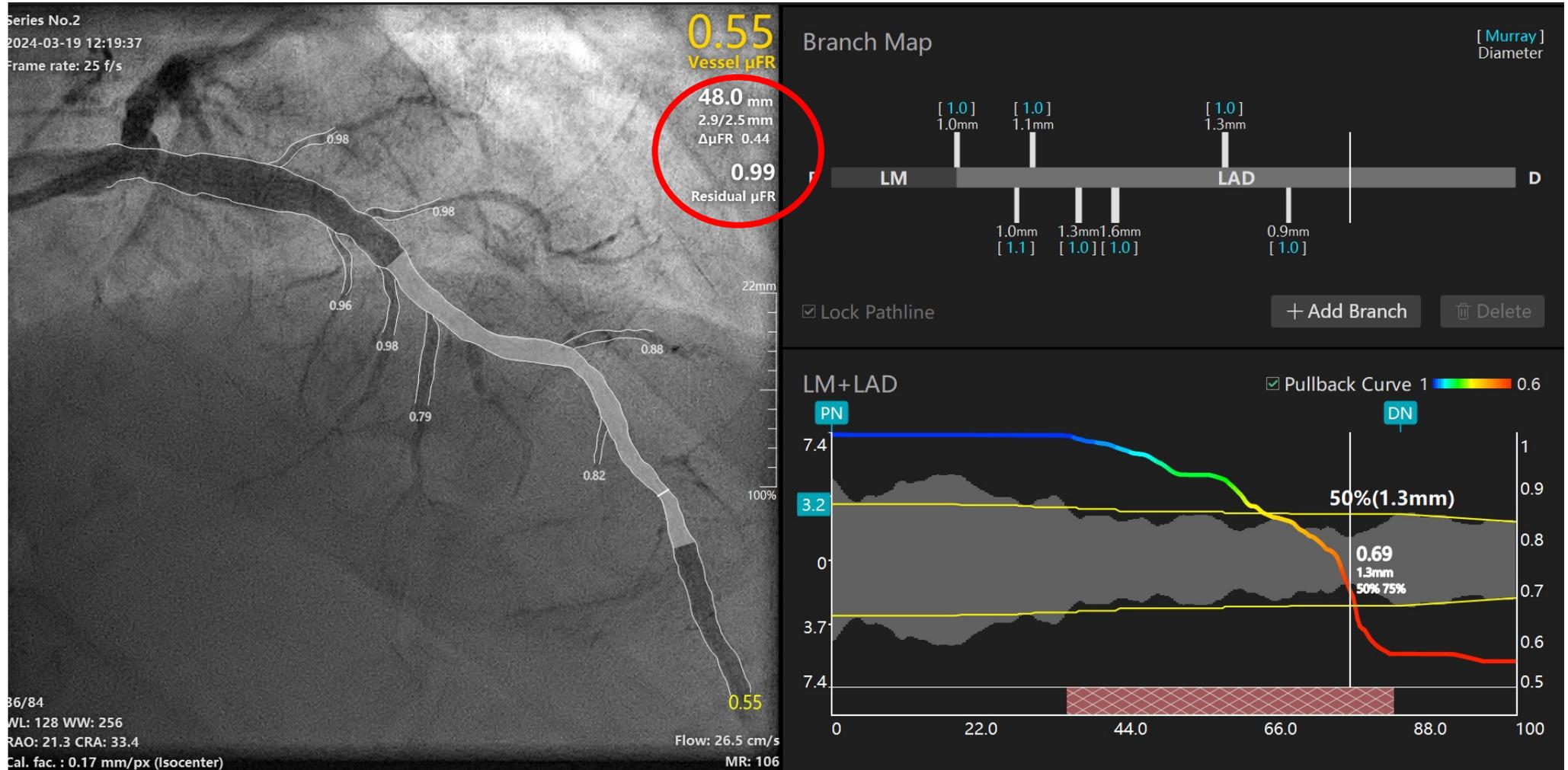
Post stenting
2,75 x 9 mm



Cas n°3

Angor stable

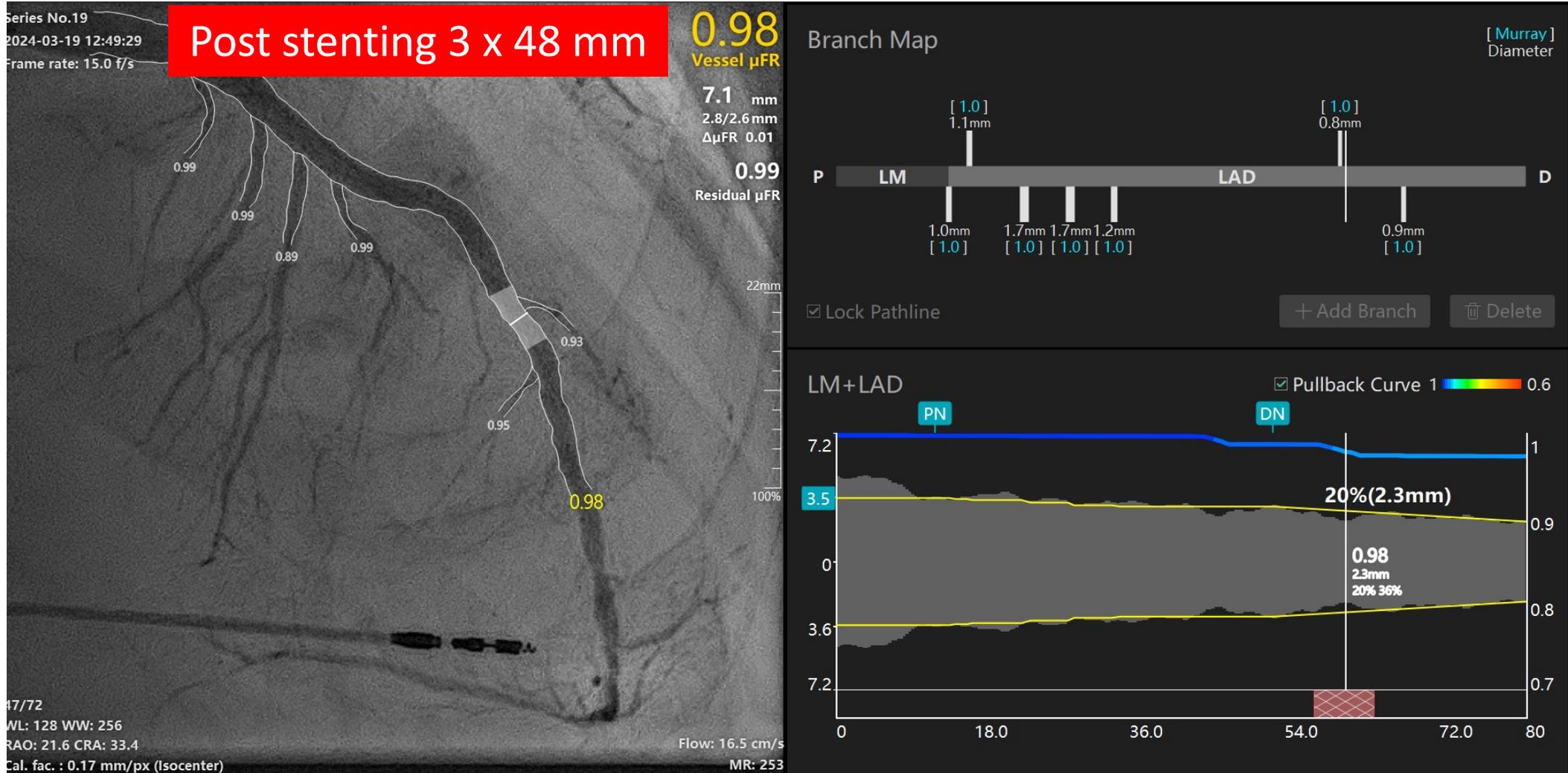
Virtual stenting : 48 mm => μ FR prédite 0,99



Cas n°3

Angor stable

Virtual stenting : 48 mm => μ FR prédite 0,99



Cas n°4

Blockpnée d'effort AC/FA

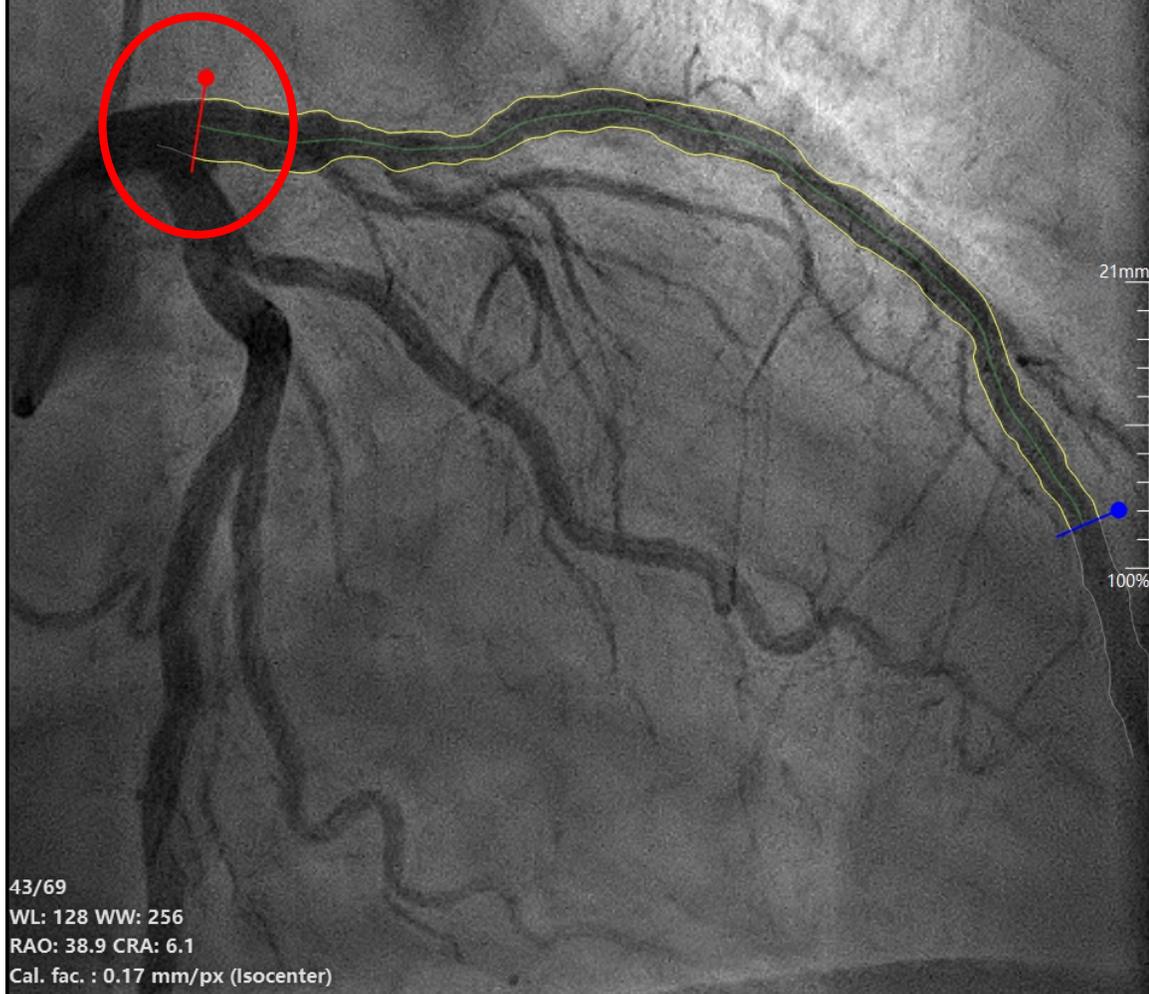
The screenshot displays a medical software interface with several components:

- Preview:** A vertical strip on the left showing a series of small image thumbnails labeled 10 through 14, with associated projection angles and CRA values (e.g., RAO 34.6 CRA 2.5, RAO 1.7 CRA 25.3, RAO 0.6 CRA 21.7, RAO 35.3 CRA 5.5, RAO 38.9 CRA 6.0).
- Browser:** The main central area containing two tables and a dialog box.
 - Patient/Study Information Table:**

No.	Patient ID	Patient Name	Gender	Birthdate	Modality	Study Date	Study ID	Accession Number	Description	File Path
197	100022545157		M	1975-07-31	XA	2024-03-27	468396	C468396	Coronarographie	D:\PStationData\Import\1.2.2
196	100016645941		M	1947-08-17	XA	2024-03-27	468394	C468394	Coronarographie	D:\PStationData\Import\1.2.2
195	900000018354							C468386	Coronarographie	D:\PStationData\Import\1.2.2
194	900000018017							C468275	Coronarographie	D:\PStationData\Import\1.2.2
193	test-10								Cardiac	D:\PStationData\Import\1.2.2
192	test-09								DSA	D:\PStationData\Import\1.2.2
191	test-08								CARD HDR NEW	D:\PStationData\Import\1.2.2
190	test-06								CARD HDR NEW	D:\PStationData\Import\1.2.2
189	test-07								DSA	D:\PStationData\Import\1.2.2
188	test-05								CARD HDR NEW	D:\PStationData\Import\1.2.2
187	test-04								DSA	D:\PStationData\Import\1.2.2
186	test-03								Cardiac	D:\PStationData\Import\1.2.2
 - Series Information Table:**

No.	Series No.	Frames	Modality	Series Date/Time	Projection Angle	File Name	Description	Notes
8	8	68	XA	2024-03-27 14:10:25	LAO 85.9 CAU 6.4	XA1.3.46.670589.28.68172...	Coro 15 i/s Normal	
9	9	100	XA	2024-03-27 14:18:47	LAO 34.6 CAU 2.5	XA1.3.46.670589.28.68172...	Coro 15 i/s Faible	
10	10	24	XA	2024-03-27 14:19:01	RAO 1.7 CRA 25.3	XA1.3.46.670589.28.68172...	Coro 15 i/s Faible	
11	11	98	XA	2024-03-27 14:20:01	RAO 0.6 CRA 21.7	XA1.3.46.670589.28.68172...	Coro 15 i/s Faible	
12	12	82	XA	2024-03-27 14:20:14	RAO 35.3 CRA 5.5	XA1.3.46.670589.28.68172...	Coro 15 i/s Faible	
13	13	64	XA	2024-03-27 14:31:34	RAO 38.9 CRA 6.0	XA1.3.46.670589.28.68172...	Coro 15 i/s Normal	
14	14	69	XA	2024-03-27 14:31:53	RAO 38.9 CRA 6.0	XA1.3.46.670589.28.68172...	Coro 15 i/s Normal	
15	0		OT	2024-03-27 14:33:16		SC1 3.46.670589.28.681722	Rapport de Dose	
 - Vessel Type Dialog:** A modal window with a graph showing CRA (0-60) vs RAO (90-0-90) and a legend for LAD, LCX, and RCA. A red circle highlights a point on the graph. A "CONFIRM" button is visible.

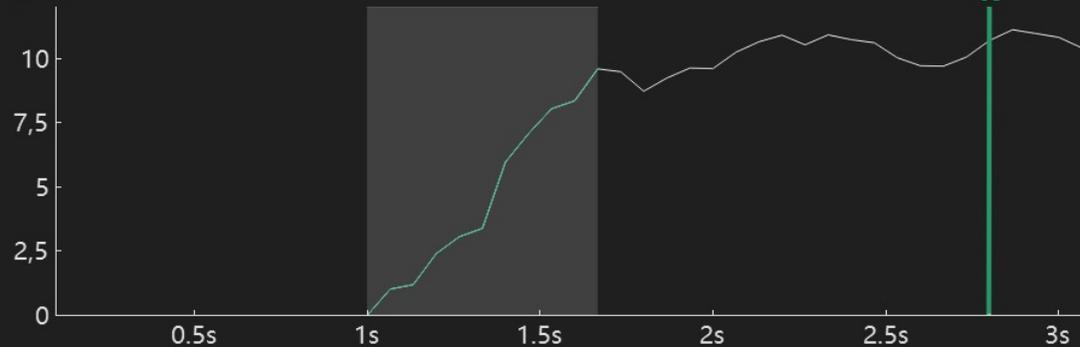
Series No.14
2024-03-27 14:31:53
Frame rate: 15.0 f/s



43/69
WL: 128 WW: 256
RAO: 38.9 CRA: 6.1
Cal. fac. : 0.17 mm/px (Isocenter)

LAD

(cm)



Flow Velocity: 16.5 cm/s
(Confidence: 99%)

Use Fixed Flow for μ FR

Check Contour

Zoom Image to Contour

Lock Pathline

Include LM



Series No.14
2024-03-27 14:31:53
Frame rate: 15.0 f/s

0.81
Vessel μ FR

19.4 mm
3.1/3.1 mm
 $\Delta\mu$ FR 0.11

0.92
Residual μ FR



43/69
WL: 128 WW: 256
RAO: 38.9 CRA: 6.1
Cal. fac. : 0.17 mm/px (Isocenter)

Flow: 16.5 cm/s
MR: 211



Flow μ FR-2D

μ FR-3D DONE

Limites de la μ FR



- Lésions ostiales (< 3mm de l'aorte)
- Superpositions
- Tortuosités importantes
- Pontages
- Flux TIMI < 3
- Hémodynamique instable
- Pont myocardique

Bifurcations : validée ...
sauf pour les branches filles
avec Medina 1,0,1 ou 1,1,1

Cas non adapté à la μ FR

Lésion difficile à dégager ;
superpositions



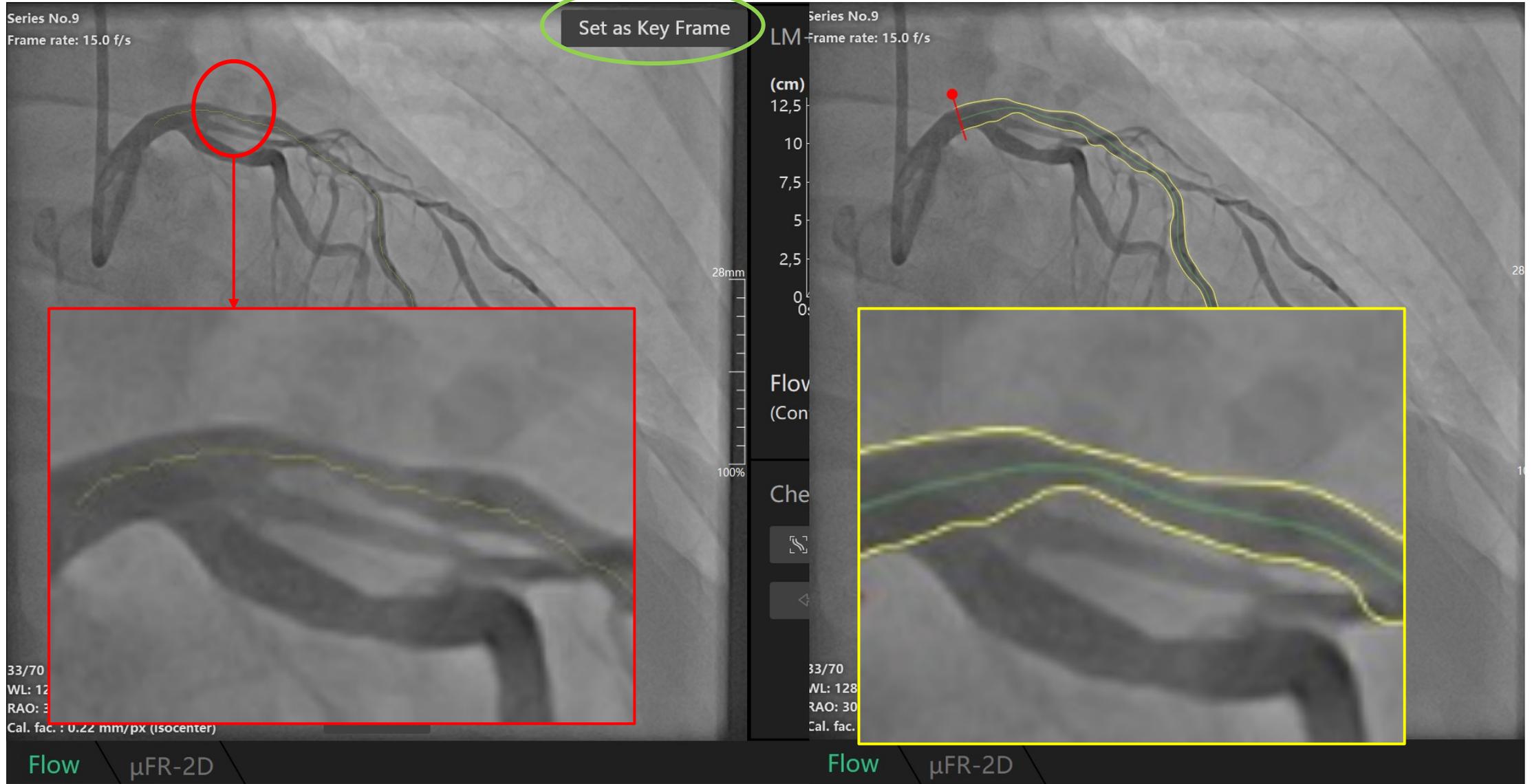
Lésion bien dégagée mais
incidence non appropriée



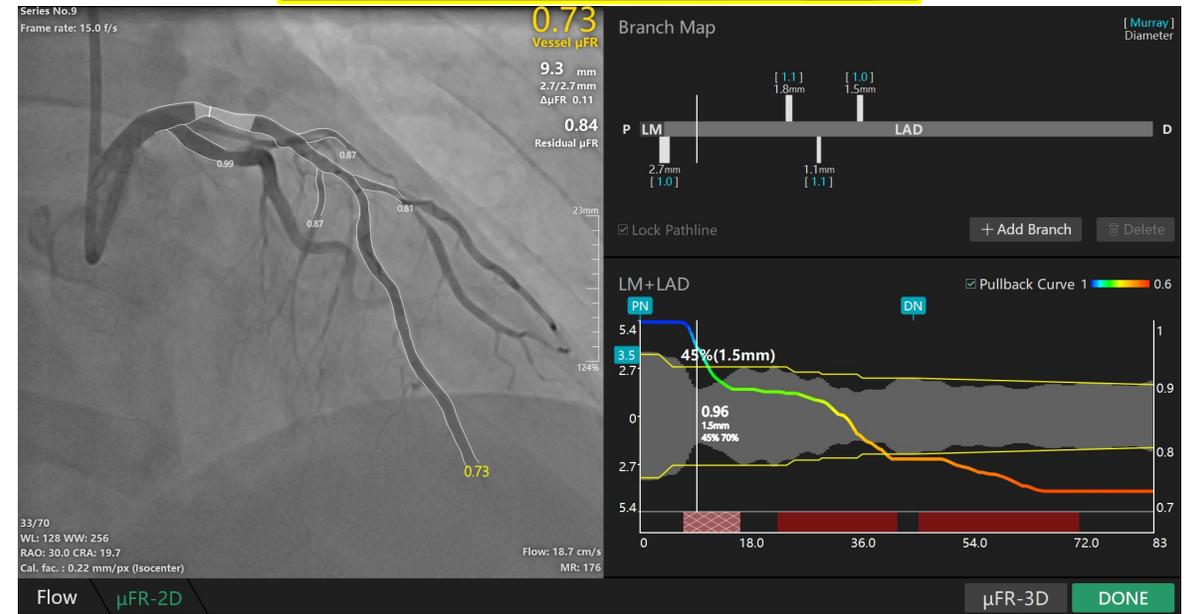
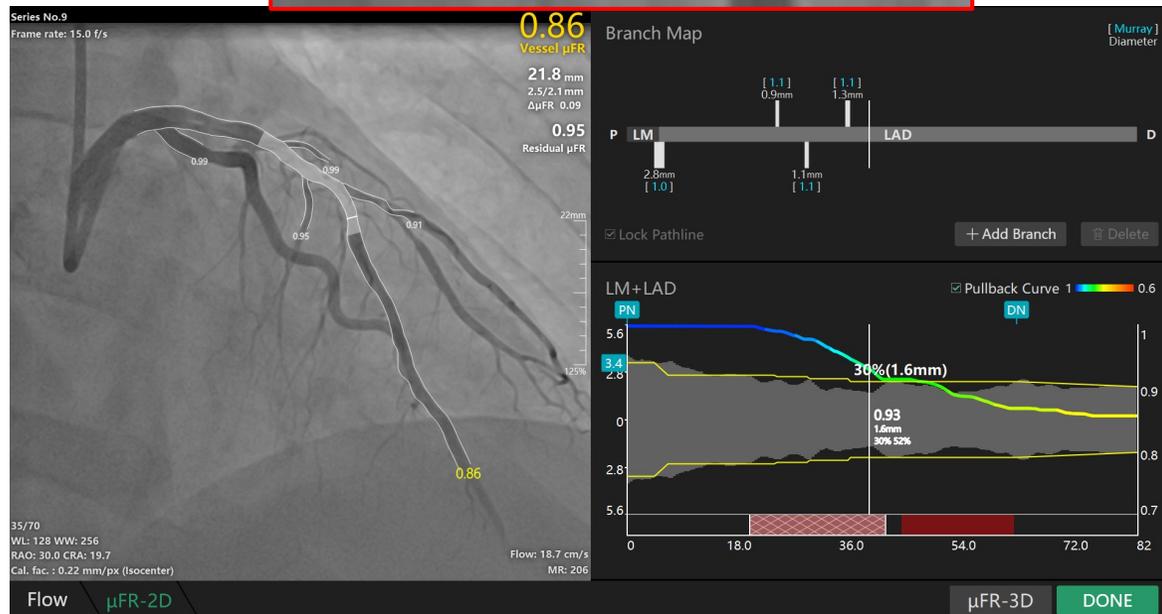
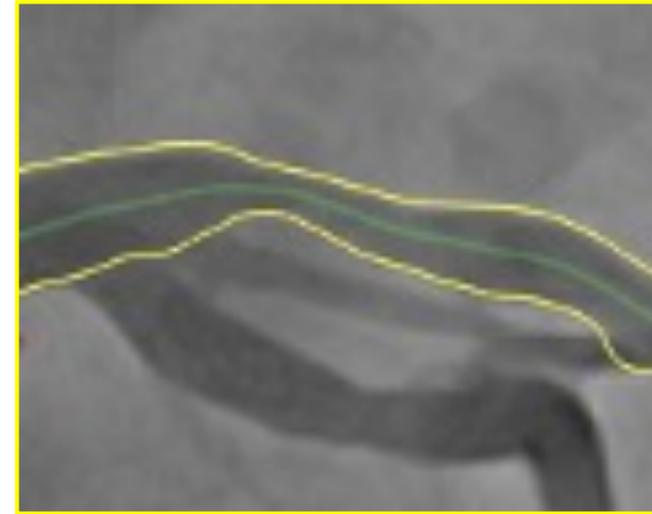
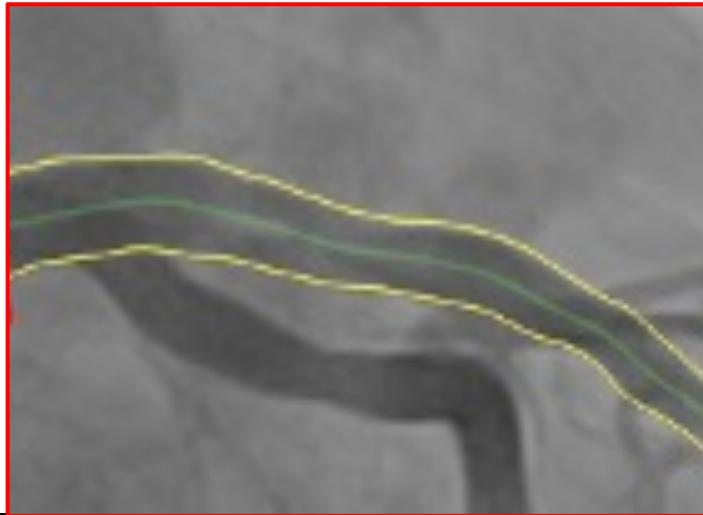
Attention aux pièges



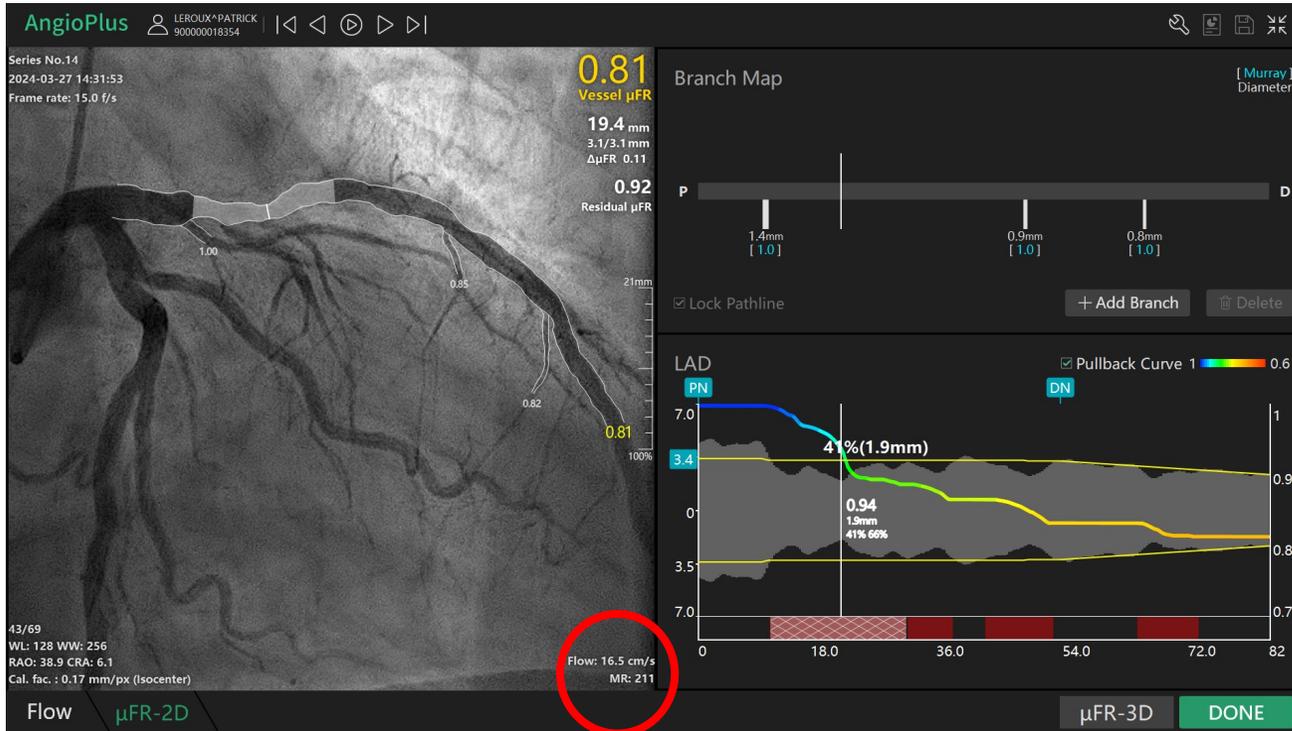
Attention aux pièges



Attention aux pièges



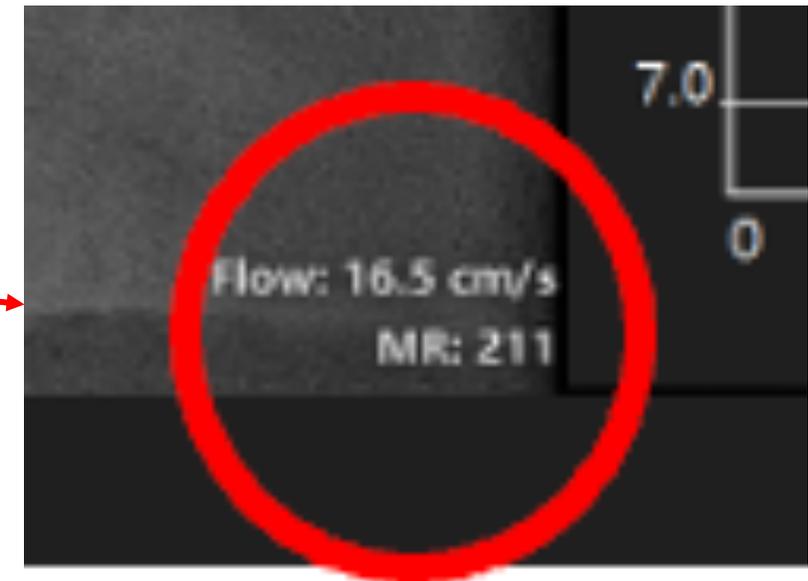
Et la microcirculation ?



$$AMR = \frac{P_d}{Velocity_{hyp}} = \frac{P_a \times \mu QFR}{Velocity_{hyp}}$$

AMR en mmHg.s / m

Cut off 250



Microcirculation

AMR : **A**ngiographic **M**icrovascular **R**esistance

Excellente corrélation avec IMR
Bonnes sensibilité et spécificité

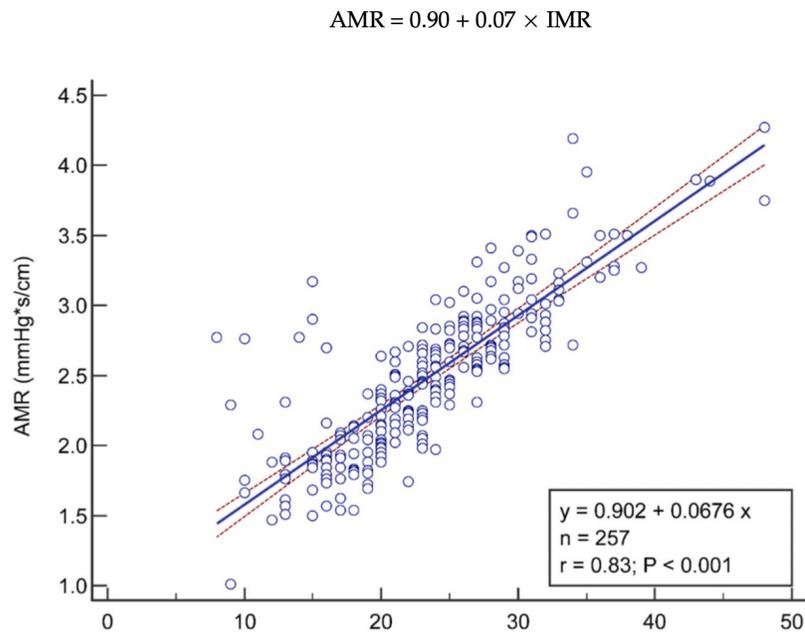


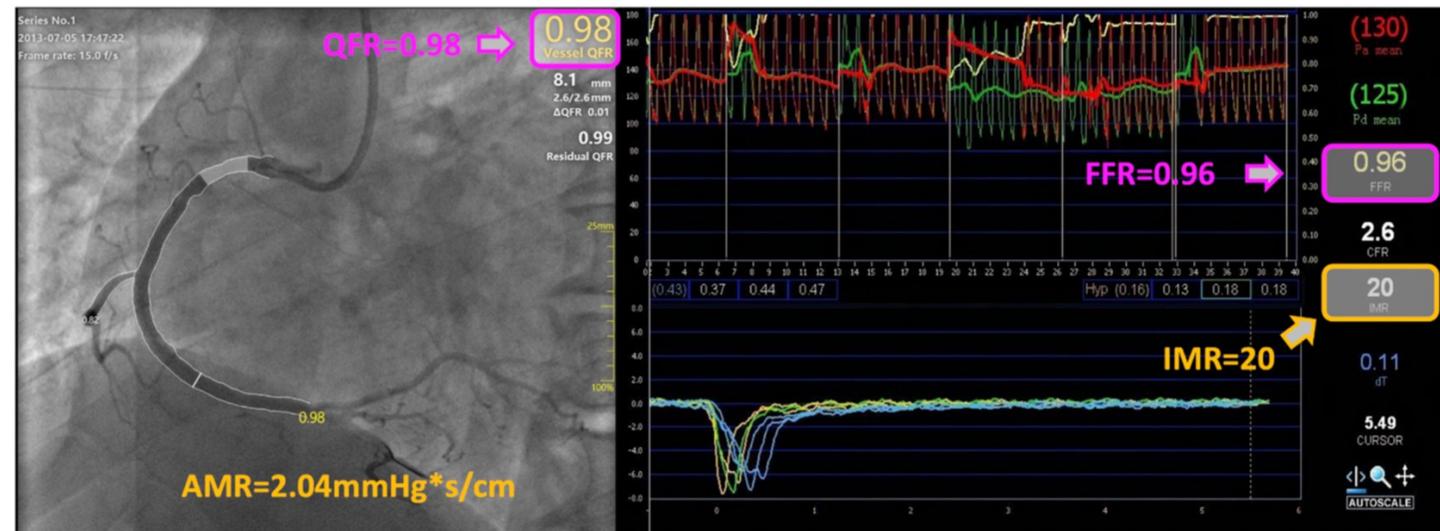
Figure 1. Correlation and the linear regression between AMR and IMR. AMR values (y axis) showed good correlation ($r = 0.83, p < 0.001$) with IMR (x axis). The red dotted line represents the 95% CI of the linear regression equation that was quantified as $AMR = 0.90 + 0.07 \times IMR$. AMR, angio-derived microcirculatory resistance; IMR, index of microvascular resistance.

Table 3. The diagnostic performance of AMR in predicting $IMR \geq 25$.

Best Cutoff Value for AMR	AMR > 2.5
Accuracy, % (95% CI)	87.2 (83.0–91.3)
Sensitivity, % (95% CI)	93.5 (87.0–97.3)
Specificity, % (95% CI)	82.7 (75.6–88.4)
PPV, % (95% CI)	79.4 (71.2–86.1)
NPV, % (95% CI)	94.7 (89.3–97.8)
+LR, (95% CI)	5.39 (3.80–7.70)
–LR, (95% CI)	0.08 (0.04–0.20)

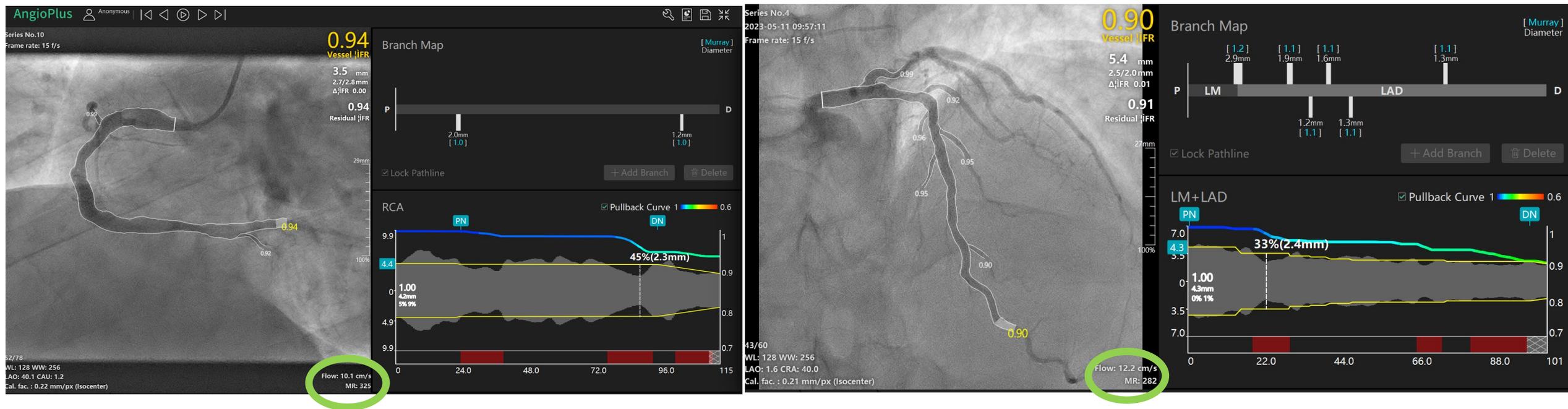
LR, likelihood ratio; NPV, negative predictive value; PPV, positive predictive value.

The best cutoff value for AMR in predicting $IMR \geq 25$ defined by Youden test from the ROC analysis was 2.5 mmHg*s/cm.



Cas n°1

Angor, IRM de stress positive
Pas de lésion coronaire significative (μ FR négative)



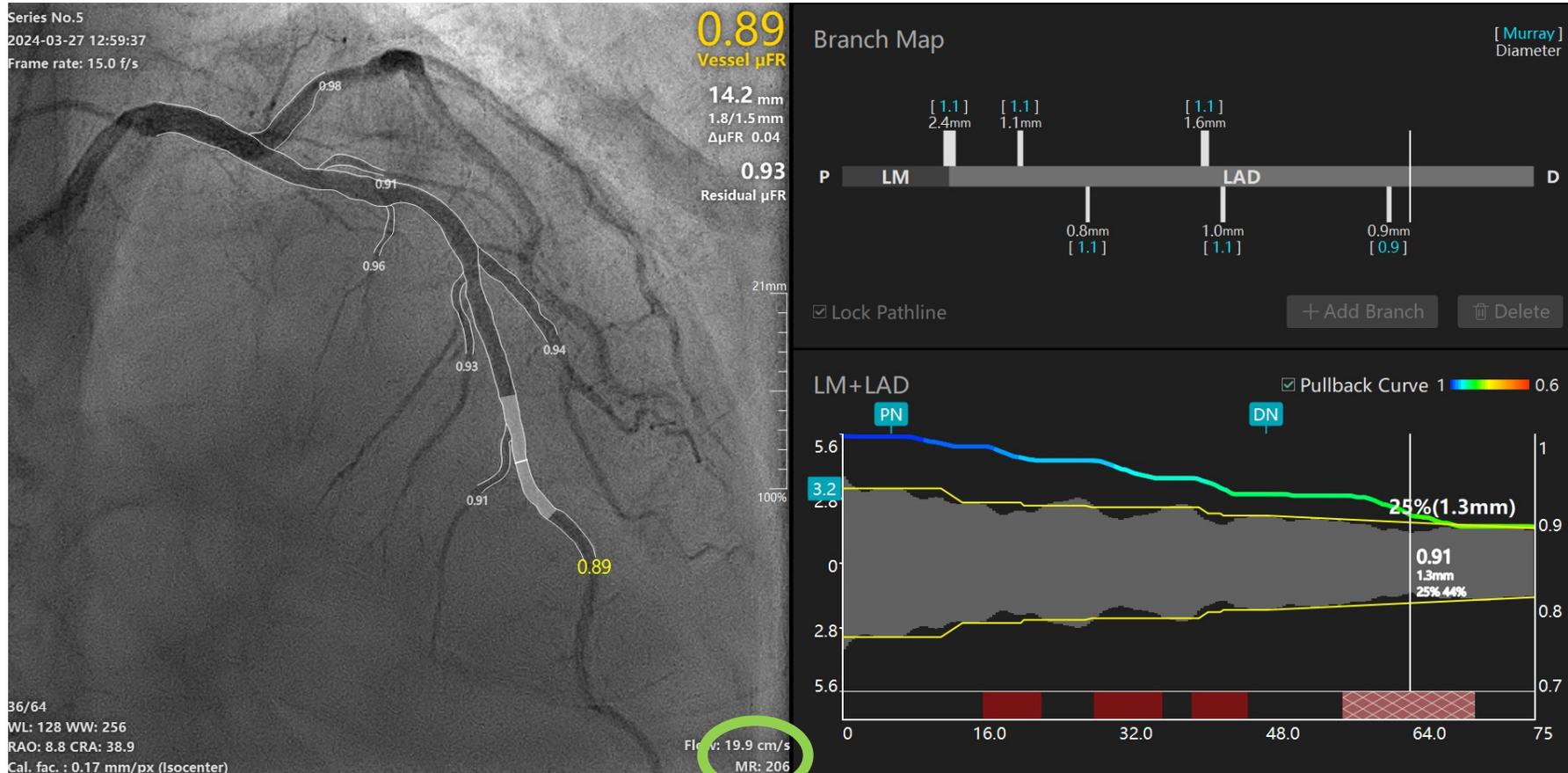
AMR élevée à 325 mmHg x s / m

AMR élevée à 282 mmHg x s / m

Angor microcirculatoire

Cas n°2

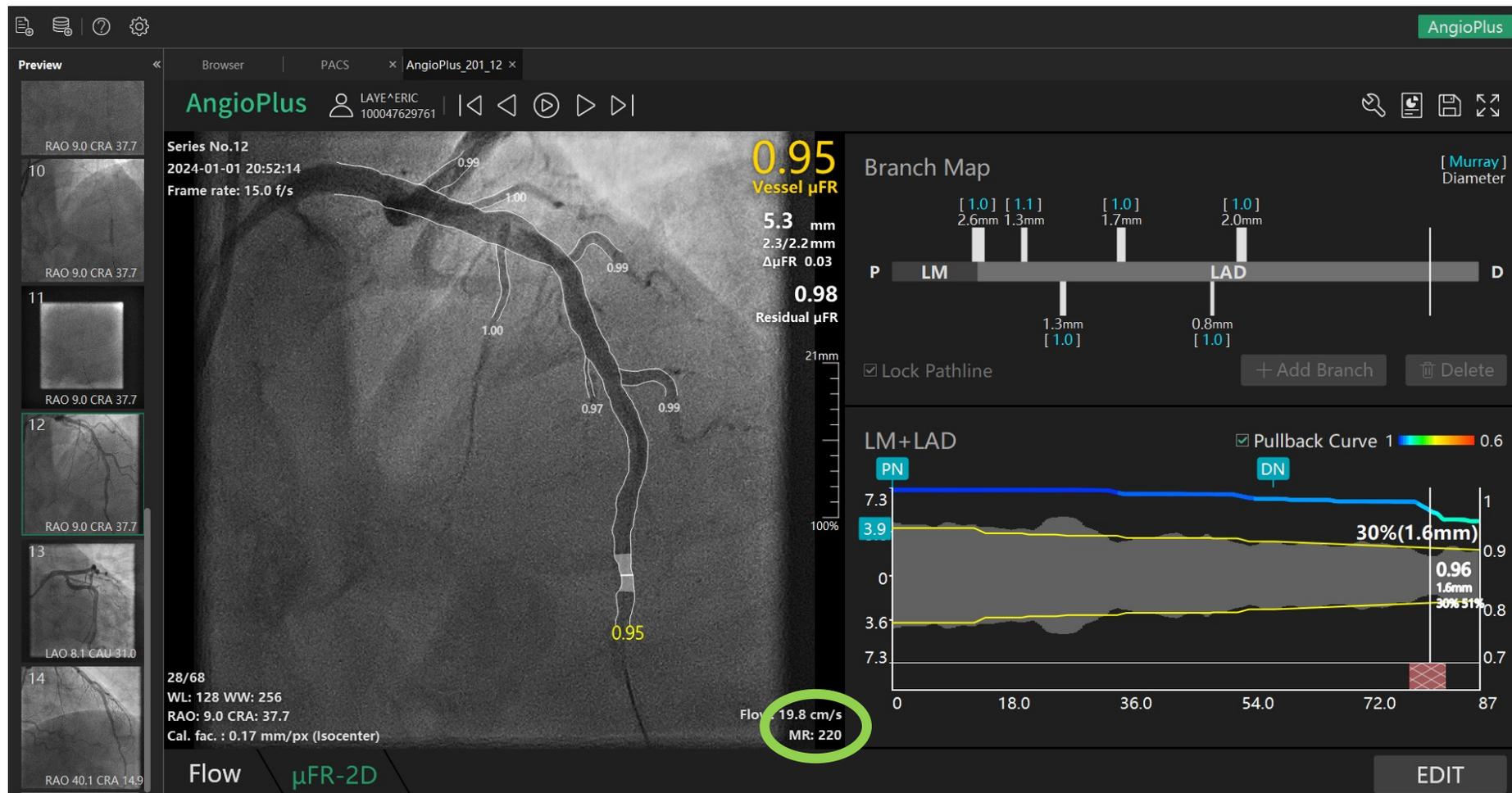
Pas de lésion coronaire significative (μ FR négative)
ANOCA



AMR normale à 206

Cas n°3

Post-infarctus antérieur



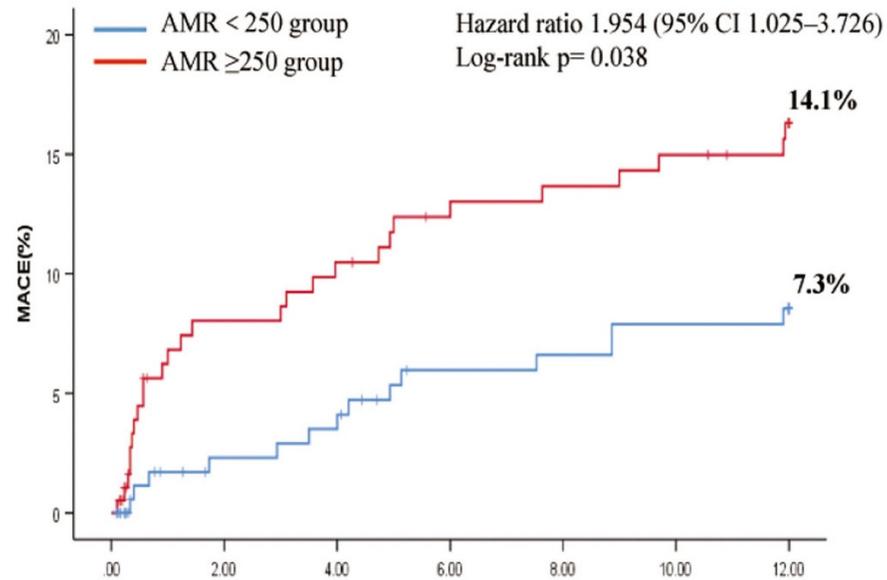
AMR 220

Valeur pronostique de l'AMR en post-infarctus

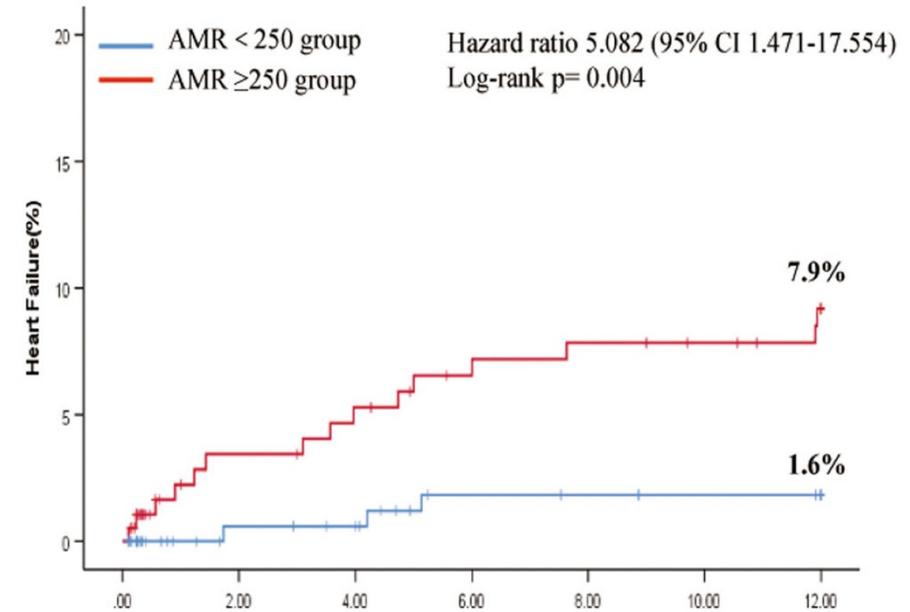
Application of AMR in evaluating microvascular dysfunction after ST-elevation myocardial infarction

Clin Cardiol 2024;47:e24196

Cut off AMR : 250



Number at risk	0	2	4	6	8	10	12
AMR ≥ 250 group	191	165	158	155	154	152	148
AMR < 250 group	191	168	165	158	157	155	154

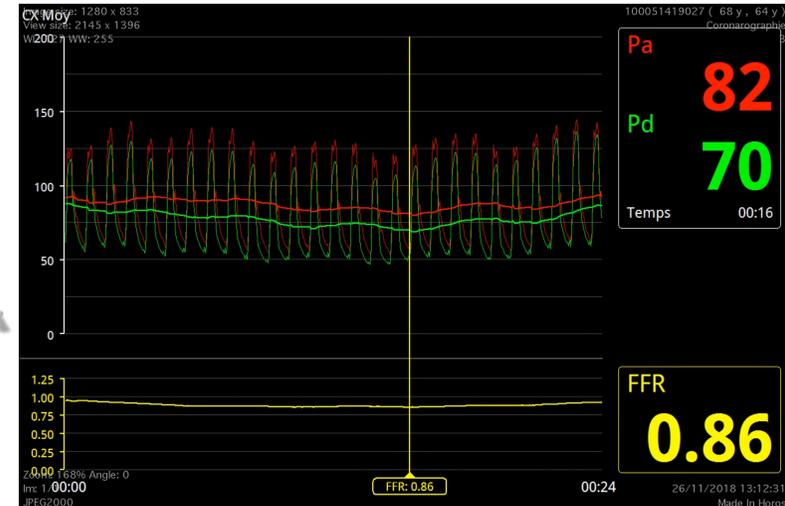


Number at risk	0	2	4	6	8	10	12
AMR ≥ 250 group	191	173	168	165	164	164	160
AMR < 250 group	191	171	171	165	165	165	165

À quoi s'attendre demain ?

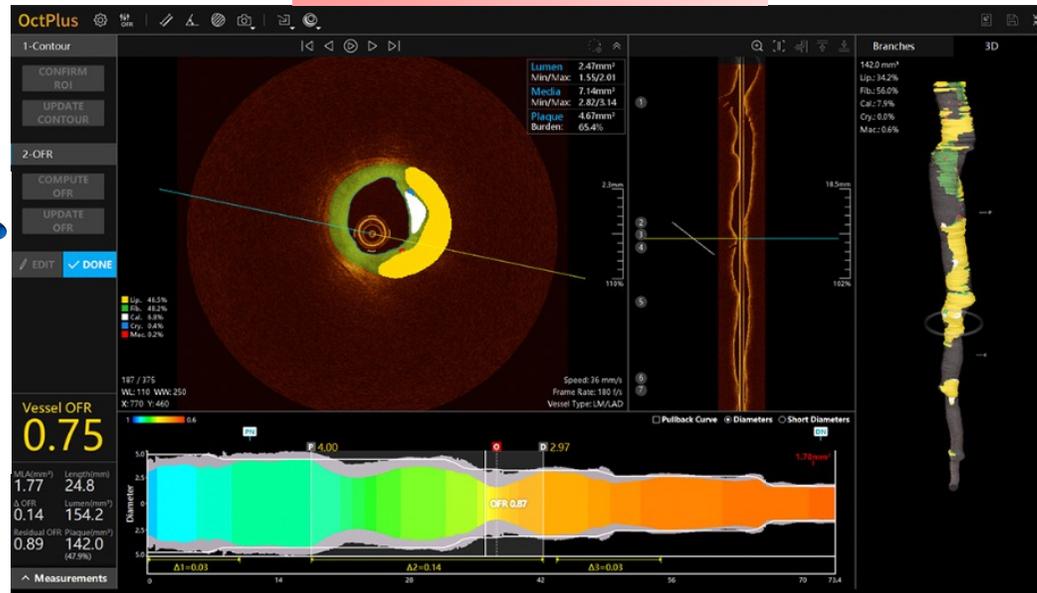


Évaluation lumière coronaire
Morphologie de la plaque
Apposition et expansion stent



Référence pour évaluation fonctionnelle d'une sténose coronaire

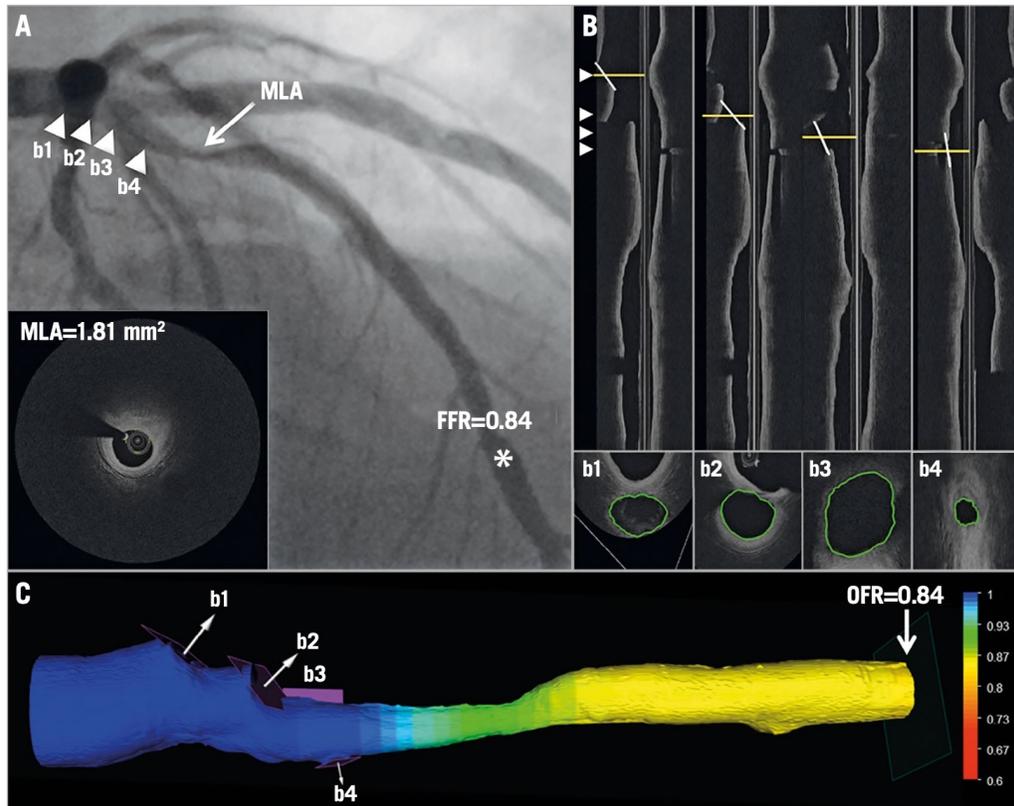
OFR



- Un seul outil – un seul cathéter
- Évaluation morpho-fonctionnelle basée sur l'OCT

Diagnostic accuracy of optical flow ratio: an individual patient data meta-analysis Eurointervention 2023;19:e145-e154

Fukang Hu¹, BSc; Daixin Ding², MSc; Jelmer Westra³, MD, PhD; Yingguang Li⁴, PhD; Wei Yu¹, PhD; Zhiqing Wang⁵, MD; Takashi Kubo⁶, MD, PhD; Juan Luis Gutiérrez-Chico⁷, MD, PhD; Yundai Chen⁸, MD, PhD; William Wijns², MD, PhD; Shengxian Tu^{1*}, PhD

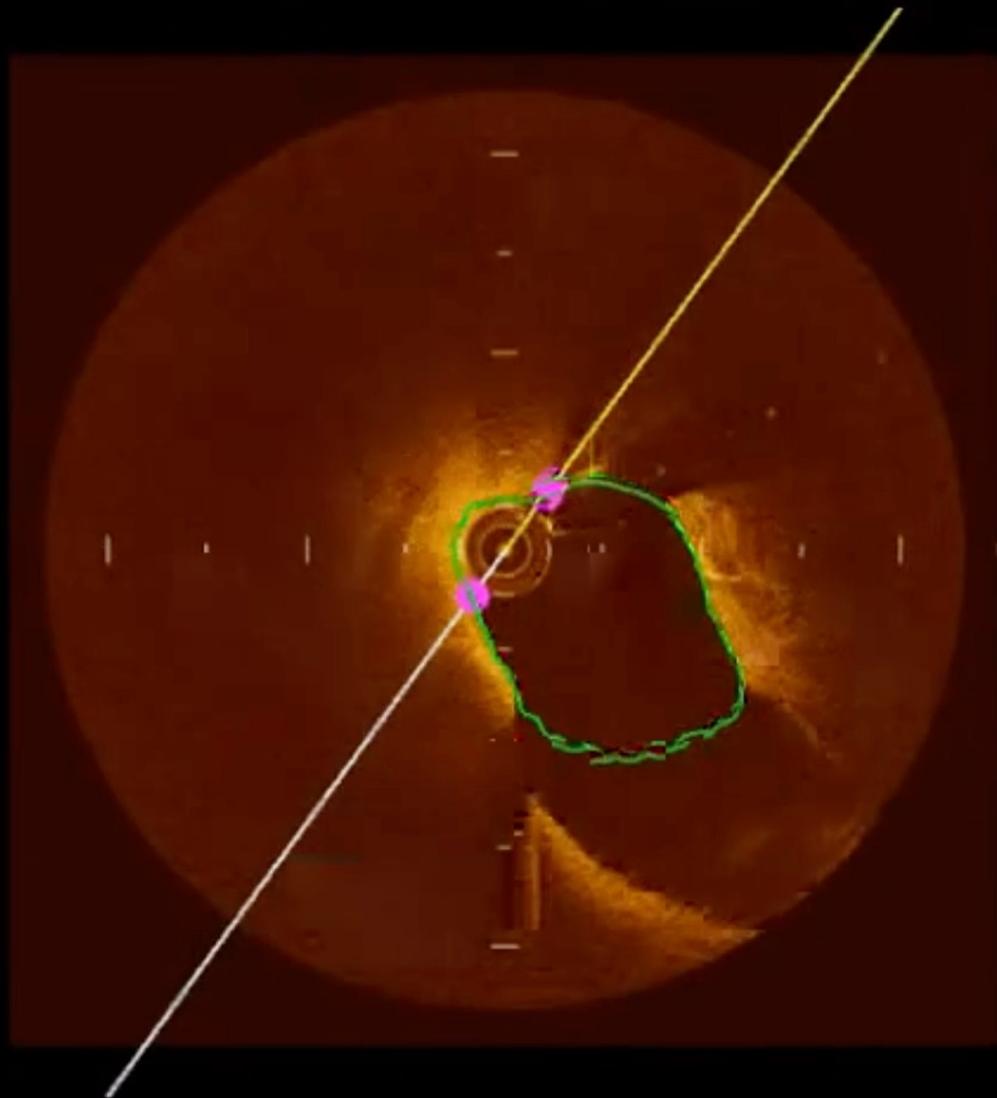


Study	Patients (vessels)	Median FFR	FFR ≤0.80	FFR ≤0.90	Correlation	SD	Accuracy, % (95% CI)	AUC (95% CI)
Yu et al ³	118 (125)	0.80 (0.79-0.82)	50.4%	86.4%	0.70	0.07	90 (84-95)	0.93 (0.87-0.97)
Huang et al ⁴	181 (212)	0.83 (0.81-0.85)	40.1%	75.0%	0.87	0.05	92 (88-95)	0.97 (0.93-0.99)
Gutierrez-Chico et al ⁵	53 (67)	0.84 (0.82-0.86)	34.3%	79.1%	0.82	0.05	93 (86-99)	0.95 (0.86-0.99)
Emori et al ⁶	103 (103)	0.91 (0.89-0.93)	7.8%	52.4%	0.84	0.02	90 (82-95)	0.90 (0.83-0.95)
Ding et al ⁷	119 (119)	0.94 (0.92-0.95)	3.4%	26.1%	0.80	0.04	84 (77-91)	0.89 (0.82-0.94)

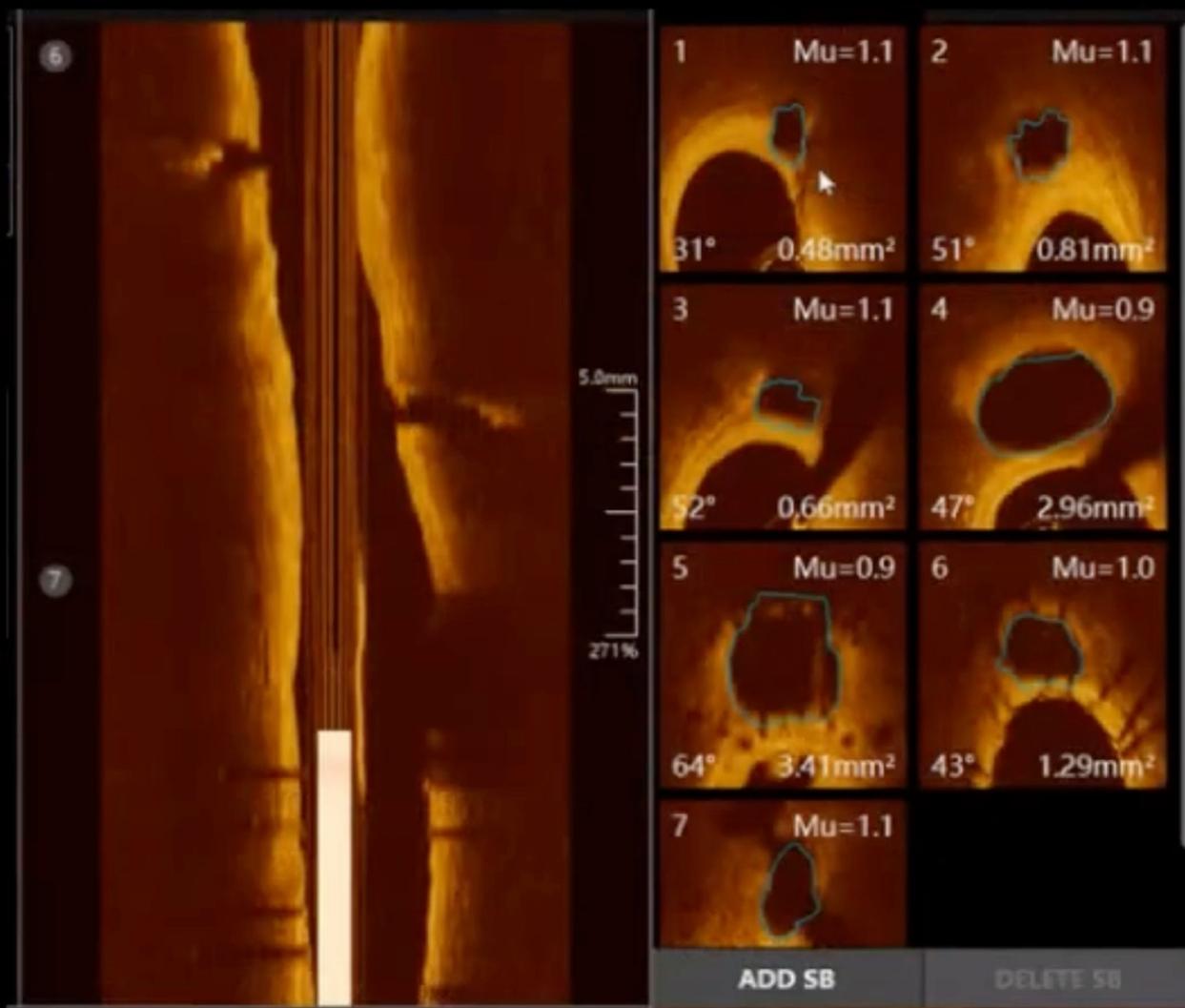
AUC: area under the curve; CI: confidence interval; FFR: fractional flow reserve; SD: standard deviation

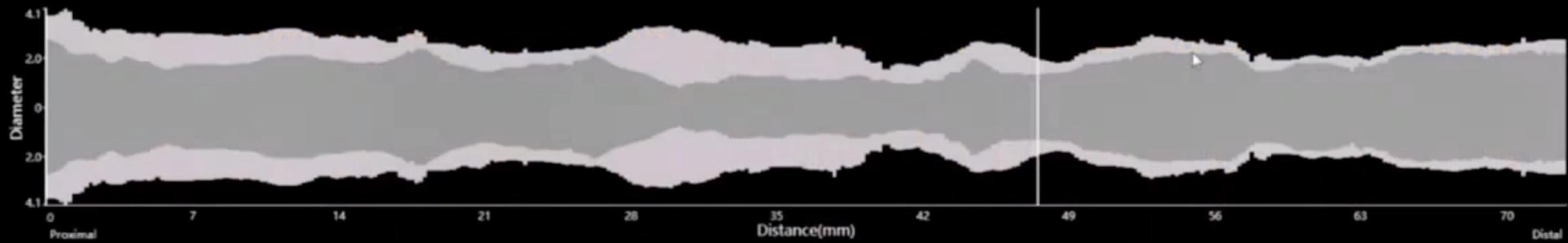
**Concordance OFR / FFR : 90 %
(91% en pré-PCI et 87% en post-PCI)**

Lumen Segmentation



Sidebranch Ostia Quantification

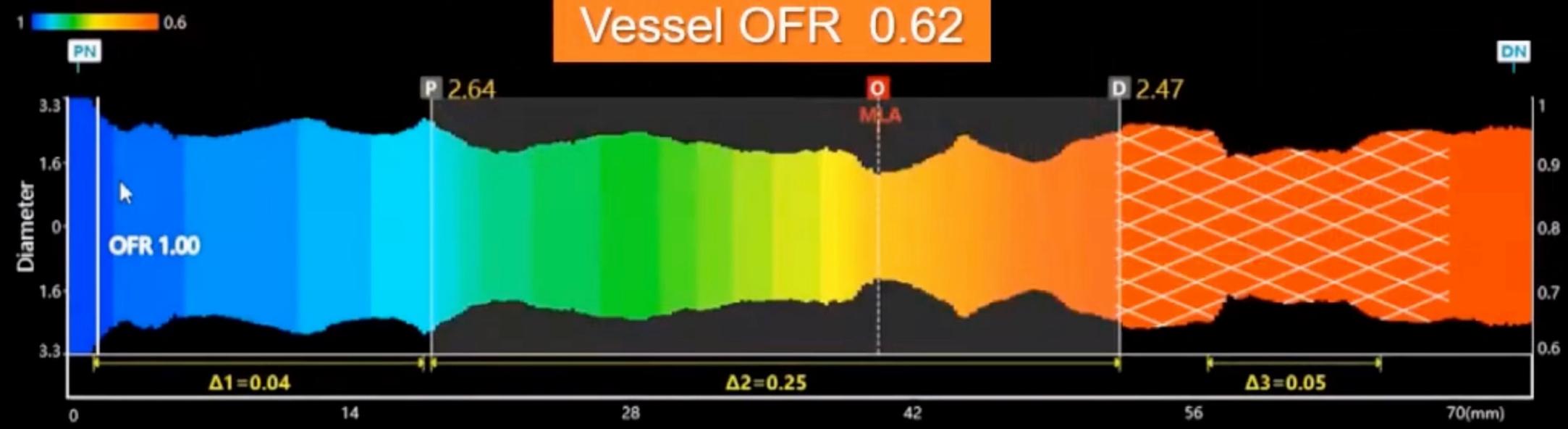




Fluid Dynamics Equations



Vessel OFR 0.62



Series Date/Time: 1899-12-30 00:00:00
Series Number: 0
Patient Name: Anonymous
Patient ID:
Gender: O
Birthday: 1899-12-30

Long Diam: 5.09 mm
Short Diam: 4.63 mm
Ref. Diam: 4.80 mm
Lumen Area: 18.45 mm²

AI-based Plaque Characterization

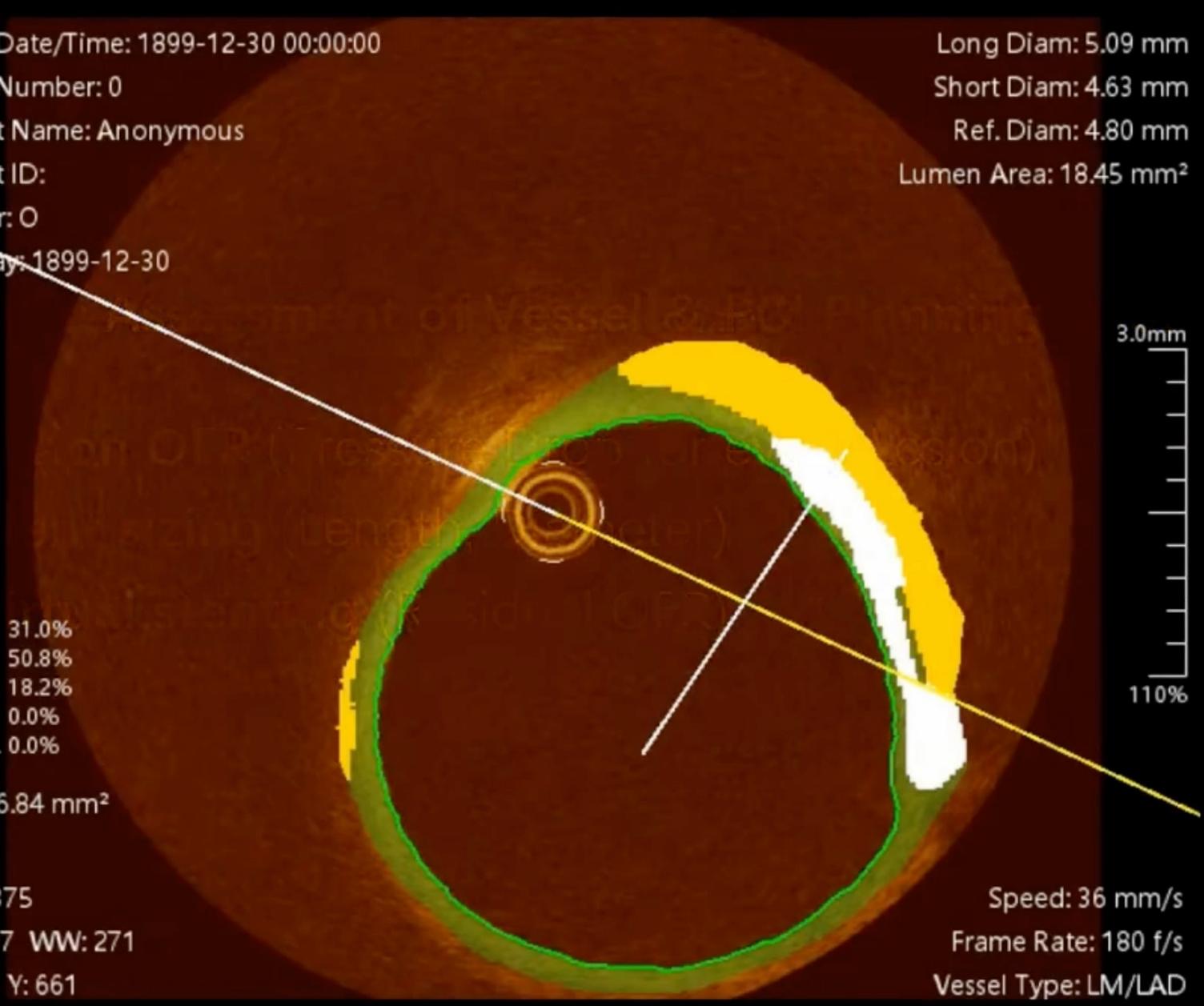
- Lip. 31.0%
- Fib. 50.8%
- Cal. 18.2%
- Cry. 0.0%
- Mac. 0.0%

Total: 6.84 mm²

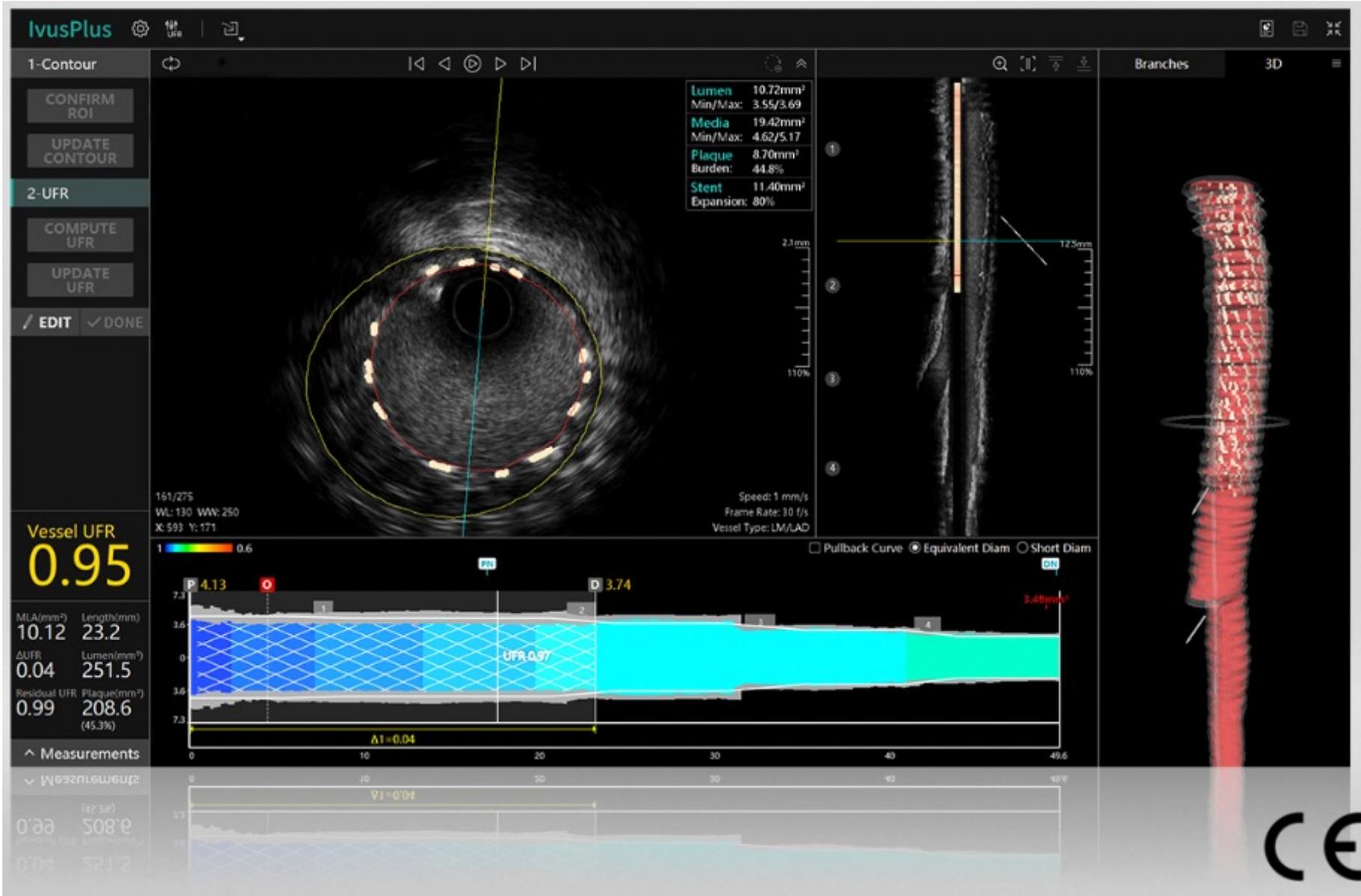
349 / 375

WL: 107 WW: 271

X: 312 Y: 661



UFR : Ultrasonic Flow Ratio



RWS : Radial Wall Strain

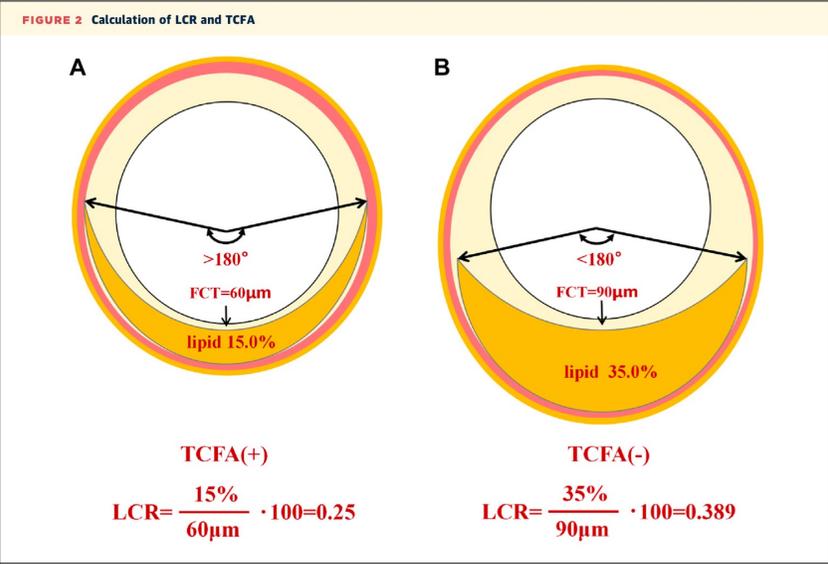
Radial wall strain: a novel angiographic measure of plaque composition and vulnerability *Eurointervention* 2023;18:1001-10

$$RWS = \frac{D_{max} - D_{min}}{D_{max}}$$

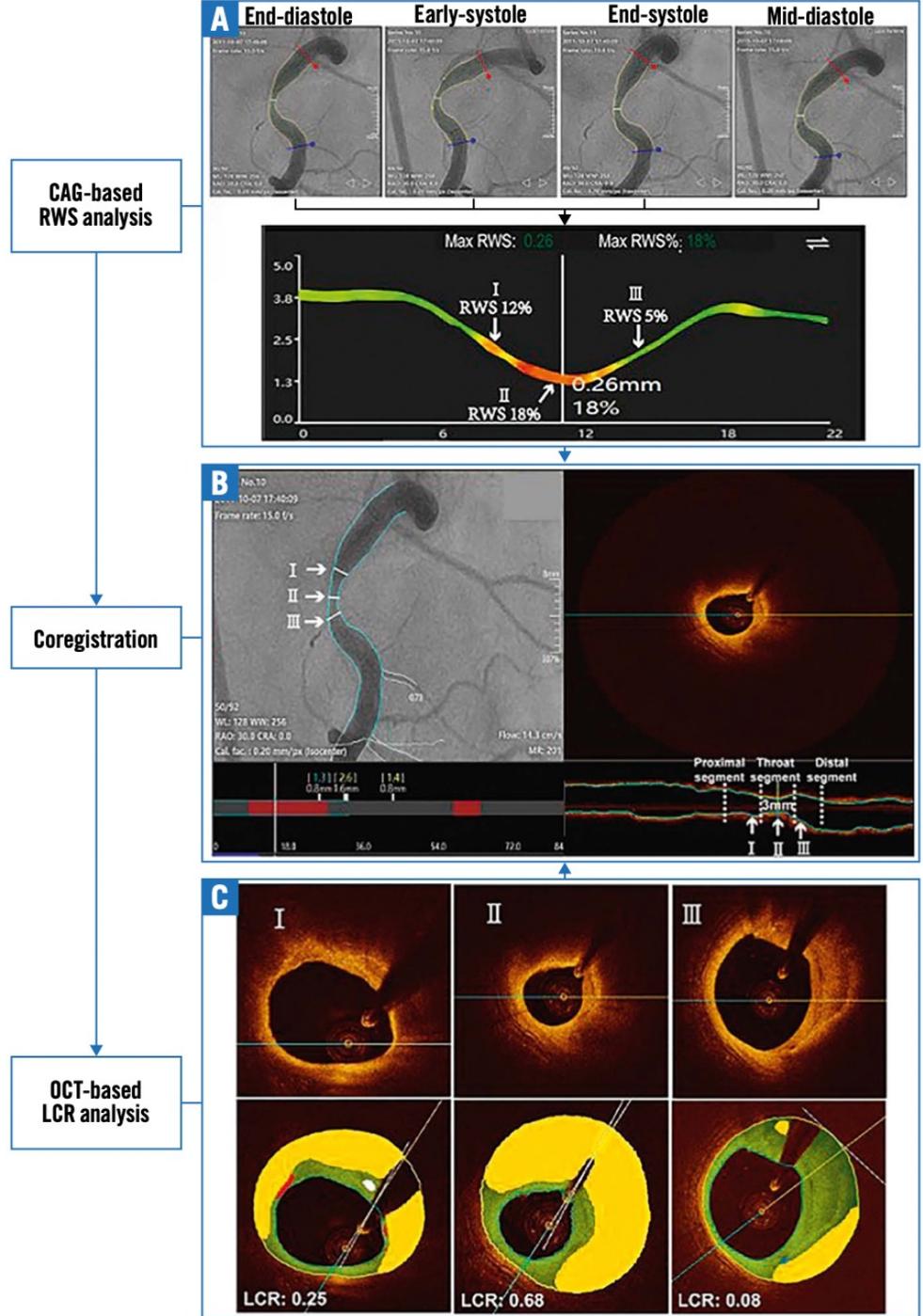
RWS_{max} = RWS maximal le long de la lésion étudiée

$$LCR = \frac{LPB}{FCT}$$

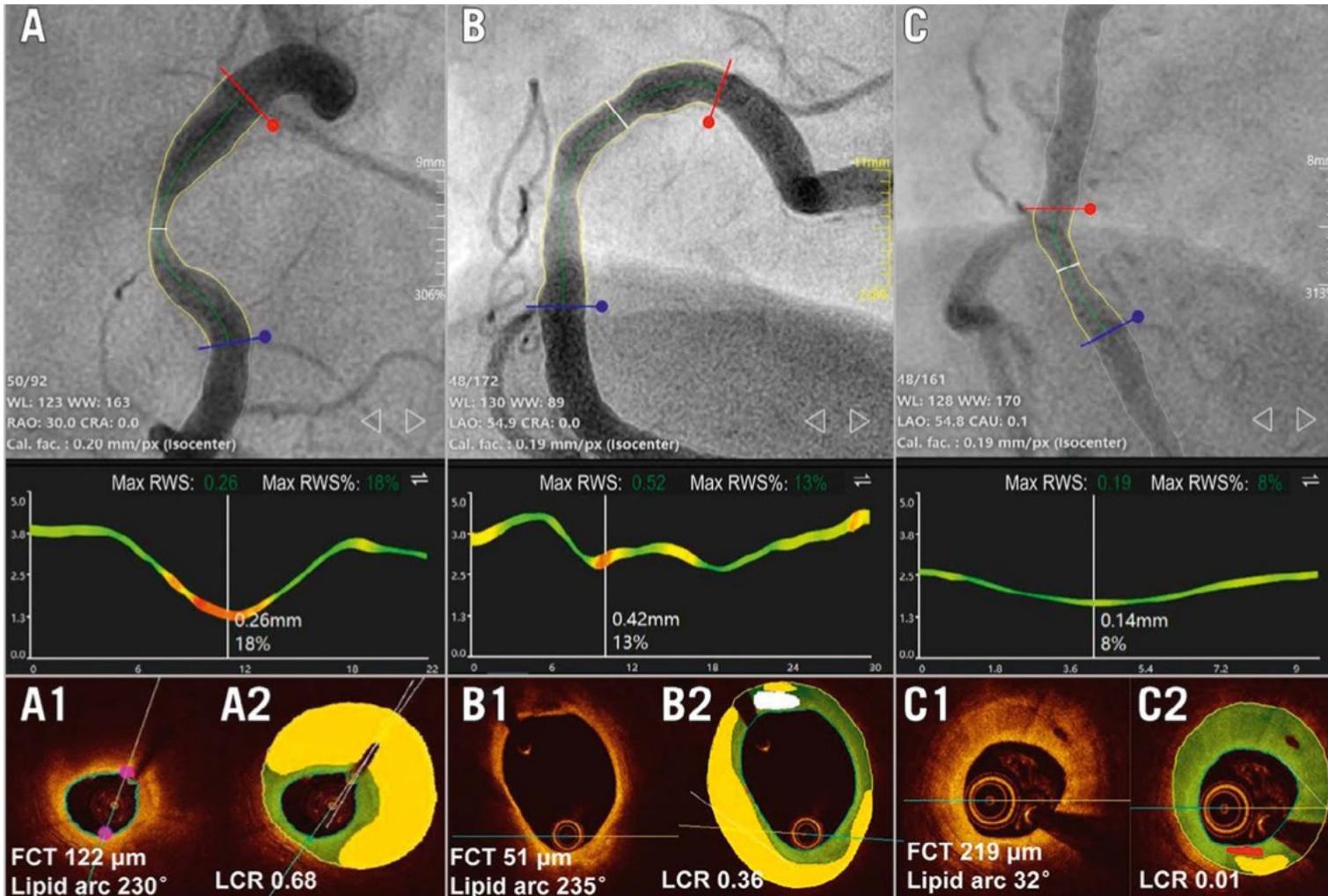
LCR : Lipid to Cap Ratio
 LPB : Lipid Plaque Burden
 FCT : Fibrous cap thickness



JACC: Asia 2022;2:460-72



RWS : Radial Wall Strain



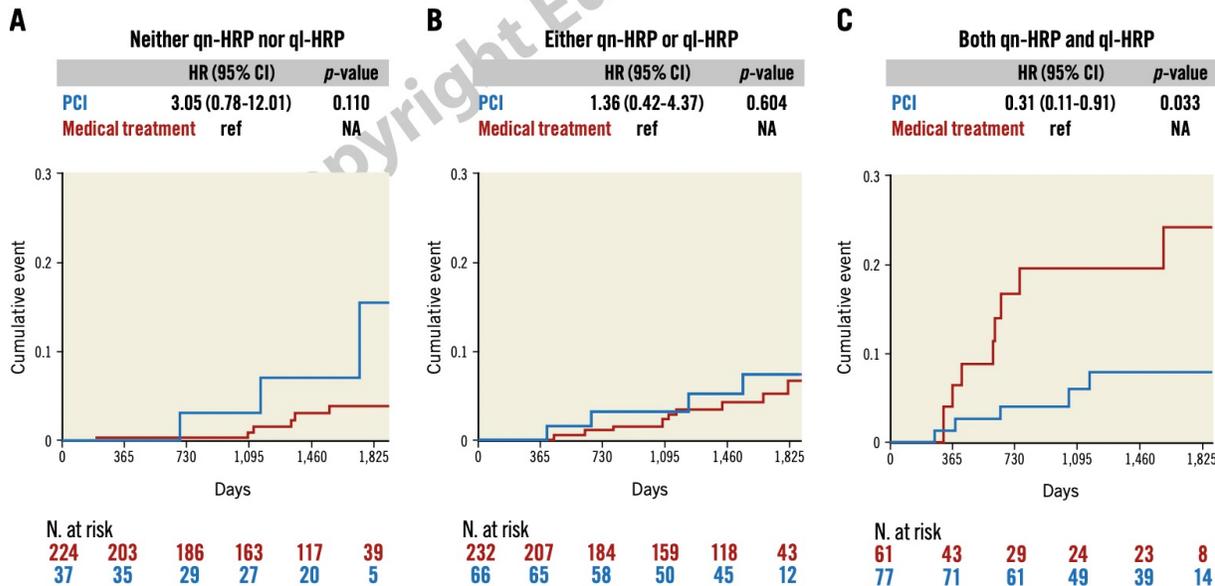
$RWS_{max} > 12\%$ prédit $LCR > 0,33$
(quelle que soit l'OFR)

RWS_{max} obtenu en 57 sec

1/3 des lésions non significatives
avaient $RWS_{max} > 12\%$ ou $LCR > 0,33$

Identifier les plaques vulnérables : l'avenir de l'angioplastie ?

Outcomes of non-ischaemic coronary lesions with high-risk plaque characteristics on coronary CT angiography



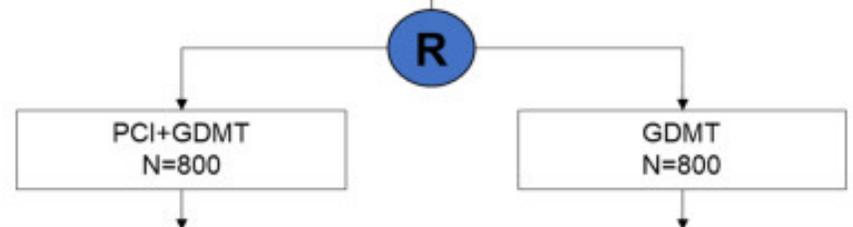
Eurointervention 2023;18:1011-21

The PREVENTive Coronary Intervention on Stenosis With Functionally Insignificant Vulnerable Plaque

PREVENT Trial

Any Significant Epicardial Coronary Stenosis (DS>50%) with $FFR > 0.80$ and with **Two** of the following

1. IVUS MLA $< 4.0\text{mm}^2$
2. IVUS Plaque Burden $> 70\%$
3. Lipid-Rich Plaque on NIRS ($_{\text{max}}\text{LCBI}_{4\text{mm}} > 315$)
4. TCFA by OCT or VH-IVUS



Primary endpoint: Target Vessel Failure at 2 years
(Death from cardiac cause, target vessel myocardial infarction, ischemic-driven target vessel revascularization, or unplanned hospitalization due to unstable or progressive angina)

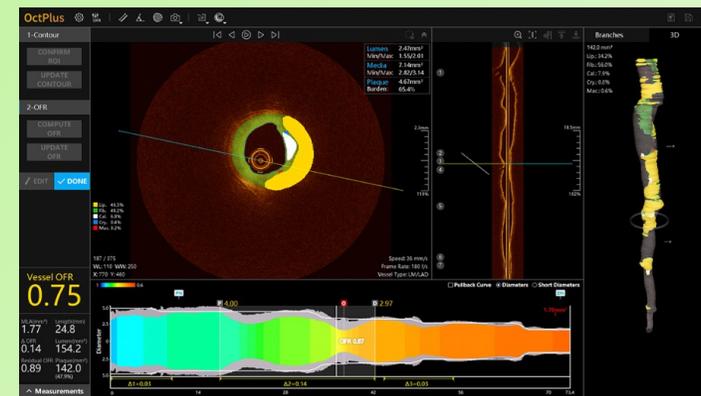
Am Heart J 2023;264:83-96

La μ FR d'aujourd'hui

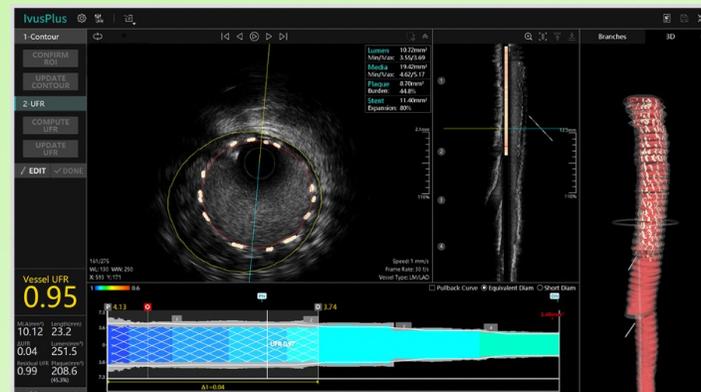
- Simple vue angiographique
- Analyse des bifurcations
- Analyse de la microcirculation
- Analyse du flow velocity
- Stenting virtuel : prédiction de la μ FR résiduelle
- Rapide < 1 min
- Non opérateur dépendant

L'avenir proche

OFR



UFR



RWS

