Cardiologie interventionnelle du futur

Julien Adjedj

Introduction

CARDIOVASCULAR MEDICINE AND SOCIETY

Past, Present, and Future of Interventional Cardiology

David R. Holmes, Jr, MD, Mohamad Alkhouli, MD

Plan

IMPACT ON INTERVENTIONAL CARDIOLOGY

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Workforce Issues

- **Cardiopathie Ischémique: quand la morphologie et la physiologie se rencontrent**

- **Cardiopathie structurelle: Parier sur le gagnant?**

- **Training: Et si on faisait comme dans l'aviation?**

- **Heart team: Fini le héro solitaire bienvenue la caution solidaire**

Holmes et al. JACC 2020

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Holmes et al. JACC 2020

FFR virtuelle: methodologie

CLINICAL REVIEW
Clinical update

ESC
European Society
of Cardiology

# Fractional flow reserve in clinical practice: from wire-based invasive measurement to image-based computation

Shengxian Tu [1*†], Jelmer Westra [2†], Julien Adjedj [3,4†], Daixin Ding[1], Fuyou Liang[5,6], Bo Xu [7], Niels Ramsing Holm[2], Johan H.C. Reiber[8], and William Wijns [9]

[1]School of Biomedical Engineering, Shanghai Jiao Tong University, No. 1954 Hua Shan Road, Shanghai 200030, China; [2]Department of Cardiology, Aarhus University Hospital, Skejby, Palle Juul-Jensens Boulevard 99, 8200 Aarhus N, Denmark; [3]Cardiology Department, Arnault Tzanck Institute, 171 Rue du Commandant Gaston Cahuzac, 06700 Saint-Laurent-du-Var, France; [4]Cardiology Department, CHUV, Rue du Bugnon 46, 1011 Lausanne, Switzerland; [5]School of Naval Architecture, Ocean and Civil Engineering, Shanghai Jiao Tong University, 800 Dongchuan Road, Shanghai 200240, China; [6]Institute for Personalized Medicine, Sechenov University, 8-2 Trubetskaya st., Moscow 119991, Russia; [7]Catheterization Laboratories, Fu Wai Hospital, National Center for Cardiovascular Diseases, Chinese Academy of Medical Sciences, National Clinical Research Center for Cardiovascular Diseases, A 167, Beilishi Road, Xicheng District, Beijing 100037, China; [8]Division of Image Processing, Department of Radiology, Leiden University Medical Center, Albinusdreef 2, 2333 ZA Leiden, The Netherlands; and [9]The Lambe Institute for Translational Medicine and Curam, National University of Ireland Galway, University Road, Galway H91 TK3, Ireland
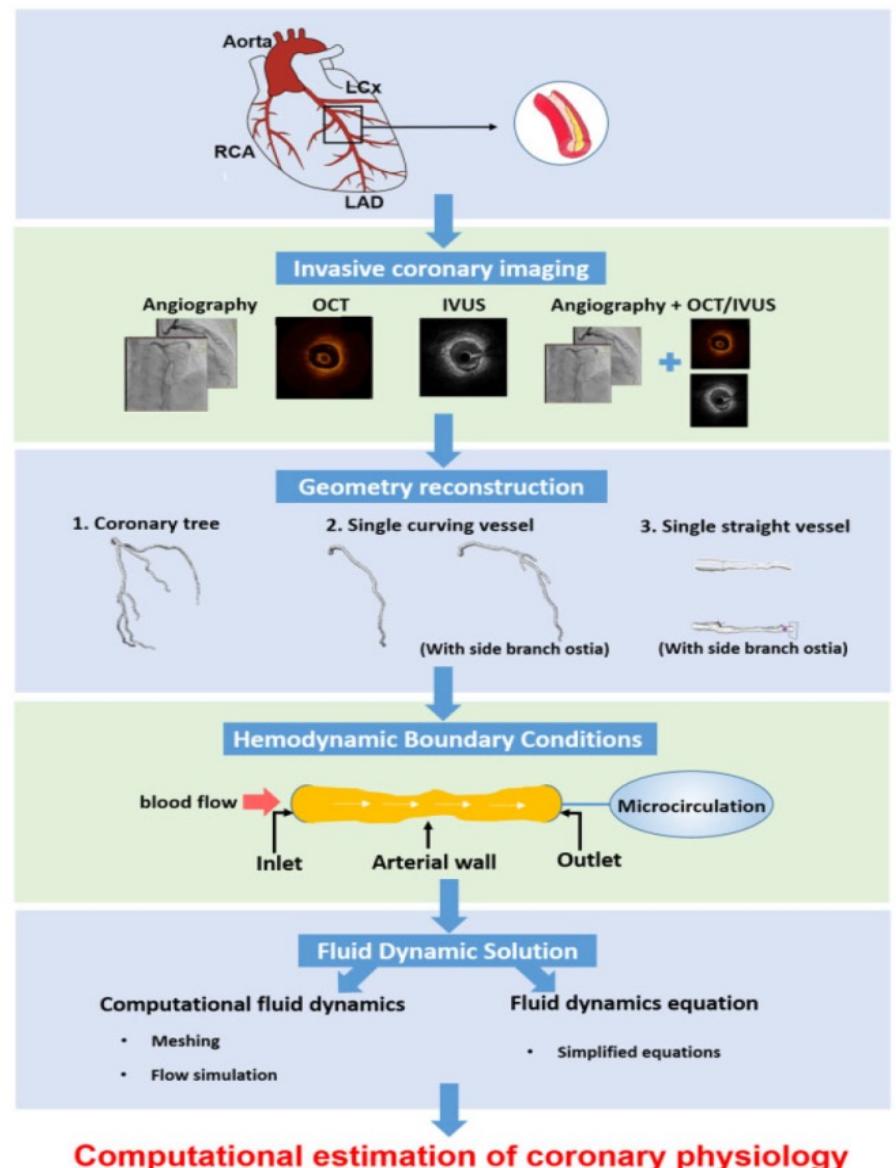
Quantitative flow ratio (QFR): angiography-based FFR

QFR: approved for use in China, Europe, and US

Standard Angiogram

Data transferred by network

Two image runs with angle difference ≥25°

3D Reconstruction **Modified Frame Count** **QFR**

Without *in*ducing hyperemia

Study	Patients/Vessels	Accuracy
FAVOR II China [1]	308/332	92.7%
FAVOR II E/J [2]	272/317	86.8%
FAVOR Pilot [3]	73/84	87%
WIFI II [4]	172/255	86%
Mejía-Rentería [5]	248/300	83%
Yazaki, K. [6]	142/151	88.7%
Smit, J.M. [7]	85/255	90%
Spitaleri, G. [8]	45/49	94%
Emori, H. [9] Prior MI (+)	75/75	87%
Emori, H. [9] Prior MI (-)	75/75	92%
Kołtowski[10]	306/268	85.4%
Emori[11]	100/100	94%
Stähli[12]	436/516	93.4%
Smit, J.M. [13]	290/386	86%
Smit, JM [14] Diabetic (+)	82/66	88%
Smit, JM [14] Diabetic (-)	238/193	85%
Hwang, D [15]	264/358	90.8%
Ties, D [16]	96/101	90%
Tanigaki, T[17]	152/233	85%
Choi[18]	452/599	91.2%

[1] J Am Coll Cardiol
[3] [5] [17] J Am Coll Cardiol Interv
[2][15] JAHA

[4] Circ Cardiovasc Imaging
[8] Circ Cardiovasc Interv
[6] [9] Cir J

[7] Eur J NuclMed Mol Imaging
[10] Clin Res Cardiol
[11] Coron Artery Dis

[12] [16] Int J Cardio
[13] EHJ - Cardiov. Imaging
[14] Am J Cardiol

Tu et al. J Am Coll Cardiol Interv 2016.

Xu et al. J Am Coll Cardiol 2017.
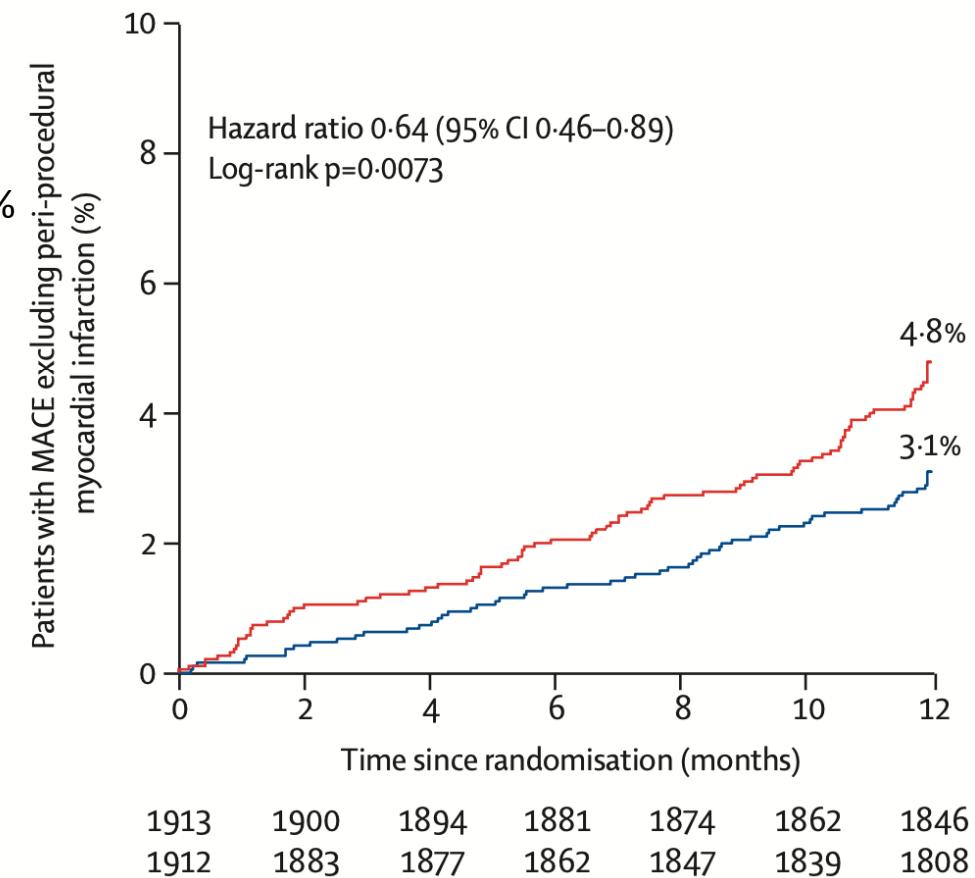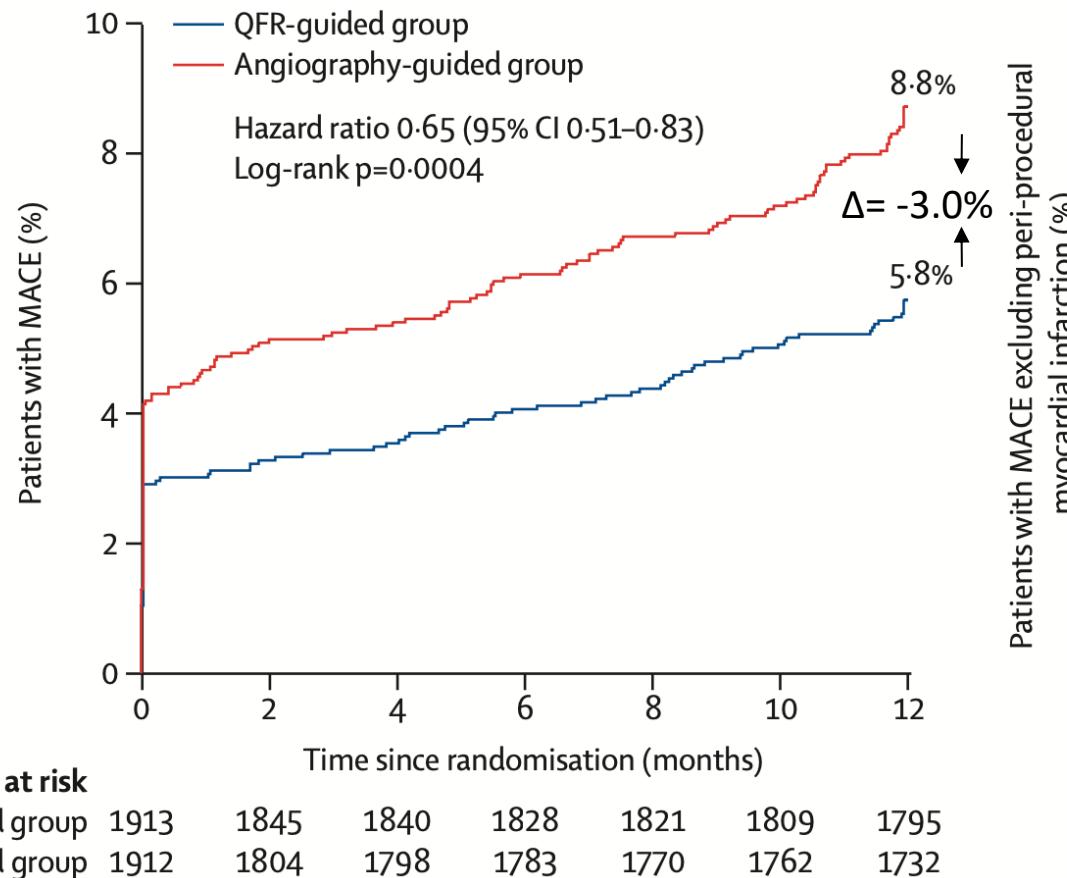
Conclusion: QFR-guided strategy of lesion selection improved 1-year clinical outcomes compared with standard angiography guidance

Xu, Tu, Song..., et al. *Lancet* 2021

Nouvelle QFR: µQFR sur une seule vue

Single angiographic view → Improved feasibility

Include side branches → Improved accuracy

Automated frame counting (by AI) → Improved efficiency (1 min)

AngioPlus Core　（Pulse Medical）

	µQFR ≤0.80	DS% ≥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)

Tu et al. Catheter Cardiovasc Interv 2021

Place de l'imagerie endocoronaire

- Angiographie superposition des vaisseaux et raccourcissement
- Optimisation Post-PCI : stent mal-apposition/sous-expansion
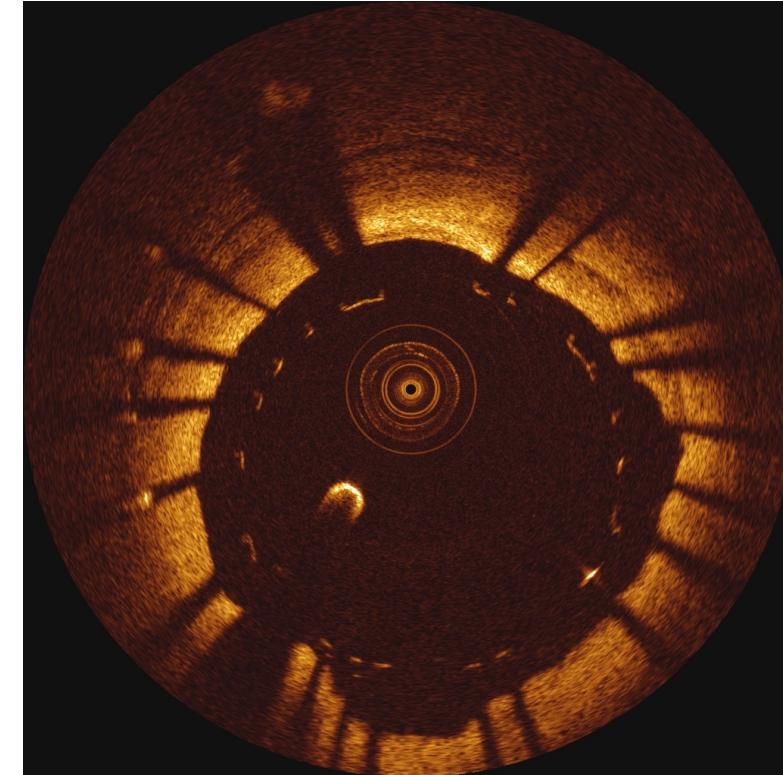
Pourquoi l'OFR?

Pour avoir le meilleur des deux mondes

2 procedures

2 instrumentations séparées
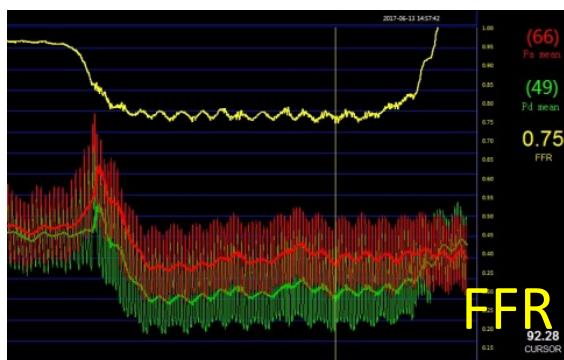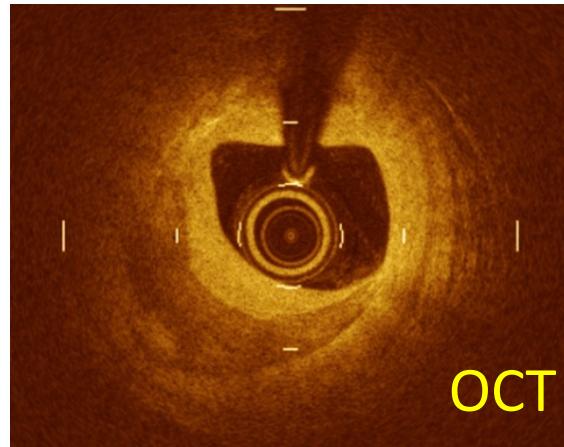
**1 procedure & instrumentation**

OCT + computed FFR (OFR)

2 en 1
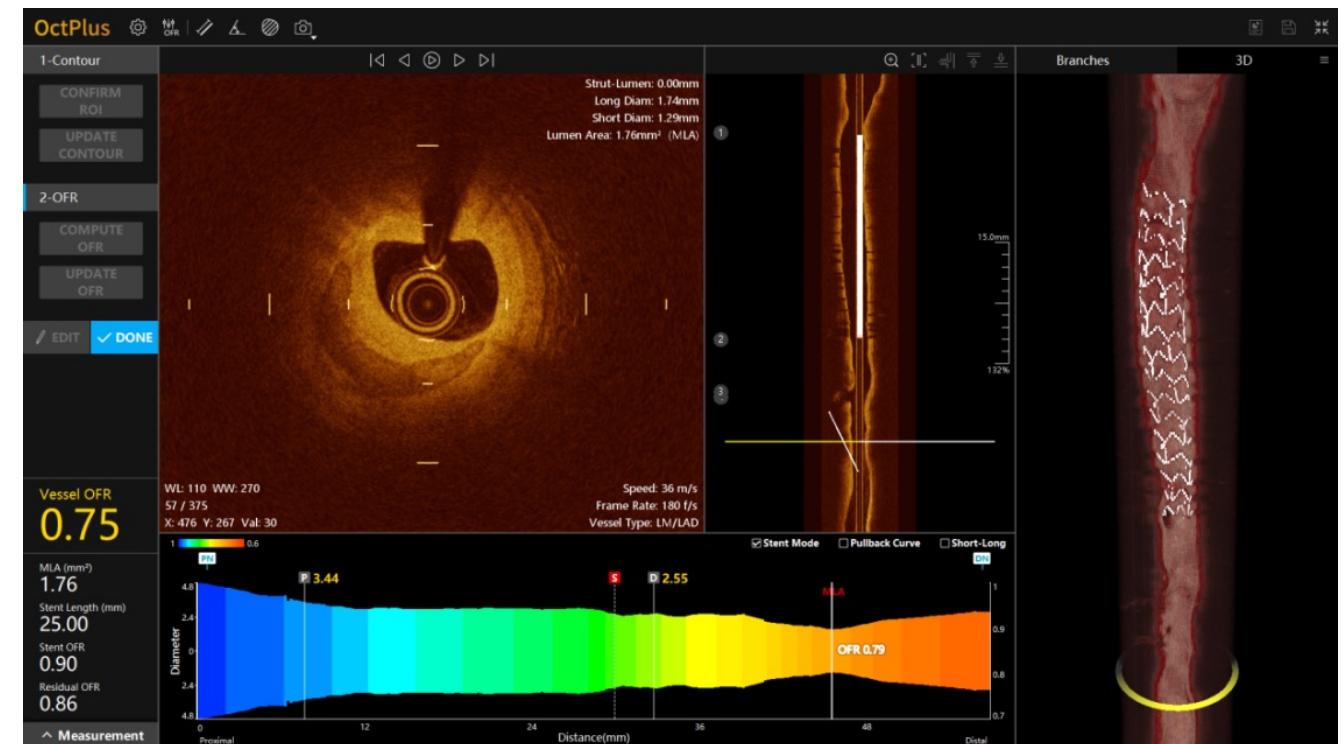
OctPlus (Pulse Medical, Shanghai, China)

Comment ca marche l'OFR?

1. **Detection automatique des contours de l'OCT et reconstruction 3D**
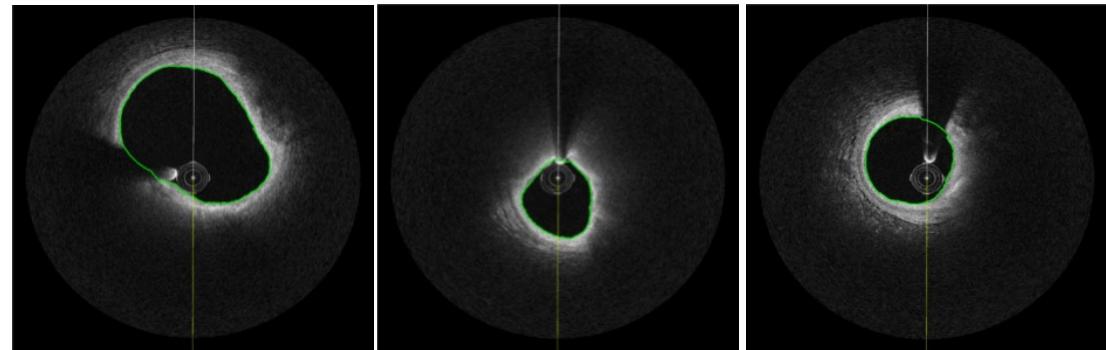
2. **Reconstruction 3D en coupant les ostia des colaterales**
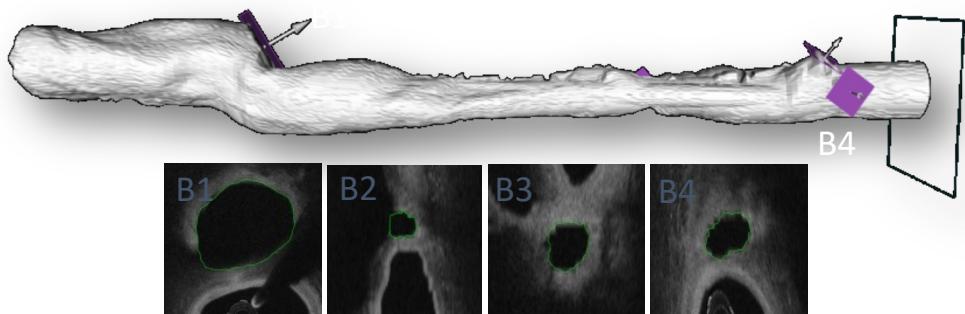
3. **Estimation du flux et de l'OFR**

Temps d'analyse ≈ 1 minute

Step 1

Step 2

Step 3

Yu, ...,Tu. EuroIntervention 2019; 15:189-197

2/8/23
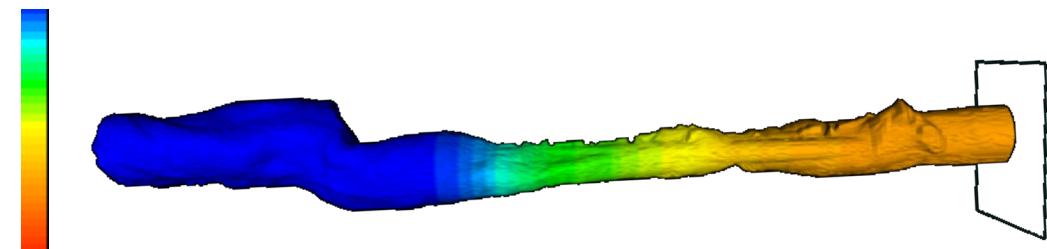
OFR second validation study (Japan single center)

Diagnostic Performance of OFR (with FFR as reference standard)

212 vessels from Wakayama Medical University

OFR has the highest diagnostic performance

pre-PCI	OFR ≤ 0.80	QFR ≤ 0.80	OCT-MLA ≤1.88 mm²	3D QCA-DS%>50.7%
Accuracy, %	92	87	76	75
Sensitivity, %	86	88	79	74
Specificity, %	95	87	74	75
PPV, %	92	82	67	66
NPV, %	91	92	84	81
LR+	18.2	7.0	3.0	2.9
LR-	0.2	0.1	0.3	0.4
AUC	0.97	0.92	0.82	0.80

OFR: 0.97 (0.93 - 0.99)
QFR: 0.92 (0.87 - 0.95)
MLA: 0.82 (0.76 - 0.87)
DS%: 0.80 (0.74 - 0.85)

Huang, ..., Tu. EuroIntervention. 2020 Jan 21. Epub ahead of print.
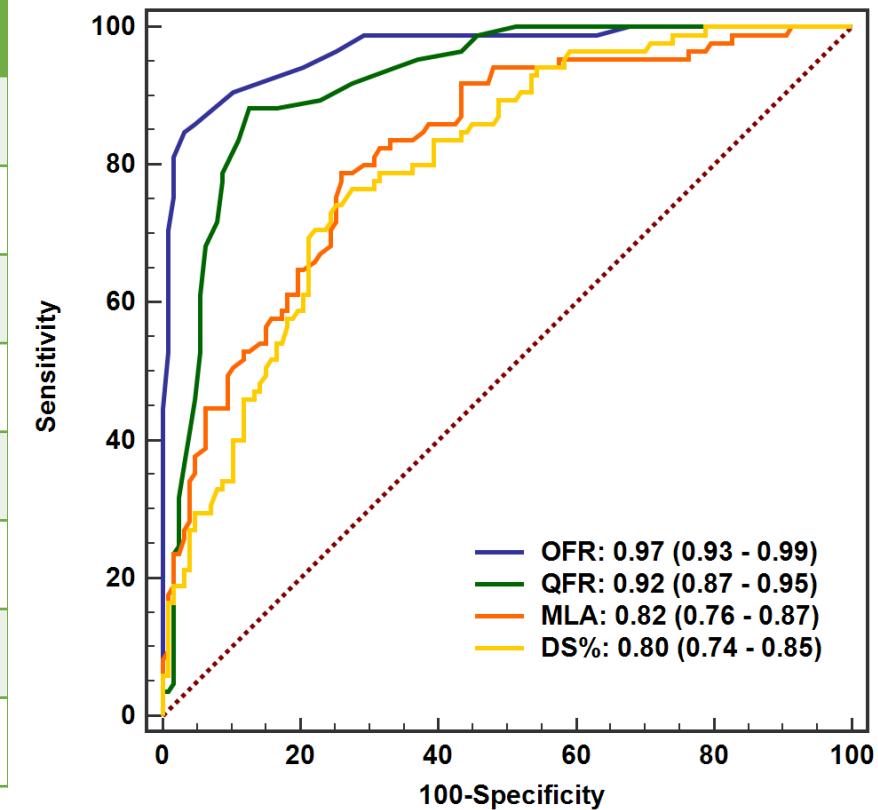
Detection automatique des stents et reconstruction par OCT

Wu,...,Tu. Biomedical Optics Express 2020
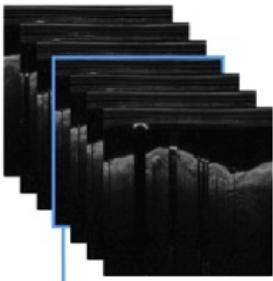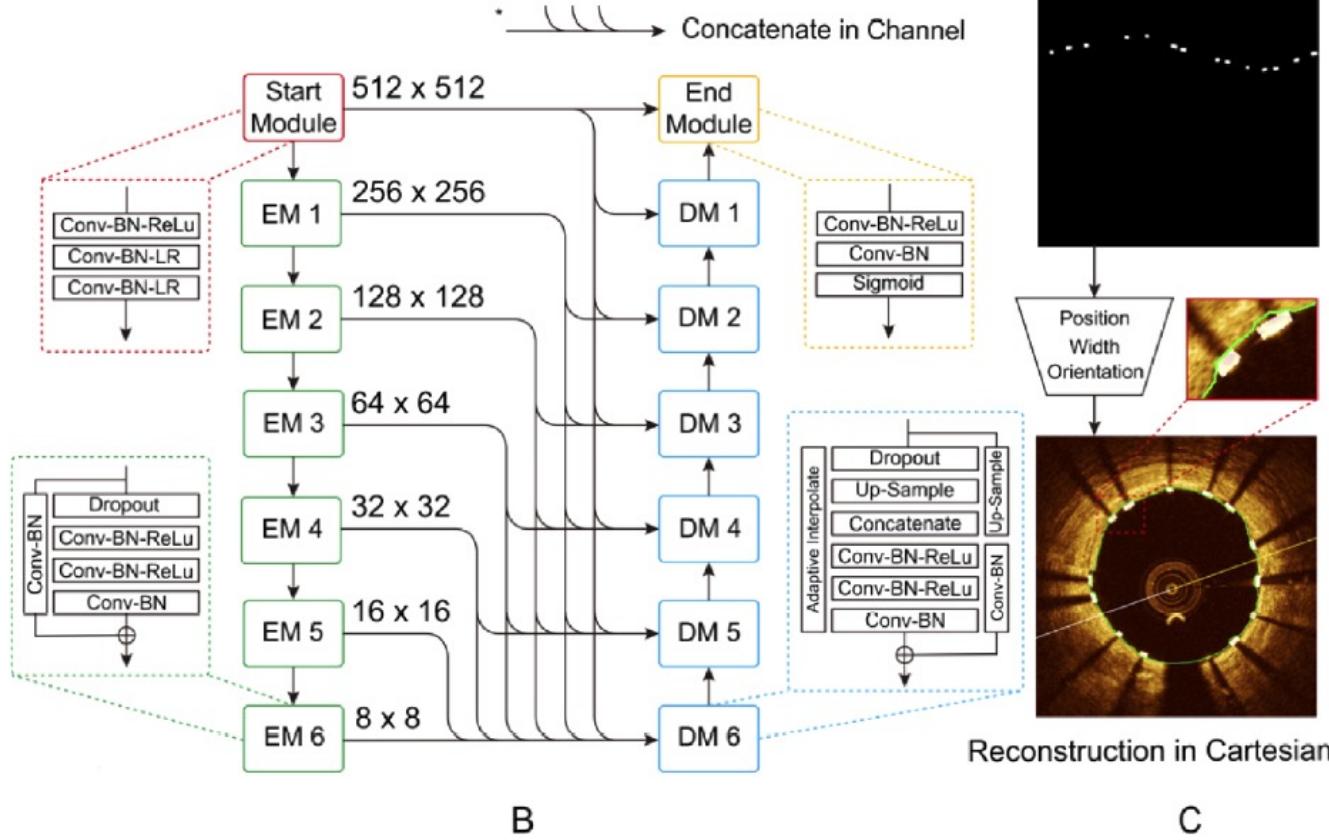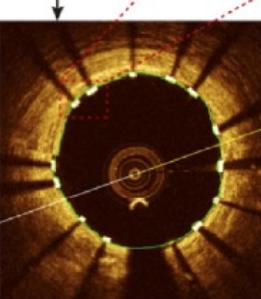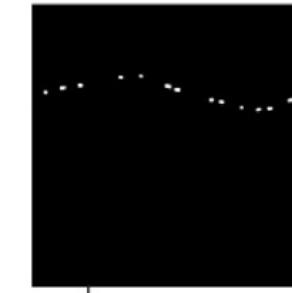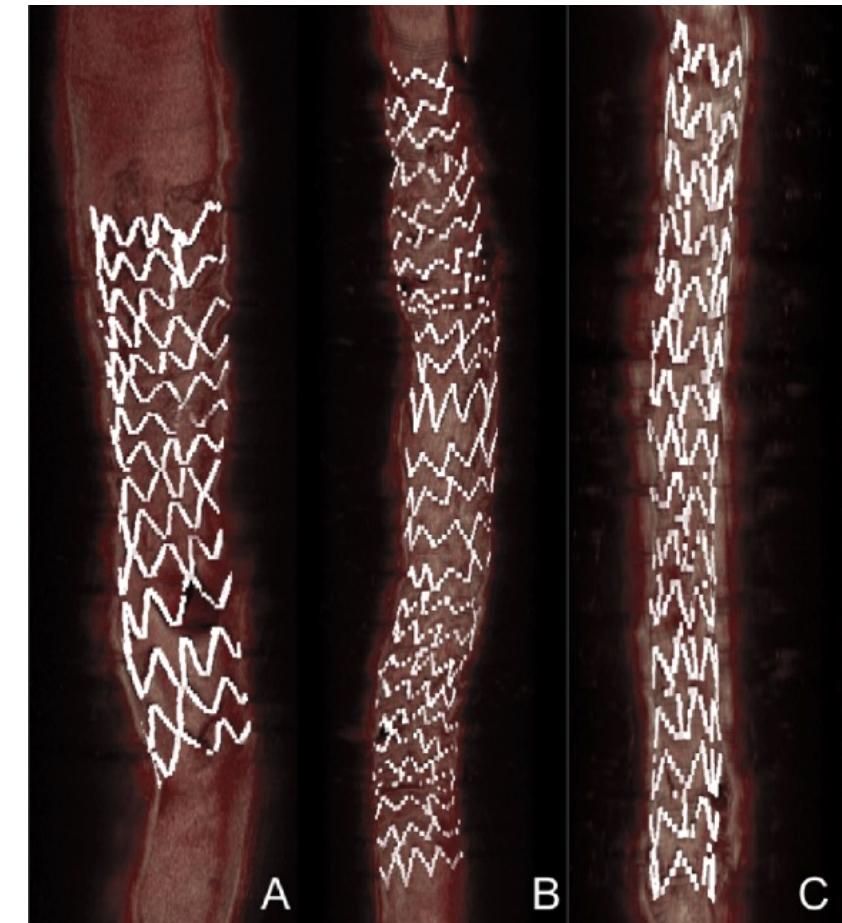
Stent expansion et intra-stent chute de pressure
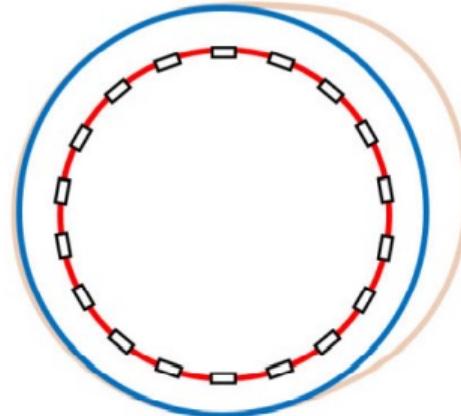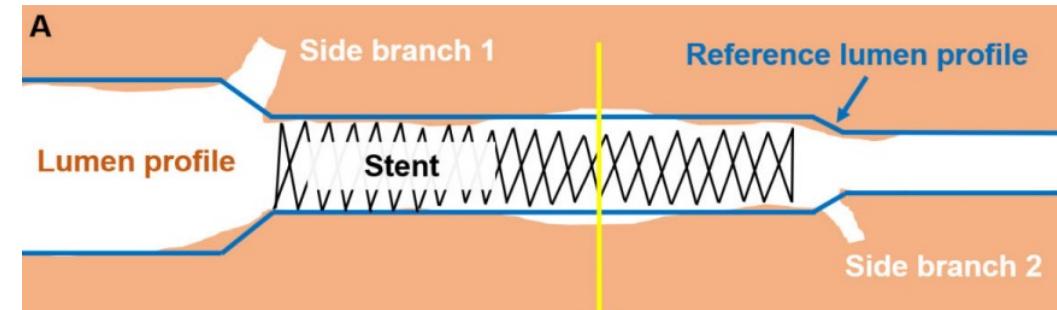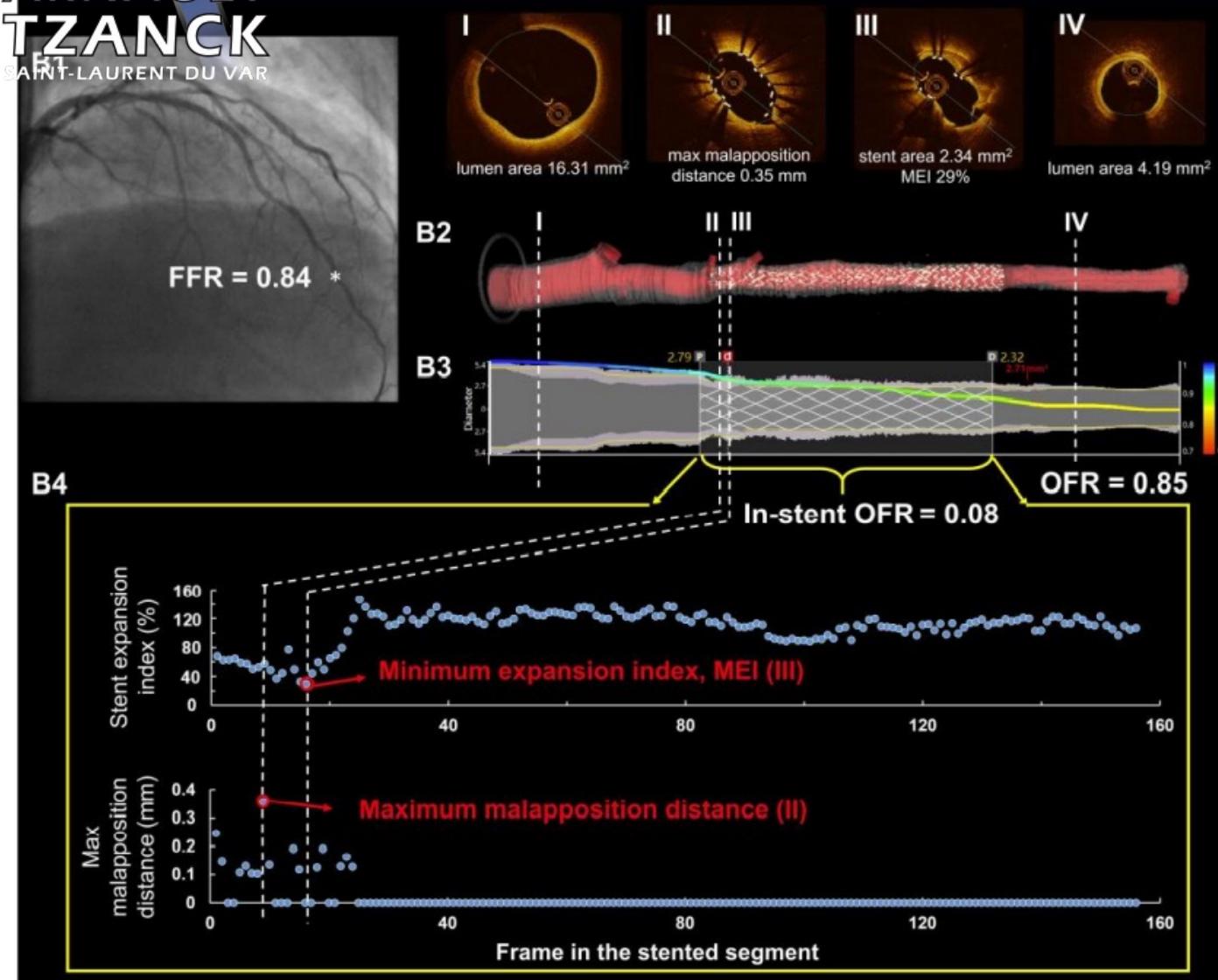
MEI showed moderate correlation (r=-0.49, p < 0.001) with in-stent OFR drop

Ding,...,Tu. EuroIntervention 2021

Combinaison OFR & caractérisation de la plaque
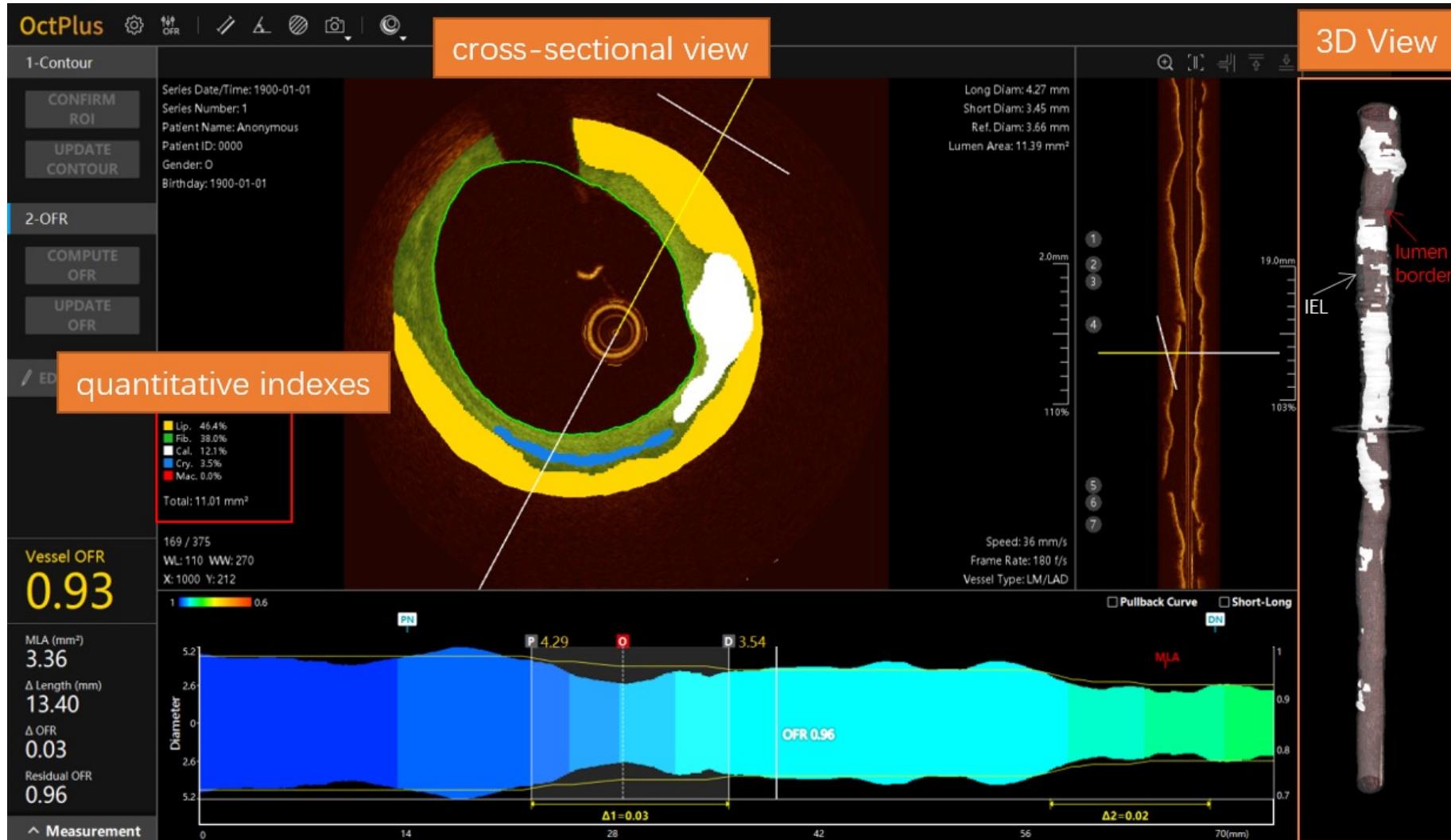
OctPlus (version V2, Pulse Medical, Shanghai, China)

Caractérisation de la plaque par IA: Validation

Expert-result   **AI-result**

Correct ■ Incorrect

518 (86.6%) — All Regions — 80 (13.4%)

fibrous 163 (97.6%) 4 (2.4%)

lipidic 162 (90.5%) 17 (9.5%)

calcium 138 (88.5%) 18 (11.5%)

macrophages (48.1%) 37 40 (51.9%)

cholesterol crystal (94.7%) 18 1 (5.3%)
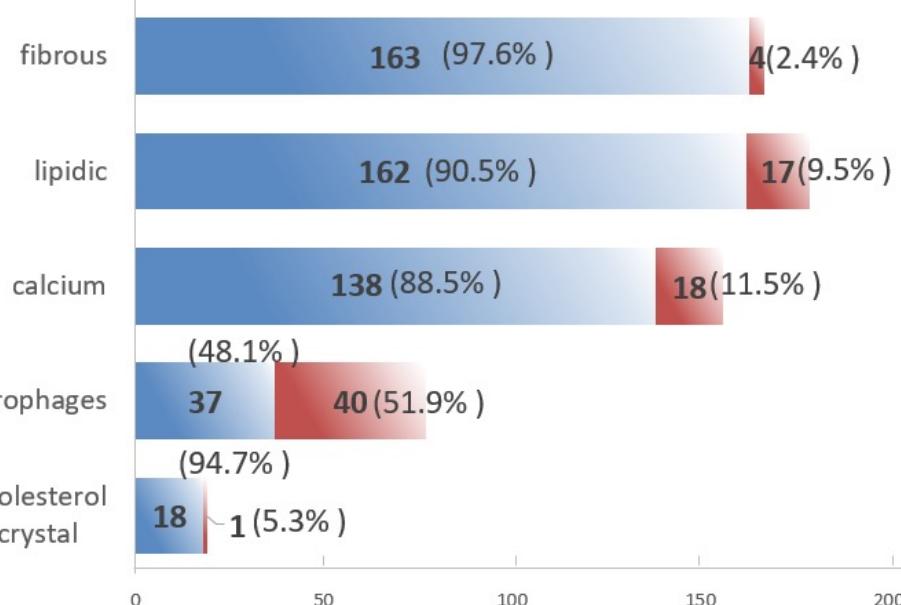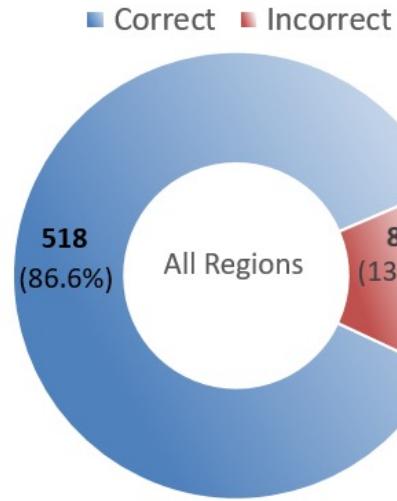
Diagnostic accuracy was 92.2% for main plaque compositions (fibrous/calcium/lipid), using consensus of three leading international OCT reading core labs as reference standard

■ Fibrous/intimal   ■ Lipid   □ Calcium   ■ Malcrophage   ■ Cholesterol crystal
■ Side-branch   ■ Guide-wire

Chu,…,Tu. EuroIntervention 2021
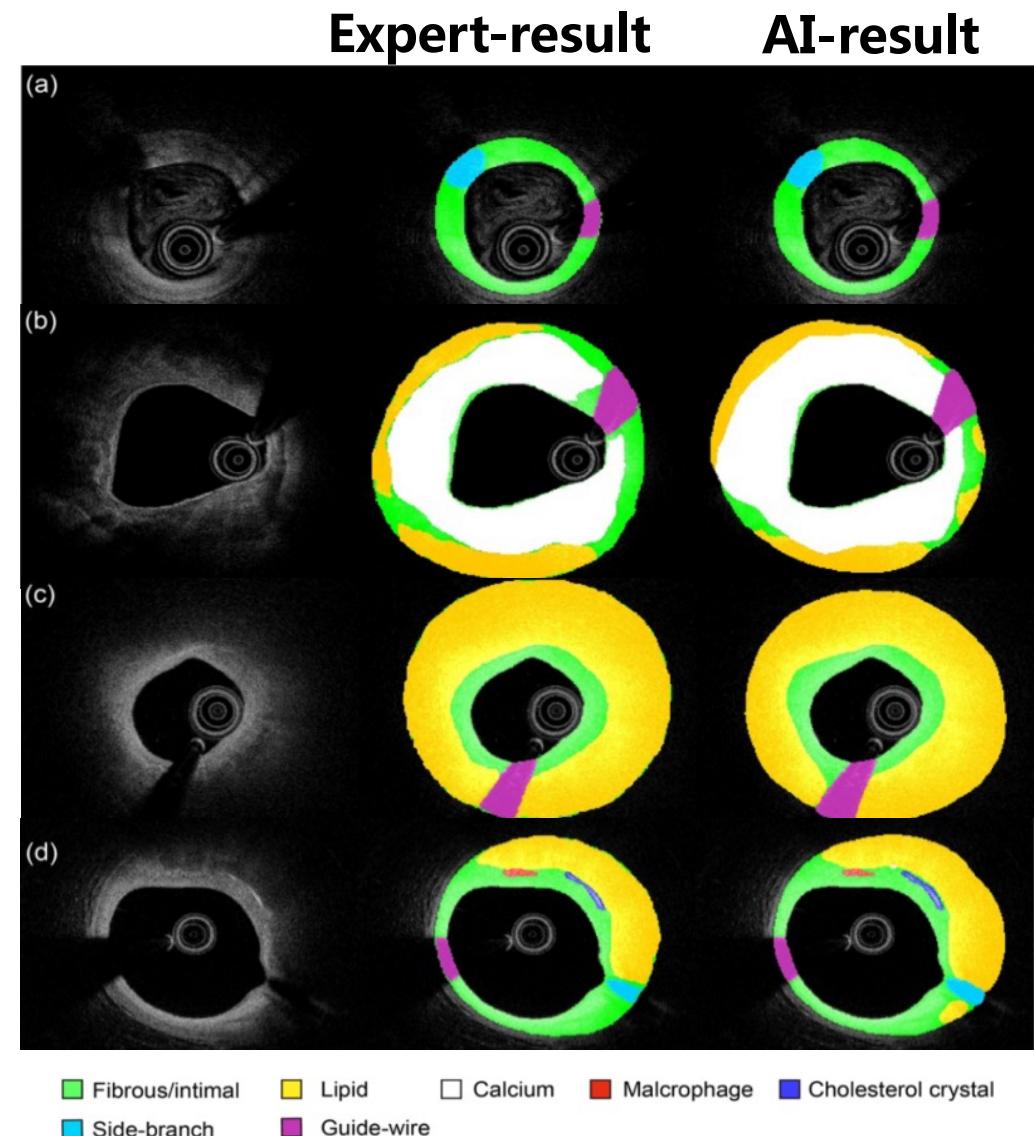
OFR & composition de la plaque

LPV: lipid plaque volume

FPV: fibrous plaque volume

CPV: calcified plaque volume

Overestimation: OFR – FFR > 0.05

Underestimation: FFR – OFR > 0.05

Zeng,…,Tu. Cardiovasc Diagn Ther 2022
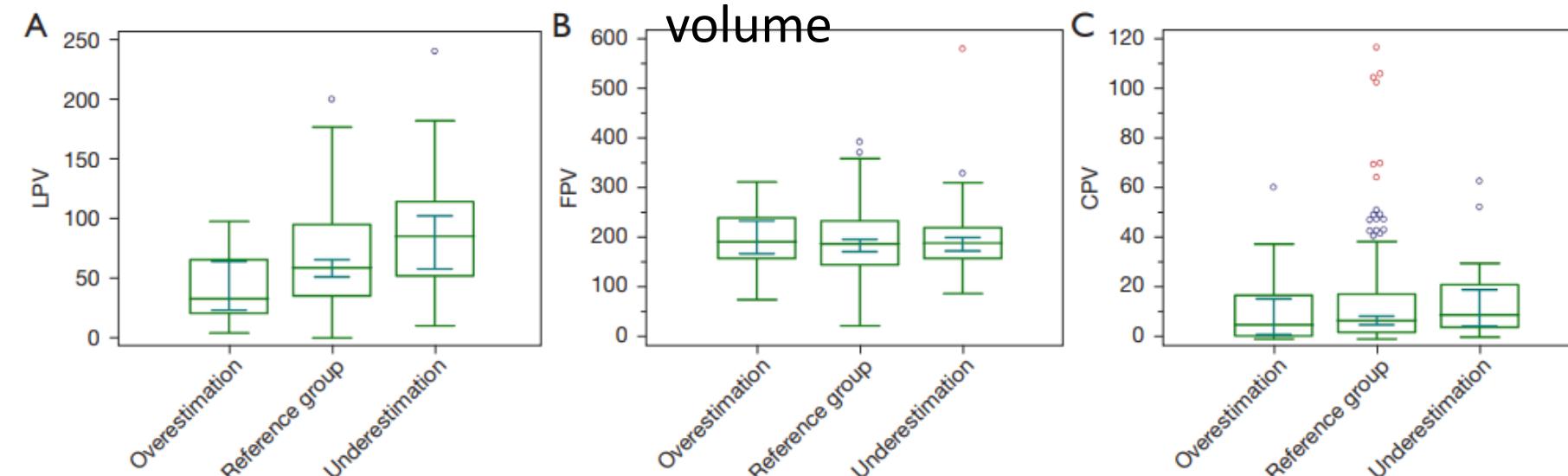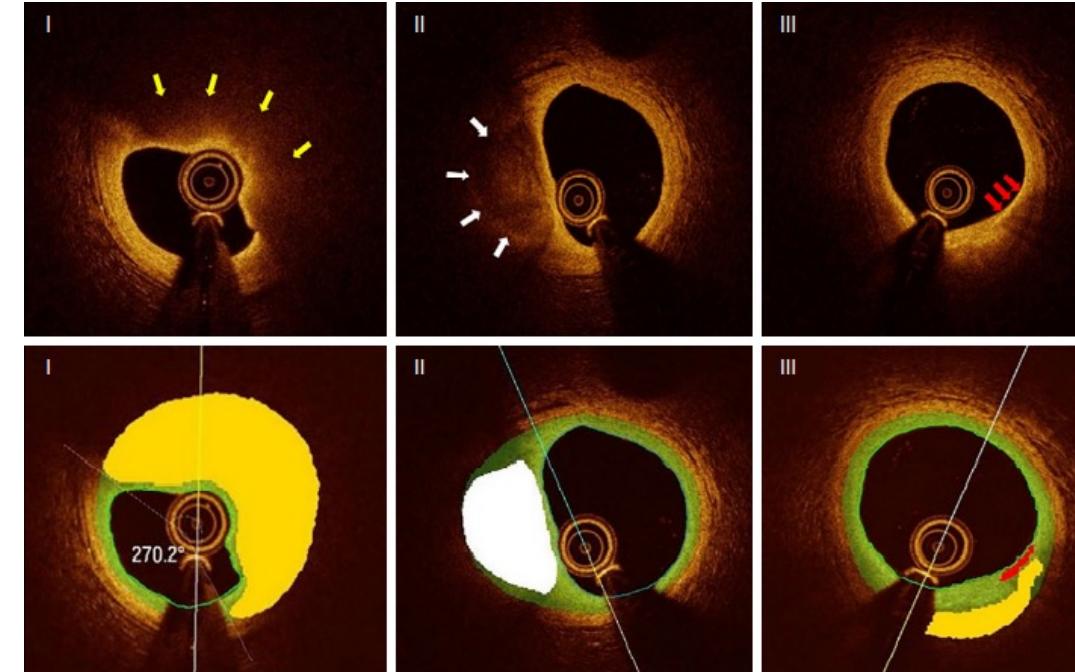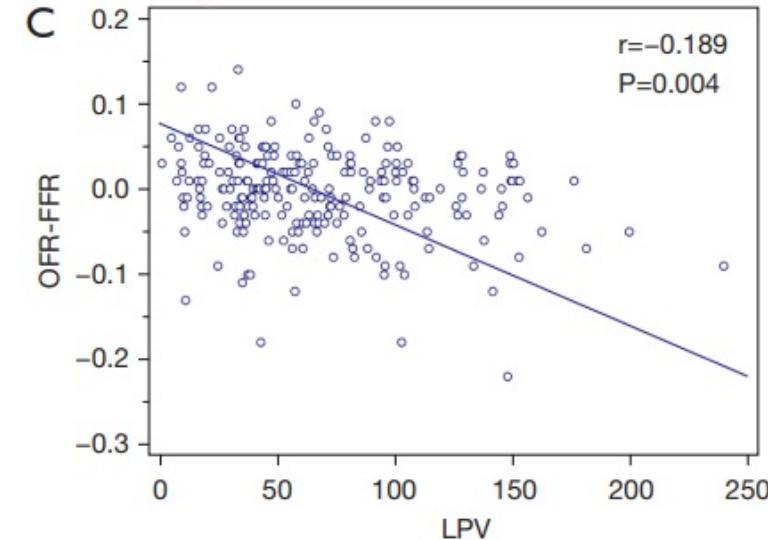
OCT-derived plaque burden par IA

validation of OCT-derived plaque burden

proximal frame   AI-IEL   distal frame
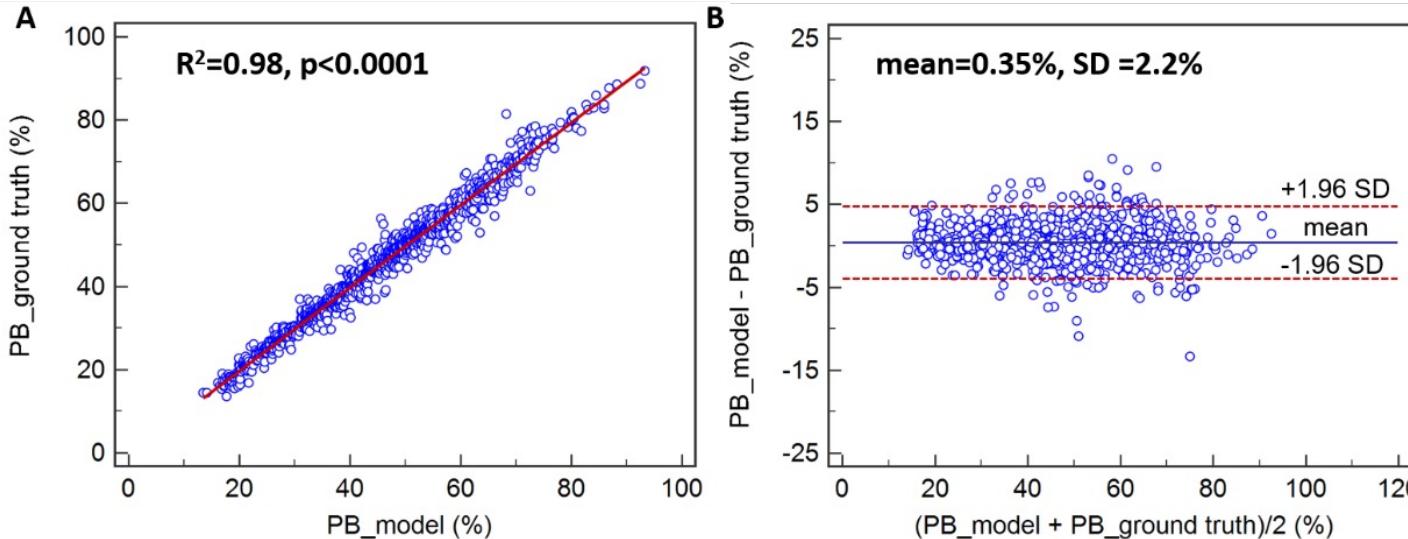
Excellent accuracy in automatic quantification of plaque burden by AI

Chu,…,Tu. EuroIntervention 2021
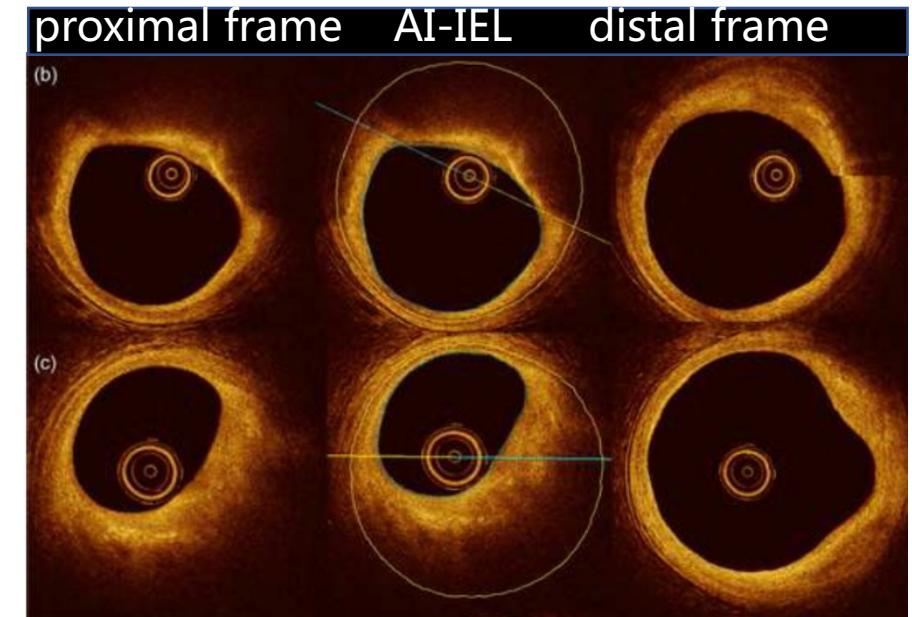
OCT-derived plaque burden by AI: compared to IVUS

Huang et al. Cath Cardiovasc Interv 2022
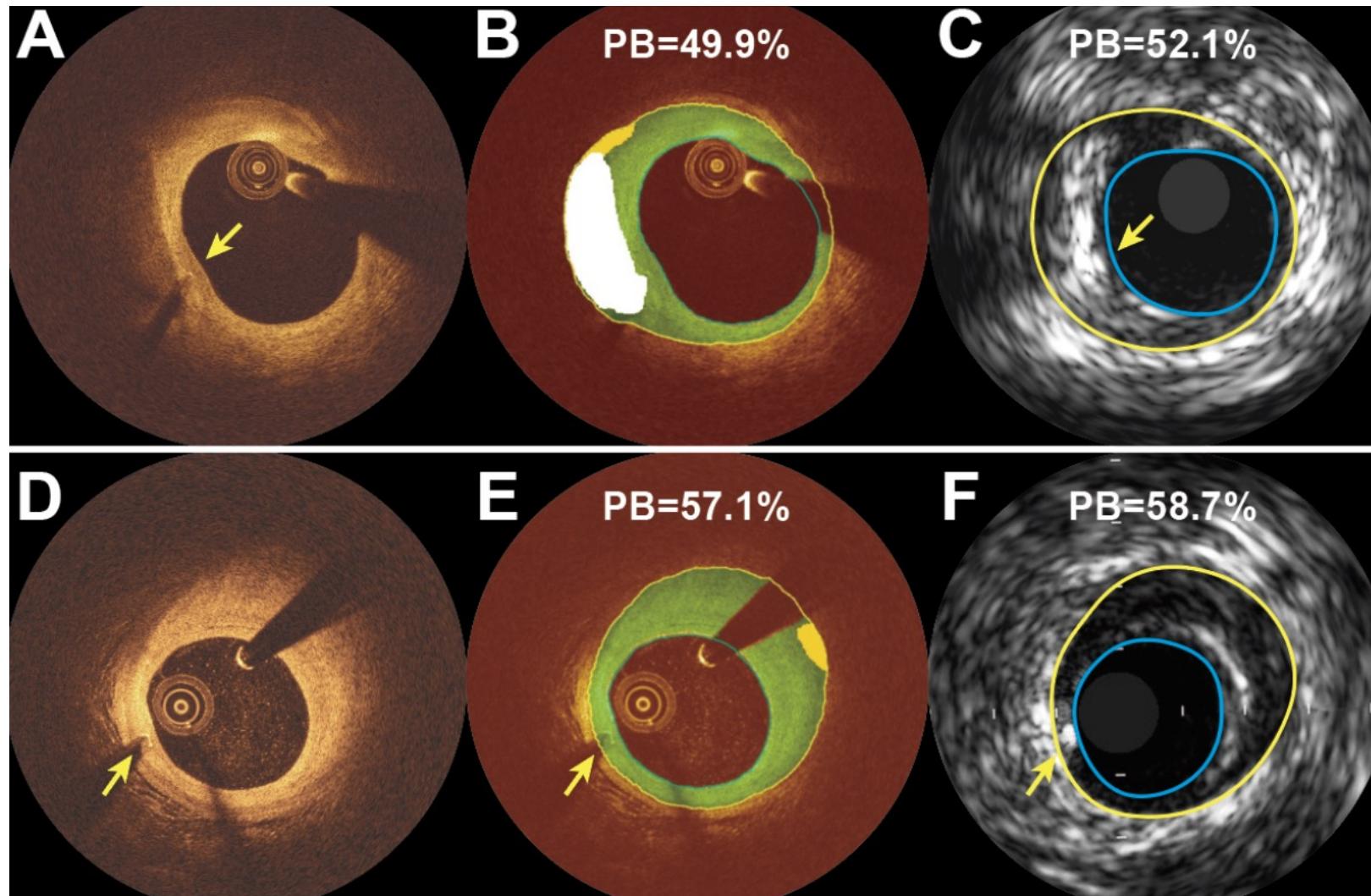
Un nouvel index de vulnerabilité de la plaque: LCR

OctPlus (Pulse Medical, Shanghai, China)
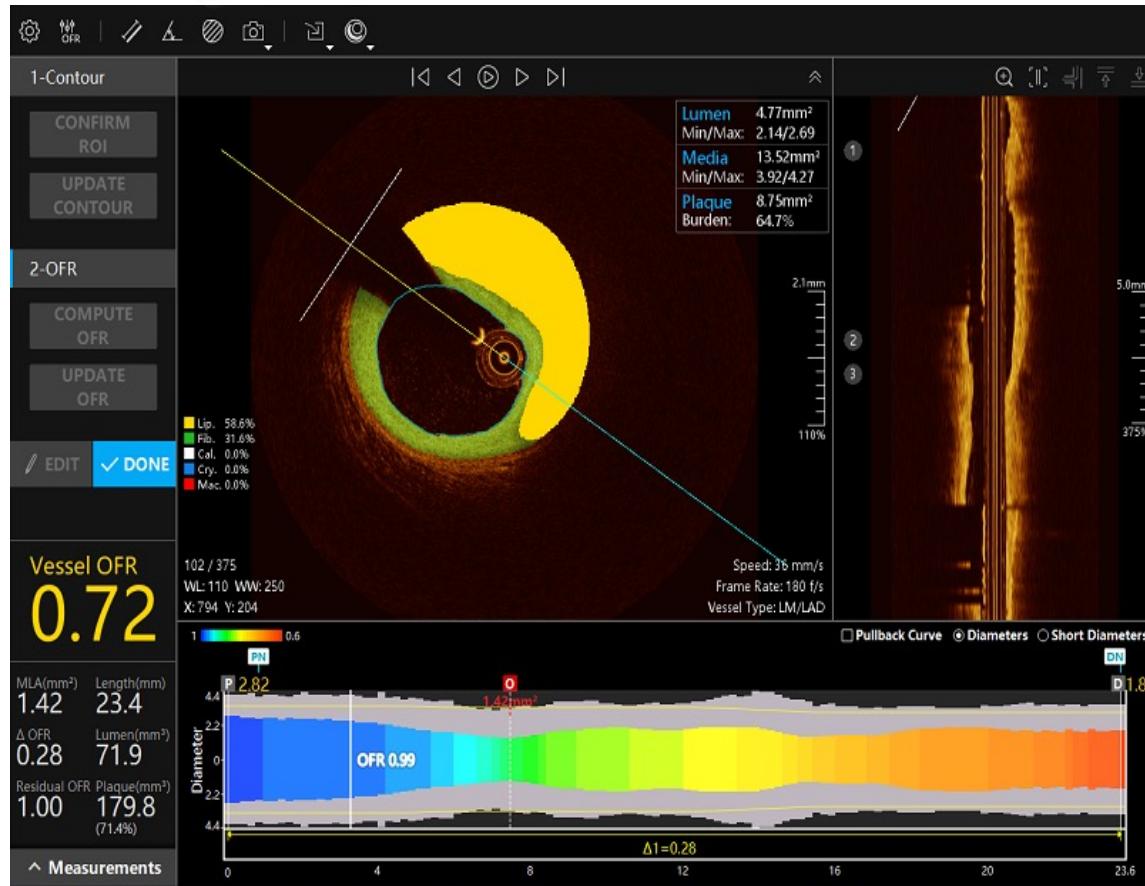
TCFA= thin-capped fibroatheroma
(thinnest fibrous cap<65um & lipid arc>180°)

LCR = lipid-to-cap ratio

A

>180°

FCT=60μm

lipid 15.0%
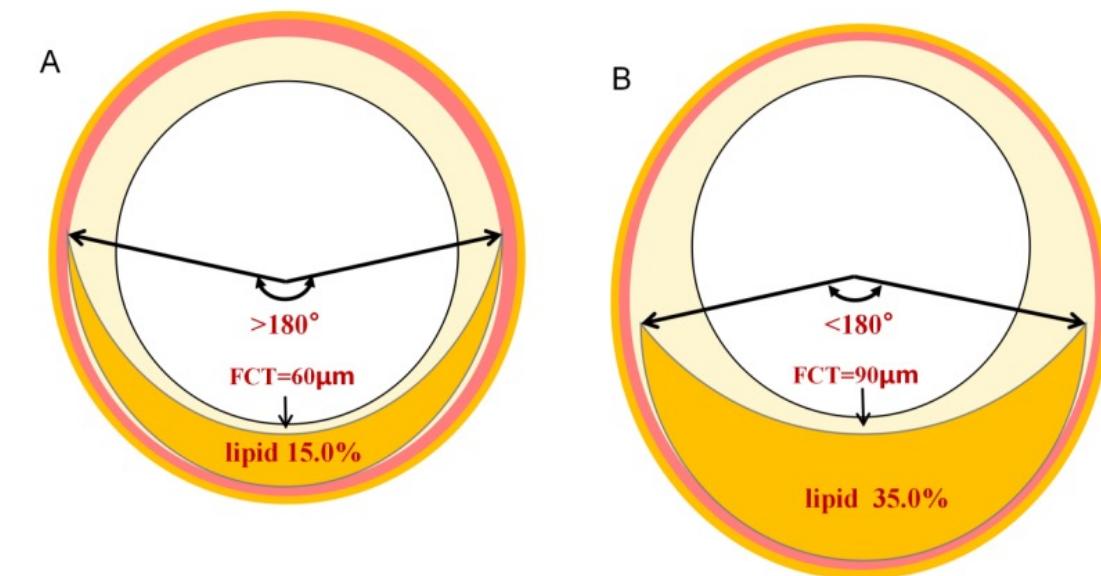
TCFA(+)

$$LCR= \frac{15\%}{60\mu m} *100=0.25$$

B

<180°

FCT=90μm

lipid 35.0%

TCFA(-)

$$LCR= \frac{35\%}{90\mu m} *100=0.389$$

Tu et al. EuroPCR 2021, LBT

OFR & LCR predits evenements de la lesion non coupable

Hong,…,Tu. JACC: Asia 2022

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Holmes et al. JACC 2020

Cardiopathie structurelle

RM: INOUE

Cardiopathie structurelle
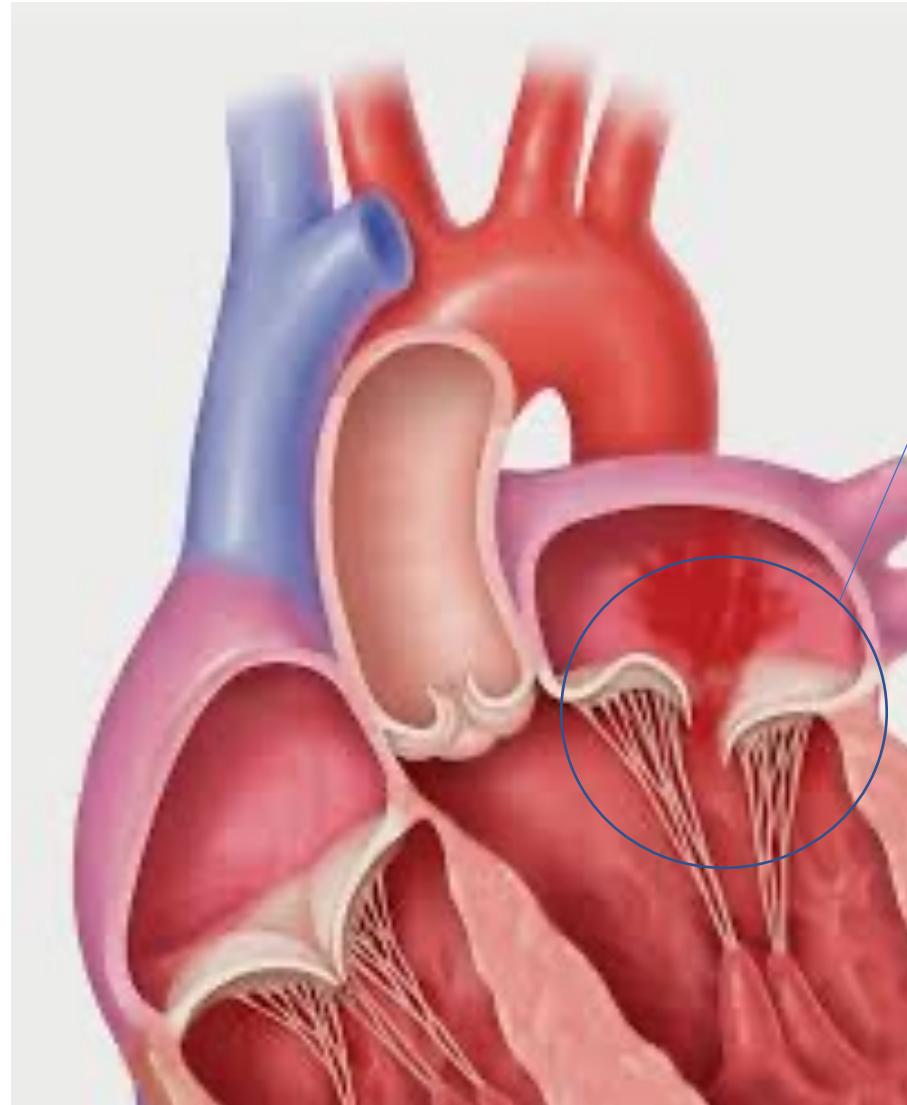
IM:
remplacement versus plastie
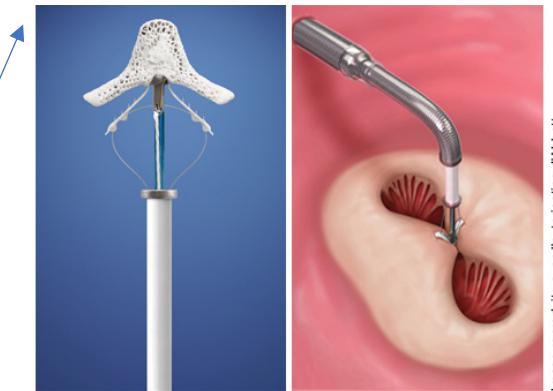
Image reproduite avec l'autorisation d'Abbott.

CENTRAL ILLUSTRATION: Transcatheter Mitral Valve Replacement Systems With Available Clinical Data

Transapical Systems

A   B   C

Transseptal Systems

D   E   F

G   H   I

Hensey, M. et al. J Am Coll Cardiol Intv. 2021;14(5):489–500.

Cardiopathie structurelle

RAo:
remplacement versus plastie
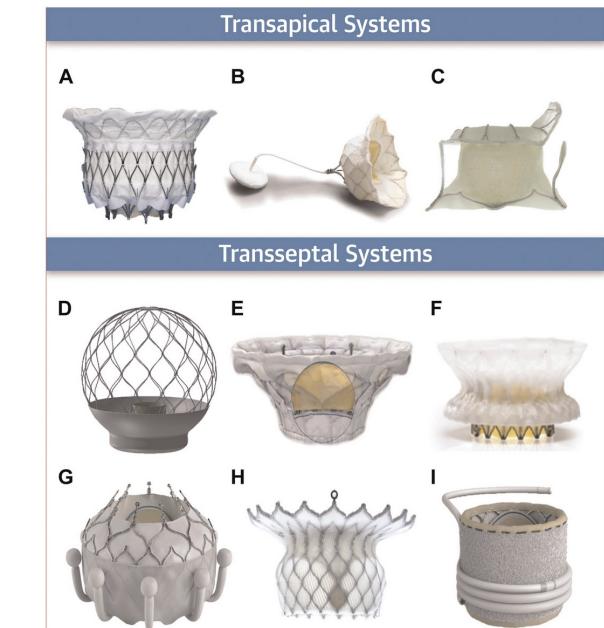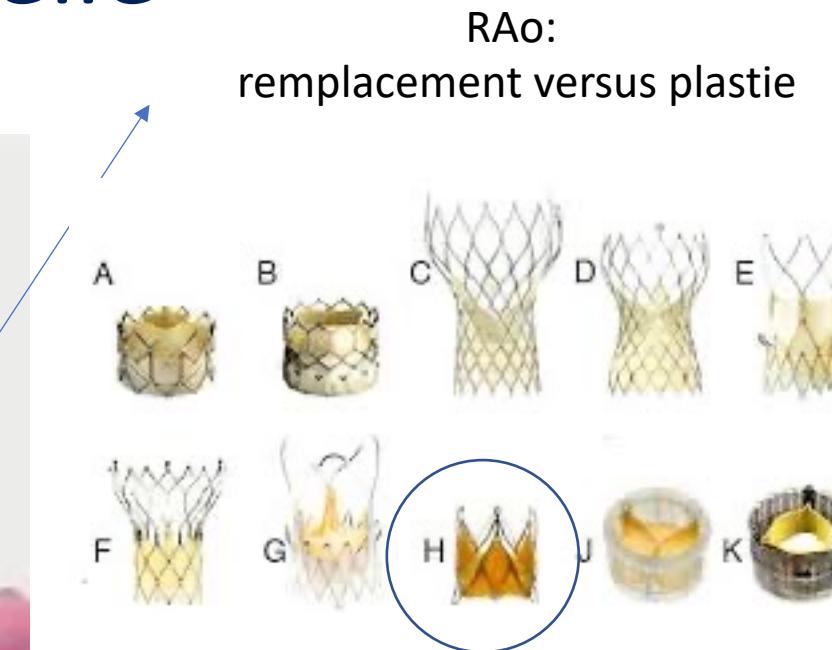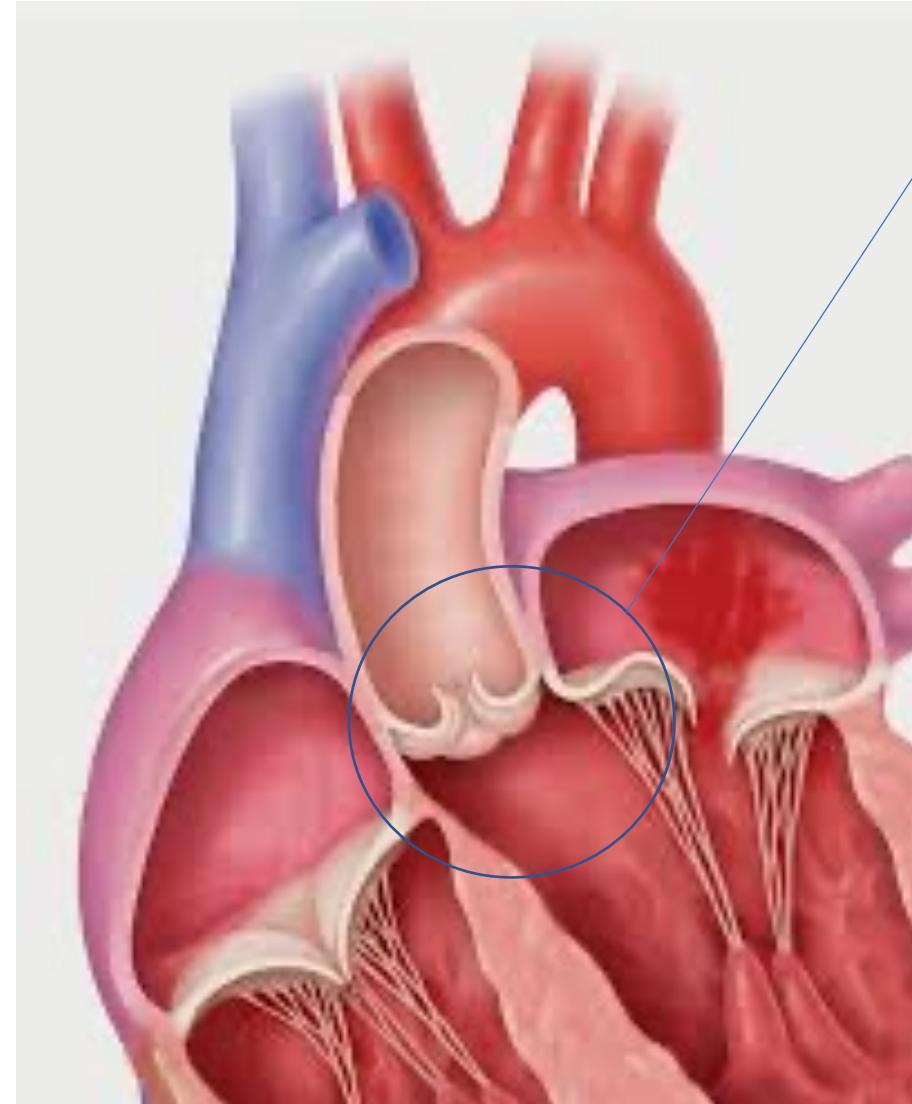
Cardiopathie structurelle

IAo:
remplacement versus plastie
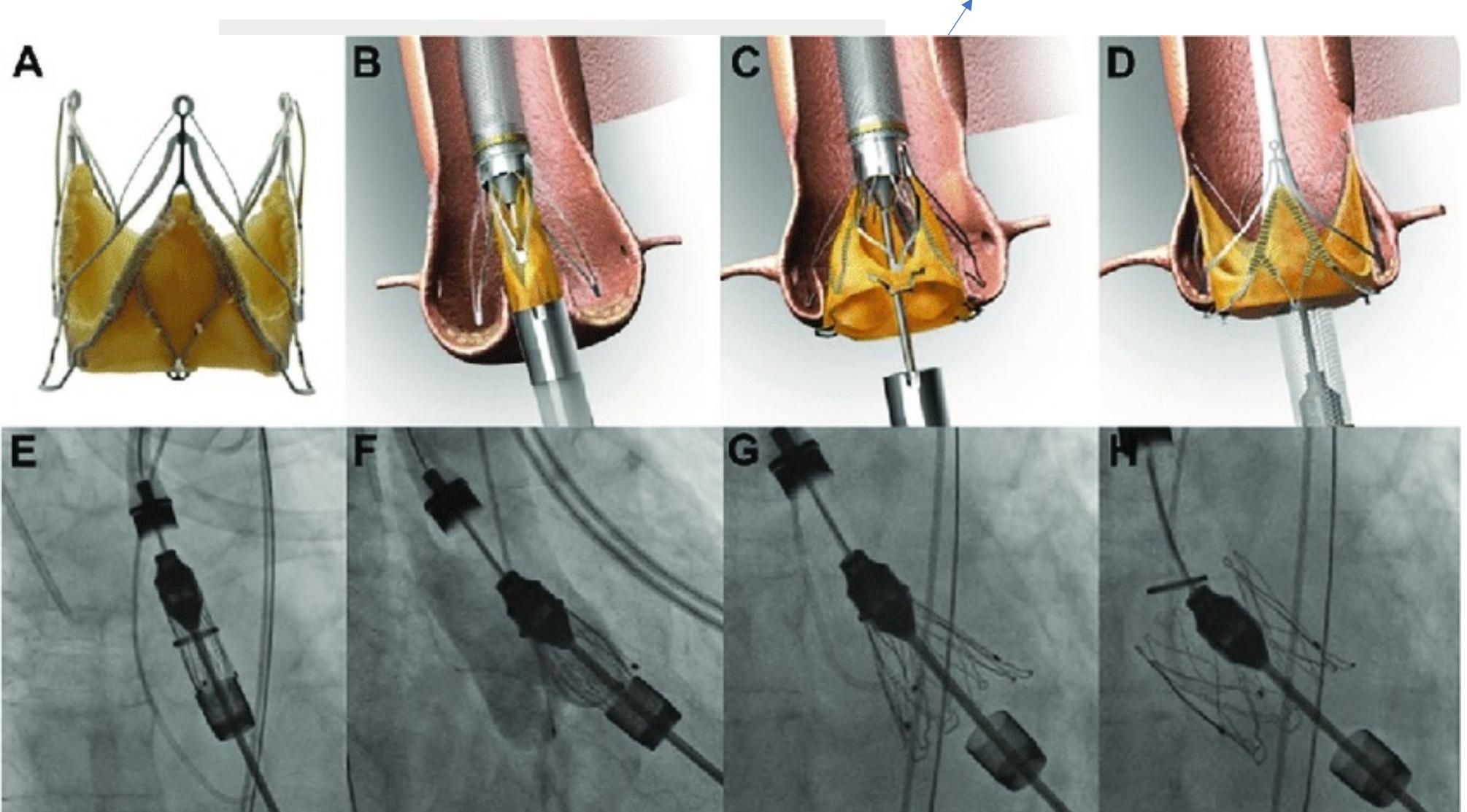
IT: plastie ou

CENTRAL ILLUSTRATION: Transcatheter Tricuspid Landscape

Coaptation Devices
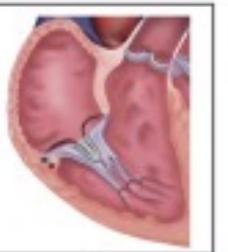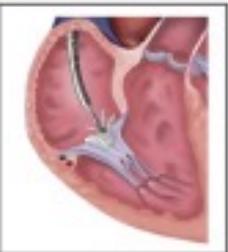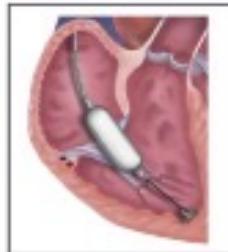
Suture Annuloplasty
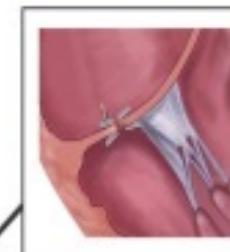
Heterotopic Caval Valve Implant
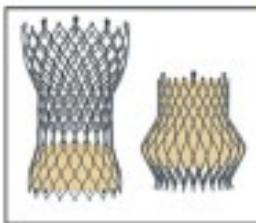
Ring Annuloplasty
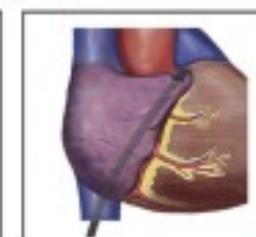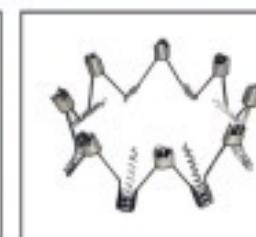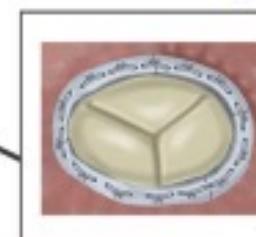
Transcatheter Tricuspid Valve Replacement

Asmarats, L. et al. J Am Coll Cardiol. 2018;71(25):2935–56.

Cardiopathie structurelle: Place de l'imagerie +++

Cardiopathie structurelle: du sur mesure
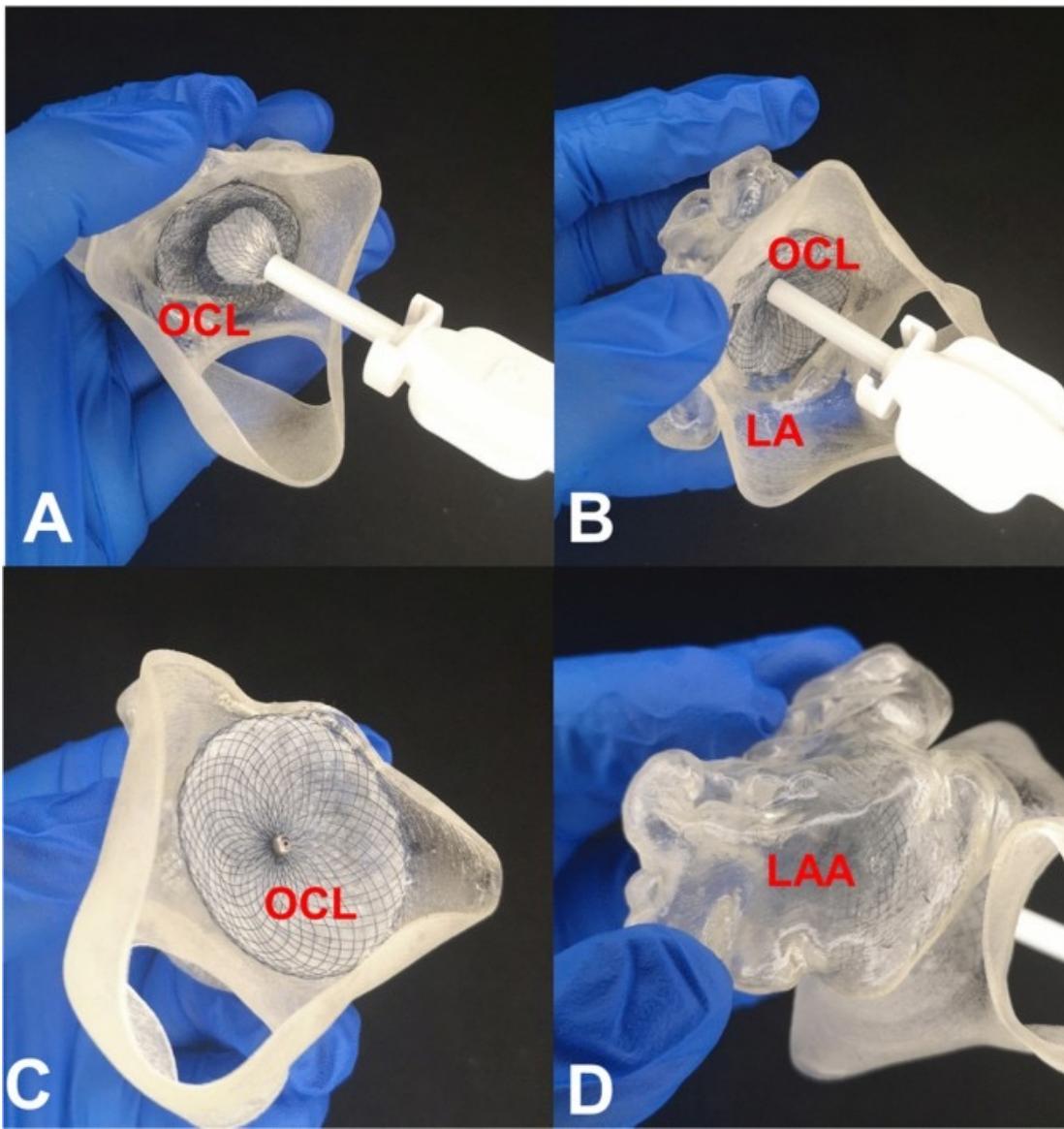
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Holmes et al. JACC 2020

Ateliers de simulation

JESFC 2023
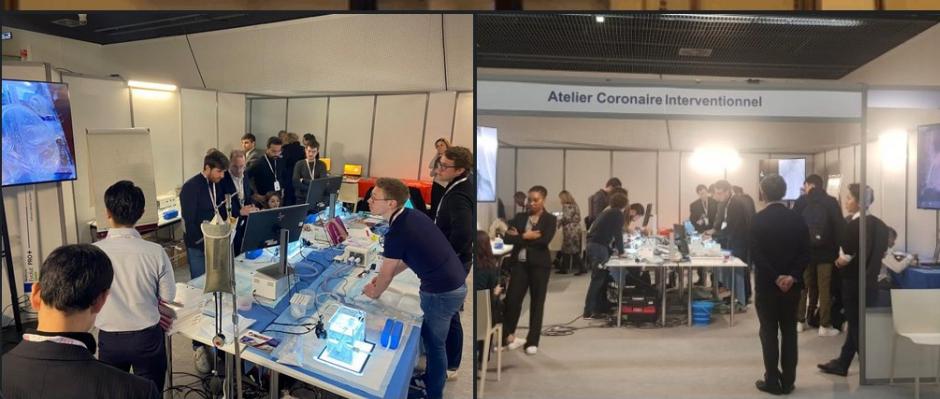
GRCI 2022

ACTIF

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Holmes et al. JACC 2020

Heart team: RCP

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CARE TEAM
Patient Selection
Credentialing
Guidelines

• Decision solitaire

IC PRACTICE
Salary Structure
Ultra-Specialization
Workforce Issues

Holmes et al. JACC 2020

Conclusion

- Image ou physiologie

- Peu d'alternative therapeutiques

- Training par compagnonnage

- Decision solitaire

- Morpho-physiologie guidée par l'IA

- « trop » d'alternative therapeutiques→ surinformation et sens critique +++

- Jamais une première fois sur un patient (possibilité de simuler les complications etc…)

- Discussion en heart team et décision solidaire

Holmes et al. JACC 2020