

# PHYSIO DAY

JOURNÉES DE PHYSIOLOGIE  
EN CARDIOLOGIE INTERVENTIONNELLE

## Quel avenir pour la FFR en 2024 ?

Symposium ABBOTT

C. Pouillot, Clinique Sainte Clotilde, La Réunion

**5 & 6 AVRIL 2024**

HÔTEL SHERATON · NICE



# Un coup de tonnerre dans un ciel serein !!

28 février 2023

JOURNAL OFFICIEL DE LA RÉPUBLIQUE FRANÇAISE

Texte 35 sur 135

## Décrets, arrêtés, circulaires

### TEXTES GÉNÉRAUX

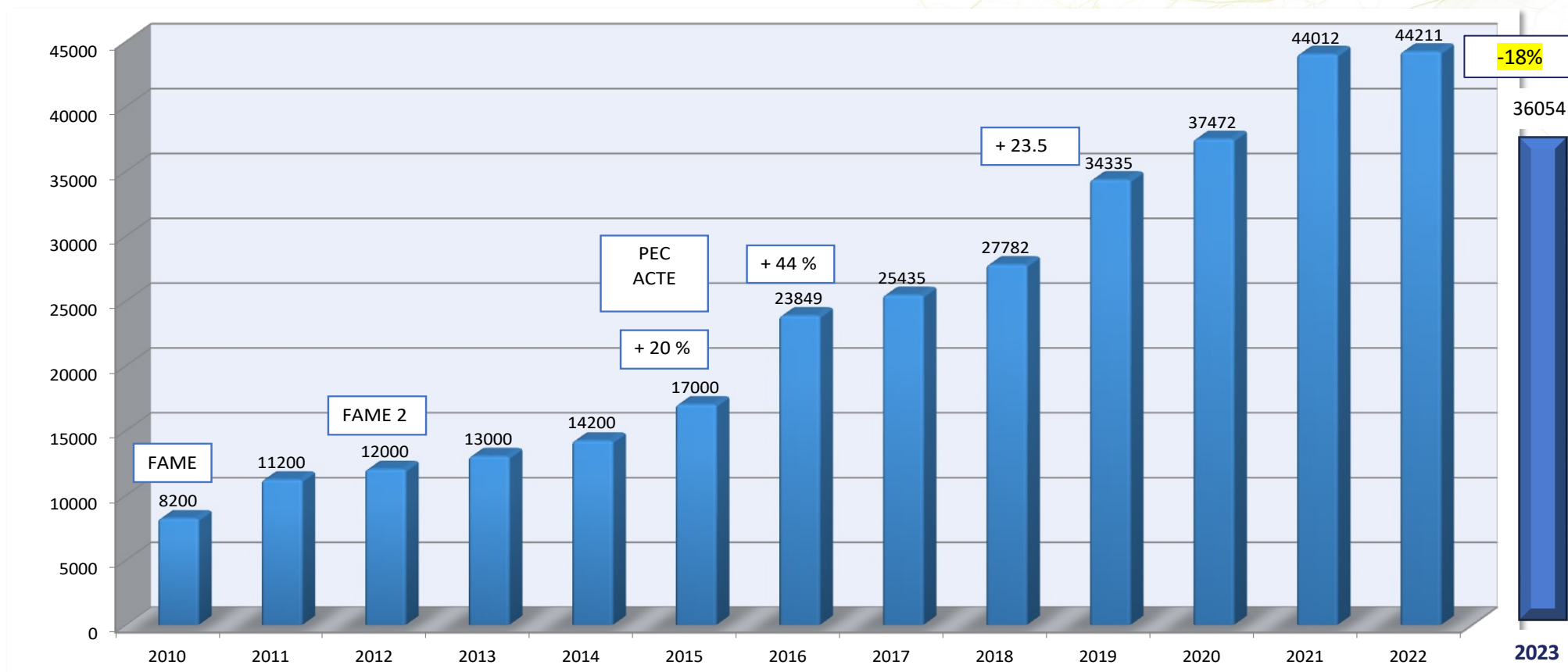
#### MINISTÈRE DE LA SANTÉ ET DE LA PRÉVENTION

Arrêté du 24 février 2023 modifiant l'arrêté du 2 mars 2005 pris en application de l'article L. 162-22-7 du code de la sécurité sociale et fixant la liste des produits et prestations mentionnés à l'article L. 165-1 du code de la sécurité sociale pris en charge en sus des prestations d'hospitalisation

Le guide de pression est déremboursé !



# Evolution de l'activité FFR en France jusqu'à 2023







# 2012 : l'apparition de la FFR Angio... Serait ce l'avenir de la FFR ?

## 2012, Premières publications :

*Huo Y, Svendsen M, Choy JS, Zhang ZD, Kassab GS : A validated predictive model of coronary fractional flow reserve. J R Soc Interface. 2012 ; 9 ; 1325-1338.*

## Depuis : un intérêt considérable !

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angiography derived FFR

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838 results

RESULTS BY YEAR

1999 2023: 120

**Angiography-Derived FFR as Novel Parameter in Assessing Flow-Limiting CAD?**

1

Cite Schindler TH, Fearon WF.

Share JACC Cardiovasc Imaging. 2023 Oct;16(10):1332-1334. doi: 10.1016/j.jcmg.2023.03.004. Epub 2023 Apr 26.

PMID: 37115161 No abstract available.

**FFR(CT) derived from computed tomography angiography: the experience in**





# Pourquoi la FFR Angio?

 **State-of-the-Art**  
by EuroIntervention

## Functional coronary angiography for the assessment of the epicardial vessels and the microcirculation

Daniel Faria<sup>1,2</sup>, MD; Breda Hennessey<sup>1</sup>, MD; Asad Shabbir<sup>1</sup>, MD; Hernán Mejía-Rentería<sup>1</sup>, MD, PhD;  
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Bon-Kwon Koo<sup>6</sup>, MD, PhD; Bo Xu<sup>7</sup>, MD, PhD; Sergio Bravo Baptista<sup>2,8</sup>, MD, PhD;  
Nieves Gonzalo<sup>1</sup>, MD, PhD; Javier Escaned<sup>1\*</sup>, MD, PhD

### *Abstract*

« Le nouveau domaine de la coronarographie fonctionnelle (FFR Angio) a attiré l'attention des cardiologues cliniciens & interventionnels, car il permet d'anticiper une nouvelle ère d'évaluation physiologique facilitée de la pathologie coronaire, sans nécessiter d'instrumentation coronaire ou de drogue vasodilatatrice et ainsi une meilleure adoption des revascularisations guidée par l'ischémie. »

Daniel Faria, Madrid



# La FFR Angio : comment ça marche ?

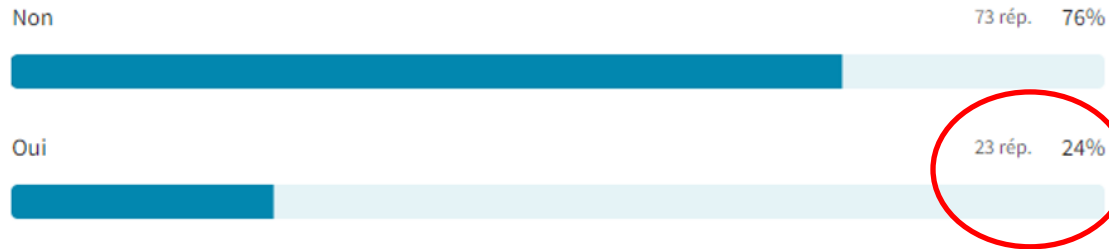
1. **Reconstruction 3D de l'arbre coronaire** obtenu à partir d'une ou plusieurs projections **d'angiographie invasive**
2. **Résolution des équations de la mécanique des fluides** (solutions différentes selon les logiciels)
  - Le plus souvent, **dynamique des fluides « computationnelle »** (calculs mathématiques permettant d'analyser le flux sanguin)
  - Peuvent s'y ajouter selon les logiciels :
    - TIMI Frame Count (apprécie la vitesse du flux)
    - Pression aortique (limite d'entrée du modèle dynamique)
    - Limites de sortie incluant :
      - Résistance de la micro-circulation
      - P veineuse centrale
      - Le plus souvent préétablies



# Nombre de centres français équipés FFR Angio

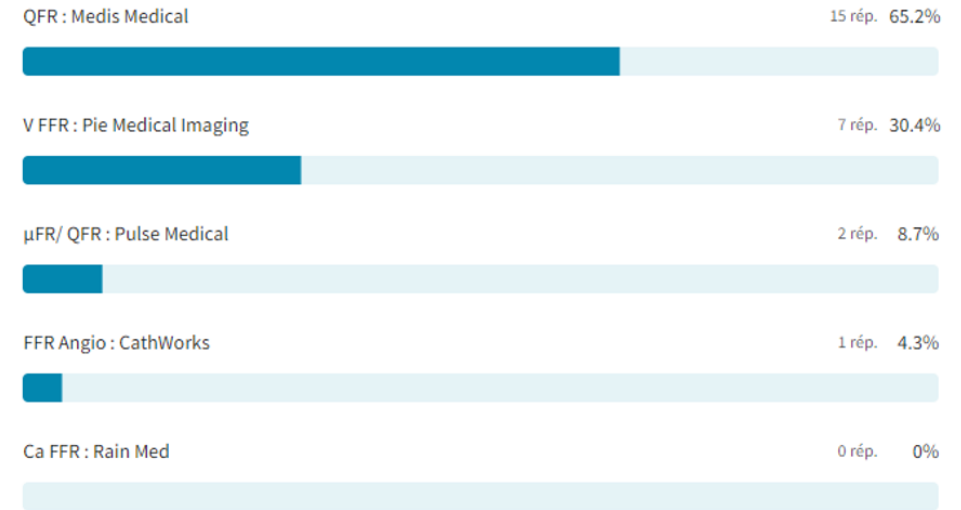
Source: Enquête Physio Abbott octobre 2023

Q12- Êtes-vous équipé d'un logiciel de FFR-Angio ?



➔ 1/4 centres français équipés FFR Angio  
en septembre 2023

Q15- Vous êtes équipés du (des) logiciel(s) de FFR-Angio suivant(s) :

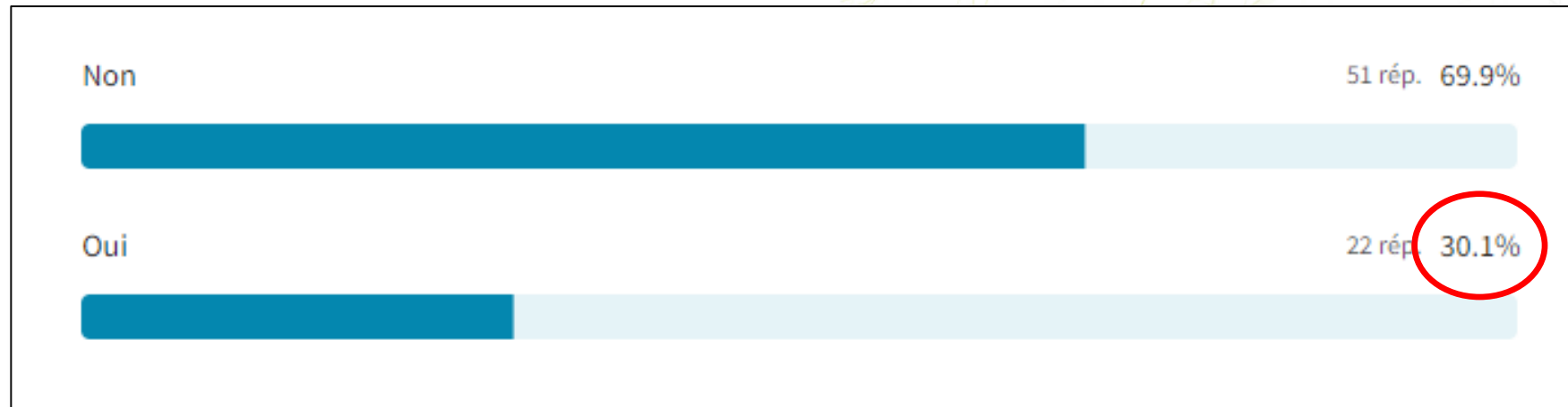


- 2/3 QFR : Médis médical.
- 1/3 V-FFR : Pie médical.
- Quelques μ FR : Pulse Médical.
- Quelques FFR Angio : Cath work





# Envisagez-vous prochainement l'achat d'un logiciel de FFR-Angio ?



→ Fin 2024 > **50% des centres** français seront équipés d'un logiciel de FFR Angio.



# Les différents logiciels de FFR Angio disponibles sur le marché français

**EuroIntervention**

**CENTRAL ILLUSTRATION** Current commercially available functional indices based on invasive coronary angiography.

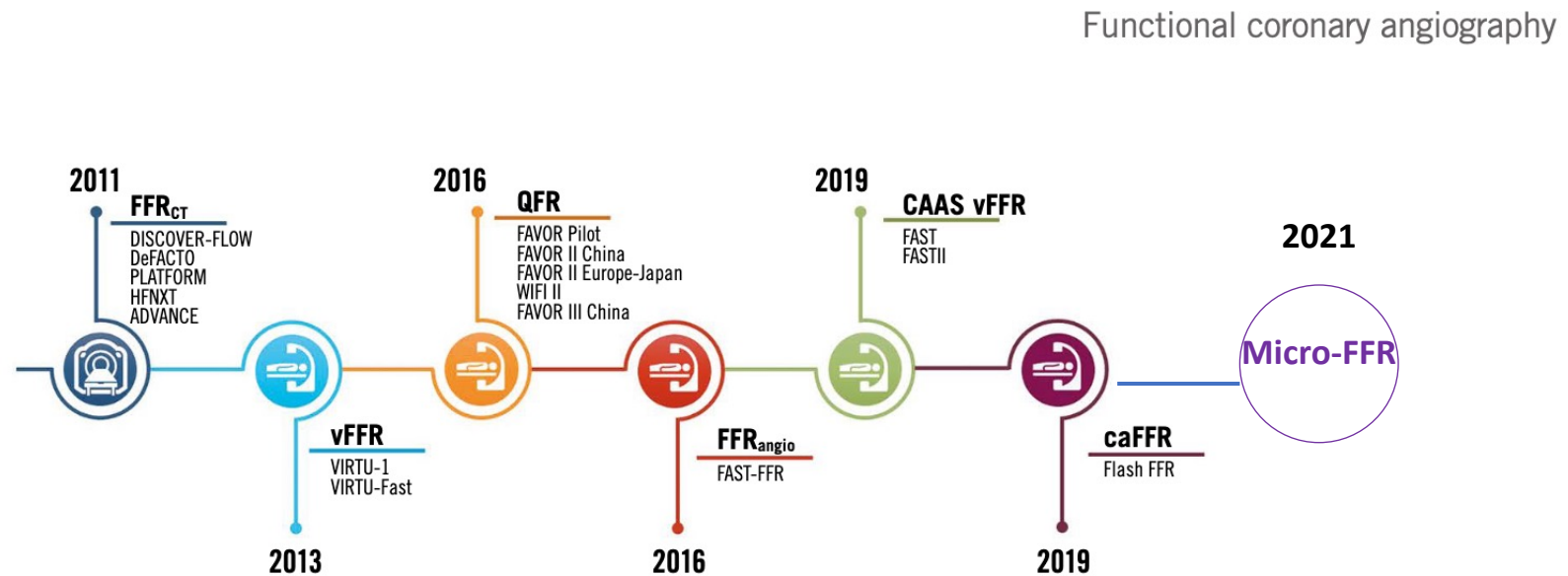
	User display	Projections needed	Pressure sensor	Microcirculation	Side branches	Available data
QFR		2	No	Yes	No	
CAAS vFFR		2	No	No	No	
caFFR		2	Yes	Yes	No	
FFR <sub>angio</sub>		3	Yes	No	Yes	
μQFR		1	No	Yes	Yes	

The columns from left to right show user interface display after index calculation; number of angiographic projections needed; need for mean aortic pressure input; capacity to provide microcirculatory resistance evaluation; simultaneous side branch physiological interrogation; and the quality and quantity of published evidence. Colour code: green=advantage; yellow=amenable; red=disadvantage.

CAAS vFFR: vessel fractional flow reserve; caFFR: computational pressure-flow dynamics derived FFR; FFR: fractional flow reserve; FFR<sub>angio</sub>: angiography-derived FFR; QFR: quantitative flow ratio; μQFR: Murray law-based QFR



# La chronologie des études FFR-Angio



■ EuroIntervention 2023;19:203-221

**Figure 1.** Timeline of the evolution of non-invasive coronary physiology and the respective landmark studies. CAAS vFFR: vessel fractional flow reserve; caFFR: computational pressure-flow dynamics derived FFR; FFR: fractional flow reserve; FFR<sub>angio</sub>: angiography-derived FFR; FFR<sub>CT</sub>: computed tomography-derived FFR; QFR: quantitative flow ratio; vFFR: virtual fractional flow reserve





# QFR : FAVOR Studies depuis 2016


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ISSN 1936-8798/\$36.00  
<http://dx.doi.org/10.1016/j.jcin.2016.07.013>

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

**The International Multicenter FAVOR Pilot Study**

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





# FAVOR II China Study (2017)

**Accepted Manuscript**



Angiography-Based Quantitative Flow Ratio for Online Assessment of Coronary Stenosis: FAVOR II China Study

Bo Xu, MBBS, Shengxian Tu, PhD, Shubin Qiao, MD, Xinkai Qu, MD, Yundai Chen, MD, Junqing Yang, MD, Lijun Guo, MD, Zhongwei Sun, MSc, Zehang Li, BSc, Feng Tian, MD, Weiyi Fang, MD, Jiyan Chen, MD, Wei Li, PhD, Changdong Guan, MSc, Niels R. Holm, MD, William Wijns, MD, PhD, Shengshou Hu, MD

PII: S0735-1097(17)41278-2  
DOI: [10.1016/j.jacc.2017.10.035](https://doi.org/10.1016/j.jacc.2017.10.035)  
Reference: JAC 24376

To appear in: *Journal of the American College of Cardiology*

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Accepted Date: 16 October 2017





# FAVOR II Europe Japan Study (2018)

ORIGINAL RESEARCH



## Diagnostic Performance of In-Procedure Angiography-Derived Quantitative Flow Reserve Compared to Pressure-Derived Fractional Flow Reserve: The FAVOR II Europe-Japan Study

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**Background**—Quantitative flow ratio (QFR) is a novel modality for physiological lesion assessment based on 3-dimensional vessel reconstructions and contrast flow velocity estimates. We evaluated the value of online QFR during routine invasive coronary angiography for procedural feasibility, diagnostic performance, and agreement with pressure-wire-derived fractional flow reserve (FFR) as a gold standard in an international multicenter study.

**Methods and Results**—FAVOR II E-J (Functional Assessment by Various Flow Reconstructions II Europe-Japan) was a prospective, observational, investigator-initiated study. Patients with stable angina pectoris were enrolled in 11 international centers. FFR and online QFR computation were performed in all eligible lesions. An independent core lab performed 2-dimensional quantitative coronary angiography (2D-QCA) analysis of all lesions assessed with QFR and FFR. The primary comparison was sensitivity and specificity of QFR compared with 2D-QCA using FFR as a reference standard. A total of 329 patients were enrolled. Paired assessment of FFR, QFR, and 2D-QCA was available for 317 lesions. Mean FFR, QFR, and percent diameter stenosis were  $0.83 \pm 0.09$ ,  $0.82 \pm 10$ , and  $45 \pm 10\%$ , respectively. FFR was  $\leq 0.80$  in 104 (33%) lesions. Sensitivity and specificity by QFR was significantly higher than by 2D-QCA (sensitivity, 86.5% [78.4–92.4] versus 44.2% [34.5–54.3];  $P < 0.001$ ; specificity, 86.9% [81.6–91.1] versus 76.5% [70.3–82.0];  $P = 0.002$ ). Area under the receiver curve was significantly higher for QFR compared with 2D-QCA (area under the receiver curve, 0.92 [0.89–0.96] versus 0.64 [0.57–0.70];  $P < 0.001$ ). Median time to QFR was significantly lower than median time to FFR (time to QFR, 5.0 minutes [interquartile range, –6.1] versus time to FFR, 7.0 minutes [interquartile range, 5.0–10.0];  $P < 0.001$ ).

**Conclusions**—Online computation of QFR in the catheterization laboratory is clinically feasible and is superior to angiographic assessment for evaluation of intermediary coronary artery stenosis using FFR as a reference standard.

**Clinical Trial Registration**—URL: <https://www.clinicaltrials.gov>. Unique identifier: NCT02959814. (*J Am Heart Assoc.* 2018;7:e009603. DOI: 10.1161/JAHA.118.009603.)

Etude multi centrique > 300 pts ..  
Montrait simplement que la FFR Angio  
était mieux corrélée à la FFR wire que  
le QCA ...





# FAVOR III China

## Angiographic quantitative flow ratio-guided coronary intervention (FAVOR III China): a multicentre, randomised, sham-controlled trial



Bo Xu\*, Shengxian Tu\*, Lei Song\*, Zening Jin, Bo Yu, Guosheng Fu, Yujie Zhou, Jian'an Wang, Yundai Chen, Jun Pu, Lianglong Chen, Xinkai Qu, Junqing Yang, Xuebo Liu, Lijun Guo, Chengxing Shen, Yaojun Zhang, Qi Zhang, Hongwei Pan, Xiaogang Fu, Jian Liu, Yanyan Zhao, Javier Escaned, Yang Wang, William F Fearon, Kefei Dou, Ajay J Kirtane, Yongjian Wu, Patrick W Serruys, Weixian Yang, William Wijns, Changdang Guan, Martin B Leon†, Shubin Qiao\*†, Gregg W Stone†, and the FAVOR III China study group†

### Summary

**Background** Compared with visual angiographic assessment, pressure wire-based physiological measurement more accurately identifies flow-limiting lesions in patients with coronary artery disease. Nonetheless, angiography remains the most widely used method to guide percutaneous coronary intervention (PCI). In FAVOR III China, we aimed to establish whether clinical outcomes might be improved by lesion selection for PCI using the quantitative flow ratio (QFR), a novel angiography-based approach to estimate the fractional flow reserve.

**Methods** FAVOR III China is a multicentre, blinded, randomised, sham-controlled trial done at 26 hospitals in China. Patients aged 18 years or older, with stable or unstable angina pectoris or patients who had a myocardial infarction at least 72 h before screening, who had at least one lesion with a diameter stenosis of 50–90% in a coronary artery with a reference vessel of at least 2.5 mm diameter by visual assessment were eligible. Patients were randomly assigned to a QFR-guided strategy (PCI performed only if QFR  $\leq 0.80$ ) or an angiography-guided strategy (PCI based on standard visual angiographic assessment). Participants and clinical assessors were masked to treatment allocation. The primary endpoint was the 1-year rate of major adverse cardiac events, a composite of death from any cause, myocardial infarction, or ischaemia-driven revascularisation. The primary analysis was done in the intention-to-treat population. The trial was registered with ClinicaTrials.gov (NCT03656848).

**Findings** Between Dec 25, 2018, and Jan 19, 2020, 3847 patients were enrolled. After exclusion of 22 patients who elected not to undergo PCI or who were withdrawn by their physicians, 3825 participants were included in the intention-to-treat population (1913 in the QFR-guided group and 1912 in the angiography-guided group). The mean age was 62.7 years (SD 10.1), 2699 (70.6%) were men and 1126 (29.4%) were women, 1295 (33.9%) had diabetes, and 2428 (63.5%) presented with an acute coronary syndrome. The 1-year primary endpoint occurred in 110 (Kaplan-Meier estimated rate 5.8%) participants in the QFR-guided group and in 167 (8.8%) participants in the angiography-guided group (difference,  $-3.0\%$  [95% CI  $-4.7$  to  $-1.4$ ]; hazard ratio 0.65 [95% CI 0.51 to 0.83];  $p=0.0004$ ), driven by fewer myocardial infarctions and ischaemia-driven revascularisations in the QFR-guided group than in the angiography-guided group.

**Interpretation** In FAVOR III China, among patients undergoing PCI, a QFR-guided strategy of lesion selection improved 1-year clinical outcomes compared with standard angiography guidance.

Lancet 2021; 398: 2149–59

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[https://doi.org/10.1016/S0140-6736\(21\)02248-0](https://doi.org/10.1016/S0140-6736(21)02248-0)

See Comment page 2130

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Première étude FFR angio avec end points cliniques..  
Stratégie de guidage de l'angioplastie coronaire par QFR est meilleure que par angiographie .😊



# FAVOR III Europe-Japan

**QFR guided PCI strategy vs FFR wire guided PCI strategy :**

- 2000 patients
- Clinical end points
- Résultats 2025 ?

**Une stratégie de guidage de l'angioplastie coronaire par la QFR VS FFR wire est-elle équivalente** en termes d'end points cliniques ?



# V-FFR : FAST studies depuis 2019

Received: 6 November 2019 | Revised: 2 August 2020 | Accepted: 21 September 2020  
DOI: 10.1002/ccd.29311

ORIGINAL STUDIES

WILEY

## Validation of novel 3-dimensional quantitative coronary angiography based software to calculate fractional flow reserve post stenting

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**Abstract**  
**Objectives:** To validate novel dedicated 3D-QCA based on the software to calculate post PCI vessel-FFR (vFFR) in a consecutive series of patients, to assess the diagnostic accuracy, and to assess inter-observer variability.  
**Background:** Low post percutaneous coronary intervention (PCI) fractional flow reserve (FFR) predicts future adverse cardiac events. However, FFR assessment requires the insertion of a pressure wire in combination with the use of a hyperemic agent.  
**Methods:** FAST POST study is an observational, retrospective, single-center cohort study. One hundred patients presenting with stable angina or non ST-elevation myocardial infarction, who underwent post PCI FFR assessment using a dedicated microcatheter were included. Two orthogonal angiographic projections were acquired to create a 3D reconstruction of the coronary artery using the CAAS workstation 8.0. vFFR was subsequently calculated using the aortic root pressure.  
**Results:** Mean age was 65±12 years and 70% were male. Mean microcatheter based FFR and vFFR were 0.91±0.07 and 0.91±0.06, respectively. A good linear correlation was found between FFR and vFFR ( $r = 0.88$ ;  $p < .001$ ). vFFR had a higher accuracy in the identification of patients with FFR values  $<0.90$ , AUC 0.98 (95% CI: 0.96-1.00) as compared with 3D-QCA AUC 0.62 (95% CI: 0.94-0.74). Assessment of vFFR had a low inter-observer variability ( $r = 0.95$ ;  $p < .001$ ).  
**Conclusion:** 3D-QCA derived post PCI vFFR correlates well with invasively measured microcatheter based FFR and has a high diagnostic accuracy to detect FFR  $<0.90$  with low inter-observer variability.

**KEYWORDS**  
coronary angiography, fractional flow reserve, quantitative coronary angiography

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Catheter Cardiovasc Interv. 2020;1-7. | wileyonlinelibrary.com/journal/ccd | 1





# FAST STUDY (2020)

**CORONARY INTERVENTIONS**  
CLINICAL RESEARCH

Special feature: Physiology indices

## Validation of a three-dimensional quantitative coronary angiography-based software to calculate fractional flow reserve: the FAST study



**Kaneshka Masdjedi**<sup>1</sup>, MD; Laurens J.C. van Zandvoort<sup>1</sup>, BSc; Matthew M. Balbi<sup>1</sup>, MD; Frank J.H. Gijssen<sup>1</sup>, PhD; Jurgen M.R. Ligthart<sup>1</sup>, RT; Marcel C.M. Rutten<sup>2</sup>, ir. PhD; Miguel E. Lemmert<sup>1</sup>, MD, PhD; Jeroen Wilschut<sup>1</sup>, MD; Roberto Diletti<sup>1</sup>, MD, PhD; Peter de Jaegere<sup>1</sup>, MD, PhD; Felix Zijlstra<sup>1</sup>, MD, PhD; Nicolas M. Van Mieghem<sup>1</sup>, MD, PhD; Joost Daemen<sup>1\*</sup>, MD, PhD

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**KEYWORDS**

- fractional flow reserve
- other technique
- QCA
- stable angina

**Abstract**

**Aims:** The aim of this study was to validate novel software to calculate vessel fractional flow reserve (vFFR) based on 3D-QCA and to assess inter-observer variability in patients who underwent routine preprocedural FFR assessment for intermediate coronary artery stenosis.

**Methods and results:** *In vitro* validation was performed in an experimental model. Clinical validation was performed in an observational, retrospective, single-centre cohort study. A total of 100 patients presenting with stable angina or non-ST-segment elevation myocardial infarction and an indication to perform FFR between January 2016 and October 2016 were included. vFFR was calculated based on the aortic root pressure along with two angiographic projections and validated against pressure wire-derived FFR. Mean FFR and vFFR were 0.82±0.08 and 0.84±0.07, respectively. A good linear correlation was found between FFR and vFFR ( $r=0.89$ ;  $p<0.001$ ). Assessment of vFFR had a low inter-observer variability ( $r=0.95$ ;  $p<0.001$ ). The diagnostic accuracy of vFFR in identifying lesions with an FFR  $\leq 0.80$  was higher as compared with 3D-QCA: AUC 0.93 (95% CI: 0.88-0.97) vs 0.66 (95% CI: 0.55-0.77), respectively.

**Conclusions:** The 3D-QCA-derived vFFR has a high linear correlation to invasively measured FFR, a high diagnostic accuracy to detect FFR  $\leq 0.80$  and a low inter-observer variability.

EuroIntervention 2020;16:591-599 published online 1 May 2019

DOI: 10.4244/EIJ-D-19-00101



# FAST II study (2021)

**CORONARY INTERVENTIONS**  
CLINICAL RESEARCH

**Vessel fractional flow reserve (vFFR) for the assessment of stenosis severity: the FAST II study**

Kaneshka Masdjedi<sup>1</sup>, MD, PhD; Nobuhiro Tanaka<sup>2</sup>, MD, PhD; Eric Van Belle<sup>3</sup>, MD, PhD; Sina Porouchani<sup>3</sup>, MD; Axel Linke<sup>4,5</sup>, MD, PhD; Felix J. Woitek<sup>4</sup>, MD, PhD; Antonio L. Bartorelli<sup>6</sup>, MD, PhD; Ziad A. Ali<sup>7,8</sup>, MD, DPhil; Wijnand K. den Dekker<sup>1</sup>, MD, PhD; Jeroen Wilschut<sup>1</sup>, MD; Roberto Diletti<sup>1</sup>, MD, PhD; Felix Zijlstra<sup>1</sup>, MD, PhD; Eric Boersma<sup>1</sup>, MD, PhD; Nicolas M. Van Mieghem<sup>1</sup>, MD, PhD; Ernest Spitzer<sup>9</sup>, MD, PhD; Joost Daemen<sup>1\*</sup>, MD, PhD and the FAST II Study Investigators

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**KEYWORDS**

- fractional flow reserve
- other technique
- QCA

**Abstract**

**Background:** Fractional flow reserve (FFR)-guided percutaneous coronary intervention (PCI) is superior to angiography-guided PCI. The clinical uptake of FFR has been limited, however, by the need to advance a wire in the coronary artery, the additional time required and the need for hyperaemic agents which can cause patient discomfort. FFR derived from routine coronary angiography eliminates these issues.

**Aims:** The aim of this study was to assess the diagnostic performance and accuracy of three-dimensional quantitative coronary angiography (3D-QCA)-based vessel FFR (vFFR) compared to pressure wire-based FFR ( $\leq 0.80$ ).

**Methods:** The FAST II (Fast Assessment of STenosis severity) study was a prospective observational multicentre study designed to evaluate the diagnostic accuracy of vFFR compared to the reference standard (pressure wire-based FFR  $\leq 0.80$ ). A total of 334 patients from six centres were enrolled. Both site-determined and blinded independent core lab vFFR measurements were compared to FFR.

**Results:** The core lab vFFR was  $0.83 \pm 0.09$  and pressure wire-based FFR  $0.83 \pm 0.08$ . A good correlation was found between core lab vFFR and pressure wire-based FFR ( $R=0.74$ ;  $p<0.001$ ; mean bias  $0.0029 \pm 0.0642$ ). vFFR had an excellent diagnostic accuracy in identifying lesions with an invasive wire-based FFR  $\leq 0.80$  (area under the curve [AUC] 0.93; 95% confidence interval [CI]: 0.90-0.96;  $p<0.001$ ). Positive predictive value, negative predictive value, diagnostic accuracy, sensitivity and specificity of vFFR were 90%, 90%, 90%, 81% and 95%, respectively.

**Conclusions:** 3D-QCA-based vFFR has excellent diagnostic performance to detect FFR  $\leq 0.80$ . The study was registered on clinicaltrials.gov under identifier NCT03791320.

DOI: 10.2244/EJ.03

Etude X centrique > 300 pts..  
V FFR bonne corrélation avec la FFR wire



# FAST III trial

## Fractional flow reserve or 3D-quantitative-coronary-angiography based vessel-FFR guided revascularization. Rationale and study design of the prospective randomized fast III trial

Alessandra Scoccia<sup>1</sup>, Robert A Byrne<sup>2</sup>, Adrian P Banning<sup>3</sup>, Ulf Landmesser<sup>4</sup>, Eric Van Belle<sup>5</sup>, Ignacio J Amat-Santos<sup>6</sup>, Manel Sabaté<sup>7</sup>, Jan G P Tijssen<sup>8</sup>, Ernest Spitzer<sup>9</sup>, Joost Daemen<sup>10</sup>

**Study design and objectives:** The FAST III is an investigator-initiated, open label, multicenter randomized trial comparing vFFR guided versus FFR guided coronary revascularization in approximately 2228 patients with intermediate coronary lesions (defined as 30%-80% stenosis by visual assessment or QCA).

Résultats en 2025 ?

**Première étude comparant stratégie d'angioplastie coronaire guidée par la V FFR VS FFR wire avec end points cliniques**





# FFR angio : études depuis 2017

## Circulation

Volume 139, Issue 4, 22 January 2019; Pages 477-484  
<https://doi.org/10.1161/CIRCULATIONAHA.118.037350>



### ORIGINAL RESEARCH ARTICLE

## Accuracy of Fractional Flow Reserve Derived From Coronary Angiography

Editorial, see p 485

William F. Fearon, MD, Stephan Achenbach, MD, PhD, Thomas Engstrom, MD, PhD, Abid Assali, MD, Richard Shlofmitz, MD, Allen Jeremias, MD, Stephane Fournier, MD, Ajay J. Kirtane, MD, Ran Kornowski, MD, Gabriel Greenberg, MD, Rami Jubeh, MD, Daniel M. Kolansky, MD, Thomas McAndrew, PhD, Ovidiu Dressler, MD, Akiko Maehara, MD, Mitsuaki Matsumura, BS, Martin B. Leon, MD, and Bernard De Bruyne, MD, PhD For the FAST-FFR Study Investigators

### Conclusions:


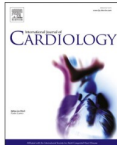
FFRangio measured from the coronary angiogram alone has a high sensitivity, specificity, and accuracy compared with pressure wire-derived FFR. FFRangio has the promise to substantially increase physiological coronary lesion assessment in the catheterization laboratory, thereby potentially leading to improved patient outcomes.



# Une des rares études comparatives de FFR Angio FFR Angio vs QFR

International Journal of Cardiology 399 (2024) 131663

Contents lists available at [ScienceDirect](#)


 **International Journal of Cardiology** 

journal homepage: [www.elsevier.com/locate/ijcard](http://www.elsevier.com/locate/ijcard)

**Head-to-head comparison of two angiography-derived fractional flow reserve techniques in patients with high-risk acute coronary syndrome: A multicenter prospective study**

Ioannis Skalidis<sup>a,b,1</sup>, Nathalie Noirclerc<sup>a,1</sup>, David Meier<sup>a</sup>, Wongsakorn Luangphiphat<sup>a</sup>, Aurelien Cagnina<sup>a</sup>, Sarah Mauler-Wittwer<sup>a</sup>, Thabo Mahendiran<sup>a</sup>, Bernard De Bruyne<sup>a,c</sup>, Alessandro Candreva<sup>d</sup>, Carlos Collet<sup>c</sup>, Jeroen Sonck<sup>c</sup>, Olivier Muller<sup>a</sup>, Stephane Fournier<sup>a,\*</sup>

<sup>a</sup> Department of Cardiology, Lausanne University Hospital and University of Lausanne, Lausanne, Switzerland  
<sup>b</sup> School of Medicine, University of Crete, Greece  
<sup>c</sup> Cardiovascular Center Aalst, Aalst, Belgium  
<sup>d</sup> Department of Cardiology, University Hospital of Zurich, Zurich, Switzerland



**Conclusion:** In patients with high-risk ACS, FFRangio and QFR demonstrated excellent diagnostic performance. FFRangio seems to have better correlation to invasive FFR compared to QFR but further larger validation studies are required.



# $\mu$ FFR : études depuis 2021

- Logiciel basé sur la loi fractale « Murray Law » simplifiée par G. Finet « Loi de Finet ».
- Autorise **la reconstruction 3D avec une seule projection angiographique.**





Received: 8 January 2021 | Revised: 16 February 2021 | Accepted: 19 February 2021  
DOI: 10.1002/ccd.29592

**ORIGINAL STUDIES**

WILEY

## 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<sup>1,2</sup>  | Daixin Ding MSc<sup>1,3</sup> | Yunxiao Chang MSc<sup>4</sup> |  
Chunming Li BSc<sup>1</sup> | William Wijns MD, PhD<sup>3</sup> | Bo Xu MBBS<sup>5</sup>

**Objectives:** We aimed to evaluate the diagnostic accuracy of computation of fractional flow reserve (FFR) from a single angiographic view in patients with intermediate coronary stenosis.

**Results:** The  $\mu$ QFR was successfully computed in all 330 vessels of 306 patients. There was excellent correlation ( $r = 0.90$ ,  $p < .001$ ) and agreement (mean difference =  $0.00 \pm 0.05$ ,  $p = .378$ ) between  $\mu$ QFR and FFR. The vessel-level diagnostic accuracy for  $\mu$ QFR to identify hemodynamically significant stenosis was 93.0% [...].



# Certaines FFR Angio sont-elles meilleures que les autres ?



ESC

European Society  
of Cardiology

European Heart Journal (2018) 39, 3314–3321  
doi:10.1093/eurheartj/ehy445

**META-ANALYSIS**

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

Carlos Collet<sup>1,2</sup>, Yoshinobu Onuma<sup>3,4</sup>, Jeroen Sonck<sup>2</sup>, Taku Asano<sup>1</sup>, Bert Vandeloos<sup>2</sup>, Ran Kornowski<sup>5</sup>, Shengxian Tu<sup>6</sup>, Jelmer Westra<sup>7</sup>, Niels R. Holm<sup>7</sup>, Bo Xu<sup>8</sup>, Robbert J. de Winter<sup>1</sup>, Jan G. Tijssen<sup>1</sup>, Yosuke Miyazaki<sup>4</sup>, Yuki Katagiri<sup>1</sup>, Erhan Tenekecioglu<sup>4</sup>, Rodrigo Modolo<sup>1</sup>, Ply Chichareon<sup>1</sup>, Bernard Cosyns<sup>2</sup>, Daniel Schoors<sup>2</sup>, Bram Roosens<sup>2</sup>, Stijn Lochy<sup>2</sup>, Jean-Francois Argacha<sup>2</sup>, Alexandre van Rosendaal<sup>9</sup>, Jeroen Bax<sup>9</sup>, Johan H.C. Reiber<sup>10,11</sup>, Javier Escaned<sup>12</sup>, Bernard De Bruyne<sup>13</sup>, William Wijns<sup>14</sup>, and Patrick W. Serruys<sup>15\*</sup>

### Conclusion:

The accuracy of angiography-derived FFR was good to detect haemodynamically significant lesions with pressure-wire measured FFR as a reference. **Computational approaches and software packages did not influence the diagnostic accuracy of angiography-derived FFR.** A diagnostic strategy trial with angiography-derived FFR evaluating clinical endpoints is warranted.



# Logiciels FFR angio tous été validés dans essais clinique vs FFR Wire avec une excellente accuracy (AUC 0.92 à 0.97)

## Angio-derived FFR- reported correlation with FFR



TABLE I. THREE CORONARY ANGIOGRAPHY-DERIVED PHYSIOLOGIC INDICES AND THEIR DIAGNOSTIC PERFORMANCE AGAINST WIRE-BASED FFR

Index	Company	Clinical Studies	Year	Correlation With FFR	Sensitivity	Specificity	Accuracy	AUC (95% CI)	
FFRangio	CathWorks	Komowski et al <sup>2</sup>	2016	0.90-0.93	0.88	0.98	0.94	-	
		Pellicano et al <sup>3</sup>	2017	0.88	0.88	0.95	0.93	0.97 (N/A)	
		FAST-FFR <sup>4</sup>	2019	0.80	0.94	0.91	0.92	0.94 (0.92-0.97)	
		Kobayashi et al <sup>5</sup>							
		- LAD	2020	-	0.93	0.99	-	-	
		- LCX		-	1.00	0.86	-	-	
		- RCA		-	0.92	0.84	-	-	
		Witberg et al <sup>6</sup>							
		- FFR (range, 0.75-0.85)	2020	-	0.82	0.89	0.86	-	
		Omori et al <sup>7</sup>							
- MVD	2019	0.83	0.92	0.92	0.92	0.92 (0.84-0.97)			
QFR	Medis Medical Imaging/Pulse Medical Imaging Technology	FAVOR Pilot <sup>4</sup>	2016	0.77	0.74	0.91	0.85	0.92 (0.84-0.97)	
		FAVOR II China <sup>6</sup>	2017	0.86	0.95	0.92	0.92	0.96 (0.94-0.98)	
		FAVOR II Europe-Japan <sup>7</sup>	2018	0.80	0.87	0.87	0.87	0.92 (0.89-0.96)	
		- FFR (range, 0.75-0.84)	-	-	-	-	0.71	-	
vFFR	Pie Medical Imaging	FAST <sup>8</sup>	2020	0.89	-	-	-	0.93 (0.88-0.97)	

Abbreviations: AUC, area under the curve; FFR, fractional flow reserve; LAD, left anterior descending artery; LCX, left circumflex artery; MVD, multivessel disease; N/A, not available; QFR, quantitative flow ratio; RCA, right coronary artery; vFFR, vessel fractional flow reserve.





# Alors, la messe est dite...

## La FFR angio est :

- Moins invasive
- Ne nécessite pas de vaso dilatateurs
- Moins coûteuse
- Economise du temps

**Pourquoi continuer à s'ennuyer avec la FFR Wire dont le guide n'est plus remboursé ?**



# Cependant certaines limitations existent... (1)

- ≈ **15 à 20 %** des angiogrammes non utilisables pour FFR angio (qualité technique insuffisante, tortuosités, superpositions...)
- La FFR angio ne s'applique pas :
  - **Lésions ostiales** – Tronc commun ou CD ;
  - **Lésions de bifurcations ; Vaisseaux pontés ; CTO ; RIS ; lésions diffuses ;**
  - Le plus souvent, la FFR angio **ignore la micro circulation.**
- Le problème de la **correction manuelle** :
  - Subjective → différences inter observateurs



## (2) | excellente accuracy des logiciels FFR Angio vs FFR Wire dans les études des constructeurs (AUC 0.92 à 0.97)

### Angio-derived FFR- reported correlation with FFR



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# Est elle retrouvée dans la « vraie vie » ?





JACC: Cardiovascular Interventions  
Volume 16, Issue 14, 24 July 2023, Pages 1778-1790



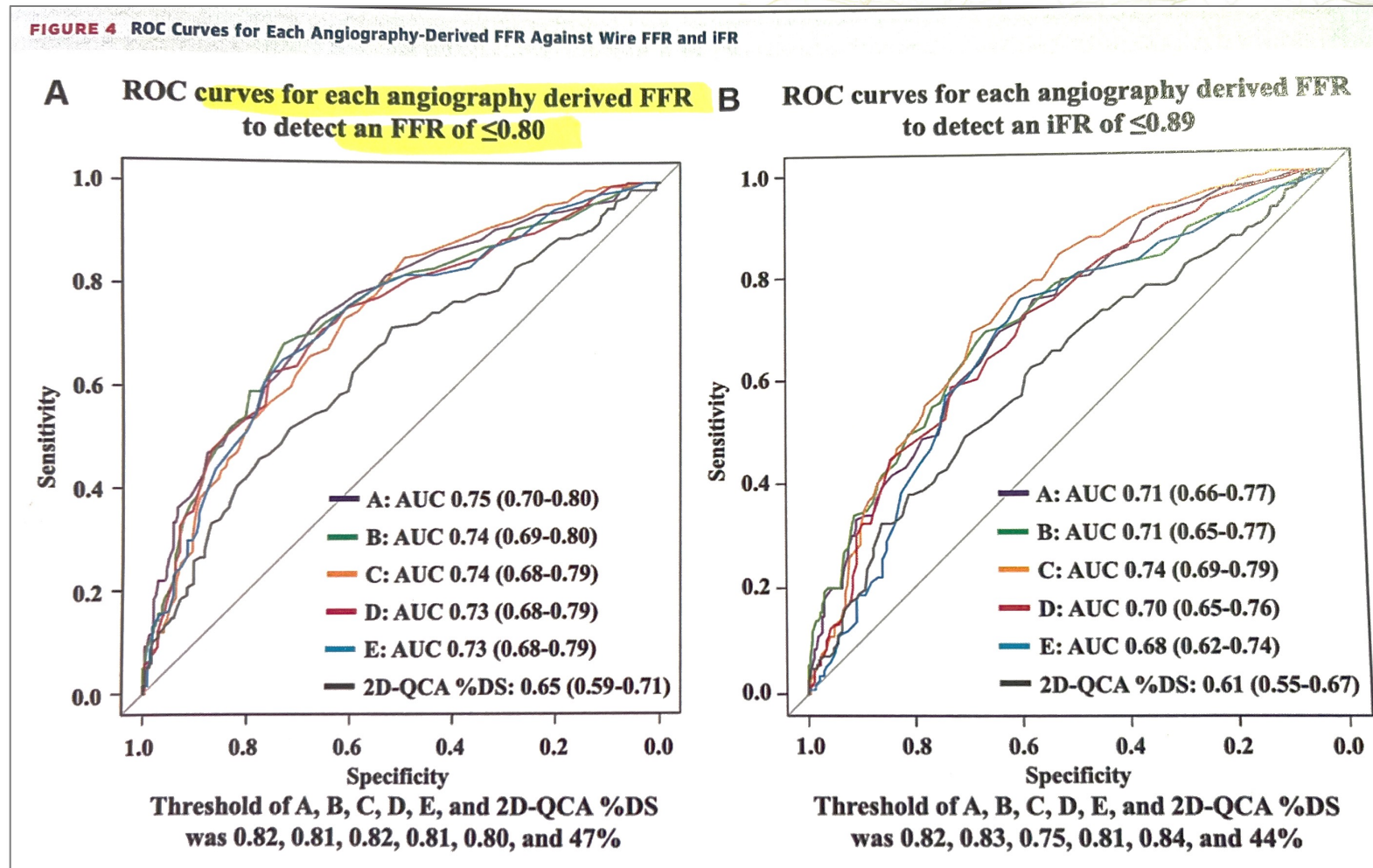
New Research Paper  
Coronary

## Anonymous Comparison of Various Angiography-Derived Fractional Flow Reserve Software With Pressure-Derived Physiological Assessment

Kai Ninomiya MD<sup>a\*</sup>, Patrick W. Serruys MD, PhD<sup>a b\*</sup>  , Nozomi Kotoku MD<sup>a</sup>,  
Jinying Zhou MD<sup>a</sup>, Shigetaka Kageyama MD<sup>a</sup>, Shinichiro Masuda MD<sup>a</sup>, Pruthvi C. Revaiah MD<sup>a</sup>,  
Bo Wang MD<sup>a</sup>, Xingqiang He MD<sup>a</sup>, Tsung-Ying Tsai MD<sup>a</sup>, Momoko Kageyama MD<sup>a</sup>,  
Emelyne Sevestre BA<sup>a</sup>, Faisal Sharif MD, PhD<sup>a</sup>, Scot Garg MD, PhD<sup>c</sup>, Takashi Akasaka MD, PhD<sup>d</sup>,  
Javier Escaned MD, PhD<sup>e</sup>, Manesh R. Patel MD, PhD<sup>f</sup>, Yoshinobu Onuma MD, PhD<sup>a</sup>



# Moins bonne corrélation FFR angio vs FFR wire (AUC 0.68-0.74)





# En synthèse..

- **Excellente Accuracy** des études FAVOR ,FAST,.. **des constructeurs (AUC 0.92 à 0.97)**
- **Plus modeste Accuracy** dans la « vraie vie » ANONYMOUS (AUC 0.73 à 0.75)

## De plus pour certains sous-groupes de lésions:

- IVA : FFR angio + faux positifs / CX ou CD vs FFR Wire.
- Lésions coronaires en **zone grise**  $0.75 < \text{FFR angio} < 0.85$  : **AUC 0.63.**

**P. Serruys « Les lésions FFR angio 0.70 à 0.90 pourraient encore nécessiter une étude FFR wire ».**





# Alors : FFR Angio vs FFR Wire ?

Il nous faudra attendre encore **1 à 2 ans** pour pouvoir trancher cette question avec les résultats **FAVOR III Europe – Japan et FAST III**

*(comparant le guidage de l'angioplastie coronaire par la FFR Angio vs FFRw ; > 2000 pts, end points cliniques).*

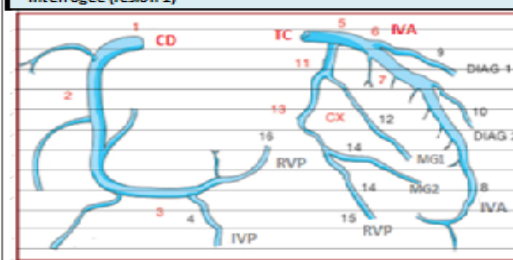


# Que faire en attendant ?

## Votre propre registre FFR angio VS Pressure wire FFR !

### Registre Réunion CSC v-FFR vs Pressure wire FFR :

- > 100 pts, > 130 lésions,
- Inclusions terminées
- Résultats statistiques en attente

Prénom:		Segment d'artère Interrogée (lésion 1)	
Nom: (1ère lettre):			
DDN:	Age:	1 CD I	5 TC G
IPP:		2 CD II	6 IVA I
No examen:		3 CD III	7 IVA II
<b>Opérateur</b>		4 IVP	8 IVA III
FFR wire		16 RVP	9 DIAG 1
V FFR			10 DIAG 2
<b>Antécédents</b>			11 CX I
PCI			12 MG 1
Pontages			13 CX II
<b>facteurs de risque</b>			14 MG 2
Diabète			15 RVP - CX
Hypercholestérolémie			17
Hypertension			Bissectrice
Tabac	ancien / actif	<b>Incidence de coregistration</b>	
	0	<b>Lésions/QCA</b>	
	modérée	Diamètre référence (mm)	
	sévère	Longueur (mm)	
	dialyse	% Sténose	
		MLD (mm)	
		<b>Résultats:</b>	
		V FFR	
		Pressure Wire FFR	
		<b>Indications Contrôle FFR</b>	
		wire/ V FFR : registre CSC	
		<b>PA au début de la FFR angio</b>	
		<b>Technique</b>	
		KT diagnostique 5F	
		KT guide	
		5F	
		6F	
		7F	
		<b>Traitement</b>	
		TNT 3mg	
		* Intra coronaire	
		* Intra artériel radial	
		Héparine IV z 50 U/Kg	
		Aspegic IV 250 mg	
		Adénosine IV 180 gamma/kg/min	
		<b>Décision thérapeutique</b>	
		OMT	
		PCI	
		Pontages	
		Signature consentement par le patient et le médecin en 2 exemplaires :	
		Signature cardiologue v FFR	
		signature cardiologue Pressure Wire FFR	
<b>Obésité</b>			
surpoids (IMC 25-30)			
obésité (IMC > 30)			
<b>Présentation clinique</b>			
Angor stable			
Asymptomatique à test d'ischémie +			
Asymptomatique et pas de test d'ischémie			
SCA ST -			
SCA ST + (artère non coupable)			
Coro systématique, bilan pré op vasc/valvulaire			
<b>FEVG</b>			
Normale			
40-50%			
30-40%			
< 30%			
<b>Coronarographie</b>			
1 TC			
2 TC			
3 TC			



# La réalisation de votre « registre Home-made »

Avec votre propre logiciel, piloté par votre propre équipe médicale ou paramédicale :

→ Votre propre accuracy (vs FFRw)

→ Votre propre corrélation

→ Quels cas nécessiteraient encore une validation par la FFR invasive (grey zone)... ?





# Take home Message

Attendez encore un peu avant de remiser vos Pressure wires  
au placard..





# Le mot de la fin...





# Le dernier mot à Patrick Serruys

**La FFR Angio  
durera 5 ans**



*PCR Mai 2023*





# Dans un avenir proche (5 ans ?)

La FFR Angio sera probablement **remplacée par la FFR CT**, réellement non invasive (à la différence de la FFR Angio basée sur la coronarographie invasive).

- La FFR CT permettant de guider et planifier la revascularisation coronaire :
  - ↳ besoins de coronarographie invasive
  - ↳ besoins de FFR wire



# Conclusion

« Pour ou contre: le scanner coronaire en investigation de première intention dans les syndromes coronariens chroniques ? »

DEBATE ■

EuroIntervention 2023;19:459-461

**Coronary CT as a first-line investigation in chronic coronary syndromes: pros and cons**

Antonio L. Bartorelli<sup>1,2\*</sup>, MD, FESC, FACC; Daniele Andreini<sup>1,2</sup>, MD, PhD, FESC, FSCCT; Gennaro Giustino<sup>3</sup>, MD; George Dangas<sup>3\*\*</sup>, MD, PhD

*1. IRCCS Ospedale Galeazzi - Sant'Ambrogio, Milan, Italy; 2. Department of Biomedical and Clinical Sciences, University of Milan, Milan, Italy; 3. The Zena and Michael A. Wiener Cardiovascular Institute, Icahn School of Medicine at Mount Sinai, New York, NY, USA*

**Ce débat qui agite aujourd'hui la communauté cardiologique sera probablement tranché dans un proche avenir en faveur de la FFR CT.**



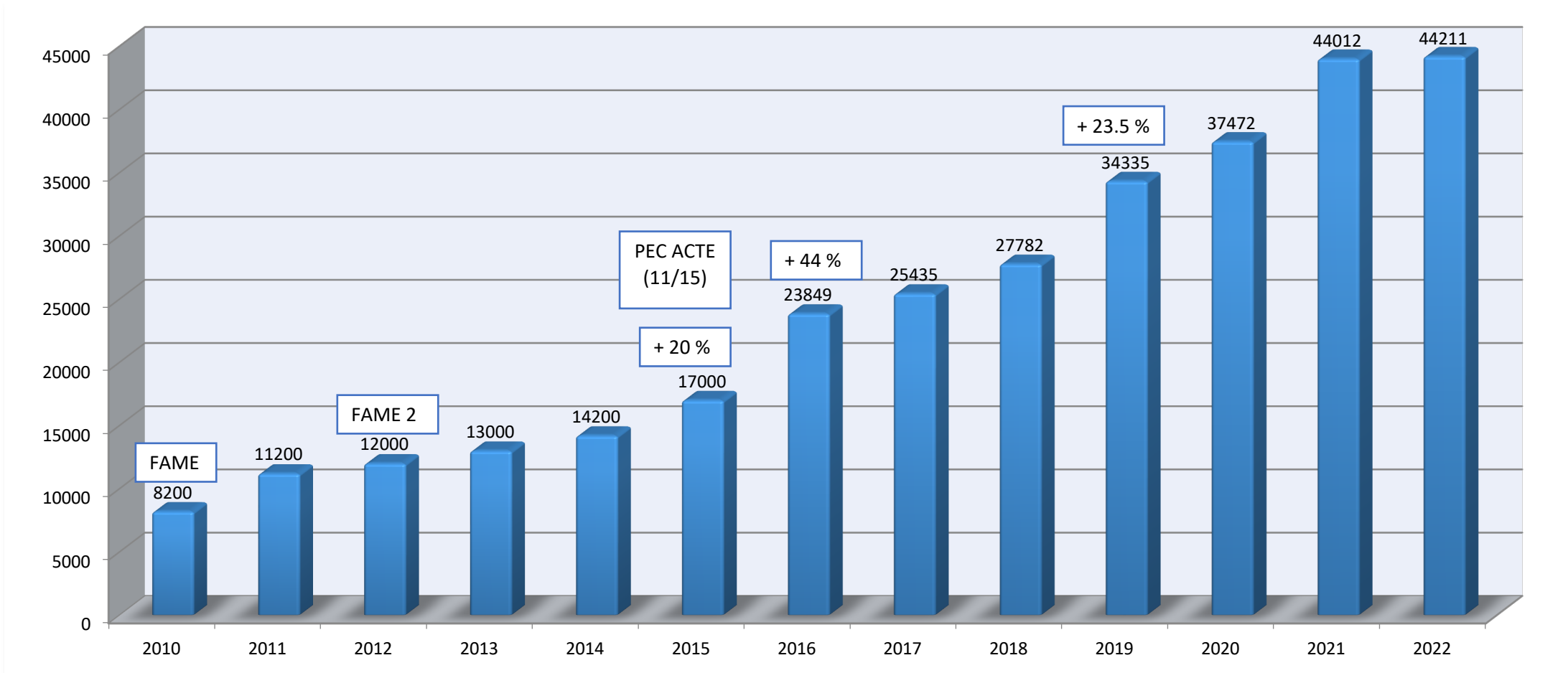
*Merci*







# Evolution activité FFR en France jusqu'à 2022\*





# Quelques précisions

- Par FFR Angio, on entend **l'ensemble des logiciels** permettant de calculer la FFR dérivée de **l'angiographie coronaire** (il ne s'agit pas du logiciel dénommé FFR angio).
- La présentation se limitera à la **FFR Angio** (dérivée de l'angiographie coronaire), **sans parler de la FFR CT** (dérivée du scanner).



# France : ratio FFR / PCI

	PCI (x1000)	FFR	Ratio FFR/PCI
2010	136	8200	6%
2011	137	11 200	8.2 %
2012	140	12 000	8.6 %
2013	140	13 000	9.3 %
2014	148	14 200	9.6 %
2015	159	17 000	10.7 %
2016	170	23 849	14%
2017	183	25 435	13.9 %
2018	189	27 781	14.7 %
2019	192	34 335	17.9 %
2020	182	37 472	20,60%
2021	219	44 012	20.1 %
2022	215	44 211	20.6 %
<b>2023</b>	<b>224 (+4%)</b>	<b>36054 (-18%)</b>	<b>16%</b>

Les constructeurs s'attendent à une activité 2024 stable / Q4 2023





- Toutes ces études comparent la FFR angio vs FFR wire (gold standard).
- Sensibilité. Spécificité. Valeur prédictive positive. Valeur prédictive négative.

**Accuracy : « la précision ou l'exactitude »**

$$\text{Accuracy (patients ou lésions)} = \frac{\text{FFR angio} \leq 0.80 \text{ ou } > 0.80}{\text{FFR wire} \leq 0.80 \text{ ou } > 0.80}$$

**Corrélation** : définie par l'aire sous la courbe et son r