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Accuracy of computational pressure-fluid dynamics applied to coronary angiography to derive fractional flow reserve: FLASH FFR

Jianping Li[1†], Yanjun Gong [1†], Weimin Wang[2], Qing Yang[3], Bin Liu[4], Yuan Lu[5], Yawei Xu[6], Yunlong Huo [7*], Tieci Yi[1], Jian Liu[2], Yongle Li[3], Shaopeng Xu[3], Lei Zhao[4], Ziad A. Ali[8,9,10], and Yong Huo [1*]

[1]Department of Cardiology, Peking University First Hospital, Beijing, China; [2]Department of Cardiology, Peking University People's Hospital, Beijing, China; [3]Department of Cardiology, Tianjin Medical University General Hospital, Tianjin, China; [4]Department of Cardiology, The Second Hospital of Jilin University, Changchun, Jilin, China; [5]Department of Cardiology, The Affiliated Hospital of Xuzhou Medical University, Xuzhou, Jiangsu, China; [6]Department of Cardiology, Shanghai Tenth People's Hospital, Shanghai, China; [7]PKU-HKUST Shenzhen-Hongkong Institution, Shenzhen, China; [8]Clinical Trials Center, Cardiovascular Research Foundation, New York, NY, USA; [9]Department of Medicine, NewYork-Presbyterian Hospital/Columbia University Medical Center, New York, NY, USA; and [10]St. Francis Hospital, Roslyn, NY, USA

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Aims Conventional fractional flow reserve (FFR) is measured invasively using a coronary guidewire equipped with a pressure sensor. A non-invasive derived FFR would eliminate risk of coronary injury, minimize technical limitations, and potentially increase adoption. We aimed to evaluate the diagnostic performance of a computational pressure-flow dynamics derived FFR (caFFR), applied to coronary angiography, compared to invasive FFR.

Methods and results The FLASH FFR study was a prospective, multicentre, single-arm study conducted at six centres in China. Eligible patients had native coronary artery target lesions with visually estimated diameter stenosis of 30–90% and diagnosis of stable or unstable angina pectoris. Using computational pressure-fluid dynamics, in conjunction with thrombolysis in myocardial infarction (TIMI) frame count, applied to coronary angiography, caFFR was measured online in real-time and compared blind to conventional invasive FFR by an independent core laboratory. The primary endpoint was the agreement between caFFR and FFR, with a pre-specified performance goal of 84%. Between June and December 2018, matched caFFR and FFR measurements were performed in 328 coronary arteries. Total operational time for caFFR was 4.54 ± 1.48 min. caFFR was highly correlated to FFR ($R = 0.89$, $P = 0.76$) with a mean bias of -0.002 ± 0.049 (95% limits of agreement -0.098 to 0.093). The diagnostic performance of caFFR vs. FFR was diagnostic accuracy 95.7%, sensitivity 90.4%, specificity 98.6%, positive predictive value 97.2%, negative predictive value 95.0%, and area under the receiver operating characteristic curve of 0.979.

Conclusions Using wire-based FFR as the reference, caFFR has high accuracy, sensitivity, and specificity. caFFR could eliminate the need of a pressure wire, technical error and potentially increase adoption of physiological assessment of coronary artery stenosis severity.

Clinical Trial Registration URL: http://www.chictr.org.cn Unique Identifier: ChiCTR1800019522.

Keywords FFR • CFD • Angiography • Coronary artery

* Corresponding authors. Tel/Fax: 86-755-26737080, E-mail: huoxl@ier.org.cn (YL.H.); Tel/Fax: 86-10-66137748, E-mail: huoyong@263.net.cn (Y.H.)

† The first two authors contributed equally to the study.

1. Introduction

Fractional flow reserve (FFR) is an important tool for guiding the decision to revascularize coronary stenoses. An FFR value of 0.80 or less, suggests a strong likelihood of a stenosis inducing myocardial ischaemia.[1–3] Randomized controlled trials demonstrate a benefit for FFR-guided vs. angiography-guided revascularization, or medical therapy alone,[4–6] resulting in Class Ia recommendations in societal guidelines.[7,8]

A number of practical limitations limit FFR utilization. Measurements are typically made using a coronary hypotube 'wire' with a piezo-resistive sensor or optical sensor near its tip, limiting their torqueability in comparison to workhorse wires, leading to technical difficulty but also elevated risk of coronary dissection.[9] FFR requires pharmacology induced hyperaemia, which may lead to patient discomfort,[10,11] but also has a risk of morbidity from arrhythmia.[9] Even when measurements are performed, 1 in 4 recordings are deemed to be technically inadequate limiting the utility of FFR in clinical practice.[12]

Coronary angiography-derived FFR is a new technique which avoids the need for wire manipulation and hyperaemic stimulus while also limiting wire-related technical inadequacies.[13–15] Multiple studies have demonstrated favourable diagnostic accuracy (DA) for these non-invasive measurements compared to invasive FFR.[14,16–21] Of the various different non-invasive techniques to derive FFR, methods utilizing computational fluid dynamics (CFD) show particularly high accuracy, however have been limited by computer processing time limiting the clinical utility of this technique.[22] Here we evaluate the diagnostic performance of a novel computational pressure-flow dynamics (CPFD) derived FFR (caFFR), applied to coronary angiography, compared to invasive FFR with total operation times under 5 min.

2. Methods

2.1 Study design

The accuracy of computational pressure-fluid dynamics applied to coronary angiography to derive fractional flow reserve (FLASH FFR) study was a prospective, multicentre, single-arm study conducted at six centres in China designed to assess the feasibility and performance of the Flash pressure transducer, console, and software (Rainmed Ltd, Suzhou, China). The study aimed to compare diagnostic accuracies of FFR derived using CPFD based on the coronary angiogram and invasive FFR. The study was approved by the Institutional Review Board (IRB) for each participating centre, conforming to the declaration of Helsinki and Good Clinical Practice Guidelines of the China Food and Drug Administration. All patients provided written informed consent. The study was registered at http://www.chictr.org.cn, identifier: ChiCTR1800019522.

2.2 Participants

Patients with one or more intermediate coronary lesions (30–90% by angiographic visual estimation), in which invasive FFR measurement was planned, were eligible for enrolment.

Participants could be included if they were aged at least 18 years and presented with stable or unstable angina pectoris with visually estimated reference vessel size ≥ 2 mm in the stenotic segment, by visual estimate, planned for invasive FFR. Only one vessel with lesions per patient was evaluated. Participants were excluded if they had suffered a myocardial infarction within the previous 6 days; had left ventricular ejection fraction ≤ 50%; estimated glomerular filtration rate <60 mL/min (or 1.73 m^2); had known severe coagulopathy or bleeding disorders; were allergic to iodine contrast agents, adenosine, or adenosine-5′-triphosphate (ATP) or participated in or were participating in another clinical trial in the past month. Angiographic exclusion criteria included if the interrogated stenosis was caused by a myocardial bridge; ostial lesions ≤ 3 mm from the aorta; poor contrast opacification, severe vascular overlap or distortion of the interrogated vessel or poor angiographic image quality precluding contour detection required by the FLASH software.

2.3 Procedures

Coronary angiography from multiple views, at the operators' discretion, was recorded at 15 frames per second. For caFFR, angiography was performed with standard manual force to opacify the entire coronary artery or using an automated injector at a rate of 4 mL/s. At least two angiographic projections avoiding vessel overlap, separated by ≥30°, without table movement during the injection of contrast, were required to generate caFFR. Aortic pressure was simultaneously recorded using a specialized pressure transducer (FlashPressure, Rainmed Ltd, Suzhou, China) connected to the guiding catheter to record the aortic pressure wave continuously during the entire procedure. The aortic pressure wave from the FlashPressure transducer was input to the FlashAngio console, which computed the mean aortic pressure averaged over the third to eighth cycles following angiography. DICOM images corresponding to the recorded pressure waves were simultaneously exported to the FlashAngio console. A simulated three-dimensional (3D) mesh reconstruction of the coronary artery was generated along the vessel path from the inlet to the most distal position (≥1 cm downstream of the most distal stenosis). Resting flow velocities (V, averaged over the two coronary angiograms) were determined by the thrombolysis in myocardial infarction (TIMI) Frame Count method.[23,24] Flow velocity ($V^{'}$) and MAP ($P_a^{'}$) from the FlashAngio software were then used by a proprietary CPFD method to solve the Navier–Stokes equation, computing a pressure drop (ΔP) along the generated mesh of the coronary artery as $FFR = \frac{P_a^{'} - \Delta P}{P_a^{'}}$. Online caFFR computation was performed blind to hospital operators. Offline caFFR was also performed by an independent core laboratory (Cardiovascular Imaging Core Laboratory of Peking University First Hospital, Beijing, China) blinded to both wire-based FFR measurement and online caFFR computation. Details of the methodology including the caFFR are included in the Supplementary material online.

2.4 Wire-based FFR measurement

After computation of caFFR, coronary pressure wire-derived FFR was measured using a commercially available pressure wire system (Certus, Abbott Vascular, Santa Clara, CA, USA) by operators blinded to the caFFR result. The pressure wire was inserted such that the pressure transducer was ≥1 cm downstream from the most distal stenosis approximating co-registration with caFFR. The position of the pressure wire was captured on cine angiography for offline comparison. Hyperaemic blood flow was induced by intravenous administration of ATP at ≥ 140 μg/kg/min and recorded after at least 60 s in the presence of stable aortic pressure decrease compared with baseline levels sustained for at least 10 beats.[25] FFR pullback was performed at the operators discretion. Pressure drift was assessed after withdrawal of the pressure wire to the guiding catheter tip and defined as Pd/Pa between 0.97 and 1.03. The FFR recordings were sent to the core laboratory blinded to the caFFR measurement.

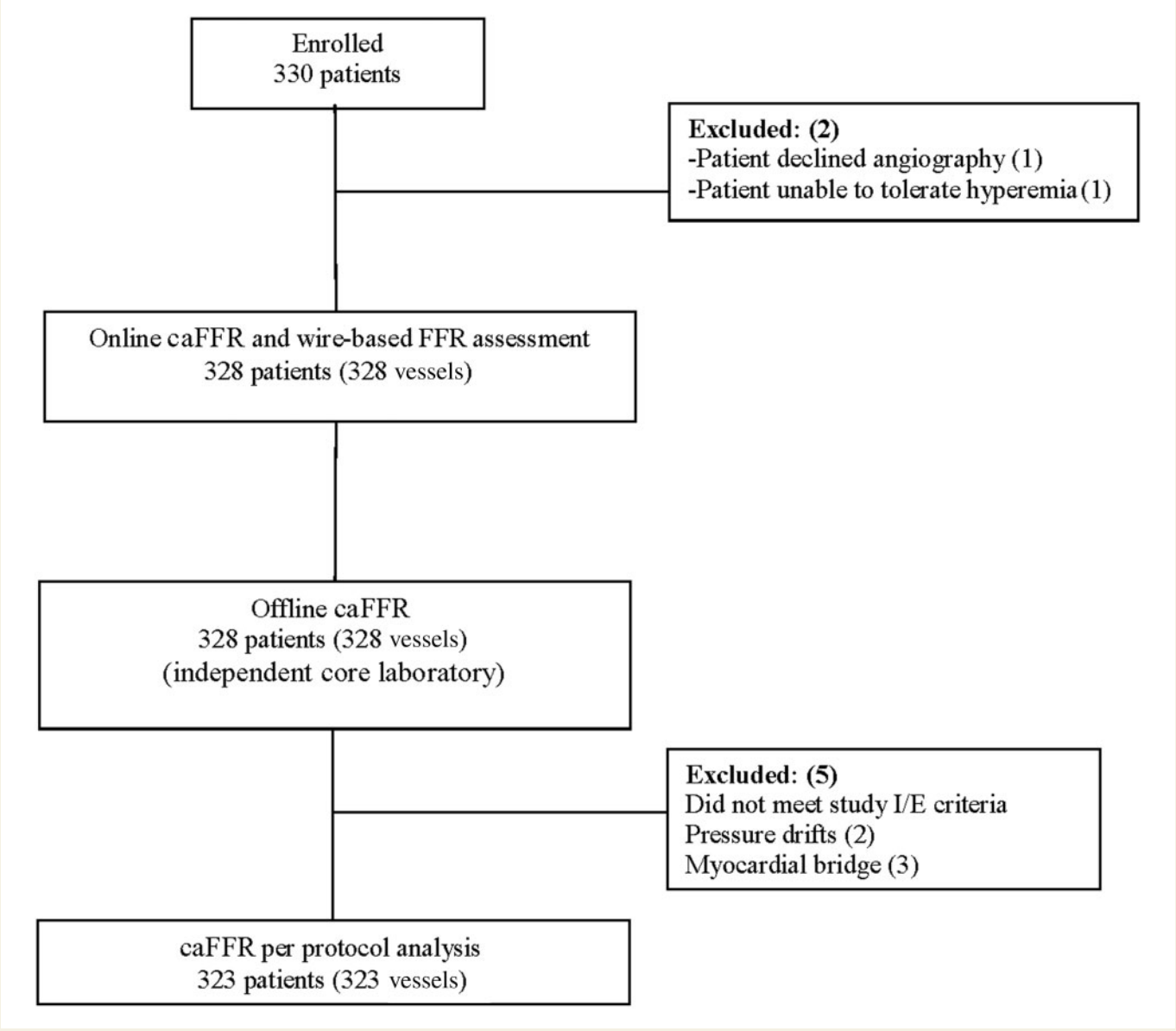

Figure 1 Study flow.

2.5 Endpoints

The primary endpoint was the diagnostic accuracy of caFFR using wire-based FFR as the reference standard with a clinical significance cut-off value of 0.80. The target goal for diagnostic accuracy was 84% with a 2-sided significance level of 0.05, based on previously published reports of computed tomography (CT)-derived FFR[26] and angiography-derived FFR.[13] Secondary endpoints included agreement, correlations, sensitivity (Sn), specificity (Sp), positive predictive value (PPV), negative predictive value (NPV), and receiver operated characteristics area under the curve (AUC) of caFFR compared to FFR. A separate per-protocol analysis was performed as a sensitivity analysis.

2.6 Statistical analysis

Based on a type I error (α) = 0.025 (two-sided), projected 10% data loss, and statistical power (1 - β) of 85%, a total of 330 vessels with lesions were required for the study.[27] Categorical variables are presented as counts and percentages. Continuous patient and procedural characteristics are presented as mean and standard deviation and compared using the student's t-test or Mann-Whitney U test. Distributions of physiological assessments are reported by median and interquartile range. Correlations are summarized by linear regression models and the coefficient of determination. Systematic differences are assessed by the Bland–Altman analysis. Two-sided 95% confidence intervals (CIs) were added using the Clopper–Pearson exact method where applicable. Statistical analysis was performed by the Proc Genmod with the repeated statement and the adjusted centre effect. Receiver operating curves of online caFFR, were generated using a logistic regression model. Analysis was by intention to treat. All statistical analyses were performed with a test significance level of 0.05 using the SAS version 9.4 (SAS Institute, Inc., Cary, NC, USA) by the Medical Research and Biometrics Center at Fuwai Hospital, China.

Table 1 Baseline characteristics of the study population

Baseline characteristics	n = 328
Age (year)	63.2 ± 9.4
Male	213 (64.9%)
BMI	25.5 ± 3.3
LV ejection fraction (%)	65.8 ± 5.6
Mean arterial pressure (mmHg)	99 ± 14
Systolic blood pressure (mmHg)	132 ± 21
Diastolic blood pressure (mmHg)	75 ± 13
Hypertension	215 (65.5%)
Hyperlipidaemia	146 (44.5%)
Diabetes mellitus	101 (30.8%)
Current smoking	85 (25.9%)
Prior PCI	88 (26.8%)
Prior CABG	3 (0.9%)
Prior myocardial infarction	26 (7.9%)
Silent ischaemia	19 (5.8%)
Stable angina pectoris	42 (12.8%)
Unstable angina pectoris	275 (83.8%)
Acute myocardial infarction within 1 month	6 (1.8%)

Values are *n* (%) or mean ± standard deviation.
BMI, body mass index; CABG, coronary artery bypass grafting; LV, left ventricle.

Table 2 Vessel characteristics obtained from coronary angiography, online caFFR, and wire-based FFR

Baseline characteristics	n = 328
Left anterior descending artery	195 (59.5%)
Left circumflex artery	36 (11.0%)
Right coronary artery	87 (26.5%)
Ramus intermediate	2 (0.6%)
Diagonal branch	3 (0.9%)
Obtuse marginal branch	5 (1.5%)
Lesions	
Reference vessel diameter (mm)	2.93 ± 0.43
Diameter stenosis (%)	64.2 ± 14.3
Lesion length (mm)	21.7 ± 11.0
Bifurcation	87 (26.5%)
Severe tortuosity	25 (7.6%)
Moderate or severe calcification	59 (18.0%)
Tandem lesions	133 (40.5%)
Online caFFR	
Mean FFR	0.83 ± 0.09
Vessels with FFR ≤ 0.80	107 (32.6%)
Vessels with 0.75 ≤ FFR ≤ 0.85	121 (36.9%)
Total operation time (min)	4.54 ± 1.48
Wire-based FFR	
Mean FFR	0.83 ± 0.11
Vessels with FFR ≤ 0.80	115 (35.1%)
Vessels with 0.75 ≤ FFR ≤ 0.85	119 (36.3%)

Values are *n* (%) or mean ± standard deviation.

3. Results

Between June and December 2018, 330 patients were enrolled in six centres. Paired caFFR and invasive FFR were available for analysis in 328 vessels with lesions in 328 patients (*Figure 1*). Baseline patient and lesion characteristics are presented in *Tables 1* and *2*. The predominant patient presentation was unstable angina pectoris. The left anterior descending artery system (59.5%) was the most commonly assessed vessel followed by the right coronary artery (RCA) (26.5%) and circumflex (11.0%). A schematic representation of caFFR is shown in *Figure 2*. The total operating time of caFFR was 4.54 ± 1.48 min. Fourteen patients (4.3%) had significant pressure drift during invasive FFR assessment. The mean caFFR was 0.83 ± 0.09 and FFR 0.83 ± 0.11 (*Table 2* and *Figure 3*).

The diagnostic accuracy of online caFFR was 95.7% (95% CI 93.4–98.1%), exceeding the pre-specified performance goal of 84%, meeting the primary endpoint of the study (*Table 3*). Overall, caFFR was highly correlated with FFR (caFFR = 0.78*FFR-0.18, $R = 0.89$, *Figure 4A*). The Bland–Altman analysis did not identify systematic differences between caFFR and FFR, with a mean difference of -0.002 ± 0.049 (95% limits of agreement -0.098 to 0.093, *Figure 4B*). The Sn (90.4%, 95% CI 84.6–96.2%), Sp (98.6%, 95% CI 96.8–100.0%), PPV (97.2%, 95% CI 93.6–100.0%), NPV (95.0%, 95% CI 91.9–98.1%), and AUC (0.979, 95% CI 0.965–0.994, *Figure 4C*) for caFFR were highly comparable to FFR. Sensitivity analysis of the offline core laboratory DA, Sn, Sp, PPV, NPV, and AUC for caFFR and FFR were consistent with the online analysis (Supplementary material online, *Table S1* and *Figures S1* and *S2*).

We performed further sensitivity analyses to evaluate the diagnostic utility of caFFR with FFR in the 'grey zone'. In 119 vessels with FFR between 0.75–0.85 and 294 vessels with diameter stenosis 40–80%, the caFFR diagnostic accuracy was 89.9% (95% CI 84.1–95.7%) and 95.6% (95% CI 93.1–98.1%), exceeding the pre-specified performance goal of 84% (*Table 3*). Finally, in 209 vessels with FFR <0.75 or >0.85, the caFFR diagnostic accuracy was 99% (95% CI 97.5–100%). DA, Sn, Sp, PPV, and NPV for sensitivity analyses are shown in *Table 3* and Supplementary material online, *Table S1*.

4. Discussion

Herein, we demonstrate the diagnostic performance of a CPFD derived caFFR, applied to coronary angiography, compared to invasive FFR. We report the following important findings; (i) the proprietary CPFD derived caFFR can be performed with a total operation time of less than 5 min with computational time less than 1 min; (ii) the overall diagnostic accuracy of 95.7% for caFFR compared to invasive FFR, exceeded the pre-specified performance goal, achieving the primary endpoint of the study; (iii) the diagnostic accuracy of caFFR in the FFR 'grey zone' and truly intermediate angiographic lesions remained high, confirming the potential utility of this technology in clinical practice.

There has been a growing interest in the utility of non-invasive physiological assessment for coronary artery stenosis severity in recent years. FFR derived from coronary CT angiography (FFR_{CT}) was the predicate for use of CFD in this regard,[26,28,29] with angiography-based FFR described more recently.[13,30,31] CFD is an established methodology, used commonly in mechanical engineering, to analyse behaviours including fluid flow, heat transfer, and associated phenomena using computer simulations. In order to simulate coronary blood flow, a domain of interest must be defined, and boundary conditions specified, both of which may represent significant challenges.[32] Thus, while the technology is quickly gaining momentum in patient screening and even more comprehensive procedural planning,[28,33] adoption remains hampered by long

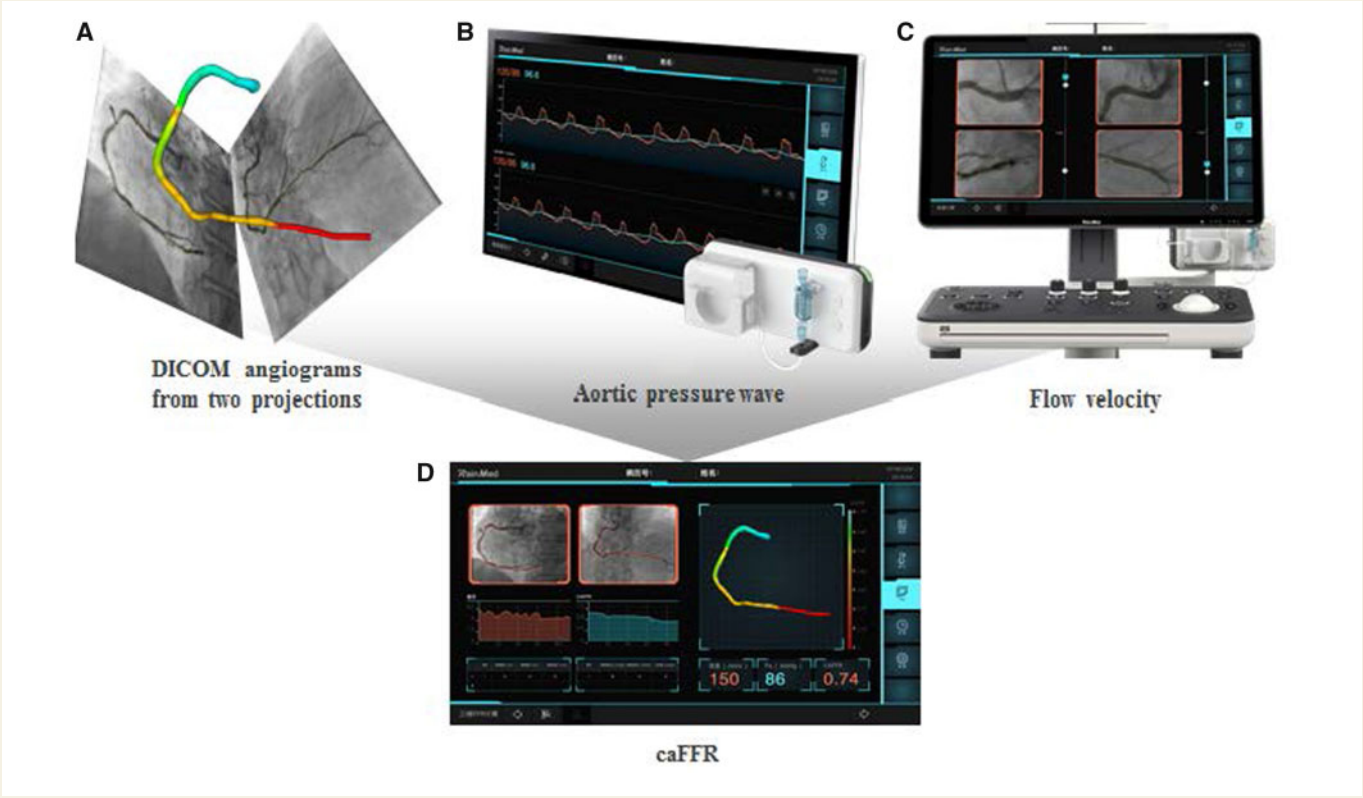

Figure 2 Schematic of the caFFR system (FlashAngio console, FlashAngio software, and FlashPressure pressure transducer). (*A*) 3D reconstruction of RCA based on angiograms from two projections separated by ≥30°; (*B*) aortic pressure wave obtained from the FlashPressure sensor; (*C*) determination of resting flow velocity based on RCA length and contrast passing time; and (*D*) caFFR display in the FlashAngio software.

computation times which limit clinical utility. Here, we describe the use of CPFD to derive FFR from coronary angiography with very high diagnostic accuracy and computational time of less than 1 min with total operation time less than 5 min, establishing caFFR as a viable alternative to wire-based invasive FFR.

A number of validation studies of different coronary angiography-derived FFR have been performed of which a few warrant specific discussion. The FAVOR Pilot Study, assessed the diagnostic accuracy of the quantitative flow ratio (QFR) offline based on the fixed empiric hyperaemic flow velocity (fQFR), modelled hyperaemic flow velocity derived from angiography without drug-induced hyperaemia (cQFR), or measured hyperaemic flow velocity derived from angiography during adenosine-induced hyperaemia (aQFR).[20] The authors observed good agreement and diagnostic accuracy (FFR ≤ 0.80) with FFR for all three QFR measurements (fQFR 0.003 ± 0.068, 80%; cQFR 0.001 ± 0.059, 85% and aQFR 0.001 ± 0.065, 87%). In the FAVOR II China prospective multicentre trial, a frame count contrast flow model to derive contrast flow velocity from coronary angiography was used for offline QFR computation.[21] The diagnostic accuracy of QFR on the vessel- and patient-level in identifying physiologically significant coronary stenoses was 92.7% and 92.4%, respectively. In the FAVOR II Europe-Japan prospective multicentre trial, online computation of QFR was compared to 2D-QCA with pressure wire-based FFR as the reference standard. Sensitivity and specificity by QFR were higher than 2D-QCA (Sn 87% vs. 44% and SP 87% vs. 77%, respectively). Currently both FAVOR III China (ClinicalTrial.gov ID: NCT03656848), a prospective multicentre randomized superiority trial comparing the clinical outcome and cost-effectiveness of QFR-guided percutaneous coronary intervention (PCI) vs. angiography-guided PCI and FAVOR III EU-JAPAN (ClinicalTrial.gov ID NCT03729739), assessing whether QFR-based diagnostic strategy yields non-inferior 12-month clinical outcome as compared to a pressure wire-based FFR are enrolling.

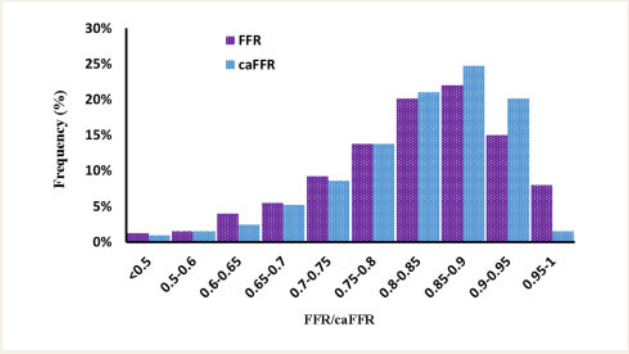

Figure 3 Frequency distribution plot of the FFR and caFFR values (Patient No. 328).

FFR_{angio} is another technology using coronary angiography to derive FFR (CathWorks Ltd., Kfar Saba, Israel). Pellicano *et al.* demonstrated a high concordance between off-site measured FFR_{angio} and

Table 3 Diagnostic characteristics of online caFFR

Diagnostic characteristics for all Interrogated vessels	
Diagnostic accuracy	95.7% (93.4–98.1%)
Sensitivity	90.4% (84.6–96.2%)
Specificity	98.6% (96.8–100.0%)
Positive predictive value	97.2% (93.6–100.0%)
Negative predictive value	95.0% (91.9–98.1%)
Diagnostic characteristics for vessels with FFR ≥ 0.75 and ≤0.85 (n = 119)	
Diagnostic accuracy	89.9% (84.1–95.7%)
Sensitivity	81.1% (69.7–92.6%)
Specificity	97.0% (92.1–100.0%)
Positive predictive value	95.6% (88.4–100.0%)
Negative predictive value	86.5% (78.0–95.0%)
Diagnostic characteristics for vessels with FFR < 0.75 and >0.85 (n = 209)	
Diagnostic accuracy	99.0% (97.5–100.0%)
Sensitivity	98.4% (94.4–100.0%)
Specificity	99.3% (97.7–100.0%)
Positive predictive value	98.4% (94.4–100.0%)
Negative predictive value	99.3% (97.7–100.0%)
Diagnostic characteristics for vessels with QCA % diameter stenosis	
QCA ≤ 40% and ≥80% (n = 294)	
Diagnostic accuracy	95.6% (93.1–98.1%)
Sensitivity	89.0% (82.0–96.0%)
Specificity	98.5% (96.6–100.0%)
Positive predictive value	96.4% (91.9–100.0%)
Negative predictive value	95.2% (92.1–98.4%)

Values are % with 95% confidence intervals.

pressure wire-based FFR,[19] and FFR_{angio} was recently validated in the prospective multicentre FAST-FFR trial comparing the accuracy of on-site FFR_{angio} with pressure wire-based FFR. The study demonstrated a high Sn (94%), Sp (91%), and accuracy (92%)[16] but was limited by a failure to report the total time needed to calculate FFR_{angio}. The CAAS 3D-QCA software, a part of the CAAS Workstation 8.0 (Pie Medical Imaging, Maastricht, the Netherlands), may also be used to compute FFR (vFFR). Using simulated 3D coronary reconstructions incorporating the aortic resting pressure,[17,34] pressure gradients may be calculated instantaneously.[35] The single centre Fast Assessment of STenosis severity (FAST) study demonstrated a high diagnostic accuracy of vFFR in the identification of significant pressure wire-based FFR [AUC of 0.93 (95% CI 0.88–0.97)] with low inter-observer variability ($r = 0.95$; $P < 0.001$).[18] A larger international prospective multicentre trial (FASTII) is currently ongoing to assess the diagnostic accuracy of both online and core lab assessed vFFR as compared to conventional pressure wire-based FFR for intermediate coronary artery lesions in patent with stable and unstable coronary artery disease (ClinicalTrials.gov ID: NCT03791320).

Coronary angiography-derived FFR holds several potential advantages compared to invasive pressure wire-based FFR. First, the risk for pressure wire-related complications is eliminated. Second, hyperaemic conditions required to measure FFR, known to induce patient discomfort, increase cost, and prolong procedural time are not required.[10,11] Third, technical inadequacies of wire-based physiological assessments such as waveform distortion, ventricularization, and signal drift,[12] are eradicated. Forth, computations of angiography-based FFR are not vessel specific, thus multi-vessel disease may be assessed quickly without the need for guide catheter exchanges and instrumentation of each vessel which adds time and risk. Finally, angiography-derived FFR allows for rapid re-assessment pre, peri, and post-PCI, allowing confirmation of not only presence of ischaemia, but also its resolve.

In turn, caFFR holds several advantages compared to the current alternative technologies. While FFR_{angio} uses a lumped model where stenoses are converted to resistances and QFR and vFFR use mathematical models, caFFR uses real-time invasive pressure coupled to computational flow modelling to determine the pressure drop across a stenosis. In comparison with the lumped and mathematical models, convective and diffusive energy losses as well as energy loss due to the constriction and expansion in lumen area proximal and distal to the stenosis respectively may be thus accounted for.[36–38] Moreover, rather than use a static aortic pressure, caFFR uses real-time pressure recordings at the time of angiography, accounting for the dynamic nature of blood pressure during PCI.

Our study has a number of important limitations. As with all angiography-derived FFR software's, caFFR is at an early stage of development and no outcome studies have been performed. In all studies to date, the calculation of angiography FFR was performed by highly trained individuals, and the implementation of software-based analysis has yet to be tested in the real-world. For example, optimal angulations, avoidance of overlap and accurate contour correction are required. Moreover, non-panning angiography is practiced infrequently, and will require a practice shift for many operators. The accuracy of angiography-derived FFR in complex lesions (bifurcations, left main disease, heavily calcified vessels, and diffusely diseased vessels) has not been assessed. Of course any derivation implements assumptions regarding myocardial blood flow and microvascular resistance, which may be compounded by the use of TIMI frame count to determine rest velocity, where pressure injector settings or force of manual injection may impact contrast passage. Although an autoinjector was adopted to improve the accuracy of TIMI frame count measurements, it was not used in the catheterization laboratory of all centres because autoinjectors are not often used in most catheterization laboratories worldwide for coronary angiography image acquisition.

In conclusion, using wire-based FFR as the reference, caFFR has high accuracy, sensitivity, and specificity. caFFR could eliminate the need of a pressure wire, technical error and potentially increase adoption of physiological assessment of coronary artery stenosis severity.

Supplementary material

Supplementary material is available at *Cardiovascular Research* online.

Authors' contributions

YL.H. wrote the main manuscript; JP.L., Y.G., W.W., Q.Y., B.L., Y.L., Y.X., T.Y., J.L., YL.L., S.X., and L.Z. performed the clinical trials; Y.H. designed the experiment; and Z.A.A. and Y.H. revised the main manuscript text. All authors reviewed the manuscript.

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Conflict of interest: none declared.

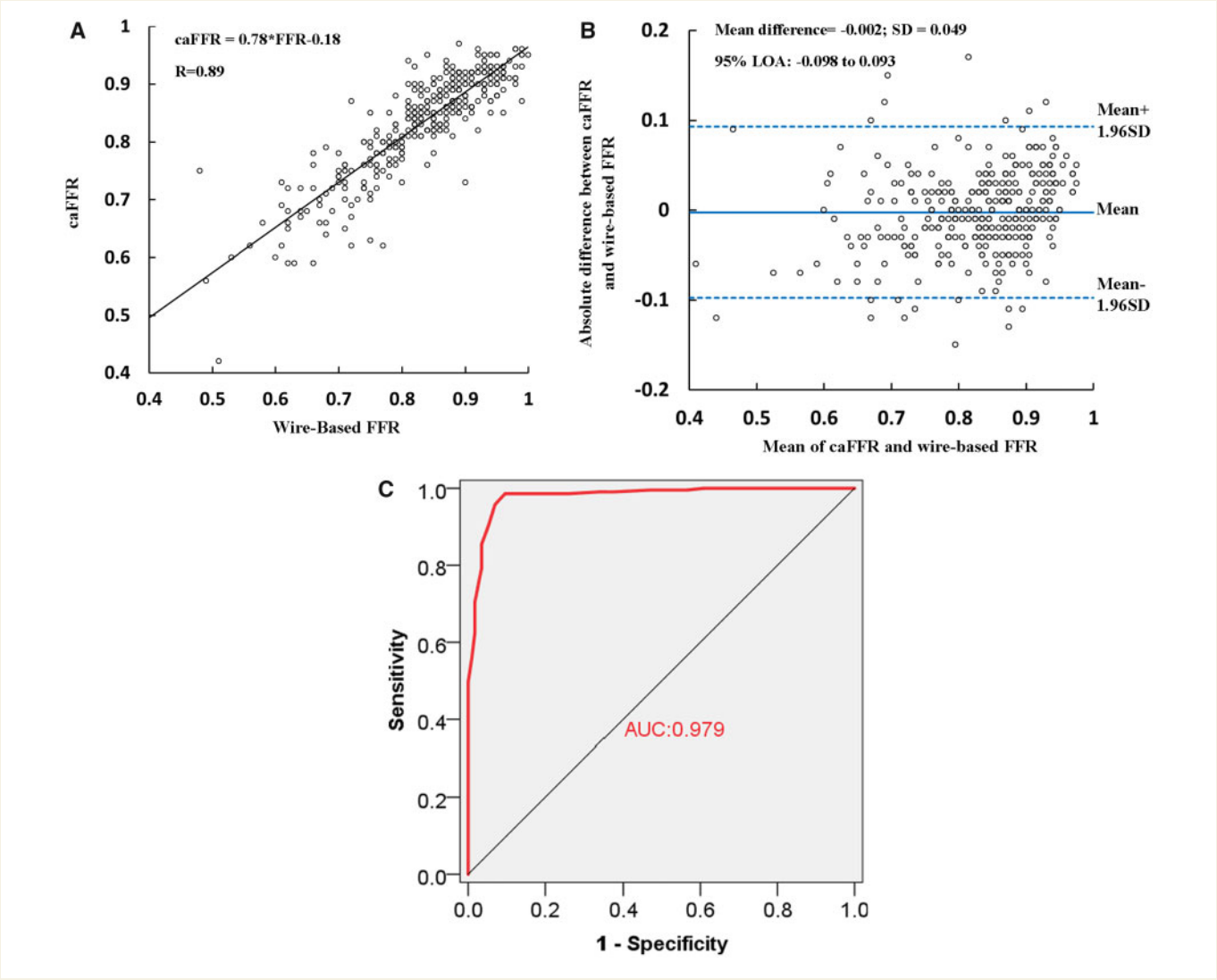

Figure 4 Comparison of caFFR and wire-based FFR (Patient No. 328). (*A*) A least-squares fit shows a strong correlation caFFR = 0.78·FFR - 0.18 ($R = 0.89$; $P = 0.76$). (*B*) The Bland–Altman plots for pairwise comparisons (mean difference: -0.002; SD: 0.049; 95% limits of agreement -0.098 to 0.093). (*C*) Receiver-operating curve for online caFFR showing AUC 0.979 (95% CI 0.965–0.994).

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Translational perspective

Using wire-based FFR as the reference, caFFR has high accuracy, sensitivity, and specificity. caFFR could eliminate the need of a pressure wire, technical error and potentially increase adoption of physiological assessment of coronary artery stenosis severity.