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Resting Full Cycle Ratio (RFR) and Instantaneous Wave-Free Ratio (iFR): Simultaneous Measurements for Assessment of Coronary Stenosis☆

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In the absence of evidence of ischaemia, invasive functional assessment of intermediate-grade coronary stenosis is recommended [1]. Two large-scale randomized trials showed comparable outcomes between revascularization guided by the hyperaemic fractional flow reserve (FFR) and the resting diastolic instantaneous wave-free ratio (iFR), providing clinical evidence for the use of resting pressure-derived indices in coronary stenosis severity evaluation [2]. Furthermore, a recent study showed elegantly that a number of other diastolic resting indices were identical to iFR, both numerically and with respect to their agreement with FFR, suggesting a class effect among non-hyperaemic indices [3].

The resting full-cycle ratio (RFR) is a novel hyperaemia-free resting index of coronary artery severity [4]. It is calculated as the absolute lowest distal coronary pressure (Pd) to aortic pressure (Pa) ratio (Pd/Pa) during the whole cardiac cycle irrespective of systole or diastole. It was recently validated against instantaneous wave-free ratio (iFR) in a retrospective analysis of 651 waveforms in which iFR was measured using a proprietary Philips/Volcano wire. RFR was found to be diagnostically equivalent to iFR [4].

In our case, a 68-year-old man with a background of hypertension and hypercholesterolemia presented to our centre with exertional angina. He underwent elective coronary angiography and physiological assessment of a proximal LAD lesion. A PressureWire X (Abbott Vascular, USA) and a Verrata wire (Philips Volcano, USA) were used for the physiological measurements. RFR was calculated using the CoroFlow™ software (Coroventis, Sweden) and iFR using the proprietary software (Volcano Corporation). Both wires were normalised simultaneously for aortic pressure at the tip of the catheter and advanced to the distal LAD were simultaneously measurements were performed. The results of the physiological measurements are shown in Fig. 1; RFR was 0.75 and iFR 0.76. Subsequently intravenous adenosine was administered and during maximum hyperaemia FFR was calculated as 0.60 by both wires. Adenosine was stopped and after one minute measurements were repeated. RFR was 0.68 and iFR 0.67, showing that adenosine's vasodilatory effect had not eliminated yet and confirming their diagnostic agreement in hyperaemic conditions too.

Resting pressure-derived indices do not require the induction of a hyperaemic stimulus when used for the assessment of coronary stenosis severity. Therefore, they have the advantages of shorter procedural time, lower cost and reduced patients' discomfort compared to FFR. Although the diagnostic agreement between iFR and FFR has been reported to be around 80% [5], iFR was shown to be non-inferior to FFR regarding clinical outcomes in two recent large randomized control trials [2]. iFR is measured during a period of diastole defined as the wave-free period. As described in the initial study introducing iFR, the wave-free period is determined as the diastolic window beginning 25% of the way into diastole and ending 5 ms before the end of diastole [6]. The theory behind iFR accepts that during this period the resting blood flow is maximal and the microcirculatory resistance is minimal [6]. Nevertheless, a recent study comparing five pressure-derived indices calculated in different periods during diastole showed that all of them were identical to iFR [3]. In contrast to the diastolic indices, RFR is calculated across the whole cardiac cycle as the absolute lowest Pd/Pa. In the left coronary system coronary blood flow is maximized during diastole. However, in the right coronary artery (RCA) the peak flow may occur during systole or very early in diastole [7–9]. This is important since there may be significant differences between a diastolic index and a whole cycle resting index. In our case the interrogated vessel was the LAD, so RFR and iFR were almost identical. This could be different in case the vessel under interrogation was the RCA. In the recently published VALIDATE RFR study, RFR was detected outside diastole in 32% of the cardiac cycles in the RCA [4]. Whether this finding translates into clinical significant differences needs to be explored by further research.

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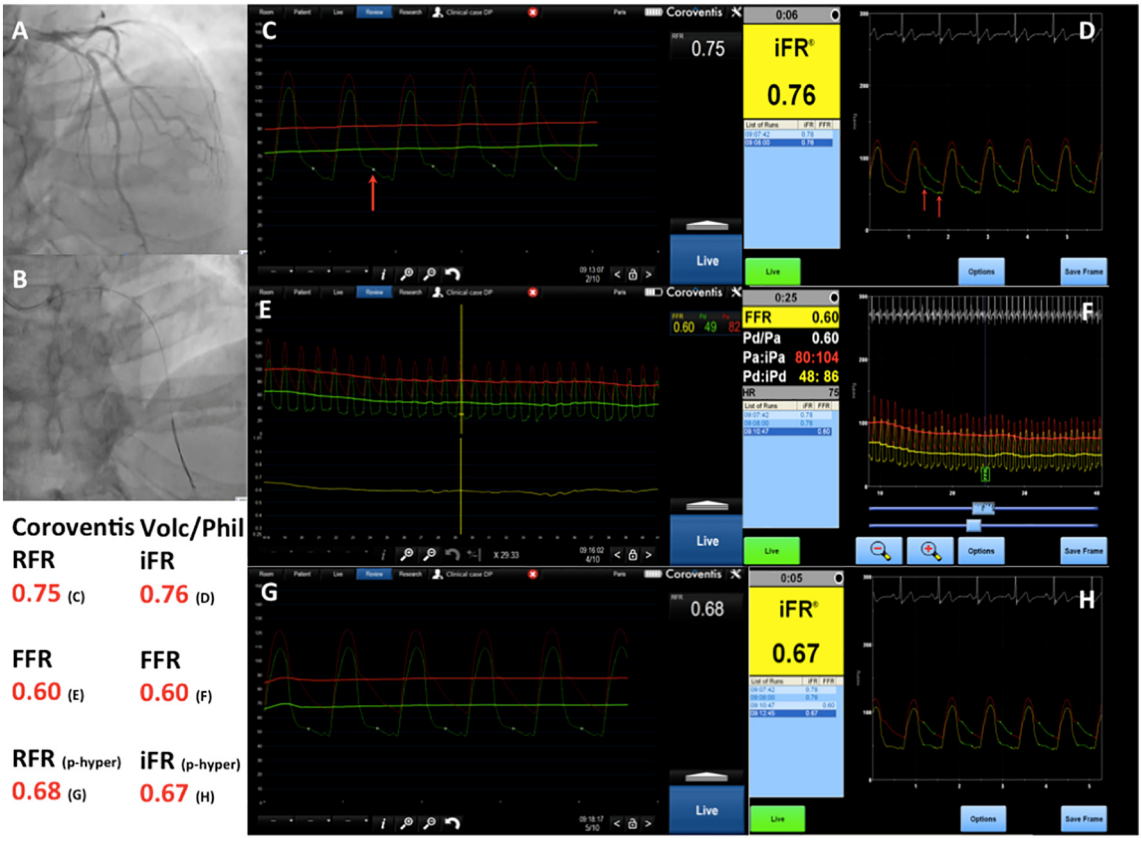

Fig. 1. Simultaneous Resting Full Cycle Ratio (RFR) and instantaneous wave-free ratio (iFR) measurements. A) Intermediate stenosis of proximal LAD. B) Simultaneous use of PressureWire X and Verrata wires. C & D) Simultaneous RFR and iFR measurements. The point where RFR is measured during each cardiac cycle is automatically indicated by the Coroventis CoroFlow software with a white mark (highlighted by a red arrow for the 2nd cycle in the figure). Equally, the iFR software automatically indicates the wave-free period for each cardiac cycle with green discoloration over both aortic (red) and distal coronary (yellow) pressure traces. In the figure, red arrows highlight the onset and offset of the wave-free period for the 2nd cardiac cycle. E & F) Simultaneous FFR measurement with two different pressure wire and software. G & H) Simultaneous RFR and iFR under partial hyperaemia (1 min after cessation of adenosine infusion).

This case of simultaneous real-life RFR and iFR measurements supports the excellent diagnostic agreement previously shown by offline pressure traces analysis.

References

[1] Neumann FJ, Sousa-Uva M, Ahlsson A, Alfonso F, Banning AP, Benedetto U, et al, ESC Scientific Document Group. 2018 ESC/EACTS Guidelines on myocardial revascularization. Eur Heart J 2018. https://doi.org/10.1093/eurheartj/ehy394 [Epub ahead of print].
[2] Echavarría-Pinto M, Collet C, Escaned J, Piek JJ, Serruys PW. State of the art: pressure wire and coronary functional assessment. EuroIntervention 2017;13(6):666–79.
[3] Van't Veer M, Pijls NHJ, Hennigan B, Watkins S, Ali ZA, De Bruyne B, et al. Comparison of different diastolic resting indexes to iFR: are they all equal? J Am Coll Cardiol 2017; 70(25):3088–96.
[4] Svanerud J, Ahn JM, Jeremias A, van 't Veer M, Gore A, Maehara A, et al. Validation of a novel non-hyperaemic index of coronary artery stenosis severity: the resting full-cycle ratio (VALIDATE RFR) study. EuroIntervention 2018;14(7):806–14.
[5] Jeremias A, Maehara A, Généreux P, Asrress KN, Berry C, De Bruyne B, et al. Multicenter core laboratory comparison of the instantaneous wave-free ratio and resting Pd/Pa with fractional flow reserve: the RESOLVE study. J Am Coll Cardiol 2014;63(13): 1253–61.
[6] Sen S, Escaned J, Malik IS, Mikhail GW, Foale RA, Mila R, et al. Development and validation of a new adenosine-independent index of stenosis severity from coronary wave-intensity analysis: results of the ADVISE (ADenosine Vasodilator Independent Stenosis Evaluation) study. J Am Coll Cardiol 2012;59(15):1392–402.
[7] Marcus JT, Smeenk HG, Kuijer JP, Van der Geest RJ, Heethaar RM, Van Rossum AC. Flow profiles in the left anterior descending and the right coronary artery assessed by MR velocity quantification: effects of through-plane and in-plane motion of the heart. J Comput Assist Tomogr 1999;23(4):567–76.
[8] Johnson K, Sharma P, Oshinski J. Coronary artery flow measurement using navigator echo gated phase contrast magnetic resonance velocity mapping at 3.0 T. J Biomech 2008;41(3):595–602.
[9] Wilson RF, Laughlin DE, Ackell PH, Chilian WM, Holida MD, Hartley CJ, et al. Transluminal, subselective measurement of coronary artery blood flow velocity and vasodilator reserve in man. Circulation 1985;72(1):82–92.