

# A case report of the clinical effect of chronic total occlusion recanalization on the instantaneous wave-free ratio in the donor artery

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## Introduction

Coronary physiology is recommended for guiding percutaneous coronary intervention (PCI). Previous cases have demonstrated changes in fractional flow reserve in a donor collateral vessel after PCI to a chronic total occlusion (CTO). The behaviour of instantaneous wave-free ratio (iFR) in the context of CTO has not been described.

## Case presentation

In this case, we share the first case of the effect of CTO recanalization on iFR in the donor artery, and show how iFR can reflect the amount of myocardium subtended by a stenosis.

## Discussion

Instantaneous wave-free ratio is able to incorporate the amount of subtended myocardium in its quantification of coronary stenosis severity.

## Keywords

iFR • FFR • Coronary physiology • Chronic total occlusion • Case report

## Learning points

- Coronary physiology is recommended for guiding percutaneous coronary intervention (PCI). Previous cases have demonstrated changes in fractional flow reserve in a donor collateral vessel after PCI to a chronic total occlusion.
- In this case, we share the first case of the effect of chronic total occlusion recanalization on the instantaneous wave-free ratio (iFR) in the donor artery, and show how iFR can reflect the amount of myocardium subtended by a stenosis.

## Introduction

Coronary physiology is recommended for guiding percutaneous coronary intervention (PCI). Recent randomised controlled trials have demonstrated non-inferiority between fractional flow reserve (FFR) and the instantaneous wave-free ratio (iFR), which is measured at rest and without the need for hyperaemia.<sup>1,2</sup> Previous cases have demonstrated changes in FFR in a donor collateral vessel after PCI to a chronic total occlusion (CTO). This was thought to be dependent on pharmacological hyperaemia and has not previously been reported with iFR. In this case, we share the first case of the effect of CTO recanalization on the iFR in the donor artery.

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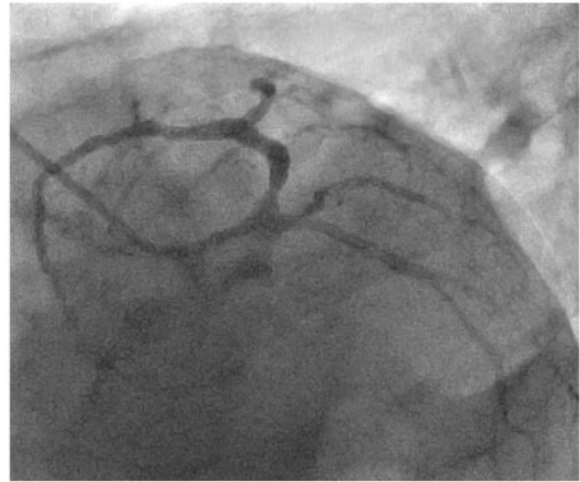
## Timeline

Day 1	Patient presents with Canadian Cardiovascular Society Class III angina
Day 2	Computed tomography coronary angiography showed a chronic total occlusion (CTO) of the right coronary artery (RCA) with moderate angiographic disease in the proximal segment of the left anterior descending (LAD) artery. Perfusion magnetic resonance imaging demonstrated ischaemia in both the RCA and the LAD territories.
Day 5	Invasive coronary angiography demonstrated a moderate stenosis in the proximal LAD and a CTO of his RCA collaterals providing retrograde flow to the RCA from the LAD. Coronary physiology was performed in the LAD, with an instantaneous wave-free ratio (iFR) of 0.72 indicating a flow-limiting stenosis. Successful RCA CTO percutaneous coronary intervention (PCI) was performed.
Day 12	Clinical assessment post-CTO PCI demonstrated a complete resolution of the patient's angina.
Day 15	Because of the potentially prognostic nature of the LAD lesion, invasive coronary angiography was performed. This revealed a good result from CTO PCI. Physiological assessment of the LAD was repeated with the pressure sensor in the same location as before. Instantaneous wave-free ratio at this repeat measurement was 0.90, conferring an increase in 0.18 iFR units from the pre-CTO PCI measurement. The fractional flow reserve (FFR) was 0.85 and LAD PCI was therefore deferred.

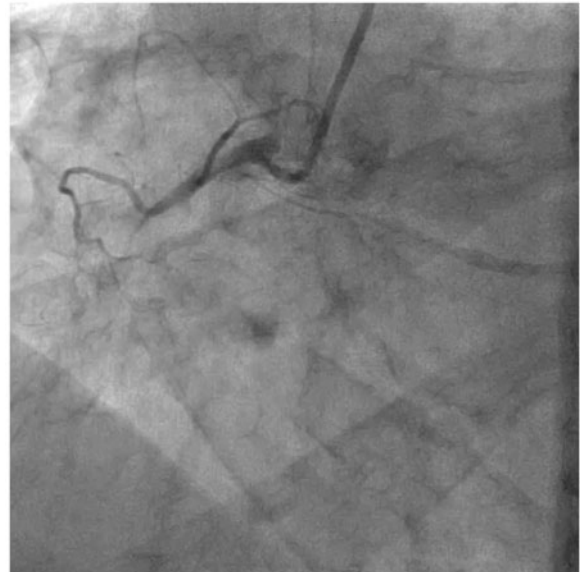
## Case presentation

A 65-year old man presented with Canadian Cardiovascular Society (CCS) Class III angina. He had no significant past medical history. His blood pressure was 134/76 mmHg and his heart rate was 72 b.p.m. in sinus rhythm. There was no clinical evidence of heart failure, and the physical examination was otherwise unremarkable. A computed tomography coronary angiogram demonstrated a CTO of the right coronary artery (RCA) with a moderate angiographic disease in the proximal segment of the left anterior descending (LAD) artery. Perfusion magnetic resonance imaging demonstrated ischaemia in both the RCA and LAD territories. He was referred for invasive coronary angiography and commenced on aspirin 75 mg once daily, clopidogrel 75 mg once daily, atorvastatin 40 mg once daily, and bisoprolol 2.5 mg once daily.

Subsequent invasive coronary angiographic assessment demonstrated an angiographically moderate stenosis in the proximal LAD (Figure 1), a non-dominant circumflex and a CTO of his RCA (Figure 2) with Rentrop grade 2 collaterals providing retrograde flow



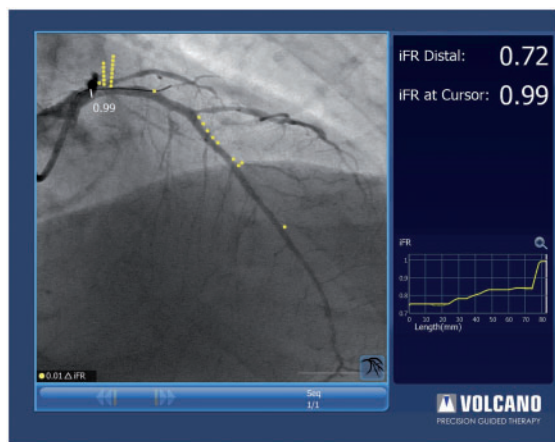
**Figure 1** Moderate proximal left anterior descending artery stenosis in the left anterior oblique caudal (Spider) projection.



**Figure 2** Chronic total occlusion of the right coronary artery.

to the distal RCA from the LAD artery (Supplementary material online, Videos S1–S3).

Physiological assessment of the LAD was undertaken. An EBU3.5 guiding catheter was engaged in the left coronary artery, and 8000 units of heparin administered. Three hundred micrograms of nitrates were administered via the intracoronary route to stabilise epicardial tone. A Verrata Plus Pressure guidewire was inserted and pressures were equalized at the ostium of the LAD artery, and advanced distal to the stenosis. The iFR was 0.72, indicative of significant myocardial ischaemia distal to the proximal LAD stenosis. A co-registered iFR pullback



**Figure 3** Instantaneous wave-free ratio co-registered pullback in the left anterior descending artery. The distal instantaneous wave-free ratio is strongly positive at 0.72, with the majority of the pressure loss occurring across the proximal stenosis.

assessment demonstrated the majority of the pressure loss was across the proximal stenosis (Figure 3). The patient explicitly stated he did not want to be considered for coronary artery bypass grafting.

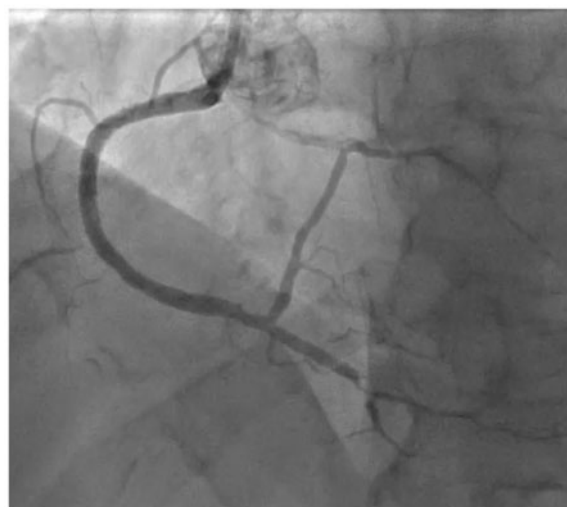
Accordingly, the patient underwent RCA CTO PCI using a 6Fr Amplatzer 0.75 guiding catheter. The occlusion was crossed via an antegrade approach with an Asahi Fielder XT wire and 1.5 mm over the wire (OTW) balloon support. The lesion was pre-dilated and stented with a 3.0 × 48 mm drug-eluting stent. Finally, IVUS-guided post-dilatation was performed with a 3.25 mm non-compliant balloon inflated to 24 atmospheres, achieving an excellent angiographic result (Supplementary material online, Video S4). In view of the collateral flow from the LAD to the RCA, a decision was made to defer LAD PCI and reassess with physiology at a later date.

The patient returned for clinical assessment 1 week later, where a complete resolution of symptoms (CCS Class 0) was noted. However, because of the potentially prognostic nature of the LAD lesion, invasive coronary angiography was performed. This revealed that the RCA stent was widely patent and a good result from CTO PCI (Figure 4) was confirmed. The moderate LAD lesion was angiographically unchanged (Figure 5). Physiological assessment of the LAD was repeated with the pressure sensor located in the same location distal to the stenosis as before. Instantaneous wave-free ratio at this repeat measurement was 0.90 (Figure 6), conferring an increase in 0.18 iFR units from the pre-CTO PCI measurement. The FFR was 0.85 (Figure 7). Left anterior descending PCI was therefore deferred.

The patient was last seen in clinic 9 months following the initial presentation and remains asymptomatic.

## Discussion

The haemodynamic significance of a coronary stenosis is a result of both the physical geometry of the stenosis and the coronary flow velocity across the stenosis. The flow parameter is related to the amount of myocardium subtended by the stenosis<sup>3</sup>: the greater the amount of myocardium distal to the stenosis, the higher the flow



**Figure 4** Right coronary artery following successful chronic total occlusion percutaneous coronary intervention.

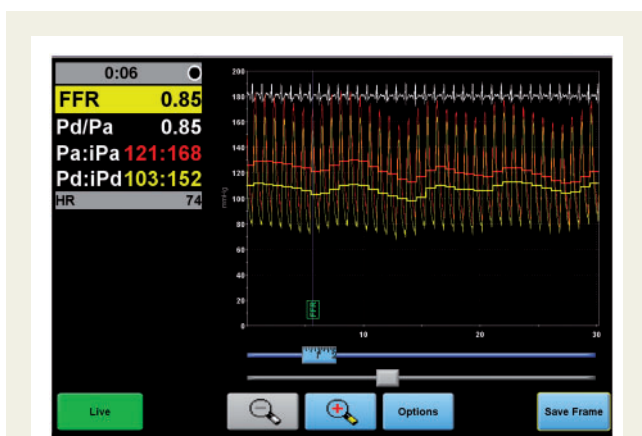


**Figure 5** Moderate proximal left anterior descending stenosis with unchanged angiographic appearance at repeat coronary angiography.

velocity across the stenosis and the greater the trans-stenotic pressure loss.<sup>4</sup> Hyperaemic indices of stenosis severity such as FFR have been stated to assimilate the amount of myocardium subtended by a coronary stenosis<sup>4</sup>. Previous cases have demonstrated significant changes in FFR post-CTO intervention in a major collateral donor vessel.<sup>5</sup> As donor vessel collaterals regress post-CTO recanalization, the amount of subtended myocardium supplied by the donor vessel is reduced; and the haemodynamic significance of the stenosis in the donor vessel therefore changes.<sup>5</sup> The instantaneous wave free ratio is an index of stenosis severity that is measured under baseline conditions, without the administration of adenosine.<sup>6</sup>



**Figure 6** Instantaneous wave-free ratio in the left anterior descending following successful right coronary artery chronic total occlusion percutaneous coronary intervention. The distal instantaneous wave-free ratio value is now negative, and percutaneous coronary intervention was therefore deferred.



**Figure 7** Fractional flow reserve in the left anterior descending following successful right coronary artery chronic total occlusion percutaneous coronary intervention. This distal fractional flow reserve value is now negative, and percutaneous coronary intervention was therefore deferred.

The iFR is an index of stenosis severity that is measured under baseline conditions, without the administration of adenosine.<sup>4</sup> Its ability to integrate the amount of subtended myocardium in its quantification of physiological stenosis severity has not previously been demonstrated. We present here the first case of the effect of CTO recanalization on the iFR in the donor artery. In this case, the iFR in the LAD was profoundly ischaemic in the presence of the RCA CTO, to which the LAD was the donor vessel supplying collaterals. One week after successful RCA CTO PCI, the iFR had increased significantly to above current recommended treatment thresholds, indicating the LAD territory was adequately perfused and PCI could therefore safely be deferred.

This case provides an illustrative demonstration of how the diastolic resting index of iFR dynamically reflects the amount of myocardium subtended by a stenosis.

## Conclusion

This case demonstrates the clinical effect of CTO recanalization on the iFR in the donor vessel. Instantaneous wave-free ratio is able to incorporate the amount of subtended myocardium in its quantification of coronary stenosis severity; this can influence therapeutic decisions.

## Supplementary material

Supplementary material is available at *European Heart Journal - Case Reports* online.

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**Consent:** The author/s confirm that written consent for submission and publication of this case report including image(s) and associated text has been obtained from the patient in line with COPE guidance.

**Conflicts of interest:** Dr Al-Lamee have conducted teaching sessions supported by Volcano Corporation. Dr Davies holds patents pertaining to the instantaneous wave-free ratio (iFR) technology, which is under license to Volcano Corporation, and has received significant research funding from Volcano Corporation. Dr Sen has attended and conducted teaching sessions supported by Volcano Corporation, St. Jude Medical, Medtronic, Pfizer, and AstraZeneca; has received research grant support from Philips, AstraZeneca, Medtronic, and Pfizer; and has received speaking honoraria from Pfizer and Volcano-Philips. Dr Ahmad has no conflicts of interest to declare.

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