



Case Report

Pressure Recovery in the Left Main Stenosis

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Received : 03 May 19
Accepted : 01 July 19
Published : 02 August 19

DOI
10.25259/JCIS_40_2019

Quick Response Code:



ABSTRACT

A 76-year-old male patient with dyspnea was referred on a suspicion of coronary artery disease. A coronary computed tomography angiography (CTA) revealed a distal left main (LM) stenosis and in the right (right coronary artery [RCA]), left circumflex (LCX) and left anterior descending (LAD) coronary arteries stenosis could not be excluded. CTA-derived fractional flow reserve (FFR_{CT}) was 0.75, 0.72, 0.74, 0.86, and 0.94 in the LM, LAD, LCX, ramus, and RCA, respectively. Invasive coronary angiography confirmed a stenosis in the LM and LAD. FFR was 0.73 and 0.85 in the LCX and ramus, respectively. The patient was referred for coronary artery bypass surgery. The FFR and FFR_{CT} values in the ramus demonstrate the phenomenon of pressure recovery. This case shows that preserved FFR and FFR_{CT} cannot always be used to exclude the hemodynamic significance of upstream coronary lesions.

Keywords: Coronary artery disease, Coronary computed tomography angiography, Fractional flow reserve

INTRODUCTION

Invasive coronary angiography (ICA) with measurement of fractional flow reserve (FFR) is the gold standard for decision-making before revascularization of intermediate coronary stenoses.^[1] FFR quantifies lesion-specific ischemia from the linear relationship between flow and pressure during maximal hyperemia when coronary autoregulation is exhausted.^[2] An FFR ≤ 0.80 is considered indicative of hemodynamic significance.^[3] Coronary computed tomography angiography (CTA) is increasingly used in the diagnostic workup of patients suspected of stable coronary artery disease. Recently, the UK National Institute for Health and Care Excellence guidelines recommended CTA to be used as the frontline test in patients with atypical or typical stable chest pain. However, correlation between stenosis severity and lesion-specific ischemia is poor.^[4] Within the past decade, calculation of FFR based on modeling of CTA images and computational fluid dynamics (CTA-derived FFR [FFR_{CT}]) has emerged as a second-line test for physiologic evaluation of lesions determined by CTA. FFR_{CT} has demonstrated high diagnostic performance when compared to FFR^[5] and ability to favorably change clinical practice and improve outcomes.^[6] While invasively measured FFR is only available in segments which have been interrogated by the pressure wire, FFR_{CT} provides simultaneous calculation of pressure and flow across the entire coronary tree. This plethora of information may give rise to challenges in interpretation.^[6,7] In this report, we present a case with significant post-stenotic pressure recovery which imposed initial challenges in the interpretation of the FFR_{CT} report.

CASE REPORT

A 76-year-old male patient was referred for evaluation of dyspnea and occasional slight chest discomfort on exertion. The patient had hypertension and ceased smoking 25 years ago. Blood

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cholesterol was 5.1 mM/L (low-density lipoprotein 2.6 mM/L) and blood pressure was 150/70 mmHg. The electrocardiogram showed sinus rhythm and T-wave inversion in the lateral leads and the echocardiogram was normal. Coronary CTA was prescribed as the first-line test. The Agatston score was 975. The CTA showed a codominant coronary artery system with severe diffuse atherosclerosis [Figure 1]. In the left main (LM) coronary artery, a distal moderate stenosis was present. Stenoses in the proximal left anterior descending (LAD), proximal left circumflex (LCX), and mid-right (right coronary artery [RCA]) coronary arteries could not be excluded due to the presence of calcium. The patient was referred to ICA, and as an adjunctive test to elucidate the hemodynamic significance of the suspected stenosis in the RCA, an FFRCT was ordered at HeartFlow (Redwood City, CA, U.S.A.) [Figure 2]. The FFRCT value pertaining to the RCA was normal. A focal drop in the FFRCT value to 0.75 was seen distal to the LM stenosis. In the proximal LAD and LCX, the FFRCT values were 0.72 and 0.74, respectively. In the ramus, the FFRCT value was 0.86. Within a week after the CTA, the ICA confirmed a stenosis in the distal LM and a moderate elongated stenosis in the LAD. No stenosis was present in the LCX [Figure 3]. FFR interrogation in the LAD was not technically possible due to vessel angulation

and calcification. However, FFR measured in the proximal portions of the LCX and the ramus was 0.73 and 0.85, respectively. The LM stenosis was deemed hemodynamically significant, and the patient was referred to coronary artery bypass grafting.

DISCUSSION

This case demonstrates high correlation between FFR and FFRCT. In contrast to FFR which measures pressure loss at the location of the pressure wire, FFRCT values are provided at any point in the coronary tree, thus presenting a plethora of information. As anticipated the FFRCT values were low in the LAD and LCX, however, at first glance, the insignificant drop in FFRCT in the ramus, which was confirmed by FFR, was puzzling. According to Bernoulli's principle, pressure will reach a minimum in the throat of a stenosis and pressure recovery will occur just distal to the stenosis due to the increase in cross-sectional area of the vessel and then decrease again due to the continuous decrease in the cross-sectional area of the vessel. As demonstrated in the present case, this occurred in the LAD and LCX, but not in the ramus. The origins of the LAD and the LCX from the LM in this case were angulated, whereas the course of the ramus

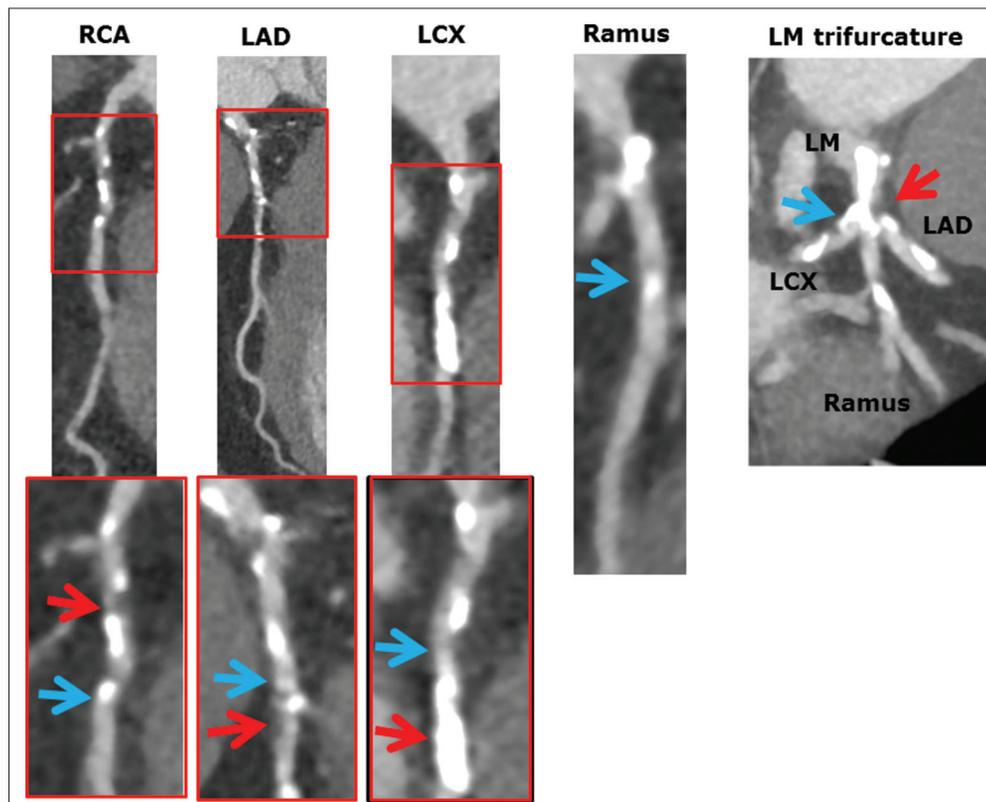


Figure 1: A 76-year-old man with dyspnea subsequently diagnosed with coronary artery disease. Coronary computed tomography (CT) angiography curved multiprojection reconstructions of the right (right coronary artery), the left anterior descending, the left circumflex, and the left main coronary arteries as well as the ramus. Red arrow: Coronary stenosis; blue arrow: CT-derived fractional flow reserve reading [cf. Figure 2].

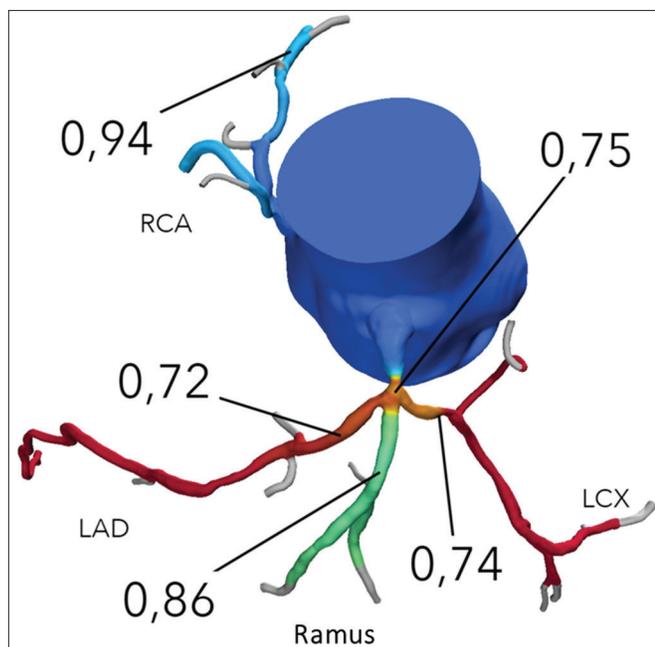


Figure 2: A 76-year-old man with dyspnea subsequently diagnosed with coronary artery disease. Computed tomography-derived fractional flow reserve (FFR_{CT}) report. Numbers indicate FFR_{CT} readings 15 mm distal to the stenoses in the left main (LM) coronary artery and right coronary artery (RCA), respectively, corresponding to the blue arrows in Figure 1. The FFR_{CT} value was ≤ 0.75 in the distal LM, proximal left anterior descending coronary artery, and proximal left circumflex coronary artery, whereas it was 0.86 in the ramus. The FFR_{CT} value in the RCA was normal.

followed a straight line from the LM. Thus, the flow from the LM was directed into the ramus and due to the fact that the cross-sectional area of the ramus was larger than that of the minimum lumen area of the LM stenosis, and less flow entered the ramus than left the LM, pressure recovery persisted.

CONCLUSION

This case demonstrates the phenomenon of pressure recovery which due to inherent methodological differences may be more frequently encountered with FFR_{CT} than with the traditional FFR technique. This case underscores the importance of acknowledging interaction between anatomy and physiology not to misinterpret the “true” significance of coronary lesions. Preserved FFR and FFR_{CT} imply normal flow. However, as demonstrated by this case, preserved FFR and FFR_{CT} do not always exclude hemodynamic significance of upstream coronary lesions.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given his

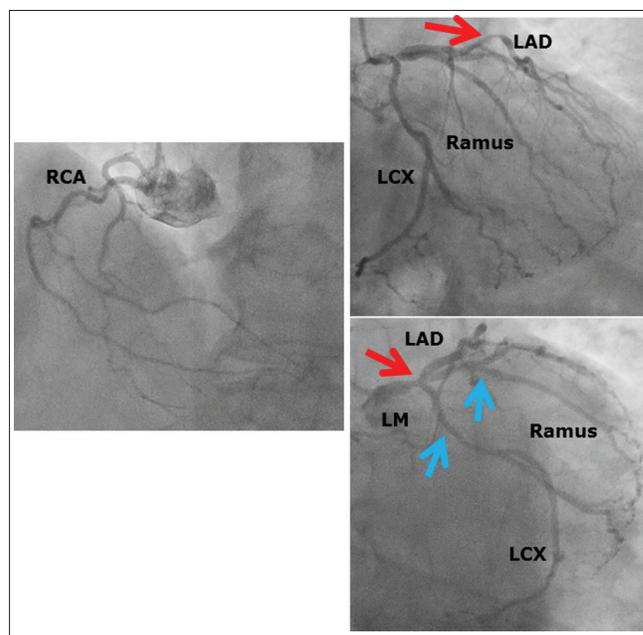


Figure 3: A 76-year-old man with dyspnea subsequently diagnosed with coronary artery disease. Invasive coronary angiography. Left: Right coronary artery which is without coronary stenosis. Right top: Left anterior descending coronary artery with moderate elongated stenosis (red arrow). The ramus and left circumflex coronary artery are without coronary stenosis. Right bottom: Left main coronary artery with distal moderate stenosis (red arrow). Blue arrow: Points of FFR measurements.

consent for his images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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How to cite this article: Jensen JM, Bøtker HE, Sand NP, Nørgaard BL. Pressure recovery in the left main stenosis. *J Clin Imaging Sci* 2019;9:39.