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Case Report

Innovative Use of Adenosine-Free Constant Resistance Ratio to Evaluate Distal Blood Flow during Perfusion Balloon Dilation: A Case Report

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Abstract

Coronary interventional therapy effectively achieves myocardial reperfusion in coronary heart disease. New surgical instruments may enhance treatment selectivity and reduce discomfort. The constant resistance ratio (cRR) is a non-congestive measurement that directly assesses coronary function without vasodilators including adenosine, simplifying operations and minimizing drug side effects compared to fractional flow reserve (FFR). As a novel device in interventional treatment, the perfusion balloon (PB)'s ability to preserve distal blood flow during inflation is not been fully understood. The case aims to evaluate the extent of blood flow preservation by using cRR.

Keywords

coronary interventional therapy; adenosine-free constant resistance ratio; perfusion balloon; left anterior descending; case report

Introduction

Balloons are integral to interventional treatments for coronary heart diseases. Traditional drug coated balloons benefit from longer inflation times that enhance drug absorption and reduce risks of severe dissection and acute recoil. However, prolonged complete blockage of blood flow during dilation can be intolerable for some patients. To address this, perfusion balloon (PB) has holes at one end that allow blood to passage during inflation. The constant resistance ratio (cRR) serves as a non-congestive coronary physiology index, measuring coronary function directly without vasodilators like adenosine or adenosine triphosphate (ATP). This simplifies clinical procedures, improves surgical efficiency, and provides functional guidance for patients contraindicated for vasodilator drugs. While fractional flow reserve (FFR) has measured distal flow in left main artery lesions during PB dilation [1], further studies are needed to evaluate distal flow during PB occlusion using cRR. The CARE checklist was used when writing this case report (Supplementary Fig. 1).

Case Report

An 85-year-old man with a history of hypertension and chronic heavy alcohol use was admitted to hospital after experiencing intermittent chest pain over the past half month. Upon admission, his blood pressure was 144/82 mmHg, and his heart rate was 70 bpm. High sensitivity troponin I and N-terminal pro-B-type natriuretic peptide (NT-pro-BNP) were within the normal range. Electrocardiogram showed sinus rhythm with abnormally deep Q waves in inferior wall leads. Physical examination revealed nothing significant. As coronary heart disease could not be excluded, coronary angiography (CAG) was performed. This revealed 50–70% obstruction in the proximal segment of right coronary artery and 80–90% obstruction in the proximal left circumflex branch (LCX). The proximal and middle left anterior descending (LAD) segments were 90% occluded (Fig. 1a). Syntax score was 10. Intravascular ultrasound demonstrated a mid-LAD lesion measuring 19 mm in length with 70% plaque burden. LAD lesion had a cRR of 0.77 and a jump pressure curve of approximately 10 mmHg in the mid-LAD lesion (Fig. 2).

After percutaneous coronary intervention (PCI) of middle LAD lesion, a proximal LAD lesion had a cRR of 0.88. Following intravascular ultrasound guidance, a stent was implanted in the proximal lesion. Subsequently PCI to the LAD was performed, improving cRR to 0.94 following two coronary stents implantation. These interventions significantly improved LAD blood flow (Fig. 1b). A PB was positioned via guide wire and inflated to 20 atmosphere (atm) pressure, featuring holes at one end allowing partial blood flow during the dilation (Fig. 3). Despite PB (Hengyi, 3.0 × 20 mm, Hengsheng medical factory) occlusion, the distal balloon cRR remained near 0.34. The distal blood flow also remained near 30% during PB dilation. Two months post-procedure, the patient reported no discomfort during a following-up survey and underwent a successful intervention for LCX occlusion.

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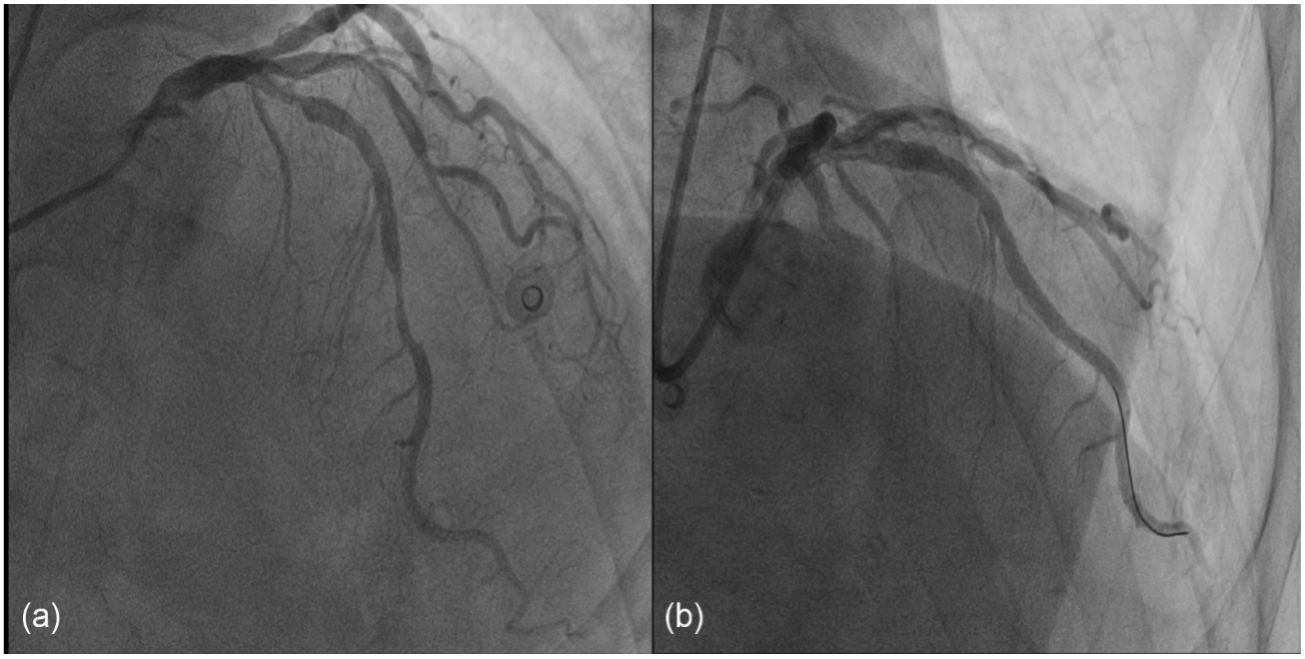

Fig. 1. Coronary angiography during the interventional procedure. (a) Coronary angiography (CAG) revealed severe stenosis in the proximal and middle section of left anterior descending (LAD). (b) Final CAG showed restored LAD blood flow.

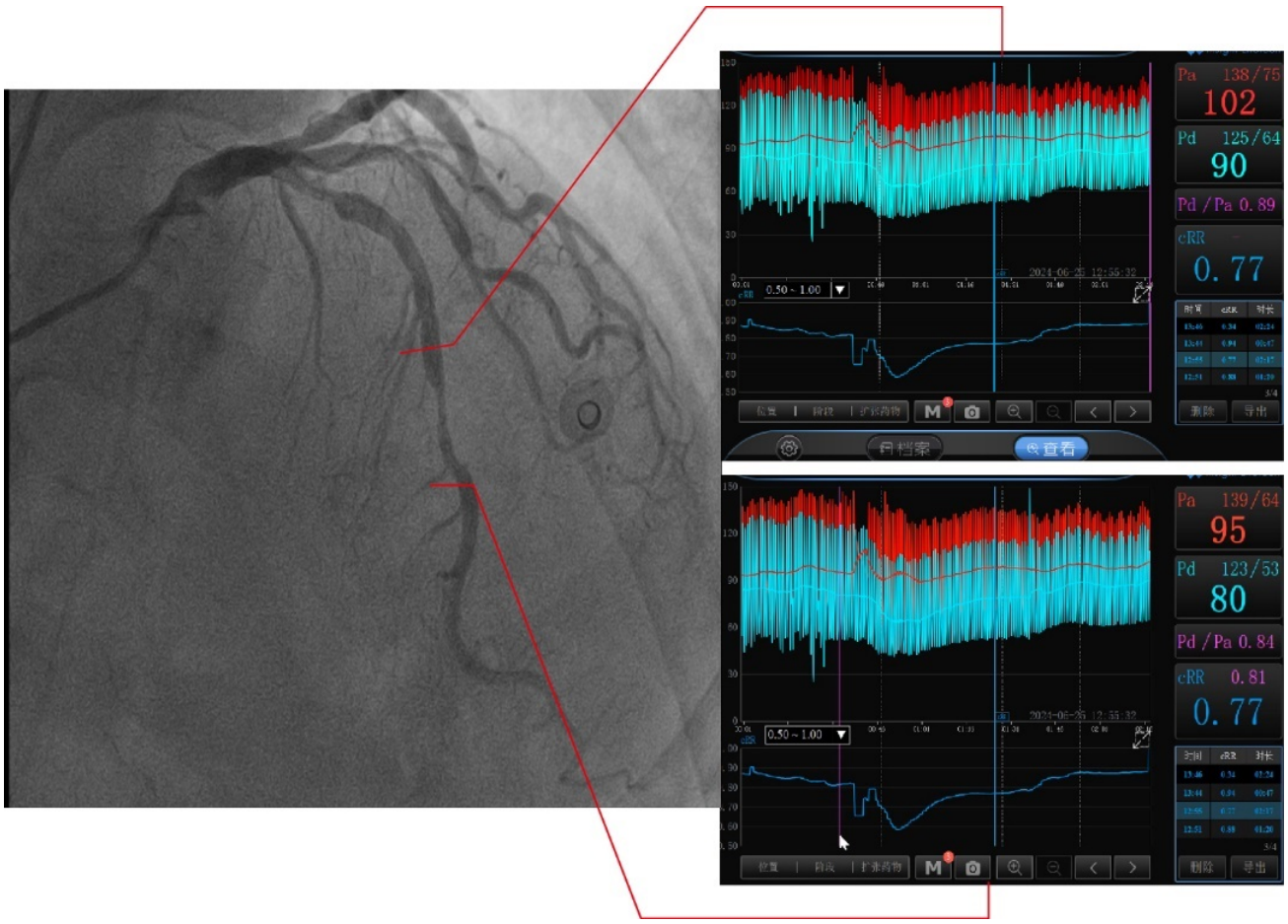

Fig. 2. Assessing cRR. The LAD lesion cRR was 0.77. Lesion pullback pressure of middle LAD had a gradient of 10 mmHg (80 to 90). cRR, constant resistance ratio.

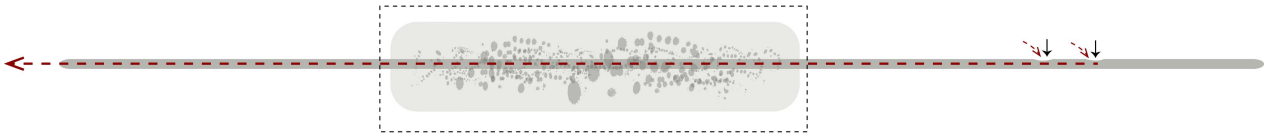

Fig. 3. Perfusion balloon (PB) structure. Black arrows point to holes at the PB end, with the dotted box representing the drug coated balloon. The guide cavity communicates with the exterior. Red dashed line and arrows indicate the blood flow path during balloon dilation.

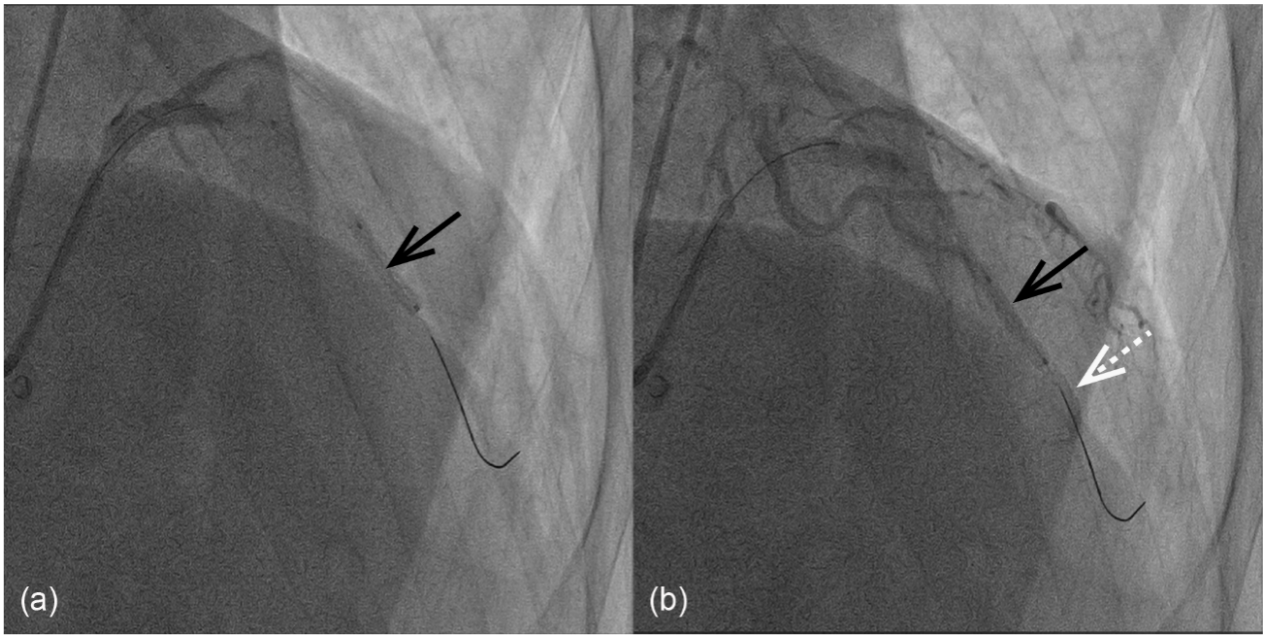

Fig. 4. Application of PB to surgery. (a) The black solid arrow showed perfusion balloon (PB). (b) The white dotted arrow indicated distant blood flow within the expanding PB.

Discussion

Using instantaneous wave-free ratio (iwFR) and FFR is a Class 1 recommendation with Class A evidence based on functional testing from the 2018 ESC/EACTS Guidelines on myocardial revascularization [2]. Assessing iwFR requires specific vendor software, which limits the availability. Measuring distal to artery pressure (Pd/Pa), cRR is similar to iwFR and precisely correlates with FFR, demonstrating excellent diagnostic performance in detecting ischemia [3]. cRR is suitable for patients with contraindications to vasodilation drugs, such as high-grade atrioventricular block without pacemaker, asthma, hypotension or severe chronic obstructive pulmonary disease. Additionally, cRR does not require pull back guide wires, thus reducing potential hazards compared to FFR. PB has several holes to maintain distal blood flow during dilation [4]. However, the extent to which PB preserves distal blood flow is not sufficiently understood. Warisawa *et al*. [1] were pioneers using FFR to demonstrate that distal blood flow remained over 30% in left main artery lesion during PB occlusion. To the best of our knowledge, there are no previous studies investigating distal flow during PB inflation using cRR in coronary interventions.

In this case, we innovatively utilized the cRR technique to assess blood flow retention in the LAD lesion during PB dilation preserving approximately 30% of distal flow as measured by cRR (Fig. 4a,b). The patient experienced no significant discomfort, suggesting the feasibility of temporary LAD midsection occlusion with PB. This method is a more convenient alternative for patients with contraindications to vasodilators compared reported by Warisawa *et al*. [1]. Our findings contribute additional evidence supporting the safety of PB in coronary interventions.

Limitations include a lack of in-depth comparison between cRR and other functional measurements in real word settings. Further large-scale clinical trials are needed to validate these findings. As emerging technologies, PB and cRR are not yet included in clinical guideline, and more evidence is needed to establish their clinical value and advantages over traditional methods.

Conclusion

In summary, our case is the first to digitally measure distal flow, with about 30% retention during PB expansion using cRR, demonstrating PB's feasibility in LAD stenoses management. Our data suggest that PB may be viable for patients sensitive to ischemia or with compromised cardiac function.

Availability of Data and Materials

All data points generated or analyzed during this study are included in this published article.

Author Contributions

All authors contributed to the design and conceptualization of this case report. The first draft of the manuscript and data analysis were performed by WWY. TL was responsible for data acquisition. Data analysis and critical revision of article were performed by CLL. All authors read and approved the final manuscript. All authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Ethics Approval and Consent to Participate

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. This study was approved by the Ethics Committee of the Second Hospital of Tianjin Medical University (approval number KY2023007). Informed consent was obtained.

Acknowledgment

Not applicable.

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Conflict of Interest

The author declares no conflict of interest. TL serve-son the editorial board of this journal. TL declares that he was not involved in the processing of this article and has no access to information regarding its processing.

Supplementary Material

Supplementary material associated with this article can be found, in the online version, at https://doi.org/10.59958/hsf.8047.

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