BMC Cardiovascular Disorders

CASE REPORT Open Access

Stingray-ADR technique creating a channel between double CTO lesions in a previous CABG patient

Huan Wang[1], You-hu Chen[1], Gen-rui Chen[1], Cheng-xiang Li[1] and Hao-kao Gao[1*]

Abstract

Patients presenting with previous coronary artery bypass grafting (CABG) exhibit an accelerated progression of atherosclerosis in native coronary arteries following surgical revascularization. When saphenous vein grafts (SVGs) become diseased or occluded, the treatment of the entire native vessels becomes significantly more challenging. Herein, we present a patient who was admitted to our hospital due to heart failure. He had undergone CABG 12 years earlier, with a left internal mammary artery (LIMA) grafted to the left anterior descending (LAD) artery, a saphenous vein graft (SVG) to the first diagonal branch (D1), and another SVG to the right coronary artery (RCA). Furthermore, a stent was implanted in the SVG to the RCA five years ago. During the current admission, angiography identified multiple chronic total occlusion (CTO) lesions in the native proximal LAD and RCA, as well as in the SVG-D1, along with in-stent occlusion of the SVG to RCA. The percutaneous coronary intervention (PCI) strategy primarily focused on recanalization of the CTO in the RCA. We successfully implemented the Stingray-based antegrade dissection reentry (ADR) technique in the LAD CTO lesion to establish a critical channel. Leveraging this channel, we subsequently accomplished retrograde recanalization of the RCA CTO via septal collateral vessels. This case demonstrates that the Stingray-ADR technique can serve as a promising and effective approach in facilitating the recanalization of more complex multi-vessel CTO lesions.

Clinical trial number: Not applicable.

Keywords Coronary artery bypass grafting (CABG), Chronic total occlusions (CTO), Percutaneous coronary intervention (PCI), Saphenous vein grafts (SVGs), Antegrade dissection reentry (ADR)

Background

The prevalence of native artery chronic total occlusions (CTOs) in patients undergoing coronary angiography (CAG) reaches 54% in the post-coronary artery bypass grafting (CABG) population, which is higher than in those without prior CABG [1]. Approximately 43% of bypassed native coronary arteries will develop CTO within one year after CABG [2]. Treating complex CTO lesions in native arteries, particularly those characterized by severe calcification or extensive length, poses significant challenges in percutaneous coronary intervention (PCI). As such, several reports have identified previous CABG as a predictor of procedural failure in CTO PCI [3–5]. To achieve native coronary revascularization, cardiovascular interventionists should master more CTO PCI skills. The recent introduction of the hybrid algorithm to CTO PCI has been associated with higher success rates, particularly for more complex CTO lesions,

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such as those observed in patients with previous CABG. The antegrade and retrograde dissection and re-entry (ADR/RDR) approaches constitute a critical component of the hybrid strategy for CTO PCI [6–7].

Herein, we present the case of a patient who previously underwent CABG and subsequently developed in-stent total occlusion in the saphenous vein graft (SVG) to the right coronary artery (RCA), concurrent with CTO lesions occurring in the proximal segments of the left anterior descending artery (LAD) and RCA. The application of the Stingray-based ADR technique in the LAD CTO lesion successfully created a critical channel, and leveraging this channel facilitated retrograde recanalization of the RCA CTO via septal collateral vessels.

Case presentation

A 70-year-old male patient was admitted to our hospital due to intermittent chest discomfort for 17 years, with symptoms worsening over the past two years and chronic heart failure. The patient had a 20-year history of hypertension and a 50-year smoking history, averaging approximately two packs per day. In 2007, he underwent CABG, during which with the left internal mammary artery (LIMA) grafted to the mid-LAD, and two SVG grafts separately to mid-RCA middle part and to the first diagonal (D1) vessel, respectively. In 2014, he was diagnosed with non-ST elevation myocardial infarction (NSTEMI), and a drug-eluting stent (DES) was subsequently implanted in the proximal SVG-RCA. Over the past two years, symptoms of chest discomfort have worsened, and exercise tolerance has decreased despite receiving optimized medical therapy. Upon admission, cardiac enzyme levels were within normal limits. The electrocardiogram (ECG) showed ST-segment depression in leads I, aVL, II, III, aVF, and V4-6 (Fig. 1A) and transthoracic echocardiography (TTE) demonstrated atrial and left ventricular enlargement, accompanied by globally reduced left ventricular wall motion and a markedly decreased left ventricular ejection fraction (LVEF = 28%) (Fig. 1B).

The coronary angiography (CAG) revealed the proximal RCA total occlusion without a visible stump (Fig. 2A, Video 1), along with the proximal LAD occlusion and severe stenosis of the D1 branch and the left circumflex artery (LCx) (Fig. 2B-C, Video 2, 3). Furthermore, there was the SVG-RCA graft total occlusion without a stump (Fig. 2D), as well as the SVG-D1 graft total occlusion, with only a small residual bump observed on the aortic wall. Notably, the LIMA graft to the LAD remained patent, providing flow to the distal bifurcation of the RCA via septal collateral vessels (Figs. 2E-F, Video 4). In this scenario, the SVG-RCA graft encountered in-stent occlusion. Consequently, the native RCA CTO was selected as the target for PCI treatment in this instance. The RCA CTO was characterized by the absence of an occlusion stump, an occlusion length exceeding 20 mm, and the presence of well-visualized septal collateral vessels supplying blood flow to the distal RCA at the bifurcation site. Based on the global CTO hybrid algorithm, the primary retrograde approach was deemed the optimal choice. However, the tortuously long LIMA graft served as the critical vessel supplying the majority of the anterior wall myocardium (Fig. 2E). In this context, using the LIMA graft as a retrograde access was very dangerous and posed a high risk of hemodynamic collapse. Consequently, the feasible strategy was to recanalize the LAD CTO to establish an alternative conduit. Utilizing this channel could subsequently facilitate the retrograde recanalization of the RCA CTO.

First, the PCI accesses were performed via both right and left femoral arteries. The left coronary artery (LCA) was engaged using a *7 Fr* EBU 3.75 guiding catheter (GC) via the right femoral artery, while the LIMA graft using a *6 Fr* JR 4.0 GC via the left femoral artery. Second, the LAD CTO was attempted by antegrade approach, and stiffer guidewires (GW) such as the Gaia 3 (Asahi Intecc, Japan), Conquest pro, and Conquest pro12 (Asahi Intecc, Japan) were utilized to attempt the pro-LAD CTO lesion; however, all entered the subintimal space (Fig. 3A-B). Subsequently, a Pilot 200 wire (Abbott Vascular, USA) was knuckled and advanced into the LAD CTO distal segment (Fig. 3C, Video 5) and along this wire, the Corsair catheter was pushed into the calcified CTO body to create tunnel space for subsequent interventions. Changing the Pilot 200 wire to the Miracle 12 wire (Asahi Intecc, Japan); subsequently, the Corsair catheter was withdrawn and replaced with the Stingray balloon (Boston Scientific) (Fig. 3D). The Stingray balloon was deliberately deployed at the proximal point of the LAD CTO distal cap to facilitate a re-entry puncture while minimizing the subintimal segment. Adequate inflation of the Stingray balloon with contrast was confirmed under multiple angiographic views (Fig. 3E, Video 6). Subsequently, the Conquest Pro12 was utilized to puncture towards the distal true lumen, and retrograde contrast injection verified its position within the mid-LAD true lumen (Fig. 3F, Video 7) until the wire reached the distal vessel. As expected, the Stingray-ADR technique established a channel through the LAD CTO lesion, allowing for the subsequent retrograde recanalization of the RCA CTO via septal collaterals.

The JR4.0 GC, which was initially engaged in the LIMA graft, was withdrawn from the left femoral artery and replaced with a 7 Fr AL1.0 GC that was subsequently engaged in the RCA. Thereafter, a Sion wire (Asahi Intecc, Japan), supported by a 150-cm microcatheter, was advanced across the 3rd septal vessel of the LAD into the posterior-lateral vessel (PLV). The angiography conducted through selective tip injection using the Corsair

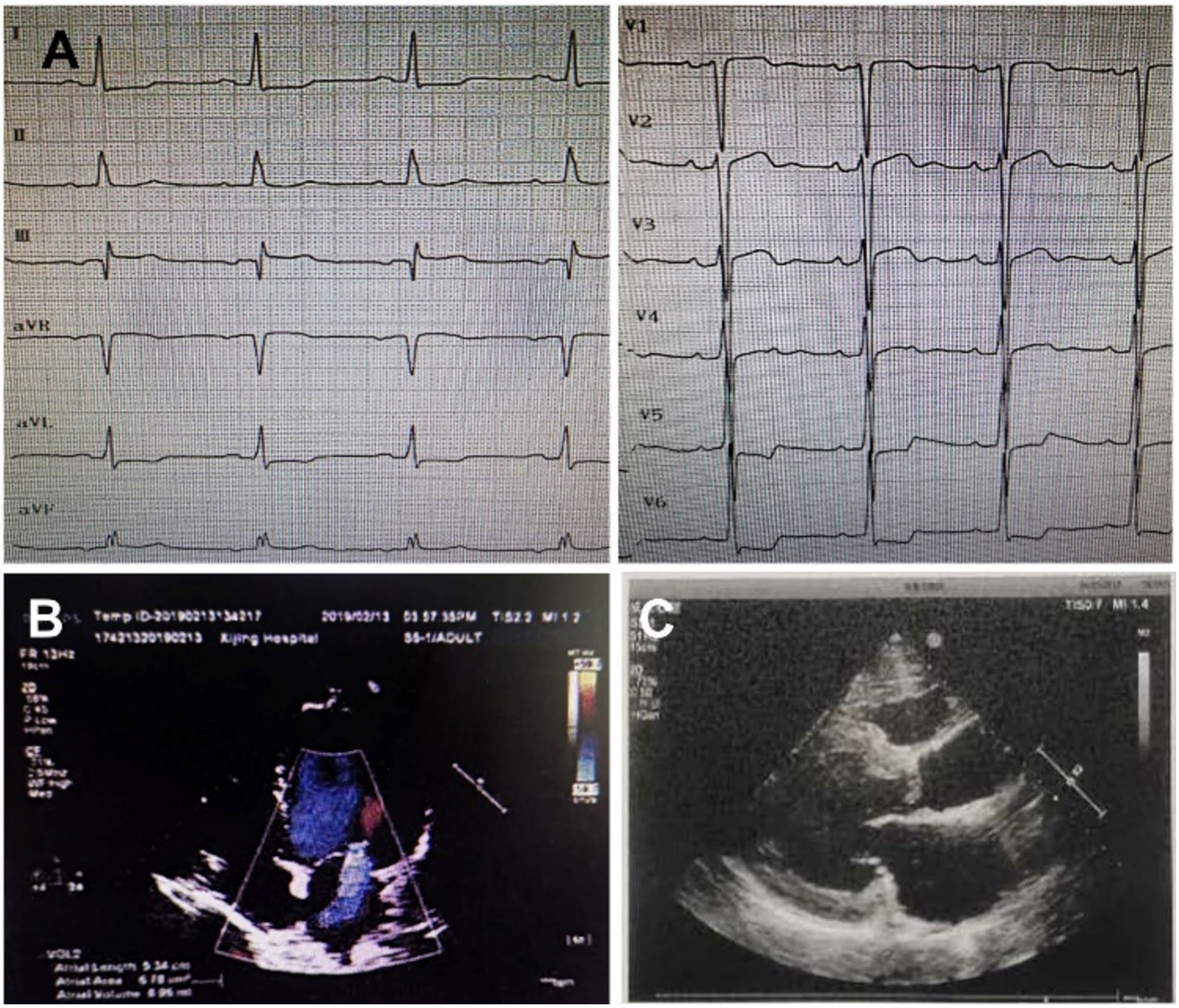

Fig. 1 ECG and TTE results. **A**: ECG showed ST elevation in leads of avR/V1-V4 and ST depression in leads of avL/V5-V6 and T wave inversion in leads of avL/I/V5-V6 before PCI procedure. **B**: TTE showed hypokinesis of global left ventricular wall and ventricular septum with EF of 28% before PCI procedure. **C**: TTE showed hypokinesis of left ventricular anterior wall and ventricular septum with EF of 40% (1year after PCI procedure). ECG: Electrocardiography; TTE: Transthoracic Echocardiography (TTE)

catheter revealed distal occlusion of the RCA CTO at the site proximal to the bifurcation (Fig. 4A, Video 8). The retrograde wire, a Field XT-A wire (Asahi Intecc, Japan), was knuckled and successfully advanced into the mid-segment of the RCA CTO. Subsequently, the antegrade Conquest pro wire was successfully advanced into the proximal cap of the RCA CTO and then exchanged for a Pilot 200 wire, which was carefully maneuvered into the mid- segment of the RCA CTO, overlapping with the retrograde Field XT-A wire (Fig. 4B, Video 9). An extension catheter was utilized to successfully retrieve the retrograde Pilot 200 wire (Fig. 4C-D) after applying the reverse controlled anterograde and retrograde tracking technique (r-CART) using a 2.0 × 20 mm balloon. Subsequently, the RG3 wire completed fully externalization through the RCA CTO lesion.

Three XIENCE PRIME stents were successfully deployed sequentially from the distal to the proximal segment of the RCA, achieving Thrombolysis In Myocardial Infarction (TIMI) 3 flow (Fig. 4E, Video 10). Furthermore, angiographic assessment of the retrograde approach revealed no evidence of vascular injury (Fig. 4F). No procedural complications occurred. The total fluoroscopy time for the procedure was 165 min, and the total contrast volume used was 350 ml. The patient was followed up for one year and exhibited mild symptoms.

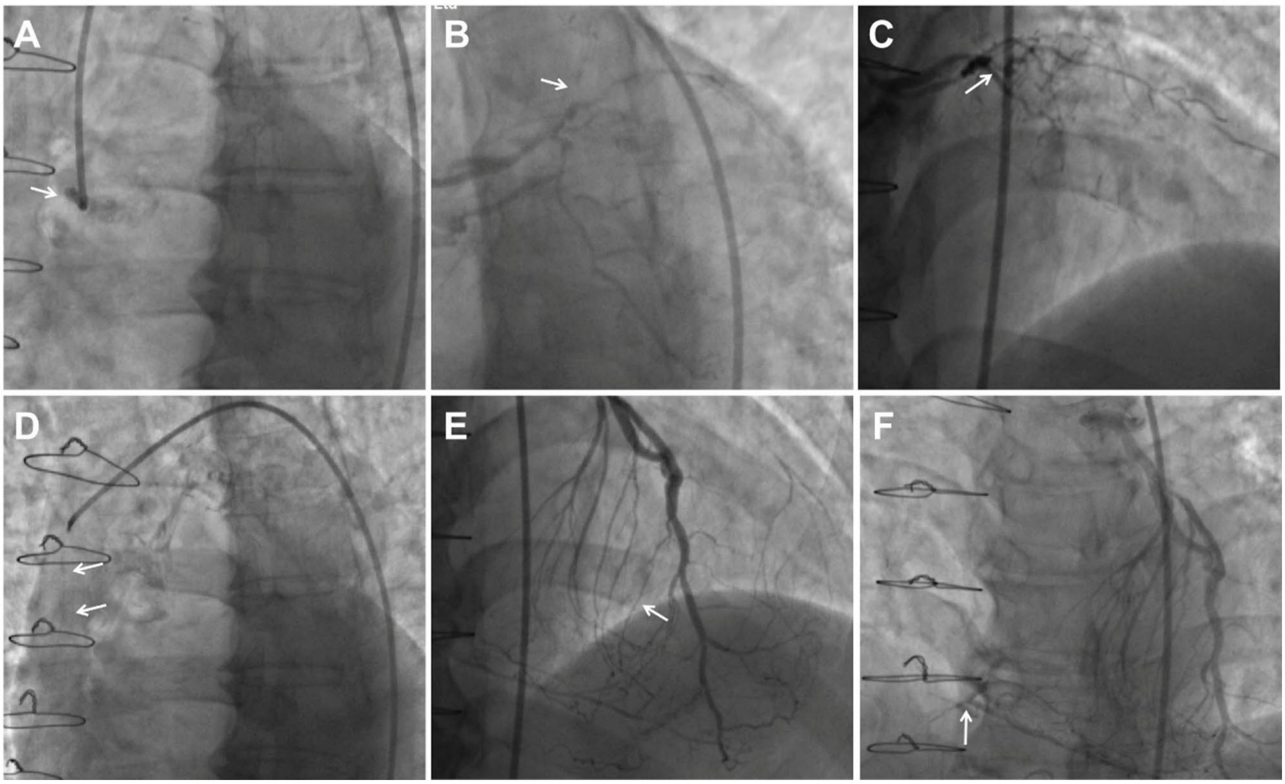

Fig. 2 CAG results of native vessels and grafts. **A**: RCA CTO without stump (arrow); **B**: Proximal LAD CTO (arrow) and diffused stenosis of LCx; **C**: LAD CTO (arrow); **D**: SVG-RCA in-stent CTO (arrow); **E**: Good septal collaterals from LIMA-LAD to RCA (arrow); **F**: Distal RCA CTO at bifurcation (arrow). CAG: Coronary angiography; RCA: Right coronary artery; LAD: Left Anterior Descending; CTO: Chronic Total Occlusion; LCx: Left Circumflex; SVG: Saphenous Vein Grafts; LIMA: Left internal Mammary Artery

Discussion

Patients exhibit an accelerated progression of atherosclerosis in native vessels following surgical revascularization [8]. When SVGs occur diseased or occluded, the entire native coronary tree undergoes significant alterations, making it more challenging to manage. In this case, the culprit lesion was the in-stent total occlusion of SVG-RCA and the CAG revealed occluded SVG-RCA without visible stump. It has been documented SVGs occlusion without stump represents a relative contraindication for intervention due to a higher risk of complications and a lower success rate [9–10]. Consequently, the occluded SVG-RCA graft was deemed unsuitable for PCI and also not an appropriate retrograde approach to recanalize the native RCA CTO.

In this case, there were well-developed septal collateral vessels connecting LIMA-LAD, providing blood flow to the distal vessels of the RCA. Previous studies have demonstrated that using a LIMA graft as the retrograde access for PCI could be safe, with high procedural success rates and low rates of in-hospital complications [11]. Nevertheless, in this specific scenario, the LIMA-LAD graft served as the critical vessel supplying the majority of the anterior wall myocardial blood flow, and utilizing the LIMA graft as a retrograde approach would pose an extreme risk. In this context, we attempted antegrade wire escalation and dissection reentry techniques to recanalize the LAD CTO; nonetheless, both approaches entered subintimal spaces. Subsequently, we performed the device-based ADR technique, and the Stingray-ADR successfully established a channel for retrograde wire crossing via LAD-septal collaterals into the RCA, thereby completing the recanalization of the RCA CTO.

According to the news hybrid CTO PCI strategy, the optimal techniques and technologies are applied during the specific times of the procedure when they are most likely to be effective. The practical ramifications of this method are that changes in strategy should occur very early and often cycle rapidly to maximize the likelihood of early successful crossing. To the best of our knowledge, this represents the first documented report of utilizing the Stingray-ADR technique to establish a channel from LAD CTO to RCA CTO. The technique has demonstrated remarkable efficacy and safety. Based on our clinical experience, for longer CTO lesions with tortuous anatomy and and severe calcification, the active knuckle technique should be considered early in the procedure. Moreover, for more complex CTO lesions, the successful implementation of the "hybrid approach" requires

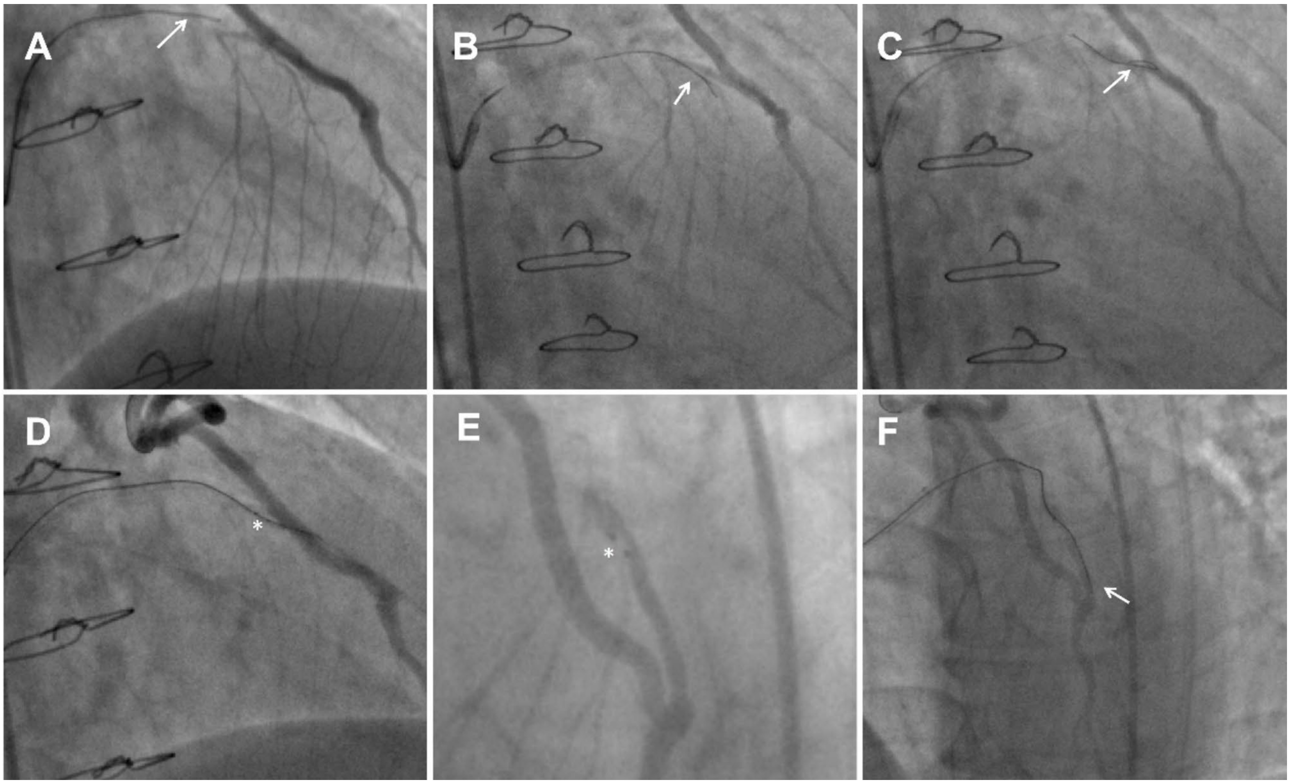

Fig. 3 Stingray-ADR technique in LAD CTO. **A**: Wire in false lumen (white arrow). **B**: Wire failed into diagonal vessels (arrow). **C**: Pilot 200 wire knuckled (arrow) into CTO landing zone. **D**: Stingray balloon located into subintimal space (asterisk). **E**: Stingray balloon underneath of the true lumen (asterisk). **F**: Pilot 200 into LAD distal true lumen, verified by LIMA angiography (arrow). ADR: Antegrade Dissection and Re-entry

specialized training and extensive procedural expertise. The patient exhibited mild symptoms, and cardiac function improved with an increase in LVEF from 28 to 40% at the 1-year follow-up (Fig. 1C).

Conclusion

The Stingray-ADR technique can be utilized to create an optimal channel in one CTO vessel, thereby enabling retrograde recanalization of another CTO vessel via interconnected collaterals. Although this technique is challenging to perform, it holds the potential for achieving favorable outcomes in carefully select cases with minimal complications.

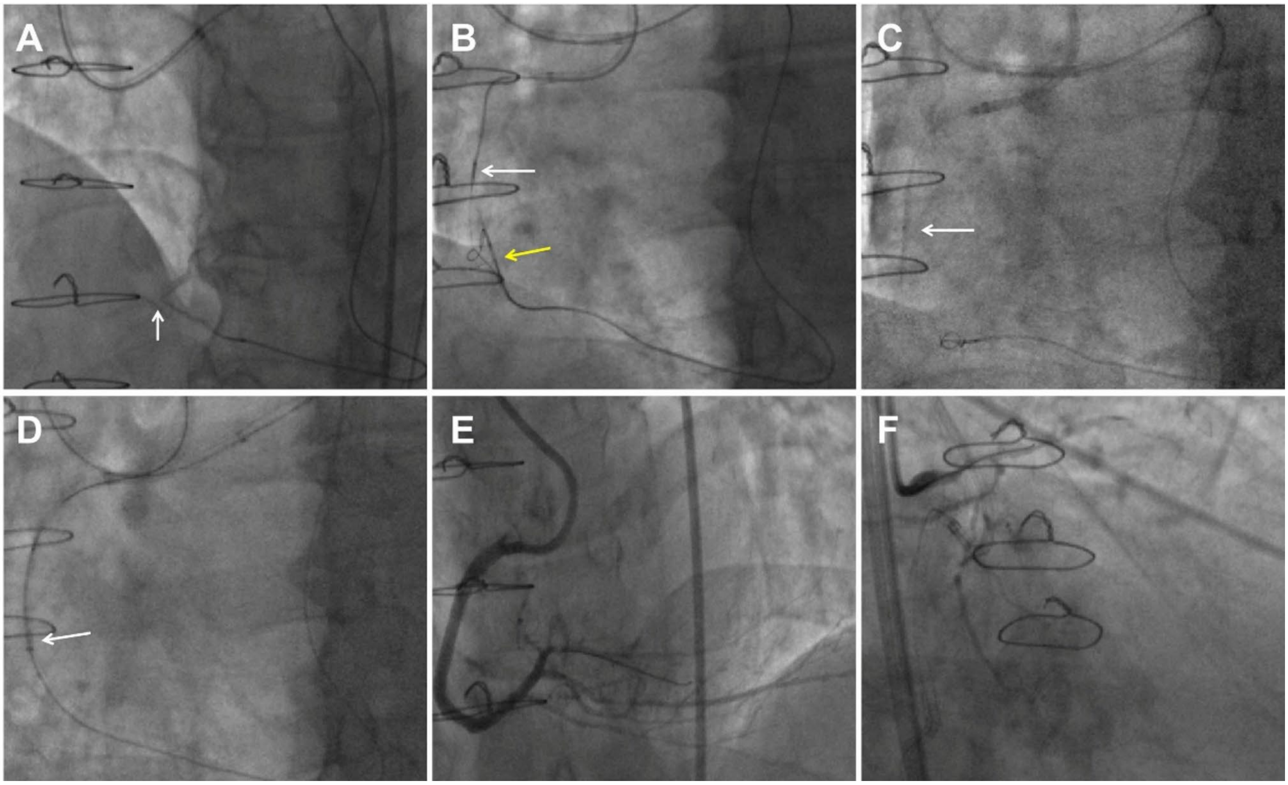

Fig. 4 Retrograde RCA recanalization process. **A**: Tip injection showed distal CTO at bifurcation (white arrow). **B**: Antegrade wire (white arrow) and retrograde wire (yellow arrow) knuckled into middle part and overlapped. **C**: Reverse CART in RCA CTO (white arrow). **D**: Guidezilla catheter (white arrow) pick-up retrograde wire and corsair. **E**: TIMI 3 grade flood in RCA after stents. **F**: LAD without injury. TIMI: Thrombolysis In Myocardial Infarction

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12872-025-04799-1.

Supplementary Material 1: Video 1: RCA ostium CTO

Supplementary Material 2: Video 2: LAD CTO and LCx diffused stenosis in caudal view

Supplementary Material 3: Video 3: LAD CTO in cranial view

Supplementary Material 4: Video 4: LIMA graft to LAD distal vessel

Supplementary Material 5: Video 5: Pilot 200 wire knuckled to LAD CTO body

Supplementary Material 6: Video 6: Stingray balloon located underneath of the true vessel

Supplementary Material 7: Video 7: Conquest Pro wire was successfully advanced into the LAD true lumen under Stingray balloon assisted, as verified by LIMA graft angiography

Supplementary Material 8: Video 8: Tip injection from Corsair catheter showed RCA CTO distal located at the bifurcation

Supplementary Material 9: Video 9: The reverse controlled anterograde and retrograde tracking technique (r-CART)

Supplementary Material 10: Video 10: The finial angiography results

Acknowledgements
None.

Author contributions
Wang Huan wrote the main manuscript text; Chen Youhu and Chen Genrui prepared Figures; Li Chengxiang and Gao Haokao revised the manuscript. All authors reviewed the manuscript.

Funding
This study was supported by the Shaanxi Province Key Research and Development Project (No: 2024GX -YBXM-136).

Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics statement
This study was approved by the ethics committee of the Department of Cardiology, the First Affiliated Hospital of Air Force Military Medical University, Xi'an 710032, China.

Consent to publish
Written informed consent was obtained from the patient for publication of this case report.

Competing interests
The authors declare no competing interests.

Received: 17 February 2025 / Accepted: 23 April 2025
Published online: 06 May 2025

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