

# Left anterior descending/right coronary artery bifurcation angioplasty in a rare case of single coronary artery: a case report

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Received 15 October 2020; first decision 5 November 2021; accepted 19 January 2021

## Background

Single coronary artery (SCA) is a rare congenital coronary anomaly with incidence of 8–66 per 100 000 cases. Percutaneous coronary intervention (PCI) in patients with SCA is technically challenging. This is a case of bifurcation angioplasty involving left anterior descending/right coronary artery (LAD/RCA) in a patient with SCA and 1-year follow-up with computed tomography coronary angiography (CTCA).

## Case summary

A 52-year-old female with history of PCI to LAD 4 months back, presented with non-ST-elevation myocardial infarction. Coronary angiogram showed 90% stenosis in mid-LAD, distal to the previous stent and proximal to an anomalously originating RCA from mid-LAD. She was planned for LAD/RCA provisional bifurcation angioplasty and a drug-eluting stent was deployed in LAD across RCA, following which patient developed angina with ischaemic electrocardiogram (ECG) changes due to significant pinching of RCA. Using Reverse crush technique, RCA was stented successfully with resolution of angina and ECG changes. At 1-year follow-up, patient is in New York Heart Association class I with normal left ventricular function and patent LAD/RCA bifurcation stent on CTCA.

## Discussion

SCA poses a great challenge to interventional cardiologists during PCI, especially in the event of a complication. Detailed anatomical knowledge, appropriate hardware and operator expertise are the key factors for successful PCI of SCA. This is, to the best of our knowledge, the first case report of bifurcation angioplasty of LAD/RCA in a rare case of SCA. This case also describes the use of reverse crush technique as a bailout strategy during provisional bifurcation angioplasty.

## Keywords

Single coronary artery • Coronary anomalies • Bifurcation PCI • Reverse crush technique • CT coronary angiogram • Case report

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Handling Editor: Michel Corban

Peer-reviewers: Ying Xuan Gue; Sameh Shaheen; Poonam Velagapudi

Compliance Editor: Stefan Simovic

Supplementary Material Editor: Mariame Chakir

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## Learning points

- Single coronary artery (SCA) is a rare coronary anomaly. Right coronary artery arising from mid left anterior descending is even rarer and poses a challenge to interventionalists due to the risk of compromising the blood flow in the entire coronary vasculature in case of any complication involving the left main.
- As per our review of the literature, bifurcation stenting in a SCA has never been attempted prior to this. Knowledge of the variation in coronary anatomy with a careful and thorough approach to selection of appropriate hardware and techniques is integral to a successful result in high-risk cases such as this.
- Reverse crush technique offers a good bail out strategy when provisional bifurcation or single stent strategy fails.

## Introduction

Coronary artery anomalies are very rare with a reported incidence of 160–1300 per 100 000 cases.<sup>1,2</sup> Single coronary artery (SCA) is an even rarer anomaly with an incidence of 8–66 per 100 000 cases.<sup>2</sup> Although the majority of SCAs are asymptomatic, some are associated with increased risk of myocardial infarction, syncope, ventricular arrhythmias, and exercise-related sudden death.<sup>3,4</sup> Attempting percutaneous coronary intervention (PCI) in SCAs poses a technical challenge as any complication would compromise the blood supply of the entire myocardium. However, revascularization strategies in such cases are not well defined and much of the evidence comes from anecdotal reports. This is a rare case of SCA with right coronary artery (RCA) arising from mid left anterior descending (LAD) artery, wherein the patient underwent LAD/RCA bifurcation angioplasty with reverse crush technique.

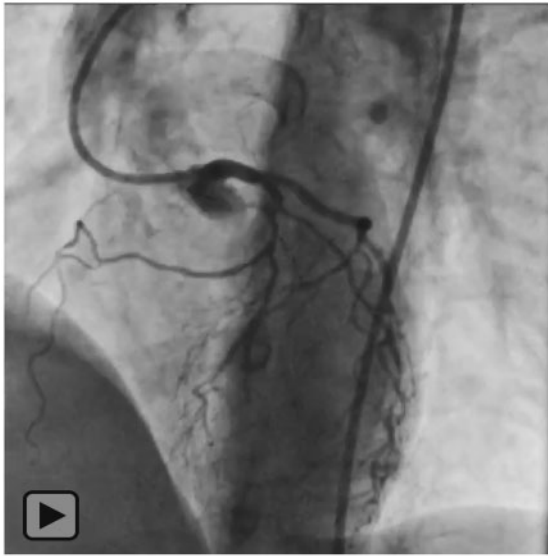
## Timeline

## Case presentation

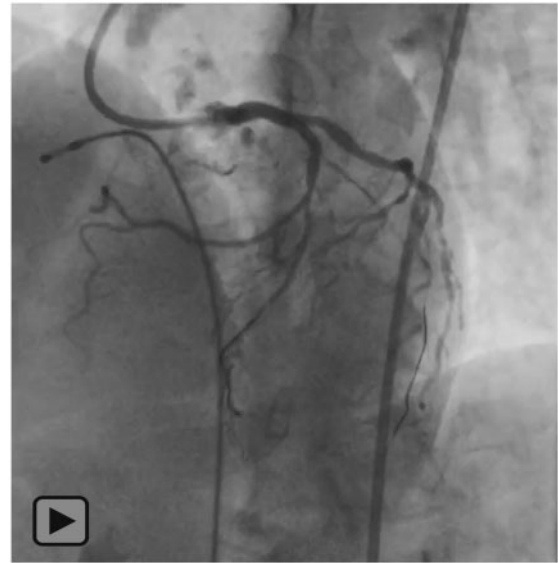
A 57-year-old non-diabetic, non-hypertensive, non-smoker female with no family history of coronary artery disease, presented to our emergency room with complaints of rest angina of two days duration. Her pulse rate was 90/min, blood pressure was 146/86 mm of Hg, respiratory rate was 16/min, and systemic examination was unremarkable.

The past medical history was significant for unstable angina 4 months back. Coronary angiography (CAG) done at that time showed SCA originating from left coronary sinus with RCA arising from mid LAD. There was a 80% tubular, heavily calcified lesion in the proximal LAD. Optical coherence tomography showed heavily calcified proximal LAD with minimal luminal area of 1.48 mm<sup>2</sup> and distal reference diameter of 2.86 mm proximal to the origin of the RCA (Supplementary material online, Figure S1). A 3 × 22 mm Resolute Onyx (Zotarolimus-Eluting Coronary Stent System, Medtronic™, Minneapolis, MN, USA) was placed in proximal to mid LAD before origin of the RCA after lesion modification with rotational atherectomy (Videos 1–3). Patient was discharged 2 days after angioplasty.

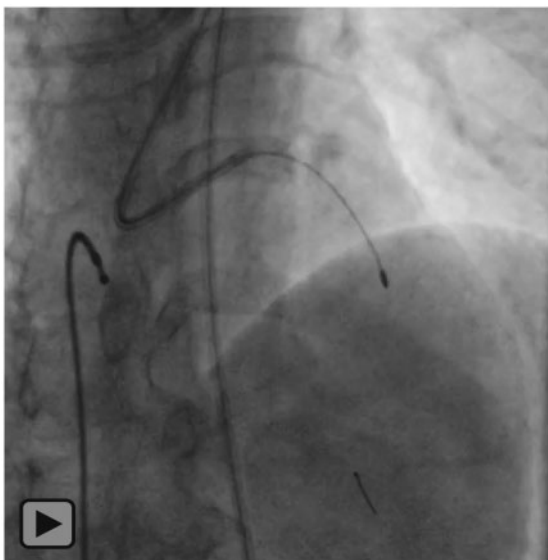
Date	Event
Past History—May 2019	
Presentation to the hospital	Patient presented with unstable angina.
Coronary angiography	Coronary angiogram (CAG) showed single coronary artery (SCA) with heavily calcified significant stenosis in proximal left anterior descending (LAD) and right coronary artery (RCA) originating from mid LAD.
Intervention	Percutaneous coronary intervention to LAD was done with rotational atherectomy and one drug-eluting stent implantation.
Result	Thrombolysis in myocardial infarction (TIMI) III flow achieved. Patient was asymptomatic and was discharged on dual antiplatelet therapy.
Presentation—September 2019	
Presentation to the hospital	Patient presented with non-ST-elevation myocardial infarction.
Coronary angiography	CAG showed 90% stenosis in mid LAD, distal to the previous stent and proximal to anomalously originating RCA from mid LAD.
Intervention	Provisional bifurcation stenting converted to two-stent strategy with reverse crush technique as patient developed angina following LAD stent deployment due to significant pinching of RCA.
Result	TIMI III flow achieved. Patient was discharged after 2 days on dual antiplatelet therapy.
1 year after presentation—September 2020	
Follow-up	One-year follow-up with computed tomography coronary angiography showed SCA with patent LAD/RCA bifurcation stents.



**Video 1** Angiogram showing significant stenosis in the mid left anterior descending artery proximal to right coronary artery origin.



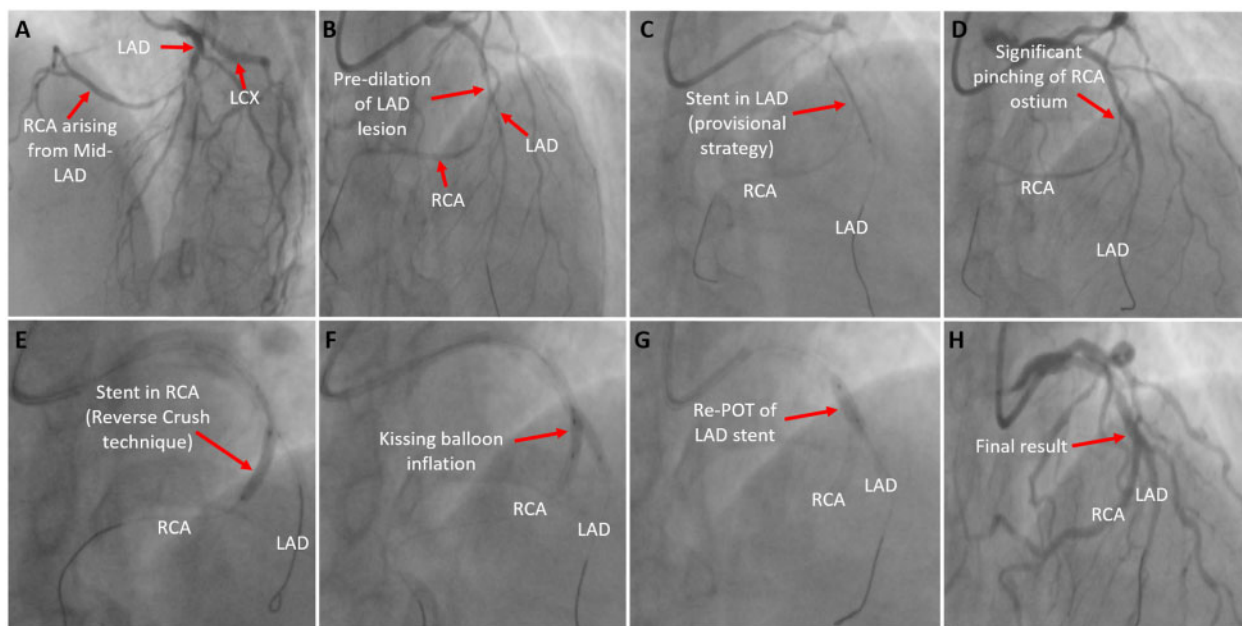
**Video 3** Final angiogram after left anterior descending artery stent deployment showing good end result.



**Video 2** Angiogram showing rotational atherectomy burr passing across the lesion.

During the present hospitalization, electrocardiogram (ECG) showed ST-segment depression in anterior chest leads and echocardiogram revealed LAD territory hypokinesia with an ejection fraction of 45%. Cardiac biomarker tests revealed raised Creatine Kinase-MB-86 mg/dL, (normal < 25 mg/dL) and troponin T-12.9 ng/mL (normal < 0.4 ng/mL). All other laboratory parameters were within normal limits. The patient was diagnosed as a case of non-ST-elevation myocardial infarction and taken for CAG which showed a LAD/RCA

bifurcation lesion (Medina class 1, 1, 0) with maximal stenosis of 90% just before the origin of RCA from LAD (*Figure 1A*), ([Supplementary material online, Video S1](#)). This LAD lesion was at the distal edge of the proximal LAD stent implanted 4 months ago. Management options were discussed in detail with the patient and her family, including coronary artery bypass graft surgery (CABG) and PCI. The patient opted to proceed with angioplasty after expressing understanding about the risks of the procedure. She was taken up for provisional LAD/RCA bifurcation angioplasty with haemodynamic support on standby after taking written informed consent. Left main was hooked with a 7 French extra backup guide catheter, both LAD and RCA were wired and the LAD lesion was pre-dilated with a 2.5 × 15 mm non-compliant (NC) balloon at 15 atmospheres (*Figure 1B*). A 3 × 26 mm Resolute Onyx stent was placed in mid LAD across the RCA and overlapping the proximal LAD stent (*Figure 1C*). The RCA got significantly pinched immediately following LAD stent deployment (*Figure 1D*) ([Supplementary material online, Video S2](#)) and the patient developed angina with ischaemic ECG changes. A decision was made to stent the RCA using reverse crush bifurcation technique (*Figure 2*). Other bailout techniques including Culotte and TAP were not chosen due to the differing vessel sizes and side branch angle <70° respectively. Proximal optimization technique (POT) was done using a 3.5 × 10 mm NC balloon at 15 atm. RCA was rewired and another 2.75 × 15 mm Resolute Onyx stent was deployed in the RCA with 1–2 mm protrusion in LAD (*Figure 1E*) ([Supplementary material online, Video S3](#)). A 3 × 12 NC balloon was kept in the LAD across the RCA origin while the stent was being deployed. The protruding RCA stent struts were then crushed by the LAD balloon after removing RCA stent balloon and wire. Patient became asymptomatic with resolution of ECG changes. RCA was rewired and final kissing balloon inflation was done using two 3 × 12 NC balloons, one each in LAD and RCA at 12 atm (*Figure 1F*). Re-POT was done using a



**Figure 1** Angiogram showing bifurcation lesion with (Medina 1, 1, 0) 90% stenosis of mid LAD at distal margin of previously placed stent and proximal to origin of anomalous RCA (A). LAD lesion was pre-dilated with a  $2.5 \times 15$  mm NC balloon (B) and a DES of size  $3 \times 26$  mm was deployed in mid LAD across the anomalous RCA (provisional bifurcation strategy) (C). TIMI III flow achieved in LAD after stent deployment with significant pinching of side branch (anomalous RCA) (D). Using Reverse crush technique, a DES of size  $2.75 \times 15$  mm deployed in RCA with slight protrusion in to LAD which was crushed by a non-compliant balloon placed in LAD (E). FKBI done with  $3.0 \times 12$  balloons one each in LAD and RCA (F) and Re-POT done in proximal part of LAD stent with a  $3.5 \times 12$  mm non-complaint balloon (G). Final result of bifurcation PCI of LAD/RCA with TIMI III flow (H). DES, drug-eluting stent; FKBI, final kissing balloon inflation; LAD, left anterior descending; NC, non-compliant; PCI, percutaneous coronary intervention; POT, proximal optimization technique; RCA, right coronary artery; TIMI, thrombolysis in myocardial infarction.

$3.5 \times 10$  mm NC balloon at 15 atm (Figure 1G). Final angiogram showed thrombolysis in myocardial infarction III flow in both LAD and RCA (Figure 1H) (Supplementary material online, Video S4). Patient was discharged the next day. At the follow-up of 1 year, patient is in New York Heart Association class I with normal left ventricular function and patent LAD/RCA bifurcation stent on computed tomography (CT) coronary angiography (CTCA) (Figure 3A–D).

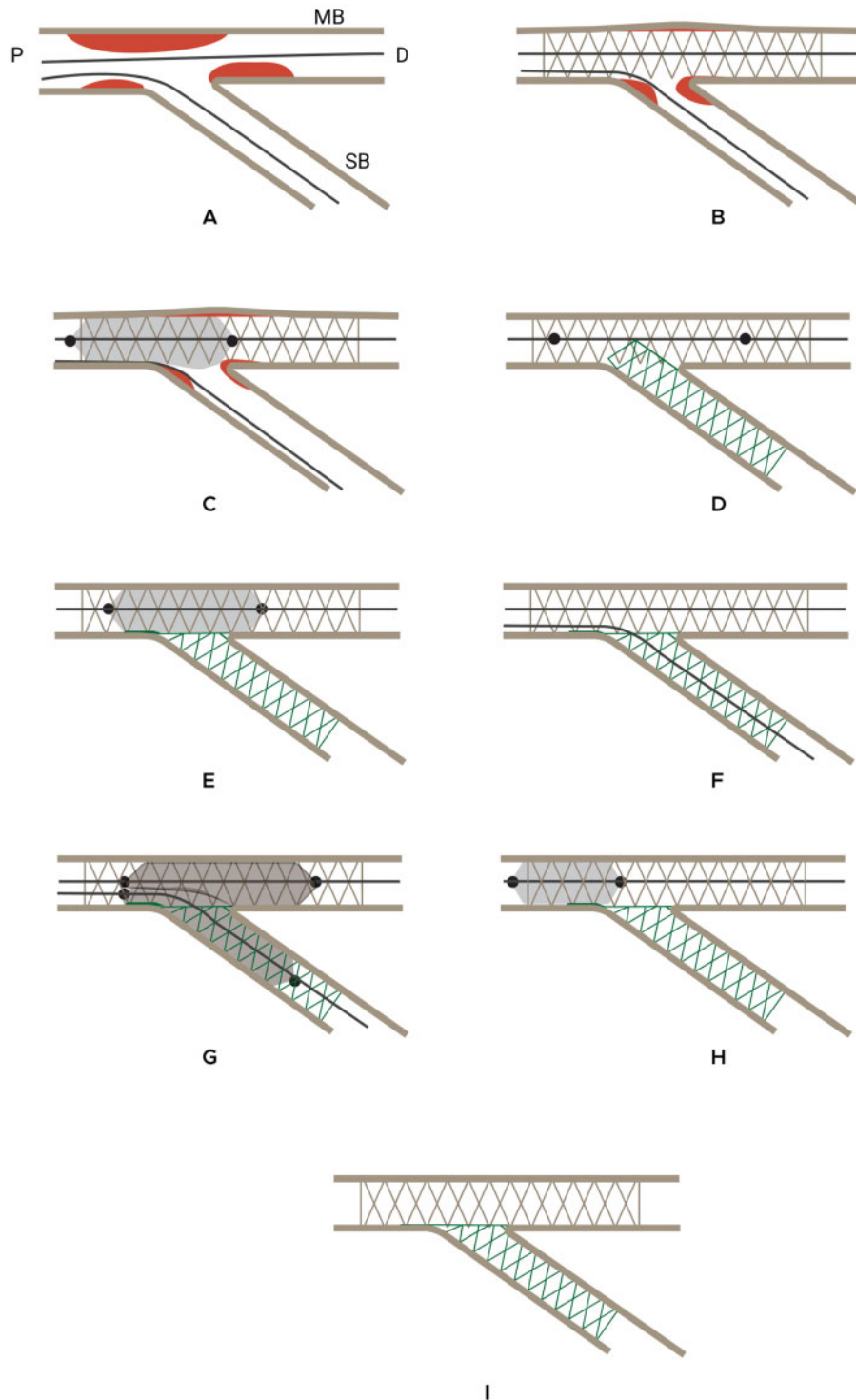
## Discussion

This is a case of LAD/RCA bifurcation angioplasty using reverse crush technique in a rare case of SCA. SCA is a rare congenital coronary anomaly, wherein the coronary artery arising from a single aortic orifice or origin provides perfusion to the entire myocardium.<sup>4,5</sup> It can occur as an isolated anomaly or in association with other congenital disorders like coronary cameral fistula, bicuspid aortic valve, truncus arteriosus, tetralogy of fallot, ventricular septal defect, patent ductus arteriosus etc.<sup>6</sup> Lipton et al. proposed a classification, later modified by Yamanaka et al.,<sup>7</sup> for SCAs without additional congenital anomalies based on the origin of the vessel and its course.<sup>1</sup> As per Lipton, an anomalous artery originating from the right or left sinus of Valsalva was designated as 'R'; or 'L', respectively. It was then designated into three groups (I, II, III) depending on the anatomical course of the artery. Finally, the relationship of the anomalous artery to the aorta and

pulmonary artery was identified [anterior (A), posterior (P), in-between (B), Septal (S), or Combined (C) patterns].<sup>1,7</sup> This patient's coronary artery anomaly fails to conform to any of the categories mentioned by Lipton et al. or its modification, further confirming the rarity of its occurrence.

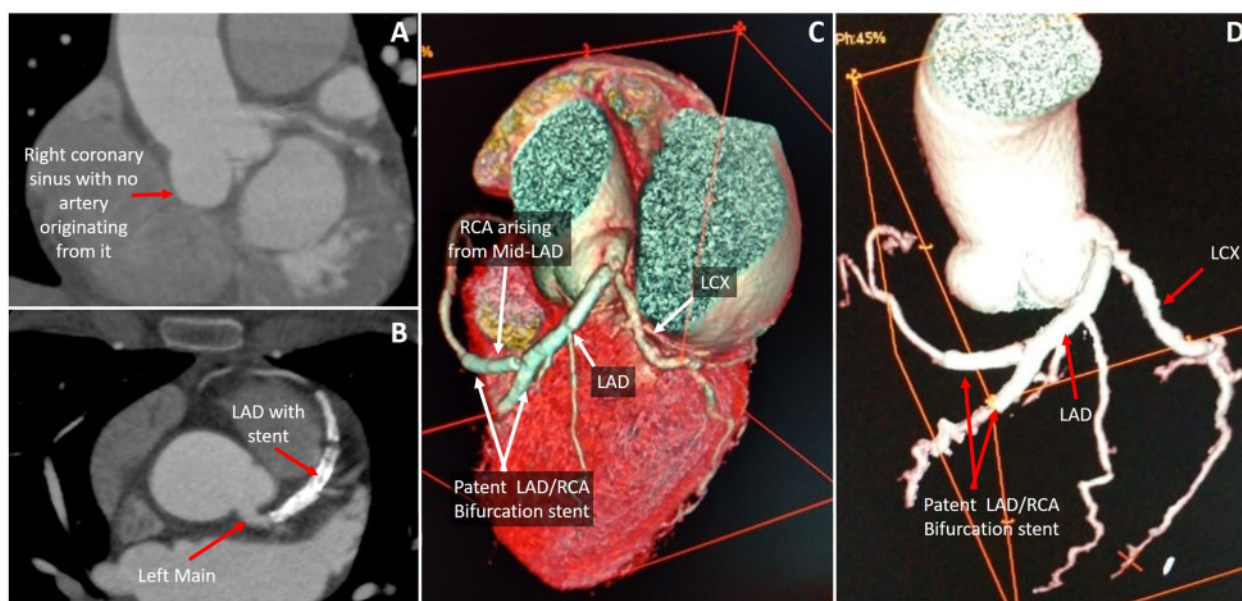
SCAs are usually asymptomatic, however some variants can present with angina, myocardial infarction, ventricular arrhythmias, exercise-related death or even sudden death.<sup>4</sup> Anomalous vessels may significantly alter myocardial perfusion, causing decreased vasodilatory response, vasospasm, flap like ostium closure or compression between the aorta and pulmonary artery, in addition to atherosclerosis.<sup>8</sup> Atherosclerosis occurs in these anomalous vessels with an incidence of 26–60% and may require revascularization.<sup>5,9</sup> Multimodality imaging including CTCA is important in identifying the origin, course and relation of the SCA with other structures especially the great arteries.<sup>10</sup>

Only a handful of case reports have been described in literature regarding an anomalous RCA arising from mid-LAD<sup>11</sup> and revascularization in these cases is quite challenging because of the complex anatomy. PCI and CABG have been reported as revascularization strategies in far and few reports and while CABG may be employed as a treatment modality, cases supporting its use in SCA are even more limited.<sup>12–17</sup> Hence there is very limited data to support the superiority of one over the other and the decision may often be dependent upon the patient's wish and the operator's expertise.



**Figure 2** Steps of reverse crush bifurcation stenting technique. (A) Bifurcation lesion Medina class (1, 1, 0) planned for provisional strategy. SB pinching after MB stent placement due to plaque shift is seen in B. In (C), POT is being done with distal marker of balloon at the level of carina. Proximal reference diameter is used to choose the size of POT balloon. SB is rewired as seen in D and a stent placed in the SB with 1–2 mm protrusion in the MB. A balloon is kept in the MB across SB during stent deployment. (E) SB stent being crushed with MB balloon after removing SB stent balloon and wire. Thereafter, SB is rewired (F) and Kissing balloon inflation is done (G). (H) Re-POT being done and (I) shows final result after provisional reverse crush bifurcation technique. D, distal; MB, main branch; P, proximal; POT, proximal optimization technique; SB, side branch.





**Figure 3** CT coronary angiogram showing left coronary artery arising from the left sinus with no vessel seen arising from the right sinus (A) and well expanded stent in the LAD (B). 3D reconstruction of CT coronary angiography showed well expanded and patent LAD/RCA bifurcation stents (C and D). CT, computed tomography; LAD, left anterior descending; PCI, percutaneous coronary intervention; RCA, right coronary artery.

Review of literature revealed that percutaneous revascularization in patients with RCA arising from mid-LAD has been attempted in only four cases.<sup>12,13,16,17</sup> In all of these cases, PCI of LAD was done, but PCI of RCA arising from LAD has not been described. In the report by Calabro et al., provisional bifurcation stenting was done for a mid-LAD 90% stenosis just adjacent to origin of anomalous RCA.<sup>16</sup>

Angioplasty in SCA lesions present a challenge owing to the origin, course and nature of atherosclerosis in these vessels and any complication during angioplasty could risk a large area of the myocardium. This necessitates the presence of haemodynamic support devices in the catheterization laboratory and operator expertise on the use of these devices. Bifurcation stenting in such cases is even more challenging. Use of good catheter support with selective and coaxial cannulation for exchange of hardware is an important step in the PCI of single coronary arteries. Hence, knowledge of the coronary vessel anatomy and the hardware is essential before proceeding for PCI.

Additionally, in bifurcation lesions, angiography alone cannot visualize the carina due to overlapping segments and use of intravascular imaging for assessing the side branch helps in devising the appropriate intervention strategy (provisional vs. two-stent bifurcation strategy).<sup>18</sup> The non-availability of intravascular imaging during this case may have led to underestimation of ostial RCA plaque. The authors recommend the use of imaging in any case of bifurcation stenting, and believe the lack of thereof may result in sub-optimal PCI.

In the index case, CTCA was done to assess the patency of the stent. Although follow-up invasive angiography would have been a better modality to assess patency of the stents in such patients, in this case where the patient was unwilling to undergo another invasive procedure, CTCA was considered to be a reasonable alternative due

to the relatively larger size of stents and low to intermediate probability for restenosis.<sup>19</sup>

This case is unique in several ways: (i) it reports a rare anatomy not described in Lipton's classification, (ii) LAD/RCA bifurcation angioplasty was performed in this rare SCA anatomy, and (iii) 1-year follow-up with CTCA showed a good result. In view of the anatomy of the vessel, and the presence of bifurcation lesion, provisional bifurcation strategy was planned with a single LAD stent across RCA. In this case, the reverse crush technique was used successfully as a bail out procedure following severe pinching of the RCA. To the best of our knowledge, this is the first case of a LAD/RCA bifurcation angioplasty for an RCA anomalously originating from the mid LAD with 1-year follow-up CTCA images to be reported.

## Lead author biography



Ankush Gupta is a professor of medicine and interventional cardiologist. He has done medicine from JNMCH, AMU Aligarh followed by fellowship in cardiology from PGIMER Chandigarh, India. He has keen interest in complex coronary intervention and intracoronary imaging. He has done innovative work on saline optical coherence tomography and protocols for cath-lab radiation reduction.

## Supplementary material

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

**Slide sets:** A fully edited slide set detailing this case and suitable for local presentation is available online as [Supplementary data](#).

**Consent:** The authors confirm that written consent for submission and publication of this case report including images and associated text has been obtained from the patient in line with COPE guidance.

**Conflict of interest:** None declared.

**Funding:** None declared.

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