Chronic Total Occlusion and Heavy Calcification of Native Right Coronary Artery After Coronary Artery Bypass Grafting Successfully Treated Using Forced Halfway Rotational Atherectomy: A Case Report

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Abstract

Chronic total occlusion in heavily calcified segments of coronary lesions is not uncommon. How to deal with such lesions depends on lesion characteristics, cath lab facilities, patient susceptibility, and technique of operators. Our case report demonstrates the usefulness of forced halfway rotational atherectomy in a CABG patient who had a long, heavily calcified lesion of the native right coronary artery with chronic total occlusion 5 years after bypass grafting.

Keywords: rotational atherectomy, halfway, chronic total occlusion (CTO)

HISTORY OF PRESENTATION

A 57-year-old man was admitted to our department with a presentation of recurrent typical effort angina, Canadian Cardiovascular Society (CCS) class III. The symptoms were the same as 5 years prior when he had suffered acute non-ST elevation myocardial infarction (NSTEMI).

PAST MEDICAL HISTORY

The patient's medical history included hypertension and hyperlipidemia. He had one episode of acute NSTEMI in 2012. At that hospitalization, diagnostic coronary angiography revealed critical double-vessel disease, with 99% stenosis of the left anterior descending artery (LAD) ostial segment and chronic total occlusion (CTO) of the right coronary artery (RCA) middle segment. Coronary artery bypass grafting (CABG) was performed (left internal mammary artery [LIMA] to LAD; reverse saphenous venous graft [RSVG] sequential anastomosis to the first diagonal branch [D1] of LAD, then posterior descending artery [PDA] of RCA).

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INVESTIGATIONS

Transthoracic echocardiography revealed mild concentric left ventricle hypertrophy and mild reduced systolic function (ejection fraction 46%). Further myocardial perfusion imaging with technetium-99m sestamibi SPECT revealed decrease of myocardial perfusion with partial recovery in the apex, the inferior and inferolateral walls, which may have been due to coronary artery disease (ischemia combined with or without infarction). The total perfusion defect (TPD) was 12% (Figure 1).

The patient then underwent diagnostic coronary angiography, which revealed patent left main coronary artery (LMCA) and non-dominant left circumflex artery (LCX) (Figure 2A), LAD blocked in the proximal segment (Figure 2B), patent LIMA to LAD (Figure 2C), RCA blocked in the middle segment (Figure 2D), patent RSVG to LAD-D1 and to PDA, but critical stenosis of PDA (Figure 2E).

Since a non-invasive stress test of myocardial perfusion and coronary angiography both showed myocardial ischemia in RCA territory, percutaneous recanalization of the long and totally occluded RCA was attempted.

MANAGEMENT

The intervention was performed using local anesthesia with xylocaine. A 7-F, short-tip

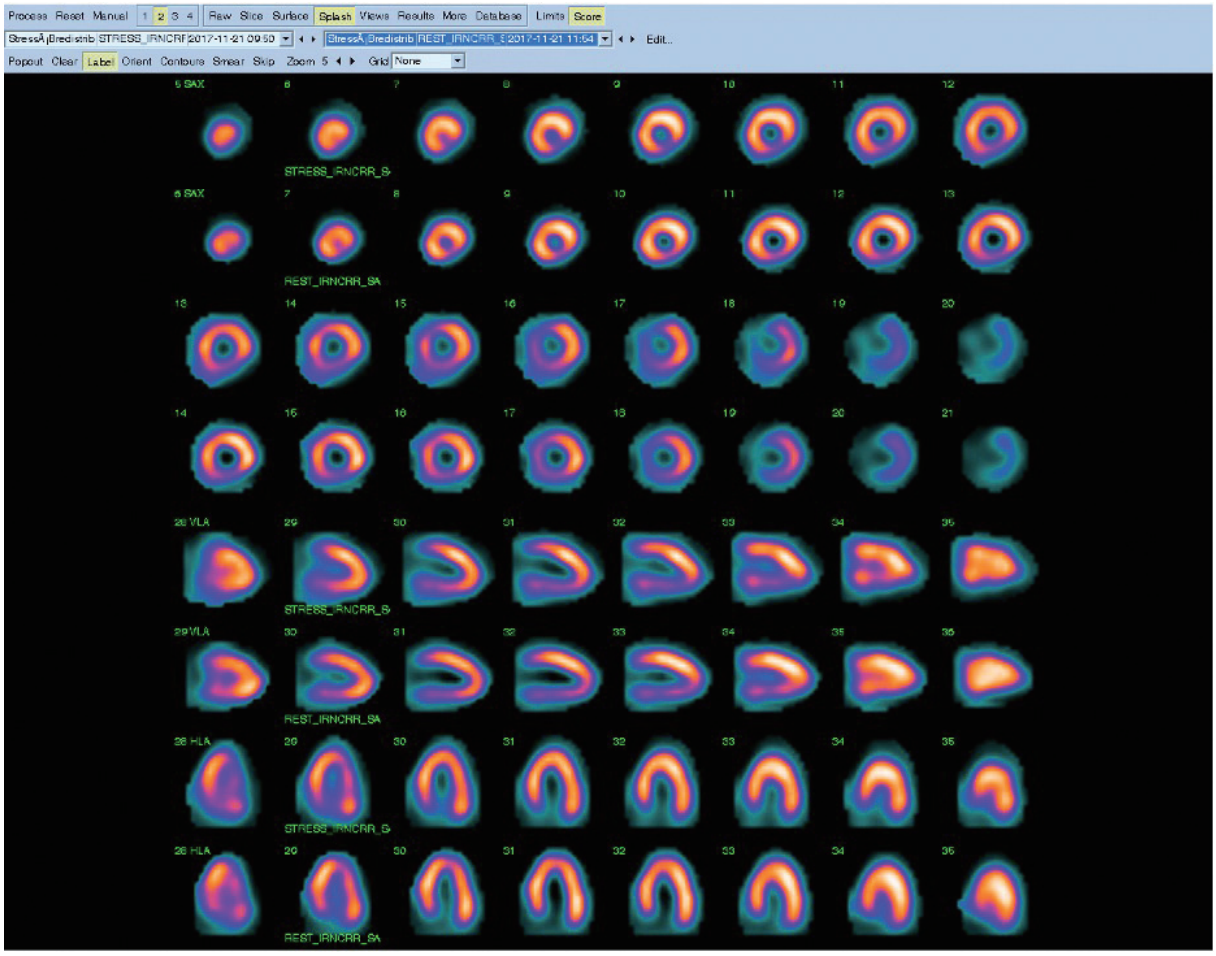
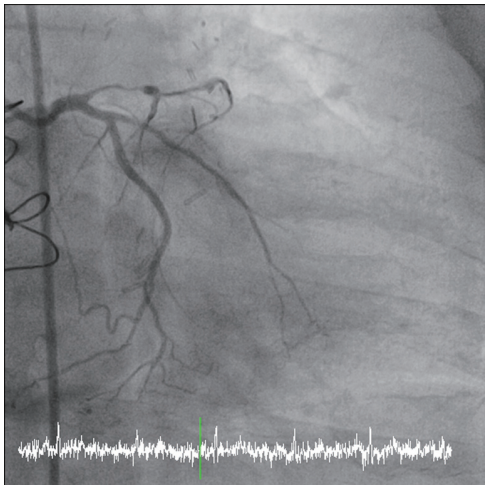
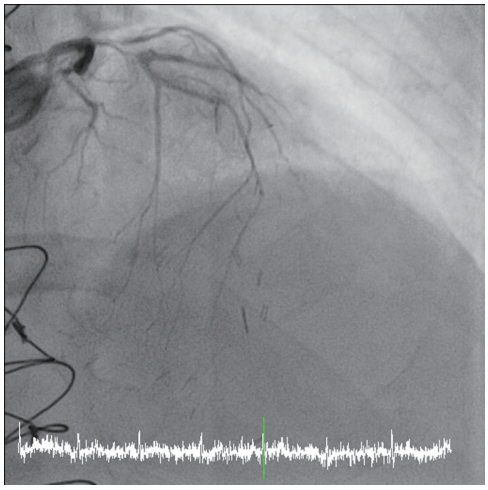


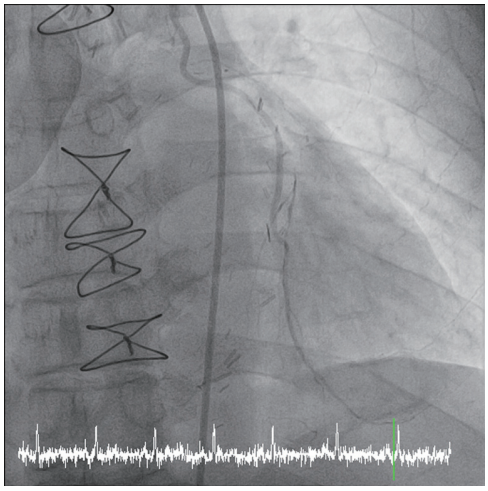
Figure 1. Myocardial perfusion imaging with technetium-99m sestamibi SPECT. Decrease of myocardial perfusion with partial recovery in the apex, inferior and inferolateral walls.



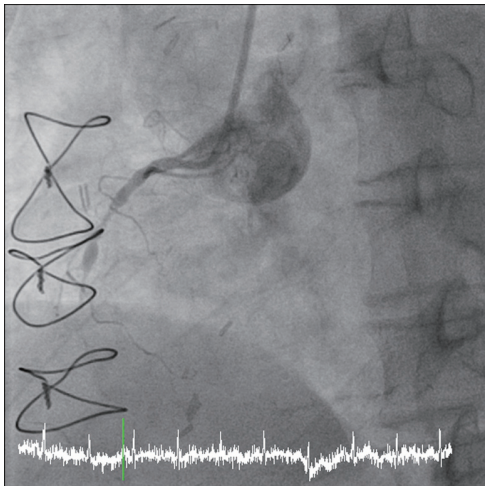
2A. Patent LMCA and non-dominant LCX.



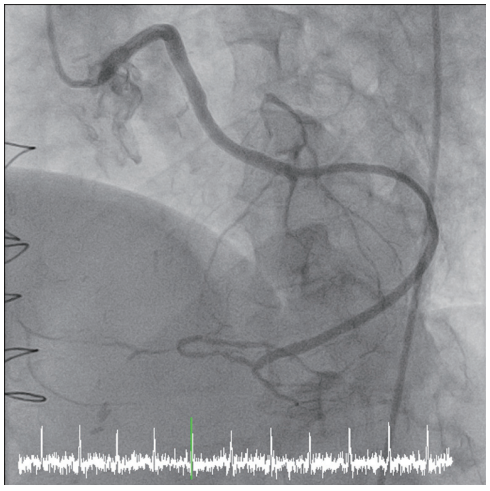
2B. Proximal LAD CTO.



2C. Patent LIMA to LAD.



2D. Middle RCA CTO.

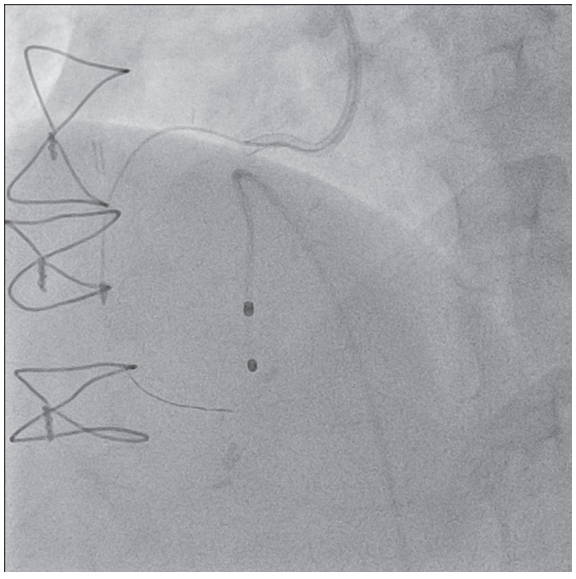


2E. Patent RSVG to LAD-D1 and PDA but critical stenosis of PDA.

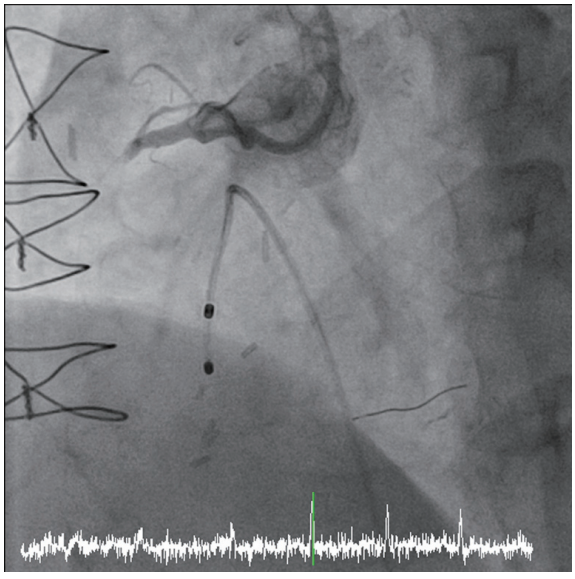
Figure 2. Diagnostic Coronary Angiography.

Amplatz Left (SAL) guiding catheter was inserted via the right femoral artery to engage the RCA. Another 6-F, Right Judkins 4 (JR) guiding catheter was inserted via the left femoral artery to engage the vein graft for contralateral injection of contrast medium. After several attempts, both Fielder XT-A and Gaia-1 guide wires (Asahi Intecc Co. Ltd., Aichi, Japan) could be manipulated to the RCA posterolateral branch (RCA-PLV), but they failed to cross the CTO segment despite using the smallest balloon (1.0 mm), Corsair channel dilator (Asahi Intecc) and the assistance of a 6-F Guideliner extension catheter. The CTO was considered to be very old and with heavy calcification, a situation calling for conventional rotational atherectomy (RA) (Rotablator system, Boston Scientific, Natick, Massachusetts).

RA proceeded after bailout wiring of a 0.009 inch RotaWire floppy to the RCA-PLV. Before the RA, a transvenous temporary pacing (TVP) system was placed via the right femoral vein to maintain heart rhythm. RA verapamil cocktails and intracoronary vasodilators were infused before the RA. RA began with a 1.25 mm burr with a speed up to 180,000 rev/min. However, while the burr succeeded in ablating the proximal cap of the CTO segment, it was difficult to advance the rotating RA burr beyond the CTO proximal cap, even after 8 sessions, due to high resistance (Figure 3A). Meanwhile, the patient suffered from chest tightness, cold sweating, nausea and vomiting while the RA was ongoing. ECG monitor showed junctional rhythm with back-up pacing, but subsequent RCA angiography showed no reflow (Figure 3B). Hence, the conventional RA method was stopped and the strategy shifted to forced halfway RA method. After the proximal calcified plaque cap was modified by RA, the Corsair channel dilator was successfully advanced to the RCA-PLV and anastomosed vein graft. Following serial balloon dilatations of varying sizes, a 20 MHz phased-array catheter (2.9



3A. It was difficult to advance the rotating RA burr beyond the CTO proximal cap due to high resistance. Strong reaction force caused displacement of the guiding catheter and RotaWire.



3B. No-reflow phenomenon after failed RA.

Figure 3. Conventional RA.

F Eagle Eye, Volcano Therapeutics, Rancho Cordova, California) was used and revealed superficial but thick 180-degree calcified lesions (Figure 4). Finally, 3 drug-eluting stents (Resolute Onyx Zotarolimus-eluting stent 2.0 × 30 mm, 2.25 × 38 mm, 3.0 × 30 mm, Medtronic, Santa Rosa, California) were scaffolded from distal to proximal RCA, as if to form a full metal jacket. The procedure was complete after serial post-dilatations with larger non-compliant balloons (2.5 mm and 3.0 mm). The angiographic result was found to be very good with TIMI 3 grade flow (Figure 5).

During the procedure, the patient was hemodynamically stable under transvenous temporary back-up pacing. The patient suffered some degree of angina, cold sweating, breathlessness, nausea and vomiting while the RA was ongoing. Morphine and isosorbide dinitrate were injected for relief of symptoms. After the procedure, junctional rhythm with back-up ventricular pacing was maintained for 2 days and sinus rhythm resumed later. The peak serum CPK activity showed a 4-fold increase within 48 hours.

FOLLOW-UP

The patient developed mild angina around 1 year later. Coronary angiography was done 18 months after the index procedure, which revealed RCA middle segment in-stent, diffuse 60-70% re-stenosis (ISR) (Figure 6A) . Intra-coronary Optical Coherence Tomography (OCT) image showed heterogenous fibrous plaque morphology with minimal lumen area (MLA) 0.89 mm^2 (Figure 7A). Balloon angioplasty was followed by the application of drug-coated balloon (DCB) (Pantera Lux, Biotronik, Switzerland) . The results from angiography (Figure 6B) and OCT imaging were good with MLA 4.19 mm^2 (Figure 7B) .

DISCUSSION

Halfway RA is a novel strategy in which a coronary interventionist does not advance the RA burr to the end of a continuous calcified lesion and performs balloon dilatation to treat the remaining part of the calcified lesions, in contrast to conventional RA in which the coronary

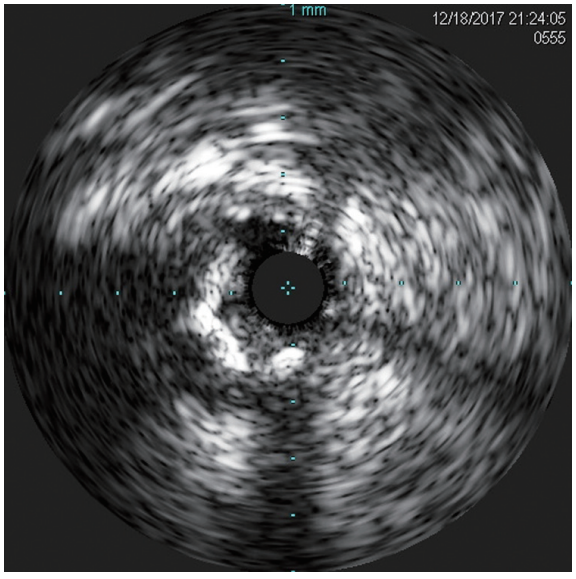


Figure 4. IVUS image. After halfway RA and serial balloon dilatations, IVUS showed superficial but thick 180 degree calcified lesions.

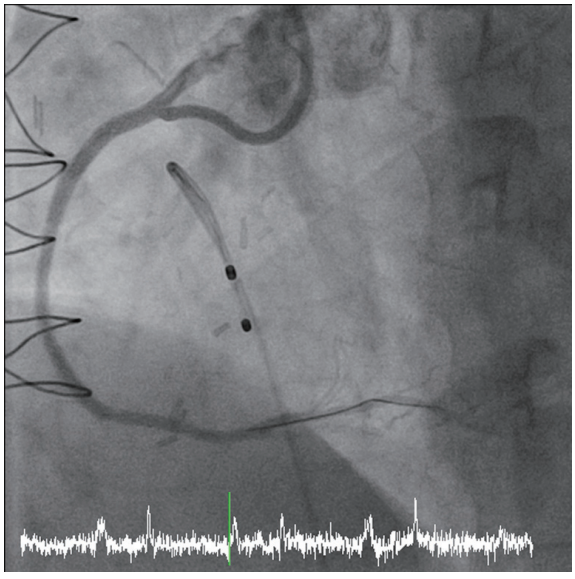
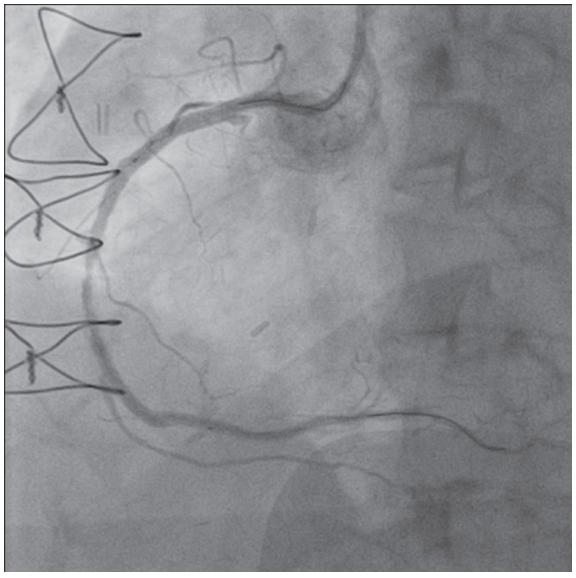
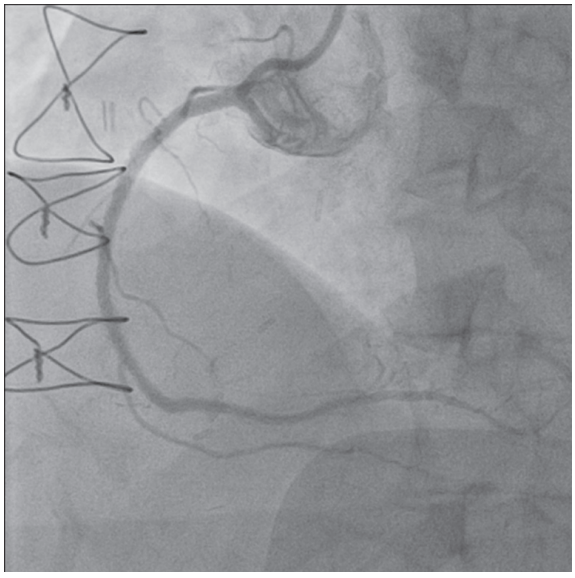


Figure 5. Final RCA Angiography: Final flow was TIMI grade 3.

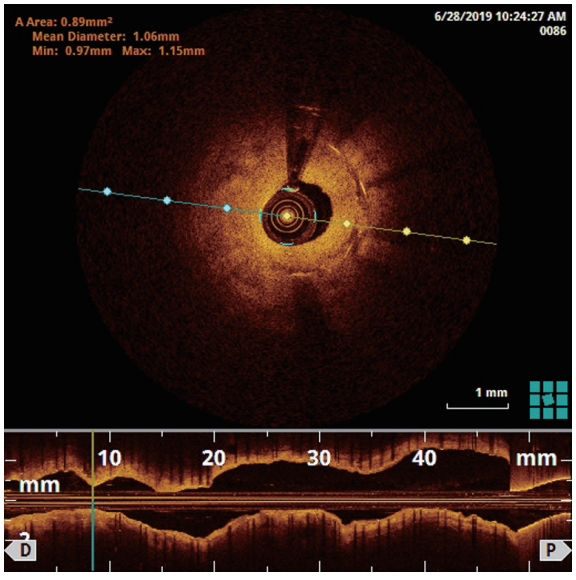


6A. Middle RCA 60-70% ISR.

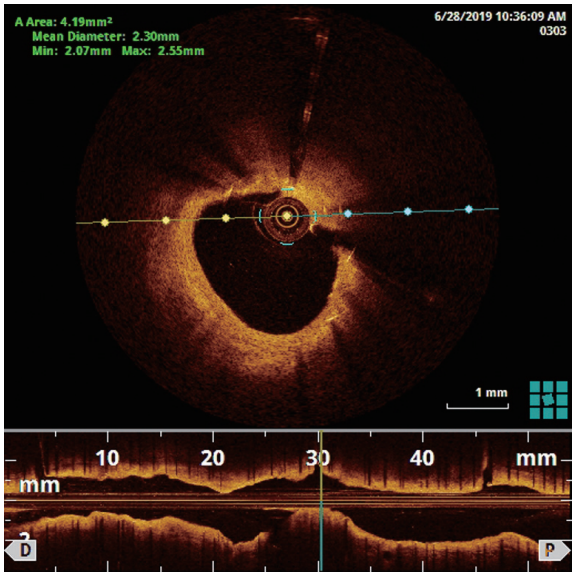


6B. After balloon dilatation and DCB application.

Figure 6. RCA Angiography 18 months after index procedure.



7A. Heterogenous fibrous characteristics of ISR, MLA 0.89 mm^2.



7B. After balloon dilatations and DCB application, MLA 4.19 mm^2.

Figure 7. OCT image of RCA ISR.

interventionist advances the RA burr to the end of a continuous calcified lesion.[1]

The proximal cap of a CTO is often fibrocalcific and more resistant to intervention.[2] In this situation, halfway RA can create cracks over the proximal cap, facilitating further balloon dilatation. Further balloon dilatation is likely to cause a continuous crack because the edge of the crack would be under high pressure from the balloon dilatation.[3] Halfway RA might also reduce the total resistance of the long and calcified CTO segment, facilitating the crossing of the lesion.

Conventional RA risks several serious complications such as burr entrapment or vessel perforation. In a propensity-score matched analysis,[1] Sakakura et al. observed burr entrapment (0.8%) and major perforation (0.8%) in a conventional RA group (n = 244), whereas there was no burr entrapment or perforation in a halfway RA group (n = 63). The success rate of halfway RA was 90.5%, with unsuccessful balloon dilatation following halfway RA observed in 6 cases (9.5%). Five of the six cases required switching from halfway RA to conventional RA, but both strategies failed in one CTO case. The incidences of slow flow and periprocedural myocardial infarction were similar in both groups. The lesion length was significantly greater in the halfway RA group (29.19 ± 14.15 mm) than in the conventional RA group (23.95 ± 15.50 mm) (P = 0.004). Halfway RA was performed intentionally in most cases (intentional halfway RA, n = 56); however, operators were occasionally forced to perform halfway RA (forced halfway RA, n= 7) rather than conventional RA because of severe ST elevation during RA. Forced halfway RA was successful in 6 of these 7 lesions.

This case proved above theory that forced halfway RA can help to complete the complex procedure in a case with chronic, very long, heavily calcified, totally occluded native coronary arteries. Since the forceful forward debulking step of conventional RA is very risky, a rapid shift of strategy to halfway RA may prevent serious complications, as in this case. However, the halfway RA has its negative aspects. There is no guarantee[1] that the lesion beyond the CTO point can be dilated with a balloon following halfway RA. Actually, the shift between the two strategies is very easily and quickly undertaken.

Lesion length is a strong determinant of slow flow and no-reflow phenomena after RA,[4] and is significantly greater in cases requiring halfway RA, compared to those receiving conventional RA.[1] Therefore, the incidence of slow flow or no-reflow phenomena is greater in the halfway RA group than in the conventional RA group.[1] In the presented case, verapamil based RA cocktail, containing verapamil 10 mg, nitroglycerin 5 mg, and heparin 10,000 U in 1000 mL saline, was infused through the 4 F Teflon sheath of the rotablator system during RA. However, there was still no sign of reflow. Some studies have reported the risk factors for complications during RA such as emergency procedure, hemodialysis, and previous myocardial infarction.[5] This patient had previous myocardial infarction history and a very long lesion, so the chances of no reflow were very high. Nicorandil based RA cocktail, using nicorandil (24 mg) instead of verapamil, is more effective[6] at preventing slow flow or no reflow, but intravenous nicorandil is unavailable in Taiwan.

High-risk coronary intervention represents an indication for hemodynamic or rhythmic support.[7] Michael et al. reported that heart block or temporary pacing was employed in 53% of patients who underwent RA to the RCA.[8] In this case, the pre-inserted TVP system helped to back-up the heart rhythm and was a very important step for hemodynamic stability.

Positive remodeling of coronary arteries distal to CTOs does occur after successful intervention in some cases.[9] The study found that after a mean follow-up of 2.3 ± 1.9 months the vessel lumen one segment distal to the CTO had become significantly enlarged, as compared with immediately post balloon dilatation (2.0 ± 0.6 mm vs. 1.7 ± 0.6 mm, P = 0.004). However, high binary angiographic re-stenosis rate (60.7%) and re-occlusion rate (21.4%) was also observed in the

series. Staged intervention to choose optimal stent size and length can be considered for potential positive remodeling of the chronic totally occluded coronary arteries. In this case, however, the RCA was encased with heavy calcification and chronic, long term occlusion impaired the endothelial function. Positive remodeling seldom occurs in such diffusely diseased and calcified vessels. Immediate full metal jacket stenting strategy was chosen in this case because the risk of re-stenosis and re-occlusion was higher after this very complex intervention.

CONCLUSIONS

This case report shows that halfway RA is a useful strategy to deal with long and heavily calcified coronary lesions. It avoids the complications produced by the high-risk forward pushing RA movement. Halfway RA reduces the need for forward pushing by cracking the proximal cap of the CTO segment and further expanding these cracks by balloon dilatation, thereby reducing the total resistance of long, heavily calcified, CTO lesions. Appropriate selection of coronary artery CTO cases is important for the adoption of the halfway RA strategy.

AUTHOR DISCLOSURES

The authors report that they have no relationships relevant to the contents of this paper to disclose.

REFERENCE

1. Sakakura K, Taniguchi Y, Yamamoto K, Wada H, Momomura SI, Fujita H. Halfway rotational atherectomy for calcified lesions: Comparison with conventional rotational atherectomy in a propensity-score matched analysis. *PLoS One* 2019 Jul 5;14(7):e0219289.
2. Fujii K, Ochiai M, Mintz GS, Kan Y, Awano K, Masutani M, Ashida K, Ohyanagi M, Ichikawa S, Ura S, Araki H, Stone GW, Moses JW, Leon MB, Carlier SG. Procedural implications of intravascular ultrasound morphologic features of chronic total coronary occlusions. *Am J Cardiol* 2006 May 15;97(10):1455-62.
3. Sakakura K, Taniguchi Y, Matsumoto M, Wada H, Momomura S, Fujita H. How Should We Perform Rotational Atherectomy to an Angulated Calcified Lesion? *Int Heart J* 2016 May 25;57(3):376-9.
4. Sakakura K, Taniguchi Y, Yamamoto K, Tsukui T, Jinnouchi H, Seguchi M, Wada H, Fujita H. Modifiable and unmodifiable factors associated with slow flow following rotational atherectomy. *PLoS One* 2021 Apr 26;16(4):e0250757.
5. Sakakura K, Inohara T, Kohsaka S, Amano T, Uemura S, Ishii H, Kadota K, Nakamura M, Funayama H, Fujita H, Momomura SI. Incidence and Determinants of Complications in Rotational Atherectomy: Insights From the National Clinical Data (J-PCI Registry). *Circ Cardiovasc Interv* 2016 Nov;9(11):e004278.
6. Matsuo H, Watanabe S, Watanabe T, Warita S, Kojima T, Hirose T, Iwama M, Ono K, Takahashi H, Segawa T, Minatoguchi S, Fujiwara H. Prevention of no-reflow/slow-flow phenomenon during rotational atherectomy --a prospective randomized study comparing intracoronary continuous infusion of verapamil and nicorandil. *Am Heart J* 2007 Nov;154(5):994.e1-6.
7. Ajmi I, Mahnkopf C, Brachmann J, Sinani M, Oudeh M, Schnupp S. Rotablation of Heavily Calcified Left Main Stenosis and Aortic Valve Valvuloplasty Under ECMO Cardiopulmonary Support. *JACC Case Rep* 2020 Nov 25;2(15):2448-2454.
8. Mitar MD, Ratner S, Lavi S. Heart block and temporary pacing during rotational atherectomy. *Can J Cardiol* 2015 Mar;31(3):335-40.
9. Lo WJ, Hu YC, Chen WJ, Chen YW, Lai CH, Su JS, Liu TR, Lee WL, Chang WC. Positive Distal Vessel Remodeling After Initial Balloon Dilatation of Chronic Total Occlusions and Staged Stenting in a Selected Group of Patients. *J Taiwan Cardiovasc Interv* 2021;12:16-24.