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Case Report

How to decide appropriate percutaneous coronary intervention (PCI) technique for managing heavy calcified coronary lesions: serial case-report

Fahreza Caesario[1*], Mohammad Saifur Rohman[2]

[1]Brawijaya Cardiovascular Research Center, Department of Cardiology and Vascular Medicine, Faculty of Medicine, Universitas Brawijaya, Malang, Indonesia.
[2]Department of Cardiology and Vascular Medicine, Faculty of Medicine, Universitas Brawijaya, Malang, Indonesia.

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ABSTRACT

Background: Coronary artery calcification (CAC) is still challenging for interventional cardiologists. Their contribution to major adverse cardiac events occurs from the high risk of stent thrombosis or in-stent restenosis and target lesion revascularization. Optimal preparation, such as coronary plaque modification before stenting, is required to reduce the risk of periprocedural adverse events. This case presentation aimed to describe the appropriate management of heavy calcified coronary lesions.
Case Presentation: Two cases of heavy calcified coronary lesions with different baselines as Acute Coronary Syndromes (ACS) and elective PCI were presented. In our ACS patients, the Primary PCI was done by coronary angioplasty without stenting because of the complexity of the heavily calcified lesion. A referral to tertiary health care was made for further PCI procedures using a combination of calcium-ablation and balloon-based techniques. A treatable complication occurred after the orbital atherectomy was performed with good results. The second case was an elective PCI patient with heavy calcified lesions findings from coronary angiography. The balloon-based technique was performed using non-compliant and scoring balloons without complication and showed good results.
Conclusion: The challenging points in managing heavy calcified coronary lesions are procedure complexity and the higher stent failure rate. Many modifying coronary calcification algorithms using advanced modalities have been proposed, which could be used to select the appropriate technique as experienced and increase the success rate.

1. Introduction

Coronary artery calcification (CAC) is still a challenging threat for interventional cardiologists in the Percutaneous Coronary Intervention (PCI) era, with heavily calcified lesions existing in up to 20% of all PCI cases.[1] Various advanced tools have been made to deal with these complex lesions. Coronary calcification modification before stenting is required to reduce the risk of peri and post-procedural adverse events such as stent thrombosis or in-stent restenosis and target lesion revascularization.[2] We present two cases of calcified coronary artery lesions with different bases and aim to discuss the appropriate management further.

2. Case Description

Case 1

A male, 49 years old, hypertensive, and a smoker, complained of sudden typical chest pain with a VAS of 9/10 when he was working. The diagnosis of anterior extensive STEMI was stated at the hospital at 3.5 hours of onset, and conservative management was preferred, refusing the Primary PCI (PPCI) procedure. PPCI was approved on the fourth day because of the unimproving condition. Angiography results showed CAD 2VD with acute total occlusion in the mid-left Anterior Descending (LAD) coronary artery as the culprit. Cineangiography evaluation revealed distal coronary flow with a heavily calcified lesion at mid-LAD after crossing the wire. Predilatation using a scoring balloon was done several times and showed minimal stenosis improvement due to the recoil. Drug-eluting stent (DES) tried to cross the calcified lesion but could not get through. Because of the maximum contrast and hemodynamic instability, the procedure ended with TIMI flow 2-3 and 50% residual stenosis.

The patient was then referred on the fifth day of care to our hospital and planned for staging PCI using an atherectomy device the day after. The angiography evaluation still showed TIMI flow three at the culprit artery (LAD) with 80% heavy calcified stenosis at mid-LAD and Diagonal 2 (D2) branches. The procedure initiated by dilatation of the non-compliance (NC) balloon continued with Orbital atherectomy (OA) at mid-LAD, which was performed twice until the lesion could be crossed. Slow flow occurred, and TIMI flow 3 was relieved after intracoronary injection of nitrate and heparin were administered. Scoring balloon dilatation followed by the implantation of DES to proximal-distal of LAD was then performed. The procedure was successfully done with the good results without any untreatable complications. (Illustration of PPCI and staging PCI process showed in Fig.1)

* Corresponding author at: Brawijaya Cardiovascular Research Center, Department of Cardiology and Vascular Medicine, Faculty of Medicine, Universitas Brawijaya, Malang, Indonesia.
E-mail address: fahrezacaesario@gmail.com (F. Caesario).

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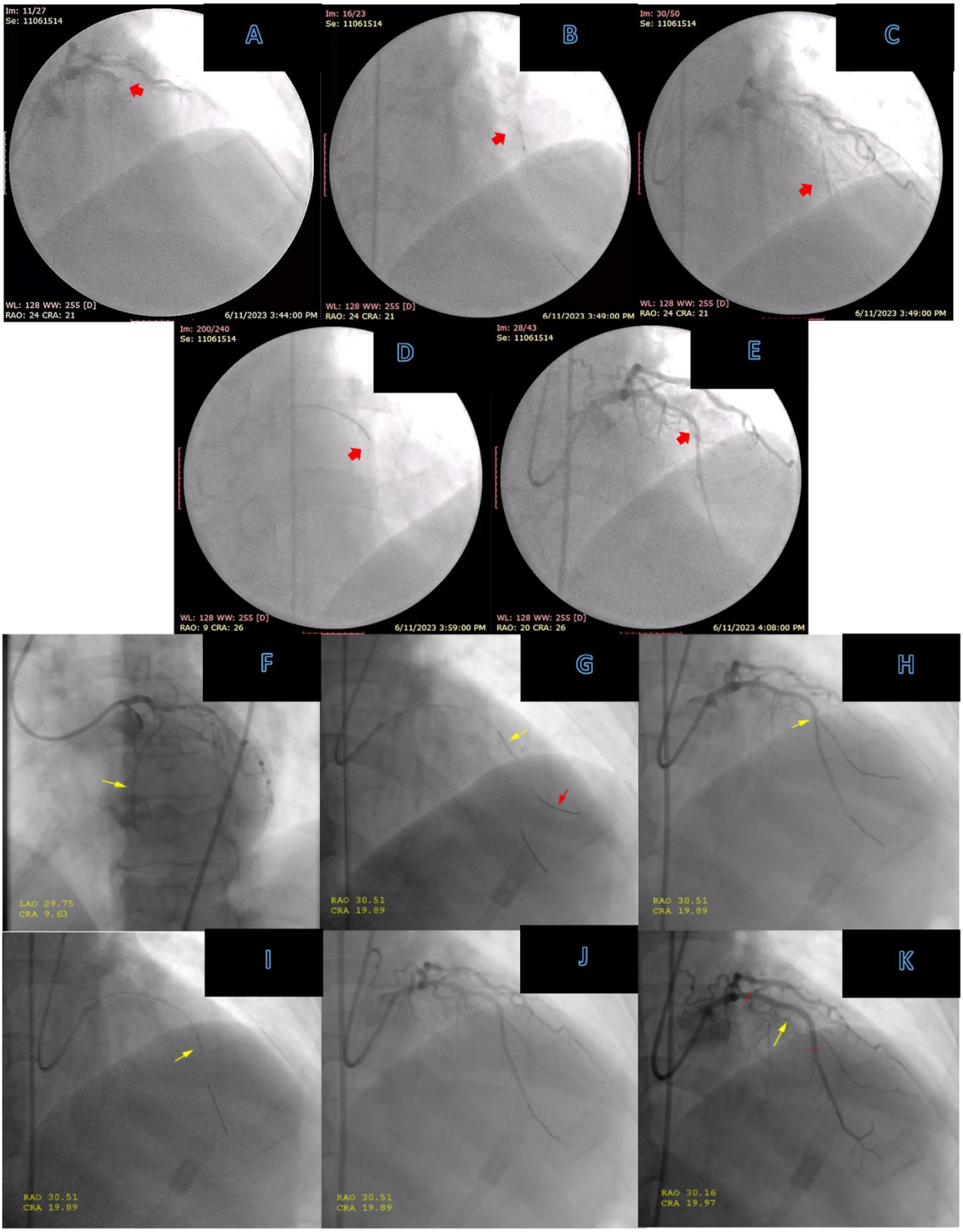

Figure 1. Case 1. (A) Acute total occlusion at mid-LAD (right after septal branch), (B) Guidewire crossed using small size balloon support with the visualization of the heavily calcified lesion at mid-LAD, (C) Cineangiography evaluation showed TIMI 2 flow, (D) DES could not cross the tight lesion, (E) Cineangiography showed recoil lesion at the heavy calcified part; (F) Staged PCI in referral hospital: Angiography showed distal LAD flow remain; (G) Floppy guidewire inserted to D2 (Red arrow), NC balloon went through LAD-D2 (Yellow arrow) and inflated several times; (H) LAD-D2 lesion improved; (I) OAS could cross the lesion at second attempt; (J) Cineangiography evaluation showed improvement of the stenosis; (K) Final evaluation after DES implantation. *(Red and yellow arrow show detailed procedure).

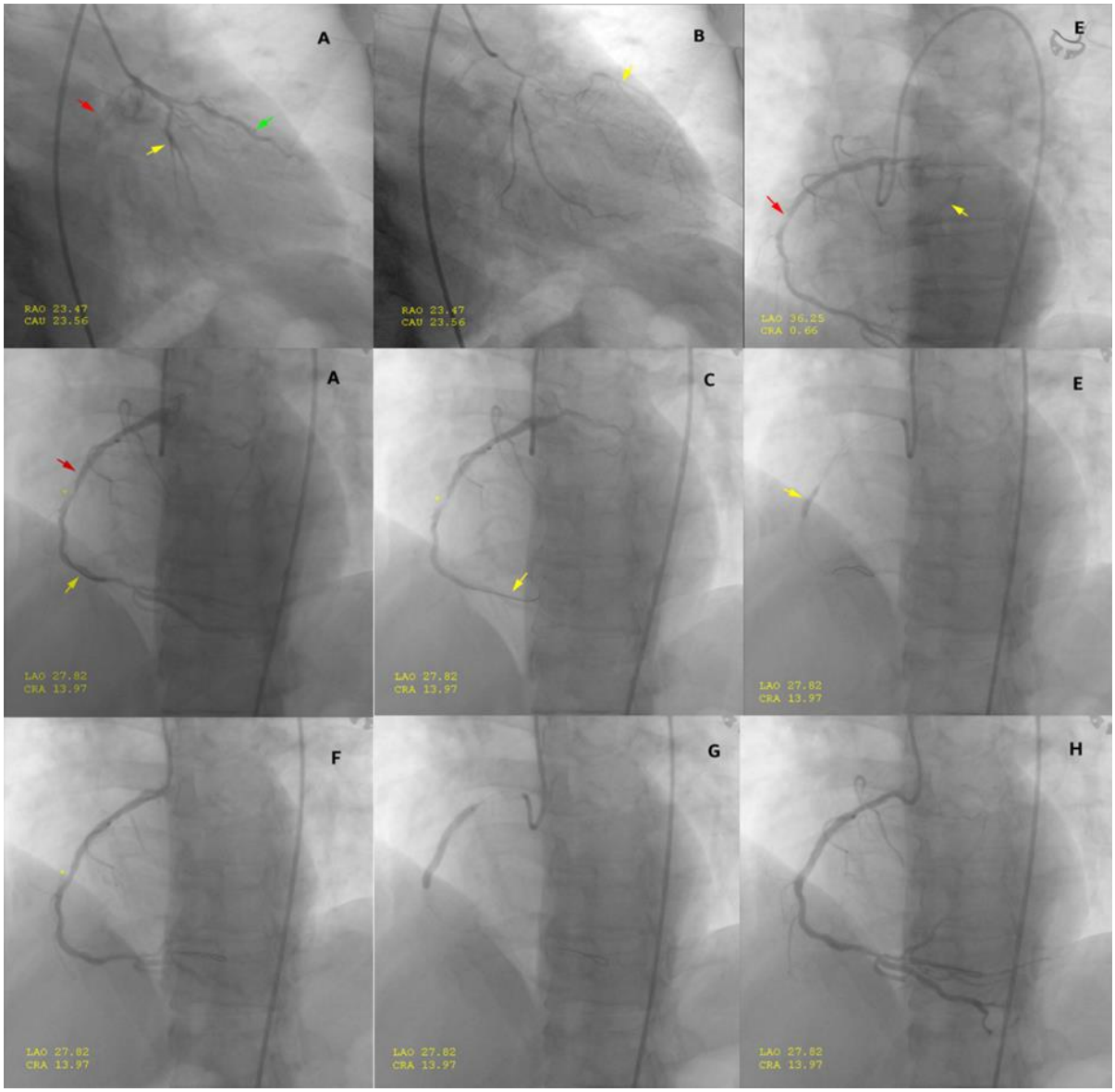

Figure 2. Case 2. (A) Angiography RAO-CAU projection in the first cardiac cycle showed the absence of LAD, the D1 branch was prominent (Green arrow), and non-significant stenosis at LCx (Yellow arrow), with visualization of RCA vessel by the diffuse and heavy coronary calcification (Red arrow); (B) LAD visualized in the third cardiac cycle from the collaterals, defining CTO lesion at proximal LAD; (C) Succesful engagement to osteal RCA using GC AL 0.75 6F, angiography evaluation showed diffuse heavy calcified lesion from proximal-distal RCA with maximum stenosis 90-95% at mid-RCA (Red arrow) and the sinus node branch giving collateral to LAD (Yellow Arrow); Process of PCI : (D) Floppy wire could not reach the distal part of RCA because of entrapment in the tight lesion, Balloon 1.0x10mm inserted for releasing the entrapment; (E) The heavily calcified lesion did not significantly improve but wire entrapment resolved.

Case 2

57-year-old male smoker referred to our hospital for undergoing planned DCA AdHoc procedure because of persisting stable angina despite routine medication with a positive treadmill stress test. Diagnostic angiography at the left coronary artery was performed and showed chronic total occlusion (CTO) at proximal LAD with non-significant stenosis at the Obtuse Marginal (OM) branch. Angiography of the right coronary artery (RCA) was done using an amplatz left (AL) catheter because of the posterosuperior position of the osteal part. It showed diffuse heavy calcified lesions from the proximal to the distal with critical stenosis in mid-RCA.

The procedure continued with PCI at the RCA as the target lesion. A small-sized compliance balloon dilated several times at mid-RCA showed no stenosis improvement and got ruptured. The scoring balloon could not cross the lesion, so the operator switched to a shorter NC balloon and succeeded in crossing the lesion with minimal stenosis improvement after several dilatations. The previous scoring balloon could then be used across mid-RCA stenosis and inflated until the stenosis improved without recoil. The procedure continued with DES implantation at proximal-mid RCA with final results TIMI flow 3 with no residual stenosis. The procedure was ended without any complications. (Illustration of DCA and PCI process showed in Fig.2).

3. Discussion

Heavy calcified coronary lesion impedes device delivery and limits stent expansion, the most crucial predictor of stent failure.[3] This lesion could be found in the stable angina patients and in ACS patients like our first case, as reported frequently on a pooled analysis of the ACS trials (HORIZONS-AMI and ACUITY trials).[4]

In the first case, we faced a STEMI with heavily calcified lesions as the culprit that were uncrossable by stent during PPCI. We decided to perform balloon angioplasty only to regain the coronary flow. It was stated in the guidelines that PPCI of the infarct-related is indicated, and stenting is recommended over balloon angioplasty.[5] In order to get a better outcome and reduce the risk of stent failure, the referral was made to the more capable hospital. A similar case was also reported as staged-PCI using rotational atherectomy in STEMI patients six days after PPCI at the complex PCI-capable hospital in order to ensure a safe and effective angioplasty of heavy calcified coronary lesion.[6] In contrast, early stenting in PPCI with moderate-to-

Table 1. Comparison of the coronary lesions of both cases.

	1st Case	2nd Case
Calcification Severity (ICA analysis)	Heavy Calcification	Heavy Calcification
Lesion Classification (ACC/AHA Classification)	Type C lesion (Diffuse Lesion, Heavy Calcified)	Type C lesion (Diffuse lesion, Heavy Calcified)
Wire Crossability	Yes	Yes
Small Balloon Crossability	Yes	Yes
Recoil Lesion	Yes	No

severe coronary calcification using atherectomy devices either as a planned or bail-out strategy had been reported with successful periprocedural outcomes.[7]

Based on EAPCI in 2023, the preparation and structured management strategies for heavily calcified coronary stenoses were started from imaging assessment appropriate tool selection based on the encountered lesions that could be uncrossable/undilatable and superficial/deep calcium lesions.[8] Invasive coronary imaging (Invasive coronary angiography and intra-coronary imaging) was needed mainly to identify the calcification, characterize it, and give detailed guidance for the techniques preparation.[9] Our cases use invasive coronary angiography (ICA) as the imaging modality to identify the heavily calcified lesion. Angiograms showed straight X-ray attenuation along coronary arteries as coronary calcification, which was classified as mild/no, moderate, or severe/heavy. The coronary calcification in our cases was classified as heavily calcified lesions based on the severe calcification criteria of radiopacity on both sides of the artery lumen in the absence of cardiac motion.[10]

The next important step for coronary calcification modification is selecting appropriate tools and devices. Many algorithms have been proposed to guide the operators in managing heavily calcified lesions.[11] The first step of both of our heavy calcified lesions modification was using compliance or non-compliance balloon dilatation, just like most preparation strategies if the lesion was crossable.[12]

In our first case, the first pre-dilatation showed a sub-optimal result due to the recoil of the lesion, and the calcium ablation techniques were continued using orbital atherectomy (OA). The decision to use OA or rotational atherectomy (RA) was made by considering the structure of the calcified lesion and the operator's familiarity with both modalities.[13] Orbital atherectomy is best suited for discrete large vessel stenosis, eccentric lesions, or thick calcium cap lesions, as shown in our first case.[14] Common complications of the calcium-ablation techniques using OA as a slow-flow phenomenon were red in our first case and entirely resolved after administering intracoronary nitrates and heparin. The risk of slow-flow/no-reflow was negligible in OA because the residues produced are smaller and do not alter coronary flow during its application.[15]

The balloon-based technique was only chosen in our second case because the heavily calcified lesion improved after balloon dilatation without a recoil lesion. Non-compliance balloon (NC) sized up to 1:1 diameter with the vessel was the common primary step for coronary calcification modification. If this is not achievable due to residual waste, the ultrahigh-pressure balloon (OPN-NC) or modifying balloons such as a cutting balloon (CB) and scoring balloon (SB) could be the next choice for calcified lesion modifications.[12] These balloons create small, discrete incisions within lesions, which may allow for better lesion expansion and decreased elastic recoil.[16]

A comparison analysis of the lesion characteristics of both cases was made in e 1 to help us decide on the precise technique. Although many similarities occurred in both cases, our first heavy calcification case had a recoil lesion even though a scoring balloon had predicted it. That was the reason why the calcification ablative techniques were chosen. Through the different PCI techniques used for managing both heavily calcified lesions, the final result of both our patients was good with TIMI 3 flow and no residual stenosis.

4. Conclusions

Procedure complexity and the higher rate of stent failure are the challenges in managing a heavy calcified coronary lesion. Many coronary calcification algorithms using advanced modalities and techniques have been developed, and they could be used to select the appropriate technique as experienced, increasing the success rate.

5. Declaration

5.1 Ethics Approval and Consent to participate
Patient has provided written informed consent prior to involvement in the study.

5.2. Consent for publication
Not applicable.

5.3 Availibility of data and materials
Data used in our study were presented in the main text.

5.4 Competing interests
Not applicable.

5.5 Funding Source
Not applicable.

5.6 Authors contributions
Idea/concept: FC, MSR. Design: FC. Control/supervision: MSR. Data collection/processing: FC, MSR. Analysis/interpretation: FC, MSR. Literature review: FC. Writing the article: FC. Critical review: MSR. All authors have critically reviewed and approved the final draft and are possible for the content and similarity index of the manuscript.

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