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Long-term Clinical Outcomes of Coronary Rotational Atherectomy for Specific Indications

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Abstract

Objective: This study aimed to compare the long-term outcomes between specific indications and on-label use of rotational atherectomy (RA) for severely calcified coronary lesions. **Methods:** Data of patients treated for RA from 2015 to 2020 in a single-center registry were analyzed. The specific indication group included patients with ostial lesions, unprotected left main coronary artery stenosis, chronic total occlusions, stent ablation, angulated lesions, and cardiac dysfunction, whereas patients who had none of the above-mentioned characteristics were included in the on-label group. The primary endpoint between groups were compared. **Results:** 176 patients in the on-label group and 125 patients in the specific indication group were included. Clinical characteristics were comparable between groups. The incidence of complications during the procedure was higher in the specific indication group than in the on-label group (20.0% vs. 10.8%, *P*=0.018). There was no significant difference in in-hospital MACCE between groups (12.5% vs 9.7%, *P*=0.392). During 35 (10-57) months of follow-up, MACCE occurred in 46 patients (15.3%). The incidence of MACCE was much higher in the specific indication group than in the on-label group (25.6% vs 13.6%, *P*=0.034). **Conclusions:** RA for specific indications had a higher incidence of complications during the procedure and poor long-term clinical

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outcomes.

1 Introduction

Approximately 1/3 of patients have moderate to severe calcified coronary lesions on coronary angiography. One study which included 6,855 patients showed that the incidence of moderate and severe coronary calcification was 32%, of which 5.9% included severe calcification (1,3). Coronary calcification significantly increases the difficulty of coronary intervention and leads to a poor prognosis. Coronary rotational atherectomy (RA) is the most effective method for treating severely calcified lesions. There are several specific indications for coronary RA, such as ostial lesions, unprotected left main coronary artery stenosis, chronic total occlusions, stent ablation, and angulated lesions (>45°) (4,5). The frequency of coronary RA for specific indications is greater than that of on-label RA use in clinical practice. A previous study reported that the incidence of in-hospital complications was significantly greater in patients with specific indications than in patients with on-label RA use (6). However, the long-term clinical outcomes of RA for specific indications remain unknown. The purpose of the present study was to compare the long-term clinical outcomes of RA use for specific indications and on-label RA use.

2 Methods

2.1 Study design and population

This single-center cohort study included all patients who received RA before stenting because of severe coronary calcification from July 2015 to December 2020 at Peking University People's Hospital. Specific indications for coronary RA were defined as ostial lesions (right coronary or left main coronary artery), unprotected left main artery stenosis, chronic total occlusion, stent ablation, angulated lesions (>45°), and cardiac dysfunction (left ventricular ejection fraction <40%). Patients who had ⩾1 of the above characteristics were included in the specific indication group, whereas patients who had none of the above characteristics were included in the on-label group. The main exclusion criteria were cardiogenic shock, saphenous vein graft

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lesion, severe coronary dissection, angulated lesions (>90°), last remaining vessel, and acute ST-segment elevation myocardial infarction (STEMI).

2.2 Follow-up and endpoint

Clinical follow-up was obtained either through clinic visits or structured telephone interviews with the patient every six months. The demographic and clinical characteristics of all patients were obtained from an electronic record system.

The primary endpoint was the incidence of major adverse cardiovascular and cerebral events (MACCE), defined as the composite endpoint of all-cause death, ischemia-driven target vessel target vessel revascularization (TVR), non-fatal myocardial infarction (MI), in-stent thrombus, and stroke.

This study was approved by the ethics committee of the Peking University People's Hospital, and written informed consent was obtained from all patients before participation.

2.3 Definition of indices

Left main coronary disease was defined as stenosis >50% of the left main coronary artery. Multivessel disease was defined as significant stenosis (>70%) in two or more major coronary arteries (left descending, left circumflex, and right coronary artery). Bailout RA was defined as RA after failure of balloon dilatation or stent delivery. Planned RA was defined as RA employed up-front as an elective strategy, without previous device failure. PCI-related MI was defined according to the third universal definition of MI (7).

2.4 RA details

Before the procedure, all patients received an oral loading dose of 300 mg of aspirin and 600 mg of clopidogrel. During the procedure, all patients received unfractionated heparin at a dose of 70–100 U/kg or bivalirudin, a direct thrombin inhibitor, to maintain an activated clotting time (ACT) >300 s. The choice of vascular access and burr size was left at the operator's discretion. RA was performed using a rotablator (Scimed, Boston Scientific, Maple Grove, MN, USA). The burr size was selected to reach a burr/vessel ratio of 0.5–0.6. RA speed ranged between 140,000 and 180,000

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rpm and ablation time was 15–20 s. During RA, a continuous intracoronary infusion of unfractionated heparin and nitroglycerin was given.

2.5 Statistical analysis

Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS) for Windows 18.0 (SPSS, Chicago, IL). Continuous variables were expressed as mean ± standard deviation (SD), and categorical variables were presented as frequencies (%). Univariate comparisons between the two groups were performed using Pearson's chi-squared test for categorical variables and Student's t-test for continuous variables. The Kaplan–Meier method was used to analyze the cumulative incidence of clinical events during follow-up. Differences were considered statistically significant at $P < 0.05$.

3 Results

3.1 Patients baseline characteristics

A total of 301 patients were included in this study between July 2015 and December 2020. Patient baseline characteristics are shown in Table 1. RA was performed for on-label indications in 176 patients in the on-label group. In the remaining 125 patients in the specific indication group, RA was performed for specific indications. Angulated lesions (>45°) were the most common specific indications, followed by cardiac dysfunction (Table 2). The clinical characteristics were comparable between the two groups, and most patients had multivessel disease. The proportion of femoral access, total stent length, procedural time, and fluoroscopy volume were higher in the specific indication group than in the on-label group due to the complexity of the lesions in the former.

3.2 Procedural complications

The incidence of complications was higher in the specific indication group than that in the on-label group (10.8% vs. 20.0%, $P = 0.018$). The most common complication was coronary dissection (at least type C), followed by slow or no reflow (Table 3). One patient in the specific indication group underwent an emergency coronary artery bypass graft (CABG) due to coronary perforation and tamponade.

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3.3 In-hospital outcomes

In-hospital MACCE (consisting of all-cause death, PCI-related MI, ischemia-driven TVR, in-stent thrombus, and stroke) was slightly higher in the specific indication group than that in the on-label group, but the difference was not statistically significant. The most common MACCE during hospitalization was PCI-related MI (Table 4).

3.4 Long-term outcomes

The median follow-up duration of the 301 patients was 35 (10–57) months. During follow-up, MACCE occurred in 46 patients (15.3%) (Table 5). The incidence of MACCE was much higher in the specific indication group (25.6%) than in the on-label group (13.6%) (P = 0.034). The Kaplan–Meier curve for MACCE is shown in Figure 1.

4 Discussion

RA is the most effective treatment for severely calcified lesions. As the frequency of RA for specific indications is very common in clinical practice, it is difficult to avoid any specific indications (6). However, RA for specific indications, such as ostial lesions, unprotected left main coronary artery stenosis, chronic total occlusions, stent ablation, angulated lesions (>45 °), and cardiac dysfunction are known to be technically difficult, and their long-term outcomes are not well known (8-13). Our study showed that the incidence of complications during RA for specific indications was higher than that of RA for on-label use, and the long-term clinical outcomes of RA for specific indications were poor.

Diffuse long lesions (>25 mm) are very common in real-world clinical practice and require RA (14,15). The European expert consensus and Japan expert consensus document on RA both documented diffuse long lesions as a specific indication during RA (4,5). However, a previous study showed that treating coronary lesions ≥25 mm in length with RA did not affect short- and long-term outcomes, especially in patients with second-generation drug eluting stents (DES) (15). RA for diffuse long lesions (≥25 mm) would be as safe as on-label RA use. Therefore, the specific indication

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group did not include diffuse, long lesions in our study.

The most common specific indications were angulated lesions in our study, unlike in some previous research (16). The risk of complications, such as burr entrapment or coronary perforation, is greater in angulated lesions and should be taken into consideration (12). Some experts have reported the utility of halfway RA for angulated lesions (17).

Our study showed that in-hospital outcomes were comparable between the two groups, but the MACCE in specific indication group was higher than that in on-label group. The reason maybe due to the higher proportion of left main lesions, Chronic total occlusion and cardiac dysfunction in specific indication group. All of which had a poor long-time outcome.

Our study has several limitations. First, this was a single-center observational study, which induced selection bias. Second, the distribution of specific indications was heterogeneous, and the numbers of cases of ostial lesion, chronic total occlusion, stent ablation, and left main coronary artery lesions were small.

Our study showed that RA for specific indications was common in clinical practice; RA for specific indications had a higher incidence of complications and poor long-term clinical outcomes relative on-label RA use.

6 Conflict of interest

The authors declare that they have no conflict of interest.

7 Author Contributions

Cheng-fu CAO was the major contributor to the writing of the manuscript and is the corresponding author. Teng-wei and Qi analyzed and interpreted the patient data, and Yu-liang, Hong, Ming-yu, Jian, and Wei-min collected the patient data. All authors have read and approved the final manuscript.

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None.

10 Data Availability Statement

The datasets used in the current study are available from the corresponding author upon reasonable request.

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12 Figure Legends

Figure 1. Kaplan–Meier curves for MACCE

Kaplan–Meier curves for MACCE between specific indications and on-label groups.

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The P value was calculated using the log-rank test.

MACCE, major adverse cardiac and cerebral events; ST, stent thrombus; MI, myocardial infarction; TVR, target vessel revascularization

13 Tables

Table 1. Baseline Characteristics of the Study Population

	on-label group (n=176)	Specific indication group (n=125)	*P* value
Male (n, %)	104 (59.1)	87 (69.6)	0.062
Age (years)	70.0±8.7	68.3±9.1	0.102
BMI (kg/m^2)	25.1±3.3	25.1±2.9	0.980
systolic pressure (mmHg)	132.7±18.3	135.4±17.6	0.197
Heart rate (beat/minute)	67.6±9.3	68.9±10.9	0.254
Hypertension (n, %)	127 (72.2)	101 (90.8)	0.085
Diabetes mellitus (n, %)	89 (50.6)	73 (58.4)	0.180
Dyslipidemia (n, %)	65 (36.9)	48 (38.4)	0.796
Smoking (n, %)	77 (43.8)	65 (52.0)	0.159
CKD (⩾stage 2) (n, %)	19 (10.8)	18 (14.4)	0.350
Prior PCI (n, %)	37 (21.0)	35 (28.0)	0.163
Prior CABG (n, %)	6 (3.4)	3 (2.4)	0.614
Clinical presentation			0.741
SCAD (n, %)	41 (23.3)	36 (28.8)	
ACS (n, %)	135 (76.7)	89 (71.2)	
LVEF（%）	66.4±8.1	62.5±10.7	0.001
LVEF＜40%（n,%）	0	19（15.2）	＜0.001
Left main disease (n, %)	34 (19.3)	36 (28.8)	0.055
Multivessel disease (n, %)	161 (91.5)	121 (96.8)	0.541
Aspirin (n, %)	174 (98.9)	125 (100)	0.816
P_2Y_{12} inhibitor (n, %)	175 (100)	122 (97.6)	0.425

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Statins (n, %)	171 (97.7)	120 (96.0)	0.621
β blocker (n, %)	130 (74.3)	98 (78.4)	0.344
Vessel access (n, %)			0.012
Radial	142 (81.1)	85 (68.0)	
Femoral	34 (18.9)	40 (32.0)	
Target vessel (n, %)			0.115
LM	0	12 (9.6)	
LAD	129 (73.3)	85 (68.0)	
LCX	12 (6.8)	7 (5.6)	
RCA	35 (19.9)	20 (16.0)	
ECMO/IABP	1 (0.6)	5 (4.0)	0.134
Burr/artery ratio	0.53±0.06	0.53±0.05	0.759
Final burr size(mm) (n, %)			0.223
1.25	60 (34.1)	56 (44.8)	
1.5	105 (59.7)	58 (46.4)	
1.75	10 (5.7)	11 (8.8)	
2.0	1 (0.6)	0	
More than 1 burr (n, %)	15 (8.5)	7 (5.6)	0.339
RA time (n, %)			0.078
Planned RA	137 (77.8)	86 (68.8)	
Bailout RA	39 (22.2)	39 (31.2)	
Cutting/scoring balloon (n, %)	12 (6.8)	9 (7.2)	0.667
IVUS/OCT-guided (n, %)	57 (32.4)	38 (30.4)	0.372
Total stent length (mm)	57.8±21.6	64.9±22.7	0.007
Average stent diameter (mm)	3.0±1.5	3.1±1.8	0.852
Procedural time (min)	86.4±32.3	95.5±35.4	0.022
Contrast volume (ml)	254.9±90.0	275.0±89.4	0.056
Fluoroscopy volume (mGy)	1279.4±906.2	1627.7±1227.6	0.006
Procedural success (n, %)	174(98.9%)	120（96.0%）	0.105

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BMI: body mass index, CKD: chronic kidney disease, PCI: percutaneous coronary intervention, CABG: coronary artery bypass graft, SCAD: stable coronary artery disease, ACS: acute coronary syndrome, LM: left main, LAD: left descending artery, LCX: left circumflex artery, RCA: right coronary artery, ECMO: Extracorporeal Membrane Oxygenation, IABP: intra-aortic balloon pump, RA: rotational atherectomy, IVUS: intravascular ultrasound, OCT: optical coherence tomography

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Table 2. Lesion Distribution in the Specific Indication Group

Specific Indications	N (%)
Ostial lesion	6 (4.8)
Chronic total occlusion	9 (7.2)
Stent ablation	5 (4)
Left main disease	3 (2.4)
Angulated lesion (>45°)	91 (72.8)
Cardiac dysfunction （LVEF<40%）	19 (15.2)

LVEF: left ventricular ejection fraction

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Table 3. Comparison of complications Between the Two Groups

	On-label group (n=176)	Specific indication group (n=125)	*P* value
Total Complications (n, %)	19 (10.8)	25 (20.0)	0.018
Bradycardia (n)	2	5	0.819
Coronary dissection (at least type C)(n)	8	10	0.006
Slow/no reflow (n)	6	6	0.545
Coronary perforation (n)	1	2	0.376
Tamponade (n)	1	1	0.808
Burr entrapment (n)	0	1	0.236
Rota-wire fracture (n)	1	0	0.400

CABG: coronary artery bypass graft

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Table 4. Comparison of in-hospital Outcomes Between the Two Groups

	On-label group (n=176)	Specific indication group (n=125)	*P* value
MACCE (n, %)	17 (9.7)	16 (12.5)	0.392
Death (n)	2	1	0.773
PCI related MI (n)	13	12	0.494
TVR (n)	1	2	0.376
In-stent thrombus (n)	1	0	0.400
stroke (n)	0	1	0.236

MACCE: major adverse cardiovascular and cerebral events, PCI: percutaneous coronary intervention, MI: myocardial infarction, TVR: target vessel revascularization.

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Table 5. Comparison of long-term outcomes Between Two Groups

	On-label group (n=176)	Specific indication group (n=125)	*P* value
MACCE	24 (13.6)	32 (25.6)	0.034
Death	11	18	0.018
Non-fatal MI	2	3	0.394
TVR	8	4	0.558
Stent thrombus	1	4	0.079
stroke (n)	2	3	0.400

MACCE: major adverse cardiovascular and cerebral events, MI: myocardial infarction, TVR: target vessel revascularization.