Determinants of Periprocedural Myocardial Infarction in Current Elective Percutaneous Coronary Interventions

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Summary

Periprocedural myocardial infarction (PMI) is closely associated with long-term cardiovascular events. The factors associated with PMI are not fully understood. The purpose of this study was to investigate the determinants of PMI in contemporary elective percutaneous coronary intervention (PCI). Overall, 731 elective PCI was divided into the PMI ($n = 27$) and non-PMI ($n = 704$) groups. Univariate and multivariate logistic regression analysis was used to find factors associated with PMI. In the univariate analysis, PMI was associated with complex lesion characteristics, such as the lesion length, lesion angle, calcification, and Medina classification. In the multivariate logistic regression analysis, the lesion length (per 10-mm increase: odds ratio (OR), 1.477; 95% confidence interval (CI), 1.161–1.879; $P = 0.002$), lesion angle $\geq 45^\circ$ (versus lesion angle $< 45^\circ$: OR, 4.244; 95% CI, 1.187–15.171; $P = 0.026$), and Medina classification (0,1,1)/(1,1,1) (versus other lesions: OR, 14.843; 95% CI, 6.235–35.334; $P < 0.001$) were significantly associated with PMI. Of the 24 lesions with lesion angle $\geq 45^\circ$ in the PMI group, 14 had final TIMI flow grade ≤ 2 in side branches and 9 had transient slow flow in main branches/transient ST elevation during PCI. Of the 87 lesions with Medina classification (1,1,1)/(0,1,1), 19 had final TIMI grade ≤ 2 in side branches. In conclusion, the lesion length, lesion angle $\geq 45^\circ$, and Medina classification (0,1,1)/(1,1,1) were significantly associated with PMI in contemporary elective PCI. Preventing flow limitation in both side branches and main vessels in elective PCI for the diffuse long, angulated, or true bifurcation lesions is important.

(Int Heart J 2020; 61: 1121–1128)

Key words: Bifurcation, Complications, Medina classification

Percutaneous coronary intervention (PCI) plays an important role for the treatment of ischemic heart diseases.^{1,2)} The development of devices such as balloons, microcatheters, and stents has improved the quality of PCI and decreased the incidence of complications, especially in elective PCI.^{1,3–5)} However, complications such as periprocedural myocardial infarction (PMI) still exist.^{6,7)} Although the incidence of PMI widely varied among 2%–30%, which depended on the definitions of PMI, PMI was associated with future cardiovascular events, including cardiac death.^{7–11)} Earlier studies reported the relationship between PMI and clinical factors such as lesion/stent length, bifurcation lesions, SYNTAX score, and left main disease.^{7,9,12,13)} However, the factors associated with PMI in contemporary elective PCI were not fully understood. Therefore, the aim of this study was to investigate the determinants of PMI in contemporary elective PCI.

Methods

Study lesions: This was a retrospective, single-center study. We reviewed all PCI cases in the Saitama Medical Center, Jichi Medical University, from January 2018 to March 2019. The inclusion criterion was elective PCI cases performed during the study period. Elective PCI cases included the culprit lesions of acute myocardial infarction as long as the revascularization was performed as elective PCI. The exclusion criteria were (1) cases that did not have either CK or CK-MB values at the next day of PCI, (2) cases in which ≥ 2 vessel were treated simultaneously, and (3) saphenous vein graft lesions. In patients whose baseline CK levels were normal, PMI was defined as an elevation of CK levels of ≥ 2 times of the upper limit of normal (ULN) with an elevation of CK-MB levels above the ULN at the next day of PCI.^{6,14–16)} If baseline CK levels were already elevated, PMI was defined as further increase of CK levels at the next day of PCI than CK level at baseline.¹⁶⁾ We divided the study cases into a PMI and non-PMI groups according to the incidence of PMI.

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Received for publication March 24, 2020. Revised and accepted July 9, 2020.

Released in advance online on J-STAGE November 13, 2020.

doi: 10.1536/ihj.20-215

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Bifurcation lesions were divided into seven categories according to the Medina classification system.¹⁷⁾ In this system, we recorded any narrowing of $\geq 50\%$ in angiography in each of the three arterial segments of the bifurcation in the following order: proximal main vessel, distal main branch, and side branch: 1 indicates the presence of a significant stenosis and 0 indicates the absence of stenosis.¹⁷⁾ This study was approved by the Institutional Review Board of Saitama Medical Center, Jichi Medical University, and written informed consent was waived because of the retrospective study design.

PCI procedures: PCI procedures were performed on a biplane fluoroscopy system. The choice of PCI devices, such as guidewire, balloon, rotational atherectomy, and stent, was left at the discretion of interventional cardiologists at our cardiology center. IVUS was routinely used for almost all lesions. In bifurcation lesions, we usually insert a conventional guidewire to a side branch before stenting to the main vessel and occasionally perform jailed balloon technique/jailed corsair technique. We conducted a single stent technique and seldom selected two-stent technique, especially in elective PCI. Rotational atherectomy was performed to moderate or severely calcified lesions, diffuse lesions expected to be difficult to stent, and ostial lesions.¹⁸⁾ Our university hospital had many operators, including residents with different background. However, each PCI was strictly supervised by staff operators. Staff operators did not hesitate to take over procedures, when residents felt any difficulties in procedures. Activated coagulation time was maintained over 250 seconds during procedures.

Definition: The overweight was defined as BMI ≥ 25 kg/m².¹⁹⁾ Hypertension was defined as medical treatment for hypertension and/or a history of hypertension before admission.²⁰⁾ Dyslipidemia was defined as a total cholesterol level ≥ 220 mg/dL or low-density lipoprotein cholesterol level ≥ 140 mg/dL or medical treatment for dyslipidemia or a history of dyslipidemia.²¹⁾ Diabetes mellitus was defined as a hemoglobin A1c level $\geq 6.5\%$ (as NGSP value) or medical treatment for diabetes mellitus or a history of diabetes mellitus.²¹⁾ Chronic renal failure was defined as a creatinine level ≥ 2.0 mg/dL.¹⁸⁾ We also calculated the estimated glomerular filtration rate (eGFR) from the serum creatinine level, age, weight, and gender using the following formula: eGFR = $194 \times \text{Cr} - 1.094 \times \text{age} - 0.287$ (male) and eGFR = $194 \times \text{Cr} - 1.094 \times \text{age} - 0.287 \times 0.739$ (female).²⁰⁾

Angiographic analysis: Quantitative coronary angiography parameters were measured using a cardiovascular angiography analysis system (QAngio XA 7.3, MEDIS Imaging Systems, Leiden, Netherlands). The lesion length and reference diameter were measured. The definition of types A, B1, B2, and C lesions has been previously described.²²⁾ Calcification was identified as readily apparent radiopacities within the vascular wall at the site of the stenosis and was classified as none/mild, moderate (radiopacities noted only during the cardiac cycle before contrast injection), and severe (radiopacities noted without cardiac motion before contrast injection generally compromising both sides of the arterial lumen).²³⁾

Statistical analysis: Data are presented as a percentage

for categorical variables and the mean $\pm$ standard deviation for continuous variables. The Wilk-Shapiro test was performed to determine if the continuous variables were normally distributed. Normally distributed continuous variables were compared between the two groups using Student's *t*-test. Otherwise, continuous variables were compared using Mann-Whitney *U* test. Categorical variables were compared using a Chi-square test. Univariate and multivariate logistic regression analyses were performed to investigate associations between the clinical variables and PMI. In this model, PMI was used as the dependent variable. In the multivariate logistic regression model, the selection of independent variable was derived from the results of univariate logistic regression analysis ($P < 0.05$ in univariate analysis). Then, the multivariate stepwise logistic regression analysis was applied with backward elimination (likelihood ratio). The odds ratio (OR) and the 95% confidence interval (CI) were calculated. A *P* value of < 0.05 was considered statistically significant. We analyzed all data using IBM SPSS statistics version 25 (Chicago, IL, USA).

Results

Overall, 759 elective PCI lesions were performed during the study period. Then, 28 PCI lesions were excluded. Our final study population was 731 patients, which was divided into the PMI ($n = 27$) and non-PMI ($n = 704$) groups. The study flowchart is shown as the Figure. The comparison of clinical characteristics is shown in Table I. The lesion length was significantly longer in the PMI group (30.6 ± 4.2 mm) than in the non-PMI group (18.8 ± 0.5 mm; $P < 0.001$). The reference diameter was significantly smaller in the PMI group (2.15 ± 0.14 mm) than in the non-PMI group (2.46 ± 0.05 mm; $P < 0.001$). Rotational atherectomy was more frequently performed in the PMI group (33.3%) than in the non-PMI group (11.9%; $P = 0.004$).

Of the 24 lesions with lesion angle $\geq 45^\circ$ in the PMI group, 14 had final TIMI flow grade ≤ 2 in side branches, 9 had transient slow flow in main branches/transient ST elevation during PCI, and 2 had transient side branch occlusion. Of the 44 lesions with Medina classification (1,1,1), 7 had final TIMI flow grade ≤ 2 in side branches, in which 4 resulted in PMI. Of the 43 lesions with Medina classification (0,1,1), 12 had final TIMI flow grade ≤ 2 in side branches, in which 9 had PMI.

The univariate logistic regression model to investigate the factors associated with PMI is summarized in Table II. Complex lesion characteristics, such as lesion length, lesion angle, calcification, ACC/AHA classification, Medina classification, guiding catheter size, the use of Rotablator, and total stent/DCB length, were associated with PMI. Furthermore, LM-LAD lesions, reference diameter, the use of IABP, and final TIMI flow grade of the side branch were also associated with PMI.

We performed a multivariate stepwise logistic regression analysis by backward selection (likelihood ratio) to find the factors associated with PMI (Table III). We included LM-LAD lesions, reference diameter, lesion length, lesion angle $\geq 45^\circ$, calcification, Medina classifica-

Figure. The study flowchart. PMI, periprocedural myocardial infarction.

tion, (0,1,1)/(1,1,1), and the use of Rotablator. The lesion length (per 10-mm increase: OR, 1.477; 95% CI, 1.161 – 1.879, $P = 0.002$), lesion angle $\geq 45^\circ$ (versus lesion angle $< 45^\circ$: OR, 4.244; 95% CI, 1.187 – 15.171, $P = 0.026$), and Medina classification (0,1,1)/(1,1,1) (versus other lesions: OR, 14.843; 95% CI, 6.235 – 35.334, $P < 0.001$) were significantly associated with PMI.

Discussion

This study aimed at finding the determinants of PMI in the contemporary elective PCI. We evaluated 731 lesions and found 27 lesions with PMI. The multivariate logistic regression analysis revealed that the lesion length, lesion angle $\geq 45^\circ$, and Medina classification (0,1,1)/(1,1,1) were significantly associated with PMI. Our results suggest the importance of sufficient preparation to prevent PMI in lesions with diffuse long, steep angle, and Medina classification (0,1,1)/(1,1,1) in elective PCI.

Early studies reported the association between lesion length and PMI,^{9,13} which is consistent to our results. A possible explanation for the association between lesion length and PMI is the disturbance of microvascular circulation.²⁴ A diffuse long lesion would have larger plaque volume than the short lesion, which would increase the chance of distal embolization.²⁵ Furthermore, the distal embolization can happen even when the coronary flow is maintained after stent deployment.^{26,27} Such silent embolization may result in PMI in diffuse long lesions.²⁷ Another possible explanation is side branch occlusion/injury.²⁴ As compared to short lesions, diffuse long lesions should have more side branches, which would have a greater risk of side branch occlusion after stenting.²⁸

In the 24 lesions with lesion angle $\geq 45^\circ$ in the PMI group, persistent or transient flow limitation in side branches or main vessels was found in 21 lesions, whereas 3 lesions had transient ST elevation without apparent flow limitation. Thus, flow limitation in side branches or main vessels would be a main reason for PMI in angulated lesions. Earlier studies reported the association between lesion angle and troponin I elevation after PCI, and the mechanism would be side branch occlusion

or distal embolism after stenting.^{29,30} Our results were consistent with these earlier studies. Performing side branch protection or recross the branch after stenting in angulated lesions might be difficult.

Our result showed that the Medina classification (1,1,1)/(0,1,1) was significantly associated with PMI. In contemporary elective PCI, few studies have investigated which bifurcation lesion type in the Medina classification is related to PMI. However, it is not surprising that there should be a greater risk of side branch occlusion in the Medina classification (1,1,1)/(0,1,1) than in the (1,0,1)/(0,0,1), because diseased side branch would have a greater risk of occlusion than non-diseased side branch. Chen, *et al.* reported the significant association between PMI and one-year mortality in coronary bifurcation lesions.¹² Therefore, for better patient outcomes, it would be important to prevent PMI following side branch occlusion in bifurcation lesions.

The clinical implications of the present study should be noted. In PCI for the diffuse long, angulated, or bifurcation lesions with Medina classification (0,1,1)/(1,1,1), preventing flow limitation in both side branches and main vessels is important. However, the strategy in preventing flow limitation would be different between side branches and main vessels. For side branches, we may consider aggressive side branch protection, such as jailed balloon techniques or jailed corsair techniques.^{31,32} Moreover, complex two-stent techniques may prevent in-hospital complications in true bifurcation lesions and at the same time increase stent thrombosis.³³ For main vessels, the option to prevent flow limitation is limited. The distal protection device would not be indicated in most elective PCI. Vasodilators, such as nitroprusside or nicorandil, might recover coronary flow^{34,35} but would not be indicated for the prevention of slow flow. Although the use of Rotablator was not associated with PMI in the multivariate stepwise analysis, it was associated with PMI in the univariate analysis. Since slow flow is relatively common complications following Rotablator,³⁶ preventing slow flow following Rotablator would be important. A novel strategy to prevent microvascular embolization is warranted.

Study limitations: First, this study was a single-center

Table 1. Comparison of Patients, Lesions, and Procedural Characteristics between the PMI and Non-PMI Groups

	All (n = 731)	PMI group (n = 27)	Non-PMI group (n = 704)	P value
Patient characteristics				
Age (years)	70.9 ± 10.2	72.1 ± 9.4	70.9 ± 10.2	0.651
Men, n (%)	577 (78.9)	19 (70.4)	558 (79.3)	0.266
Overweight (BMI ≥ 25 kg/m ²), n (%)	262 (35.8)	5 (18.5)	257 (36.5)	0.056
Hypertension, n (%)	662 (90.6)	25 (92.6)	637 (90.5)	0.552
Diabetes mellitus, n (%)	333 (45.6)	15 (55.6)	318 (45.2)	0.288
Hyperlipidemia, n (%)	628 (85.9)	23 (85.2)	605 (85.9)	0.543
Current smoker, n (%)	92 (12.6)	3 (11.1)	89 (12.6)	0.552
Chronic renal failure (creatinine > 2 mg/dL), n (%)	88 (12.0)	3 (11.1)	85 (12.1)	0.587
Estimated GFR (mL/minute/1.73 m ²)	59.2 ± 26.6	49.8 ± 4.2	59.5 ± 1.0	0.017
Chronic renal failure on hemodialysis, n (%)	76 (10.4)	2 (7.4)	74 (10.5)	0.454
Statin treatment, n (%)	577 (78.9)	22 (81.5)	555 (78.8)	0.741
Creatine kinase (U/L) at the next day of PCI	82.0 (57.0-127.0)	540.0 (384.0-873.0)	80.0 (57.0-119.8)	< 0.001
Creatine kinase-myocardial band (U/L) at the next day of PCI	3.0 (1.0-7.0)	62.0 (39.0-88.0)	3.0 (1.00-6.00)	< 0.001
Lesion characteristics				
Reason for PCI				0.044
PCI to the culprit of ST elevation myocardial infarction, n (%)	5 (0.7)	1 (3.7)	4 (0.6)	
PCI to the culprit of non-ST elevation myocardial infarction, n (%)	92 (12.6)	6 (22.2)	86 (12.2)	
PCI to the non-AMI lesions, n (%)	634 (86.7)	20 (74.1)	614 (87.2)	
Target lesion				0.050
Left main-left anterior descending artery, n (%)	347 (47.5)	18 (66.7)	329 (46.7)	
Left circumflex artery, n (%)	147 (20.1)	1 (3.7)	146 (20.7)	
Right coronary artery, n (%)	237 (32.4)	8 (29.6)	229 (32.5)	
PCI to in-stent restenosis, n (%)	67 (9.2)	3 (11.1)	64 (9.1)	0.457
PCI to chronic total occlusion, n (%)	54 (7.4)	3 (11.1)	51 (7.2)	0.442
Reference diameter (mm)	2.45 ± 1.27	2.15 ± 0.14	2.46 ± 0.05	0.026
Lesion length (mm)	19.3 ± 13.4	30.6 ± 3.0	18.8 ± 0.5	< 0.001
Lesion angle				< 0.001
Mild (< 45°)	351 (48.0)	3 (11.1)	348 (49.4)	
Moderate (45°-90°)	287 (39.3)	15 (55.6)	272 (38.6)	
Severe (> 90°)	93 (12.7)	9 (33.3)	84 (11.9)	
Calcification				0.019
None/mild, n (%)	437 (59.8)	10 (37.0)	427 (60.7)	
Moderate, n (%)	125 (17.1)	5 (18.5)	120 (17.0)	
Severe, n (%)	169 (23.1)	12 (44.4)	157 (22.3)	
ACC/AHA classification				0.001
Type A and B1	211 (28.9)	1 (3.7)	210 (29.8)	
Type B2	215 (29.4)	6 (22.2)	209 (29.7)	
Type C	305 (41.7)	20 (74.1)	285 (40.5)	
Bifurcation lesion (n = 294)				
Medina classification				< 0.001
1,0,0	26 (8.8) (n = 294)	0 (0) (n = 24)	26 (9.6) (n = 270)	
1,0,1	14 (4.8) (n = 294)	0 (0) (n = 24)	14 (5.2) (n = 270)	
1,1,0	87 (29.6) (n = 294)	5 (20.8) (n = 24)	82 (30.4) (n = 270)	
1,1,1	44 (15.0) (n = 294)	7 (29.2) (n = 24)	37 (13.7) (n = 270)	
0,1,0	61 (20.7) (n = 294)	2 (8.3) (n = 24)	59 (21.9) (n = 270)	
0,1,1	43 (14.6) (n = 294)	10 (41.7) (n = 24)	33 (12.2) (n = 270)	
0,0,1	19 (6.5) (n = 294)	0 (0) (n = 24)	19 (7.0) (n = 270)	
Procedural characteristics				
Successful PCI	726 (99.3)	26 (96.3)	700 (99.4)	0.172
Guiding catheter size and system				< 0.001
5Fr, n (%)	1 (0.1)	0 (0)	1 (0.1)	
6Fr, n (%)	344 (47.1)	3 (11.1)	341 (48.4)	
7Fr, n (%)	340 (46.5)	21 (77.8)	319 (45.3)	
8Fr, n (%)	46 (6.3)	3 (11.1)	43 (6.1)	
Intra-aortic balloon pump support, n (%)	7 (1.0)	2 (7.4)	5 (0.7)	0.025
Use of Rotablator, n (%)	93 (12.7)	9 (33.3)	84 (11.9)	0.004

Table I. Comparison of Patients, Lesions, and Procedural Characteristics between the PMI and Non-PMI Groups (continued)

	All (n = 731)	PMI group (n = 27)	Non-PMI group (n = 704)	P value
Use of Diamondback 360, n (%)	18 (2.5)	1 (3.7)	17 (2.4)	0.496
Use of scoring balloon or cutting balloon, n (%)	204 (27.9)	4 (14.8)	200 (28.4)	0.121
Side branch protection				0.163
Jailed wire, n (%)	168 (23.0)	10 (37.0)	158 (22.4)	
Jailed corsair, n (%)	32 (4.4)	2 (7.4)	30 (4.3)	
Jailed balloon, n (%)	2 (0.3)	0 (0)	2 (0.3)	
Total stent and DCB length	30.910 ± 17.529 (n = 713)	48.230 ± 27.253 (n = 26)	30.260 ± 16.735 (n = 687)	< 0.001
Kissing balloon technique, n (%)	9 (1.2)	0 (0)	9 (1.3)	0.711
Final TIMI grade of the main vessel				0.232
TIMI 3, n (%)	724 (99.0)	26 (96.3)	698 (99.1)	
TIMI ≤ 2, n (%)	7 (1.0)	1 (3.7)	6 (0.90)	
Final TIMI grade of the side branch (n = 294)				< 0.001
TIMI 3, n (%)	263 (89.5) (n = 294)	8 (33.3) (n = 24)	255 (94.4) (n = 270)	
TIMI ≤ 2, n (%)	31 (10.5) (n = 294)	16 (66.7) (n = 24)	15 (5.6) (n = 270)	
Final PCI procedure				0.496
DES, n (%)	596 (81.5)	22 (81.5)	574 (81.5)	
DCB, n (%)	95 (13.0)	4 (14.8)	91 (12.9)	
DES + DCB, n (%)	13 (1.8)	0 (0)	13 (1.8)	
BMS, n (%)	8 (1.1)	0 (0)	8 (1.1)	
POBA, n (%)	14 (1.9)	0 (0)	14 (2.0)	
Other, n (%)	5 (0.7)	1 (3.7)	4 (0.6)	

BMI indicates body mass index; GFR, glomerular filtration rate; PCI, percutaneous coronary intervention; AMI, acute myocardial infarction; DCB, drug-coated balloon; TIMI, thrombolysis in myocardial infarction; DES, drug-eluting stent; BMS, bare-metal stent; and POBA, plain old balloon angioplasty.

retrospective observational study, and there is a risk of patient and group selection bias. Our university hospital had many PCI operators during the period, which would yield an operator bias. Moreover, the frequency of Rotablator usage was greater in our catheter laboratory than in the Japanese national PCI registry,³⁷⁾ which could be an institutional bias. Second, since the strategy for bifurcation lesions depended on each PCI operator, there is also a selection bias in bifurcation procedures. Third, because the number of PMI was only 27, the direct comparison of parameters between the two groups (Table I) may not be statistically appropriate. Furthermore, the number of dependent variables in the multivariate logistic regression analysis was limited after the stepwise logistic regression model with backward elimination. Fourth, our study population was not a patient-level database, but a PCI-level database. If a patient separately received two PCIs during the study period, both PCIs were separately included. If a patient simultaneously received two PCIs, both PCIs were excluded because of the study exclusion criteria. Therefore, we could not exclude the effect of the clustered nature of one or more individual measurements from one patient. Fifth, we did not include the SYNTAX score in the present study because the SYNTAX score was a patient-level score and the SYNTAX score was not available in patients with a history of CABG (n = 27, in the present study). Finally, we did not adopt the universal definition of PMI [cardiac troponin > 5 times the ULN and PCI-related clinical or angiographic complications], but we adopted the definition of PMI based on the rise of CK/CK-MB, because the universal definition of PMI might be influenced by subjective judgment. In fact,

Tricoci, *et al.* reported that cardiac troponin > 5 × ULN was observed in 13.7% of 13,038 patients with PCI, but cardiac troponin > 5 × ULN combined with clinical or angiographic complications was observed in only 2.0% of same population,¹¹⁾ suggesting that PMI was judged by the clinical/angiographic complications rather than the cardiac troponin > 5 × ULN. Furthermore, Ndrepepa, *et al.* reported that the elevation of high-sensitivity troponin T following PCI was observed in the majority of patients (77.6%), which was not associated with the long-term death.³⁸⁾ Appropriate selections of biomarkers and cutoff points should be important. Therefore, we judged PMI by only objective findings (CK/CK-MB) in this retrospective study.

Conclusions

In contemporary elective PCI, the lesion length, lesion angle ≥ 45°, and Medina classification (0,1,1) or (1,1,1) were significantly associated with PMI. It would be important to prevent flow limitation in both side branches and main vessels in PCI for the diffuse long, angulated, or true bifurcation lesions.

Acknowledgments

The authors acknowledge all staff in the catheter laboratory in Saitama Medical Center, Jichi Medical University, for their technical support in this study.

Table II. Univariate Logistic Regression Model to Find the Factors Associated with Periprocedural Myocardial Infarction

Dependent variable: Periprocedural myocardial infarction			
Independent variables	Odds ratio	95% confidence interval	P value
Age (per 1-year increase)	1.012	0.974-1.053	0.540
Male	0.621	0.267-1.448	0.270
Overweight (BMI ≥ 25 kg/m ²)	0.395	0.148-1.056	0.064
Hypertension	1.315	0.305-5.673	0.714
Diabetes mellitus	1.517	0.700-3.288	0.291
Hyperlipidemia	0.941	0.319-2.779	0.912
Current smoker	0.864	0.255-2.928	0.814
Chronic renal failure (creatinine > 2 mg/dL)	0.910	0.268-3.088	0.880
Estimated GFR (mL/minute/1.73 m ²) (per 10 mL/minute/1.73 increase)	0.886	0.772-1.018	0.087
Chronic renal failure on hemodialysis	0.681	0.158-2.934	0.606
Statin treatment	1.181	0.440-3.172	0.741
Reason for PCI			
PCI to the culprit of STEMI (versus the non-AMI lesions)	2.142	0.837-5.482	0.112
PCI to the culprit of NSTEMI (versus the non-AMI lesions)	7.675	0.820-71.813	0.074
PCI to in-stent restenosis	1.250	0.366-4.266	0.722
Target lesion			
LM-LAD (versus the non-LM-LAD lesions)	2.280	1.010-5.144	0.047
PCI to chronic total occlusion	1.600	0.466-5.495	0.455
Reference diameter (per 1-mm incremental)	0.524	0.281-0.977	0.042
Lesion length (per 10-mm incremental)	1.558	1.275-1.904	< 0.001
Lesion angle $\geq 45^\circ$ (versus lesion angle $< 45^\circ$)	7.820	2.334-26.206	0.001
Calcification			
Moderate-severe (versus none -mild)	2.630	1.187-5.828	0.017
ACC/AHA classification type B2 and C (versus type A and B1)	11.053	1.490-81.981	0.019
Medina classification			
(0,1,1)/(1,1,1) (versus the non-0,1,1/1,1,1)	15.397	6.787-34.930	< 0.001
Guiding catheter size and system ≥ 7 Fr (versus 6Fr or 5Fr)	7.558	2.255-25.328	0.001
Unsuccessful PCI	0.149	0.016-1.376	0.093
DES	0.997	0.370-2.681	0.994
Use of Rotablator	3.690	1.606-8.480	0.002
Use of Diamondback 360	0.674	0.199-12.127	0.645
Intra-aortic balloon pump support	11.184	2.069-60.469	0.005
Side branch protection			
Jailed wire (versus no protection)	2.169	0.955-4.923	0.060
Jailed corsair/jailed balloon (versus no protection)	2.142	0.469-9.773	0.325
Any side branch protection (versus no protection)	2.164	0.995-4.708	0.052
Use of scoring balloon or cutting balloon (versus no use)	0.437	0.149-1.281	0.131
Total stent and DCB length (per 10-mm increase)	1.421	1.218-1.658	< 0.001
Final TIMI grade of the main vessel			
TIMI ≤ 2 (versus TIMI 3)	4.474	0.520-38.523	0.173
Final TIMI grade of the side branch			
TIMI ≤ 2 (versus TIMI 3)	34.000	12.562-92.026	< 0.001

LM-LAD indicates left main-left anterior descending artery.

Table III. Multivariate Logistic Regression Model to Find the Factors Associated with Periprocedural Myocardial Infarction

Dependent variable: Periprocedural myocardial infarction			
Independent variables	Odds ratio	95% confidence interval	P value
Lesion length (per 10-mm increase)	1.477	1.161-1.879	0.002
Lesion angle $\geq 45^\circ$ (versus lesion angle $< 45^\circ$)	4.244	1.187-15.171	0.026
Medina classification (0,1,1)/(1,1,1) (versus other lesions)	14.843	6.235-35.334	< 0.001

In the multivariate logistic regression model, the selection of independent variables was derived from the results of univariate logistic regression analysis ($P < 0.05$ in univariate analysis): LM-LAD, reference diameter, lesion length, lesion angle $\geq 45^\circ$, calcification, Medina classification (0,1,1)/(1,1,1), and the use of Rotablator. These variables were analyzed by backward elimination (likelihood ratio).

Disclosure

Conflicts of interest: Dr. Sakakura has received speaking honoraria from Abbott Vascular, Boston Scientific, Medtronic Cardiovascular, Terumo, OrbusNeich, Japan Lifeline, and NIPRO; has served as a proctor for Rotablator for Boston Scientific; and has served as a consultant for Abbott Vascular and Boston Scientific. Prof. Fujita has served as a consultant for Mehergen Group Holdings, Inc.

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