Original paper

Predictors of periprocedural myocardial infarction after rotational atherectomy

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A b s t r a c t

Introduction: Rotational atherectomy (RA) presents superior efficacy over traditional balloon angioplasty in managing calcified plaques, albeit being associated with a perceived heightened aggressiveness and increased risk of periprocedural complications.

Aim: To assess the frequency and predictive factors of periprocedural myocardial infarction (MI) following RA.

Material and methods: This was a retrospective observational study, encompassing 534 patients. The definition of periprocedural MI was consistent with the 4th universal definition of MI.

Results: Periprocedural MI occurred in 45 (8%) patients. This subset tended to be older (74.6 ±8.2 vs. 72 ±9.3%; p = 0.04) with SYNTAX Score (SS) > 33 points (p = 0.01), alongside elevated rates of no/slow flow (p = 0.0003). These patients less often fulfilled the indication for RA, which is a non-dilatable lesion. The incidence of traditional risk factors was similar in both groups. Univariable logistic regression models revealed: male gender (OR = 0.54; p = 0.04), non-dilatable lesion (OR = 0.41; p = 0.01), prior coronary artery bypass grafting (CABG) (OR = 0.07; p = 0.01) as negative and SS > 33 (OR = 2.8; p = 0.02), older age (OR = 1.04; p = 0.04), no/slow flow (OR = 7.85; p = 0.002) as positive predictors. The multivariable model showed that occurrence of no/slow flow (OR = 6.7; p = 0.02), SS > 33 (OR = 2.95; p = 0.02), non-dilatable lesion (OR = 0.42; p = 0.02), and prior CABG (OR = 0.08; p = 0.02) were independent predictors of periprocedural MI.

Conclusions: Periprocedural MI after RA was not an uncommon complication, occurring in nearly one-twelfth of patients. Our analysis implicated female gender, older age, and more severe coronary disease in its occurrence. As expected, the presence of no/slow flow amplified the risk of periprocedural MI, whereas prior CABG and non-dilatable lesions mitigated this risk.

Key words: predictors, rotational atherectomy, percutaneous coronary interventions, myocardial infarction, coronary lesions.

S u m m a r y

Periprocedural myocardial infarction emerges as one of the significant complications of percutaneous coronary interbvention. Despite its importance, the direct impact on patient outcomes remains ambiguous. Even more doubts as to the nature of such an event occur, particularly in the case of rotational atherectomy. The results of this study offer valuable insights for operators in their day-to-day clinical practice by identifying patient groups at a heightened risk of an unsuccessful procedure. Armed with this knowledge, operators can evaluate personalized procedural risks and implement tailor-made approaches for patients, potentially enhancing the overall efficacy of rotational atherectomy interventions.

Introduction

Severe coronary artery calcifications (CAC) are a significant negative prognostic factor for patients undergoing percutaneous coronary intervention (PCI) procedures. An aging population and increasing prevalence of comorbidities contribute to higher rates of coronary calcification and the prevalence of complex calcified lesions. Recent studies have shown that approximately 20% of patients who undergo PCI have moderate to severe calcifications in coronary lesions [1]. These lesions contribute to adverse events during the procedure, including inad-

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equate stent expansion, edge dissection, and stent malposition. In the long term, these complications can lead to stent failure and increased major adverse cardiovascular event (MACE) rates [2, 3]. As a result, effective preparation of heavily calcified coronary lesions during PCI is of paramount importance. Among many other methods, such as cutting and scoring balloons, very high-pressure balloons, intracoronary lithotripsy, orbital atherectomy or excimer laser, rotational atherectomy (RA) is a commonly employed technique to optimize stent implantation outcomes in heavily calcified lesions [4, 5]. RA, performed using a drill-like device, effectively modifies calcified and fibrotic plaques in coronary vessels, facilitating proper stent implantation. While this approach improves the success rate and long term results of PCI, it is considered a complex and demanding procedure for the operators, which may lead to higher rates of periprocedural complications [6]. However, the prevalence and risk factors associated with severe cardiovascular events, specifically periprocedural myocardial infarction (MI) after PCI following RA, remain inadequately studied.

Aim

This study aims to evaluate the frequency and predictive factors of periprocedural MI occurring after RA.

Material and methods

Study design

We conducted a retrospective double-center cohort study, analyzing medical records from two leading polish RA centers identifying 534 consecutive patients who underwent RA between June 2008 and November 2018. All patients provided informed consent for the RA procedure. Treatment adhered to current standards and was at the operator's discretion. The study protocol was accepted by the Bioethics Committee of Wroclaw Medical University (ID no. 143/2016) and was in accordance with the Declaration of Helsinki.

Definitions

The definition of periprocedural MI adhered to the 4^{th} universal definition of myocardial infarction. Periprocedural MI was defined by an elevation of cTn values > 5 times the 99^{th} percentile upper reference limit (URL) in patients with a normal baseline value. In addition, among patients with elevated pre-procedural cTn values the criterion of > 20% change from the baseline value had to be met. Moreover, at least one of the following conditions had to be present: new ischemic ECG changes, development of new pathological Q waves, imaging evidence of a new loss of viable myocardium or angiographic findings consistent with a procedural flow-limiting complication [7]. Blood samples were taken prior to the procedure and, if clinical symptoms arose, additional samples were collected.

The cTn levels were assessed at local laboratories using the chemiluminescence LOCI technique.

Study groups

Patients were categorized into two groups: those who experienced periprocedural MI after RA and those who did not suffer this complication.

Statistical analysis

Statistical analyses were performed using Statistica 13.0 (StatSoft Inc., USA). The Kolmogorov-Smirnov test was employed to assess normality. Continuous variables were compared using the independent samples *t*-test or the Mann-Whitney *U* test as appropriate. Categorical variables were compared using Pearson's χ^2 test. Variables with *p*-values < 0.05 were included in univariable logistic regression. Subsequently, variables significant ($p < 0.05$) in univariable regressions were selected for multivariable logistic regression.

Results

Patient characteristics

The study encompassed 534 patients, including 358 (67%) men and 176 (33%) women. Within the entire cohort, 113 (21%) patients had previously undergone coronary artery bypass grafting (CABG), and 43 (8%) had SYNTAX scores exceeding 33. The leading indication for RA was an undilatable lesion in 247 (46%) patients. Periprocedural MI occurred in 45 (8%) patients. These patients were more often female, and more often have had a high SYNTAX score (> 33 points). The group with periprocedural MI exhibited higher rates of no/slow flow during the procedure. Balloon non-dilatable lesions and prior CABG were less frequent in this group. Other traditional risk factors exhibited similar incidence in both groups: history of PCI, hypertension, diabetes, atrial fibrillation, chronic renal failure, and heart failure. Full clinical and procedural characteristics are presented in Table I.

Univariable analysis

Univariable analysis presenting predictive factors of periprocedural MI are shown in Table II. The findings indicate that older age, SYNTAX score > 33, and no/slow flow during the procedure are positive predictors of periprocedural MI. Conversely, male gender, history of CABG, and non-dilatable lesions are negative predictors of periprocedural MI.

Multivariable analysis

Based on univariable analysis, the multivariable logistic regression showed that SYNTAX score > 33 and no/slow flow are independent positive predictors of periprocedural MI. Conversely, history of CABG and non-dilatable

Table I. Population clinical and procedural characteristics

Parameter	All patients, 534 (100)	MI –, 489 (92)	MI +, 45 (8)	*P*-value
Age [years] mean (SD)	71.9 (9.3)	72 (9.3)	74.6 (8.2)	0.04
Male gender, *n* (%)	358 (67)	334 (68)	24 (53)	0.04
Prior PCI, *n* (%)	363 (68)	337 (69)	26 (58)	0.13
Prior CABG, *n* (%)	113 (21)	112 (23)	1 (2)	0.001
Hypertension, *n* (%)	460 (86)	424 (87)	36 (80)	0.4
Diabetes mellitus, *n* (%)	387 (73)	359 (73)	18 (40)	0.2
Atrial fibrillation, *n* (%)	133 (25)	125 (26)	8 (18)	0.39
Chronic kidney disease, *n* (%)	113 (21)	105 (21)	8 (18)	0.68
Dialysis, *n* (%)	15 (3)	13 (3)	2 (4)	0.84
Left ventricular ejection fraction < 50%, *n* (%)	202 (38)	187 (38)	15 (33)	0.7
RA in setting of acute coronary syndrome, *n* (%)	85 (16)	77 (16)	8 (18)	0.82
EuroSCORE, median (Q1–Q3)	2.4 (1.4–-4.8)	2.5 (1.4–4.9)	2.3 (1.2–4.4)	0.42
High Syntax Score > 33, *n* (%)	43 (8)	35 (7)	8 (18)	0.01
Medication at discharge:				
Aspirin, *n* (%)	515 (96)	473 (97)	42 (93)	0.91
P2Y12 inhibitor, *n* (%)	515 (96)	474 (97)	41 (91)	0.29
Oral anticoagulants, *n* (%)	99 (19)	95 (19)	4 (9)	0.23
β-blocker, *n* (%)	481 (90)	439 (90)	42 (93)	0.34
Angiotensin-converting enzyme inhibitor (ACEI), *n* (%)	415 (78)	384 (79)	31 (69)	0.47
Angiotensin receptor blocker (ARB), *n* (%)	58 (11)	54 (11)	4 (9)	0.89
Diuretics, *n* (%)	276 (52)	263 (54)	13 (29)	0.01
Statin, *n* (%)	497 (93)	454 (93)	43 (96)	0.27
Nitrates, *n* (%)	75 (14)	70 (14)	5 (11)	0.83
Procedural characteristics:				
Radial access, *n* (%)	344 (65)	318 (65)	26 (58)	0.31
Calcium length ≥ 20 mm, *n* (%)	322 (60)	293 (60)	25 (55)	0.55
Balloon uncrossable lesion, *n* (%)	136 (25)	121 (25)	15 (33)	0.28
Non-dilatable lesion, *n* (%)	247 (46)	233 (48)	12 (27)	0.01
Chronic total occlusion, *n* (%)	44 (8)	38 (8)	6 (13)	0.20
Number of burrs used, median (Q1–Q3)	1 (1–1)	1 (1–1)	1 (1–1)	0.79
Burr to artery ratio > 0.5, *n* (%)	73 (14)	65 (13)	8 (18)	0.51
Maximum burr diameter, mean (SD)	1.46 (0.18)	1.46 (0.18)	1.40 (0.18)	0.05
Right coronary artery (RCA), *n* (%)	179 (34)	164 (34)	15 (34)	0.98
Left main (LM), *n* (%)	37 (7)	37 (8)	0 (0)	0.06
Left anterior descending (LAD), *n* (%)	228 (43)	204 (42)	24 (54)	0.13
Left circumflex (LCX), *n* (%)	73 (14)	70 (14)	3 (7)	0.15
Moderate/severe tortuosity, *n* (%)	345 (65)	315 (64)	30 (67)	0.76
Lesion type B2/C, *n* (%)	432 (81)	391 (80)	41 (91)	0.07
Bifurcation lesion, *n* (%)	218 (41)	194 (40)	24 (53)	0.07
Periprocedural complications:				
No/slow flow, *n* (%)	10 (2)	6 (1)	4 (9)	0.0003
Side branch occlusion, *n* (%)	6 (1)	4 (1)	2 (4)	0.03
Dissection	17 (3)	16 (3)	1 (2)	0.70
Perforation, *n* (%)	7 (1)	3 (1)	4 (9)	0.00001
AV block, *n* (%)	1 (0.2)	0 (0)	1 (2)	0.001
Emergency CABG, *n* (%)	0 (0)	0 (0)	0 (0)	1.0

Table II. Logistic regression models

Parameter	Odds ratio	95% CI [LL]	95% CI [UL]	*P*-value
Univariable analysis:				
Age	1.04	1.00	1.07	0.04
Male gender	0.53	0.29	0.98	0.04
Prior CABG	0.07	0.01	0.56	0.01
Hypertension	0.61	0.28	1.33	0.22
Diabetes mellitus	0.59	0.32	1.10	0.10
Atrial fibrillation	0.63	0.29	1.39	0.25
Chronic kidney disease	0.79	0.36	1.75	0.56
High Syntax Score > 33	2.80	1.21	6.50	0.02
Non-dilatable lesion	0.41	0.21	0.82	0.01
No/slow flow	7.85	2.12	29.04	0.002
Multivariable analysis:				
Age	1.02	0.98	1.07	0.23
Male gender	0.87	0.41	1.83	0.70
Prior CABG	0.08	0.01	0.62	0.015
High Syntax Score > 33	2.95	1.19	7.35	0.02
Non-dilatable lesion	0.42	0.21	0.85	0.016
No/slow flow	6.70	1.38	32.48	0.018

lesion are independent negative predictors of periprocedural MI. Full results are presented in Table II.

Discussion

RA is an efficient method for managing severe CAC, despite its complexity and relatively steep learning curve [8]. While it remains a primary approach for most severe CAC, guidelines for RA procedure performance rely mainly on expert opinions rather than data from randomized trials. Understanding statistical predictors of periprocedural complexity can be useful in assessing procedural risk for individual patients and considering the appropriateness of RA compared to other available methods [9].

In our study, periprocedural MI occurred in 8% of patients. Univariable analysis identified age, SYNTAX score > 33, and no/slow flow complications as positive predictors of periprocedural MI, while male gender, history of CABG, and balloon non-dilatable lesion were negative predictors. Multivariable analysis confirmed high SYNTAX scores, no/slow flow complications as a positive and prior CABG, and balloon non-dilatable lesions as negative independent predictors of periprocedural MI, highlighting their importance in assessing procedural complexity [10]. Patients with more severe and complex coronary artery disease, as indicated by higher SYNTAX scores, require a more advanced procedure involving additional burrs and longer passages, contributing to the association with periprocedural MI [11, 12]. In our study population we also observed the correlation between SYNTAX score and the usage of additional burrs, but no significant association between the quantity of used burrs and periprocedural MI was noted. The link between no/slow flow complications and RA may be attributed to the particle generated by RA, which could lead to distal embolization in the microcirculation [13, 14]. Notably, patients with a history of CABG demonstrated a lower risk of periprocedural MI; these results may be associated with better collateral circulation, resulting in a lower risk of ischemia [15]. Similarly, patients with balloon non-dilatable lesions as an indication for RA exhibited lower periprocedural MI risk; we can speculate that this is associated with a lower quantity of calcium debris produced during the procedure compared to balloon uncrossable lesions.

While operators may not have complete control over every aspect, our research findings provide a basis for adjusting the procedure's course, effectively minimizing the risk of the no-flow complication. This involves employing a deliberate approach, including verapamil and nitroglycerin within the flush solution, slow burr advancement, to-and-fro pecking motion of the burr, shorter burr runtimes (15 to 20 s), lower burr speeds (150,000 to 160,000 rpm), and strict avoidance of significant drops in rpm. This comprehensive strategy can effectively prevent the incidence of both the no-flow complication and coronary artery spasm [16].

Periprocedural MI differs from spontaneous type 1 or 2 MI and might not have the same impact on patient mortality; however, it remains a useful marker for procedural complexity [10, 17]. While the impact of periprocedural MI on a patient's prognosis is still a subject of debate, there are studies that have linked periprocedural MI to an increased rate of MACE within 30 days after the procedure [18]. However, in Zeitouni *et al.*'s research, the analysis was conducted on a general group of patients undergoing elective coronary stenting, with RA utilization only in 1% of the study group [18]. In contrast, another study that specifically investigated the influence of periprocedural MI after RA found no association between periprocedural MI and the occurrence of MACE within 1 year [19]. There are conflicting results among studies regarding the impact of periprocedural MI on patients' prognosis. Moreover, there is a lack of new studies that consider this issue in accordance with the current definition of periprocedural MI, which hinders the formulation of a definitive position on this topic.

Although studies on periprocedural MI predictors after RA are limited, they emphasize the need for further research to guide procedural decisions and enhance patient outcomes.

This study possesses some limitations due to its retrospective design and assessment of data from a 10-year period. Additionally, the data collection process predates the most recent definition of MI, potentially impacting the accuracy and relevance of our findings. We acknowledge that advancements in procedure performance and diagnostic standards have evolved during the considered years.

Conclusions

Periprocedural MI after RA is not uncommon and is associated with more severe coronary disease and no/slow flow. Conversely, prior CABG and non-dilatable lesions are associated with a lower risk of this complication. These predictors contribute to optimizing the efficacy of RA and improving procedural outcomes.

Further studies are required to evaluate the short- and long-term prognostic implications of periprocedural MI.

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Michał Błaszkiewicz, Kamila Florek and Wojciech Zimoch participated equally.

Conflict of interest

The authors declare no conflict of interest.

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