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Review Article

Periprocedural Myocardial Infarction: A Review Article

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ABSTRACT

Percutaneous coronary intervention (PCI) is linked to a number of complications, including periprocedural myocardial infarction (PPMI), which is defined as an increase in creatine kinase-MB (CK-MB) levels of >3 times the upper limit of the normal range in at least two blood samples with a normal baseline value, prolonged ischemia as evidenced by persistent chest pain (more than 20 minutes), and new pathological Q waves on the electrocardiogram (ECG). Periprocedural myocardial infarction occurred in roughly 6-7% of patients who had percutaneous coronary intervention (PCI) and was linked to poor outcomes, according to epidemiology. As a result, identifying the potential factors for detecting, preventing, and managing this incident is critical.

1. Introduction

Percutaneous coronary intervention (PCI) is one of the most frequent procedures directed in a patient with the coronary syndrome. Periprocedural myocardial infarction is a notable entanglement of PCI procedures and is habitually seen in a significant extent of patients who went through PCI procedures.[1,2] A few factors were recognized identified with the periprocedural myocardial ischemia. This article review talked about the plausible mechanism, diagnostic, and management of periprocedural myocardial infarction.

2. Definition

Percutaneous coronary intervention has been related to a minor but considerable increase in the risk of thrombosis, myocardial infarction (MI), hemorrhage, mortality, or stroke as a result of periprocedural complications. The most well-known of these risks is PPMI, which can range from a minor rise in cardiac enzymes to a large infarct. [1] It was challenging to define periprocedural myocardial infarction (PPMI). The ability to distinguish PPMI from index MI in patients with increased baseline biomarkers is restricted, especially if the time between admission and PCI is short, because biomarker discharge from the two events may overlap. In the Champion Phoenix study, if biomarkers were increased at baseline, the PPMI endpoint required unique symptoms, electrocardiogram (ECG) abnormalities, or angiographic evidence indicating ischemia. Furthermore, the proof of ischemia and baseline biomarker evaluation were emphasized based on the The Society for Cardiovascular Angiography and Interventions (SCAI) and Universal Definition of Myocardial Infarction (UDMI).[3]

PPMI was defined as an increased in creatine kinase-MB (CK-MB) levels that were >3 times the upper limit of the normal range in at least 2 blood tests within 48 hours of the operation. CK-MB re-raising will be at least half as significant as the most recent pre-method concentration if pre-PCI CK-MB esteems are raised more than the more common cut-off values, for example, if patients initially had acute MI.1 A subset of PPMI patients with evidence of prolonged ischemia, such as persistent chest pain (>20 minutes) or new pathological Q waves on the ECG is defined as periprocedural myocardial injury.[2]

3. Epidemiology

PPMI was found in 6.3 percent of patients and was linked to a higher risk of mortality within a year. According to the Olivier et al. study, 3% of the 885 patients with PPMI had Q-waves, 40% had a CK-MB rise of 3 to 5x ULN, 33% had a rise of 5 to 10x ULN, and 25% had a rise >10x ULN. PPMI is found in 6.3% of patients with stable angina, 5.7% of patients with unstable angina, and 7.2% of patients with non-ST-segment elevation myocardial infarction (NSTEMI).[3] Park et al. found that 7.1% of the sample had PPMI, 42.5% had a CK-MB ratio of 3 to 5, 33.8% had a CK-MB ratio of 5 to 10, and 23.7% had a CK-MB ratio of >10, as determined by the CK-MB mass assay. Men had a 6.4% PPMI rate, whereas women had an 8.6% rate. Patients with stable angina experienced 8.2% PPMI, while those with acute coronary syndrome experienced 6.3 percent. In comparison to patients without PPMI, those with PPMI had greater risk profiles for lesion, procedure-related, and patient variables.[1]

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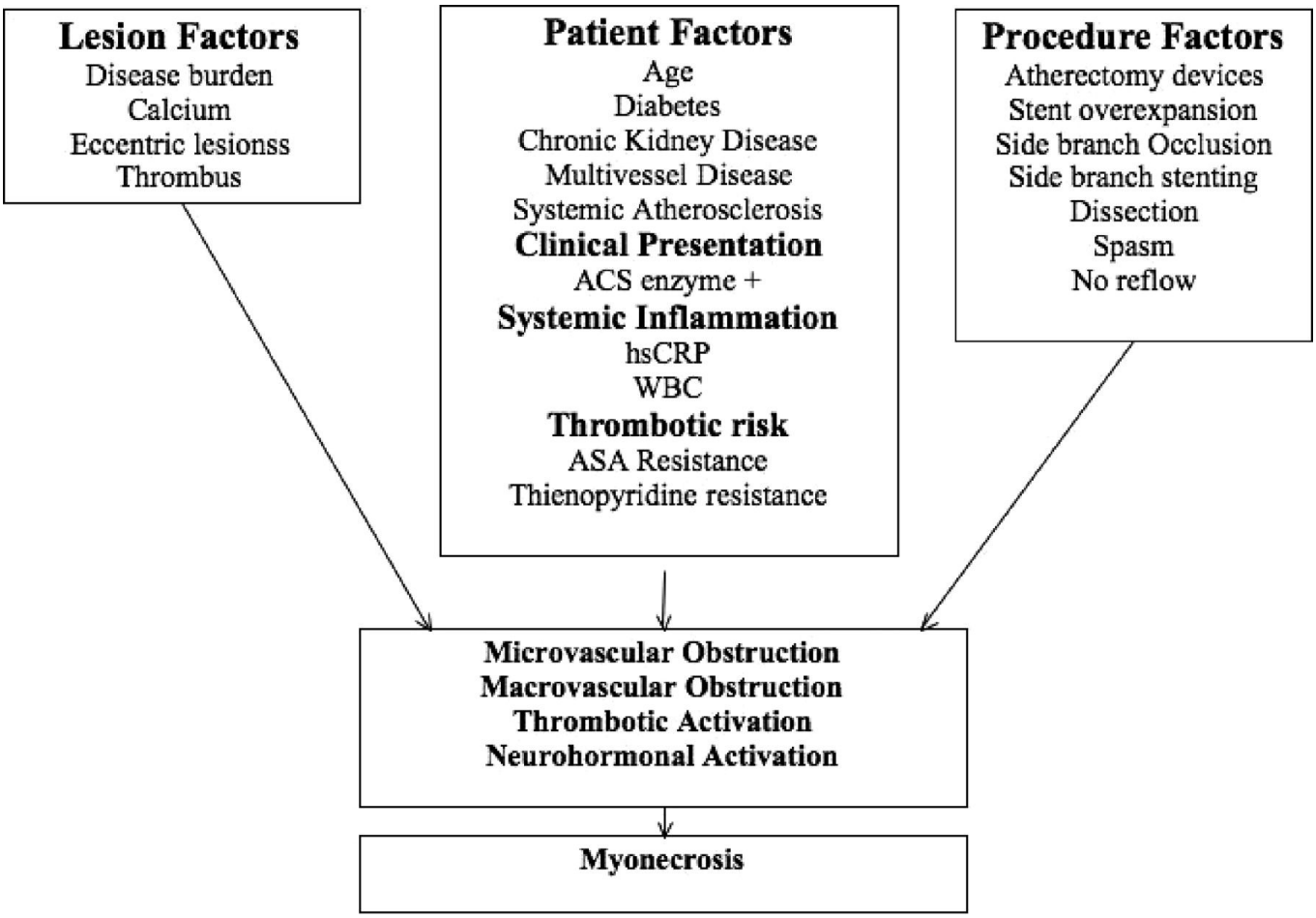

Figure 1. Risk factors and mechanisms of biomarker release after PCI.[5]

The prevalence of periprocedural myocardial injury and Q-wave MI were 2.5 percent and 0.2 percent, respectively, in a weighted meta-analysis of 65 studies including 18,061 patients who had issues following chronic total occlusion (CTO) PCI.[2] In 61 percent, 43 percent, and 31 percent of patients, periprocedural increases of cardiac troponin 3x, 10x, and 20x ULN were detected, respectively. Regardless of the troponin cut-off utilized to characterize periprocedural myocardial injury, the prevalence of periprocedural troponin elevation was higher when the retrograde technique was applied.[2] PPMI occurred in 13.8 percent of retrograde approach versus 6.7 percent of antegrade approach.[2] Damage to the myocardium along the collateral vessel used for retrograde approach, as well as the utilization of dissection operations that disrupt the side branches of small coronary artery, could be factors in the increased retrograde approach's occurrence of periprocedural myocardial injury. The higher retrograde periprocedural myocardial injury incidence could be connected to greater lesion complexity since the retrograde technique was used in the majority of cases after an antegrade crossing failure.[2]

4. Mechanism

PPMI can be caused by side-branch obstruction, no reflow due to abrupt termination, thrombus, distal embolization, collateral flow stoppage, flow-limiting dissection, and other unknown reasons. Side-branch blockage was the most common etiology of PPMI, accounting for around 57.[3] percent of cases, whereas non-identifiable mechanical reasons accounted for about one-fifth of the cases.[1] Female gender, older age, hypertension, diabetes, multivessel disease, kidney dysfunction, left main disease, left anterior descending artery disease, long lesion (>20 mm), bifurcation lesion, the number of stents, and drug-eluting stents were all independent predictors of PPMI in a multivariate logistic generalized approximate equation regression model.[1] Park et al. underline the importance of a thorough study of side-branch architecture and effective side-branch protection during intensive PCI in order to reduce procedural necrosis.[1] In 20% of PPMI cases, no mechanical reasons were discovered. This could be related to the micro-embolization of atherosclerotic or thrombotic material that is invisible on coronary angiography, as shown in a cardiac magnetic resonance imaging study.[1,4]

5. Clinical Significance

Patients are at risk for ischemia episodes that can promote myocardial necrosis if revascularization techniques involve direct manipulation or instrumentation of the coronary artery (CABG or PCI). After PCI, PPMI has been associated to lesion-related factors, procedural factors, and patient-related factors (Figure 1). Reduced left ventricular ejection fraction, multivessel disease, systemic atherosclerosis, advanced age, chronic renal disease, and diabetes mellitus increase the likelihood of CK-MB release by 1.3 to 1.8 times. The existence of systemic inflammation, including higher hs-C-reactive protein level, is associated to postprocedural elevation of CK-MB and elevated white cell admission count (>9.5x 106/L). Procedure-related issues include side branch occlusions, aggressive stent expansion leading in plaque extrusion, atherectomy, system selection, stenting of side branch, coronary dissection, distal embolization, vasospasm, no-reflow,

Table 1. Baseline characteristic of patients according to peri-procedural myocardial infarction.[1]

Variables	Overall population (n = 23 604)	Peri-procedural MI		P-value
		No (n = 21927)	Yes (n = 1677)	
Demographics				
Age (years)	61.7 ± 10.3	61.5 ± 10.3	64.0 ± 9.6	<0.001
Sex				<0.001
Men	16 424 (69.6)	15 365 (70.1)	1059 (63.1)	
Women	7180 (30.4)	6562 (29.9)	618 (36.9)	
Clinical characteristics or coexisting conditions, n (%)				
Diabetes	6995 (29.6)	6492 (29.6)	503 (30.0)	0.74
Hypertension	13 101 (55.5)	12 054 (55.0)	1047 (62.4)	<0.001
Current smoker	7211 (30.5)	6764 (30.8)	447 (26.7)	<0.001
Hyperlipidaemia	9752 (41.3)	9013 (41.1)	739 (44.1)	0.02
Previous MI	2249 (9.5)	2083 (9.5)	166 (9.9)	0.59
Previous PCI	2898 (12.3)	2710 (12.4)	188 (11.2)	0.17
Previous bypass surgery	419 (1.8)	397 (1.8)	22 (1.3)	0.14
Previous congestive heart failure	315 (1.3)	290 (1.3)	25 (1.5)	0.56
Previous stroke	1327 (5.6)	1206 (5.5)	121 (7.2)	0.003
Peripheral vascular disease	390 (1.7)	353 (1.6)	37 (2.2)	0.07
Renal dysfunction	513 (2.2)	460 (2.1)	53 (3.2)	0.004
Acute coronary syndrome	13 656 (57.9)	12 798 (58.4)	858 (51.2)	<0.001
Ejection fraction (%)				0.54
<40%	852 (3.6)	789 (3.6)	63 (3.8)	
40 – 50%	2668 (11.3)	2492 (11.4)	176 (10.5)	
>50	20 084 (85.1)	18 646 (85.0)	1438 (85.7)	
Mean	59.1 ± 8.9	59.1 ± 9.0	59.1 ± 8.8	0.89
Lesion and procedural characteristics, n (%)				
Multivessel disease	12 004 (50.9)	10 857 (49.5)	1147 (68.4)	<0.001
Left anterior descending artery disease	14 206 (60.2)	13 085 (59.7)	1121 (66.8)	<0.001
Left main disease	1441 (6.1)	1272 (5.8)	169 (10.1)	<0.001
Bifurcation lesion	5393 (22.8)	4822 (22.0)	571 (34.0)	<0.001
Long lesion (.20 mm)	16 207 (68.7)	14 753 (67.3)	1454 (86.7)	<0.001
Total occlusion	27.0 (11.4)	2544 (11.6)	157 (9.4)	0.005
Use of glycoprotein IIb/IIIa inhibitor	3823 (16.2)	3574 (16.3)	249 (14.8)	0.12
Stent type				0.002
Bare-metal stents	4260 (18.0)	4005 (18.3)	255 (15.2)	
Drug-eluting stents	19 344 (82.0)	17 922 (81.7)	1422 (84.8)	
Number of stents				<0.001
1	12 561 (53.4)	12 114 (55.5)	447 (26.7)	
2	6482 (27.6)	5952 (27.3)	530 (31.6)	
≥3	4465 (19.0)	3766 (17.2)	699 (41.7)	
Mean	1.7 ± 1.0	1.7 ± 1.0	2.4 ± 1.3	<0.001
Total stent length (mm)	41.3 ± 27.3	40.0 ± 26.3	58.4 ± 33.9	<0.001

Data are shown as mean (SD) for continuous variables and absolute numbers (percentage) for dichotomous variables. MI, myocardial infarction; PCI, percutaneous coronary intervention.

Table 2. Classification of Myocardial Necrosis Occurring After Percutaneous Coronary Intervention.[10]

Types	Definition	Nomenclature	Independent Association with Mortality
1	Isolated troponin increase or troponin increase with CK-MB 1– 3 times ULN	Infarctlet or necrosette	Uncertain
2	CK-MB 3– 8 times ULN	Moderate PMI	Moderate association that increases linearly with the degree of CK-MB rise
3	CK-MB >8 times ULN with no Q waves	Large non– Q-wave PMI	Strong
4	New Q waves in ≥2 contiguous leads	Q-wave PMI	Very strong
5	Stent thrombosis	Stent thrombosis	Very strong
6	Spontaneous MI occurring >24 hours after PCI	Spontaneous MI	Very strong

Note. Abbreviations: CK-MB, creatine kinase-MB fraction; MI, myocardial infarction; PCI, percutaneous coronary intervention; PMI, periprocedural myocardial infarction; ULN, upper limit of normal.

angiographic compaction, and unsuccessful surgical procedures. Increased periprocedural enzyme release is predicted by burden of the disease, calcification, lesion eccentricity, and the presence of thrombus. The great majority of people with periprocedural myocardial injury don't show any signs or symptoms. The most common symptom is chest pain.[5]

6. Diagnostic

The newest consensus documents advocate the use of cardiac troponin (I or T) as the ideal biomarker for myocardial necrosis due to its excellent myocardial tissue specificity and clinical sensitivity. When compared to CK-MB tests, cardiac troponin could significantly increase the prevalence of PPMI due to its higher sensitivity. Troponin testing have been found in several studies to increase the rate of MI diagnosis by doubling or tripling.[1]

This periprocedural myocardial injury principle, with minimal adjustments, has been used in recent clinical research. In the Timing of Intervention in Acute Coronary Syndrome (TIMACS), Early Glycoprotein IIb-IIIa Inhibition in Non-ST-Segment Elevation Acute Coronary Syndrome (EARLY ACS), and Acute Catheterization and Urgent Intervention Triage Strategy (ACUITY) studies, periprocedural myocardial injury was defined as new Q waves or CK-MB >3 times when baseline CK-MB values before PCI were normal or were elevated but decreasing (ACUITY).[3,4,6] The development of persistent ischemic symptoms lasting around 30 minutes or new Q waves or ischemic ST abnormalities following PCI, as well as an increase of at least 50% of the next CK-MB, were used to diagnose periprocedural myocardial injury in increased CK-MB patients that was rising and who underwent PCI within 24 hours of presentation.[7–10]

7. Prevention

Statin

Patients who do not take statins have an increased risk of periprocedural CK-MB release. The use of statins prior to PCI has also been connected to a massive reduction in CK-MB. The 80 mg atorvastatin loading dose given 24 hours before PCI decreased periprocedural myocardial injury by 50% to 66%. The use of atorvastatin (an 80-mg loading dose given 12 hours before coronary angiography, followed by a 40-mg dose given 2 hours before the procedure) decreased periprocedural myocardial injury by 2.5 times in people who had been taking statins for a long time. A single high-dose statin has been found to diminish periprocedural myocardial injury by modifying inflammatory responses, plaque stability, and thrombus formation in a short period of time. In addition, preprocedural statin usage reduced periprocedural myocardial injury by 70% independently in an analysis of 803 individuals undergoing rotablation. According to this study, which used rotablation as a specific human plaque microembolization model, statins stabilize the atherosclerotic plaque, reduced oxidant-induced mitochondrial dysfunction-related cardiac injury, and minimize distal embolization.[11,12]

Antiplatelet

With adequate thienopyridine preloading and management, dual antiplatelet treatment has resulted in considerable decreases in PPMI. In acute coronary syndrome patients, clopidogrel 600 mg loaded at least 2 hours before intervention or prasugrel 60 mg reduced PPMI rates by 20% and 30%, respectively. In the Enhanced Suppression of Integrilin Therapy Platelet IIb/IIIa Receptor (ESPRIT) and the Evaluation of Platelet IIb/IIIa Inhibitor of Stenting (EPISTENT) studies, glycoprotein IIb/IIIa antagonists lowered the 30-day risk of MI by 50%, partly via reducing periprocedural myocardial injury.[13,14] In those with high-risk ACS, a combination of glycoprotein IIb/IIIa antagonists plus clopidogrel reduced the risk of MI, particularly periprocedural myocardial injury (Intracoronary Stenting and Antithrombotic Regimen: Rapid Early Action for Coronary Treatment 2 [ISAR-REACT 2] trial).[15] In the Clopidogrel Loading with Eptifibatide to Arrest Platelet Reactivity-2 (CLEAR-PLATELETS2) study,[16] but not in the broader ISAR-REACT 2 tudy,[15] glycoprotein IIb/IIIa antagonists reduced periprocedural myocardial injury risk in stable CAD patients who were appropriately preloaded with clopidogrel. In high-risk SVG procedures, however, the glycoprotein IIb/IIIa antagonists benefit is debatable.[17]

Ischemic Preconditioning

When a coronary occlusion is followed by ischemia in short period and then reperfusion, the degree of myocardial necrosis is reduced. Ischemia can occur spontaneously or as a result of a 90-second balloon expansion during PCI, followed by a 5-minute reperfusion cycle and another 90-second balloon expansion. This is referred to as ischemia preconditioning. In a randomized study including 150 patients receiving PCI, Laskey et al. discovered that ischemia preconditioning produced during PCI reduced postprocedural creatine kinase (CK) increase by 70% when compared to multiple inflations without intervening reperfusion intervals or single balloon inflation >60 seconds.[18] In a later big study, ischemic preconditioning was connected to a decreased risk of death and MI in the hospital and over the course of a year.19 Ischemic preconditioning also improves tissue

ischemia-reperfusion injury in distant places and gives local security. In reality, a remote ischemic preconditioning technique to create limb ischemia reduced troponin release and serious adverse cardiac events after six months. The technique consisted of inflating the cuff over the upper arm to 200 mm Hg for 5 minutes, then deflating for 5 minutes to allow reperfusion, which was repeated twice more. Simultaneously, additional research is required to determine the importance of ischemic disease.

8. Prognostic

Percutaneous coronary intervention (PCI) is known to cause periprocedural myocardial injury, which has been linked to a greater death rate despite the absence of symptoms or electrocardiographic changes.[2] A statistically significant increase in the probability of one-year death was connected to periprocedural myocardial injury. There was no significant link between CK-MB elevations of 3 to 5x ULN or 5 to 10x ULN and one-year death, whereas CK-MB elevations of 10x ULN increased mortality risk. When the UDMI CK-MB was used to describe Form 4a MI, it was discovered that it was linked to a greater one-year mortality rate.[3]

For more than two decades, the prognostic significance of CK-MB elevations during PCI has been debated. These findings suggest that PPMI is still therapeutically important in the new era of aggressive antiplatelet therapy focused on secondary prevention, enhanced procedural techniques, and advanced equipment, according to interventionists. Despite revealing an increased baseline risk, atherosclerotic burden, and procedural complexity, this study was unable to demonstrate that PPMI directly caused death.[2,6,20] The Lo et al. study indicated a greater incidence of MACE among CTO PCI patients who had periprocedural myocardial injury after a median follow-up of 2.3 years. Microembolization of distal collateral vessels, an increase in post-PCI periprocedural myocardial injury inflammatory state, a tendency to arrhythmias after infarction, and greater CTO PCI failure index rates are all possible explanations.[2] From a clinical standpoint, the presence of PPMI will be considered a sufficient biomarker description for identifying high-risk individuals for potential clinical outcomes.[1]

9. Conclusion

Percutaneous coronary intervention is linked to a number of risks, including periprocedural myocardial infarction. A number of variables, including procedural factors, lesion-related factors, and patient-related factors have been linked to PPMI after PCI. Preventing PPMI requires the use of statins and antiplatelet medications.

10. Declarations

10.1. Ethics Approval and Consent to participate
This study was approved by local Institutional Review Board, and all participants have provided written informed consent prior to involvement in the study.

10.2. Consent for publication
Not applicable.

10.3. Availability of data and materials
Data used in our study were presented in the main text.

10.4. Competing interests
Not applicable.

10.5. Funding source
Not applicable.

10.6. Authors contributions
Idea/concept: IM, MSR; Design: IM, FHA, TA, MBA, PAK, RP, AAD, KAN; Control/supervision: MSR; Literature review: IM, MSR; Writing the article: IM, MSR; Critical review: IM, MSR. Reviewed and approved the final draft and are responsible for the content and similarity index of the manuscript.

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