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Original Article

Assessment of Peri-Procedural Myocardial Injury by High-Sensitivity Troponin-I Levels after Successful Elective Percutaneous Transluminal Coronary Angioplasty

Fahad Khan Toru, Muhammad Shabbir, Iftikhar Ahmed, Aneela Shabbir*, Sarwat Paiker, Zeeshan Arif, Zeeshan Ahmad, Abdul Hameed Siddiqui

Department of Adult Cardiology, Armed Forces Institute of Cardiology & National Institute of Heart Diseases/National University of Medical Sciences (NUMS), Rawalpindi Pakistan, *Department of Biochemistry, Foundation University, Islamabad Pakistan

ABSTRACT

Objective: To determine the incidence of Peri-Procedural Myocardial Injury (PMI) after elective, successful Percutaneous Transluminal Coronary Angioplasty (PTCA) as assessed by High Sensitivity troponin-I (HS-Trop-I) levels, and to find out association between PMI and clinical, angiographic and procedural variables.

Study Design: Analytical cross-sectional study.

Place and Duration of Study: Armed Forces Institute of Cardiology/National Institute of Heart Diseases, Rawalpindi Pakistan, from Dec 2022 to Jun 2023.

Methodology: Total one hundred and thirty-one cases were included using consecutive sampling technique. Patients with stable angina and having at least one positive stress test, baseline pre-PCI cardiac troponin level below the 99th percentile upper reference limit (normal baseline troponin), and a target lesion with a stenosis of >70% on qualitative angiography were included in study. Patients were divided into two groups; (Group-I=HS-Trop-I>40ng/L and Group-II=HS-Trop-I≤40 ng/L). Independent samples t-test and Pearson's Chi-square test were applied to compare the study variables among study groups and $p<0.05$ was considered as statistically significant.

Results: PMI was reported in 60(45.8%) out of 131 patients. Hypertension and previous myocardial infarction demonstrated slightly higher prevalence in group-I but there was insignificant difference in frequencies of demographics and comorbid in study groups ($p>0.05$). Total stent length and max balloon time, were significantly higher in the group-I (50.73±25.19mm vs 31.13±17.83mm; 26.80±7.51sec vs 22.42±5.94sec respectively) ($p<0.001$). There was also statistically significant difference in frequency of AHA classification, number of diseased vessels and multi-vessel PCI in study groups ($p<0.001$).

Conclusion: PMI is a common complication of elective PCI, especially when patients present with high-risk features for PCI as demonstrated by increased complexity & severity of angiographic findings and procedural parameters (number of diseased vessels, total length of implanted stents and amount of contrast used).

Keywords: High-sensitivity troponin-I, Myocardial injury, Percutaneous transluminal coronary angioplasty.

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INTRODUCTION

Percutaneous Transluminal Coronary Angioplasty (PTCA) stands as one of the foremost invasive interventions employed for coronary revascularization in the field of interventional cardiology. The American Heart Association (AHA) reported an astounding number of PCI procedures (914,000) conducted solely in the United States during 2014.[1] Over the years, the techniques associated with PCI have undergone remarkable advancements, traceable back to the seminal balloon coronary angioplasty performed by Andreas Gruentzig in 1979. The revolutionary introduction of coronary stents has played a pivotal role in treating coronary artery disease, transitioning from bare metal stents to drug-eluting stents. As a cutting-edge therapy in PCI, newer generation drug-eluting stents have achieved the status of standard treatment by significantly diminishing the incidence of restenosis and long-term morbidity. This advancement has been made possible through the utilization of more biocompatible polymers, state-of-the-art stent platforms, and diverse drug agents.[2]

Despite significant advances in Percutaneous Coronary Intervention (PCI) techniques, the occurrence of cardiac enzyme elevation, indicative of various degrees of myocardial damage, persists post PCI, even in the absence of clinical and angiographic evidence of ischemia, as demonstrated by Magnetic Resonance Imaging (MRI) studies.[3,4]

Unlike spontaneous myocardial infarction, which typically results from a unifying mechanism, such as acute plaque rupture with superimposed thrombus,

Correspondence: Dr Fahad Khan Toru, Department of Adult Cardiology, AFIC & NIHD, Rawalpindi Pakistan

peri-procedural biomarker elevation lacks a common underlying process. Potential mechanisms include side branch occlusions, distal embolization of disrupted plaques by the balloon or stent, platelet-rich microthrombi, vasospasm, and transient ischemia caused by balloon inflation.[5]

In the context of detecting myocardial cell injury, both cardiac troponins and creatine kinase MB (CK-MB) are employed as biomarkers, with troponin-I offering the advantage of superior sensitivity. High-sensitivity Troponin-I (HS-Trop-I) assays are now routinely used due to their ability to measure troponin-I concentrations 5-100 times lower than conventional assays, enabling the detection of even smaller amounts of myocardial necrosis. Rapid identification of patients with acute myocardial infarction using HS-Trop-I assays facilitates timely intervention, leading to improved patient outcomes.[6]

For patients with stable coronary artery disease, troponin-I elevation greater than 5 times the 99th percentile upper reference limit after successful elective PCI has been associated with adverse cardiac events at one year.[7] A local cross-sectional study conducted at the Armed Forces Institute of Cardiology, Rawalpindi Pakistan, revealed that the main modifiable risk factors responsible for elevated cardiac enzyme levels post successful PCI were Diabetes Mellitus (84%), raised low-density lipoprotein (LDL) levels (79%), smoking (68%), and hypertension (58%).[8]

Despite the existing knowledge on cardiac enzyme elevation post PCI, there is a lack of data concerning the post-coronary angioplasty rise of HS-Trop-I in our setup. This information will play a role in devising new strategies to help mitigate peri-procedural myocardial injury during PCI in stable coronary artery disease patients. Thus, the aim of this study was to assess the occurrence of increased HS-Trop-I levels after successful stent deployment and to explore potential relationships with clinical, angiographic and procedural variables.

METHODOLOGY

This Analytical Cross-sectional study was conducted at the Armed Forces Institute of Cardiology/National Institute of Heart Diseases, Rawalpindi, from Dec 2022 to Jun 2023 after approval from the Institutional Ethical Review Board (IERB) (letter # 9/2/R&D/2022/229).

Sample size was calculated by taking 9.4% prevalence of peri-procedural myocardial injury[9] in general population, using WHO sample size calculator yielding sample size of (n=131) with 95% confidence level and 5% margin of error.

Inclusion criteria: Patients regardless of age and gender with stable angina and having at least one positive stress test, a baseline pre-PCI cardiac troponin level below the 99th percentile upper reference limit (normal baseline troponin patients), and a target lesion with a stenosis of 70% or more on qualitative angiography were included for study purpose.

Exclusion criteria: Patients with acute myocardial infarction within the last 3 months, unstable angina, significant side branches at the target lesion (>2.5cm), those who experienced instant thrombosis after the procedure evident by clinical presentation, new onset ECG changes, angiographic findings and/or new regional wall motion abnormality and patients with decompensated heart failure (NYHA class III/IV).

Peri-Procedural Myocardial Injury (PMI) was defined as HS-Trop-I value >99th percentile upper reference limit (i.e.>40ng/L) within 16-24h post PCI. Data collection was carried out through non-probability consecutive sampling, involving all eligible patients who underwent elective, successful PTCA after obtaining informed consent. Patients were divided into two groups [Group-I=HS-Trop-I>40 ng/L (n=60) and Group-II=HS-Trop-I≤40 ng/L (n=71)]. A closed-ended questionnaire was used to collect patients' demographic data and relevant clinical, angiographic, and procedural variables. HS-Trop-I levels were measured before the procedure and 16-24hours post-procedure using venous samples from the patients. Only patients with normal baseline HS-Trop-I levels (pre-procedure) were included in the study group.

Data confidentiality was maintained to ensure the privacy of participants. The identities of the patients were kept confidential. Data was analyzed using Statistical Package for Social Sciences (SPSS) version-28:00. Continuous variables were expressed as mean and standard deviation, while categorical variables were represented as frequencies and percentages. The association of raised post-procedure HS-Trop-I levels with continuous variables was determined using unpaired t-test, and with categorical variables, Pearson's chi-square test was applied. The significance level for statistical analysis was set at $p<0.05$.

RESULTS

A total of one hundred and thirty-one (n=131) patients who underwent successful elective PTCA

were included in the study. Table-I presented the clinical and demographic characteristics of patients with cardiac high-sensitivity troponin-I (HS-cTn-I) i.e. having peri-procedural myocardial injury (PMI) levels greater than 40 ng/L (Group-I) and those with HS-cTn-I levels less than or equal to 40ng/L after successful angioplasty (Group-II).

Table-I: Comparison of Clinical and Demographic Characteristics of Patients Among Study Groups (n=131)

Characteristics		Peri-Procedural MI		*p*-value
		Group I (HS-Trop-I>40 ng/L) (n=60) Frequency (%)	Group II (HS-Trop-I≤40 ng/L) (n=71) Frequency (%)	
Gender	Male	42(70.0)	54(76.1)	0.56
	Female	18(30.0)	17(23.9)	
Age (years) (Mean±SD)		60.06±7.89	58.80±12.50	0.48
Comorbids	Hypertension	34(56.7)	34(47.9)	0.41
	DM	27(45.0)	29(40.8)	0.76
	Smoking	18(30.0)	19(26.7)	0.83
	Previous MI	33(55.0)	33(46.5)	0.43
	Prior CABG	3(5.0)	1(1.4)	0.49

DM=Diabetes Mellitus; MI=Myocardial Infarction; CABG=Coronary Artery Bypass Grafting

There were 60(45.8%) patients with PMI and 71(54.19%) had low HS-cTn-I level and no PMI. The mean age of patients in both groups (Group-I and Group-II) was comparable (60.06±7.89 years vs 58.80±12.50 years respectively). The majority of patients were males in both groups, with 42(70.0%) and 54(76.1%) respectively (p>0.05). Regarding medical history, majority of hypertensive patients developed PMI 34(56.7%). History of MI was more prevalent in Group-I compared to Group-II [33(55.0%) vs 33(46.5%) respectively]. Prior Coronary Artery Bypass Grafting (CABG) was noted in 3(5.0%) of patients in Group-I and 1(1.4%) in Group-II. However, there was no significant differences observed for demographics and comorbids between the two groups (p>0.05).

Table-II illustrated comparison between Angiographic and Procedural Characteristics of patients among the two study groups. ACC/AHA Target Lesion Classification showed statistically significant difference between the two groups (p=0.008) with higher frequency of Type A 25(35.2%) in Group-II and Type B&C in Group-I [34(56.7%) and 19(31.7%) respectively]. The distribution of target vessels

Table-II: Comparison of Angiographic and Procedural Characteristics of Patients Among Study Groups (n=131)

Characteristics		Group I (HS-Trop-I>40 ng/L) (Total=60) Frequency (%)	Group II (HS-Trop-I≤40 ng/L) (Total=71) Frequency (%)	*p*-value
ACC/AHA Target lesion classification	Type A	7(11.7)	25(35.2)	0.008
	Type B	34(56.7)	29(40.8)	
	Type C	19(31.7)	17(23.9)	
Target Vessels	LAD	23(38.3)	39(54.9)	0.08
	LCx	9(15.0)	13(18.3)	
	RCA	14(23.3)	15(21.1)	
	LAD+RCA	5(8.3)	2(2.8)	
	LAD+ Trifurcation	2(3.3)	-	
	LAD+LCx	3(5.0)	1(1.4%)	
	LAD+RCA	2(3.3)	-	
	RCA+LCX+ LAD	2(3.3)	-	
	Trifurcation	-	1(1.4)	
Diseased Vessels	SVCAD	13(21.7)	34(47.9)	0.005
	DVCAD	25(41.7)	16(22.5)	
	TVCAD	22(36.7)	21(29.6)	
Multi Vessel PCI		15(25.0)	4(5.6)	0.002
Total Stent length(mm) (Mean±SD)		50.73±25.19	31.13±17.83	<0.001
Number of implanted stents	0	0(0.0)	2(2.8)	<0.001
	1	30(50.0)	61(85.9)	
	2	24(40.0)	6(8.5)	
	3	6(10.0)	2(2.8)	
Max Balloon Time(sec) (Mean±SD)		26.80±7.51	22.42±5.94	<0.001
Max Balloon Pressure(atm) (Mean±SD)		17.21±2.96	13.60±2.12	<0.001
Contrast Volume(ml) (Mean±SD)		152.33±49.918	116.90±39.87	<0.001
HS-cTn-I (ng/L) (Mean±SD)		225.31±166.82	20.91±10.23	-

LAD=Left Anterior Descending artery; LCx=Left circumflex Artery; RCA=Right coronary Artery; HS-cTn-I =High sensitivity cardiac troponin-I; PCI=Percutaneous Coronary Intervention.

exhibited that LAD artery was more frequently present in Group-II 39(54.9%) compared to Group-I 23(38.3%); and the Left Circumflex (LCx) artery was present in 13(18.3%) patients of Group-II and 9(15.0%) patients of Group-I. The Right Coronary Artery (RCA) showed almost similar distribution in both Group-I & II (23.3% vs 21.1%). However, association of target vessel between two study groups was insignificant (p=0.08).

Group-II showed a higher proportion of single-vessel disease compared to the Group-I [34(47.9%) vs 13(21.7%) respectively]. Conversely, double and triple-vessel disease was more prevalent in the Group-I compared to Group-II with statistically significant association (p=0.005). Multi-vessel PCI was performed more frequently in Group-I 15(25.0%) compared to Group-II 4(5.6%), (p=0.002).

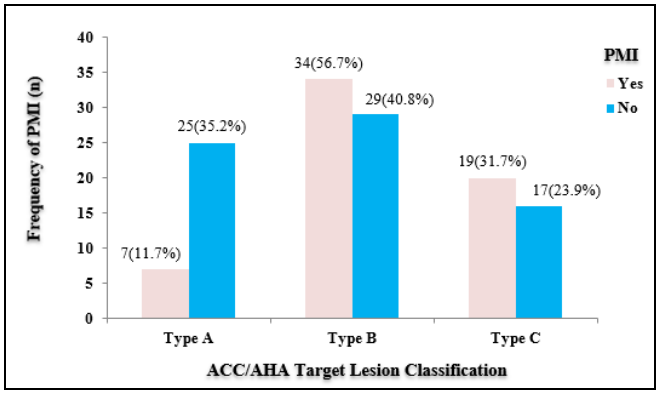

Figure-1: Frequency of PMI as per ACC/AHA Target Lesion Classification (n=131)

PMI=Peri-Procedural Myocardial Injury; ACC=American College of Cardiology; AHA=American Heart Association

Regarding procedural variables, Group-I exhibited significantly longer mean stent length (50.73±25.19mm) compared to Group-II (31.13±17.83mm) with significant mean difference (p<0.001). Single stent was employed in majority of the patients of both groups (50.0% vs 85.9%). Mean of maximum balloon time was longer in Group-I (26.80±7.51seconds) than in Group-II (22.42±5.94 seconds, p<0.001) and max balloon pressure and contrast volume were also significantly higher in group-I (p<0.001).

As illustrated in Figure-1, the incidence of PMI was higher in more complex target lesions based on AHA target lesion classification (Type B&C)

Angiographic characteristics of type A, B, and C lesions according to the modified ACC/AHA lesion classification

Type A	Type B*	Type C
Discrete	Tubular	Diffuse
Concentric	Eccentric	Extreme tortuosity
Readily accessible	Moderate tortuosity	Extremely angulated segment (>90°)
Non-angulated segment	Moderately angulated segment (45°–90°)	Total occlusion >3-month-old
Smooth contour	Irregular contour	Inability to protect major side branch
Little or no calcification	Moderate or heavy calcification	Degenerated vein graft lesion
Non-ostial	Total occlusion <3-month-old	
No major side branch involved	Ostial	
Absence of thrombus	Bifurcation	
	Thrombus present	

*B1: 1 adverse characteristic; B2: ≥2 adverse characteristics

Figure-2: ACC/AHA Classification of Target Lesion

DISCUSSION

The present study aimed to assess the occurrence of PMI after successful elective PCI using high-sensitivity troponin-I (HS-Trop-I) levels and to explore potential relationships with various clinical, angiographic, and procedural variables. The results of this study revealed that 60(45.8%) of patients had elevated HS-Trop-I levels (>40 ng/L), while 71(54.2%) had HS-Trop-I levels (40≤ng/L) after successful PCI. These findings indicated that PMI, as assessed by HS-Trop-I levels, is a common occurrence following elective PCI, consistent with previous study findings by Lansky AJ *et al.*[10]

The study investigated several clinical and demographic characteristics, including age, gender, and medical history, to explore their association with HS-Trop-I elevation. Although hypertension and previous myocardial infarction showed slightly higher prevalence in Group-I compared to Group-II, no statistically significant differences were observed for age, gender, and most disease histories between the two groups (p>0.05). This is consistent with the findings of Zeitouni M *et al.*, where they reported no significant association between these factors and HS-Trop-I elevation post PCI.[11] However, a past study reported conflicting results, with some suggesting an association between diabetes and increased troponin levels post PCI.[12] Therefore, further investigation is warranted to clarify the role of these risk factors in HS-Trop-I elevation after PCI.

Angiographic and procedural characteristics were also assessed to understand their impact on HS-Trop-I levels post PCI. The distribution of target vessels exhibited insignificant variations between the groups, with the LAD artery being more frequently involved in the HS-Trop-I (S≤40) group, while the LCx artery was involved more frequently in Group-I. These

differences in vessel distribution could potentially be attributed to variations in disease severity and lesion complexity, which have been previously associated with HS-Trop-I elevation, in consistent with results of past literature.[13,14] The mean number of diseased vessels was slightly higher in the Group-I, although this difference did not reach statistical significance. Interestingly, Group-I showed a higher proportion of patients with triple-vessel disease and multivessel PCI, which aligns with previous studies linking more extensive coronary artery disease with increased troponin release after PCI.[15,16]

Furthermore, procedural variables, such as total stent length, number of implanted stents, and max balloon time, were found to be significantly higher in Group-I. These findings were consistent with previous findings of Skorupski W *et al*., and Herman J *et al*., that suggested longer procedural times and greater stent complexity were associated with elevated troponin levels post PCI. Additionally, the occurrence of peri-procedural myocardial infarction (PMI) was significantly higher in Group-I, indicating that HS-Trop-I elevation is associated with a greater risk of myocardial injury during the PCI procedure. This observation was supported by previous studies that had linked HS-Trop-I elevation to adverse procedural outcomes.[15,17]

A significant difference in HS-Trop-I levels between the two groups was found in this study. Patients with HS-Trop-I (>40 ng/L) demonstrated substantially higher troponin levels, indicating more significant myocardial injury. This is in line with a research work done previously, where, findings showed that HS-Trop-I elevation to be a sensitive marker of myocardial damage after PCI.[18]

LIMITATIONS OF STUDY

This study was conducted in a single-center setting, which may introduce selection bias and limit the generalizability of the results to other populations. The cross-sectional design of our study restricts us from establishing a causal relationship between elective, successful PCI and PMI. Future studies with larger, multicenter cohorts are warranted to validate our findings.

Longitudinal studies with follow-up assessments would provide more robust evidence regarding the prognostic value of the PMI in predicting outcomes and guiding therapeutic interventions in patients

CONCLUSION

Peri procedural myocardial injury is a common complication of elective PCI, especially when patients present with high-risk features for PCI as demonstrated by increased complexity& severity of angiographic findings and procedural parameters (number of diseased vessels, total length of implanted stents and amount of contrast used). Hence, this underscores the importance of careful evaluation of angiogram with pre-procedural planning prior to an elective PCI, in order to minimize the incidence of myocardial injury.

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Conflict of Interest: None.

Authors' Contribution

Following authors have made substantial contributions to the manuscript:

FKT & MS: Concept, drafting the manuscript, data analysis, approval of final version to be published

IA & AS: Data acquisition, data analysis, critical review, approval of final version to be published

SP & ZA: Study design, data interpretation, critical review, approval of final version to be published

ZA & AHS: Data interpretation, critical review, approval of final version to be published

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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