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Predictors of Periprocedural Myocardial Injury Following Elective PCI

Khaled Elsayed Hamada [1], Mohammed Kamal Salama[1] , Wael Anwar Haseeb[1] , Reda Biomy Bastawisy [1]

[1]Cardiology Department, Kafrelsheikh University, 33516 Kafrelsheikh, Egypt

***Corresponding Author: (Khaled Hamada)**
Email: Kh.hamada90@gmail.com
Telephone: +201066096496
Address: 22-Alrouda St., Highway, Tanta, Egypt.31516.

Abstract

Background: Periprocedsural myocardial injury is associated with major adverse cardiovascular events (MACE) after percutaneous coronary intervention (PCI). The aim of this work was to evaluate the predictors of periprocedural myocardial injury following elective PCI.
Methods: This prospective observational cohort study was carried out on 300 adult cases of both sexes who were diagnosed with chronic coronary syndromes (CCS) and were treated by elective PCI and had normal baseline levels of high sensitivity cardiac troponin I (hs-cTnI). Patients were categorized into two groups according to the post-PCI hs-cTnI level: no post-PCI myocardial injury group with hs-cTnI level (≤99th percentile URL) and post-PCI myocardial injury group with elevation of hs-cTnI level > 99th percentile URL.
Results: The multivariate regression analysis illustrated that the age, stent number and total stent length were independent predictors of myocardial injury, while EF, lesion complexity, syntax score, PCI vessels number and average stent diameter were not. CV death, cardiac arrest, MI, MACEs and all cause death were significantly higher in group II than group I.
Conclusions: In CCS patients undergoing elective PCI, age, stent number and total stent length were independent predictors of myocardial injury. Myocardial injury with higher hs-cTnI level > 99th percentile URL was associated with higher risk of CV death, cardiac arrest, MI, MACEs and all cause death.

Keywords: MACEs, All-Cause Death, Periprocedural Myocardial Injury& PCI.

Introduction:

Percutaneous coronary interventions (PCI) are a widely used revascularization modality for patients with obstructive coronary artery disease (CAD), with an estimated 5 million procedures performed worldwide each year [1]. In a substantial number of PCI cases for acute coronary syndrome (ACS) and chronic coronary syndrome (CCS), periprocedural myocardial injury and infarction occur, the actual incidences of which depend on the cardiac biomarker measured and the definitions used [2].

Both these PCI-related complications may be associated with an increased risk of future major adverse cardiovascular events (such as death, re-infarction, and revascularization). Although the incidence rates of serious complications such as perforation and death have dramatically

decreased, periprocedural myocardial injury remains a common phenomenon after PCI, with a reported frequency of 3–50%, depending on variable biomarkers and thresholds [3, 4].

Although technical advances and new pharmacological therapies have drastically reduced PCI-related complications such as acute stent thrombosis or access site bleeding events, post-PCI increases in cardiac biomarkers are frequent, especially if high sensitivity cardiac troponins (hs-cTn) are systematically measured after the procedures [5].

The diagnostic and prognostic value of myocardial injury infarction associated with PCI is a subject of debate, particularly concerning the application of cardiac troponin [3].

The aim of this work was to evaluate the predictors of periprocedural myocardial injury following elective PCI.

Patients and Methods:

This prospective observational cohort study was carried out on 300 adult cases of both genders who were diagnosed with CCS and were treated by elective PCI. The work was performed from June 2021 to June 2023 following permission from the Ethics Committee Kafrelsheikh University Hospitals, Kafrelsheikh, Egypt. All participants provided a well-informed written consent.

Exclusion criteria were patients who presented with acute coronary syndromes (ACS); STEMI, non–STEMI, or unstable angina, patients with high baseline hs-cTnI levels, patients with missing post-PCI cardiac biomarkers levels, cardiogenic shock, end-stage renal disease (ESRD) and serious liver dysfunction.

All patients were subjected to history taking, clinical examination, laboratory investigations (Haemoglobin, serum creatinine and VIDAS® Highly sensitive Troponin I), surface ECG and trans-thoracic echocardiographic (TTE).

According to post-PCI hs-cTnI levels, the individuals were separated into two groups: no post-PCI myocardial injury group with normal hs-cTnI level (≤99th percentile URL) group and post-PCI myocardial injury group with elevation of hs-cTnI level > 99th percentile URL group [4].

Cardiac catheterization: All patients were subjected to ICA. Coronary angiography was evaluated by at least 2 experienced interventional cardiologists. Coronary lesions were classified into type A, type B1, type B2, and type C according to the ACC/AHA definition. Multivessel disease (MVD) was defined as luminal narrowing of ≥ 70% in ≥ two major coronary arteries or in one coronary artery plus a 50% or greater narrowing of the left main trunk. PCI was performed to angiographically significant lesions. Angiographically significant stenosis was defined as a luminal diameter reduction of ≥50% for LM disease as ≥70% for non-LM disease [7-9].

Follow-up: The follow-up phase lasted for a duration of twelve months. Follow-up data was collected via conducting interviews with people, either face-to-face or via telephone, as well as with their relatives.

The primary outcome of the study was to evaluate predictors of periprocedural myocardial injury after elective PCI.

Statistical analysis

Statistical analysis was done by SPSS v27 (IBM©, Armonk, NY, USA). Shapiro-Wilks test and histograms were used to evaluate the normality of the distribution of data. Quantitative

parametric data were presented as mean and standard deviation (SD) and were analysed by unpaired student t-test. Quantitative non-parametric data were presented as the median and interquartile range (IQR) and were analysed by Mann Whitney-test. Qualitative variables were presented as frequency and percentage (%) and analysed using the Chi-square test or Fisher's exact test when appropriate. Multivariate regression was also used to estimate the relationship between a dependent variable and more independent variables. A two-tailed P value < 0.05 was considered statistically significant.

Results

Gender, HTN, dyslipidaemia, smoking, family history, previous PCI, previous CABG, creatinine and haemoglobin were insignificantly different between both groups. Age, DM and previous myocardial infarction (MI) were significantly higher in group II than group I (P <0.05). EF was significantly lower in group II than group I (P =0.003). **Table 1**

Table 1: Demographic data and clinical characteristics of the studied groups

		Group I (n=70)	**Group II (n=230)**	**P value**
Age (years)		58.46 ± 13.29	63.05 ± 10.84	**0.004***
Gender	**Male**	44 (62.86%)	154 (66.96%)	0.526
	Female	26 (37.14%)	76 (33.04%)	
Risk factors	**HTN**	34 (48.57%)	134 (58.26%)	0.153
	DM	27 (38.57%)	129 (56.09%)	**0.01***
	Dyslipidaemia	41 (58.57%)	144 (62.61%)	0.543
	Smoking	31 (44.29%)	95 (41.3%)	0.658
	Family history	8 (11.43%)	24 (10.43%)	0.814
	Previous MI	8 (11.43%)	78 (33.91%)	**<0.001***
	Previous PCI	16 (22.86%)	46 (20%)	0.605
	Previous CABG	2 (2.86%)	7 (3.04%)	0.936
EF (%)		56.27 ± 9.67	52.05 ± 10.58	**0.003***
Creatinine (mg/dL)		1.12 ± 0.32	1.06 ± 0.39	0.218
Haemoglobin (g/dL)		12.73 ± 1.83	12.48 ± 1.27	0.202

Data are presented as mean ± SD or frequency (%). *: Statistically significant at p ≤ 0.05, HTN: Hypertension, DM: Diabetes mellitus, EF: Ejection fraction, MI: Myocardial infarction, PCI: Percutaneous coronary intervention, CABG: Coronary artery bypass graft.

Lesion complexity and PCI vessels number were significantly different between both groups. Syntax score, stents number, total stent length, average stent diameter and contrast volume were significantly higher in group II than group I. **Table 2**

Table 2: Angiographic & PCI characteristics of the studied groups

		Group I (n=70)	**Group II (n=230)**	**P value**
Diseased vessels	**LM**	2 (2.86%)	10 (4.35%)	0.577
	LAD	46 (65.71%)	169 (73.48%)	0.207
	LCX	30 (42.86%)	94 (40.87%)	0.767

	RCA	26 (37.14%)	97 (42.17%)	0.454
	RI	4 (5.71%)	15 (6.52%)	0.808
	SVG	2 (2.86%)	3 (1.3%)	0.374
Lesion complexity	**A**	26 (37.14%)	42 (18.26%)	**0.002***
	B1	19 (27.14%)	50 (21.74%)	
	B2	16 (22.86%)	78 (33.91%)	
	C	9 (12.86%)	60 (26.09%)	
Syntax score		12 (10 -15)	15.5 (12 -19)	**<0.001***
PCI vessels number	**1**	48 (68.57%)	117 (50.87%)	**0.031***
	2	17 (24.29%)	83 (36.09%)	
	3	5 (7.14%)	30 (13.04%)	
	MVD PCI	22 (31.43%)	113 (49.13%)	
Stenting parameters				
Pre-dilation		49 (70%)	156 (67.83%)	0.732
Direct stenting		23 (32.86%)	87 (37.83%)	0.450
Post-dilation		38 (54.29%)	146 (63.48%)	0.167
Stent number		2 (1 – 3)	2 (2 – 3)	**0.01***
Total stent length (mm)		52 (34.75 – 74.73)	64.4 (50.05 – 80.88)	**<0.001***
Average stent diameter (mm)		3.6 (3.13 – 3.88)	3.4 (2.9 – 3.9)	**0.004***
TIMI				
Before				
0		8 (11.43%)	11 (4.78%)	0.079
I		0 (0%)	9 (3.91%)	
II		13 (18.57%)	38 (16.52%)	
III		49 (70%)	172 (74.78%)	
After				
0		0 (0%)	0 (0%)	0.139
I		0 (0%)	0 (0%)	
II		0 (0%)	7 (3.04%)	
III		70 (100%)	223 (96.96%)	
Contrast volume (ml)		197.53 ± 25.81	211.1 ± 48.04	**0.024***

Data are presented as mean ± SD or frequency (%) or median (IQR). *: Statistically significant at $p \leq 0.05$, PCI: Percutaneous coronary interventionLM: Left main, LAD: Left anterior descending artery, LCX: Left circumflex artery, RCA: Right coronary artery, SVG: Saphenous vein graft, MVD: Multivessel disease, TIMI: Thrombolysis in myocardial infarction.

In univariate regression, age, EF, lesion complexity, syntax score, PCI vessels number, stent number, total stent length and average stent diameter were independent predictors of myocardial injury. In multivariate regression, age, stent number and total stent length were independent predictors of myocardial injury while EF, lesion complexity, syntax score, PCI vessels number and average stent diameter were not. **Table 3**

Table 3: Univariate and multivariate logistic regression analysis for the parameters affecting post-PCI myocardial injury

	Univariate			Multivariate		
	OD	**95% CI**	**P**	**OD**	**95% CI**	**P**
Age	1.069	1.027- 1.11	**0.001***	1.059	1.012 – 1.11	**0.013***
EF	0.957	0.92- 0.99	**0.028***	0.965	0.922 - 1.01	0.123
Lesion complexity	7.932	1.054 –59.67	0.044*	7.019	0.869 – 56.64	0.067
Syntax score	1.185	1.05-1.033	0.005*	1.153	0.998 – 1.33	0.053
PCI vessels number	3.019	1.27 -7.18	0.012*	1.767	0.666 – 4.689	0.253
Stent number	2.559	1.35 -4.85	0.004*	2.34	1.165 – 4.699	**0.017***
Total stent length	0.971	0.948 -0.994	0.014*	0.971	0.945 – 0.997	**0.033***
Average stent diameter	2.193	1.037 – 4.64	0.039*	2.102	0.852 – 5.188	0.107

*Significant as P value ≤0.05, CI: Confidence interval, EF: Ejection fraction, OD: odds ratio

CV death, cardiac arrest, MI, MACEs and all cause death were significantly higher in group II than group I (P <0.05). Rehospitalization for unstable angina (UA) was not different between both groups. **Table 4**

Table 4: Clinical outcomes at 12 months of the studied groups

	Group I (n = 70)	**Group II (n = 230)**	**P value**
CV death	0 (0%)	13 (5.65%)	**0.042***
Cardiac arrest	0 (0%)	14 (6.09%)	**0.035***
MI	1 (1.43%)	25 (10.87%)	**0.014***
Rehospitalization for UA	2 (2.86%)	9 (3.91%)	0.681
MACEs	1 (1.43%)	20 (8.7%)	**0.037***
All cause death	0 (0%)	13 (5.65%)	**0.042***

Data are presented as frequency (%) or median (IQR). *: Statistically significant at p ≤ 0.05, CV: Cardiovascular, MI: Myocardial infarction, UA: Unstable angina, MACEs: Major adverse cardiovascular event.

Discussion

Elective PCI is considered as a safe procedure, but the rate and prognosis of periprocedural myocardial injury is often underestimated [5]. In recent years, sensitive and specific biomarkers for myocardial injury, such as troponin, have been widely used in routine practice [10]. We measured hs-cTnI because it is more sensitive and specific and is now commonly recommended for the diagnosis of myocardial injury and MI.

The major findings in the present study reported that previous MI were significantly higher in group II with lower EF than group I. In agreement with our finding, Zeitouni et al. [5] showed that myocardial injury group had a significantly lower mean EF.

According to the present study, Lesion complexity, PCI vessels number, Syntax score, stents number, total stent length, average stent diameter and contrast volume were significantly higher in group II than group I. In accordance with the our results, Sarilar et al. [11] demonstrated that the mean syntax score was higher in myocardial injury compared to the control group. Also, Ndrepepa et al. [12] reported that complex lesions were significantly higher in myocardial injury groups compared to control group.

The current study demonstrated that the multivariate regression analysis illustrated that the age, stent number and total stent length were independent predictors of myocardial injury while EF, lesion complexity, syntax score, PCI vessels number and average stent diameter were not.

Our results were supported by Zeitouni et al. [5] who found that the patients with periprocedural MI and myocardial injury were older, had more frequently impaired renal function, multi-vessel disease as well as multiple stenting.

The multivariable logistic regression analysis by Zhou et al. [10] revealed that, in patients with periprocedural myocardial injury older age (65 years), prior PCI, multivessel disease (defined as target vessels 2), calcified plaque, higher Syntax scores, longer stent implantation with the use of a greater number of stents were independent predictors associated with periprocedural myocardial injury.

Periprocedural myocardial injury and infarction were predicted by the presence of multivessel artery disease, the use of retrograde approach and the occurrence of procedural complications [13].

The present study demonstrated a significantly elevated mean stent number, average total stent length and average stent diameter in the group II compared to group I. This could be explained by higher prevalence of DM and MVD PCI in group II than I. Ndrepepa et al. [12] showed that patients with myocardial injury had a statistically longer mean stent length compared to the control group.

Regarding Clinical outcomes at 12 months, the current study showed that CV death, cardiac arrest, MI, MACEs and all cause death were significantly higher in group II than group I.

Similarly, a meta-analysis showed the same results that patients with periprocedural myocardial injury had a higher incidence of MACE [14]. In Kong et al. [13] study, the results showed that patients in the periprocedural myocardial injury group had a higher risk of MACE in hospital and during one month follow up. This may be related to the presence of more procedural complications in the periprocedural myocardial injury group. Another research showed that severe dissection, hematoma and perforation affected the distal blood perfusion which increased the operation time as well as aggravated myocardial ischemia [15].

In accordance with our results, previous reports found that myocardial injury has already been associated with an increased short- and long-term mortality [5, 16]. Moreover, studies demonstrating that loss of viable myocardium is proportional to the extent of troponin elevation provide supportive arguments for the impact of myocardial injury, although probably driven by the highest increase in troponin release post-PCI [17].

Myocardial injury can be related to silent myocardial cell necrosis corresponding to microvascular perfusion impairment, thrombus micro-embolization, or slow-flow that could not be captured [18].

Patients who develop periprocedural myocardial injury tend to have more MACE than those who do not develop PMI [13]. Moreover, Lo et al. [19] reported that the incidence of MACE in patients with periprocedural myocardial injury was 1.5 times than the control group.

Different results were obtained by Zhou et al. [10] who found that the risk of death and MI did not increase with elevated values of cTnT, even when the level of cTnT increased more than 5 times the URL. This difference could be partially limited by the small sample number only 176

patients in the cohort had cTnT values more than 5xURL after PCI. However, the frequency of revascularization was significantly higher among patients with PMI.

A meta-analysis conducted by Feldman et al. [20], demonstrated that an elevation of cTnT after nonemergent PCI was predictive of an increase in long-term mortality as well as the composite adverse events of all-cause mortality/MI.

The mechanism of the association between periprocedural myocardial injury and short& long-term complications can be explained by that the long-term myocardial injury may impair left ventricular function and predispose to arrhythmias, resulting in increased the risk of adverse cardiovascular events [14]. Also, patients with elevated hs-cTn were more likely to have more severe coronary artery disease, complex lesion morphology, congestive heart failure, peripheral vascular disease, and the need for more advanced coronary interventions. Therefore, an elevated hs-cTn represented the severity of coronary atherosclerosis lesions, and which has been proved to have a significant relationship with the worse prognosis [21].

The present study had some limitations: This is a single-center experience including a limited number of patients. The follow up time was only one year; extended follow-up time may show different results. Patients who presented with ACS, history of ESRD and patients with elevated baseline cardiac biomarkers levels were not included in the study population. These patients represent a high-risk group with documented higher rates of MACEs. Less frequent use of intravascular imaging (IVUS and OCT) and invasive functional coronary assessment (FFR, IFR). More extensive use of these advanced modalities could have resulted in less unnecessary implantation of coronary stents, better identification of plaque morphology and enhanced technical results than conventional 2-D angiography guided PCI, especially in complex coronary interventions, with less incidence of MI and MACEs.

Conclusions:

In CCS patients undergoing elective PCI, age, stent number and total stent length were independent predictors of myocardial injury. Myocardial injury with higher hs-cTnI level > 99th percentile URL was associated with higher risk of CV death, cardiac arrest, MI, MACEs and all cause death.

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