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Original Article

Association Between Door to Balloon Time and Reperfusion with Left Ventricular Function and Heart Failure in Patients With ST Segment Elevated Myocardial Infarction Treated with Primary Percutaneous Intervention

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ABSTRACT

Objective: To determine the association between prolonged D2B time and heart failure in patients with STEMI treated with primary PCI.

Study Design: Prospective longitudinal study

Place and Duration of Study: Cardiology department of Punjab Institute of Cardiology, Lahore Pakistan, from Oct 2024 to Feb 2025.

Methodology: This study was carried out on 120 patients diagnosed with acute STEMI undergoing primary PCI after taking informed consent. Data was collected using pre-designed proforma. Patients were categorized into two groups based on door-to-balloon time, to compare the incidence of heart failure at 48 hours post-PCI. Relative risk was calculated, and data analysis was performed using SPSS version 26, with *p*-value <0.05 considered significant.

Results: Heart failure was observed in 23% exposed patients vs. 15% non-exposed patients, relative risk of heart failure in exposed group was 1.556 (95% CI: 0.730–3.317).

Conclusion: This study suggests that prolonged door-to-balloon time is linked to higher frequency of heart failure in patients with STEMI undergoing primary PCI, with relative risk indicating increased likelihood of heart failure in those with delayed intervention.

Keywords: Door to balloon time, heart failure, STEMI.

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INTRODUCTION

STEMI accounts for 38% among those presenting to hospital with acute coronary syndrome.[1] Its risk factors include hypertension, dyslipidemia, smoking, diabetes, and family history of coronary artery disease. Estimated annual incidence of MI is around 550,000 new cases and 200,000 recurrent cases, with 57% of cases occurring in men and 43% in women.[2]

Early revascularization is cornerstone of STEMI management. Initially, coronary reperfusion was achieved using thrombolytic, with success rates ranging from 40% to 70%, though associated with significant bleeding risk.[3] However, in past decade, primary PCI has transformed acute STEMI care, offering near-complete and rapid revascularization, significantly reducing cardiac muscle loss, complications, and mortality.[4] In PCI-capable facilities, goal is door-to-balloon (D2B) time of under 90 minutes, measured from emergency department arrival to guidewire passage across the culprit lesion.[5]

Despite significant advancements in treatment of acute STEMI over past two decades, MI remains leading cause of heart failure (HF).[6] Among patients with history of MI, development of HF increases overall mortality risk threefold and cardiovascular mortality fourfold.[7] The impact of D2B time on outcomes in STEMI patients has been extensively studied. Shorter D2B times have been consistently linked to improved clinical outcomes, including lower in-hospital and long-term mortality, reduced major adverse cardiac events, and better left ventricular function at discharge.[8] Studies indicate that delays in D2B time are associated with increased one-year mortality and higher risk of HF admissions. Patients with shorter D2B times tend to have better EF both immediately and at follow-up, along with improved blood flow in infarct-related artery and reduced rates of recurrent MI within 30 days.[9] While some studies have not found significant association between D2B time and HF incidence, others have reported higher

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risk of HF during hospitalization among patients with longer D2B times.[10]

We are conducted this study, because there is controversy in previous literature regarding association of delayed revascularization in STEMI patients in terms of reduced LVEF and incidence of new onset heart failure. Moreover, no local study conducted in this regard. This study will improve our strategy toward STEMI patients and hence will improve long term outcomes.

METHODOLOGY

After taking approval from the IRB (REF: RTPGME-Research-310; dated 10-10-2024, this prospective longitudinal stud was conducted at Cardiology department of PIC, Lahore from October 2024 to February 2025. This study was conducted on 120 patients meeting the selection criteria.

Inclusion Criteria: Patients of either gender, 20-60 years of age, diagnosed with acute STEMI (ST segment elevation > 1 mm in two contiguous limb leads and 2 mm in precordial leads or new-onset LBBB) presenting within 12 hours of symptoms onset and undergoing primary PCI were included.

Exclusion Criteria: Patients with heart failure at presentation, late presentation after symptoms onset (>12 hours), previous history of MI or CABG, pregnancy, alcoholism, chronic kidney disease (serum creatine >1.6mg/dl), chronic liver disease (liver cirrhosis on ultrasound, hepatitis B or C positive), or chronic obstructive pulmonary disease were excluded.

Sample size of 120 patients (60 in each group) was calculated using WHO sample size calculator, using 95% Confidence level, 80% power of test, and expected percentage of heart failure with prolonged D2B time taken as 53% vs 31% in without prolonged D2B time.[11] Patients were enrolled using non-probability consecutive sampling.

Patients were categorized into two groups: exposed group (prolonged D2B time >60 minutes), and non-exposed group, (without prolonged D2B time). Door to balloon time refers to time (minutes) interval between patient's arrival at hospital (door) and inflation of the balloon during PCI. The following demographic data of all patients was taken including name, age, gender, and time of presentation following symptoms onset. All patients had 12-lead ECG, transthoracic echocardiography and routine investigations including levels. Presence of risk factors were asked and noted including diabetes mellitus, hypertension, dyslipidemia, smoking, and family history of IHD. Baseline investigations including renal function tests, cardiac enzymes, and serial ECG's were done. Patients underwent echocardiography before PCI, and Pre PCI LVEF noted. All patients underwent PCI by same cardiologists team expert in relevant field for minimum duration of 4 years. Details of PCI procedure, including culprit artery, and number of vessels involved were noted. Reperfusion was declared at TIMI flow grade 3.[12] All patients remained in CCU for 24 hours. Door to balloon time was noted and patients were divided according to door to balloon time to compare incidence of heart failure (defined as Killip Class ≥2 or greater than 10% decline in LVEF from pre PCI) at 48hrs post PCI. The researcher was responsible for record maintenance, and data was collected manually using pre-designed proforma. Data was analyzed and entered in Statistical Package for the Social Sciences version 26. Quantitative variables like age, and LVEF presented as mean and standard deviation, whereas qualitative variables gender, risk factors, heart failure, and decline in LVEF presented as frequency and percentage. Relative risk was calculated to determine the association between D2B time and HF. Data was stratified for effect modifiers, post-stratification chi square test was applied and relative risk was also calculated, *p*-value <0.05 taken as significant.

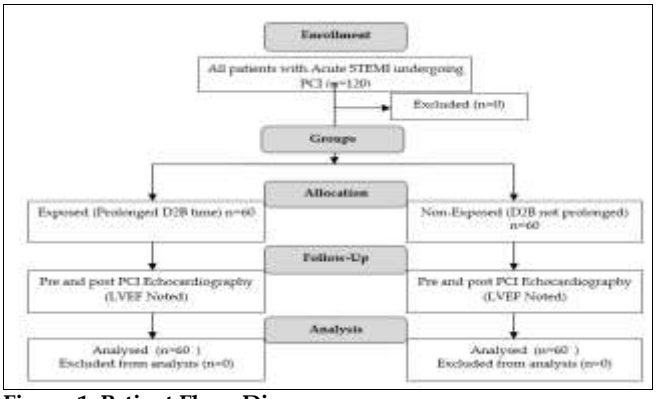

Figure-1: Patient Flow Diagram

RESULTS

A total of 120 patients with ST-segment elevation myocardial infarction (STEMI) were included in the study. The demographic characteristics of both exposed and non-exposed groups were comparable. Majority patients aged ≥50 years in both groups (60% in exposed group and 57% in non-exposed group; *p*=0.71). Regarding gender distribution, males

predominated in both groups, comprising 72% of exposed group and 73% of non-exposed group (p=0.83).

In terms of comorbid conditions, diabetes mellitus was found in 45% among group and 47% in non-exposed group (p=0.855), while hypertension was reported in 57% and 50%, respectively (p=0.46). Smoking was noted in 30% of exposed patients versus 35% of non-exposed patients (p=0.55). Dyslipidemia was present in 40% of exposed patients compared to 43% in non-exposed group (p=0.71). A family history of ischemic heart disease was found in 40% of exposed group versus 45% of non-exposed group (p=0.58).

Regarding angiographic findings, culprit vessel varied between groups. The left main coronary artery was involved in 30% of exposed versus 23% of non-exposed patients; LAD in 35% vs. 42%, RCA in 17% vs. 22%, and LCX in 18% vs. 13% (p=0.63). Most patients in both groups had single-vessel involvement (68% in exposed vs. 72% in non-exposed), while multi-vessel disease was observed in 32% vs. 28%, respectively (p=0.69).

Table-I: Comparison of Study Variables Among Exposed and Non-exposed (n=120)

		Prolonged D2B time (n=60)	Without prolonged D2B time (n=60)	*p*-value
Age	<50 years	24 (40%)	26(43%)	0.71
	≥ 50 years	36 (60%)	34(57%)	
	Mean±SD	51.88±6.47	51.21±6.88	0.58
Gender	Male	43 (72%)	44(73%)	0.83
	Female	17 (28%)	16(27%)	
DM	Yes	27 (45%)	28(47%)	0.855
	No	33 (55%)	32(53%)	
HTN	Yes	34 (57%)	30(50%)	0.46
	No	26 (43%)	30(50%)	
Smoking	Yes	18 (30%)	21(35%)	0.55
	No	42 (70%)	39(65%)	
Dyslipidemias	Yes	24 (40%)	26(43%)	0.71
	No	36 (60%)	34(57%)	
Family history of IHD	Yes	24 (40%)	27(45%)	0.58
	No	36 (60%)	33(55%)	
Culprit artery	Left Main	18 (30%)	14(23%)	0.63
	LAD	21 (35%)	25(42%)	
	RCA	10 (17%)	13(22%)	
	LCX	11 (18%)	8(13%)	
Vessels involved	Single	41 (68%)	43(72%)	0.69
	Multiple	19 (32%)	17(28%)	
LVEF (%)	Pre PCI	48.41±4.75	47.40±4.34	0.22
	Post PCI	44.55±7.85	43.75±5.49	0.51

As shown in Table II; heart failure was observed in 23% exposed patients vs. 15% non-exposed patients, relative risk of heart failure in exposed group was 1.556 (95% CI: 0.730–3.317), indicating higher risk among exposed patients, however, this difference was not significant; p=0.246.

Table-II: Frequency of Heart Failure Among Exposed vs Non-exposed and Relative Risk (n=120)

Group		Heart failure		Relative risk	95% Confidence interval		*p*-value
		Yes	No		Lower	Upper	
Prolonged D2B time	Frequency(%)	14 (23%)	46 (77%)	RR=1.556	0.730	3.317	0.246
Without prolonged D2B time	Frequency (%)	9 (15%)	51 (85%)				

Data was stratified as shown in Table III; relative risk of heart failure was found to be higher among patients aged less than 50 years (RR=1.62, 95% CI: 0.521–5.066, p=0.39) compared to those aged 50 years or older (RR=1.51, 95% CI: 0.548–4.167, p=0.41). Similarly, patients with family history of IHD had higher RR (RR=2.25, 95% CI: 0.631–8.02, p=0.194) compared to those without family history of IHD (RR=1.22, 95% CI: 0.474–3.15, p=0.67). Among gender groups, females had higher RR (RR=1.88, 95% CI: 0.564–6.288, p=0.28) compared to males (RR=1.36, 95% CI: 0.516–3.604, p=0.52). Patients without DM had higher RR (RR=2.58, 95% CI: 0.752–8.88, p=0.11) than those with DM (RR=1.03, 95% CI: 0.381–2.82, p=0.94). Similarly, patients without HTN had higher RR (RR=2.30, 95% CI: 0.640–8.321, p=0.184) compared to hypertensive patients (RR=1.17, 95% CI: 0.461–3.005, p=0.733). RR was found to be higher among smokers (RR=1.75, 95% CI: 0.328–9.34, p=0.50) compared to non-smokers (RR=1.45, 95% CI: 0.629–3.38, p=0.37). Patients with dyslipidemia had increased RR (RR=2.16, 95% CI: 0.608–7.71, p=0.21) compared to those without dyslipidemia (RR=1.25, 95% CI: 0.487–3.25, p=0.63). However, none of these associations reached statistical significance at p<0.05.

DISCUSSION

In current study, majority of patients with STEMI in both groups were male and belonged to age group ≥ 50 years. Previous study by Oliveira et al. reported mean age of 69.1 years for women with STEMI, compared to 58.5 years for men. However, we did not stratify age according to gender in our analysis.[13] Similarly, Kuehnemund *et al*., found that STEMI was

Table-III: Association of Study variables and RR calculation (n=120)

Effect modifiers		Heart failure	Groups		Relative risk	95% Confidence interval		*p*-value
			Prolonged D2B time	Without prolonged D2B time		Lower	Upper	
Age	<50 years	Yes	6(60%)	4(40%)	1.62	0.521	5.066	0.39
		No	18(45%)	22(55%)				
	≥ 50 years	Yes	8(61.5%)	5(38.5%)	1.51	0.548	4.167	0.41
		No	28(49.1%)	29(50.9%)				
Gender	Male	Yes	8(57%)	6(43%)	1.36	0.516	3.604	0.52
		No	35(48%)	38(52%)				
	Female	Yes	6(67%)	3(33%)	1.88	0.564	6.288	0.28
		No	11(46%)	13(54%)				
DM	Yes	Yes	6(50%)	6(50%)	1.03	0.381	2.82	0.94
		No	21(49%)	22(51%)				
	No	Yes	8(73%)	3(27%)	2.58	0.752	8.88	0.11
		No	25(46%)	29(53%)				
HTN	Yes	Yes	8(57%)	6(43%)	1.17	0.461	3.005	0.73
		No	26(52%)	24(48%)				
	No	Yes	6(67%)	3(33%)	2.30	0.640	8.321	0.18
		No	20(43%)	27(57%)				
Smoking	Yes	Yes	3(60%)	2(40%)	1.75	0.328	9.34	0.50
		No	15(44%)	19(56%)				
	No	Yes	11(61%)	7(39%)	1.45	0.629	3.38	0.37
		No	31(49%)	32(51%)				
Family history of IHD	Yes	Yes	6(67%)	3(33%)	2.25	0.631	8.02	0.19
		No	18(43%)	24(57%)				
	No	Yes	8(57%)	6(43%)	1.22	0.474	3.15	0.67
		No	28(51%)	27(49%)				
Dyslipidemias	Yes	Yes	6(67%)	3(33%)	2.16	0.608	7.71	0.21
		No	18(44%)	23(56%)				
	No	Yes	8(57%)	6(43%)	1.25	0.487	3.25	0.63

more common among men (64.7%) than women (35.3%).[14]

Heart failure was observed in 23% of patients with prolonged D2B time compared to 15% of those with shorter D2B time, yielding RR 1.556. Incidence of heart failure in patients with prolonged D2B times following STEMI is significant concern.[7] Consistent with our findings, Karkabi *et al*., reported heart failure in 18% of patients with prolonged D2B times, compared to 9.5% in those with shorter D2B times.[15] Prolonged D2B times are associated with increased mortality and adverse clinical outcomes. In cohort of 700 STEMI patients, 15.7% developed heart failure during median follow-up of 43.6 months. Predictors of heart failure included advanced age, diabetes, and left ventricular ejection fraction <50%. The same study identified D2B time as an independent predictor of heart failure, with hazard ratio of 1.002, suggesting slight but measurable increase in risk with prolonged D2B times.[6]

Similarly, another study supported our findings, demonstrating an association between prolonged D2B times and adverse outcomes, including heart failure, with a relative risk of 2.37 (p=0.06).[16] In contrast, analysis by Marcusohn *et al*., found no significant impact of D2B time on heart failure incidence, although longer D2B times were linked to higher mortality and increased recurrence of acute coronary syndrome.[17] Furthermore, meta-analysis suggested that while prolonged D2B times are strongly correlated with higher mortality rates, direct relationship between D2B time and heart failure incidence remains inconclusive.[18]

Early hospital presentation has been strongly associated with shorter D2B times and improved clinical outcomes. One study found that patients treated within 90 minutes had significantly better prognoses, with variations observed based on age and gender, supporting our current findings.[19,20]

Overall, the findings indicate that prolonged D2B time is associated with worse clinical outcomes,

including higher incidence of heart failure, increased mortality, and adverse cardiac events. While some studies suggest no direct impact on heart failure, the correlation between delayed intervention and poorer prognosis remains evident.

LIMITATIONS OF STUDY

We did not investigate the factors contributing to prolonged D2B time, which could provide deeper insights into delays in treatment. Additionally, the study did not include long-term follow-up of patients, limiting our ability to assess the sustained impact of prolonged D2B time on clinical outcomes.

CONCLUSION

This study suggests that prolonged D2B time is linked to higher frequency of heart failure in patients with STEMI undergoing primary PCI, with relative risk indicating increased likelihood of heart failure in those with delayed intervention.

Conflict of Interest: None.

Funding Source: None.

Authors' Contribution

Following authors have made substantial contributions to the manuscript as under:

MT & SA: Data acquisition, data analysis, critical review, approval of the final version to be published.

MJ & MK: Study design, data interpretation, drafting the manuscript, critical review, approval of the final version to be published.

H & SJD: Conception, data acquisition, drafting the manuscript, approval of the 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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