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ORIGINAL ARTICLE

Predictors of Suboptimal Coronary Blood Flow during Primary Percutaneous Intervention

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ABSTRACT
Background and aim: Suboptimal coronary blood flow following first percutaneous coronary intervention (PCI) is a multivariate phenomenon with several causes. Despite substantial research, recognized modifiable risk factors and an effective management plan are lacking. The present study intended to determine the several causes of suboptimal coronary blood flow during primary percutaneous intervention.
Patients and Method: A retrospective study was carried out on 486 STEMI patients in the Interventional Cardiology Department, MTI-Hayatabad Medical Complex, Peshawar from June 2021 to May 2022. Patients (age>20 years) presented with initial percutaneous coronary intervention within 12 hours after onset of symptoms were enrolled. Patients' physical examination, medical history, different risk factors, vital signs assessment, echocardiography, Killip class, laboratory investigation, and post-procedural ECG were recorded along with PCI data and associated catheterization. Clinical outcomes included MACE, ischemia-driven target vessel revascularization, reinfection, cardiac mortality, and post-catheterization were recorded. Descriptive statistics was done in SPSS version 26.
Results: Of the total 486 STEMI patients, there were 412 (84.8%) male and 74 (15.2%) females. The overall mean age was 52.62± 8.64 years. The incidence of suboptimal flow (TIMI flow ≤2) and optimal flow (TIMI-3 flow) were 112 (23%) and 374 (77%) respectively. Age [OR 1.041/year: p<0.001], total stent length [OR 1.019 per 1 mm], low SBP [OR 1.021 per mm Hg], thrombus burden grade [OR 1.78], and baseline TIMI flow (≤1) [OR 1.72; p=0.021] were suboptimal flow independent predictors. Cardiac mortality and MACE were significantly higher after 30-days in suboptimal flow as compared to optimal flow. The prevalence of in-hospital mortality in suboptimal flow and optimal flow was 9.1% and 2.1% respectively.
Conclusion: The present study found that suboptimal coronary flow after first PCI is substantially associated with higher in-hospital and cardiovascular mortality in STEMI. The most significant predictor of poor coronary flow is predilatation prior to stenting.
Keywords: Suboptimal coronary flow, Primary percutaneous intervention, Predictors

INTRODUCTION
Acute ST-elevation myocardial infarction patients could be effectively treated with primary percutaneous coronary intervention (PCI). After first percutaneous coronary intervention (PCI), there are several factors that contribute to an inadequate coronary blood flow [1, 2]. Despite extensive investigation, there are no identified modifiable risk factors or an effective management approach. In elevated facilities, patients having primary PCI have better ventricular function and reduced mortality rates [3, 4]. Even in the present era of stenting and appropriate pharmacotherapy, initial PCI is related with a 4-11% incidence of inadequate coronary flow [thrombolysis in myocardial infarction (TIMI) r 2]. Furthermore, TIMI of up to 2 flows has been related to a poor outcome [5-7]. Epicardial coronary vessels obstruction including dissection, residual stenosis, and thrombus and vascular endothelium (plaque debris, reperfusion injury, thrombotic distal embolization, and leukocyte) and coronary microcirculation disturbance level have been explained by many mechanism [8, 9].

There is a lack of information regarding the predictors and suboptimal TIMI flow impacts of primary PCI as well as effective management strategies. Patients with acute anterior STEMI were identified as being at significant risk of developing suboptimal coronary blood flow if their left anterior descending (LAD) artery impact was minimized [10, 11]. Consequently, the current study aimed to identify predictors of suboptimal coronary blood flow during primary percutaneous intervention.

METHODOLOGY
A retrospective study was carried out on 486 STEMI patients in the Interventional Cardiology Department, MTI-Hayatabad Medical Complex, Peshawar from June 2021 to May 2022. Patients (age>20 years) presented with initial percutaneous coronary intervention within 12 hours after onset of symptoms were enrolled. Study protocol was approved by research and ethical committee. Patient's physical examination, medical history, different risk factors, vital signs assessment, Killip class, echocardiography, laboratory investigation, and post-procedural ECG were recorded along with PCI data and associated catheterization. Clinical outcomes included MACE, ischemia-driven target vessel revascularization, reinfection, cardiac mortality, and post-catheterization were assessed. Risk factors associated clinical history included age, diabetes, gender, smoking, hypertension, myocardial infarction, hypercholesterolemia, family history of cardiovascular disease, and PCI were recorded. Duration of chest pain onset-toreperfusion and door-to-balloon were recorded.

Laboratory findings regarding cardiac catheterization were recorded. ECG (12-lead) were performed in each individual after hospitalization. Typical ischemic chest pain with electrocardiograph lasted for ≥20 min with elevated cardiac biomarkers were defined as anterior STEMI. Coronary angiography confirmed by LAD and left lesion diagnosis. Total leucocytic count, hemoglobin, blood glucose level, serum creatinine, and platelets were included in laboratory investigation. The data was analyzed using SPSS version 26. Continuous variables were expressed as means and standard deviations. Frequency and percentage were used to describe categorical variables. Predictor power was determined by multiple regression analysis. All statistical analysis was carried out on 95% confidence interval and 5% level of significance.

RESULTS
Of the total 486 STEMI patients, there were 412 (84.8%) male and 74 (15.2%) females. The overall mean age was 52.62± 8.64 years. The incidence of suboptimal flow (TIMI flow ≤2) and optimal flow (TIMI-3 flow) were 112 (23%) and 374 (77%) respectively. Age [OR 1.041/year: p<0.001], total stent length [OR 1.019 per 1 mm], low SBP [OR 1.021 per mm Hg], thrombus burden grade [OR 1.78], and baseline TIMI flow (≤1) [OR 1.72; p=0.021] were

suboptimal flow independent predictors. Cardiac mortality and MACE were significantly higher after 30-days in suboptimal flow as compared to optimal flow. The prevalence of in-hospital mortality in suboptimal flow and optimal flow was 9.1% and 2.1% respectively. Figure-1 illustrate the gender's distribution. Prevalence of optimal and suboptimal flow is depicted in Figure-2. Baseline characteristics are shown in Table-I. Incidence of potential risk factors are shown in Figure-3. Table-II represent the primary PCI procedure and angiographic data. Multivariate regression analysis of independent risk factors are shown in Table-III.

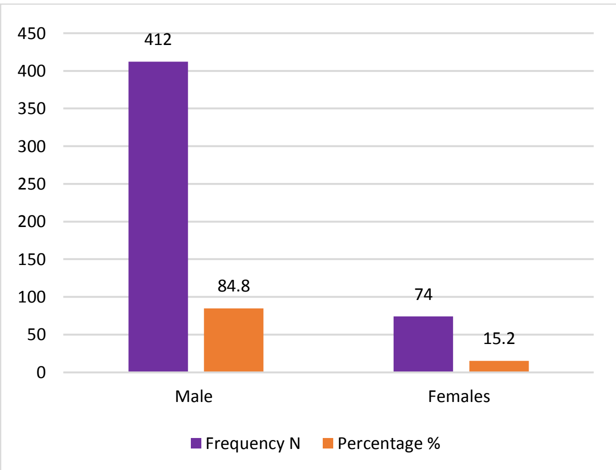

Figure-1: Gender's distribution

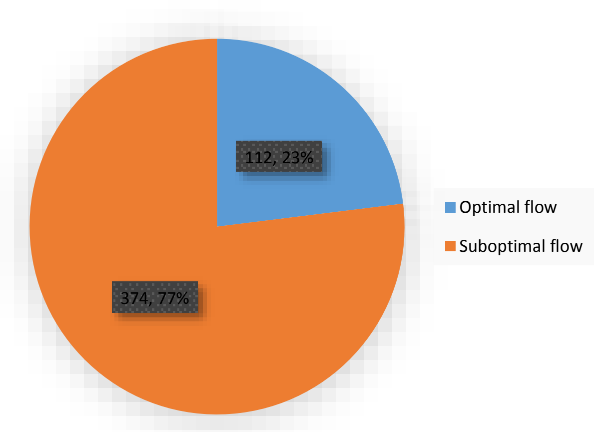

Figure-2: Prevalence of optimal and suboptimal flow

Table-1: Baseline characteristics

Parameters	Suboptimal flow (n=112)	Optimal flow (n=374)	P-value
Mean age (yrs.)	51.82± 7.92	53.42± 9.36	<0.001
Mean weight (kg)	68.62± 14	70.82± 10	0.135
Total ischemic time	4.3 (2.5–7.9)	4.9 (2.5–7.5)	0.237
Mean systolic blood pressure, mm Hg	126.7 ± 20.8	134.8 ± 20.6	< 0.001
Mean diastolic blood pressure, mm Hg	80.8 ± 10.6	86.4 ± 12.6	< 0.001
Killip class > 1, n (%)	40 (35.7)	92 (24.6)	< 0.001
Mean serum Creatinine, umol/L	68.2 ± 18.42	64.82 ± 16.82	0.011
Mean HDL cholesterol, mmol/L	1.02 ± 0.32	1.04 ± 0.37	0.134
Mean LDL cholesterol, mmol/L	2.62 ± 0.98	2.61 ± 0.95	0.213

Table-2: primary PCI procedure and angiographic data

Parameters	Suboptimal flow (n=112)	Optimal flow (n=374)	P-value
Left main involvement N (%)	18 (16.1)	48 (12.8)	<0.001
LAD lesion location N (%)			0.561
Proximal	88 (78.6)	264 (70.6)	
Mid	20 (17.9)	106 (28.3)	
Distal	4 (3.6)	4 (1.1)	
Approach n (%)			0.426
Radial	105 (93.8)	358 (95.7)	
Femoral	7 (6.2)	16 (4.3)	
Stents, n (%)			0.005
PTCA	3 (2.7)	14 (3.7)	
One	59 (52.7)	250 (66.8)	
Two	42 (37.5)	108 (28.9)	
Three	8 (7.1)	2 (0.5)	
Thrombus Aspiration, n (%)	44 (39.3)	98 (26.2)	0.002

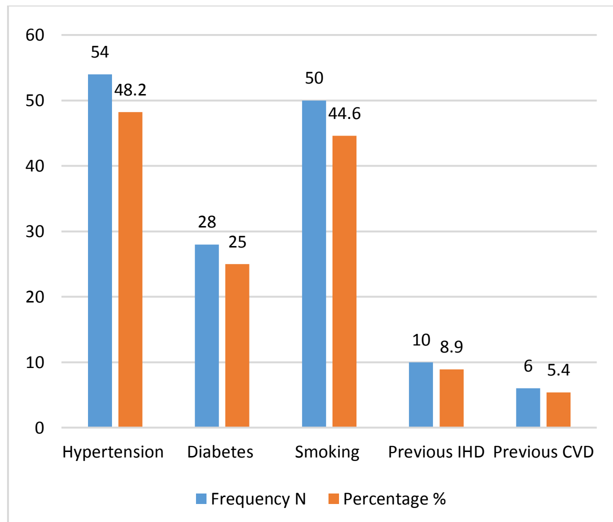

Figure-3: Incidence of potential risk factors

Table 3: Multivariate regression analysis of independent risk factors

Independent risk factors	Odd Ratio (OR), 95% CI	P-value
Age	1.041/year	<0.001
Total stent length	1.019 per 1 mm	0.021
Low SBP	1.021 per mm Hg	0.021
Thrombus burden grade	1.78	0.019
Baseline TIMI flow (≤1)	1.72	0.021

DISCUSSION

The present study mainly focused on potential risk factors and predictor of coronary blood flow during primary percutaneous intervention and reported that suboptimal coronary flow after first PCI is substantially associated with higher in-hospital and long-term cardiovascular mortality in STEMI. The most significant predictor of poor coronary flow is predilatation prior to stenting. Regardless of PCI modalities development, normal TIMI flow through interventional devices are difficult to achieve in anterior STEMI patients and significantly related with specific factors such as lower SBP and age and angiographic factors like heavy thrombus, baseline TIMI flow (≤1), and total stent length. A higher cardiac mortality was found in suboptimal flow as compared to optimal flow. Additionally, cardiogenic shock, increased CK, malignant arrhythmias, and heart failure were significantly associated with MACE and cardiac mortality.

Numerous studies carried out on 1st generation DES included in STEMI patients in the bare metal stent era extended up to 24 hours [12, 13]. The suboptimal flow higher rate (23%) was observed as compared to previously reported 5% to 23% [14, 15].

Various studies demonstrated an association between increased incidence of suboptimal flow and larger infarct size [16]. The largest myocardial infarction has been accounted for typical proximal LAD in IRA lesion [17]. Previous few studies reported that increased heart rate, advance age, lower SBP, and LVEF <50% were TIMI flow suboptimal predictors and higher in-hospital mortality [18, 19].

Following primary PCI, coronary blood flow sub optimality is independently predicted by thrombus burden. In contrast, another study by McNamara et al [20] reported that STEMI patients with minimal thrombus burden could be happened in suboptimal coronary flow and prolong reperfusion times. Suboptimal flow could developed by microvascular circulation caused by adverse effected prolong ischemia [21]. No significant association has been correlated between TIMI flow and ischemic time that resembles with previous studies [22, 23].

The present study found that mean total stent length was 34.8 mm that was longer than previous studies [24, 25]. Moreover, it is possible to achieve optimal expansion and angiographic results following stent deployment by routine balloon predilation and NC balloon postdilation. PCI strategy has been increasingly used for suboptimal flow higher incidence in contemporary exercise. The pre- and post-dilatation lengths and the stent length increase the opportunity for mechanical fragmentation of the plaque and subsequent dislodgement of the thrombus [26].

The adverse outcomes could be mainly indicated after primary PCI leading to suboptimal coronary blood flow as reported in the present study. Early identification, effective management, and risk factors control in suboptimal TIMI flow are necessary [27]. Low systolic blood pressure, baseline TIMI flow ≤1, heavy thrombus burden, and longer stent use were significant and independent risk factors for suboptimal flow in the current study.

Suboptimal flow was mostly experienced in cardiogenic shock and hypertension in patients. Patients with hypertension who have appropriate vasopressors and other hemodynamic devices may aid to maintain myocardial perfusion pressure and microvascular permeability to enhance primary PCI results and distal TIMI flow [28, 29]. IRA restoring patency is significantly associated with better outcomes [30].

Suboptimal flow effective treatment is not currently available and suboptimal flow development is still avoided. Heart attack increase awareness symptoms and immediate medical care seeking measures should be implied. Additionally, interventional techniques must be followed for prevention of abnormalities and minimizing the door-to-ballooon time.

CONCLUSION

The present study found that suboptimal coronary flow after first PCI is substantially associated with higher in-hospital and long-term cardiovascular mortality in STEMI. The most significant predictor of poor coronary flow is predilatation prior to stenting.

REFERENCES

1. Elakabawi K, Huang X, Shah SA, Ullah H, Mintz GS, Yuan Z, Guo N. Predictors of suboptimal coronary blood flow after primary angioplasty and its implications on short-term outcomes in patients with acute anterior STEMI. BMC Cardiovascular Disorders. 2020 Dec;20(1):1-2.
2. Thygesen K, Alpert JS, Jaffe AS, Chaitman BR, Bax JJ, Morrow DA, et al. Fourth universal definition of myocardial infarction (2018). Russian J Cardiol. 2019;24:107–38. https://doi.org/10.15829/1560-4071-2019-3-107-138.
3. Heusch G, Skyschally A, Kleinbongard P. Coronary microembolization and microvascular dysfunction. Int J Cardiol. 2018;258:17–23. https://doi.org/10.1016/j.ijcard.2018.02.010.
4. Nakahashi T, Sakata K, Masuda J, Kumagai N, Higuma T, Ogimoto A, Tanigawa T, Hanada H, Nakamura M, Takamura M, Dohi K. Impact of hyperuricemia on coronary blood flow and in-hospital mortality in patients with acute myocardial infarction undergoing percutaneous coronary intervention. Journal of Cardiology. 2022 May 17.
5. Rashed MI, Saleh MA, Elfekky EM, Elmahmoudy AM. CHA2DS2 VASc score and brachial artery flow-mediated dilation as predictors for no-reflow phenomenon in patients with ST-segment elevation myocardial infarction undergoing primary percutaneous coronary intervention. The Egyptian Heart Journal. 2022 Dec;74(1):1-8.
6. Kobayashi S, Sakakura K, Jinnouchi H, Taniguchi Y, Tsukui T, Watanabe Y, Yamamoto K, Seguchi M, Wada H, Fujita H. Comparison of door-to-balloon time and in-hospital outcomes in patients with ST-elevation myocardial infarction between before versus after COVID-19 pandemic. Cardiovascular Intervention and Therapeutics. 2022 Jan 10:1-0.
7. S.H. Rezkalla, R.V. Stankowski, J. Hanna, et al. Management of no-reflow phenomenon in the catheterization laboratory JACC Cardiovasc Interv, 10 (3) (2017), pp. 215-223.
8. Refaat H, Tantawy A, Gamal AS, Radwan H. Novel predictors and adverse long-term outcomes of No-reflow phenomenon in patients with acute ST elevation myocardial infarction undergoing primary percutaneous coronary intervention. Indian Heart Journal. 2021 Jan 1;73(1):35-43.
9. J. Tian, Y. Liu, Y. Liu, et al. Prognostic association of circulating neutrophil count with no-reflow in patients with ST-segment elevation myocardial infarction following successful primary percutaneous intervention Dis Markers (2017), Article 8458492.
10. S. Choudhary Association of syntax score with short-term outcomes among acute ST-elevation myocardial infarction patients undergoing primary PCI Indian Heart J, 69 (1) (2017), pp. S20-S23.
11. S. Gupta, M.M. Gupta No reflow phenomenon in percutaneous coronary interventions in ST-segment elevation myocardial infarction Indian Heart J, 68 (4) (2016), pp. 539-551.
12. P. Sabin, A.G. Koshy, P.N. Gupta, et al. Predictors of no-reflow during primary angioplasty for acute myocardial infarction, from Medical College Hospital, Trivandrum Indian Heart J, 69 (1) (2017), pp. S34-S45.
13. K. Thygesen, J.S. Alpert, A.S. Jaffe, et al. Fourth universal definition of myocardial infarction J Am Coll Cardiol, 72 (18) (2018), pp. 2231-2264.
14. M. Noguchi, J. Ako, T. Morimoto, et al. Modifiable factors associated with prolonged door to balloon time in patients with ST-segment elevation myocardial infarction undergoing primary percutaneous coronary intervention Heart Ves, 33 (10) (2018), pp. 1139-1148.
15. Elakabawi K, Huang X, Shah SA, Ullah H, Mintz GS, Yuan Z, et al. Predictors of suboptimal coronary blood flow after primary angioplasty and its implications on short-term outcomes in patients with acute anterior STEMI. BMC Cardiovasc Disord. 2020;20(1):391.
16. Kobayashi, S., Sakakura, K., Jinnouchi, H. et al. Comparison of door-to-balloon time and in-hospital outcomes in patients with ST-elevation myocardial infarction between before versus after COVID-19 pandemic. Cardiovasc Interv and Ther 37, 641–650 (2022). https://doi.org/10.1007/s12928-022-00836-4
17. Zhu QY, Tai S, Tang L, Peng W, Zhou SH, Liu ZG, et al. STEMI could be the primary presentation of acute aortic dissection. Am J Emerg Med. 2017;35(11):1713–7.
18. Ali M, Lange SA, Wittlinger T, Lehnert G, Rigopoulos AG, Noutsias M. In-hospital mortality after acute STEMI in patients undergoing primary PCI. Herz. 2018;43(8):741–5.
19. Shiomi H, Nakagawa Y, Morimoto T, Furukawa Y, Nakano A, Shirai S, et al. Association of onset to balloon and door to balloon time with long term clinical outcome in patients with ST elevation acute myocardial infarction having primary percutaneous coronary intervention: observational study. BMJ. 2012;344:e3257.
20. McNamara RL, Wang Y, Herrin J, Curtis JP, Bradley EH, Magid DJ, et al. Effect of door-to-balloon time on mortality in patients with ST-segment elevation myocardial infarction. J Am Coll Cardiol. 2006;47(11):2180–6.
21. Nallamothu BK, Normand S-LT, Wang Y, Hofer TP, Brush JE, Messenger JC, et al. Relation between door-to-balloon times and mortality after primary percutaneous coronary intervention over time: a retrospective study. Lancet. 2015;385(9973):1114–22.
22. Foo CY, Bonsu KO, Nallamothu BK, Reid CM, Dhippayom T, Reidpath DD, et al. Coronary intervention door-to-balloon time and outcomes in ST-elevation myocardial infarction: a meta-analysis. Heart. 2018;104(16):1362–9.
23. Tsukui T, Sakakura K, Taniguchi Y, Yamamoto K, Seguchi M, Wada H, et al. Association between the door-to-balloon time and mid-term clinical outcomes in patients with ST-segment elevation myocardial infarction. Intern Med. 2020;59(13):1597–603.
24. Sawano M, Yamaji K, Kohsaka S, Inohara T, Numasawa Y, Ando H, et al. Contemporary use and trends in percutaneous coronary intervention in Japan: an outline of the J-PCI Registry. Cardiovasc Interv Ther. 2020;35(3):218–26.
25. Tsukui T, Sakakura K, Taniguchi Y, Yamamoto K, Wada H, Momomura SI, et al. Determinants of short and long door-to-balloon time in current primary percutaneous coronary interventions. Heart Vessels. 2018;33(5):498–506.
26. Sim WJ, Ang AS, Tan MC, Xiang WW, Foo D, Loh KK, et al. Causes of delay in door-to-balloon time in south-east Asian patients undergoing primary percutaneous coronary intervention. PLoS ONE. 2017;12(9):e0185186.
27. Tungsubutra W, Ngoenjan D. Door-to-balloon time and factors associated with delayed door-to-balloon time in ST-segment elevation myocardial infarction at Thailand's largest tertiary referral centre. J Eval Clin Pract. 2019;25(3):434–40.
28. R.W. Harrison, A. Aggarwal, F.S. Ou, et al. Incidence and outcomes of no-reflow phenomenon during percutaneous coronary intervention among patients with acute myocardial infarction Am J Cardiol, 111 (2) (2013), pp. 178-184.
29. J.K. Fajar, T. Heriansyah, M.S. Rohman The predictors of no reflow phenomenon after percutaneous coronary intervention in patients with ST elevation myocardial infarction: a meta-analysis Indian Heart J, 70 (3) (2018), pp. S406-S418.
30. M. Süleymanoğlu, I. Rencüzoğullari, Y. Karabağ, et al. The relationship between atherogenic index of plasma and no-reflow in patients with acute ST-segment elevation myocardial infarction who underwent primary percutaneous coronary intervention Int J cardiovasc Imaging, 36 (5) (2020), pp. 789-796.