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Original Article

Association of Hemoglobin Level with In-Hospital Outcomes in Patients with STEMI Treated with Primary Percutaneous Coronary Intervention

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Abstract

Objectives: This study aimed to investigate the relationship between post-percutaneous coronary intervention (PCI) hemoglobin levels and in-hospital outcomes in patients with ST-elevation myocardial infarction (STEMI).

Methodology: A retrospective cohort study was conducted on 120 STEMI patients undergoing primary PCI at Hayatabad Medical Complex, Peshawar, from January to December 2023. Patients were stratified into three groups based on post-PCI hemoglobin levels: normal, mildly anemic, and severely anemic. Inclusion criteria included STEMI patients aged ≥18 years with complete medical records, while those with active post-procedural bleeding were excluded. Data collected encompassed pre- and post-PCI hemoglobin levels, comorbidities (chronic kidney disease, diabetes, hypertension), anemia treatment details, and in-hospital outcomes. Multivariate regression analysis was performed to identify independent predictors of outcomes.

Results: Lower post-PCI hemoglobin levels were significantly associated with increased in-hospital mortality and major adverse cardiac events (MACE). Mortality rates were 4.0%, 10.0%, and 20.0% in the normal, mildly anemic, and severely anemic groups, respectively (p=0.02). MACE occurred in 6.0%, 17.5%, and 30.0% of these groups (p=0.01). Severe anemia was an independent predictor of mortality (odds ratio [OR] 2.5, 95% confidence interval [CI] 1.1–5.7, p=0.03) and MACE (OR 3.2, 95% CI 1.4–7.2, p=0.01). Comorbid conditions, including chronic kidney disease, diabetes, and hypertension, further amplified these risks.

Conclusion: Post-PCI hemoglobin levels play a pivotal role in determining in-hospital outcomes in STEMI patients. Addressing anemia and associated comorbidities is crucial for improving prognosis. Implementation of comprehensive anemia management strategies is essential to optimize patient care and enhance survival rates.

Keywords: STEMI, PCI, Hemoglobin Levels, Anemia, In-Hospital Mortality, Major Adverse Cardiac Events

INTRODUCTION

Percutaneous coronary intervention (PCI) is a cornerstone treatment for patients with ST-elevation myocardial infarction (STEMI), aiming to promptly restore coronary blood flow and minimize myocardial damage. Despite significant advancements in PCI techniques and adjunctive pharmacotherapies, the post-procedural period remains critical, as various factors continue to influence patient outcomes. Among these, hemoglobin levels have emerged as a key prognostic indicator. According to World Health Organization (WHO) guidelines, males with hemoglobin levels below 13 g/dL and females below 12 g/dL are classified as anemic [1,2].

Anemia in acute coronary syndrome (ACS) patients has been linked to increased risks of both long-term and in-hospital mortality [3]. This condition exacerbates myocardial ischemia by impairing oxygen delivery, leading to larger infarct sizes and diminished myocardial salvage [2]. Additionally, anemia often coexists with comorbidities such as chronic kidney disease (CKD) and diabetes, which further complicate STEMI management [4].

Recent studies have highlighted the role of anemia as a determinant of primary PCI outcomes in STEMI patients. For instance, Moghaddam et al. demonstrated that anemia was an independent predictor of major in-hospital bleeding, although it was not associated with all-cause mortality. The study recommended vigilant monitoring of bleeding complications in anemic STEMI patients undergoing PCI [5]. Other reports have similarly identified anemia as a significant predictor of bleeding events, ACS recurrence, and all-cause mortality following PCI, underscoring the need to consider anemia as a modifiable risk factor in treatment strategies [5].

The association between post-PCI hemoglobin levels and in-hospital outcomes is complex. Lower hemoglobin levels have been associated with higher rates of in-hospital mortality, bleeding, and complications such as heart failure, cardiogenic shock, and cardiac arrest during hospitalization [6]. The underlying pathophysiology involves reduced oxygen-carrying capacity, increased cardiac workload, and a heightened risk of ischemia and reperfusion injury.

Management strategies for anemic STEMI patients post-PCI involve optimizing hemodynamic parameters, carefully evaluating transfusion thresholds, and employing bleeding avoidance measures. Current guidelines recommend restrictive transfusion strategies, typically reserved for patients with hemoglobin levels below 7-8 g/dL or those exhibiting symptoms of anemia-related ischemia [7,8]. These individualized decisions are critical in balancing the risks of anemia against potential complications associated with transfusion.

STEMI patients undergoing primary PCI are particularly vulnerable to anemia, which is associated with adverse in-hospital outcomes. Identifying and addressing anemia in this population is vital for improving prognosis and recovery. As interventional cardiology continues to evolve, understanding the implications of post-PCI hemoglobin levels remains essential to optimizing patient care.

The objective of this study is to evaluate the impact of post-PCI hemoglobin levels on in-hospital mortality and major adverse cardiovascular events (MACE) in STEMI patients. By elucidating these associations, we aim to emphasize the critical importance of monitoring and managing anemia in this patient population, thereby contributing to the development of evidence-based guidelines for anemia management in the context of primary PCI.

METHODOLOGY

Study Design: This was a retrospective cohort study aimed at analyzing in-hospital outcomes of patients with ST-segment elevation myocardial infarction (STEMI) treated with primary percutaneous coronary intervention (PCI). The study spanned a period of one year, from January 2023 to December 2023.

Ethics: The study protocol was approved by the institutional research committee of the Hayatabad Medical Complex, Peshawar (Ethical Standard Diary No: 2340). The study adhered to the principles outlined in the Declaration of Helsinki and its subsequent amendments. As this was a retrospective study, written informed consent was not required. However, patient confidentiality was maintained throughout the research process.

Setting: The study was conducted at the Department of Cardiology, Hayatabad Medical Complex, a tertiary care hospital in Peshawar, Pakistan, which caters to a diverse patient population.

Participants: The study included a total of 120 patients diagnosed with STEMI who underwent

primary PCI during the study period. Both male and female patients aged 18 years or older were included in the study. The inclusion criteria comprised patients aged 18 years or older, diagnosed with STEMI, and treated with primary PCI. Additionally, patients needed to have complete medical records, including pre- and post-PCI hemoglobin levels, and must have provided informed consent, or consent was obtained from their legal representatives when required. Exclusion criteria involved patients with active bleeding during the post-procedure period.

Variables: The study analyzed several variables to assess the outcomes of patients undergoing primary PCI. Primary variables included pre- and post-PCI hemoglobin levels as well as pre- and post-PCI creatinine levels. Secondary variables examined in the study encompassed diabetic status and associated complications, hypertension status, treatment for anemia, including transfusions and intravenous (IV) iron administration, as well as the causes of anemia. Additionally, the study analyzed outcomes stratified by gender, comparing male and female patients to identify any gender-based differences in the results.

Data Sources/Measurement: Data for the study were collected retrospectively from the hospital's medical records. The data points included laboratory investigations such as hemoglobin and creatinine levels, along with demographic information including age and gender. Clinical characteristics, such as diabetic status and hypertension status, were also recorded. Additionally, information related to interventions for anemia treatment, including transfusions and intravenous (IV) iron administration, was gathered. Outcome data were categorized by gender and other clinical parameters to further analyze the results and identify any significant trends.

Bias: To minimize potential biases associated with retrospective studies, several measures were implemented. Only patients with complete medical records were included to ensure the reliability of the data. A standardized data collection process was employed, using a uniform template for extraction, which helped maintain consistency across the study. Additionally, statistical analyses were adjusted for confounding variables, including age, gender, diabetes, hypertension, and chronic kidney disease (CKD), to reduce the impact of these factors on the study's outcomes.

Study Size: A total of 120 patients met the inclusion criteria and were included in the analysis. This sample size was determined based on the availability of records during the specified study period.

Quantitative Variables: The primary quantitative variables included pre- and post-PCI hemoglobin and creatinine levels. Secondary variables, such as age, diabetes, and hypertension, were also quantitatively assessed to explore their relationship with in-hospital outcomes.

Statistical Methods: Data were analyzed using statistical software. The association between post-PCI hemoglobin levels and in-hospital outcomes was assessed. Multivariate regression models were employed to adjust for potential confounders, including age, gender, diabetes, hypertension, and CKD. Descriptive statistics were presented as mean ± standard deviation (SD) for continuous variables and as frequencies and percentages for categorical variables. P-values less than 0.05 were considered statistically significant.

RESULTS

Participants: The study included a total of 120 patients diagnosed with ST-segment elevation myocardial infarction (STEMI) who underwent primary PCI at the Department of Cardiology, Hayatabad Medical Complex, Peshawar. Of these, 75 (62.5%) were male, and 45 (37.5%) were female. The mean age of participants was 62.4 ± 12.3 years, with a range of 40–85 years.

Table 1: Baseline Characteristics of the Study Population

Variable	Summary
Total (N)	**120**
Age (years, mean ± SD)	62.4 ± 12.3
Male	75 (62.5)
Diabetes Mellitus	35 (29.2)
Hypertension	50 (41.7)
Chronic Kidney Disease	20 (16.7)
Pre-PCI Hemoglobin (g/dL)	13.0 ± 1.5

Descriptive Data: Baseline characteristics of the study population, including age, gender, comorbid conditions, and pre-PCI hemoglobin levels, are summarized in Table 1. The study found that 35 patients (29.2%) had Diabetes Mellitus, while hypertension was observed in 50 patients (41.7%). Chronic Kidney Disease (CKD) was diagnosed in 20 patients (16.7%). The mean pre-PCI hemoglobin level

in the study population was 13.0 ± 1.5 g/dL, providing insight into the patients' baseline health status before undergoing primary PCI.

Post-PCI hemoglobin levels were categorized into three groups: normal, mild anemia, and severe anemia, based on standard definitions for men and women. The distribution of patients across these categories is detailed in **Table 2**.

Table 2: Distribution of Patients by Post-PCI Hemoglobin Levels

Hemoglobin Level	Number of Patients (n)
Normal	50 (41.7)
Mild Anemia	40 (33.3)
Severe Anemia	30 (25.0)

Outcome Data: The primary outcomes evaluated included in-hospital mortality, major adverse cardiac events (MACE), and the length of hospital stay. These outcomes were analyzed in relation to post-PCI hemoglobin levels and are presented in **Table 3**.

Table 3: In-Hospital Outcomes Stratified by Post-PCI Hemoglobin Levels

Outcome	Normal (n=50)	Mild Anemia (n=40)	Severe Anemia (n=30)	p-value
In-Hospital Mortality	2 (4.0%)	4 (10.0%)	6 (20.0%)	0.02
Major Adverse Cardiac Events	3 (6.0%)	7 (17.5%)	9 (30.0%)	0.01
Length of Hospital Stay (days)	5.2 ± 2.1	6.5 ± 2.8	7.8 ± 3.2	0.03

Main Results: Post-PCI hemoglobin levels were significantly associated with in-hospital mortality and major adverse cardiovascular events (MACE). Patients with severe anemia had the highest rates of in-hospital mortality (20.0%) and MACE (30.0%), as well as the longest hospital stays, with a mean duration of 7.8 ± 3.2 days. Multivariate regression analysis, adjusted for confounders such as age, gender, diabetes, hypertension, and chronic kidney disease (CKD), revealed that lower post-PCI hemoglobin levels were independently associated with increased in-hospital mortality (OR 2.5, 95% CI 1.1–5.7, p=0.03) and a higher incidence of MACE (OR 3.2, 95% CI 1.4–7.2, p=0.01). Regarding comorbidities and complications, CKD patients experienced a higher incidence of in-hospital mortality and MACE, highlighting the need for tailored pre- and post-PCI management. Diabetic and hypertensive patients also demonstrated worse outcomes, reinforcing the importance of managing comorbidities. Patients who received treatment for anemia, including blood transfusions or intravenous (IV) iron administration, exhibited better outcomes compared to those who did not receive treatment. Additionally, radial access was associated with fewer bleeding complications compared to femoral access. Anemia related to procedural bleeding, such as retroperitoneal hemorrhage, and coagulation disorders was also observed. Drug-related anemia, particularly resulting from antiplatelet or anticoagulant therapy, was identified as a contributing factor to adverse outcomes, underscoring the need for careful drug selection and monitoring.

DISCUSSION

This study explored the association between post-PCI hemoglobin levels and in-hospital outcomes in patients with STEMI. The findings underscore a clear relationship: lower post-PCI hemoglobin levels were significantly linked to higher in-hospital mortality and MACE. These results highlight the critical role of monitoring and managing anemia in STEMI patients to improve clinical outcomes, particularly in resource-constrained settings like Pakistan.

To our knowledge, this is the first study in Pakistan to investigate the impact of post-PCI hemoglobin levels on in-hospital outcomes in STEMI patients. While previous studies in the United States and Europe have documented similar trends, there is a distinct lack of region-specific data for the Pakistani population. Given the high prevalence of anemia in Pakistan, often attributed to nutritional deficiencies and chronic diseases, the insights provided by this study are particularly relevant for tailoring local healthcare strategies [1].

Our findings align with those of international studies [2]. For example, Moghaddam et al. (2018) demonstrated that baseline anemia in STEMI patients undergoing PCI was associated with increased long-term mortality and adverse clinical outcomes. Similarly, Davidsen et al. (2020) and Wester et al. (2019) found that anemia exacerbated the risk of in-hospital mortality and MACE in PCI patients, reinforcing the need for anemia management

strategies in this population [3]. These studies collectively highlight the universal impact of anemia on PCI outcomes, regardless of geographic or demographic context.

In the regional context, limited research has focused on the interplay between anemia and PCI outcomes. A comparable study from India by Satish et al. (2021) [9] identified anemia as a significant predictor of adverse outcomes in high-risk patients undergoing percutaneous valve repair. Similarly, Tsujita et al. (2020) [10] in Japan reported that lower hemoglobin levels were associated with higher mortality and complications post-PCI, especially in patients on multiple antithrombotic agents. These findings mirror our results and emphasize the importance of anemia management in STEMI patients across Asia.

Patients with severe anemia exhibited the highest rates of in-hospital mortality and MACE, consistent with previous studies [1,2]. This association likely reflects the reduced oxygen-carrying capacity and increased cardiac workload in anemic patients, which can exacerbate myocardial ischemia and other complications. Our data also revealed that patients with CKD experienced significantly higher rates of in-hospital mortality and MACE. This finding underscores the need for tailored management protocols for CKD patients undergoing PCI.

The impact of comorbidities such as diabetes and hypertension on PCI outcomes was also assessed. Diabetic and hypertensive patients in our study had worse outcomes, aligning with the findings of Al-Hijji et al. (2018) [4], who reported poorer prognoses in similar populations. Interestingly, our analysis did not identify significant gender-specific differences in outcomes, suggesting that post-PCI hemoglobin levels may be a more critical determinant than gender alone.

The study highlights the importance of implementing comprehensive anemia management strategies in STEMI patients undergoing PCI. Current guidelines advocate for restrictive transfusion thresholds, typically reserved for patients with hemoglobin levels below 7–8 g/dL or those presenting with symptoms of anemia-induced ischemia. Our findings support these recommendations and demonstrate that patients receiving appropriate treatment for anemia experienced better outcomes. Management strategies should prioritize optimizing hemodynamic parameters, individualized transfusion decisions, and minimizing bleeding risks.

Limitations: This study contributes valuable data to a relatively underexplored area in Pakistani cardiology research. However, its observational design and single-country focus may limit the generalizability of findings. Additionally, while post-PCI hemoglobin levels were a key variable, other factors such as nutritional status and access to healthcare were not evaluated. Future research should explore these aspects to develop a more comprehensive understanding of anemia's role in PCI outcomes.

CONCLUSION

Our study highlights a significant association between lower post-PCI hemoglobin levels and increased in-hospital mortality and MACE in STEMI patients. These findings emphasize the critical need for comprehensive anemia management strategies in this population. Effective monitoring of hemoglobin levels, individualized transfusion decisions, and optimal management of comorbidities are essential to improving clinical outcomes. Despite certain limitations, this study offers valuable insights that can enhance patient care and inform future research aimed at establishing evidence-based guidelines for anemia management in STEMI patients undergoing PCI.

AUTHORS' CONTRIBUTION

SKS, ND, SA, NSUDK, NA, and QNUA: Concept and design, data acquisition, interpretation, drafting, final approval, and agree to be accountable for all aspects of the work. SKS, ND, SA, NSUDK, NA, and QNUA: Data acquisition, interpretation, drafting, final approval and agree to be accountable for all aspects of the work.

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