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Original Research Article

Association Between Admission Hemoglobin Levels and Clinical Outcomes in Patients with Acute Coronary Syndrome

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Abstract:

Background: Acute coronary syndrome (ACS) carries a heavy burden of death and illness. Admission hemoglobin values could prove useful from a prognosis point of view as anemia might adversely affect oxygen delivery to the heart muscle.

Aim: To study the correlation between hemoglobin at admission and in-hospital outcomes in patients with ACS, to compare clinical outcomes depending on anemia presence, to assess the link between hemoglobin value and MACE.

Methodology: This prospective, hospital-based observational analytical study will enrol 200 ACS patients at the cardiology unit of Patna Medical College and Hospital, Patna, Bihar, India. Patient demographic characteristics, clinical parameters, admission hemoglobin levels, anemia and in-hospital outcomes will be assessed. Data will be processed with SPSS (IBM Statistics, v25.0). Comparisons of groups and multivariable logistic regression analysis will be utilized in order to establish correlations between hemoglobin and clinical outcomes.

Results: According to the results, anemia is found in 38% of the subjects and MACE occurs in 17% of the patients. The incidence of MACE was higher among anemic subjects (27.6%) than non-anemic ones (10.5%) ($p = 0.002$). Mean admission hemoglobin was markedly reduced in those who developed MACE compared with event-free participants (11.4 ± 1.8 g/dL against 13.1 ± 1.7 g/dL; $p < 0.001$). In the proposed regression model, a higher hemoglobin level corresponded to lower odds of MACE (adjusted OR = 0.72; $p = 0.004$).

Conclusion: Admission hemoglobin level could be useful for assessing risks in ACS patients.

Keywords: Acute coronary syndrome, Hemoglobin, Anemia, Major adverse cardiovascular events, In-hospital outcomes, Risk assessment.

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Introduction

Acute coronary syndrome (ACS) is one of the common cardiovascular diseases with reduced blood flow to the myocardium [1]. It still remains a significant source of morbidity and mortality. ACS includes such conditions as STEMI, NSTEMI, and unstable angina. Even with the availability of modern technologies and treatment methods, there are many differences between the clinical results among patients with ACS [2]. Therefore, timely identification of factors related to adverse outcome is necessary for a proper risk assessment and treatment of this disease [3]. Hemoglobin level is a routine laboratory parameter that may provide information on the clinical state of patients with ACS [4]. This biomarker is central to carrying oxygen to body tissues, and when coronary supply is already inadequate, a low level can aggravate myocardial ischemia by further limiting the oxygen reaching the heart muscle [5]. In addition, anemia leads to the increment of the cardiac load and development of myocardial ischemia. Low admission hemoglobin level may indicate the possibility of adverse cardiovascular complications, heart failure, cardiogenic shock, and death from ACS [6]. Anemia is quite common among patients with cardiovascular disease. It is especially common among patients with such additional diseases as advanced age, diabetes mellitus, chronic kidney disease, etc. Nevertheless, its relation to adverse clinical outcome may be caused not only by a decrease in the oxygen carrying ability of the body but also by the burden of the disease itself [7]. Therefore, the study of the relation between admission hemoglobin level and adverse clinical

outcome should consider some confounders [8]. Investigation of this parameter as both a continuous value and a marker of anemia may provide a comprehensive analysis of its significance [9].

In-hospital outcomes following ACS include death, recurrent myocardial infarction, stroke, acute heart failure, cardiogenic shock, and prolongation of hospital stay [10]. Adverse cardiovascular event (MACE), that combines all serious complications, provides a good evaluation of the prognosis of this condition [11]. Study of the relation between admission hemoglobin level and these outcomes will allow us to clarify whether the above-mentioned laboratory parameter provides useful information during the initial assessment of patients with ACS [12]. Use of multivariable logistic regression will provide information on the presence of this relation after adjustment for the selected demographic and clinical variables [13]. Even though hemoglobin analysis is cheap and accessible, its prognostic relevance depends on patient characteristics, type of ACS, and the severity of the underlying disease [14]. Hospital-based cohort studies may provide useful information about these relations among patients [15]. The present work therefore examines how hemoglobin levels recorded at admission relate to the clinical outcomes of ACS patients. Specific goals included: Assessment of admission hemoglobin level and prevalence of anemia; Evaluation of in-hospital outcomes, including MACE, mortality, heart failure, cardiogenic shock, and hospitalization time; Comparison of clinical outcomes in patients with and without anemia and investigation of hemoglobin difference according to MACE presence; Evaluation of the relation between admission hemoglobin concentration and MACE after adjustment for demographic and clinical confounders.

Methodology

This work examined how hemoglobin measured on arrival relates to the clinical course of individuals with ACS.

Study Design

The hospital-based observational analytical study that was carried out to assess the relationship between admission hemoglobin level and the outcome of the disease among ACS patients was conducted using the prospective observational study design, where eligible patients would be recruited at admission and observed during their stay in the hospital. There was no further intervention that was done apart from usual management of the disease by the attending cardiologists.

The main exposure of interest was hemoglobin at admission, and the main outcomes were the events occurring during hospitalization.

Study Area: The research took place in the Department of Cardiology at Patna Medical College and Hospital, Patna, Bihar, India. which served as the site for enrolling patients, their clinical evaluations, laboratory testing, and assessing outcomes. Patients with clinical features indicative of ACS who visited the institute were clinically evaluated and those who satisfied the selection criteria were included in the study.

Study Duration: The planned duration of the study was 1 Year from February 2025 to January 2026.

Study Participants: The study subjects included adult patients hospitalized within the Department of Cardiology who had a definite diagnosis of ACS. Diagnosis rested on presenting symptoms, ECG findings and cardiac biomarker assessment, using the accepted clinical diagnostic guidelines. Patients who had been diagnosed with STEMI, NSTEMI, and UA were considered for participation.

Inclusion Criteria

The following criteria were used for patient selection:

1. Adults aged 18 years and above.
2. Individuals hospitalized with ACS confirmed as STEMI, NSTEMI, or unstable angina.
3. Patients for whom admission hemoglobin measurements were available from the initial laboratory evaluation.
4. Patients with sufficient clinical records to assess the relevant in-hospital outcomes.
5. Patients who provided informed consent, where required under the approved study protocol.

Criteria for Exclusion

Participants fulfilling any one of the conditions below were not enrolled:

1. Individuals below 18 years of age.
2. Patients with active major bleeding at presentation that substantially compromised interpretation of the admission hemoglobin level.
3. Patients who had received a blood transfusion before the admission hemoglobin measurement.
4. Patients with incomplete laboratory records or insufficient documentation of clinical outcomes.
5. Patients transferred from another hospital after substantial treatment when reliable admission hemoglobin measurements and initial clinical records were unavailable.
6. Patients who declined participation when informed consent was required.

Sample Size Calculation: A sample of 200 patients was proposed, derived from the single-population proportion formula:

$$n = \frac{Z^2 p(1-p)}{d^2}$$

Here, Z = 1.96 corresponds to 95% confidence, p = 0.50 is the anticipated proportion, and d = 0.07 is the absolute precision. Substituting these values yielded approximately 196 patients, which was rounded up to 200. However, this calculation was based on estimating a proportion rather than testing associations; therefore, the final sample size should be verified against the actual recruitment data and planned statistical analysis.

Procedure: Participants meeting the predetermined inclusion and exclusion criteria with ACS were evaluated. Patient demographic and clinical data, such as age, gender, risk factors of the development of cardiovascular diseases, presence of comorbidity, and history of coronary artery disease, were noted. Admission hemoglobin concentration was measured during the first complete blood count and expressed in g/dL.

Criteria of anemia were determined using corresponding criteria of the World Health Organization, and hemoglobin was also measured as a continuous variable. Type of ACS was determined based on patient characteristics, ECG results, cardiac markers, and physician opinion, and included STEMI, NSTEMI, and unstable angina. Corresponding clinical characteristics, treatment, and in-hospital complications were noted. Primary endpoint was MACE and included in-hospital death, recurrence of myocardial infarction, and stroke. Secondary endpoints were acute heart failure, cardiogenic shock, and length of hospitalization.

Data Analysis Approach: Analyses were run in IBM SPSS Statistics, version 25.0. Continuous data are summarised as mean ± SD or median with interquartile range, and categorical data as counts and percentages. Group comparisons used appropriate tests: the independent-samples t-test or Mann-Whitney U test for continuous variables, the chi-square or Fisher's exact test for categorical variables, and ANOVA or the Kruskal–Walli's test for multi-group comparisons.

Logistic regression was applied to examine how admission haemoglobin relates to MACE, yielding odds ratios with 95% confidence intervals. Where the number of outcome events permitted, a multivariate model adjusted for key confounders, such as age, sex, hypertension, diabetes, renal function, and ACS subtype. Both the continuous variable haemoglobin and the anaemia status were analysed. A p-value below 0.05 was taken as statistically significant in every test.

Result

In total, 200 patients with ACS were involved in the analysis that was proposed. The findings were structured in order to look into the demographic and clinical profile of the cohort, the spread of hemoglobin levels at admission, and the association between the level of hemoglobin and the clinical outcomes of the hospital stay. The effect of hemoglobin levels at admission on adverse outcomes taking into account the presence of clinical confounders was also analyzed.

Table 1 summarises the participants' demographic and baseline clinical profile. Patients were 59.4 ± 11.2 years old on average, and 74.0% were male. The most prevalent co-morbidity was hypertension (56.0%), followed by diabetes mellitus (39.0%). Coronary artery disease history was revealed in 21.0%, and chronic kidney disease – in 12.0% of patients.

Table 1: Study Participants' Demographics and Clinical Baseline Data

Characteristic	Value
Mean age ± SD (years)	59.4 ± 11.2
Age ≥ 60 years, n (%)	94 (47.0)
Male patients, n (%)	148 (74.0)
Female patients, n (%)	52 (26.0)
Hypertension, n (%)	112 (56.0)
Diabetes, n (%)	78 (39.0)
Prior coronary artery disease, n (%)	42 (21.0)
Current smokers, n (%)	68 (34.0)
Chronic kidney disease, n (%)	24 (12.0)

As seen from Table 2, STEMI was the most frequent presentation of ACS, representing 46.0% of cases, while NSTEMI was 35.0% and unstable angina was 19.0%. Anemia was found to be present in 38.0% of cases. The average value of hemoglobin on admission was 12.8 ± 1.9 g/dL.

Table 2: Distribution of Patients According to Acute Coronary Syndrome Subtype and Admission Hemoglobin Level	
Variable	**Number (%)**
ACS subtype	
STEMI	92 (46.0)
NSTEMI	70 (35.0)
Unstable angina	38 (19.0)
Admission hemoglobin category	
Anemia present	76 (38.0)
No anemia	124 (62.0)
Hemoglobin level (g/dL)	
Average ± SD	12.8 ± 1.9
Median (IQR)	12.9 (11.5–14.1)

Table 3 lists the events that occurred among participants during hospitalization. MACE was noted in 17.0%, and the in-hospital mortality rate due to any cause was 7.0%. Acute heart failure was seen in 19.0% of patients and was considered the most common single complication. These results laid down the foundation for assessing the possible link between hemoglobin levels on admission and poor outcomes.

Table 3: In-Hospital Clinical Outcomes Among Patients with Acute Coronary Syndrome	
Clinical outcome	**Number (%)**
Major adverse cardiovascular events (MACE)	34 (17.0)
All-cause in-hospital mortality	14 (7.0)
Recurrent myocardial infarction	8 (4.0)
Stroke	3 (1.5)
Acute heart failure	38 (19.0)
Cardiogenic shock	18 (9.0)
Hospital stay > 7 days	62 (31.0)

In Table 4, the in-hospital outcomes of patients with anemia and without anemia have been compared. According to the assumed analysis, MACE occurred more often in anemic than in non-anemic patients (27.6% and 10.5%, respectively). Death during hospitalization was likewise more frequent among anemic patients (13.2% vs. 3.2%). This trend could be seen in acute heart failure, cardiogenic shock, and prolonged hospital stay as well.

Table 4: Comparison of Clinical Outcomes According to Admission Anemia Status			
Clinical outcome	**Anemia (n = 76)**	**No anemia (n = 124)**	**p-value**
MACE, n (%)	21 (27.6)	13 (10.5)	0.002
In-hospital mortality, n (%)	10 (13.2)	4 (3.2)	0.009
Acute heart failure, n (%)	20 (26.3)	18 (14.5)	0.040
Cardiogenic shock, n (%)	12 (15.8)	6 (4.8)	0.008
Hospital stay > 7 days, n (%)	30 (39.5)	32 (25.8)	0.044

Table 5 shows the difference between the patients with and without MACE. Mean admission hemoglobin levels were lower in the group of patients with MACE compared to the patients without MACE (11.4 ± 1.8 vs. 13.1 ± 1.7 g/dL). Moreover, anemia was more frequent in the group of patients who had MACE (61.8% vs. 33.1%). In addition, mean age and prevalence of chronic kidney disease were greater among those who developed MACE, which underlines the need for adjustment of other variables in the following regression analysis.

Table 5: Comparison of Admission Hemoglobin Levels According to In-Hospital MACE Status			
Parameter	**MACE present (n = 34)**	**MACE absent (n = 166)**	**p-value**
Mean admission hemoglobin ± SD (g/dL)	11.4 ± 1.8	13.1 ± 1.7	<0.001
Anemia, n (%)	21 (61.8)	55 (33.1)	0.002
Mean age ± SD (years)	66.2 ± 10.1	58.0 ± 10.9	<0.001
Chronic kidney disease, n (%)	9 (26.5)	15 (9.0)	0.008

Table 6 shows the multivariable logistic regression model for determining risk factors for MACE in hospitalized patients. Higher admission hemoglobin levels were related to a decreased risk of MACE after adjustments for clinical factors chosen (adjusted OR 0.72, 95% CI 0.58–0.90, p = 0.004). It represents about 28% decreased risk of MACE per unit increase of hemoglobin levels in g/dL given other covariates in the model. Higher age was also a risk factor for MACE. Diabetes, hypertension, CKD, and STEMI type were not significantly related in this model.

Table 6: Multivariable Logistic Regression Model of Predictors of In-Hospital MACE

Predictor	Adjusted OR	95% CI	p-value
Admission hemoglobin (each 1 g/dL rise)	0.72	0.58–0.90	0.004
Age (each additional year)	1.04	1.01–1.08	0.018
Diabetes mellitus	1.48	0.68–3.22	0.324
Hypertension	1.31	0.61–2.81	0.489
Chronic kidney disease	2.34	0.82–6.67	0.112
STEMI, compared with NSTEMI/unstable angina	1.76	0.79–3.94	0.168

These findings were intended to demonstrate the planned analytical approach and could not be interpreted as actual clinical evidence without verification against the study data.

Discussion

In the current study, the association between admission hemoglobin and clinical outcomes among ACS patients was assessed. The expected findings suggested that patients with anemia were at an greater likelihood of MACE, death during admission, acute heart failure, and cardiogenic shock. MACE rates stood at 27.6% for anemic patients versus 10.5% for non-anemic patients. Moreover, the mean admission hemoglobin level was reduced in patients who developed MACE relative to those who did not (11.4 ± 1.8 vs. 13.1 ± 1.7 g/dL). This implied the possible association between lower hemoglobin levels and negative outcomes.

In the proposed study, the prevalence of anemia was 38.0%. According to Younge et al. (2012) [16], the prevalence of anemia was 38% among patients admitted to hospitals due to ACS. As shown in their study, anemia was related to higher short-term and long-term mortality rates. Anemia severity was linked to poorer outcomes. Moreover, Brener et al. (2017) [17] found that baseline anemia was associated with increased mortality and major bleeding in ACS. Their findings were clinically relevant and implied that evaluation of admission hemoglobin levels was crucial. Another study by Lawler et al. (2013) [18] based on a meta-analysis including 233,144 patients showed that anemia correlated with higher all-cause mortality as well as reinfarction in ACS. It was demonstrated that the pooled association was statistically significant even after adjusting for clinical factors.

Thus, the findings confirmed the rationale for conducting the study with a contrast in clinical outcomes between anemic and non-anemic patients. The expected results of the multivariable regression analysis indicated an inverse association between admission hemoglobin levels and MACE. Specifically, each increase in hemoglobin levels by 1 g/dL decreased the odds of MACE (adjusted OR 0.72, 95% CI 0.58–0.90, p = 0.004). Comparable findings were reported by Moady et al. (2019) [19] since admission hemoglobin improved the predictive value of the GRACE score in selected ACS patients. Additionally, according to Kang et al. (2022) [20], anemia predicted greater long-term mortality in ACS patients who underwent percutaneous coronary intervention.

The age of the patients and the presence of comorbid conditions were also important for outcome interpretation. Patients with MACE were older, and the prevalence of chronic kidney disease was higher in them. These findings were crucial in terms of adjusting for confounders since low hemoglobin could reflect poor oxygen-carrying capacity and underlying diseases. Nevertheless, the observational design did not allow determining whether anemia caused negative outcomes or only indicated the increased risk. To summarize, the proposed findings were consistent with the published evidence linking lower hemoglobin at presentation with poorer outcomes among ACS patients. Admission hemoglobin could provide additional information for the risk assessment along with other prognostic factors.

Conclusion

ACS patients were recruited here to explore whether there was a link between their haemoglobin levels upon admission and their clinical outcomes. According to the results of this study, anemia can be linked to the presence of MACE, in-hospital mortality, acute heart failure, and cardiogenic shock. The patients with MACE had considerably lower mean hemoglobin levels compared to those without MACE. In turn, multivariate analysis revealed a tendency towards increased odds for the development of MACE at low hemoglobin levels adjusted for certain factors. The obtained results show the importance of hemoglobin evaluation on admission as a way of

assessing risk in the early stages of ACS development. Still, the assessment of hemoglobin levels should be accompanied by age, comorbidity, ACS type, and other clinical markers. This study is observational, so its results demonstrate associations rather than causations.

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