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Original Article

Frequency of Iron Deficiency Anemia Among Heart Failure Patients with Dilated Cardiomyopathy

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ABSTRACT

Background: Iron deficiency anemia is an increasingly recognized comorbidity in patients with heart failure and may worsen functional capacity, symptom burden, and overall clinical status, particularly in those with dilated cardiomyopathy. Objective: To determine the frequency of iron deficiency anemia among patients with heart failure due to dilated cardiomyopathy presenting to a tertiary care cardiology department in Quetta. Methods: This cross-sectional study was conducted in the Department of Cardiology, Bolan Medical College/Hospital, Quetta, from 12 February 2024 to 30 September 2024. A total of 131 patients with echocardiographically confirmed dilated cardiomyopathy were enrolled. Clinical severity was assessed using NYHA functional class, and blood samples were obtained for complete blood count and iron profile evaluation. Data were analyzed using SPSS version 22.0. Frequencies and percentages were calculated for categorical variables, means and standard deviations for quantitative variables, and post-stratification chi-square testing was applied. Results: The mean age was 52.23 ± 5.62 years, and 71.8% of participants were male. Iron deficiency anemia was observed in 55 of 131 patients, yielding a frequency of 42.0%. The burden of iron deficiency anemia increased across NYHA classes, from 28.6% in class I to 57.7% in class III, with persistently high prevalence in class IV (50.0%), although the overall association was not statistically significant (p=0.066). Conclusion: Iron deficiency anemia is common in patients with heart failure due to dilated cardiomyopathy and appears more frequent among those with greater functional limitation. Routine evaluation for iron deficiency anemia may improve clinical assessment in this population. Keywords: Dilated cardiomyopathy, iron deficiency anemia, heart failure, NYHA class, cross-sectional study.

INTRODUCTION

Heart failure secondary to dilated cardiomyopathy remains an important cause of morbidity, repeated hospitalization, impaired functional capacity, and premature mortality worldwide. In patients with chronic heart failure, the burden of comorbidity substantially influences symptom severity, exercise tolerance, quality of life, and prognosis, particularly when metabolic and hematologic abnormalities coexist with impaired cardiac function (1,2). Among these comorbidities, iron deficiency and iron deficiency anemia have gained increasing attention because iron is essential not only for hemoglobin synthesis and oxygen transport but also for mitochondrial energy production and cellular metabolism in high-demand tissues such as myocardium and skeletal muscle. Consequently, iron depletion in patients with heart failure may worsen fatigue, dyspnea, reduced exercise capacity, and overall functional limitation, even beyond the effect attributable to cardiac dysfunction alone (3).

The clinical relevance of iron deficiency in heart failure extends beyond laboratory abnormality. Previous literature has shown that iron deficiency, with or without overt anemia, is associated with poorer clinical status and worse outcomes in patients with heart failure, while correction of isolated anemia

without addressing the underlying iron deficit has not consistently improved prognosis. This distinction is important because anemia may at times reflect disease severity, whereas iron deficiency itself may represent a modifiable therapeutic target with direct physiologic and symptomatic implications in patients with reduced cardiac reserve (3-5). Diagnostic thresholds based on serum ferritin and transferrin saturation have therefore become increasingly important in evaluating patients with heart failure, particularly those with reduced ejection fraction and persistent symptoms despite standard therapy (4,5).

In dilated cardiomyopathy, where ventricular dilatation and systolic dysfunction already compromise effective systemic perfusion, coexistence of iron deficiency anemia may further aggravate tissue hypoxia, reduce exercise tolerance, and intensify symptomatic limitation. Although several international studies have described a considerable prevalence of iron deficiency or iron deficiency anemia among patients with heart failure, the frequency varies across settings because of differences in population characteristics, nutritional status, disease severity, and diagnostic criteria (6,7). Despite the clinical importance of this problem, locally relevant evidence from our population remains scarce, and no sufficiently documented data were available from our setting to quantify the burden of iron deficiency anemia among patients with heart failure due to dilated cardiomyopathy.

Establishing the frequency of iron deficiency anemia in this patient group is clinically important because timely recognition may support more comprehensive evaluation and management in routine cardiology practice. In resource-constrained settings, where patients often present late and comorbid nutritional or chronic disease burdens are high, local epidemiologic data are needed to inform screening priorities and improve care pathways. Therefore, this study was conducted to determine the frequency of iron deficiency anemia among heart failure patients with dilated cardiomyopathy presenting to a tertiary care cardiology department in Quetta.

MATERIALS AND METHODS

This cross-sectional observational study was conducted in the Department of Cardiology, Bolan Medical College/Hospital, Quetta, from 12 February 2024 to 30 September 2024. The study was designed to determine the frequency of iron deficiency anemia among patients with heart failure secondary to dilated cardiomyopathy and to examine its distribution across key demographic and clinical characteristics. Prior to study commencement, ethical approval was obtained from the hospital ethical board, and all participants provided written informed consent after being informed about the purpose of the study, the procedures involved, and the voluntary nature of participation. Confidentiality of patient information was maintained throughout data collection, entry, and analysis.

A total of 131 patients with dilated cardiomyopathy were enrolled from the cardiology outpatient department using consecutive non-probability sampling during the study period. Eligible participants were adults presenting with clinically established heart failure and echocardiographic confirmation of dilated cardiomyopathy. Patients were assessed clinically and categorized according to New York Heart Association functional class. Individuals were included only when sufficient clinical and laboratory information was available to assess anemia and iron status. Patients in whom iron status could be distorted by alternative major causes of anemia or incomplete workup were not considered for final analysis. All enrolled cases underwent standardized clinical evaluation and laboratory testing within the institutional workflow.

Demographic and clinical data were recorded on a structured proforma, including age, sex, smoking history, history of hypertension, diabetes mellitus, obesity, New York Heart Association class, and duration of disease symptoms. A detailed history was obtained and a focused clinical examination was performed for each participant. Venous blood samples were collected and sent to the hospital laboratory for complete blood count and iron profile assessment. Hemoglobin level was used to identify anemia, while iron deficiency anemia was determined on the basis of anemia in combination with biochemical evidence of iron deficiency as defined in the study workup protocol. Dilated cardiomyopathy had already

been confirmed on echocardiography, and functional severity was graded using NYHA classification. Obesity, smoking status, diabetes, hypertension, age category, and disease-duration category were treated as explanatory variables for stratified analysis.

The primary outcome variable was the presence of iron deficiency anemia. Age, hemoglobin level, disease duration, weight, height, and body mass index were handled as quantitative variables, while sex, smoking history, hypertension, diabetes mellitus, obesity status, NYHA class, and iron deficiency anemia status were handled as categorical variables. For analytic consistency, age was stratified into 55 years or below and more than 55 years, while disease duration was stratified into 24 months or below and more than 24 months, in accordance with the dataset structure used for final analysis. To reduce information bias, data were recorded using the same proforma for all patients, diagnosis of dilated cardiomyopathy was based on echocardiographic confirmation, and laboratory assessment of hematologic and iron parameters was performed through the same hospital laboratory system.

Data were entered and analyzed using SPSS version 22.0. Quantitative variables were summarized as mean and standard deviation, whereas categorical variables were presented as frequencies and percentages. The overall frequency of iron deficiency anemia was calculated for the full sample. To explore potential effect modification, stratified analyses were performed for age group, sex, smoking history, hypertension, diabetes mellitus, obesity, disease duration, and NYHA class. Post-stratification chi-square testing was applied to assess associations between categorical variables and iron deficiency anemia status, and a p-value of 0.05 or less was considered statistically significant. The analytic approach was primarily descriptive, consistent with the study objective of estimating frequency in the target population, while subgroup comparisons were used to identify clinically relevant distribution patterns across patient characteristics. Data were checked for completeness before analysis, and only records with the required variables for the study outcomes were included in the final dataset to preserve internal consistency and data integrity.

The study was conducted using a predefined data collection format, consistent eligibility assessment, standardized echocardiographic confirmation, and uniform laboratory workup procedures in order to support reproducibility. All variables analyzed in the final report were derived directly from recorded clinical and laboratory data without simulation or post hoc reconstruction. The final dataset was used to generate descriptive summaries and stratified comparisons aligned with the study objective of quantifying the burden of iron deficiency anemia among heart failure patients with dilated cardiomyopathy in the study setting.

RESULTS

A total of 131 patients with heart failure due to dilated cardiomyopathy were included in the analysis. The age of the participants ranged from 40 to 70 years, with a mean age of 52.23 ± 5.62 years. The mean hemoglobin level was 10.5 ± 1.9 g/dL, mean disease duration was 25.69 ± 6.24 months, mean weight was 71.4 ± 6.3 kg, mean height was 170.9 ± 7.8 cm, and mean body mass index was 24.5 ± 2.0 kg/m². These baseline characteristics indicate a predominantly middle-aged study population with reduced hemoglobin values and moderate chronicity of disease presentation (Table 1).

Overall, 55 of 131 patients were found to have iron deficiency anemia, giving a frequency of 42.0% with an approximate 95% confidence interval of 33.5% to 50.4%. Most participants were aged 55 years or below (64.1%), male (71.8%), and non-obese (67.2%). Hypertension was present in 56.5% and diabetes mellitus in 46.6% of patients, while 51.1% had a positive smoking history. With respect to functional severity, 30.5% of patients were in NYHA class IV, followed by class I in 26.7%, class II in 22.9%, and class III in 19.8%. This distribution suggests that a substantial proportion of the sample had advanced functional limitation at the time of evaluation (Table 2).

Stratified analysis showed that the proportion of iron deficiency anemia was 40.4% in males and 45.9% in females, 40.3% in smokers and 43.8% in non-smokers, 41.9% in hypertensive and 42.1% in non-hypertensive patients, and 41.0% in diabetic compared with 42.9% in non-diabetic patients. By age category, iron deficiency anemia was present in 39.3% of those aged 55 years or below and 46.8% of those older than 55 years. According to disease duration, the frequency was 39.0% in those with disease duration of 24 months or below and 44.4% in those with disease duration exceeding 24 months. Among obese patients, 46.5% had iron deficiency anemia compared with 39.8% among non-obese patients. None of these binary subgroup comparisons reached statistical significance, and the corresponding odds ratios all had confidence intervals crossing unity (Table 3).

The most clinically notable gradient was observed across NYHA functional class. Iron deficiency anemia was identified in 28.6% of patients in class I, 33.3% in class II, 57.7% in class III, and 50.0% in class IV. Although the overall association between NYHA class and iron deficiency anemia did not meet the conventional threshold for statistical significance, it approached significance ($p = 0.066$) and showed a clinically relevant pattern of increasing anemia burden with worsening functional status, particularly from class II to class III. This finding suggests that iron deficiency anemia may cluster more frequently among patients with greater symptomatic limitation, even though the sample size may have limited the statistical power to confirm this trend definitively (Table 3, Figure 1).

Table 1. Baseline Quantitative Characteristics of the Study Population

Variable	Mean ± SD
Age (years)	52.23 ± 5.62
Hemoglobin (g/dL)	10.5 ± 1.9
Disease duration (months)	25.69 ± 6.24
Weight (kg)	71.4 ± 6.3
Height (cm)	170.9 ± 7.8
Body mass index (kg/m²)	24.5 ± 2.0

The quantitative profile of the cohort showed a mean age of 52.23 years and a mean hemoglobin concentration of 10.5 g/dL, supporting that this was a middle-aged heart failure population with reduced hematologic reserve. Mean disease duration was 25.69 months, indicating that many patients had established rather than newly diagnosed disease. Anthropometric values showed an average BMI of 24.5 kg/m², suggesting that overt obesity was not the dominant body composition pattern in the cohort.

Table 2. Frequency Distribution of Demographic and Clinical Characteristics and Overall Iron Deficiency Anemia

Characteristic	Category	n	%
Age	≤55 years	84	64.1
	>55 years	47	35.9
Sex	Male	94	71.8
	Female	37	28.2
Smoking history	Yes	67	51.1
	No	64	48.9
Hypertension	Yes	74	56.5
	No	57	43.5
Disease duration	≤24 months	59	45.0
	>24 months	72	55.0
Diabetes mellitus	Yes	61	46.6
	No	70	53.4
Obesity	Yes	43	32.8
	No	88	67.2
NYHA class	I	35	26.7
	II	30	22.9
	III	26	19.8
	IV	40	30.5
Iron deficiency anemia	Yes	55	42.0
	No	76	58.0

Of the 131 participants, 55 had iron deficiency anemia, corresponding to an overall prevalence of 42.0%. Males comprised nearly three quarters of the cohort, while hypertension, smoking, and diabetes were each present in approximately half of the sample. NYHA class IV was the single most frequent functional category at 30.5%, and together NYHA classes III and IV accounted for 50.3% of the study population, indicating a substantial burden of moderate-to-severe symptomatic heart failure.

Table 3. Stratified Analysis of Iron Deficiency Anemia Across Binary Clinical Variables

Variable	Category	IDA Yes n (%)	IDA No n (%)	Total	Odds ratio (95% CI)	p-value
Sex	Male	38 (40.4)	56 (59.6)	94	0.80 (0.37–1.72)	0.564
	Female	17 (45.9)	20 (54.1)	37	Reference	
Smoking history	Yes	27 (40.3)	40 (59.7)	67	0.87 (0.43–1.74)	0.689
	No	28 (43.8)	36 (56.3)	64	Reference	
Hypertension	Yes	31 (41.9)	43 (58.1)	74	0.99 (0.49–2.00)	0.980
	No	24 (42.1)	33 (57.9)	57	Reference	
Diabetes mellitus	Yes	25 (41.0)	36 (59.0)	61	0.93 (0.46–1.86)	0.828
	No	30 (42.9)	40 (57.1)	70	Reference	
Age group	>55 years	22 (46.8)	25 (53.2)	47	1.36 (0.66–2.80)	0.403
	≤55 years	33 (39.3)	51 (60.7)	84	Reference	
Disease duration	>24 months	32 (44.4)	40 (55.6)	72	1.25 (0.62–2.52)	0.529
	≤24 months	23 (39.0)	36 (61.0)	59	Reference	
Obesity	Yes	20 (46.5)	23 (53.5)	43	1.32 (0.63–2.75)	0.463
	No	35 (39.8)	53 (60.2)	88	Reference	

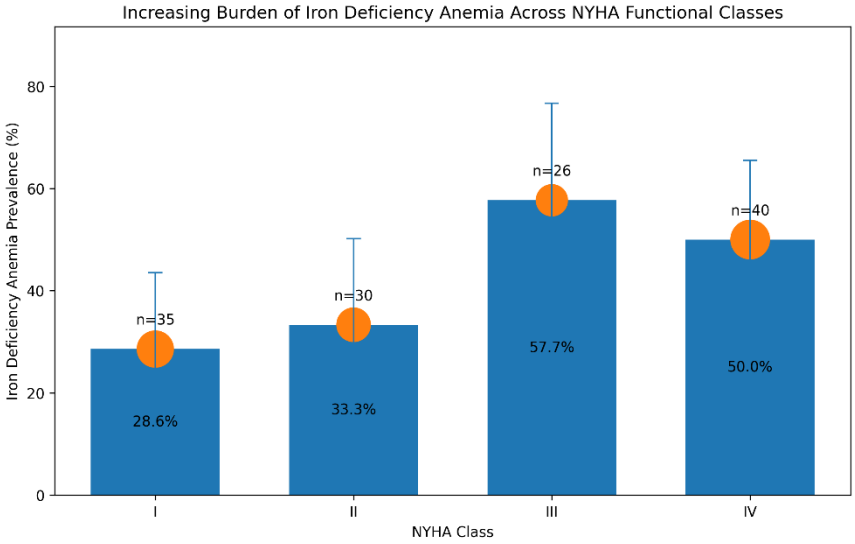

Figure 1 Increasing Burden of Iron Deficiency Anemia Across NYHA Functional Classes

The figure demonstrates a progressive rise in iron deficiency anemia prevalence across worsening NYHA classes, increasing from 28.6% in class I and 33.3% in class II to 57.7% in class III, with persistently high prevalence in class IV at 50.0%. Confidence intervals widen in the smaller subgroups but still support a clinically important upward shift in anemia burden as functional limitation increases. The largest relative concentration of anemia was observed in NYHA class III, where more than half of patients were affected despite a total subgroup size of 26, reinforcing the possibility of a severity-linked relationship that merits confirmation in larger cohorts.

Stratified comparisons showed modestly higher odds of iron deficiency anemia among patients older than 55 years, those with longer disease duration, and those with obesity; however, these associations were weak and imprecise. For example, the odds of iron deficiency anemia were 1.36 times higher in patients older than 55 years and 1.32 times higher in obese patients, but the 95% confidence intervals for both estimates crossed 1.00, indicating statistical uncertainty. Likewise, sex, smoking status, hypertension, and diabetes showed minimal between-group differences, with prevalence estimates clustered closely around the overall sample frequency of 42.0%.

Table 4. Stratified Analysis of Iron Deficiency Anemia by NYHA Functional Class

NYHA class	IDA Yes n (%)	IDA No n (%)	Total	95% CI for IDA prevalence	p-value
I	10 (28.6)	25 (71.4)	35	13.6–43.5%	0.066
II	10 (33.3)	20 (66.7)	30	16.5–50.2%	
III	15 (57.7)	11 (42.3)	26	38.7–76.7%	
IV	20 (50.0)	20 (50.0)	40	34.5–65.5%	

NYHA-based stratification revealed the strongest clinical pattern in the dataset. The prevalence of iron deficiency anemia increased from 28.6% in NYHA class I to 33.3% in class II, then rose sharply to 57.7% in class III before remaining elevated at 50.0% in class IV. Although the global association was not statistically significant at the 0.05 level, the near-threshold p-value of 0.066 and the substantial absolute increase of 29.1 percentage points between classes I and III suggest a clinically meaningful worsening gradient with greater heart failure severity.

DISCUSSION

This study found that iron deficiency anemia was present in 42.0% of patients with heart failure due to dilated cardiomyopathy, indicating that nearly two out of every five patients in this cohort had a potentially important hematologic and metabolic comorbidity. This frequency is clinically meaningful because patients with dilated cardiomyopathy already have compromised myocardial performance, and the coexistence of iron deficiency anemia may further impair oxygen delivery, worsen exercise intolerance, aggravate fatigue, and contribute to poorer functional status. The present findings therefore support the growing recognition that iron deficiency and anemia are not merely accompanying laboratory abnormalities in heart failure, but clinically relevant conditions that may influence symptom burden and overall disease expression in patients with reduced cardiac reserve (8,9).

The observed frequency is broadly consistent with previously published work suggesting that iron deficiency or iron deficiency anemia is common among patients with heart failure, although direct comparisons must be interpreted cautiously because published prevalence estimates vary according to patient selection, disease severity, underlying etiology of heart failure, and laboratory criteria used to define iron deficiency. In the current study, the burden of iron deficiency anemia appears substantial in a tertiary care population from Quetta, which may reflect delayed presentation, nutritional vulnerability, chronic disease burden, and the high proportion of patients in advanced NYHA classes. This local estimate is important because it fills a setting-specific evidence gap and provides a more relevant basis for screening considerations than extrapolation from other populations alone (10,11).

One of the most notable findings of the study was the clinically apparent gradient across NYHA functional class. The frequency of iron deficiency anemia rose from 28.6% in NYHA class I to 33.3% in class II, increased sharply to 57.7% in class III, and remained elevated at 50.0% in class IV. Although the association narrowly missed conventional statistical significance, the pattern strongly suggests that worsening functional limitation may be accompanied by an increasing burden of iron deficiency anemia. This trend is biologically plausible, as patients with more advanced heart failure may have poorer nutritional status, chronic inflammatory activation, impaired gastrointestinal absorption, renal dysfunction, and greater metabolic demand, all of which may contribute to iron depletion and anemia. From a clinical standpoint, the near-significant p-value and the marked absolute rise across functional classes are likely more informative than a simple dichotomous interpretation of statistical significance alone (12,13).

In contrast, no statistically significant associations were observed between iron deficiency anemia and sex, smoking history, hypertension, diabetes mellitus, age category, disease duration, or obesity. These findings suggest that in this dataset, iron deficiency anemia was relatively widespread across patient subgroups rather than being concentrated in a single demographic or cardiometabolic category. However, absence of statistical significance should not be interpreted as proof of no association. The effect estimates for some variables, particularly older age, longer disease duration, and obesity, suggested

modestly higher odds of iron deficiency anemia, but the confidence intervals were wide and crossed unity, indicating limited precision. It is possible that the sample size was adequate for estimating overall frequency but underpowered for detecting subgroup differences of modest magnitude (14,15).

The present findings have practical implications for routine cardiology care. Because iron deficiency anemia affected 42.0% of the study population and appeared more common in patients with greater functional limitation, structured hematologic and iron-status assessment should be considered in patients with dilated cardiomyopathy, especially those with persistent symptoms or NYHA class III or IV disease. Identification of iron deficiency anemia in such patients may allow earlier intervention, improve diagnostic completeness, and support more individualized management strategies. Even in settings where advanced therapeutic options are limited, recognition of a treatable contributory factor remains clinically valuable because symptom severity in heart failure is often multifactorial and potentially modifiable (16,17).

This study should be interpreted in light of certain limitations. Its cross-sectional design does not allow causal inference regarding whether iron deficiency anemia contributed to greater heart failure severity or developed as a consequence of advanced disease. The study was conducted at a single tertiary care center, which may limit generalizability to community settings or other regions. In addition, the analysis was primarily descriptive and stratified, without multivariable adjustment for potentially interacting clinical factors. Nevertheless, the study provides important local evidence using real-world hospital data and highlights a high burden of iron deficiency anemia in a clinically vulnerable population. These findings justify larger multicenter studies using standardized iron deficiency criteria and adjusted analyses to better define predictors, severity relationships, and treatment implications in patients with dilated cardiomyopathy (18,19).

Taken together, the results indicate that iron deficiency anemia is common among patients with heart failure due to dilated cardiomyopathy in this setting and may become more prominent as functional limitation worsens. The study therefore supports greater clinical attention to iron-status evaluation in this patient group and establishes a foundation for future work exploring prognostic impact and therapeutic benefit in local cardiovascular practice (20,21).

CONCLUSION

Iron deficiency anemia was identified in 42.0% of patients with heart failure due to dilated cardiomyopathy, demonstrating that it is a common comorbidity in this population. Although no significant associations were observed across most demographic and clinical subgroups, the frequency of iron deficiency anemia increased across worsening NYHA functional classes and was highest in class III, with persistently elevated prevalence in class IV, suggesting a clinically relevant relationship with heart failure severity. These findings support routine evaluation for iron deficiency anemia in patients with dilated cardiomyopathy, particularly in those with greater symptomatic limitation, to improve diagnostic assessment and potentially guide more comprehensive management.

REFERENCES

1. Jalali Z, Khademalhosseini M, Soltani N, Nadimi AE. Smoking, alcohol and opioids effect on coronary microcirculation: an update overview. BMC Cardiovasc Disord. 2021;21(1):1-7.

2. Wang H, Naghavi M, Allen C, Barber RM, Bhutta ZA, Carter A, et al. Global, regional, and national life expectancy, all-cause mortality, and cause-specific mortality for 249 causes of death, 1980-2015: a systematic analysis for the Global Burden of Disease Study 2015. Lancet. 2016;388(10053):1459-544.

3. Naito R, Miyauchi K. Coronary artery disease and type 2 diabetes mellitus current treatment strategies and future perspective. Int Heart J. 2017;58(4):475-80.

4. Adnan M, Aasim M. Prevalence of type 2 diabetes mellitus in adult population of Pakistan: a meta-analysis of prospective cross-sectional surveys. Ann Glob Health. 2020;86(1):7.

5. Albashir AA, Elawad OA, Khougali HS. The use of glycosylated hemoglobin (HbA1c) as a predictor of the severity of acute coronary syndrome among diabetic patients. Ir J Med Sci. 2021;190(2):609-14.

6. Song P, Xu J, Song Y, Jiang S, Yuan H, Zhang X. Association of plasma myeloperoxidase level with risk of coronary artery disease in patients with type 2 diabetes. Dis Markers. 2015;2015:1-?.

7. Dubey TN, Mundada K, Arya A. Correlation of HbA1c with mortality and severity in acute coronary syndrome. Int J Contemp Med Res. 2016;3(8):2244-7.

8. Muhammad A, Nizam A, Yousuf MH. Angiographic severity of CAD in patients with acute coronary syndrome in correlation to their glycemic status. Pak J Med Health Sci. 2019;13(1):312-6.

9. Chandel S, Parihar S, Gramani B, Dubey TN. Role of HbA1c with mortality and severity among the patients of acute coronary syndrome: a prospective study. Int J Adv Med. 2019;6(3):796-9.

10. Khan FR, Ali J, Ullah R, Hassan Z, Khattak S, Lakhta G, et al. Relationship between high glycated hemoglobin and severity of coronary artery disease in type II diabetic patients hospitalized with acute coronary syndrome. Cureus. 2021;13(3):e?.

11. Mantzoukis S, Gerasimou M. Correlation between glycosylated hemoglobin and syntax score. Achaiki Iatriki. 2020;39:167-73.

12. Roe MT, Harrington RA, Prosper DM, Pieper KS, Bhatt DL, Lincoff AM, et al. Clinical and therapeutic profile of patients presenting with acute coronary syndromes who do not have significant coronary artery disease. Circulation. 2000;102(11):1311-6.

13. Reynolds HR, Srichai MB, Iqbal SN, Slater JN, Mancini GB, Feit F, et al. Mechanisms of myocardial infarction in women without angiographically obstructive coronary artery disease. Circulation. 2011;124(13):1414-25.

14. Bertrand ME, LaBlanche JM, Tilmant PY, Thieuleux FA, Delforge MR, Carre AG, et al. Frequency of provoked coronary arterial spasm in 1089 consecutive patients undergoing coronary arteriography. Circulation. 1982;65(7):1299-306.

15. Bugiardini R, Manfrini O, Pizzi C, Fontana F, Morgagni G. Endothelial function predicts future development of coronary artery disease: a study of women with chest pain and normal coronary angiograms. Circulation. 2004;109(21):2518-23.

16. Holmvang L, Jurlander B, Rasmussen C, Thiis JJ, Grande P, Clemmensen P. Use of biochemical markers of infarction for diagnosing perioperative myocardial infarction and early graft occlusion after coronary artery bypass surgery. Chest. 2002;121(1):103-11.

17. Zimetbaum PJ, Josephson ME. Use of the electrocardiogram in acute myocardial infarction. N Engl J Med. 2003;348(10):933-40.

18. Roffi M, Patrono C, Collet JP, Mueller C, Valgimigli M, Andreotti F, et al. 2015 ESC Guidelines for the management of acute coronary syndromes in patients presenting without persistent ST-segment elevation. Eur Heart J. 2016;37(3):267-315.

19. D'Avanzo B, Santoro L, La Vecchia C, Maggioni A, Nobili A, Iacuitti G, et al. Physical activity and the risk of acute myocardial infarction. Ann Epidemiol. 1993;3(6):645-51.

20. Gong J, Campos H, Fiecas JM, McGarvey ST, Goldberg R, Richardson C, et al. A case-control study of physical activity patterns and risk of non-fatal myocardial infarction. BMC Public Health. 2013;13:122.

21. Zhang H, Sun S, Tong L, Li R, Cao XH, Zhang BH, et al. Effect of cigarette smoking on clinical outcomes of hospitalized Chinese male smokers with acute myocardial infarction. Chin Med J (Engl). 2010;123(20):2807-11.