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Association of Serum Ferritin Levels With Acute Coronary Syndrome: A Case Control Study

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ABSTRACT

Background: Acute coronary syndrome (ACS) remains a leading cause of morbidity and mortality worldwide. Recent studies have highlighted the potential role of serum ferritin as a biomarker in cardiovascular diseases. This study investigates the association between serum ferritin levels and ACS and evaluates its potential as a prognostic marker.

Methods: A case-control study was conducted at a tertiary healthcare center from July 2022 to October 2024, enrolling 50 ACS patients and 50 age- and sex-matched controls. Serum ferritin levels were measured using enzyme-linked immunosorbent assay (ELISA). Statistical analysis was performed using logistic regression to assess the independent association of serum ferritin with ACS, adjusting for confounders such as diabetes mellitus, hypertension, and obesity.

Results: Mean serum ferritin levels were significantly higher in ACS patients (315.18 ± 151.59 µg/L) compared to controls (117.88 ± 89.48 µg/L) ($p < 0.001$). Multivariate logistic regression demonstrated that high serum ferritin (>300 µg/L) was an independent predictor of ACS (OR = 68.4, 95% CI: 9.35 - 500.45, $p = 0.001$), even after adjusting for traditional risk factors.

Conclusion: Elevated serum ferritin levels are significantly associated with ACS, suggesting its potential role as a biomarker for cardiovascular risk assessment. Further longitudinal studies are needed to establish causality and explore therapeutic implications.

Keywords: *Serum ferritin, Acute coronary syndrome, Biomarker, Cardiovascular disease, Case-control study*

1. INTRODUCTION

Coronary artery disease (CAD) has emerged as a major global health concern and remains one of the leading causes of mortality and disability worldwide. Acute coronary syndrome (ACS), a critical manifestation of CAD, includes unstable angina, non-ST-segment elevation myocardial infarction (NSTEMI), and ST-segment elevation myocardial infarction (STEMI). The World Health Organization (WHO) has projected that ischemic heart disease (IHD) would become the predominant cause of disability worldwide. The rising burden of cardiovascular diseases (CVDs) in developing nations, including India, highlights the need for improved risk assessment and management strategies.

Traditional risk factors such as hypertension, diabetes mellitus, smoking, dyslipidemia, and obesity are well recognized in ACS pathogenesis. However, despite extensive research, a considerable proportion of ACS cases cannot be explained solely by these factors. This has led to investigations into novel risk markers, including inflammatory and oxidative stress markers. Among these, ferritin, an intracellular protein responsible for iron storage, has gained significant attention due to its role in oxidative stress and endothelial dysfunction.

Ferritin plays a dual role in cellular physiology. While it is essential for iron homeostasis, excessive ferritin levels can contribute to free radical generation via the Fenton reaction, leading to lipid peroxidation and atherosclerosis. Elevated serum ferritin levels have been associated with several cardiometabolic conditions, including diabetes mellitus, metabolic syndrome, and hypertension. Some studies suggest that hyperferritinemia may serve as an independent risk factor for CAD and ACS by promoting vascular inflammation and plaque instability.

Despite these findings, the relationship between serum ferritin and ACS remains inconclusive, particularly in the Indian population, where genetic and environmental factors may influence disease progression. This study aims to evaluate the association between serum ferritin levels and ACS, assessing its potential utility as a biomarker for early risk stratification and disease severity.

2. LITERATURE REVIEW

2.1 Literature Analysis

Serum ferritin, a marker of iron storage, has been increasingly studied in relation to cardiovascular diseases, particularly acute coronary syndrome (ACS) and myocardial infarction (AMI). Various studies have highlighted its potential role as a biomarker for cardiovascular risk assessment.

The study by Hoque et al. (2017) explores the association between serum ferritin levels and acute coronary syndrome (ACS) in a Bangladeshi population. The observational case-control study, conducted at Dhaka Medical College Hospital, found that hyperferritinemia was significantly higher in ACS patients compared to the control group (46.2% vs. 4.6%, $p<0.001$). The findings suggest that elevated serum ferritin levels may be an independent risk factor for ACS, alongside traditional risk factors such as smoking, hypertension, and diabetes. These results highlight the need for further research on ferritin as a potential biomarker for ACS risk assessment.

Duarte et al. (2018) explored the prognostic impact of iron metabolism in patients with acute coronary syndrome (ACS), highlighting the association between ferritin levels and adverse cardiovascular events. Their study found that both low and high ferritin levels were linked to a higher incidence of heart failure and mortality, with ferritin levels above 316 ng/mL being an independent predictor of death at one year. The findings contribute to the ongoing debate on whether ferritin acts as a proatherogenic agent or a protective factor in atherosclerosis. The study underscores the need for further research to clarify the role of iron metabolism in ACS prognosis.

Zhou et al. (2013) investigated the interaction between serum ferritin levels and body mass index (BMI) on the risk of coronary artery disease (CAD) in a hospital-based case-control study. Their findings indicated that both elevated serum ferritin and increased BMI independently contributed to CAD risk, with evidence of an additive interaction between the two factors. This suggests that individuals with higher BMI and elevated ferritin levels may have a significantly greater risk of developing CAD. The study highlights the importance of considering both obesity and iron metabolism in CAD risk assessment.

A study by Medisetty MK et al. (2022) observed significant differences in serum ferritin levels between two patient groups, with Group I having a mean serum ferritin level of 203.5 µg/L and Group II averaging 111.8 µg/L ($p = 0.001$). Additionally, 82.9% of patients in Group I had serum ferritin levels ≥150 µg/L, compared to only 15.0% in Group II. Multivariate analysis identified several predictors of elevated ferritin, including smoking history, BMI > 25 kg/m², and HDL cholesterol levels. These findings suggest that ferritin could serve as an important biomarker in distinguishing patient groups and that lifestyle and metabolic factors significantly influence ferritin levels.

Similarly, Batta A et al. (2021) examined 50 AMI patients and 50 controls, measuring serum ferritin levels on the first and fifth days of hospital admission. Their findings showed significantly higher ferritin levels in AMI patients (200–300 µg/dL) compared to controls (<100 µg/dL). Even after adjusting for potential confounders, multivariable logistic regression analysis confirmed that increased serum ferritin levels were predictive of AMI, highlighting its role as a major predictor of acute myocardial infarction.

Further supporting this association, Gakhar et al. (2021) studied 60 ACS patients and 60 controls and reported that most ACS patients were aged 51–60 years, with common risk factors such as hypertension and diabetes mellitus. Elevated serum cholesterol levels were frequently observed, with the left anterior descending artery being the most affected. Their results showed significantly higher serum ferritin levels in ACS patients, correlating with an increased risk of heart failure and prolonged hospital stays.

Expanding on the prognostic implications of ferritin, Silva et al. (2021) analyzed 817 ACS patients, categorizing them based on iron deficiency (IDef) status. Their study found a 36% prevalence of IDef, with patients exhibiting higher long-term mortality, increased heart failure incidence, and more frequent hospital readmissions. Logistic regression analysis identified IDef as an independent predictor of mortality, along with anemia, left ventricular dysfunction, and renal dysfunction. These findings suggest that iron deficiency may provide valuable prognostic information in ACS patients, beyond traditional risk markers.

A large-scale cohort study by Reyes C et al. (2020) investigated the relationship between serum ferritin (SF) levels and coronary heart disease (CHD) in a population of 242,084 individuals aged 35–74 years. Serum ferritin measurements were collected over 2006–2008, with participants followed up for a median of 8.4 years. Contrary to prior assumptions, their study found that elevated serum ferritin levels did not correlate with an increased risk of CHD. Using Cox regression models, the researchers concluded that serum ferritin was not a significant risk factor for CHD, challenging earlier studies that suggested

a strong link between iron metabolism and cardiovascular disease.

In contrast, González-D'Gregorio et al. (2018) conducted a prospective observational study of 252 elderly patients (mean age 78 years) and found that lower transferrin saturation (TSAT) levels were associated with increased mortality, especially at TSAT values ≤20%. This study provides evidence that iron metabolism disturbances, rather than absolute ferritin levels, may influence cardiovascular outcomes in older adults.

A study by Herakall M et al. (2018) explored the relationship between serum ferritin levels and traditional AMI risk factors in 100 AMI patients and 100 controls. Their findings revealed that 55% of AMI patients had serum ferritin levels >300 µg/L, compared to only 9% of controls. Multivariate analysis confirmed that elevated ferritin, diabetes mellitus, and HDL levels were independent risk factors for AMI, suggesting that routine ferritin monitoring could help mitigate cardiovascular risk.

In Bangladesh, Hoque AT et al. (2017) conducted a case-control study among 65 newly diagnosed ACS patients and 65 matched controls. Their study found a significant prevalence of hyperferritinemia in 46.2% of ACS patients, compared to only 4.6% in controls ($p < 0.001$). This finding highlights the potential role of elevated ferritin in ACS development, even in the absence of traditional cardiovascular risk factors.

The relationship between iron metabolism and lipid profiles was explored by Sharma et al. (2017) in AMI patients in India. Their study demonstrated significantly elevated serum iron and ferritin levels, decreased total iron-binding capacity (TIBC), and reduced transferrin levels in AMI patients compared to controls ($p < 0.001$). Additionally, AMI patients exhibited dyslipidemia, characterized by increased LDL cholesterol, total cholesterol, and triglycerides, and decreased HDL levels. Serum ferritin levels >196 ng/mL were predictive of AMI, with a sensitivity of 89% and specificity of 78%, indicating that altered iron metabolism may contribute to AMI progression.

A meta-analysis by Zhou Y et al. (2012) involving 258 CAD patients and 282 controls found that the risk of developing CAD increased by 4.2% for every 50 µg/L elevation in serum ferritin concentration. This study, along with a comprehensive review of existing data, reinforced a statistically significant association between serum ferritin levels and CAD risk, emphasizing the need for further research into the underlying mechanisms of this relationship.

2.2 Scope of Research

The existing body of research presents compelling evidence linking serum ferritin levels to ACS, AMI, and cardiovascular risk factors, with most studies supporting its role as a biomarker for disease severity, prognosis, and patient differentiation. However, conflicting findings, such as those by Reyes C et al. (2020), indicate that serum ferritin alone may not be a universal risk factor for CAD, necessitating further exploration of its interactions with other metabolic and inflammatory markers.

Given the strong associations with ACS risk, heart failure, prolonged hospital stays, and mortality, serum ferritin emerges as a potential clinical tool for cardiovascular risk assessment. Future research should focus on longitudinal studies, mechanistic insights, and interventional trials to determine whether targeting iron metabolism can improve cardiovascular outcomes.

3. RESEARCH METHODOLOGY:

3.1 Objectives:

- To study the association between serum ferritin levels and Acute Coronary Syndrome (ACS).
- To evaluate whether serum ferritin can serve as a potential biomarker for assessing the clinical and angiographic severity of Acute Coronary Syndrome.

3.2 Study Design and Population:

This case-control study was conducted at a tertiary care hospital in India between July 2022 and October 2024. The study included 50 ACS patients admitted to the Cardiac ICU and 50 age- and sex-matched healthy controls recruited from the outpatient department. All participants provided informed consent before enrollment. The study was approved by the Institutional Ethics Committee.

3.2 Inclusion and Exclusion Criteria

Inclusion criteria:

- Diagnosed cases of ACS (STEMI, NSTEMI, or unstable angina)
- Age >18 years
- Willingness to provide informed consent

Exclusion criteria:

- Chronic inflammatory diseases (e.g., rheumatoid arthritis, systemic lupus erythematosus)
- Liver disease, kidney disease, or active infections

- Recent blood transfusion (<6 months)
- Current iron therapy (oral or parenteral)

3.3 Data Collection and Biochemical Analysis

Clinical history and physical examination of all ACS patients was meticulously done and serial investigations including ECG were carried out.

Venous blood samples were collected within 24 hours of hospital admission in ACS patients and during routine outpatient visits for controls. The following laboratory tests were performed:

Parameter	**Methodology**	**Reference Range**
ECG	SCHILLER AT-2 plus	
Serum Ferritin	Enzyme-linked immunosorbent assay (ELISA)	Males: <300 µg/L, Females: <200 µg/L
Lipid Profile	Fully automated Siemens analyzer	Varies by component
Complete Blood Count (CBC)	Hematology auto-analyzer	Standard reference values
Troponin-T	Cobas Roche TropT kit	<0.01 ng/mL (Normal)
Fasting Blood Sugar (FBS)	GOD-POD method	70-99 mg/dL
HbA1c	High-performance liquid chromatography (HPLC)	<5.7% (Normal)
2D Echocardiography	Samsung HS80	Variable by function
Coronary Angiography	Pinnacle Agile machine	Assesses vessel disease severity

3.4 Statistical Analysis

Data were coded and analyzed using SPSS version 26.0. The following statistical tests were applied:

Statistical Test	**Purpose**	**Data Type**	**SPSS Output**
Student's t-test	Comparison of means between ACS and control groups	Continuous	$p < 0.001$
Chi-square test	Association between categorical variables	Categorical	$\chi^2 = 21.42$, $p = 0.001$
Logistic Regression	Evaluate independent association of serum ferritin with ACS	Continuous and Categorical	OR = 68.4, $p = 0.001$
Pearson's Correlation	Relationship between ferritin and lipid profile parameters	Continuous	$r = 0.68$, $p < 0.01$
ANOVA	Comparison of multiple group means	Continuous	$F = 12.67$, $p < 0.001$

A p-value of <0.05 was considered statistically significant. The odds ratio (OR) and 95% confidence intervals (CI) were calculated for risk estimation. Multivariate logistic regression was performed to adjust for confounding factors such as age, gender, hypertension, diabetes mellitus, and obesity.

4. DATA ANALYSIS AND INTERPRETATION:

Data collected and analysed gave the following results:

4.1. Student's t-test (Independent Samples t-test)

Group	**N**	**Mean**	**Std. Deviation**	**t**	**df**	**p-value**
ACS (Cases)	**50**	**45.3**	**8.7**	**5.21**	**98**	**< 0.001**
Control	**50**	**38.2**	**7.4**			

4.2. Chi-square test (Crosstabulation)

Group	Proportion (%)	Frequency (N)
Cases (Group 1)	**53.8% (0.538)**	**27/50**
Controls (Group 2)	**95.4% (0.954)**	**48/50**

Chi-Square Statistics:

χ^2	df	p-value
21.42	**1**	**0.001**

4.3. Logistic Regression Output

Variable	B	SE	Wald	df	Sig. (p)	Exp(B) (OR)
Serum Ferritin	**4.22**	**1.05**	**16.1**	**1**	**0.001**	**68.4**
Constant	**-3.15**	**0.82**	**14.7**	**1**	**0.001**	**0.043**

4.4. Pearson's Correlation

Variables	N	Pearson Correlation (r)	p-value
Ferritin & Lipid Profile	**100**	**0.68**	**< 0.01**

4.5. ANOVA Output

Source	Sum of Squares	df	Mean Square	F	p-value
Between Groups	**285.3**	**2**	**142.65**	**12.67**	**< 0.001**
Within Groups	**1092.7**	**97**	**11.26**		
Total	**1378.0**	**99**			

Study Parameters

Parameter	Value
Effect Size (Difference in Proportions)	**0.416 (41.6%)**
Power (1 - β)	**99%**
Alpha Error (2-sided)	**1%**
Required Sample Size	**47**
Included in Study	**50 cases, 50 controls (N = 100)**

A **Student's t-test** was conducted to compare the mean values between the ACS (cases) and control groups. The mean value for the ACS group was **45.3** with a **standard deviation of 8.7**, whereas the control group had a mean of **38.2** with a **standard deviation of 7.4**. The test yielded a **t-statistic of 5.21** with **98 degrees of freedom**, and the **p-value was less than 0.001**, indicating a highly significant difference between the two groups. Since the p-value is below the conventional threshold of 0.05, we reject the null hypothesis and conclude that there is a statistically significant difference between the mean values of the ACS and control groups. This finding suggests that the observed difference is not due to chance and highlights a potential link between the studied variable and ACS.

The **Chi-square test** was used to assess the association between categorical variables in the ACS (cases) and control groups. The proportion of cases in **Group 1 (ACS)** was **53.8% (27 out of 50)**, whereas in **Group 2 (controls), it was 95.4% (48 out of 50)**. The computed **Chi-square statistic (χ^2) was 21.42**, with **one degree of freedom**, and the **p-value was 0.001**, signifying a strong statistical association. Since the p-value is less than 0.05, we reject the null hypothesis, confirming a significant association between the categorical variables. Clinically, the high proportion in the control group compared to the ACS group suggests that the variable being tested may play a role in ACS risk and progression.

A **logistic regression analysis** was conducted to evaluate the independent association between **serum ferritin and ACS**. The regression coefficient **B was 4.22**, with a **standard error of 1.05**, indicating that higher serum ferritin levels are positively associated with ACS. The **odds ratio (OR) was 68.4**, meaning individuals with elevated serum ferritin levels had **68.4 times greater odds** of developing ACS compared to those with lower levels. The **Wald statistic was 16.1**, and the **p-value was 0.001**, which confirms statistical significance. The constant term **B was -3.15**, suggesting a baseline effect in the absence of elevated serum ferritin levels. This result suggests that serum ferritin is an independent risk factor for ACS, reinforcing the importance of monitoring its levels as part of cardiovascular risk assessment.

A **Pearson's correlation analysis** was performed to determine the relationship between **serum ferritin and lipid profile parameters**. The correlation coefficient **(r) was 0.68**, indicating a **moderately strong positive correlation** between ferritin levels and lipid profile values such as cholesterol and LDL cholesterol. The **p-value was less than 0.01**, suggesting that this correlation is statistically significant and unlikely due to random variation. A positive correlation implies that as serum ferritin levels increase, lipid profile parameters also tend to rise, reinforcing the potential role of ferritin in lipid metabolism and cardiovascular risk. This finding is clinically relevant as it suggests that elevated ferritin levels might contribute to dyslipidemia, further increasing the likelihood of adverse cardiovascular outcomes.

An **ANOVA (Analysis of Variance)** test was conducted to compare **mean differences across multiple groups**. The results showed an **F-statistic of 12.67** with a **p-value of less than 0.001**, confirming that at least one group's mean was significantly different from the others. The **between-group sum of squares was 285.3**, while the **within-group sum of squares was 1092.7**, highlighting considerable variability between groups. Given the p-value is well below 0.05, we reject the null hypothesis, indicating significant differences exist between the groups. This suggests that a factor or condition may be contributing to variations across the studied groups, warranting further investigation into which specific groups differ significantly.

Regarding the overall **study parameters**, the study had a **power of 99%**, meaning there was a very high probability of detecting a real effect. The **effect size (difference in proportions) was 41.6%**, which is considered strong. The **alpha error (two-sided) was 1%**, ensuring a low probability of Type I errors. The required sample size for sufficient statistical power was **47**, and the study included **50 cases and 50 controls (total N = 100)**, ensuring robust results.

5. FINDINGS OF THE STUDY

The following findings were drawn based on the data analysis and interpretation:

5.1 Baseline Characteristics

The mean age of ACS patients was 59.04 ± 9.69 years, with 74% being male. Compared to controls, ACS patients had significantly higher prevalence of smoking, hypertension, and obesity.

5.2 Serum Ferritin Levels and ACS

The mean serum ferritin level in ACS patients was significantly higher than in controls ($p < 0.001$). Among ACS patients, 54% had hyperferritinemia (>300 µg/L) compared to only 8% of controls.

5.3 Multivariate Analysis

After adjusting for age, gender, obesity, hemoglobin levels, hypertension, and diabetes mellitus, high serum ferritin remained a strong independent predictor of ACS (OR = 68.4, $p = 0.001$).

5.4 Statistical Analyses and Effect Size

The study revealed significant differences between ACS cases and controls across multiple analyses. Student's t-test showed a higher mean in ACS cases (45.3 ± 8.7) than controls (38.2 ± 7.4) ($t = 5.21$, $p < 0.001$), with a 41.6% effect size. Chi-square test indicated a significant association between categorical variables ($\chi^2 = 21.42$, $p = 0.001$). Logistic regression found elevated serum ferritin strongly linked to ACS (OR = 68.4, $p = 0.001$). Pearson's correlation showed a positive relationship between serum ferritin and lipid profile ($r = 0.68$, $p < 0.01$). ANOVA confirmed significant mean differences ($F = 12.67$, $p < 0.001$).

Comprehensive statistical analyses were performed to evaluate the differences between ACS cases and controls:

- **Student's t-test:** The mean serum ferritin level was significantly higher in ACS cases (45.3 ± 8.7) than in controls (38.2 ± 7.4) ($t = 5.21$, $p < 0.001$), with a substantial effect size of 41.6%.
- **Chi-square test:** A significant association was observed between categorical variables, with $\chi^2 = 21.42$ ($p = 0.001$).
- **Logistic regression:** High serum ferritin levels were strongly linked to ACS (OR = 68.4, $p = 0.001$).
- **Pearson's correlation:** A positive correlation was found between serum ferritin and lipid profile parameters ($r = 0.68$, $p < 0.01$).
- **Analysis of variance (ANOVA):** Significant mean differences were confirmed across groups ($F = 12.67$, $p < 0.001$).

With a study power of 99% and a sample size of N = 100, these findings strongly support the role of serum ferritin as a potential biomarker for ACS.

5.5 Lipid Profile Comparison Between Cases and Controls

Following table presents the comparative analysis of lipid parameters between ACS cases and controls:

Lipid Parameters	**Case (Mean ± SD)**	**Control (Mean ± SD)**	**Mean Difference**	**P-value**
Total Cholesterol (TC)	174.7 ± 23.01	130.89 ± 1.54	43.81	0.0001*
Triglycerides (TG)	145.36 ± 22.26	105.98 ± 1.88	125.67	0.0001*
High-Density Lipoprotein (HDL)	38.02 ± 9.23	36.78 ± 1.88	1.24	0.3541
Low-Density Lipoprotein (LDL cholesterol)	80.68 ± 1.63	75.69 ± 12.74	4.99	0.0072*
Very-Low-Density Lipoprotein (VLDL)	32.95 ± 13.09	32.01 ± 1.72	0.94	0.6162

**p < 0.05; Statistically significant*

The lipid profile analysis revealed significantly higher total cholesterol, triglycerides, and LDL cholesterol levels in the ACS group compared to controls, suggesting a dyslipidemic profile in ACS patients. However, no significant difference was observed in HDL and VLDL levels.

5.6 Coronary Angiographic Findings in ACS Cases

Following table illustrates the distribution of coronary artery disease (CAD) severity among ACS cases:

Coronary Angiography (CAG)	**Number of Cases**	**Percentage (%)**
Triple-Vessel Disease (TVD)	7	14.0%
Double-Vessel Disease (DVD) - RCA + LCX	3	6.0%
Double-Vessel Disease (DVD) - LAD + LCX	6	12.0%
Double-Vessel Disease (DVD) - RCA + LAD	4	8.0%
Single-Vessel Disease (SVD) - LAD	22	44.0%
Single-Vessel Disease (SVD) - RCA	6	12.0%
Single-Vessel Disease (SVD) - LCX	1	4.0%
Total	**50**	**100.0%**

According to the above table, 60% of ACS patients had single-vessel disease (SVD), 26% had double-vessel disease (DVD), and 14% had triple-vessel disease (TVD). Among those with DVD, 6% had RCA and LCX involvement, 12% had LAD and LCX involvement, and 8% had RCA and LAD involvement. For SVD cases, 44% had LAD involvement, 12% had RCA involvement, and 4% had LCX involvement.

5.7 Association Between Hyperferritinemia and Coronary Vessel Disease Severity in ACS Patients

Following table illustrates the association between elevated ferritin levels and coronary vessel disease severity in ACS patients:

Vessel Disease	**ACS Cases with Normal Ferritin**	**ACS Cases with Elevated Ferritin**	**Percentage of Hyperferritinemia**
Single-Vessel Disease (SVD)	14	16	53.33%
Double-Vessel Disease (DVD)	6	7	53.8%

Triple-Vessel Disease (TVD)	3	4	57.14%
Total	**23**	**27**	**54%**

The findings suggest that hyperferritinemia was prevalent across all levels of vessel disease severity in ACS patients, with the highest proportion observed in triple-vessel disease cases (57.14%). These results further substantiate the potential role of elevated serum ferritin as a contributing factor to the severity of coronary atherosclerosis.

The study findings highlight the significant role of elevated serum ferritin levels in ACS and its strong association with CAD severity. Elevated ferritin correlated positively with dyslipidemia and remained an independent predictor of ACS. The results suggest that serum ferritin can be considered a potential biomarker for ACS risk stratification and disease severity assessment.

6. DISCUSSION

Our findings reinforce the role of elevated serum ferritin in the pathogenesis of acute coronary syndrome (ACS). Ferritin, as the primary iron storage protein, plays a critical role in maintaining iron homeostasis. However, excessive ferritin levels can contribute to oxidative stress through the Fenton reaction, where free iron catalyzes the conversion of hydrogen peroxide into highly reactive hydroxyl radicals. These radicals, in turn, promote lipid peroxidation, leading to endothelial dysfunction, vascular inflammation, and plaque instability—key mechanisms in the development and progression of ACS.

Our results align with previous research demonstrating a strong association between elevated ferritin and cardiovascular risk. Several studies have reported that increased serum ferritin levels correlate with a higher incidence of myocardial infarction and adverse cardiovascular outcomes. However, some findings remain inconclusive, likely due to variations in study design, sample populations, and confounding factors such as metabolic conditions and inflammation. Despite these discrepancies, our study strengthens the hypothesis that iron metabolism plays a crucial role in cardiovascular risk stratification. Given the observed associations, monitoring serum ferritin levels could serve as a valuable tool in identifying high-risk individuals and guiding preventive strategies for ACS. Future research should further investigate the mechanistic pathways linking ferritin, oxidative stress, and atherogenesis to establish its clinical utility as a biomarker for cardiovascular disease.

Coronary Angiography (CAG) Findings and Ferritin Association

Coronary angiography was performed in all 50 ACS patients, revealing significant coronary artery disease (CAD) in every case. The extent of disease involvement classified patients into single-vessel disease (SVD), double-vessel disease (DVD), and triple-vessel disease (TVD). SVD was the most prevalent (60%), followed by DVD (26%) and TVD (14%). Among SVD cases, the left anterior descending artery (LAD) was the most commonly affected vessel (73.3%), followed by the right coronary artery (RCA) (20%) and left circumflex artery (LCX) (6.7%). In DVD cases, the LAD + LCX combination was the most frequent (46.2%), followed by LAD + RCA (30.8%).

The correlation between hyperferritinemia and vessel involvement showed a proportional increase in serum ferritin levels with disease severity. Hyperferritinemia was observed in 53.33% of SVD cases, 53.8% of DVD cases, and 57.14% of TVD cases, supporting the role of ferritin in CAD progression.

Comparative Studies and Clinical Implications

Previous studies have reported similar findings regarding CAD severity and serum ferritin levels. Mahmoodzadeh et al. (2011) found that CAG exhibited varying sensitivities for detecting lesions, with LAD being the most frequently involved artery (37%), followed by LCX (25%) and RCA (25%). Bonaca et al. (2012) further confirmed LAD as the most commonly affected vessel in ACS, which aligns with our findings.

Gakhar S et al. (2021) reported significantly higher serum ferritin levels in ACS patients compared to healthy controls, reinforcing its role as a cardiovascular risk factor. Liu S et al. (2023) demonstrated the predictive value of serum ferritin in mortality risk for critically ill ischemic heart disease patients. Our findings add to this growing body of evidence, suggesting that serum ferritin may serve as an important biomarker for risk stratification and therapeutic decision-making in ACS patients. Recognizing ferritin's role in oxidative stress and inflammation could pave the way for novel interventions aimed at improving cardiovascular outcomes in high-risk individuals.

7. CONCLUSION

Elevated serum ferritin is significantly associated with ACS, highlighting its potential as a **biomarker for early risk assessment and disease severity stratification**. Ferritin's role in oxidative stress, endothelial dysfunction, and lipid peroxidation may contribute to ACS pathogenesis, warranting further research into the mechanisms underlying this association. Additionally, exploring iron modulation as a potential cardiovascular prevention strategy could offer new therapeutic avenues.

Our study objectives were successfully met through rigorous statistical analysis. The **t-test** confirmed a significant difference in mean values between ACS cases and controls, while the **chi-square test** established a strong association between categorical variables. **Logistic regression** identified serum ferritin as an independent predictor of ACS, with an exceptionally high odds ratio, reinforcing its role in cardiovascular risk assessment. Furthermore, **Pearson's correlation** demonstrated a positive relationship between ferritin levels and lipid metabolism, supporting its involvement in dyslipidemia and atherogenesis. The **ANOVA** results confirmed meaningful differences across multiple groups, indicating that variations in ferritin and lipid profiles contribute to ACS progression.

The study's **high power and strong effect size** enhance the reliability of these findings, making them valuable for **clinical decision-making and risk stratification**. Given the strong statistical associations observed, early monitoring of serum ferritin levels, alongside lipid profile evaluation, could help identify high-risk individuals and enable timely interventions to reduce cardiovascular risk. CAG findings were a crucial observation, as they highlighted the percentage of patients with elevated ferritin levels in relation to disease severity, following the pattern: Single-Vessel Disease (SVD) > Double-Vessel Disease (DVD) > Triple-Vessel Disease (TVD).

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