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General Medicine

A STUDY OF CORRELATION BETWEEN SERUM LIPID PROFILE AND IRON DEFICIENCY ANEMIA IN INDIAN PATIENTS

Dr Ananya P Aithal	Postgraduate, Department Of General Medicine, J J M Medical College, Davangere.
Dr P M Chinmai	MBBS, M S RAMAIAH Medical College, Bengaluru.
Dr P M Chirag	MBBS, SREE BALAJI Medical College, Chennai.
Dr Vinaya Swami P M	Professor , Department Of General Medicine, J J M Medical College, Davangere.
Dr Sanath Manjunath	Consultant Physician - Mahabodhi Charitable Hospital Leh.
Dr Mohanish N M	Postgraduate, Department Of General Medicine, J J M Medical College, Davangere.

ABSTRACT **Background:** Iron deficiency anemia (IDA) is a prevalent condition globally, particularly in India, where it affects a significant proportion of the population. Dyslipidemia, characterized by abnormal lipid levels, is also common and linked to cardiovascular risks. The relationship between IDA and lipid profile alterations remains underexplored. **Objective:** This study aimed to evaluate the association between IDA and serum lipid profiles, assess demographic and clinical features of anemic patients, and determine if anemia severity or type influences lipid sub-fractions. **Methods:** A prospective case-control study was conducted at Chigateri General Hospital and Bapuji Hospital, Davangere, India, from April 2021 to August 2022. Fifty patients with IDA (hemoglobin <13 g/dL for men, <12 g/dL for women) and 50 age- and sex-matched non-anemic controls were included. Fasting lipid profiles (total cholesterol, triglycerides, HDL, LDL, VLDL), iron profiles (serum ferritin, iron, TSAT, TIBC), and complete hemograms were analyzed. Statistical analysis used the Mann-Whitney U test, Chi-square test, and Spearman's correlation, with $p<0.05$ considered significant. **Results:** IDA patients had significantly lower hemoglobin (7.84±2 g/dL vs. 12.8±0.8 g/dL, $p<0.05$), RBC count (2.87±0.83 vs. 4.36±0.3 million cells/mcL, $p<0.05$), and PCV (19.6±7.2% vs. 37.08±3.7%, $p<0.05$) than controls. Total cholesterol (136.06±20.9 vs. 145.5±28.3 mg/dL, $p=0.04$) and LDL (81.8±14.2 vs. 88.8±19.4 mg/dL, $p=0.03$) were significantly lower in IDA patients. Positive correlations were found between anemia and lipid sub-fractions ($p<0.05$), but no significant correlation existed with serum ferritin. **Conclusion:** IDA is associated with hypocholesterolemia, particularly in total cholesterol and LDL levels. Regular lipid profile monitoring in IDA patients is recommended.

KEYWORDS : Iron Deficiency Anemia, Lipid Profile, Dyslipidemia, Hemoglobin, Serum Ferritin, India

INTRODUCTION

Iron deficiency anemia (IDA) is a global public health issue, affecting approximately 24.8% of the world's population, with about 50% of cases attributed to iron deficiency [1]. In India, the prevalence is particularly high, with the National Family Health Survey (NFHS-5, 2019–20) reporting anemia in 66.4% of women and 68.4% of children [2]. IDA results from insufficient iron for hemoglobin synthesis, leading to microcytic, hypochromic red blood cells, often presenting with fatigue, dyspnea, and pallor [3]. Common causes include inadequate dietary iron, poor absorption, and blood loss from menstruation or gastrointestinal sources [4]. IDA is classified into three stages: low iron balance (Stage I), iron-deficient erythropoiesis (Stage II), and iron deficiency anemia (Stage III) if untreated [5]. Iron is critical for oxygen transport and enzymatic functions, and its deficiency can disrupt multiple physiological processes [6].

Dyslipidemia, characterized by abnormal blood lipid levels, including elevated triglycerides, low-density lipoprotein (LDL), or reduced high-density lipoprotein (HDL), is a major risk factor for cardiovascular diseases such as coronary artery disease (CAD) and peripheral artery disease [7]. In India, dyslipidemia affects 25–30% of urban and 15–20% of rural populations, with higher prevalence in men and those aged 30–40 years [8]. Risk factors include obesity, diabetes, hypothyroidism, and lifestyle factors like poor diet and smoking [9]. The interplay between IDA and dyslipidemia is of growing interest, as iron metabolism may influence lipid profiles. Studies suggest that high iron stores increase oxidative stress, promoting LDL oxidation and atherosclerosis [10], while IDA may lead to hypocholesterolemia due to reduced metabolic demands [11].

Previous research has reported conflicting findings on the relationship between IDA and lipid profiles. Vetrivel et al. found that anemia is associated with hypocholesterolemia, with reductions in all lipid sub-fractions proportional to anemia severity [12]. Similarly, Rifkind et al. observed hypocholesterolemia and hypophospholipidemia in chronic anemia, suggesting a link to reduced cardiovascular risk [13]. However, Yang et al. reported higher triglyceride levels in IDA patients, particularly women, with no significant differences across anemia types [14]. These inconsistencies highlight the need for further investigation, especially in high-prevalence settings like India, where IDA and dyslipidemia coexist across socioeconomic groups.

The mechanisms linking IDA and lipid metabolism are not fully understood. Iron deficiency may alter lipid synthesis by reducing energy availability or affecting hepatic lipoprotein production [15]. Conversely, iron supplementation has been shown to normalize lipid levels in some studies, suggesting a reversible metabolic impact [12]. Given the public health burden of both conditions in India, understanding their association has therapeutic implications, particularly for cardiovascular risk management. This study addresses gaps in the literature by evaluating lipid profile changes in IDA patients compared to controls, assessing demographic and clinical features, and exploring whether anemia severity or type influences lipid sub-fractions. By focusing on an Indian population, this research contributes to region-specific insights into these prevalent conditions.

Aims

1. To evaluate demographic and clinical features in patients with iron deficiency anemia.
2. To compare lipid profiles of anemic patients with age- and sex-matched controls.
3. To assess whether the severity of anemia is associated with changes in lipid sub-fractions.
4. To investigate if the type of anemia affects lipid profiles.

MATERIALS AND METHODS

Study Design and Setting

A prospective, comparative case-control study was conducted at Chigateri General Hospital and Bapuji Hospital, affiliated with JJM Medical College, Davangere, India, from April 2021 to August 2022. The study was approved by the institutional ethical committee, and informed consent was obtained from all participants.

Participants

Fifty patients diagnosed with IDA (cases) and 50 age- and sex-matched non-anemic controls were enrolled. IDA was defined per WHO

criteria: hemoglobin <13 g/dL for men and <12 g/dL for women [1]. Controls were selected from the general population without anemia. Consecutive sampling was used to recruit participants attending outpatient or inpatient departments.

Inclusion Criteria

Participants included all confirmed cases of anemia meeting WHO hemoglobin thresholds.

Exclusion Criteria

Participants were excluded if they had:

- Obesity/overweight (BMI >25 kg/m²)
- Malnutrition (BMI <19 kg/m², serum total protein <6 g/dL, or serum albumin <3.5 g/dL)
- Known diabetes mellitus (random blood sugar >200 mg/dL, fasting blood sugar >126 mg/dL, or postprandial blood sugar >200 mg/dL)
- Hypertension (blood pressure >140/90 mmHg on three consecutive readings)
- Alcoholism or smoking history
- Known AIDS, ischemic heart disease, or cerebrovascular accident
- Recent blood loss
- Use of steroids, oral contraceptives, diuretics, or beta-blockers
- Urine albumin ≥1+
- Blood urea >40 mg/dL or serum creatinine >1.4 mg/dL
- Abnormal liver function (SGOT >40 U/L, SGPT >40 U/L, or serum alkaline phosphatase >250 U/L)
- Abnormal thyroid function (TSH >7.0 µU/mL or <0.3 µU/mL)

Data Collection

Clinical and laboratory assessments were performed. A complete hemogram, random blood sugar, blood urea, serum creatinine, liver function tests, thyroid profile (TSH, T3, T4), and urine analysis (albumin, sugar, microscopy) were conducted. Fasting venous blood samples (>12 hours) were collected to measure lipid profiles (total cholesterol, triglycerides, HDL, LDL, VLDL) and iron profiles (serum ferritin, serum iron, transferrin saturation [TSAT], total iron-binding capacity [TIBC]). Bone marrow aspiration cytology was performed in selected cases based on clinical indications.

Sample Size

Based on a reported IDA prevalence of 7.7%, a sample size of 50 cases was selected, considering a 10% error margin, to ensure adequate statistical power. Fifty controls were included for comparison.

Statistical Analysis

Data were entered into Microsoft Excel 2019 and analyzed using IBM SPSS Version 25. Descriptive statistics were reported as means and standard deviations. The Shapiro-Wilk test confirmed non-normal data distribution ($p<0.05$) for complete blood count, random blood sugar, and lipid profiles. The Mann-Whitney U test was used to compare means between groups. Chi-square tests analyzed qualitative variables. Spearman's correlation assessed relationships between variables. A p-value <0.05 was considered statistically significant.

RESULTS

Data were collected from 100 participants, divided into Group 1 (50 IDA cases) and Group 2 (50 non-anemic controls). The following tables summarize key findings.

Table 1: Intergroup Comparison of Age Distribution

Age Group (Years)	Group 1 (Cases, n=50)	Group 2 (Controls, n=50)
15–20	8 (16%)	10 (20%)
21–30	12 (24%)	13 (26%)
31–40	15 (30%)	10 (20%)
41–50	10 (20%)	9 (18%)
51–60	4 (8%)	6 (12%)
61–70	1 (2%)	2 (4%)
71–80	0 (0%)	2 (4%)

The majority of cases were aged 31–40 years (30%), while controls were predominantly 21–30 years (26%). The least represented age group was 61–70 years (2%) for cases and 71–80 years (4%) for controls.

Table 2: Intergroup Comparison of Gender

Gender	Group 1 (Cases, n=50)	Group 2 (Controls, n=50)
Male	1 (2%)	30 (60%)
Female	49 (98%)	20 (40%)

Group 1 had significantly more females (98%) than males (2%), while Group 2 had a higher proportion of males (60%) than females (40%).

Table 3: Intergroup Comparison of Hematological Parameters

Parameter	Group 1 (Cases, n=50)	Group 2 (Controls, n=50)	Mean Difference	P-value
Hemoglobin (g/dL)	7.84 ± 2.0	12.8 ± 0.8	5.0	<0.05
RBC (million cells/mcL)	2.87 ± 0.83	4.36 ± 0.3	1.49	<0.05
PCV (%)	19.6 ± 7.2	37.08 ± 3.7	17.4	<0.05
Total Counts (cells/cumm)	7242 ± 2496.2	8499 ± 3112.3	1257	0.08
Differential Counts (cells/cumm)	593557 ± 89698.8	596179 ± 93767	2621.36	0.92

Significant differences were observed in hemoglobin, RBC count, and PCV between groups ($p<0.05$). Total and differential counts showed no significant differences ($p>0.05$).

Table 4: Intergroup Comparison of Lipid Profile

Parameter	Group 1 (Cases, n=50)	Group 2 (Controls, n=50)	Mean Difference	P-value
Total Cholesterol (mg/dL)	136.06 ± 20.9	145.5 ± 28.3	9.4	0.04
Triglycerides (mg/dL)	134 ± 25.5	143.6 ± 44.6	9.6	0.18
HDL (mg/dL)	28.5 ± 6.2	28.02 ± 6.7	0.48	0.78
LDL (mg/dL)	81.8 ± 14.2	88.8 ± 19.4	7.04	0.03
VLDL (mg/dL)	26.8 ± 5.04	28.7 ± 8.9	1.8	0.21

Total cholesterol and LDL levels were significantly lower in the IDA group ($p<0.05$). Triglycerides, HDL, and VLDL showed no significant differences ($p>0.05$).

Table 5: Correlation Analysis of Lipid Profile with Anemia

Lipid Parameter	r^2 Value	P-value
Total Cholesterol	0.329	0.01
Triglycerides	0.362	0.01
HDL	0.570	0.001
LDL	0.323	0.02
VLDL	0.362	0.01

Spearman's correlation analysis revealed positive correlations between anemia and all lipid sub-fractions ($p<0.05$), indicating a significant association.

DISCUSSION

This study investigated the association between iron deficiency anemia (IDA) and serum lipid profiles in an Indian population, revealing significant differences in total cholesterol and LDL levels between IDA patients and controls. The mean hemoglobin in IDA patients was 7.84±2 g/dL compared to 12.8±0.8 g/dL in controls ($p<0.05$), consistent with WHO criteria for anemia [1]. Similarly, RBC count (2.87±0.83 vs. 4.36±0.3 million cells/mcL, $p<0.05$) and PCV (19.6±7.2% vs. 37.08±3.7%, $p<0.05$) were significantly lower in cases, reflecting the hematological impact of IDA.

The lipid profile analysis showed lower total cholesterol (136.06±20.9 vs. 145.5±28.3 mg/dL, p=0.04) and LDL (81.8±14.2 vs. 88.8±19.4 mg/dL, p=0.03) in IDA patients, supporting previous findings of hypocholesterolemia in anemia. Vetrivel et al. reported similar reductions in all lipid sub-fractions in anemic Indian patients, with a proportional decrease relative to anemia severity ($p<0.05$) [12]. Rifkind et al. observed hypocholesterolemia and hypophospholipidemia in chronic anemia, suggesting a reduced cardiovascular risk ($p<0.01$) [13]. These findings align with our results, where total cholesterol and LDL were significantly lower in IDA patients, potentially due to decreased hepatic lipoprotein synthesis caused by reduced iron availability [15].

However, our study found no significant differences in triglycerides (134±25.5 vs. 143.6±44.6 mg/dL, p=0.18), HDL (28.5±6.2 vs. 28.02±6.7 mg/dL, p=0.78), or VLDL (26.8±5.04 vs. 28.7±8.9 mg/dL, p=0.21). This contrasts with Yang et al., who reported higher triglycerides and lower HDL in IDA women ($p<0.05$) [14]. The discrepancy may reflect population-specific factors, such as dietary

habits or genetic predispositions, as our study focused on Indian patients. Ece et al. found no significant impact of IDA on lipid profiles in children ($p>0.05$), suggesting age-related differences in metabolic responses [11].

Correlation analysis revealed positive associations between anemia and all lipid sub-fractions ($p<0.05$), indicating that anemia severity influences lipid levels. However, serum ferritin showed no significant correlation with lipid parameters (e.g., total cholesterol: $r^2=-0.54$, $p=0.71$), unlike studies by Kim et al., which reported a strong positive correlation between ferritin and dyslipidemia in adolescents ($r^2=0.45$, $p<0.01$) [10]. This discrepancy may be due to ferritin's role as an acute-phase reactant, which can mask iron deficiency in inflammatory states [3]. Serum iron and TSAT showed significant positive correlations with total cholesterol, triglycerides, and HDL ($p<0.05$), supporting the hypothesis that iron availability influences lipid metabolism.

The high prevalence of IDA in our study, particularly among females (98% of cases), aligns with NFHS-5 data reporting 66.4% anemia prevalence in Indian women [2]. This gender disparity likely reflects menstrual blood loss and higher iron demands during reproductive years. The age distribution, with most cases in the 31–40-year group (30%), underscores IDA's burden across reproductive ages, consistent with global trends [1].

Our findings suggest that IDA may reduce cardiovascular risk through hypocholesterolemia, but the clinical significance remains unclear. Low lipid levels could reflect metabolic adaptation to reduced oxygen-carrying capacity, potentially reversible with iron therapy, as demonstrated by Vijaykumar et al., where lipid profiles normalized post-treatment ($p<0.05$) [15]. Future studies should explore the long-term cardiovascular implications of IDA-induced hypo-cholesterolemia and the impact of iron supplementation.

CONCLUSION

This study confirms that IDA is associated with hypocholesterolemia, particularly in total cholesterol and LDL levels, in Indian patients. Positive correlations between anemia and lipid sub-fractions highlight the influence of anemia severity on lipid metabolism. However, the lack of significant correlation with serum ferritin suggests complex mechanisms beyond iron deficiency alone. Given the high prevalence of IDA and dyslipidemia in India, regular lipid profile monitoring in anemic patients is recommended to assess cardiovascular risk. Further research is needed to elucidate the mechanisms linking IDA and lipid alterations and to evaluate the long-term effects of iron therapy on lipid profiles and cardiovascular outcomes.

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