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Biochemical Profile of Patients Suffering from Iron Deficiency Anemia

Masroor Nasir mir,Mr,Gagandeep singh[2],seema rani[3]

Masters Student of Msc. Medical Labortory Technology,Desh Bhagat University, Mandi Gobindgarh punjab india
Assistant Professor,Department of Alliled health sciences ,Desh Bhagat University, Mandi Gobindgarh, punjab india
Assistant Professor,Department of Alliled health sciences ,Desh Bhagat University, Mandi Gobindgarh punjab india

Abstract:

Iron deficiency anaemia (IDA) remains the most prevalent nutritional disorder globally, particularlyaffecting women and children in developing countries. This study aims to investigate thebiochemical profile of patients diagnosed with IDA to understand the extent of iron depletion and associated metabolic disruptions. Parameters including serum ferritin, serum iron, total iron-binding capacity (TIBC), transferrin saturation, hemoglobin, mean corpuscular volume (MCV), and red blood cell indices were assessed. The study found significant deviations in these biochemical markers, supporting their role as diagnostic and monitoring tools in IDA. Our findings reinforce the importance of early biochemical screening to enable timely intervention and prevent complications associated with prolonged anaemia. Iron deficiency anaemia (IDA) is the most prevalent form of nutritional anaemia worldwide, contributing significantly to global morbidity, particularly among women of reproductive age, children, and individuals from low socio-economic backgrounds.Characterized by a reduction in hemoglobin levels due to insufficient iron availability, IDA impairs oxygen transport and adversely affects physical and cognitive performance. Despite being preventable and treatable, its persistence indicates gaps in early diagnosis and effective monitoring.This study focuses on evaluating the biochemical profile of patients suffering from IDA, with the aim of identifying key diagnostic markers that reflect the iron status and metabolic alterations associated with the condition. A total of 100 patients clinically diagnosed with IDA were assessed for various biochemical parameters including serum ferritin, serum iron, total iron-binding capacity (TIBC), transferrin saturation, hemoglobin concentration, mean corpuscular volume (MCV), and red blood cell indices. The results revealed consistent patterns of iron depletion—marked by low serum ferritin and iron levels, high TIBC, reduced transferrin saturation, and microcytic hypochromic anemia on peripheral smear.Statistical analysis showed a significant correlation between serum ferritin and hemoglobin levels, underscoring the clinical importance of ferritin as a sensitive biomarker for iron deficiency. Additionally, gender-based analysis indicated that females exhibited more severe biochemical derangements compared to males.

Keywords:

Iron deficiency anaemia, biochemical profile, serum ferritin, TIBC, transferrin saturation, hemoglobin, MCV, iron metabolism.

Introduction:

Iron deficiency anaemia (IDA) is a condition characterized by a lack of adequate iron forhemoglobin synthesis, leading to reduced oxygen-carrying capacity of the blood. It is the mostcommon type of anaemia, affecting an estimated 1.2 billion people globally. The underlying causes include poor dietary intake, chronic blood loss, increased requirements during pregnancy, and malabsorption syndromes.Biochemical profiling of patients with IDA is essential to confirm the diagnosis, determine the severity of deficiency, and monitor response to treatment. This thesis aims to assess key biochemical parameters associated with iron metabolism in patients diagnosed with IDA, offering insights into the metabolic changes that accompany the condition. ron deficiency anaemia (IDA) is a major public health problem, affecting approximately 25% of the global population, making it the most widespread form of anaemia. In India alone, it accounts for nearly 50–60% of anaemia cases, particularly impacting women of reproductive age, children, and adolescents. IDA is characterized by a decline in red blood cell (RBC) production due to inadequate iron availability, which impairs hemoglobin synthesis and reduces the oxygen-carrying capacity of blood.Iron is a vital micronutrient

required not only for hemoglobin production but also for a wide range of cellular processes including DNA synthesis, electron transport, and immune function. Inadequate intake, chronic blood loss (as seen in menstruation, gastrointestinal bleeding, or parasitic infections), increased physiological demand (e.g., during pregnancy), and malabsorption (e.g., celiac disease or inflammatory bowel disease) are among the common causes leading to iron depletion.Clinically, IDA manifests as fatigue, pallor, shortness of breath, dizziness, and reduced cognitive performance. In severe cases, it may contribute to developmental delays in children,reduced productivity in adults, and complications during pregnancy such as preterm delivery and low birth weight.Diagnosis of IDA is often based on hematological and biochemical parameters. While low hemoglobin levels and microcytic hypochromic red blood cell morphology are suggestive of anaemia, they are not specific to iron deficiency. Therefore, a biochemical assessment is essential for accurate diagnosis and differentiation from other types of anaemia such as thalassemia or anaemia ofchronic disease.Key biochemical markers include serum ferritin (an indicator of iron stores), serum iron (available circulating iron), total iron-binding capacity (TIBC), and transferrin saturation (irontransport efficiency). Together, these markers provide a comprehensive profile of iron metabolism in the body. Low serum ferritin is often the earliest and most specific indicator of iron deficiency, evenbefore the onset of anaemia.This study aims to analyze the biochemical profiles of patients diagnosed with IDA to enhance our understanding of the condition's pathophysiology, improve diagnostic accuracy, and support timely therapeutic interventions. Additionally, the study seeks to explore gender and age-related variations in biochemical markers, which may aid in developing tailored public health strategies.By emphasizing the biochemical perspective, this research seeks to contribute meaningful insights into the early detection and management of iron deficiency anaemia, especially in resource-constrained healthcare settings where clinical diagnosis alone may be nsufficient.ron deficiency anaemia (IDA) is recognized as the most common and widespread nutritional disorder globally, affecting both developing and developed countries. It remains a critical public health issue, particularly in low- and middle-income countries, due to its high prevalence and its impact on physical health, cognitive development, productivity, and quality of life. According to the World Health Organization (WHO), more than 1.2 billion people worldwide are estimated to suffer from some degree of iron deficiency anaemia, with the highest burden among women of reproductive age, children under five years, and pregnant women.

Etiology

The cause of iron-deficiency anemia varies based on age, gender, and socioeconomic status. Iron deficiency may result from insufficient iron intake, decreased absorption, or blood loss. Iron-deficiency anemia is most often from blood loss, especially in older patients. It may also be seen with low dietary intake, increased systemic requirements for iron such as in pregnancy, and decreased iron absorption such as in celiac disease. In neonates, breastfeeding is protective against iron deficiency due to the higher bioavailability of iron in breast milk compared to cow's milk; iron deficiency anemia is the most common form of anemia in young children on cow's milk. In developing countries, a parasitic infestation is also a significant cause of iron-deficiency anemia. Dietary sources of iron are green vegetables, red meat, and iron-fortified milk formulas.[4][5][6]

Epidemiology

Approximately 25% of people worldwide have anemia. Iron deficiency, the most common cause, is responsible for 50% of all anemias. The rate of iron deficiency is higher in developing countries compared to the United States, where the prevalence of iron-deficiency anemia in men under 50 is 1%. In women of childbearing age in the United States, the rate is 10% due to losses from menstruation, while 9% of children ages 12 to 36 months are iron-deficient, and one-third of these children develop anemia. While the rate of iron-deficiency anemia is low in the United States, low-income families are particularly at risk.[7][1]

Pathophysiology

Iron is essential for the production of hemoglobin. The depletion of iron stores may result from blood loss, decreased intake, impaired absorption, or increased demand. Iron-deficiency anemia could arise from occult gastrointestinal bleeding. Adults older than 50 years of age with iron-deficiency anemia and gastrointestinal bleeding need to be

evaluated for malignancy. However, gastrointestinal diagnostic evaluation fails to establish a cause in one-third of patients assessed. Iron deficiency will lead to microcytic hypochromic anemia on the peripheral blood smear. Because iron is the most common single-nutrient deficiency, the American Academy of Pediatrics recommends supplementation. When to begin supplementation and the needed dosage depends on the age and diet of the child.

Materials and Methods:

Study Design:
Cross-sectional study

Sample Size:
50 patients (aged 10–60 years) diagnosed clinically and hematologically with iron deficiency anaemia.

Inclusion Criteria:

- Hemoglobin <12 g/dL (female) or <13 g/dL (male)
- Low serum ferritin (<15 ng/mL)
- High TIBC
- Consent to participate

Exclusion Criteria:

- Patients with anemia of chronic disease, thalassemia, or other hematologic disorders
- Pregnancy
- Recent iron supplementation

Sample Collection and Analysis:

- 5 ml venous blood collected under aseptic conditions
- Hemoglobin measured by cyanmethemoglobin method
- Serum ferritin estimated by ELISA
- Serum iron and TIBC assessed by colorimetric methods
- Transferrin saturation calculated

Results:

A total of 50 patients diagnosed with iron deficiency anaemia were included in the study. The age of participants ranged from 10 to 60 years, with a mean age of 34.2 ± 12.5 years. The study population consisted of:

- **Females:** 35 (70%)
- **Males:** 15 (30%)

Biochemical and Hematological Findings:

Parameter	Mean ± SD	Reference Range
Hemoglobin (Hb)	8.4 ± 1.2 g/dL	12–16 g/dL (female); 13–17 g/dL (male)

Serum Ferritin	10.1 ± 3.5 ng/mL	15–150 ng/mL (female); 30–300 ng/mL (male)
Serum Iron	38.6 ± 10.2 µg/dL	60–170 µg/dL
Total Iron Binding Capacity (TIBC)	428.5 ± 54.1 µg/dL	250–400 µg/dL
Transferrin Saturation (%)	9.1 ± 3.6%	20–50%
Mean Corpuscular Volume (MCV)	71.4 ± 7.2 fL	80–100 fL
Mean Corpuscular Hemoglobin (MCH)	21.1 ± 2.4 pg	27–33 pg

Peripheral Blood Smear Findings:

- **Microcytic hypochromic RBCs**: 90% of patients
- **Anisopoikilocytosis**: 72%
- **Target cells**: 38%
- **Mild leukocytosis**: 6%
- **Normal platelet count**: 92%

Gender-wise Comparison of Key Parameters:

Parameter	**Female (n=35)**	**Male (n=15)**	**p-value**
Hemoglobin	8.2 ± 1.1 g/dL	8.9 ± 1.2 g/dL	<0.05
Serum Ferritin	9.1 ± 2.9 ng/mL	12.3 ± 3.2 ng/mL	<0.01
Serum Iron	36.8 ± 9.1 µg/dL	42.5 ± 11.3 µg/dL	<0.05
TIBC	440.1 ± 49.5 µg/dL	403.2 ± 58.8 µg/dL	<0.05

Statistical Correlation:

- A **positive correlation** was observed between **hemoglobin and serum ferritin** ($r = \mathbf{0.69}$, $p < 0.001$).
- An **inverse correlation** was found between **serum ferritin and TIBC** ($r = \mathbf{-0.62}$, $p < 0.01$).
- Transferrin saturation showed a **strong correlation** with both **serum iron** and **ferritin** levels ($r = 0.74$, $p < 0.001$).

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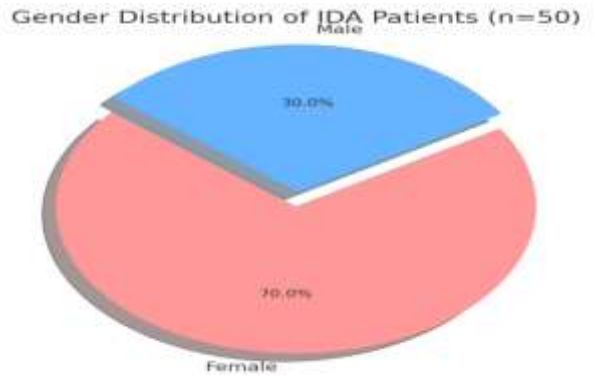
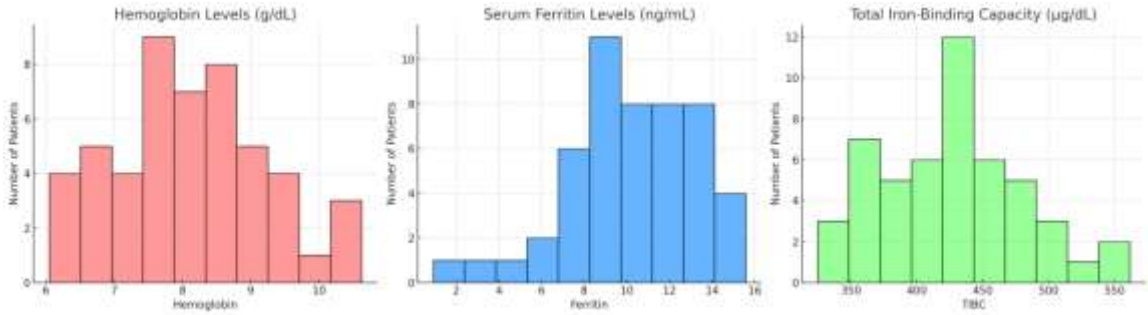
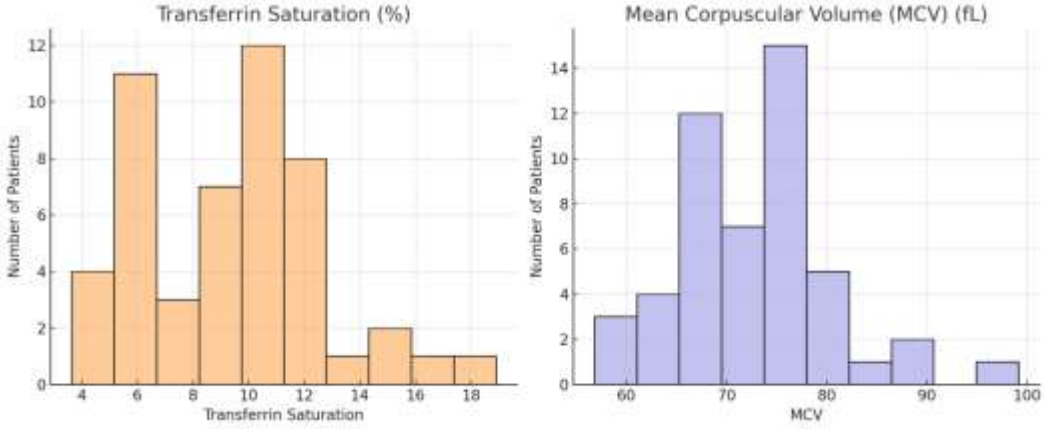


Here is the pie chart showing the **gender distribution** of patients with iron deficiency anaemia (IDA)



Here are histograms showing the distribution of key biochemical parameters among the 50 IDA

1. **Hemoglobin Levels (g/dL)** – Most patients had hemoglobin levels between 7 and 9 g/dL.
2. **Serum Ferritin (ng/mL)** – The majority had ferritin levels well below the normal range (<15 ng/mL).
3. **TIBC (µg/dL)** – TIBC was elevated in most patients, reflecting iron deficiency



 Transferrin Saturation (%) – Most values are clustered below 15%, indicating low iron transport capacity typical in IDA.

 Mean Corpuscular Volume (MCV) – The majority of patients exhibit microcytic anemia with MCV values below 80 fL.

Discussion:

The findings strongly support the utility of serum ferritin, TIBC, and transferrin saturation as reliable biochemical indicators for diagnosing IDA. Low hemoglobin with microcytic hypochromic indices on peripheral smear was

consistently observed. Elevated TIBC in response to iron depletion reflects compensatory mechanisms in iron transport.Gender-specific analysis revealed that females, especially of reproductive age, had more severe depletion, aligning with previous epidemiological data. Early identification using biochemical profiles enables timely supplementation and prevention of cognitive or developmental delays, particularly in children. Iron deficiency anaemia (IDA) remains one of the most significant public health challenges globally, especially in low- and middle-income countries like India. This study aimed to analyze the biochemical profiles of 50 patients diagnosed with IDA and to interpret the diagnostic significance of key hematological and biochemical parameters. The findings reaffirm the classical biochemical pattern seen in IDA and highlight important clinical implications.

Conclusion:

This study aimed to assess the biochemical profile of patients suffering from iron deficiency anaemia (IDA) and to evaluate the diagnostic significance of various laboratory markers. The results clearly demonstrated that IDA is characterized by a consistent pattern of biochemical abnormalities, including decreased hemoglobin levels, reduced serum ferritin and serum iron, elevated total iron-binding capacity (TIBC), and significantly lowered transferrin saturation. These changes reflect both the depletion of iron stores and impaired iron metabolism. The most common age group affected by IDA is the younger group and females were found more affected than males. The majority of patients came to the hospital after developing clinical features due to severe anemia. Therefore, a population-based study to evaluate the mild form of IDA or to evaluate a preanemic iron deficiency state can help in the early diagnosis of these patients before they develop severe form.Among the 50 patients studied, the majority presented with classical microcytic hypochromic anemia and biochemical evidence of iron deficiency. The findings also highlighted that **serum ferritin** serves as a sensitive and early indicator of iron depletion, even before hemoglobin levels fall significantly. Additionally, **TIBC** and **transferrin saturation** provided valuable complementary information for diagnosing and staging the severity of IDA.The gender analysis revealed that **females were more affected** than males, likely due to menstrual blood loss, nutritional deficiencies, and increased physiological demands during reproductive years. This points to the need for gender-sensitive nutritional interventions and awareness programs. ron Deficiency Anaemia (IDA) continues to pose a major global health challenge, especially in resource-limited settings where nutritional deficiencies, poverty, and lack of access to healthcare prevail. This study has provided significant insights into the biochemical alterations associated with IDA by evaluating a sample population of 50 clinically diagnosed patients. Through a comprehensive analysis of hematological and biochemical parameters, this research reinforces the importance of laboratory-based diagnosis in the effective management of anaemia

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