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Prevalence and Hematological Profile of Anemia of Chronic Disease in Asthmatic Patients: A Case-Control Study

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Abstract

Background: Asthma is a widespread chronic respiratory condition linked to substantial illness and, in severe instances, life-threatening complications. Anemia of Chronic Disease (ACD) commonly occurs in diseases marked by systemic inflammation, such as asthma. However, the precise role of ACD in asthma and its biological basis remains poorly understood. **Objective:** This study aimed to examine the serum iron status in Sudanese individuals with asthma and investigate the potential link between asthma and ACD. **Methods:** A retrospective cross-sectional case-control design was employed, involving 240 subjects—120 individuals diagnosed with bronchial asthma and 120 healthy controls. Key parameters assessed included serum iron, ferritin, total iron-binding capacity (TIBC), hemoglobin concentration, and transferrin saturation. Data analysis was conducted using SPSS version 26, utilizing independent t-tests and multiple linear regression techniques. **Results:** Compared to healthy controls, asthma patients showed significantly reduced levels of serum iron, hemoglobin, and saturation percentage ($p < 0.001$), while ferritin concentrations were significantly elevated ($p < 0.001$). The prevalence of anemia among the asthma group was 80%, predominantly ACD. Regression analysis demonstrated a strong inverse correlation between ferritin and serum iron ($r = -1.776$, $p < 0.001$). **Conclusion:** The findings indicate a high rate of ACD among asthmatic individuals, suggesting a possible causal relationship. Routine anemia screening in asthma patients is advised to support early diagnosis and management. Further investigations are required to clarify the pathophysiological mechanisms connecting asthma and ACD.

Keywords: Asthma, Anemia of Chronic Disease, Iron Deficiency, Ferritin, Total Iron-Binding Capacity.

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Introduction

Asthma is a chronic and potentially fatal condition that significantly affects patients, their families, and the wider healthcare system. It is often marked by respiratory symptoms that can escalate, requiring emergency intervention, and occasionally resulting in death [1]. Globally, asthma impacts an estimated 334 million individuals, emphasizing its role in long-term disability [2]. Projections indicate a 50% rise in prevalence each decade, with incidence rates surpassing 10% in wealthier nations and rising in developing areas undergoing westernization [3]. Anemia of Chronic Disease (ACD) frequently emerges in disorders characterized by prolonged inflammation. Asthma, known for inducing systemic inflammatory responses, may trigger the development of ACD [4-6]. The dysregulated immune activity in asthma alters iron-regulatory cytokines like hepcidin, contributing to ACD. This form of anemia, sometimes termed anemia of inflammation, involves disrupted red blood cell production, modified erythropoietin function, and increased red cell turnover [7-9]. Although ACD and Iron Deficiency Anemia (IDA) exhibit overlapping blood profiles—such as reduced hemoglobin and serum iron—they differ significantly in etiology, treatment response, and disease management [10]. Chronic illnesses such as malignancy, heart failure, and chronic obstructive pulmonary disease (COPD) are established risk factors for ACD [11-14]. Whether asthma has a similar effect remains uncertain. Nonetheless, initial findings have hinted at a possible association, with childhood atopic conditions like asthma linked to increased anemia rates [15]. Our prior investigations also found a higher prevalence of anemia in asthmatic individuals, particularly in those with poor symptom control [15,16]. This research intends to further explore this association by evaluating serum iron indices—including ferritin, serum iron, TIBC, and transferrin saturation—in Sudanese patients with asthma.

Materials and Methods

This study used a retrospective cross-sectional case-control approach, recruiting 240 participants (99 males, 141 females). The case group included 120 asthmatic patients (mean age: 43 ± 14 years), while the control group comprised 120 healthy individuals (mean age: 32 ± 4 years). Participants with a diagnosis of anemia or any underlying condition known to elevate the risk of ACD or IDA in the two years preceding enrollment were excluded. Specific exclusion criteria included:

1. Systemic infections (e.g., meningitis, tuberculosis, HIV-related illness)
2. Hepatitis
3. Chronic kidney disease
4. Congestive heart failure
5. Diabetes mellitus
6. Autoimmune diseases (e.g., SLE, rheumatoid arthritis)
7. Malignancies

Recruitment occurred at Ibrahim Malik Hospital and Khartoum Teaching Hospital through simple random sampling. Participants completed a self-administered questionnaire and provided informed consent. Blood samples were collected for measurement of hemoglobin (Hb), serum iron, TIBC, and ferritin using Spinreact spectrophotometry kits. Transferrin saturation (%) was calculated using:

$$\textbf{Saturation (\%)} = \textbf{(Serum Iron / TIBC)} \times \textbf{100}$$

ACD is typically indicated by hemoglobin levels above 7 g/dL and normocytic, normochromic RBCs, distinguishing it from IDA, and thereby often overlooked clinically. Data were analyzed using SPSS version 26. Independent t-tests were applied to assess differences in means between cases and controls and between sexes. Multiple linear regression was conducted to examine the influence of ferritin on other iron markers. A p-value < 0.05

was considered statistically significant, using a 95% confidence interval.

Results

Table 1 presents the socio-demographic data of the participants. The asthmatic group had a higher average age (43 years) compared to the control group (41 years), a difference that reached statistical significance (p = 0.001). Gender distribution varied significantly as well, with 21 males and 99 females in the case group, versus 26 males and 94 females among the controls (p = 0.002). While Body Mass Index (BMI) values were closely matched, the asthma group showed a slightly higher mean BMI (23.7) compared to controls (23.5), which was statistically significant (p = 0.005). These characteristics offer relevant context for interpreting clinical and laboratory findings.

Table 2 compares key hematological and iron metabolism parameters between the case and control groups. Hemoglobin levels were significantly reduced in asthma patients (10.30 ± 1.37 g/dL) compared to healthy controls (12.02 ± 1.05 g/dL; p = 0.000). Serum iron levels were notably lower in the asthma group (42.6 ± 14.5 µg/dL) than in controls (106.3 ± 41.2 µg/dL; p = 0.000). Although TIBC did not differ significantly between the two groups (p = 0.593), ferritin was markedly higher among asthmatic patients (284.4 ± 184.4 ng/mL) relative to controls (86.4 ± 32.2 ng/mL; p = 0.000). Additionally, the transferrin saturation percentage was significantly reduced in cases (17.5 ± 8.6%) compared to controls (33.6 ± 10.9%; p = 0.001). These findings suggest altered iron homeostasis in asthmatic individuals, likely due to chronic inflammation.

Table 3 explores sex-based differences in iron status among asthmatic participants. Female patients demonstrated significantly lower serum iron levels (67.4 ± 35.2 µg/dL) compared to males (84.5 ± 53.9 µg/dL; p = 0.006). Similarly, transferrin saturation was reduced in females (23.9 ± 10.6%) versus males (28.4 ± 14.5%; p = 0.022). However, there were no statistically significant differences in TIBC (p = 0.178) or ferritin levels (p = 0.648) between the sexes.

Table 4 details the multiple linear regression results exploring the relationship between ferritin and other iron markers. A strong inverse relationship was found between ferritin and serum iron (r = -1.776, p < 0.000), indicating that increased ferritin is linked to lower serum iron. TIBC (r = 0.124, p = 0.621) and saturation percentage (r = -0.314, p = 0.352) were not significantly associated with ferritin levels.

Table 1: Socio-demographic Characteristics of study participants

Variables	Case	Control	p.value
Age	43±5	41±7	0.001
Sex (male/female)	21/99	26/94	0.002
BMI%	23.7	23.5	0.005

Table (2) comparison of serum iron, TIBC, ferritin, and saturation % in case and control **(n=240).**

	Case (mean± SD)	**Control (mean ±SD)**	***P* value**
Hb (g/dl)	10.30 ±1.366	12.02±1.1.05	0.000
serum iron	42.6 ± 14.5	106.3 ± 41.2	0.000
TIBC	256.1 ± 73.3	312.0 ± 65.4	0.593
Ferritin	284.4 ± 184.4	86.40 ± 32.2	0.000
saturation %	17.5 ± 8.6	33.6 ± 10.9	0.001

Table (3) comparison of serum iron, TIBC, ferritin, and saturation %between male and female asthmatic patients (n=120).

Parameter	**Male (mean± SD)**	**Female (mean ±SD)**	***P* value**
Serum iron	84.5 ±53.9	67.4 ± 35.2	.006
TIBC	287.6 ± 67.3	281.5 ±79.9	.178
Ferritin	195.3 ± 169.1	178.4 ± 163.4	.648
saturation %	28.4 ±14.5	23.9 ±10.6	.022

Table 4: Multiple linear regression in asthmatic patients for the association of ferritin with serum iron, TIBC, and saturation%. (n=120).

Predictor	r	P value
Serum iron	-1.776	.000
TIBC	.124	. 621
Saturation %	-.314	.352

*r correlation coefficient

Discussion

The objective of this study was to determine the prevalence and nature of anemia among individuals with asthma. Findings revealed that 80% of asthmatic patients were anemic, with the predominant type being ACD. This form of anemia, often normochromic and normocytic, may occasionally present as hypochromic microcytic anemia due to disrupted iron processing in the reticuloendothelial system. Inflammatory mediators released during asthma, including hepcidin, inhibit iron absorption and recycling, reducing iron availability for erythropoiesis [17]. Activated macrophages retain iron and hinder its release for red blood cell synthesis. Furthermore, they convert iron into biologically unavailable forms and stimulate apoferritin production, resulting in elevated serum ferritin levels [17,18]. Previous research supports this, indicating a higher risk of anemia in asthmatic individuals compared to non-asthmatics [19]. In agreement with our results, other studies (e.g., Brigham EP [21] and Hamed HM [22]) have documented decreased serum iron and elevated ferritin in asthmatic populations. However, Elsayed W [20] reported contradictory findings of lower ferritin, highlighting the complexity of this relationship. The immunopathology of asthma primarily involves Th2-mediated or innate type 2 immune responses, characterized by cytokines like IL-4, IL-5, IL-13, and eosinophilic inflammation. These immune pathways have been linked to disturbances in iron metabolism. Macrophages play a pivotal role by sensing iron demands and modulating iron availability, thus influencing whether immune responses skew toward inflammation or resolution [23]. Chronic immune activation in asthma may therefore induce functional iron deficiency, a precursor to ACD [24]. A study by Li M further corroborates a direct association between asthma and iron deficiency [25]. Both asthma and anemia significantly reduce quality of life and are associated with increased cardiovascular risk and mortality, particularly among older adults [26–29].

Conclusion

This study concludes that asthma is closely associated with anemia of chronic disease, as evidenced by reduced hemoglobin and serum iron levels and elevated ferritin among asthmatic patients. Routine screening for anemia in individuals with asthma is recommended to facilitate early identification and treatment. Future research is essential to unravel the molecular and immunological mechanisms connecting asthma with ACD, which may inform more targeted therapeutic strategies.

Conflict of interest: NIL

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