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Case Study

Estimation of Serum Ferritin and Complete Blood Count among Tuberculosis Patients Attending Kosti Teaching Hospital, White Nile State, Sudan

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Abstract

Introduction: Iron deficiency (ID) is the most common cause of nutritional deficiency anemia in the developing world, and complete blood count (CBC) is one of the most common blood tests that is used to diagnose hematological abnormalities. Also, serum Ferritin is a more sensitive test used to evaluate and reflect iron status in the body. Tuberculosis is a major of a big health problem in the world, especially in Sudan. This study was done in Kosti teaching hospital from June to September 2018.

Study design: Case-control study. Fifty patients infected with tuberculosis were selected as cases, and fifty normal persons (without TB) were matched as a control group.

Methodology: 2.5 ml blood samples were taken in ethylene diamine tetraacetic acid (EDTA) treated tubes and were analyzed in the Mindray BC-3000 automated hematology analyzer. The Biosystem BTS-350 spectrophotometer protocol has been used for Ferritin measurement. ESR was read using the Westergren tube method.

Results: The results showed highly significant differences in all hematological parameters in TB patients when compared with healthy person and the P value was 0.000 in all parameters, 0.01 in the Hb. Also, patients with normal and high serum Ferritin were detected (17 with normal value and 23 with a high serum Ferritin), and less than 10 cases of low serum Ferritin were those suffering from iron deficiency anemia. The ESR values of TB patients obtained in this study were significantly higher than control values.

Conclusion: Most of the patients were anemic with low Hb and RBC indices. The study found a strong positive association of anemia without iron deficiency and TB (23 cases with high serum Ferritin and 10 cases with low serum Ferritin), suggesting that factors other than iron deficiency also contribute to the association of anemia with poor outcomes, which may be due to chronic infection.

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Keywords: Complete blood count; Tuberculosis; Ethylene diamine tetraacetic acid

Abbreviations: CBC: Complete Blood Count; TB: Tuberculosis; EDTA: Ethylene Diamine Tetra Acetic Acid; Hb: Hemoglobin; ACD: Anemia of Chronic Disease; ID: Iron Deficiency; SF: Serum Ferritin; CD: Chronic Disease; ESR: Erythrocyte Sedimentation Rate

Introduction

Iron deficiency (ID) is the most common cause of nutritional deficiency anemia in the developing world [1].

There is also a high incidence of various chronic illnesses, such as tuberculosis, in this population. The incidence of tuberculosis is as high as 1/1000 in our population [2].

It is important to establish the presence of ID in these patients with tuberculosis and other chronic inflammatory or infectious diseases, as even mild iron deficiency causes a significant impairment in the immunological status and reduces the capacity of such patients to control infections. This is of special importance in developing countries because iron deficiency, if established in these patients, could be corrected with cheap iron supplementation that would not only improve anemia but also influence the clinical outcome of the infectious disease [3].

Determination of conventional hematological indices and biochemical variables is of little help in demonstrating iron deficiency in these patients, as they are similarly affected in both ID and anemia of chronic disorders (ACD) [4,5].

Bone marrow examination for iron is the gold standard for detecting ID in such conditions. Being an invasive procedure, it causes patient discomfort and anxiety. Hence, Serum Ferritin (SF), a non-invasive parameter reflecting iron stores, is being extensively studied. SF 10g/l is diagnostic of absent bone marrow iron stores in any clinical setting [4,5]. However, SF is an acute-phase reactant and is increased in inflammations and infections. In most cases of CD, SF is disproportionately increased relative to iron stores [6,7].

In such a clinical setting of CD, it is, therefore, not reflective of bone marrow iron. To compensate for this inflammatory component, many authors have suggested higher cut-off values, predictive of ID in patients with anemia of chronic disorders [8-13].

Fe-deficiency anaemia is the most common cause of anaemia in developing countries. And many chronic infections, including tuberculosis (TB), are highly prevalent. Fe is an essential nutrient for both host and mycobacteria that play a pivotal role in host immunity and mycobacterial growth. Fe is an essential component of Hb, as Fe binds and transports O_2 [14].

Several lines of evidence have suggested that iron is critical for *Mycobacterium tuberculosis* growth in macrophages.

Iron deficiency is considered the most important contributor to the development of anemia worldwide, but other causes often coexist. If iron deficiency were established as an important contributor to TB-associated anemia, the targeted provision of supplemental iron may be used to increase blood hemoglobin concentrations and improve clinical outcomes in TB patients. The contribution of iron deficiency without anemia to TB disease progression may also be of direct importance, because iron deficiency has been associated with impaired immune function and reduced capacity to control infection [15-17].

Complete Blood Count (CBC) is the routine investigation done for a patient, irrespective of the type of infection, that provides important information about the kinds and numbers of cells in the blood, especially red cells, white cells, and platelets, and provides much-needed information for making a decision on treatment [18,19].

Anemia is a frequent complication of tuberculosis and represents a significant contributor to disease-related morbidity, particularly in low- and middle-income countries. Among the various causes of anemia in tuberculosis, iron deficiency anemia is of particular clinical importance because it is potentially inexpensive, easily identifiable, and correctable through targeted nutritional or therapeutic interventions [14-17,20]. Iron plays a critical role in hemoglobin synthesis, oxygen transport, and immune function, and its deficiency has been associated with impaired host defense mechanisms and reduced capacity to control *Mycobacterium tuberculosis* infection [14-16]. Distinguishing iron deficiency anemia from anemia of chronic disease is therefore essential, as inappropriate iron supplementation in the absence of iron deficiency may be ineffective or potentially harmful due to iron sequestration during inflammation [6-10]. Accurate identification of iron deficiency in tuberculosis patients can allow for timely intervention, improve hemoglobin levels, and may contribute to better clinical outcomes and overall patient management [20-22].

The objective of the present study was to describe the prevalence of anemia and of its types in hospitalized patients with pulmonary tuberculosis, as well as to examine the relationship between anemia and the clinical and nutritional status of anemic patients in comparison with non-anemic patients (controls).

Materials and methods

Study design: Case Control study.

Study population

Inclusion study:

For Patient: Known patients with acid-fast bacilli, ZN stain +ve smear.

For control: A healthy person with acid-fast bacilli, ZN stain -ve smear.

Exclusion study:

For patient: Known patients with acid-fast bacilli ZN stain -ve smear.

For control: person with acid-fast bacilli, ZN stain +ve smear.

Study area: Kosti teaching hospital, White Nile state, Sudan.

Sample size: 100 Venous blood samples 50 blood samples from patients infected with TB, and 50 blood samples from healthy persons as controls.

Data collection method: Data was collected using a structured interviewing questionnaire.

Ethical consideration: All participants completed an individual informed consent form.

Data analysis

Data were analyzed using the Microsoft Excel program, and SPSS version21 was used for data entry and analysis. The *p* value less than 0.05 is considered significant.

Materials

During the study, the following equipment and materials were used: syringes. Cotton, EDTA containers, Mindray BC-3000 automated hematology analyzer, Racks, The method for measurement of Ferritin on the Biosystem BTS-350 spectrophotometer by using Biosystem reagent. ESR was read using the Westergren tube method. All results are cited in the questionnaire.

The hematological and biochemical methods applied in this study were selected in accordance with widely accepted laboratory standards that remain clinically relevant in current practice. Automated hematology analyzers, such as the Mindray BC-3000 system used in this study, continue to be recommended for complete blood count analysis due to their accuracy, reproducibility, and efficiency in evaluating red cell indices, leukocyte differentials, and platelet parameters in both infectious and inflammatory conditions [18,19,23,24]. Recent studies have reaffirmed the utility of automated CBC analysis in the assessment of hematological alterations associated with tuberculosis and other chronic infections, particularly in resource-limited settings where advanced molecular diagnostics may not be readily available [23,25-27].

Serum ferritin measurement using spectrophotometric immunoassay-based techniques remains a validated and commonly applied approach for evaluating iron stores in clinical research and routine practice [1,4,11,12]. Despite the known role of ferritin as an acute-phase reactant, contemporary literature supports its use—when interpreted alongside inflammatory markers such as ESR and CBC indices—for distinguishing iron deficiency anemia from anemia of chronic disease in tuberculosis patients [6-10,20-22]. The Westergren method for erythrocyte sedimentation rate determination continues to be regarded as the reference standard and is recommended in recent guidelines for assessing inflammatory activity in chronic infectious diseases [26,28,29]. Together, these methodologies provide a robust and clinically meaningful framework for evaluating hematological and iron-related abnormalities in tuberculosis patients.

Results

One hundred Venous blood samples, 50 from patients infected with TB attending Kosti teaching hospital, were matched with 50 from healthy individuals as control (without TB), were analyzed for hematological parameters change using automated hematological analyzers method (Mindray BC-3000) and The method for measurement of Ferritin on the Biosystem BTS-350 spectrophotometer by using Biosystem reagent, ESR were read using Westergren method.

The result was processed statistically by using SPSS (version 21). The following tables show the results obtained (Tables 1-6).

Discussion

Pulmonary tuberculosis is a major infectious disease with a very high incidence in developing countries.

This is a case-control study conducted in Kosti teaching hospital in White Nile State, Sudan, from June to September 2018 to reveal changes in hematological profile and serum Ferritin in pulmonary tuberculosis patients who are clinically positive with acid-fast bacilli in sputum.

The patients were lying in average ages between 15-30 years, 31-45 years, and <15 years, and 31 cases of patients had a family history of TB (Table 1).

Our present study show haemoglobin concentration, packed cell volume, mean cell volume and mean cell haemoglobin of pulmonary tuberculosis patients (9.93 ± 1.827, 31.3 ± 5.27, 79.63 ± 8.85, 25.6 ± 3.61) respectively, was significantly lower ($p < 0.05$) than that of control subjects (12.95 ± 1.728, 39.22 ± 3.50, 87.4 ± 4.20, 28.72 ± 1.76), while RBC count and MCHC of patients was found normal (3.92 ± 0.735, 31.88 ± 1.38) near to that of control subject **(**4.55 ± 0.400, 32.7 ± 0.93**) (**Table 2).

These finding is agree with result of Mubarak I Idriss, et al. which was done on Kassala Area, Eastern Sudan on August 2013, who found that sixty-three (63%) had haemoglobin between 7g/dl and11g/dl, (9.2%) had haemoglobin less than 7g/dl. 26 (26.5%) of the patients with haemoglobin more than 11g/dl, MCV 70.6 ± 9.5 fl, MCH 25.3 ± 4.6 pg, MCHC 35.8 ± 3.6g/dl, and RBC count 4 471 000 ± 9 517 [25].

Concerning RDW value in PTB patients (16.06 ± 2.66) were found in our current study, significantly higher when compared with the control one (13.58 ± 0.9) (p value = .000). This result similar to those finding of a Gribel M. and her collageous which done in the state of Rio de Janeri between March 2007 and December of 2010 and concluded that high RDW (16.63 ± 3.47%) (Table 2) [26].

In the study done by Muhammad Shafee and his colleagues Platelets count was found in the normal range in most of the patients with thrombocytopenia.

This finding is consistent with our study, which shows normal platelet count in 39 of cases, thrombocytopenia in 11 of cases (Table 4) [23].

The prevalence of leukocyte count in the present study was coinciding to study done by Iqbal and his colleagues in Military Hospital, Rawalpindi [24]. Neutrophilia and Eosinophilia are reported in (15 cases, 12 cases respectively) of patients, monocytosis in (26) cases, and low lymphocyte count in (37) cases. This result agrees in points and disagrees in another point with various studies, like neutrophilia documented by Iqbal and his colleagues in Military Hospital, Rawalpindi different from our result, may be due to improving of patient status with successful treatment [24].

Table 1: Gender, Age, and Family History of TB Patients.

No	Variables	Category	Study group $n = 50$		Control group $n = 50$	
			Frequency	Percent	Frequency	Percent
1	Gender	Male	32	32	32	32
		Female	18	18	18	18
2	Age	<15 years	16	16	16	16
		15-30 years	12	12	12	12
		31-45 years	17	17	17	17
		>45 years	5	5	5	5
4	Family history	Yes	31	31	0	0
		No	19	19	50	50

❖ 32 cases are Male.
❖ The most frequent age of TB patients (31-45 years) represents 17 cases.
❖ Most of the patients had a family history of 31 cases, and 19 cases of patients had no history of TB.

Table 2: Hb, RBC counts, RBC indices, RDW of TB patients.

No	Parameters	Category	Study group $n = 50$		Control group $n = 50$		p value
			Frequency and percent	Mean ± SD	Frequency and percent	Mean ± SD	
1	Hb	Less than 8g/dl	3	9.93 ± 1.827	0	12.95 ± 1.728	0.010*
		8-11g/dl	33		0		
		11.1-14g/dl	14		0		
2	RBCs count	(1.8-3.79) x 10^9cell	7	3.92 ± 0.735	2	4.55 ± 0.400	0.000*
		(3.8-5.5) x 10^9cell	42		48		
		>5.5 x 10^9cell	1		0		
3	PCV	15-30%	21	31.3 ± 5.27	20	39.22 ± 3.50	0.000*
		31-45%	29		30		
4	MCV	60-70 fl	2	79.63 ± 8.85	0	87.4 ± 4.20	0.000*
		70-80.9 fl	19		10		
		81-901 fl	29		40		
5	MCH	13-19.9 pg	4	25.6 ± 3.61	1	28.72 ± 1.76	0.000*
		20-26.9 pg	36		3		
		27-32 pg	9		45		
		>32 pg	1		1		
6	MCHC	26.4-31.4%	6	31.88 ± 1.38	6	32.7 ± 0.93	0.000*
		31.5-34.5%	44		40		
		>34.5%	0		4		
7	RDW	12-16%	17	16.06 ± 2.66	21	13.58 ± 0.9	0.000*
		16.1-20%	27		29		
		>18%	23		0		

* Significant ($p \leq 0.05$).
❖ Most of the Hb concentration in patients is low (5-11g/dl), represent 33 cases.
❖ Most of the RBC count of patients is normal (3.8-5.5) x 10^9 cell represent 42 cases.
❖ Most of the PCV of patients is low (15-30%) represent 21 cases
❖ Most of the MCV of patients is low (50-79 fl), representing 21 cases.
❖ Most of the MCH of patients is low (20-26.9 pg) represent 36 cases.
❖ Most of the MCHC in patients is normal (31.5-34.5%) represent 44 cases.
❖ More than half of the RDW of patients is high (12-16%) represent 27 cases

Comparing with the study done by Bala J. and his colleagues in India in 2015, our findings in patients in case of lymphocyte count are matched, but concerning Eosinophil count, mismatched results were obtained. Bala J. and his colleagues documented normal Eosinophil count in 92.5% of patient (Table 3) [27].

In the present study, the proportion of patients with anemia of chronic disease was higher than was that of those with iron-deficiency anemia (40 vs10), a finding that was in agreement with those reported in other studies done by Lee SW, Kang YA in Korea [21,22]. But different from those reported in another study done by Sahiratmadja E, Wieringa FT in Indonesia [22].

Ferritin levels are the most sensitive method for the diagnosis of iron deficiency [20].

Given that microcytosis was observed in most of the patients in the present study, increased RDW and decreased level of MCV might be useful to demonstrate iron deficiency. This agrees with our similar study done by Monteiro L. Valoresdere [30].

This study, however, has several limitations. First, we defined iron deficiency in this population using MCV. MCV reflects the mean RBC volume and has been the most widely used index for the evaluation of nutritional iron deficiency [31].

Table 3: WBC counts and differential counts of TB patients.

No	Parameters	Category	Study group *n* = 50		Control group *n* = 50		
			Frequency and percent	Mean ± SD	Frequency and percent	Mean ± SD	*p* value
1	WBCs counts	1-3.9 x 10^9 cell	12	7.081 ± 2.97	10	5.628 ± 1.35	0.000*
		4-10 x 10^9 cell	27		40		
		10-13 x 10^9 cell	11		0		
2	Neutrophil counts	30-80%	35	57.22 ± 10.58	44	54.25 ± 6.04	0.000*
		More than 80%	15		6		
3	Eosinophil	1-6%	38	8.74 ± 5.151	48	6.24 ± 2.123	0.000*
		>6%	12		2		
4	Basophil	<1%	46	0.66 ± 0.68	0	0.74 ± 0.463	0.000*
		1-2%	4		50		
5	Monocyte	Less than 5	11	8.93 ± 5.07	36	9.30 ± 3.07	0.000*
		5-15%	13		14		
		More than 15	26				
6	Lymphocyte	15-25%	37	24.91 ± 9.46	50	29.21 ± 5.63	0.000*
		26-40%	12		0		
		>40%	1		0		

* Significant ($p \leq 0.05$).
- ❖ More than half of the WBC count of patients is normal (4-10) x 10^9cell) represent 27 cases.
- ❖ Most Neutrophil counts in patients are high (30-50) represent 35 cases and 15 cases are normal.
- ❖ More than half of the Eosinophil counts in patients are normal, 38 cases, and 12 cases are high.
- ❖ Almost all Basophil counts in patients are normal (1-2%), represent 50 cases.
- ❖ Most Monocyte counts in patients are high in 26 cases.
- ❖ More than half of the lymphocyte counts in patients are low represent 37 cases.

Table 4: Platelet count of TB patients.

No	Parameter	Category	Study group *n* = 50		Control group *n* = 50		
			Frequency and percent	Mean ± SD	Frequency and percent	Mean ± SD	*p* value
	Platelet counts	<150 x 10^9 cell	11	275.19 ± 141.4	1	255.99 ± 67.50	0.000*
		150-410 x 10^9 cell	39		49		

Significant ($p \leq 0.05$).
- ❖ Most of Platelet count of the patients are normal (150-410) x 10^9 cell) represent 39 cases, and 11 cases show Thrombocytopenia.

Table 5: Serum Ferritin of TB patients.

No	Parameter	Category	Study group *n* = 50		Control group *n* = 50		*p* value
			Frequency	Percent	Frequency	Percent	
1	Serum Ferritin	Less than 100	10	10	0	0	0.000*
		100-250	17	17	42	42	0.000*
		More than 250	23	23	8	8	0.000*

Significant ($p \leq 0.05$).
- ❖ Serum Ferritin was high in 23 of the study cases, low in 10 cases and normal in 17 of the study cases.

Table 6: ESR of TB patients and controls.

No	Parameters	Category	Study group *n* = 50		Control group *n* = 50		
			Frequency and percent	Mean ± SD	Frequency and percent	Mea *n* ± SD	*p* value
1	ESR	10-35 mm/hr	2	69.07 ± 17.68	47	20.71 ± 4.80	0.000*
		>35 mm/hr	48		3		

* Significant ($p \leq 0.05$).
- ❖ Most of the ESR of patients is high (>35 mm/hr), represent 48 of cases.

Low MCV, however, is not specific to iron deficiency and can result from other causes, including Thalassemia and, less commonly, anemia of chronic disease [32]. Low MCV in this population may be well correlated with iron deficiency, but this cannot be confirmed with the data available. Biochemical measures more specific to iron deficiency, such as Ferritin [33].

In the present study, high serum Ferritin in 23 cases and low in 10 cases. This agrees with a study done by Morris, et al. found increased iron stores in 81% and low in 19% of their patients with pulmonary tuberculosis. [28].

In the present study, the proportion of patients with anemia of chronic disease was higher than that of those with iron-deficiency anemia (40 cases *vs.* 10 cases), a finding that was similar to those reported in other studies [34,35] but different from those reported in another study [36].

The ESR values of PTB patients (69.07 ± 17.68 mm/hr) obtained in this study were significantly higher than control values (20.71 ± 4.80 mm/hr). This agrees with previous findings, which stated that high ESR (60.30 ± 39.84**)** [26] (Table 6). ESR is often raised in infections and inflammatory conditions due to increased production of acute phase

proteins, often observed in chronic infections, and release of proteins by the causative organism (*M.tuberculosis)* into the circulation.

To our knowledge, this is the first study done in my country to relate serial measures of anemia and iron deficiency with the risk of poor clinical outcomes in TB.

Conclusion

Our study shows that anemia is a frequent and important problem among patients with tuberculosis. Most of the patients had low hemoglobin levels, changes in red blood cell indices, and raised ESR values, reflecting the ongoing inflammation and overall poor health associated with TB. Importantly, our findings suggest that anemia in tuberculosis is largely driven by chronic infection and inflammation rather than iron deficiency alone. While the majority of patients had anemia of chronic disease with high serum ferritin levels, a smaller number were found to have true iron deficiency anemia. Although fewer in number, these patients are clinically important because iron deficiency is a treatable condition, and timely iron supplementation could lead to meaningful improvements in hemoglobin levels, immune response, and general well-being. Overall, these results highlight the need for careful evaluation of anemia and iron status in tuberculosis patients so that management can be tailored appropriately, especially in resource-limited settings where simple interventions can make a significant difference in patient outcomes.

Recommendations

Iron supplementation is recommended for the treatment of iron deficiency anemia (10 cases in our study).

Also recommended is bone marrow examination for iron because BM is the gold standard for detecting iron and also to differentiate iron deficiency anemia from other types of anemia.

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