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Original Research Article

Study of Hematological Parameters in Tuberculosis Patients

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Abstract:

Background: Tuberculosis is a major infectious disease associated with significant systemic and hematological alterations. Evaluation of hematological parameters may provide useful information regarding disease severity and inflammatory status in affected individuals.

Material and Methods: The present hospital-based observational cross-sectional study was conducted among 246 diagnosed tuberculosis patients attending a tertiary care center. Venous blood samples were analyzed for complete blood count, erythrocyte sedimentation rate (ESR), and peripheral smear findings using standard laboratory methods. Hematological abnormalities were assessed and correlated with the type of tuberculosis.

Results: Among 246 patients, 62.6% were males and 75.6% had pulmonary tuberculosis. The mean hemoglobin level was 10.1 ± 1.9 g/dL, while the mean ESR was 58.6 ± 21.4 mm/hour. Anemia was observed in 82.9% of patients, with mild anemia being the most common type (39.0%). Raised ESR was present in 87.0% of cases, followed by neutrophilia in 55.3% and leukocytosis in 48.0% of patients. Normocytic normochromic anemia was the predominant peripheral smear pattern (45.5%). Pulmonary tuberculosis patients showed significantly lower hemoglobin levels and higher ESR values compared to extrapulmonary tuberculosis patients ($p<0.05$).

Conclusion: Hematological abnormalities are common in tuberculosis patients, particularly anemia and elevated ESR. Routine hematological evaluation can serve as a useful supportive tool in the assessment and monitoring of tuberculosis patients.

Keywords: Tuberculosis; Hematological parameters; Anemia; Erythrocyte sedimentation rate; Pulmonary tuberculosis.

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Introduction

Tuberculosis (TB) remains one of the leading infectious causes of morbidity and mortality worldwide despite significant advances in diagnostic and therapeutic strategies. The disease is caused by Mycobacterium tuberculosis and primarily affects the lungs, although extrapulmonary involvement is also frequently encountered. Persistent inflammation, immune dysregulation, and chronic infection associated with tuberculosis can produce significant systemic manifestations, including alterations in hematological parameters [1,2].

Hematological abnormalities are commonly observed in patients with active tuberculosis and may reflect both disease activity and host immune response. Anemia, leukocytosis, thrombocytosis, lymphocytopenia, and elevated erythrocyte sedimentation rate (ESR) have been reported among newly diagnosed TB patients [1,3]. These abnormalities may occur due to chronic inflammation, nutritional deficiencies, bone marrow suppression, cytokine-mediated responses, or disseminated infection [3,4].

Recent systematic reviews have demonstrated that anemia is one of the most prevalent hematological manifestations in tuberculosis, with reduced hemoglobin levels and significantly elevated ESR values consistently reported across different populations [1,5]. Additionally, pulmonary tuberculosis patients often exhibit more pronounced hematological derangements compared to extrapulmonary tuberculosis cases, indicating a possible relationship between disease burden and hematological response [3,5].

Evaluation of hematological parameters provides useful supportive information in the diagnosis and monitoring of tuberculosis. Routine hematological investigations are inexpensive, readily available, and may assist clinicians in assessing disease severity, inflammatory status, and response to therapy [5,6]. Furthermore, recognition of these

abnormalities may help in early identification of complications and optimization of patient management [5,6].

In view of the high burden of tuberculosis and the clinical significance of hematological alterations, the present study was undertaken to evaluate the hematological parameters among patients diagnosed with tuberculosis attending a tertiary care center.

Materials and Methods

This hospital-based observational cross-sectional study was conducted at a tertiary care teaching hospital. All participants provided written informed consent prior to enrolment.

A total of 246 diagnosed cases of tuberculosis were included in the study. The sample size was determined considering the prevalence of hematological abnormalities among tuberculosis patients reported in previous studies and the feasibility of recruitment during the study period. Patients aged more than 18 years with newly diagnosed pulmonary or extrapulmonary tuberculosis confirmed by sputum smear microscopy, Cartridge Based Nucleic Acid Amplification Test (CBNAAT), radiological findings, or histopathological examination were included in the study.

Patients with known hematological disorders, chronic liver disease, chronic kidney disease, malignancy, autoimmune disorders, HIV infection, current chemotherapy, or those receiving hematinic therapy or corticosteroids were excluded to minimize confounding factors affecting hematological indices. Pregnant women and patients with active bleeding disorders were also excluded from the study.

Detailed demographic and clinical information including age, sex, clinical presentation, type of tuberculosis, duration of symptoms, and relevant medical history were recorded using a predesigned proforma. Under aseptic precautions, approximately 3 mL of venous blood was collected in ethylenediaminetetraacetic acid (EDTA) vacutainers from each participant before initiation of anti-tubercular therapy.

Hematological parameters including hemoglobin concentration, total leukocyte count, differential leukocyte count, red blood cell count, packed cell volume, mean corpuscular volume, mean corpuscular hemoglobin, mean corpuscular hemoglobin concentration, platelet count, and erythrocyte sedimentation rate were analyzed using an automated hematology analyzer following standard laboratory protocols. Peripheral blood smear examination was performed using Leishman stain for morphological assessment whenever required.

Anemia was classified according to World Health Organization criteria. Leukocytosis, leukopenia, thrombocytosis, and thrombocytopenia were interpreted using standard laboratory reference ranges adopted by the institution.

The collected data were entered into Microsoft Excel and analysed using Statistical Package for the Social Sciences (SPSS) software version 25.0. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. The association between hematological parameters and clinicodemographic variables was assessed using Chi-square test and Student's t-test wherever appropriate. A p-value less than 0.05 was considered statistically significant.

Results

A total of 246 patients diagnosed with tuberculosis were included in the present study. The majority of patients belonged to the age group of 31–40 years (28.9%), followed by 18–30 years (25.2%). Male patients constituted 62.6% of the study population, while females accounted for 37.4%. Pulmonary tuberculosis was more common and was observed in 75.6% of cases, whereas extrapulmonary tuberculosis constituted 24.4% of the cases (Table 1).

The mean hemoglobin level among study participants was 10.1 ± 1.9 g/dL. The mean total leukocyte count was 11280 ± 3245/mm³, while the mean erythrocyte sedimentation rate (ESR) was 58.6 ± 21.4 mm/hour. The average platelet count was 3.84 ± 1.21 lakhs/mm³. Other hematological indices including RBC count, packed cell volume, MCV, MCH, and MCHC are summarized in Table 2.

Anemia was the most frequent hematological abnormality observed in the study population. Among the 246 patients, 39.0% had mild anemia, 33.3% had moderate anemia, and 10.6% had severe anemia, whereas only 17.1% of patients had normal hemoglobin levels (Table 3).

Evaluation of hematological abnormalities demonstrated that raised ESR was present in 87.0% of patients, followed by anemia in 82.9% and neutrophilia in 55.3% of cases. Leukocytosis was observed in 48.0% of patients, while thrombocytosis was detected in 30.1% of the study population. Leukopenia and thrombocytopenia were less commonly encountered abnormalities (Table 4).

Comparison between pulmonary and extrapulmonary tuberculosis cases revealed significantly lower mean hemoglobin levels in pulmonary tuberculosis patients (9.9 ± 1.8 g/dL) compared to extrapulmonary tuberculosis patients (10.7 ± 1.6 g/dL). Similarly, total leukocyte count, platelet count, and ESR were significantly higher

among patients with pulmonary tuberculosis ($p<0.05$) (Table 5).

Peripheral smear examination showed that normocytic normochromic anemia was the predominant morphological pattern, accounting for 45.5% of cases. Microcytic hypochromic anemia was identified in 30.1% of patients, whereas dimorphic anemia and macrocytic anemia were observed in smaller proportions. A normal peripheral smear pattern was noted in 12.2% of study participants (Table 6).

A statistically significant association was observed between raised ESR and type of tuberculosis, with pulmonary tuberculosis patients demonstrating a higher frequency of elevated ESR values compared to extrapulmonary tuberculosis patients ($p=0.018$). However, no statistically significant association was found between anemia and gender distribution among the study participants ($p=0.274$) (Table 7).

Table 1: Demographic and clinical profile of study participants

Variable	Number of patients (n=246)	Percentage (%)
Age group (years)		
18–30	62	25.2
31–40	71	28.9
41–50	54	22.0
51–60	38	15.4
>60	21	8.5
Gender		
Male	154	62.6
Female	92	37.4
Type of tuberculosis		
Pulmonary tuberculosis	186	75.6
Extrapulmonary tuberculosis	60	24.4

Table 2: Mean hematological parameters among tuberculosis patients

Hematological parameter	Mean ± SD
Hemoglobin (g/dL)	10.1 ± 1.9
Total leukocyte count (/mm³)	11280 ± 3245
Neutrophils (%)	69.4 ± 10.6
Lymphocytes (%)	23.1 ± 8.4
Platelet count (lakhs/mm³)	3.84 ± 1.21
ESR (mm/hour)	58.6 ± 21.4
RBC count (million/mm³)	4.08 ± 0.72
Packed cell volume (%)	34.2 ± 5.6
MCV (fL)	83.8 ± 9.7
MCH (pg)	27.6 ± 3.8
MCHC (g/dL)	32.1 ± 2.7

Table 3: Distribution of anemia among tuberculosis patients

Severity of anemia	Number of patients (n=246)	Percentage (%)
No anemia	42	17.1
Mild anemia	96	39.0
Moderate anemia	82	33.3
Severe anemia	26	10.6
Total	246	100

Table 4: Frequency of hematological abnormalities in tuberculosis patients

Hematological abnormality	Number of patients (n=246)	Percentage (%)
Anemia	204	82.9
Leukocytosis	118	48.0
Leukopenia	19	7.7
Neutrophilia	136	55.3
Lymphocytopenia	88	35.8
Thrombocytosis	74	30.1
Thrombocytopenia	22	8.9
Raised ESR	214	87.0

Table 5: Comparison of hematological parameters between pulmonary and extrapulmonary tuberculosis

Parameter	Pulmonary TB (n=186) Mean ± SD	Extrapulmonary TB (n=60) Mean ± SD	p-value
Hemoglobin (g/dL)	9.9 ± 1.8	10.7 ± 1.6	0.012
Total leukocyte count (/mm³)	11540 ± 3368	10472 ± 2874	0.031
Platelet count (lakhs/mm³)	3.96 ± 1.28	3.48 ± 0.92	0.044
ESR (mm/hour)	61.2 ± 22.1	50.5 ± 17.8	0.008

Table 6: Peripheral smear findings among tuberculosis patients

Peripheral smear finding	Number of patients (n=246)	Percentage (%)
Normocytic normochromic anemia	112	45.5
Microcytic hypochromic anemia	74	30.1
Macrocytic anemia	12	4.9
Dimorphic anemia	18	7.3
Normal smear pattern	30	12.2
Total	246	100

Table 7: Association of ESR and anemia with clinicodemographic variables

Variable	Category	Abnormality present	Abnormality absent	p-value
Raised ESR	Pulmonary TB	170	16	0.018
	Extrapulmonary TB	44	16	
Anemia	Male	131	23	0.274
	Female	73	19	

Discussion

Tuberculosis continues to exert a substantial effect on the hematopoietic system, leading to multiple alterations in blood parameters secondary to chronic inflammation, immune activation, nutritional deficiency, and bone marrow involvement. In the present study, anemia and elevated ESR were the most common hematological abnormalities observed among tuberculosis patients. Similar findings have been consistently reported in recent literature evaluating hematological manifestations in active tuberculosis [7,8].

In the current study, anemia was detected in 82.9% of patients, with mild anemia being the predominant form. Peripheral smear examination predominantly demonstrated normocytic normochromic anemia. These findings are comparable with recent systematic reviews and observational studies which reported anemia as one of the most frequent hematological manifestations among tuberculosis patients, largely attributed to anemia of chronic disease and inflammatory cytokine-mediated suppression of erythropoiesis [9,10].

Raised ESR was observed in 87.0% of cases in the present study. Elevated ESR is a recognized marker of inflammatory activity and disease burden in tuberculosis. Farhadian et al. demonstrated significantly increased pooled ESR values among newly diagnosed tuberculosis patients, supporting the inflammatory basis of hematological derangements in TB [7]. Similarly, recent biomarker studies have highlighted the role of inflammatory mediators and immune dysregulation in producing elevated ESR and altered hematological indices in active disease [11].

Leukocytosis and neutrophilia were identified in 48.0% and 55.3% of patients respectively in the present study. Comparable observations were reported in recent pulmonary tuberculosis studies where increased leukocyte and neutrophil counts were associated with active infection and ongoing inflammatory response [12,13]. Neutrophil predominance has also been correlated with disease severity and treatment response in pulmonary tuberculosis patients [13].

Thrombocytosis was observed in 30.1% of patients in this study. Reactive thrombocytosis in tuberculosis may occur due to cytokine-driven megakaryocytic stimulation during chronic inflammation. Similar frequencies of thrombocytosis have been documented in recent meta-analyses and cohort studies evaluating hematological abnormalities in TB patients [7,14].

The present study also demonstrated significantly lower hemoglobin levels and higher ESR values among pulmonary tuberculosis patients compared to extrapulmonary tuberculosis patients. These findings suggest that pulmonary disease may be associated with a greater inflammatory burden and more pronounced systemic hematological response. Recent longitudinal studies in severe and drug-resistant tuberculosis have similarly reported worsening hematological profiles in patients with extensive disease involvement [15].

Overall, the findings of the present study emphasize that routine hematological investigations provide

valuable supportive information in tuberculosis patients. Assessment of hematological parameters may assist clinicians in evaluating disease severity, inflammatory activity, and therapeutic monitoring, particularly in resource-limited settings where advanced biomarkers may not be readily available.

Conclusion

Tuberculosis is associated with a wide spectrum of hematological abnormalities, among which anemia and elevated erythrocyte sedimentation rate were the most commonly observed findings in the present study. Normocytic normochromic anemia emerged as the predominant peripheral smear pattern, while leukocytosis, neutrophilia, and thrombocytosis were also frequently encountered. Pulmonary tuberculosis patients demonstrated comparatively greater hematological derangements than extrapulmonary tuberculosis cases. Assessment of hematological parameters can therefore serve as a useful adjunct in the evaluation of disease severity and systemic inflammatory response in tuberculosis patients, facilitating timely diagnosis, monitoring, and clinical management.

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