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Association of Hematological Changes in Pulmonary Tuberculosis Patients

Zahra
DMLT, Faculty of Allied Health Sciences, Superior University Lahore, Pakistan

Hifsa Mobeen*
Senior Lecturer DMLT-FAHS, Superior University Lahore, Pakistan / PhD Scholar, Institute of Molecular Biology and Biotechnology (IMBB), The University of Lahore, Pakistan. Email: hifsa.mobeen@superior.edu.pk

Faisal Shahzad
DMLT, Faculty of Allied Health Sciences, Superior University Lahore, Pakistan

Asma Fatima
PhD Scholar, Institute of Molecular Biology and Biotechnology (IMBB), The University of Lahore, Pakistan

ABSTRACT

Pulmonary Tuberculosis (PTB) remains a major global health burden, particularly in developing countries, and is associated with significant hematological abnormalities due to chronic inflammation and immune dysregulation. The infection triggers a complex systemic response that affects bone marrow function, leading to alterations in red blood cells, white blood cells, and platelets. Common hematological changes include anemia, leukocytosis with neutrophilia and lymphopenia, thrombocytosis, and elevated acute phase reactants like ESR.

The study was conducted to evaluate the hematological profile of Pulmonary Tuberculosis patients and correlate findings with disease severity, nutritional status, and demographic variables. A cross-sectional study was conducted on newly diagnosed Pulmonary Tuberculosis patients. ESR, peripheral smear examination, and radiological severity grading were performed. Data was analyzed using SPSS version 26.0; ANOVA, t-test, and Pearson correlation were applied ($p<0.05$ significant).

The study included 138 pulmonary tuberculosis patients, with 65.2% males and a mean age of 42.5 years. Anemia was highly prevalent, affecting 85.5% of patients, with normocytic normochromic anemia being the most common type. Mean hemoglobin was low at 10.1 g/dL, while ESR was markedly elevated at 68.4 mm/hr, and reactive thrombocytosis was also observed. As disease severity increased from mild to severe, hemoglobin progressively decreased from 12.2 to 8.2 g/dL, while ESR rose dramatically from 28.5 to 102.4 mm/hr. Smokers showed worse inflammatory markers and lower hemoglobin compared to non-smokers. A positive correlation was found between BMI and hemoglobin, while a negative correlation existed between BMI and ESR. Pulmonary Tuberculosis is associated with significant hematological abnormalities that correlate with disease severity, nutritional status, and smoking. Routine hematological assessment serves as an inexpensive tool for

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severity stratification.

Keywords: Pulmonary Tuberculosis, Anemia, Erythrocyte Sedimentation Rate, Thrombocytosis, Disease Severity, Body Mass Index.

Introduction

Tuberculosis (TB) is a chronic infectious disease caused by *Mycobacterium tuberculosis*, primarily affecting the lungs and leading to pulmonary tuberculosis (PTB).[1] It remains one of the leading causes of death from infectious diseases worldwide, with millions of new cases reported annually, especially in South Asia and Africa.[2] Pakistan is among the high-burden countries, largely due to factors such as poverty, malnutrition, overcrowding, poor sanitation, and limited healthcare access.[3]

TB infection begins when contaminated droplets are inhaled, allowing the bacteria to reach the alveoli where they are engulfed by macrophages.[4] This triggers an immune response leading to granuloma formation, which attempts to contain the bacteria but may result in caseous necrosis and lung tissue damage over time.[5]

Hematological changes are commonly observed in PTB. Neutrophilia reflects the body's initial immune response to infection, driven by inflammatory cytokines.[6] Thrombocytosis is also frequent, as platelets contribute to inflammation; however, excessive platelet production may increase the risk of thrombotic complications.[7] Elevated ESR serves as a nonspecific marker of inflammation and is useful in monitoring treatment response, typically decreasing with effective therapy.[7] Smoking further worsens TB by increasing inflammation and hematological abnormalities such as low hemoglobin, high WBC count, and elevated ESR.[8]

Although these hematological alterations are well recognized, there is limited research on their patterns and clinical significance in the Pakistani population. Therefore, this study aims to evaluate the relationship between pulmonary tuberculosis and hematological changes, helping to improve diagnosis, monitoring, and risk assessment.

Methodology

This hospital-based cross-sectional study was conducted at the Department of Pulmonology and Hematology Laboratory of Mayo Hospital and Services Hospital, Lahore, over a period of six months. A total of 138 newly diagnosed pulmonary tuberculosis (PTB) patients, aged 18–65 years of both genders and no prior or less than one week of anti-tuberculosis treatment were included, while those with extrapulmonary tuberculosis, prolonged anti-TB therapy, known hematological disorders (except anemia of chronic disease), HIV, chronic liver or kidney disease, malignancy, and pregnant or lactating women were excluded. After informed consent, demographic and clinical data including age, gender, and smoking status were recorded. Disease severity was assessed radiologically and categorized into mild, moderate, and severe, while nutritional status was evaluated using body mass index (BMI). Venous blood samples were collected under aseptic conditions and analyzed for hemoglobin, total leukocyte count, differential leukocyte count, platelet count, erythrocyte

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sedimentation rate (ESR), and red blood cell indices including MCV, MCH, and MCHC. Peripheral blood smear examination was performed to determine morphological types of anemia. Data were entered and analyzed using SPSS version 26.0; descriptive statistics were expressed as mean ± standard deviation and frequencies/percentages. Independent t-test, one-way ANOVA, and Pearson correlation were applied to assess associations between hematological parameters and variables such as disease severity, smoking status, gender, and BMI, with $p<0.05$ considered statistically significant. Ethical approval was obtained, and confidentiality of participants was maintained.

RESULTS

The study comprised a total of 138 patients diagnosed with Pulmonary Tuberculosis (PTB). The demographic and clinical characteristics of the 138 study participants. Regarding gender distribution, male patients constituted 65.2% (n=90) of the study population, while female patients comprised 34.8% (n=48). Smoking status analysis revealed that 36.2% (n=50) of patients were smokers, whereas the majority 63.8% (n=88) were non-smokers. Disease severity classification showed that 32.6% (n=45) of patients had mild disease, 36.2% (n=50) had moderate disease, and 31.2% (n=43) had severe pulmonary tuberculosis. These baseline characteristics provide essential context for interpreting the hematological findings in this patient cohort.

Table 1: Demographic and Clinical Characteristics of the Study Population (n=138)

Characteristic	Category	Frequency (n)	Percentage (%)
Gender	Male	90	65.2
	Female	48	34.8
Smoking Status	Smoker	50	36.2
	Non-Smoker	88	63.8
Disease Severity	Mild	45	32.6
	Moderate	50	36.2
	Severe	43	31.2

The figure shows demographic and clinical distribution. Males were about twice as many as females. Non-smokers were nearly double compared to smokers. Disease severity was fairly balanced, with moderate cases highest (36.2%), followed by mild (32.6%) and severe (31.2%), allowing comparison across stages.

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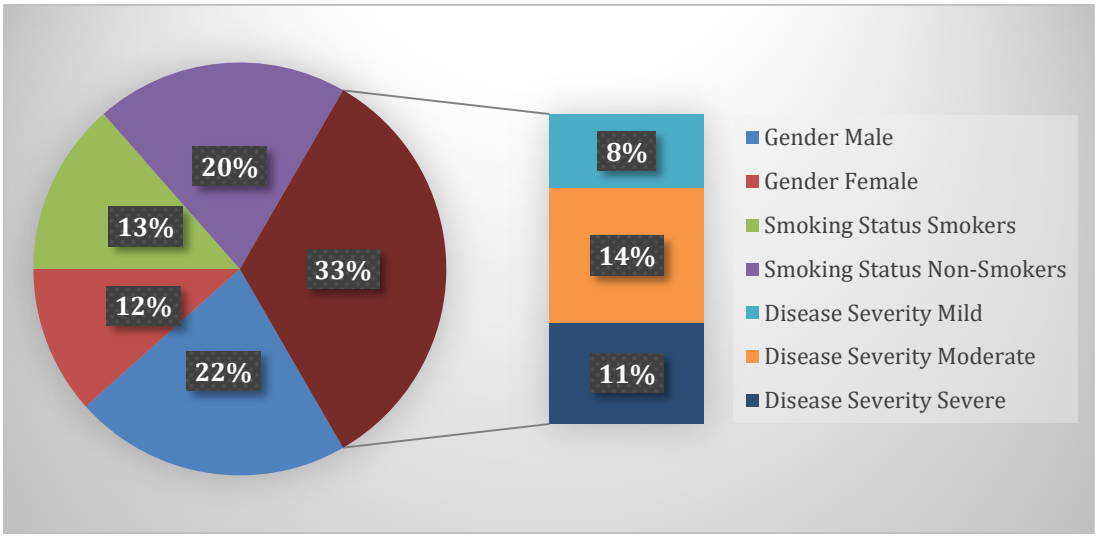

Figure 1: Characteristics of Study Population

The mean hemoglobin (10.1 ± 1.8 g/dL) was below normal, indicating anemia. Total leukocyte count (12,450 ± 3,200/µL) was elevated, showing leukocytosis. Platelet count (4.2 ± 1.1 lakhs/µL) was slightly raised, suggesting thrombocytosis. ESR (68.4 ± 32.1 mm/hr) was markedly high, reflecting strong inflammation, while MCV (82.5 ± 7.4 fL) remained normal, indicating normocytic anemia. Overall, pulmonary tuberculosis is associated with anemia, leukocytosis, thrombocytosis, and raised inflammatory markers.

Table 2: Hematological Parameters in PTB Patients

Hematological Parameter	Mean Value	Standard Deviation (SD)	Normal Range (Ref)
Hemoglobin (Hb)	10.1 g/dL	± 1.8	13.5–17.5 (M)
Total Leukocyte Count (TLC)	12,450 \mu L	± 3,200	4,000–11,000
Platelet Count	4.2 Lakhs\mu L	± 1.1	1.5–4.0
ESR (1st Hour)	68.4 mm/hr	± 32.1	< 20
MCV (RBC Index)	82.5 FL	± 7.4	80–100

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Figure 2 shows the percentage deviation of hematological parameters from normal values. ESR had the highest deviation (58%), indicating strong inflammation. Platelet count (46%) and total leukocyte count (44%) were also elevated, reflecting reactive thrombocytosis and infection. Hemoglobin showed a 26% decrease, confirming anemia, while MCV had the least change (34%), indicating normocytic anemia. Overall, ESR and platelet count were the most affected, whereas MCV remained relatively stable.

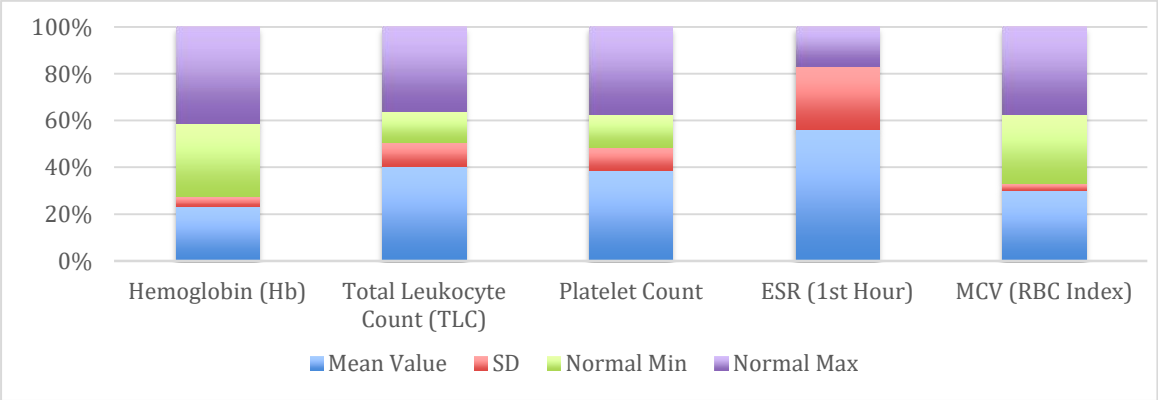

Figure 2: Hematological Parameters in PTB Patients

The study further evaluated Red Blood Cell (RBC) indices, including Mean Corpuscular Volume (MCV), Mean Corpuscular Hemoglobin (MCH), and Mean Corpuscular Hemoglobin Concentration (MCHC), to characterize the type of anemia present in the 138 PTB patients. The majority of patients displayed Normocytic Normochromic Anemia, which is consistent with the "Anemia of Chronic Disease" typically seen in tuberculosis. However, a subset of patients, particularly those with low BMI and chronic malnutrition, showed Microcytic Hypochromic features, suggesting a co-existing iron deficiency.

Table 3: Mean RBC Indices among the Study Population

RBC Index	Mean Value	SD	Reference Range
MCV (FL)	82.5	± 7.4	80 – 100
MCH (pg)	27.8	± 3.2	27 – 32
MCHC (g/dL)	32.1	± 1.8	32 – 36

Figure 3 compares mean RBC indices with normal ranges. MCV (82.5 fL), MCH (27.8 pg), and MCHC (32.1 g/dL) all remained within normal limits, close to the lower range. This confirms that the anemia is normocytic and normochromic, typical of anemia of chronic disease in tuberculosis, rather than due to iron or vitamin deficiencies.

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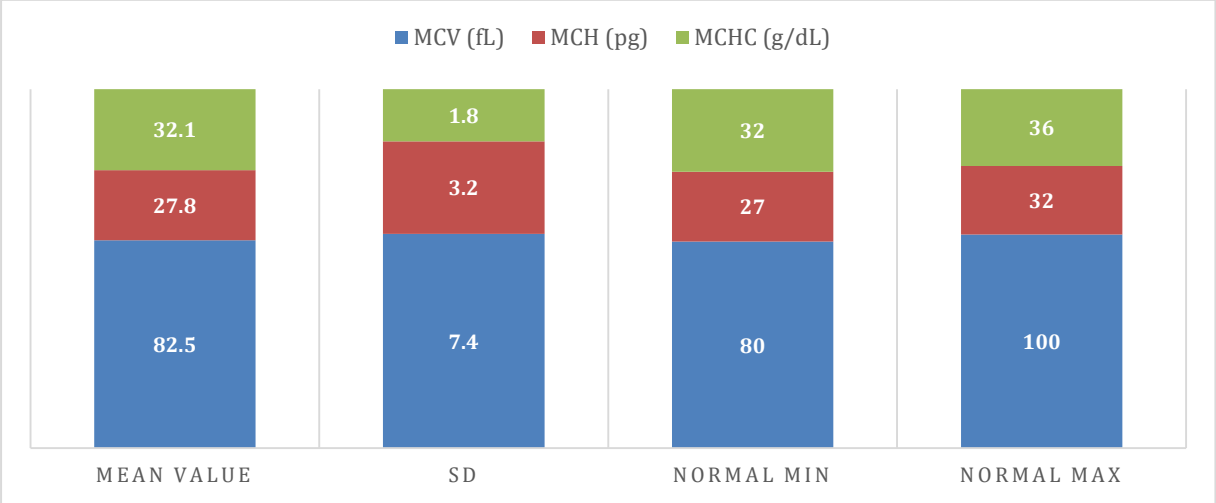

Figure 3: Mean RBC Indices among the Study Population

Normocytic normochromic anemia was the most common (59.4%), reflecting anemia of chronic disease in TB. Microcytic hypochromic anemia (20.3%) indicated iron deficiency, while dimorphic anemia (5.8%) suggested mixed deficiencies. About 14.5% had normal parameters. Overall, anemia of chronic disease predominates, though nutritional deficiencies are also present.

Table 4: Frequency Distribution of Anemia Types (N=138)

Morphological Type	Frequency (n)	Percentage (%)	Clinical Association
Normocytic Normochromic	82	59.4%	Chronic Inflammation (TB)
Microcytic Hypochromic	28	20.3%	Nutritional Deficiency
Dimorphic Anemia	8	5.8%	Mixed Deficiency
Normal (non-anemic)	20	14.5%	Mild/Early Stage

Figure 3 compares the mean values of red blood cell indices (MCV, MCH, and MCHC) in pulmonary tuberculosis patients with normal reference ranges. The mean MCV was 82.5 fL (normal range 80 to 100 fL), mean MCH was 27.8 pg (normal range 27 to 32 pg), and mean MCHC was 32.1 g/dL (normal range 32 to 36 g/dL). All three parameters fell within normal limits, though they were close to the lower end of their respective ranges. This pattern confirms normocytic normochromic anemia, which is characteristic of anemia of chronic disease associated with tuberculosis infection. The findings indicate that the anemia is not due to iron deficiency or vitamin B12 deficiency, which would have produced microcytic or macrocyticchanges.

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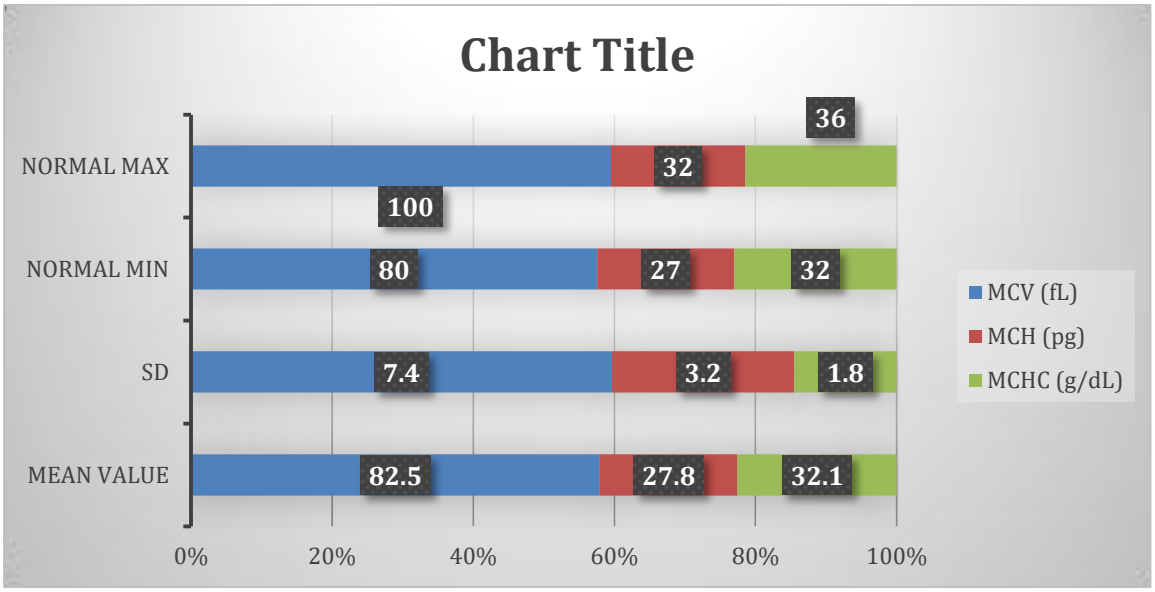

Figure 4: Frequency Distribution of Anemia Types

Neutrophils were elevated (76% ± 8.5), indicating neutrophilia, while lymphocytes were reduced (18% ± 5.2), showing lymphopenia. Monocytes were slightly increased (5% ± 1.8), consistent with chronic infection, and eosinophils remained normal (1% ± 0.5). This pattern leads to a high neutrophil-to-lymphocyte ratio, reflecting inflammation and TB severity.

Table 5: Differential Leukocyte Count Trends

Cell Type	Observed Mean (%)	SD	Status in PTB
Neutrophils	76%	± 8.5	Elevated
Lymphocytes	18%	± 5.2	Decreased
Monocytes	5%	± 1.8	Slightly Elevated
Eosinophils	1%	± 0.5	Normal

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Hemoglobin levels decreased with increasing TB severity, reaching the lowest in severe cases (8.2 g/dL). In contrast, ESR and TLC increased as disease progressed. ANOVA showed these differences were highly significant ($p < 0.001$), indicating that hematological changes reflect disease severity.

Table 6: Comparison of Hematological Parameters Across Severity Groups

Parameter	Mild (n=33)	Moderate (n=60)	Severe (n=45)	p-value
Hb (g/dL)	12.2 ± 1.1	10.4 ± 1.2	8.2 ± 0.9	< 0.001
ESR (mm/hr)	28.5 ± 10.4	62.1 ± 15.6	102.4 ± 22.8	< 0.001
TLC (cells/\mu L)	7,800 ± 1,200	11,500 ± 2,100	15,800 ± 3,400	< 0.001
Platelets (Lakhs/\mu L)	2.4 ± 0.6	3.9 ± 0.8	5.6 ± 1.2	< 0.001

Smokers (n=56) had higher TLC and ESR values compared to non-smokers (n=82), indicating increased inflammation. Their mean hemoglobin was also slightly lower than in non-smokers, likely due to the combined effects of smoking and infection.

Table 7: Hematological Parameters Based on Smoking Status

Parameter	Smokers (n=56)	Non-Smokers (n=82)	p-value
Hemoglobin (g/dL)	9.4 ± 1.5	10.6 ± 1.7	0.024
TLC (cells/\mu L)	14,200 ± 2,800	11,100 ± 2,400	0.008
ESR (mm/hr)	78.6 ± 28.4	61.2 ± 25.1	0.015

The data was further analyzed to determine if gender or age influenced the hematological response to Tuberculosis. Males (n=90) generally showed lower Hemoglobin levels compared to females (n=48) in this specific cohort, likely due to a higher prevalence of smoking and later presentation at the hospital. Additionally, patients in the older age group (>50 years) exhibited higher ESR and TLC values compared to younger patients.

Table 8: Gender-Based Distribution of Blood Parameters

Parameter	Male (n=90)	Female (n=48)	p-value
Mean Hb (g/dL)	9.8 ± 1.6	10.7 ± 1.4	0.012
Mean ESR (mm/hr)	72.5 ± 28.1	60.8 ± 22.4	0.035
Mean TLC (/\mu L)	13,100 ± 2,500	11,200 ± 2,100	0.005

To understand the relationship between nutritional status and blood parameters, a correlation analysis was performed. A positive correlation was found between BMI and Hemoglobin ($r = 0.62$), meaning as BMI decreases, anemia becomes more severe. A negative correlation was noted between BMI and ESR ($r = -0.55$), indicating that underweight patients have much higher inflammatory markers.

Table 9: Pearson Correlation Coefficients of BMI with hematological parameters

Statistics	BMI (kg/m2)	Hb (g/dL)	ESR (mm/hr)	TLC (cells/µL)

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Correlation (r)	1.00	0.62	-0.55	-0.48
Significance (p)	-	0.001	0.002	0.004

This comparison highlights that the hematological presentation of tuberculosis varies along a spectrum, with localized pulmonary disease typically showing reactive changes (leukocytosis, thrombocytosis, ACD), while disseminated disease may present with cytopenia's due to bone marrow infiltration and consumption. Clinicians must consider this differential when interpreting hematological abnormalities in TB patients.

DISCUSSION

The analysis of hematological profiles in patients with pulmonary tuberculosis showed that normocytic normochromic anemia was the most frequent morphological type, with 59.4% of patients, with microcytic hypochromic anemia being the second most frequent morphological type, 20.3% of patients, and dimorphic anemia being the last morphological type, 5.8 This result is consistent with the study by Leon, *et al*., 2015. This result also coincides with Rohini, et al., 2016, who also found much lower hemoglobin levels in TB patients than in healthy controls, and the anemia was usually normocytic normochromic.[9]

There was a large positive relationship between low BMI and low hemoglobin ($r = 0.62$, $p = 0.001$), which supports the contribution of nutritional depletion to the worsening of anemia. This result is consistent with Leon, *et al*., 2015. The microcytic hypochromic anemia, found in a significant percentage of patients, means that nutritional iron deficiency complicates the anemia of chronic disease in this patient group, which is consistent with the findings of Leon, *et al.*, 2015.[10]

The study population erythrocyte sedimentation observation is consistent with that of Farhadian, *et al*., 2022, who estimated a pooled mean ESR of 63.6 mm/hr, in their meta-analysis of tuberculosis patients. An increment in ESR was identified throughout disease severity groups, with mild disease having 28.5 mm/hr and severe disease having 102.4 mm/hr and the difference was statistically significant ($p < 0.001$). This observation is in line with Bozoky, *et al.*, 1997.[11]

The leukocyte profile observation is consistent with Khan, *et al.*, 2016, who found leukocytosis in 12% of their patients with pulmonary tuberculosis with an average of 18,000/ul total leukocyte count in the patients with a high count. The increased total leukocyte count (mean 12,450/ uL) in this research is consistent with the results of Khan *et al.*, 2016. Lymphopenia is also a well-known phenomenon in tuberculosis, which is consistent with the observation of Bozoky, *et al.*, 1997. This lymphopenia can be a reflection of various mechanisms such as the concentrations of lymphocytes at the location of infection into the lungs, apoptosis of T-cells which are activated, or suppression of bone marrow by inflammatory mediators as described by Bozoky, *et al.*, 1997.[12]

Thrombocytosis was reactive with an average platelet count of 4.2 + 1.1 lakhs/ul that is more than the normal reference range of 1.5-4.0 lakhs/ul. This result is consistent with Farhadian, *et al*., 2022, who have found that in their meta-analysis, the pooled prevalence of thrombocytosis was 31.9% in tuberculosis patients. This observation also correlates with the study conducted by Khan, *et al*., 2016. The platelet values were elevated by the severity of the disease with mild disease having a platelet value of 2.4 lakhs/ul and severe disease having a platelet value of 5.6 lakhs/ul ($p < 0.001$). This observation aligns with the

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knowledge that inflammatory cytokines, especially interleukin-6, cause thrombocytosis in tuberculosis, promoting the growth of megakaryocytes and platelets, as explained by Farhadian, *et al.*, 2022.[13]

Hemoglobin levels showed a progressive decline from 12.2 g/dL in mild disease to 8.2 g/dL in severe disease ($p < 0.001$), while ESR and total leukocyte count demonstrated corresponding increases. This finding agrees with Bozoky, *et al.*, 1997, who noted that hematological parameters correlate with disease severity and return toward normal with successful treatment. However, this finding partially disagrees with Di Gennaro, *et al.*, 2021, who reported that while anemia and elevated CRP were sensitive markers of severe disease, individual hematological variables showed limited discriminative ability with AUC values of only 0.51 to 0.56.[14]

Smokers, who constituted 36.2% of the cohort, demonstrated significantly higher inflammatory markers including total leukocyte count (14,200 vs 11,100/μL, $p = 0.008$) and ESR (78.6 vs 61.2 mm/hr, $p = 0.015$) and lower hemoglobin levels (9.4 vs 10.6 g/dL, $p = 0.024$) compared to non-smokers. This finding agrees with Leon, *et al.*, 2015, who identified tobacco use as a risk factor for anemia of chronic disease in pulmonary tuberculosis patients. Gender-based analysis revealed that males had lower mean hemoglobin (9.8 vs 10.7 g/dL, $p = 0.012$) and higher ESR (72.5 vs 60.8 mm/hr, $p = 0.035$) compared to females. This finding disagrees with Farhadian, *et al.*, 2022, whose systematic review did not find significant gender-based differences in pooled analyses. [15]

A strong positive correlation was observed between BMI and hemoglobin ($r = 0.62$, $p = 0.001$), and a negative correlation between BMI and ESR ($r = -0.55$, $p = 0.002$), underscoring the critical role of nutrition in modulating the hematological response to tuberculosis. This finding agrees with Leon, *et al.*, 2015, who found that undernourished patients had a 3.43 times higher risk of anemia of chronic disease. Older patients above 50 years of age exhibited higher ESR and total leukocyte count values compared to younger patients, and this finding agrees with Bozoky, *et al.*, 1997, who noted that older patients presented with more severe disease and worse hematological parameters.[16]

CONCLUSION

Pulmonary tuberculosis is associated with significant hematological alterations, including normocytic normochromic anemia, neutrophilia, lymphopenia, thrombocytosis, and elevated ESR. These abnormalities show a clear association with increasing disease severity. Nutritional status and lifestyle factors, particularly low BMI and smoking, further exacerbate anemia and inflammatory responses. While anemia of chronic disease is the predominant pattern, a proportion of patients also exhibit features of iron deficiency. Routine hematological investigations provide a simple, cost-effective, and valuable tool for assessing disease severity and monitoring progression, particularly in resource-limited settings.

REFERENCES

World Health Organization. Global tuberculosis report 2024. Geneva: World Health Organization; 2024.

Dasaradhan T, Koneti J, Kalluru R, Gadde S, Cherukuri SP, Chikatimalla R. Tuberculosis-Associated Anemia: A Narrative Review. Cureus. 2022 Aug 7;14(8):e27746. doi: 10.7759/cureus.27746.

Online ISSN 3007-3197
Print ISSN 3007-3189

Ashenafi S, Bekele A, Aseffa G, Amogne W, Kassa E, Aderaye G, et al. Anemia Is a Strong Predictor of Wasting, Disease Severity, and Progression, in Clinical Tuberculosis (TB). Nutrients. 2022 Aug 12;14(16):3318. doi: 10.3390/nu14163318.

Barzegari S, Afshari M, Movahednia M, Moosazadeh M. Prevalence of anemia among patients with tuberculosis: a systematic review and meta-analysis. Indian J Tuberc. 2019 Apr;66(2):299-307. doi: 10.1016/j.ijtb.2019.04.002.

Gelaw Y, Getaneh Z, Melku M. Anemia as a risk factor for tuberculosis: A systematic review and meta-analysis. Environ Health Prev Med. 2021;26(1):13. doi: 10.1186/s12199-020-00931-z.

Han C, Fang Y, Dong L, Guo D, Lei M, Guo W, et al. Correlation of tuberculosis-related anemia severity with tuberculosis-induced inflammation in children: a six-year retrospective study. Ital J Pediatr. 2024 Jun 18;50(1):116. doi: 10.1186/s13052-024-01664-3.

Morris CD. The radiography, haematology and biochemistry of pulmonary tuberculosis in the aged. Q J Med. 1989 Jun;71(266):529-36.

Bozóky G, Ruby E, Göblös I, Tóth J, Mózes E, Szabó G. Hematologic abnormalities in pulmonary tuberculosis. Orv Hetil. 1997 Apr 27;138(17):1053-6.

Olaniyi JA, Aken'Ova YA. Haematological profile of patients with pulmonary tuberculosis in Ibadan, Nigeria. Ann Ib Postgrad Med. 2006 Jun;4(1):17-21. doi: 10.4314/aipm.v4i1.39086.

Aderaye G, Aseffa G, Harries AD, Argaw D, Worku A. Hematologic and CD4+ T-cell responses in HIV-positive and HIV-negative patients with tuberculosis in Ethiopia. Ethiop Med J. 2007 Jan;45(1):39-45.

Kassa E, Enawgaw B, Gelaw A, Gelaw B. Immuno-hematological profile of tuberculosis patients in University of Gondar Hospital, Northwest Ethiopia. J Blood Med. 2016;7:163-170. doi: 10.2147/JBM.S109328.

Lawn SD, Obeng J, Acheampong JW, Griffin GE. Resolution of the acute-phase response in West African patients receiving treatment for pulmonary tuberculosis. Int J Tuberc Lung Dis. 2000 Apr;4(4):340-4.

Rutherford ME, Hill PC, Maharani W, Apriani L, Sampurno H, van Crevel R, et al. Haematological parameters in adult pulmonary tuberculosis at the time of diagnosis in Indonesia. Trans R Soc Trop Med Hyg. 2012 Oct;106(10):625-9. doi: 10.1016/j.trstmh.2012.07.003.

Tabarsi P, Merza MA, Marjani M, Mahmoudi S, Mansouri D, Farshadpour F, et al. Hematologic abnormalities in patients with tuberculosis. Tanaffos. 2012;11(4):35-40.

El-Sony AI, Khamis AH, Enarson DA, Baraka O, Mustafa SA, Bjune G. The effect of anaemia on the outcome of tuberculosis treatment. Int J Tuberc Lung Dis. 2005 Jun;9(6):669-74.

Nagu TJ, Spiegelman D, Hertzmark E, Aboud S, Makani J, Matee MI, et al. Anemia at the initiation of tuberculosis therapy is associated with delayed sputum conversion among pulmonary tuberculosis patients in Dar-es-Salaam, Tanzania. PLoS One. 2014 Mar 13;9(3):e91229. doi: 10.1371/journal.pone.0091229.