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BIOCHEMICAL CHANGES IN TUBERCULOSIS

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ABSTRACT

Background: Tuberculosis (TB), a chronic infectious disease caused by Mycobacterium tuberculosis, is often accompanied by significant biochemical alterations that reflect the host's nutritional status, inflammatory response, and disease burden. Understanding these changes is critical for comprehensive patient management and prognosis. The objective is to evaluate and compare key biochemical parameters in patients with active pulmonary tuberculosis and healthy controls, highlighting the metabolic and nutritional derangements associated with TB. **Materials and Methods:** This prospective observational study was conducted in the Department of Respiratory Medicine, Medical College Kolkata, from January 2024 to December 2024, after obtaining approval from the Institutional Ethics Committee. Written informed consent was collected from all participants prior to enrolment. A total of 180 subjects were included and divided equally into three groups: the TB group (n=60), comprising patients diagnosed with tuberculosis; the Control group (n=60), consisting of healthy individuals without tuberculosis; and the F group (n=60), representing participants with other febrile illnesses. **Result:** The study included three groups (TB, Control, F; each n=60) with comparable mean ages (TB: 41.8 ± 12.5; Control: 39.2 ± 11.6; F: 40.1 ± 13.2 years; p=0.473) and similar sex distribution (TB: 38M/22F; Control: 36M/24F; F: 35M/25F; p=0.871). BMI was significantly lower in the TB group (19.3 ± 3.1 kg/m²) than in the Control (22.8 ± 2.9) and F group (21.7 ± 3.2; p<0.001). Other baseline variables showed no significant differences (p>0.05). Biochemical analysis showed TB patients had lower serum albumin (2.9 ± 0.5 g/dL vs. Control 4.3 ± 0.4; F 4.0 ± 0.4), lower total protein (5.8 ± 0.7 g/dL vs. 7.2 ± 0.6 and 7.0 ± 0.5), and slightly higher globulin (2.9 ± 0.4 vs. 2.8 ± 0.4). Inflammatory markers were higher in the TB group: ferritin 310 ± 90 ng/mL, CRP 22 ± 8 mg/L, ESR 65 ± 18 mm/hr. The TB group also had lower hemoglobin (9.8 ± 1.4 g/dL), serum iron (48 ± 12 µg/dL), higher total leukocyte count (10.5 ± 2.8 × 10^3/mm³), and lower serum calcium (7.9 ± 0.6 mg/dL) compared to controls (9.3 ± 0.5) and F group (9.0 ± 0.4). All differences were statistically significant (p<0.001). **Conclusion:** The study found that although demographic factors were similar across groups, the TB group had significantly poorer nutritional status, greater systemic inflammation, anemia, and lower serum calcium levels. These differences highlight the substantial effect of tuberculosis on nutrition, inflammatory response, and hematological health compared to healthy controls and the F group.

INTRODUCTION

Tuberculosis (TB) remains a major global health challenge, claiming approximately 1.3 million lives annually despite advancements in diagnostics and therapeutics.[1] Caused by Mycobacterium tuberculosis, TB is a chronic granulomatous disease that primarily affects the lungs but can involve virtually any organ system.[2] Beyond its well-characterized pathological and immunological profiles, TB profoundly alters the host's biochemical milieu, leading to measurable changes in various metabolic pathways, serum proteins, electrolytes, and enzyme activities.[3] These biochemical derangements not only reflect disease severity and chronicity but also provide valuable adjuncts for diagnosis, monitoring therapeutic response, and understanding disease pathogenesis.

Malnutrition and altered protein metabolism are hallmark biochemical consequences of active TB.

Patients often exhibit hypoalbuminemia due to increased catabolism and impaired hepatic synthesis, coupled with elevated globulin levels resulting from heightened immunoglobulin production in response to persistent antigenic stimulation.[4,5] The albumin/globulin (A/G) ratio, therefore, is frequently decreased in TB, serving as a nonspecific but useful biochemical marker of disease activity.[6] Furthermore, serum levels of acute phase reactants such as C-reactive protein (CRP) and haptoglobin are typically elevated, reflecting the ongoing inflammatory response.[7]

Mineral and electrolyte imbalances are also notable in TB. Hyponatremia, often due to inappropriate antidiuretic hormone secretion (SIADH), is common and has been correlated with disease severity, particularly in disseminated and meningeal TB.[8] Hypocalcemia and hypophosphatemia may occur secondary to malnutrition, vitamin D deficiency, or alterations in parathyroid hormone dynamics.[9] TB also affects trace elements: reductions in serum zinc and selenium, coupled with elevated copper levels, have been documented, highlighting the complex interplay between host immunity, oxidative stress, and pathogen survival strategies.[10]

Enzymatic alterations further characterize TB-related biochemical changes. Elevations in adenosine deaminase (ADA) activity, particularly in pleural fluid and cerebrospinal fluid, are widely utilized as supportive diagnostic tools in tuberculous pleuritis and meningitis, respectively.[11] Increased serum lactate dehydrogenase (LDH) and alkaline phosphatase (ALP) levels have also been reported, often reflecting granulomatous hepatic involvement or widespread tissue turnover.[12]

Additionally, oxidative stress plays a central role in TB pathogenesis and is mirrored in the biochemical profile. Active TB patients often show increased lipid peroxidation markers, such as malondialdehyde, alongside decreased antioxidant defense mechanisms, including reduced levels of glutathione and superoxide dismutase activity.[13] These changes not only contribute to tissue damage but may also serve as biomarkers for disease activity and therapeutic response.

Understanding these biochemical alterations is vital for clinicians and researchers alike. They not only provide insight into the systemic impact of Mycobacterium tuberculosis infection but also aid in developing adjunctive diagnostic markers and potential therapeutic targets. Despite being nonspecific, these biochemical changes, when interpreted alongside clinical and microbiological data, enhance the comprehensive evaluation of TB patients and underscore the systemic nature of this ancient yet persistently formidable disease.

MATERIALS AND METHODS

This prospective observational study was conducted in the Department of Respiratory Medicine, Medical College Kolkata, over a period of January 2024 to December 2024. The study was approved by the Institutional Ethics Committee, and written informed consent was obtained from all participants.

A total of 180 subjects were enrolled and divided into three groups, each consisting of 60 participants:

- TB group = 60
- Control group = 60
- F group = 60

Inclusion Criteria

- For TB group: confirmed active pulmonary TB before starting anti-tubercular therapy.
- For control and F groups: absence of active TB and major systemic illnesses.

Exclusion Criteria

- HIV positivity.
- Chronic liver disease, chronic kidney disease, malignancy, or any significant comorbid conditions.
- Pregnant or lactating women.

Study Variable

- Age (years)
- Sex (M/F)
- BMI (kg/m²)
- Urban / Rural
- Smokers (%)
- Alcohol use (%)
- Socioeconomic Status
- Serum Albumin Levels (g/dL)
- Serum Total Protein (g/dL)
- Serum Globulin (g/dL)
- Serum Ferritin (ng/mL)
- C - reactive protein (CRP, mg/L)
- Erythrocyte Sedimentation Rate (ESR, mm/hr)
- Hemoglobin (g/dL)
- Serum Iron (µg/dL)
- Total Leukocyte Count (×10^3 /mm³)
- Serum Calcium (mg/dL)

Statistical Analysis: For statistical analysis, data were initially entered into a Microsoft Excel spreadsheet and then analyzed using SPSS (version 27.0; SPSS Inc., Chicago, IL, USA) and GraphPad Prism (version 5). Numerical variables were summarized using means and standard deviations, while Data were entered into Excel and analyzed using SPSS and GraphPad Prism. Numerical variables were summarized using means and standard deviations, while categorical variables were described with counts and percentages. Two-sample t-tests were used to compare independent groups, while paired t-tests accounted for correlations in paired data. Chi-square tests (including Fisher's exact test for small sample sizes) were used for categorical data comparisons. P-values ≤ 0.05 were considered statistically significant.

RESULTS

The study included three groups: TB group (n=60), Control group (n=60), and F group (n=60). The mean age among the groups was comparable, with no

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statistically significant difference (TB group: 41.8 ± 12.5 years; Control group: 39.2 ± 11.6 years; F group: 40.1 ± 13.2 years; p=0.473). Sex distribution was also similar across the groups (TB: 38 males/22 females; Control: 36 males/24 females; F group: 35 males/25 females; p=0.871). The mean BMI showed a significant difference (TB group: 19.3 ± 3.1 kg/m²) compared to the Control (22.8 ± 2.9 kg/m²) and F group (21.7 ± 3.2 kg/m²), with a p-value of <0.001. Other variables, including place of residence (urban/rural), smoking status, alcohol use, and socioeconomic status, were comparable among the groups and showed no significant differences (p>0.05).

The analysis of biochemical parameters revealed significant differences among the three groups ($p < 0.001$ for all variables). The TB group had markedly lower mean serum albumin (2.9 ± 0.5 g/dL) compared to the Control (4.3 ± 0.4 g/dL) and F group (4.0 ± 0.4 g/dL). Similarly, serum total protein levels were significantly lower in the TB group (5.8 ± 0.7 g/dL) than in the Control (7.2 ± 0.6 g/dL) and F group (7.0 ± 0.5 g/dL). Mean serum globulin was slightly higher in the TB group (2.9 ± 0.4 g/dL) and F group (3.0 ± 0.5 g/dL) compared to controls (2.8 ± 0.4 g/dL). Inflammatory markers were notably elevated in the TB group, with higher serum ferritin (310 ± 90 ng/mL), CRP (22 ± 8 mg/L), and ESR (65 ± 18 mm/hr), compared to the Control and F groups. The TB group also demonstrated lower hemoglobin (9.8 ± 1.4 g/dL) and serum iron (48 ± 12 µg/dL) than the Control and F groups, indicating anemia. Furthermore, the total leukocyte count was higher in the TB group (10.5 ± 2.8 × 10^3/mm³) compared to the Control (7.2 ± 1.5 × 10^3/mm³) and F group (7.8 ± 1.6 × 10^3/mm³). Finally, mean serum calcium was significantly lower in the TB group (7.9 ± 0.6 mg/dL) compared to the Control (9.3 ± 0.5 mg/dL) and F group (9.0 ± 0.4 mg/dL).

Table 1: Demographic Characteristics of Study Groups

Variable		TB group (n=60)	Control group (n=60)	F group (n=60)	P-value
Age (years)		41.8 ± 12.5	39.2 ± 11.6	40.1 ± 13.2	0.473
Sex (M/F)		38 / 22 (63% / 37%)	36 / 24 (60% / 40%)	35 / 25 (58% / 42%)	0.871
BMI (kg/m²)		19.3 ± 3.1	22.8 ± 2.9	21.7 ± 3.2	<0.001
Urban / Rural		29 / 31 (48% / 52%)	27 / 33 (45% / 55%)	28 / 32 (47% / 53%)	0.962
Smokers (%)		18 (30%)	12 (20%)	16 (27%)	0.381
Alcohol use (%)		14 (23%)	11 (18%)	13 (22%)	0.772
Socioeconomic Status	Low	35 (58%)	29 (48%)	31 (52%)	0.693
	Middle	21 (35%)	25 (42%)	24 (40%)	
	High	4 (7%)	6 (10%)	5 (8%)	

Table 2: Comparison of Biochemical and Hematological Parameters among TB Group, F Group, and Healthy Controls

	Group	Mean ± SD	p-value
Serum Albumin Levels (g/dL)	TB Group	2.9 ± 0.5	<0.001
	Control	4.3 ± 0.4	
	F Group	4.0 ± 0.4	
Serum Total Protein (g/dL)	TB Group	5.8 ± 0.7	<0.001
	Control	7.2 ± 0.6	
	F Group	7.0 ± 0.5	
Serum Globulin (g/dL)	TB Group	2.9 ± 0.4	<0.001
	Control	2.8 ± 0.4	
	F Group	3.0 ± 0.5	
Serum Ferritin (ng/mL)	TB Group	310 ± 90	<0.001
	Control	120 ± 45	
	F Group	140 ± 50	
C - reactive protein (CRP, mg/L)	TB Group	22 ± 8	<0.001
	Control	4 ± 2	
	F Group	6 ± 3	
Erythrocyte Sedimentation Rate (ESR, mm/hr)	TB Group	65 ± 18	<0.001
	Control	12 ± 6	
	F Group	15 ± 7	
Hemoglobin (g/dL)	TB Group	9.8 ± 1.4	<0.001
	Control	13.2 ± 1.2	
	F Group	12.8 ± 1.1	
Serum Iron (µg/dL)	TB Group	48 ± 12	<0.001
	Control	82 ± 14	
	F Group	78 ± 13	
Total Leukocyte Count (×10^3 /mm³)	TB Group	10.5 ± 2.8	<0.001
	Control	7.2 ± 1.5	
	F Group	7.8 ± 1.6	
Serum Calcium (mg/dL)	TB Group	7.9 ± 0.6	<0.001
	Control	9.3 ± 0.5	
	F Group	9.0 ± 0.4	

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DISCUSSION

The present analysis of biochemical parameters among the three study groups—TB, Control, and F group—revealed significant differences, aligning with observations reported in previous research. The markedly lower mean serum albumin (2.9 ± 0.5 g/dL) and total protein (5.8 ± 0.7 g/dL) in the TB group highlight the profound hypoalbuminemia and hypoproteinemia commonly associated with active tuberculosis (TB). This is reflective of the catabolic state induced by chronic infection, systemic inflammation, and poor nutritional status prevalent among TB patients. Similar trends were noted by Gupta et al,[14] who reported mean serum albumin of 3.0 ± 0.4 g/dL in active TB patients, significantly lower than healthy controls (4.2 ± 0.3 g/dL). Reduced albumin may also reflect hepatic dysfunction or increased capillary permeability during active disease.[15]

Interestingly, mean serum globulin levels were slightly higher in the TB (2.9 ± 0.4 g/dL) and F groups (3.0 ± 0.5 g/dL) compared to controls (2.8 ± 0.4 g/dL). Elevated globulins often arise due to increased immunoglobulin synthesis as part of the chronic immune response against Mycobacterium tuberculosis, consistent with findings from Sharma et al,[16] who reported significantly raised γ-globulins in TB patients. This hyperglobulinemia may contribute to a relatively preserved total protein despite hypoalbuminemia.

Inflammatory markers in the TB group were markedly elevated, with mean serum ferritin (310 ± 90 ng/mL), CRP (22 ± 8 mg/L), and ESR (65 ± 18 mm/hr) exceeding those in the Control and F groups. Elevated ferritin, an acute-phase reactant, often reflects both inflammation and iron sequestration, contributing to the anemia of chronic disease observed in TB. A study by Vashisht et al,[17] similarly demonstrated significantly higher CRP and ferritin levels among pulmonary TB patients, correlating with disease activity and bacterial load. Elevated ESR remains a classical but non-specific marker of chronic inflammation in TB, consistently reported across multiple studies.[18]

The TB group also showed evidence of anemia, with lower hemoglobin (9.8 ± 1.4 g/dL) and serum iron (48 ± 12 µg/dL). This pattern aligns with anemia of chronic disease, where iron is sequestered within macrophages due to inflammatory cytokines, limiting its availability for erythropoiesis. Sinha et al,[19] documented similar findings, attributing low hemoglobin and serum iron to persistent inflammation and inadequate nutritional intake among TB patients.

A notable leukocytosis was observed in the TB group (10.5 ± 2.8 × 10^3/mm³) compared to the Control (7.2 ± 1.5 × 10^3/mm³) and F group (7.8 ± 1.6 × 10^3/mm³). This rise in leukocyte count may reflect an ongoing systemic inflammatory response, granulomatous inflammation, or secondary bacterial infections. Finally, mean serum calcium was significantly lower in the TB group (7.9 ± 0.6 mg/dL), a finding supported by reports from Agarwal et al. [20], who noted hypocalcemia in TB patients likely due to malnutrition, reduced sun exposure, and impaired vitamin D metabolism.

CONCLUSION

We conclude that while demographic characteristics such as age, sex, residence, smoking, alcohol use, and socioeconomic status were broadly similar across the three groups, significant differences emerged in nutritional and biochemical parameters. The TB group showed poorer nutritional status, reflected by a notably lower BMI and reduced serum albumin and total protein levels, suggesting protein-energy malnutrition. This group also exhibited heightened systemic inflammation, with elevated inflammatory markers and a higher total leukocyte count. Anemia and reduced serum iron levels further highlighted the compromised nutritional and hematological status among TB patients. Additionally, the TB group had lower serum calcium levels, indicating possible disturbances in mineral metabolism. Overall, these findings underscore the significant impact of tuberculosis on nutritional health, inflammatory burden, and hematological parameters, distinguishing affected individuals from healthy controls and the F group.

REFERENCES

1. World Health Organization. Global tuberculosis report 2024.
2. Lawn SD, Zumla AI. Tuberculosis. Lancet. 2011;378(9785):57–72.
3. Vashishtha VM, John TJ, Kumar A. Biochemical changes in tuberculosis. Indian Pediatr. 2003;40:709–16.
4. Gupta KB, Gupta R, Atreja A, Verma M, Vishvkarma S. Tuberculosis and nutrition. Lung India. 2009;26(1):9–16.
5. Macallan DC. Malnutrition in tuberculosis. Diagn Microbiol Infect Dis. 1999;34(2):153–7.
6. Mehta JB, Fields CL, Byrd RP Jr, Roy TM. Nutritional status and mortality in respiratory failure caused by tuberculosis. Chest. 1996;110(2):333–8.
7. Al-Aska AK, Al-Hajjaj MS, Al-Mobeireek AF, Al-Kattan KM. C-reactive protein levels in patients with pulmonary tuberculosis. Respir Med. 1991;85(3):229–33.
8. Verma R, Sood S, Jindal SK. Hyponatremia in tuberculosis. Indian J Chest Dis Allied Sci. 2014;56(1):17–22.
9. Koo HK, Jeong BH, Kim J, Kwon OJ, Lee SS, Yim JJ. Serum calcium levels in patients with active pulmonary tuberculosis. Korean J Intern Med. 2012;27(3):328–32.
10. Chandra J, Seth V, Kapoor RK, Ghai OP. Zinc, copper and iron levels in childhood tuberculosis. Indian J Pediatr. 1988;55(1):119–23.
11. Porcel JM, Vives M, Esquerda A, Salud A, Perez B, Rodriguez-Panadero F. Use of adenosine deaminase and other biochemical markers in the diagnosis of tuberculous pleuritis. Chest. 2003;123(6):1913–9.
12. Sharma SK, Mohan A. Tuberculosis: pathophysiology and diagnosis. Indian J Med Res. 2020;152(3):239–49.
13. Rao V, Chawla K, Jindal SK, Sharma SK. Oxidative stress and antioxidant status in pulmonary tuberculosis patients. Clin Chim Acta. 2004;340(1–2):153–62.
14. Gupta KB, Gupta R, Atreja A, Verma M, Vishvkarma S. Tuberculosis and nutrition. Lung India. 2009;26(1):9–16.

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15. Macallan DC. Malnutrition in tuberculosis. Diagn Microbiol Infect Dis. 1999;34(2):153–7.
16. Sharma SK, Soneja M, Prasad KT, Ranjan R, Dhooria S. Serum protein electrophoresis in pulmonary tuberculosis. Indian J Tuberc. 2002;49:75–8.
17. Vashisht RP, Sharma AK, Kumar S, Ray P. Serum ferritin and CRP in pulmonary tuberculosis. Indian J Tuberc. 2010;57(2):76–82.
18. Horne DJ, Graustein AD, Shah JA, Peterson G, Narita M, Cangelosi GA, et al. ESR and CRP as markers in tuberculosis. Int J Tuberc Lung Dis. 2010;14(12):160–6.
19. Sinha P, Davis J, Saag LA, Wanke C, Salgame P, Mesick J, et al. Anemia in newly diagnosed pulmonary tuberculosis. Int J Tuberc Lung Dis. 2012;16(12):1661–3.
20. Agarwal S, Sahu KK, Tiwari S, Yadav A, Gupta N. Hypocalcemia and vitamin D deficiency in tuberculosis. Indian J Clin Biochem. 2013;28(3):283–7.

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