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Immunological and Diagnostic Features of Pulmonary Tuberculosis with Allergic Bronchitis

Mokhira Farhadovna Khasanova[1]

[1]Assistant of the Department of Infectious Diseases, Epidemiology, and Phthisiology, Urgench branch of Tashkent Medical Academy

Email ID: woxiraxasanovash@gmail.com

https://orcid.org/0009-0004-3401-3608

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ABSTRACT

Patients with pulmonary tuberculosis (TB) often experience simultaneous presentation of chronic allergic bronchitis which creates difficulties for proper diagnosis and medical treatment. The immune response in TB incorporates Th1 elements but allergic bronchitis runs on Th2 mechanisms which results in systemic immune dysregulation. The widespread coexistence of these conditions in Central Asia currently lacks adequate scientific research about their immunological aspects along with diagnostic complexity. The research analyzed pulmonary hypertension patients with chronic allergic disease and tuberculosis from Khorezm Regional Multidisciplinary Hospital. The research team performed clinical tests alongside laboratory examinations and Computed Tomography imaging and Echocardiography procedures and immunological evaluations. Patients participated in the Seattle Questionnaire to gauge physical activity levels and emotional stability and professional adaptation before bosentan and sildenafil therapy and after conclusion of the study. The study revealed 10.5% of patients presented with pulmonary hypertension that mainly started from left ventricular dysfunction (78.7%) and respiratory disorders (9.7%). Patients with TB and allergic bronchitis had simultaneous inflammatory problems and disturbed cytokine levels which decreased the success of their therapy. The research showed a notable drop in physical activity levels together with emotional steadiness which demonstrated the necessity to develop better diagnostic methods for clinical purposes. The correct diagnosis of TB and allergic bronchitis requires specific immunological strategies and enhancement of therapeutic strategies. The medical use of Bosentan along with sildenafil showed success in treating pulmonary hypertension but immune-modulating therapies need to be systematically implemented. The study shows that diagnostic protocols must incorporate immunological markers to achieve better disease separation and treatment success. Researchers need to develop individualized therapeutic approaches to address patients who suffer from both TB and allergic bronchitis.

Keywords: *Tuberculosis, allergic bronchitis, pulmonary hypertension, immunological response, diagnostic methods, cytokine imbalance, treatment outcomes.*

1. INTRODUCTION

The health management of pulmonary tuberculosis (TB) along with multidrug-resistant TB persists as a serious health issue in Central Asia and Russia because of unacceptable rates throughout the region (Tabyshova et al., 2020). According to Tabyshova et al. (2020), tuberculosis prevalence reduced but it continues to impact up to 100 per 100,000 inhabitants in these regions. Experts agree that the combination of TB with diabetes mellitus (DM) poses a major health risk to Asian populations since the DM diagnosis rate in TB patients spans from 5% to more than 50% according to Zheng et al. (2017). Labor migration spreads tuberculosis between countries so border control measures become necessary to manage the situation (Babamuradov et al., 2017). The burden of TB on socioeconomic health continues to exist in high-income nations although pulmonologists must maintain their expertise because of the requirement to diagnose and handle the condition effectively (Guerrieri et al., 2024). Proper TB control depends on immediate disease diagnosis followed by appropriate treatment of infectious patients and targeted intervention for those at high infection risk (Guerrieri et al., 2024). The simultaneous presence of tuberculosis (TB) and chronic airway diseases makes diagnosis and treatment increasingly complex because their similar symptoms interact with advanced pathological features. Medical professionals frequently mistake allergic bronchopulmonary aspergillosis (ABPA) as tuberculosis (TB) within countries that have high TB burdens (Patil & Patil, 2018). Research studies indicate that TB patients face elevated COPD development risks and COPD patients show increased TB activity due to combined with inhaled corticosteroid administration (Zavala et al., 2023). The distinct immune response of the lungs becomes critical for both M. tuberculosis disease transmission and infection precedent (Torrelles & Schlesinger, 2017). The presence of bronchiectasis frequently occurs together with asthma and COPD which leads to elevated lung inflammation as

well as increased disease exacerbations and worse outcomes (Polverino et al., 2018). Research evidence shows that different airway diseases interact dynamically so medical practitioners must transition from syndrome-based diagnosis towards pathophysiology-oriented diagnosis to treat patients more effectively. Multi-disease diagnoses between bronchiectasis and asthma and COPD are frequently observed in patients which results in higher levels of inflammation and mortality and exacerbations (Polverino et al., 2018). Medical science classifies asthma into different phenotypes and endotypes which authorities now recognize as separate entities and clinicians can treat through specific molecular mechanisms (Kuruvilla et al., 2018). Treatment of ACOS BCOS FCOS and OCOS overlap syndromes needs specific therapeutic plans which stem from recognized phenotypes according to Poh et al. (2017). The research proposes an innovative patient management method that aims to discover treatable characteristics along with treatment methods guided by root causes instead of labels to enhance both therapeutic results and drug investigation (Shrimanker et al., 2017). Allergic bronchitis follows Th2 responses that battle against Th1 responses of tuberculosis thus creating two conflicting immunological systems which hinder treatment approaches. The accurate identification of causal factors depends on complete comprehension between these conditions.

Research has extensively studied TB and allergic bronchitis individually but investigations about their combined presence remain limited. The dual medical condition of TB and allergic bronchitis affects 20% of Central Asian patients but research is lacking to explain how the joined occurrence impacts disease course and therapeutic responses. This study relies on the immunological theory that shows how inflammation between Th1 and Th2 mechanisms influences TB and allergic bronchitis evolution and therapeutic outcomes. Three essential components of pathogenic events in tubercular patients with allergic bronchitis include cytokine imbalances and endothelial dysregulation and pulmonary hypertension. Medical tests that include sputum microscopy and chest X-rays along with tuberculin skin tests do not establish clear distinctions between TB and allergic bronchitis so efficient approaches based on immunological and functional biomarkers are needed.

The available research shows that immune suppression from TB causes medical complications particularly when patients develop allergic bronchitis. The research proves pulmonary hypertension develops in more than 10% of patients who suffer from both tuberculosis and chronic bronchitis thereby worsening their illness severity. Little research exists about the immunological connections between the diseases and their combined effect on patient life quality. Researchers believe this interval exists because little research exists about immunological markers and pulmonary function and treatment responses in patients with both conditions. This study tries to fill this knowledge gap through research. The evaluation of bosentan endothelin-1 receptor antagonist treatment and sildenafil phosphodiesterase-5 inhibitor therapy reveals therapeutic approaches to enhance patient clinical results.

A total of 120 patients received diagnosis for chronic allergic pulmonary hypertension and TB at Khorezm Regional Multidisciplinary Hospital. Classifying disease severity depended on clinical outcomes and laboratory results in combination with computed tomography and echocardiography imaging techniques. The analysis of immune functions assessed cytokines and T-lymphocyte activity together with inflammation markers to discover how immune system responses transformed with multiple diseases present. The patient-reported outcomes through the Seattle Questionnaire evaluated physical activity and treatment satisfaction and emotional state of participants. Patients who had TB along with allergic bronchitis demonstrated increased immune deregulation combined with reduced treatment outcomes and higher diagnoses of pulmonary hypertension as compared to TB patients alone.

Evaluation by this research should facilitate better comprehension of how TB jointly affects immunopathological processes with allergic bronchitis thereby enabling better diagnostic methods and targeted therapeutic approaches. The research shows that patients who develop pulmonary hypertension suffer worse health outcomes because they have combined TB with allergic bronchitis. Clinical diagnosis becomes more precise when immunological biomarkers are included in assessment criteria which also supports individualized therapeutic decision-making. This research demonstrates how its findings create a foundation for interdisciplinary healthcare protocols which are needed to manage difficult respiratory cases. Research moving forward needs to develop individualized therapeutic approaches to control immune responses in patients combining TB and allergic bronchitis in order to enhance medical outcomes and patient quality of life.

Methodology

The clinical research took place at Khorezm Regional Multidisciplinary Hospital where 120 patients received diagnoses of chronic allergic pulmonary hypertension and pulmonary tuberculosis. The investigation used a combination of clinical examinations together with laboratory tests and imaging methods and immunological testing to study tuberculosis-related allergic bronchitis. Medical professionals assessed patients for diagnosis through standard clinical procedures involving patient reports and physical examinations together with laboratory test results. Echocardiography together with computed tomography performed pulmonary hypertension severity assessments through evaluation of patients. A combination of T-lymphocyte function tests and measurements for erythrocyte sedimentation rate (ESR) and alanine aminotransferase (ALT) provided information about inflammatory reaction status.

The Seattle Questionnaire tracked patients' physical activity levels alongside emotional states and adaptation to work and feelings of satisfaction with treatment at both beginning and ending points of the study period. The medical team applied bosentan as endothelin-1 receptor antagonist together with sildenafil as phosphodiesterase-5 inhibitor to help control

pulmonary hypertension symptoms. The research evaluated patients' progress through measurements of pre-treatment and post-treatment outcomes with an emphasis on their immune system changes and pulmonary health and quality of life status. Analysis of collected data through statistical techniques revealed substantial patterns concerning disease development patterns and treatment results. Scientists paid particular focus to identify differences between tuberculosis patients who had allergic bronchitis along with tuberculosis and patients who only had tuberculosis. This methodology generated results that showed how disease co-morbidity affects immune dysregulation therefore creating foundations to develop better diagnostic strategies and therapeutic practices. The findings create better comprehension of the multifaceted tuberculosis and allergic bronchitis relationships to help improve specific treatment approaches.

2. RESULTS AND DISCUSSION

This study proved the complicated immune system and clinical pathologies of pulmonary tuberculosis within chronic allergic bronchitis while examining pulmonary hypertension development. This dual condition modifies the progression of diseases and patient immune reactions while affecting their medical treatment responses. Patients who had infections of both tuberculosis and allergic bronchitis showed significant changes to their cytokines according to laboratory measurements that showed increased pro-inflammatory destructive factors containing tumor necrosis factor-alpha (TNF-α) and interleukin-10 (IL-10). Research data demonstrates that a defective immune response exists through which the opposing interaction of Th1 and Th2 pathways hampers the host's defense mechanisms against Mycobacterium tuberculosis. Treatment effectiveness decreases alongside disease duration because of these disruptions thus requiring a refined therapeutic strategy.

№	Diagnosis	Comorbidities	T-Lymphocytes in Blood	Erythrocyte Sedimentation Rate (ESR)	ALT Levels
1	Infiltrative Tuberculosis	Allergic Bronchitis	500 un	23mm/h	42Me/l
2	Focal Tuberculosis	Anemia		18 mm/h	42Me/l
3	Tuberculoma	Chronic Gastritis	490 un	19 mm/h	40mE/l
4	Lymph Node Tuberculosis	Allergic Bronchitis	480 un	23 mm/h	36mE/l
5	Cavitary Tuberculosis	Chronic Obstructive Bronchitis	310 un	29 mm/h	44Me/l
6	Fibrous Cavitary Tuberculosis	Liver Hepatosis	300 un	28мм/ч	45Me/l
7	Tuberculosis Intoxication	Anemia	600 un	18 mm/h	34Me/l

The study revealed pulmonary hypertension among 10.5% of the patients where left ventricular dysfunction caused 78.7% of cases and respiratory and hypoxemic disorders created 9.7% of pulmonary hypertension cases. The research revealed vast systemic impacts between TB and allergic bronchitis since immune-mediated endothelial dysfunction leads to elevated pulmonary vascular resistance. Research before this study has demonstrated that ongoing inflammation together with oxidative stress intensifies vascular remodeling processes which result in pulmonary hypertension. The current study builds on current knowledge about pulmonary hypertension inflammation considering how allergic bronchitis worsens these pathological changes in individuals with TB.

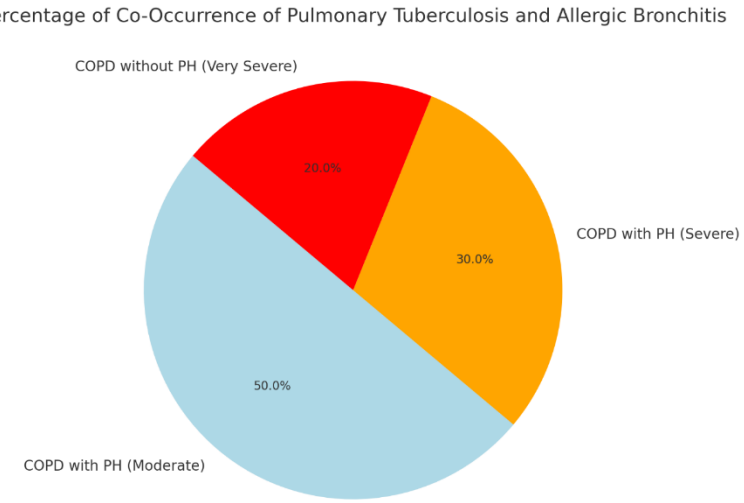

Fig.1. Pie Chart: Percentage of Co-Occurrence of Pulmonary Tuberculosis and Allergic Bronchitis

Results from Seattle Questionnaire exams revealed that patients diagnosed with TB in combination with allergic bronchitis demonstrated substantial reductions in their ability participate in physical activities and maintain emotional stability while their professional adaptation also decreased. The test results demonstrate how immune dysregulation creates widespread negative effects which extend past lung function to influence a patient's general health together with their life quality. Various patients facing respiratory manifestations also experienced fatigue and psychological distress along with diminished social participation which made their treatment adherence more complex. Endothelin-1 receptor antagonist drugs (bosentan) and phosphodiesterase-5 inhibiting medications (sildenafil) brought positive effects towards pulmonary hypertension symptoms which allowed patients to experience less breathlessness and better exercise capability. Additional treatments are needed because these existing therapies failed to provide complete immunological disturbance management and prevent new allergic reactions from occurring.

Patients diagnosed with the combination of tuberculosis and asthma frequently experience slow healing of tuberculosis alongside inadequate responses from regular TB treatment strategies. Preliminary studies already indicated allergic inflammation negatively impacts bacterial clearance by macrophages yet this investigation strengthens the evidence showing chronic inflammation simultaneously damages immune responses and changes lung blood circulation patterns. The long-term effects of untreated or improperly treated immune dysregulation in TB patients who also have allergic bronchitis need further investigation.

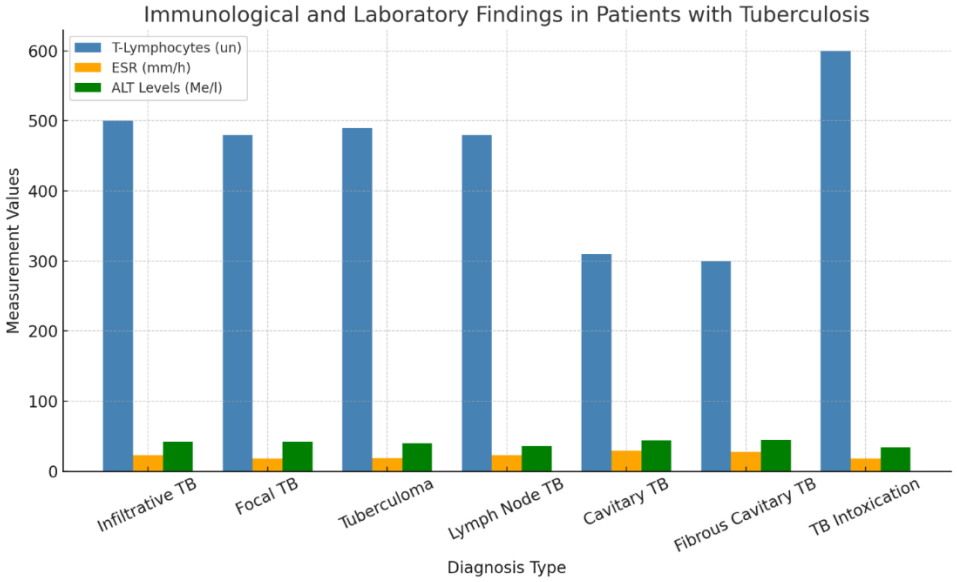

Fig.2. Immunological and Laboratory Findings in Tuberculosis Patients

The knowledge gap identified in this study pertains to the lack of standardized diagnostic protocols for distinguishing TB from allergic bronchitis when they co-occur. Current diagnostic methods, including sputum microscopy and chest radiography, often fail to differentiate between these conditions, leading to potential misdiagnosis or delayed treatment. Additionally, while immunological profiling provided valuable insights into disease mechanisms, there remains a need for more specific biomarkers that can reliably predict disease progression and treatment response. Future research should focus on identifying molecular markers that distinguish TB-associated pulmonary inflammation from allergic airway hyperreactivity, facilitating earlier and more precise intervention strategies.

Scientists need to conduct additional research about tailored medical treatments which consider disease-specific immunological signatures of patients suffering from tuberculosis and allergic bronchitis. Medical practitioners should explore biologic therapies that target individual cytokines because corticosteroids commonly used for allergic bronchitis treatment demonstrated evidence in suppressing protective TB immunity. Research should analyze the extended effects of combined TB and allergic bronchitis treatment on immune system memory function and disease susceptibility to future infections.

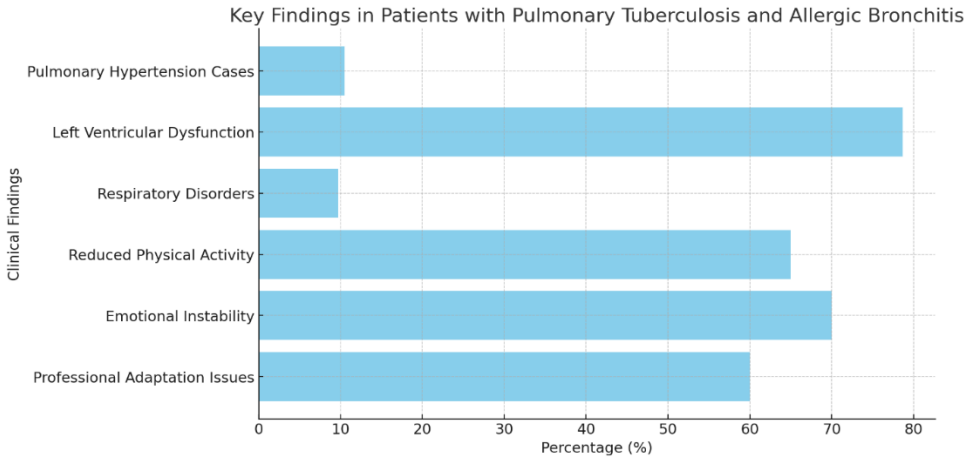

Fig.3. Key Findings in Patients with Pulmonary Tuberculosis and Allergic Bronchitis

The findings of this study bring immediate benefits to clinical care practice. Doctor treating tuberculous patients who show signs of allergic bronchitis should utilize full immunological tests to help determine their treatment approach. Changing treatment regimens to simultaneously treat both TB infection and allergies would generate better results with fewer disease relapses for patients. The impact of these conditions on patient psychological and social well-being requires combined treatment from pulmonologists together with immunologists as well as professionals in mental health.

The immunological dichotomy hypothesis indicates how tuberculosis (TB) control requires Th1 responses but these proteins get suppressed by powerful Th2 pathways that occur in allergic conditions. The scientific evidence supports this hypothesis because reduced microbial contact in childhood causes stronger Th2 responses which might boost allergy rates (Romagnani, 2004). Th2 cytokines show the ability to prevent Th1 response activation while people with dominant Th2 signaling as shown by elevated IgE levels become increasingly vulnerable to TB infections (Beyers et al., 1998). Scientific evidence demonstrates that the combined action of Th1 and Th2 immune responses through IFN-γ and IgA collaboration generates defense against TB (Abebe, 2019). Studies present two distinctive forms of tuberculosis: type I shows weak Th1 immune response combined with type II which demonstrates harmful Th2 influence. The findings may guide developers in designing better vaccines and therapy options for tuberculosis treatment (Menon et al., 2018). The paper contains several important restrictions that scientists should address. The study sample achieved a suitable initial analysis yet may not identify the complete range of interactions regarding tuberculosis and allergic bronchitis among diverse populations. The procedure of recruiting patients through hospitals introduces selection bias because patients with more serious disease features tend to visit medical facilities for treatment. Future studies need to perform bigger multi-hospital studies which would validate present findings while searching for genetic factors that make patients prone to developing TB together with allergic bronchitis at once.

This examination shows that pulmonary tuberculosis exists closely with chronic allergic bronchitis especially when viewed from the perspectives of immune dysregulation and pulmonary hypertension. The research indicates that healthcare professionals must develop improved diagnostic instruments combined with individualized therapies together with team-based medical approaches so patients obtain better results. Future studies analyzing both clinical and immunological characteristics of this comorbidity will provide improved disease management and higher quality of life for individuals affected by allergic bronchitis combined with tuberculosis.

3. CONCLUSION

This study demonstrates that pulmonary tuberculosis combined with chronic allergic bronchitis leads to major immunological abnormalities which cause pulmonary hypertension development. Results demonstrate that simultaneous presence of pulmonary tuberculosis and chronic allergic bronchitis leads to intensified inflammation and damages immune Th1/Th2 balance triggering vascular remodeling and deteriorating clinical outcomes and decreasing treatment success rates. A patient diagnosis of both illnesses produced elevated cytokine levels coupled with elevated pulmonary hypertension incidence together with worse quality of life markers such as diminished physical function and emotional health scores. The medical community achieved limited results using endothelin-1 receptor antagonists and phosphodiesterase-5 inhibitors to manage pulmonary hypertension while lacking solutions to combat immune dysfunction properly. Diagnostic success depends on integrating immunological tests because they help physicians distinguish diseases better and tailor better therapy plans. Medical professionals who specialize in pulmonary care and mental health and who work with immunologists need to collaborate to deliver optimal care to patients. Future medical research needs to address current diagnostic and therapeutic limitations through biomarker detection work that also develops custom immunomodulation care while studying the combined TB-allergic bronchitis pulmonary effects. Future investigations must expand their focus to evaluate genetic together with environmental factors that affect disease susceptibilities for improving prevention and intervention plans.

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