

# Prevalence and Pathological Patterns of Pulmonary Tuberculosis in Cadavers: A Cross-sectional Study

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## ABSTRACT

**Introduction:** Tuberculosis (TB) is a major cause of morbidity and mortality globally. Despite being a TB-endemic country, many pulmonary TB cases remain clinically undiagnosed and are detected on postmortem examination. Cadaveric lung histopathology helps reveal this hidden disease burden and characteristic TB patterns that are often missed during life, supporting improved diagnostic awareness, infection control, and public health surveillance.

**Aim:** To examine the histology of normal lung and TB infected cadaveric lungs.

**Materials and Methods:** This cross-sectional study was conducted in the Research Laboratory of the Department of Anatomy, Uttar Pradesh University of Medical Sciences Saifai, Uttar Pradesh, India, from December 2024 to June 2025. A

total of 30 lungs from 15 adult cadavers were included in this study. Demographic and background data of each cadaver-including age, sex, cause of death were collected. It assessed gross and histopathological features of cadaveric lungs using Haematoxylin and Eosin (H&E) and Ziehl-Neelsen staining.

**Results:** Out of 30 cadaveric lungs, three exhibited features of TB, including prominent scarring, cavitation, with mild pneumonic consolidation mainly seen in the right lung apical region. Histological analysis showed necrotising granulomatous inflammation, composed of epithelioid histiocytes, accompanied by number of multinucleated Langhans giant cells and lymphocytic aggregation.

**Conclusion:** This study demonstrated that pulmonary TB can remain clinically undiagnosed and is detectable only through cadaveric lung histopathology.

**Keywords:** Caseating granuloma, Histology staining, Lung fibrosis, Multinucleated giant cell

## INTRODUCTION

The TB is one of the most crucial health problems in India. India remains one of the highest TB burden countries in the world, accounting for one-fifth of the entire global TB incidence with approximately 1.97 million cases annually [1]. The prevalence of TB is common in poor socio-economic parts of the country, and cases may not be diagnosed until an autopsy or cadaver dissection is performed [2-5]. Various complications of pulmonary TB contributing to morbidity and mortality of patients include haemoptysis, post-tubercular bronchiectasis, aspergilloma, tubercular bronchitis and tracheitis, spontaneous pneumothorax, scar carcinoma, disseminated calcification in the lung, pulmonary function changes, obstructive airway disease, and secondary pyogenic infections [6]. The hallmark of TB is necrotising granulomatous inflammation, composed of epithelioid histiocytes surrounding a central necrotic zone it is accompanied by a number of multinucleated giant cells and lymphocytes, non necrotising granulomas can also be present [7]. The main function of epithelioid histiocytes is to contain the infection to a localised area, hence avoiding the spread of bacterial infection to surrounding healthy tissues and other organs, also to increase the concentration of the immune response to the infectious area [8].

The present study was undertaken to evaluate the histopathological spectrum of pulmonary TB in cadaveric lung specimens.

## MATERIALS AND METHODS

This cross-sectional study was conducted in the Research Laboratory of the Department of Anatomy, Uttar Pradesh University of Medical Sciences Saifai, Uttar Pradesh, India, from December 2024 to June 2025. Approval from the Head of the Department and ethical clearance from the Institutional Ethics Committee (IEC No. 165/2024-25) was obtained.

**Inclusion criteria:** Lungs of adult cadavers above 18 years of age of both sexes, lungs with intact tissue architecture suitable for gross and histological examination, cadavers embalmed within the past five years to ensure adequate tissue preservation for microscopic evaluation were included in the study.

**Exclusion criteria:** Lungs showing extensive decomposition that rendered them unsuitable for histological processing and analysis, cadavers with known history of lung disorders (e.g., chronic obstructive pulmonary disease, lung carcinoma, pneumonia) based on available medical or departmental records were excluded from the study.

**Sampling method:** A total of 30 lungs from 15 adult cadavers were included in this study. The sample size was based on the census sampling method, wherein all cadavers that met the inclusion and exclusion criteria during the six-month study period were enrolled.

**Data collection:** Demographic and background data of each cadaver- including age, sex, cause of death, and embalming details- were collected and thoroughly verified using the department's archival records [Table/Fig-1].

**Dissection steps:** An incision was made on the thoracic region of the cadaver. The skin, fascia, and pectoral muscles were removed, and the serratus anterior was dissected laterally. Intercostal muscles were excised, and the ribs were cut from the mid-axillary line to 1 cm medial to the sternum using a bone cutter. The endothoracic fascia, sternopericardial ligaments, and pleura were removed. Both lungs, found with severe adhesions to the pleural cavity and heart borders, were pulled laterally from the mediastinum. The hilar structures were dissected sequentially to free the lungs, which were then preserved in formalin [9].

**Histology steps:** Lung tissue samples were taken from the apex, mediastinal surface, and base of both lungs and fixed in 10%

Variable	Explanation	Data
Age (years)	Recorded to confirm inclusion of adult cadavers (>18 years) and to describe age distribution of the sample	Adult ages (e.g., 55, 60, 67 years) as all cadavers are >18 years
Sex	Documented to describe sex distribution and ensure inclusion of both sexes	9 males, 6 females
Cause of death	Obtained from records to exclude known pulmonary diseases and avoid diagnostic bias	Road traffic accident (6), Cardiac arrest (5), Cerebrovascular accident (4)
Embalming duration	Verified to ensure tissue suitability for histopathological examination ( $\leq 5$ years)	Range: 8 months-4.5 years

**[Table/Fig-1]:** Baseline characteristics and study variables of cadaveric lung specimens.

formalin for 12 hours. The tissues were dehydrated through graded alcohols, cleared in xylene-alcohol mixtures followed by absolute xylene, and embedded in paraffin wax at 60°C. Paraffin blocks were trimmed and sectioned at 6  $\mu$ m using a rotary microtome, and the sections were mounted on albumin-coated slides. The slides were then stained with H&E using standard histological procedures to assess general tissue architecture and pathological changes [10].

**Special stain:** Ziehl-Neelsen Stain: The slides were placed on a staining rack, and 1% carbolfuchsin (the primary stain) was poured over them. The slides were gently heated until vapours appeared, but boiling was avoided. The slides were left to stand for five minutes and then gently rinsed with tap water. Next, 25% sulfuric acid (the decolourising solution) was poured over the slides. The slides were left to stand for 2-4 minutes and then rinsed with tap water. Excess water was drained by tilting the slides. The slides were then counterstained with 0.1% methylene blue. They were left to stand for 30 seconds and then gently rinsed with tap water. Excess water was drained by tilting the slides, and finally, the slides were placed on a rack to air-dry [10]. After preparing the histology slide, with the help of the pathology department, TB-infected lungs were identified and were able to differentiate between normal and TB lungs [Table/Fig-2].

Parameter	Normal lungs	Tuberculosis (TB) -affected lungs
Gross appearance	Pink, spongy, well-aerated lung tissue	Gray-white to firm lungs with distorted architecture
Lobar distribution	Uniform involvement	Predominantly apical involvement, especially upper lobes
Pleural surface	Smooth pleura, no adhesions	Pleural thickening and dense adhesions
Fibrosis/scarring	Absent	Present with fibrotic bands and puckering
Cavitation	Absent	Present due to caseous necrosis
Miliary nodules	Absent	Multiple small nodules are present
Alveolar architecture (H&E)	Intact alveoli with thin septa	Destroyed alveoli with necrosis
Granuloma formation	Absent	Necrotising (caseating) granulomas present
Epithelioid histiocytes	Absent or sparse	Abundant epithelioid cell aggregates
Langhans giant cells	Absent	Present with peripheral horseshoe-shaped nuclei
Lymphocytic aggregation	Scattered lymphocytes only	Dense perigranulomatous lymphocytic cuffing
Alveolar necrosis	Absent	Present in active TB lesions
Ziehl-Neelsen stain	Negative	Granulomatous areas $\pm$ acid-fast bacilli
Overall interpretation	Normal lung morphology	Diagnostic of pulmonary Tuberculosis (TB)

**[Table/Fig-2]:** Gross and histopathological comparison between normal and Tuberculosis-(TB) affected lung tissues.

## STATISTICAL ANALYSIS

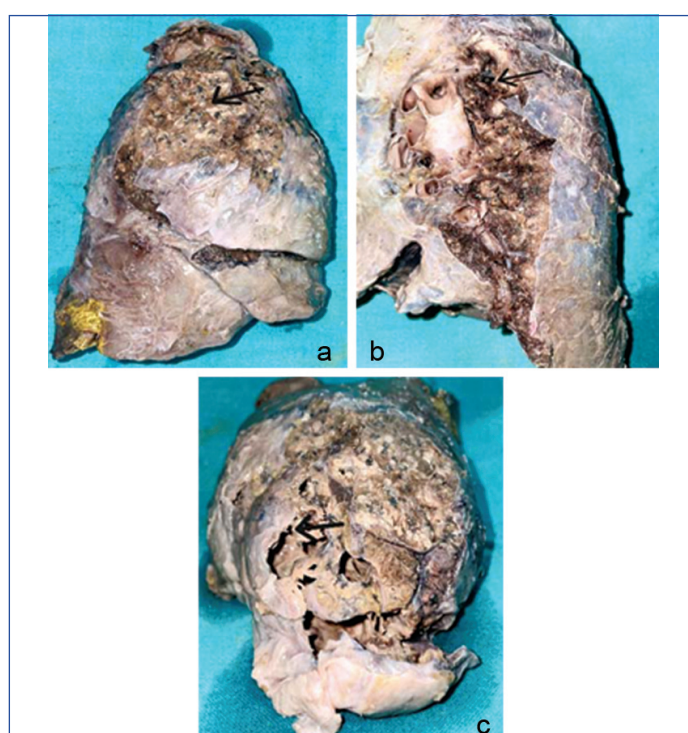
Statistical analysis and p-value determination were done using Statistical Package for the Social Sciences (SPSS) Statistics for Windows, version 27.0 (IBM Corp., Armonk, NY, USA). Chi-square test was used for analysis. When expected cell counts were <5, Fisher's exact test was applied. A p-value <0.05 was considered statistically significant.

## RESULTS

Gross changes seen were miliary nodules in only TB infected lungs [Table/Fig-3,4].

Gross finding	TB lungs (n=3)	Non TB lungs (n=27)	P-value
Miliary nodules	3 (100%)	0	<0.001
Pleural thickening	3 (100%)	1 (3.7%)	<0.001
Fibrosis and scarring	3 (100%)	2 (7.4%)	<0.001
Cavitation	2 (66.7%)	0	0.002
Apical region involvement	3 (100%)	2 (7.4%)	<0.001

**[Table/Fig-3]:** Gross pathological changes in cadaveric lungs.

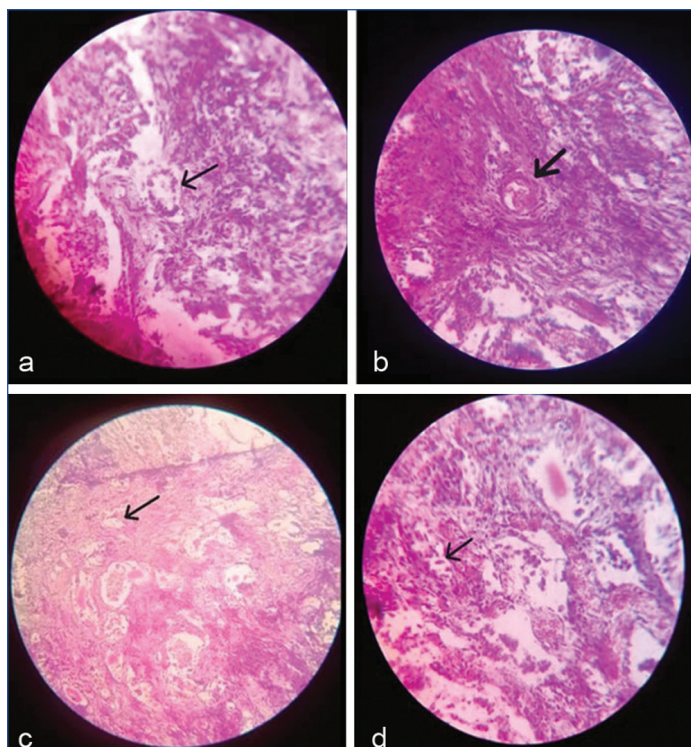


**[Table/Fig-4]:** Gross appearance of Tuberculosis (TB) affected lungs a) Miliary nodules in apex of right lung; b) Fibrosis and scarring in the right lung; c) Cavitation seen in the right lung.

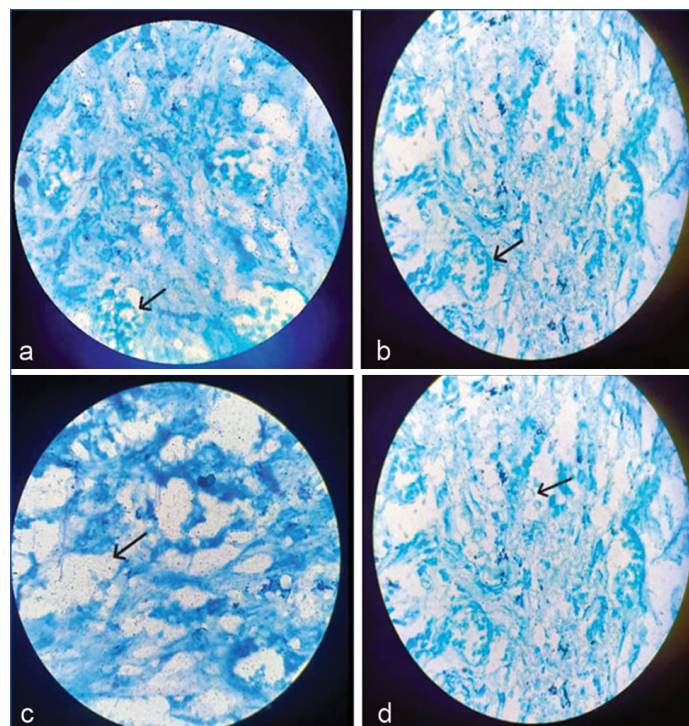
Histopathological examination revealed distinct microscopic features that reliably differentiated TB lungs from non TB lungs. Necrotising granulomatous inflammation was present in all TB lungs (100%) and absent in non TB lungs (p-value <0.001), representing the hallmark histopathological feature of TB. Epithelioid histiocytes were identified reflecting a characteristic granulomatous immune response. Alveolar necrosis was seen signifying active tissue destruction in TB. Mild lymphocytic aggregation observed in some non TB lungs may represent non specific inflammatory response or postmortem reactive changes rather than true granulomatous pathology [Table/Fig-5,6].

Histological finding	TB lungs (n=3)	Non TB lungs (n=27)	p-value
Necrotising granulomatous inflammation	3 (100%)	0	<0.001
Epithelioid histiocytes	3 (100%)	1 (3.7%)	<0.001
Langhans giant cells	3 (100%)	2 (7.4%)	<0.001
Lymphocytic aggregation	3 (100%)	3 (11.1%)	<0.001
Alveolar necrosis	2 (66.7%)	0	0.002

**[Table/Fig-5]:** Histopathological features in cadaveric lungs.



**[Table/Fig-6]:** Histological examination of Tuberculosis (TB) affected lungs; a) Langhans giant cell (Horseshoe shaped) (H&E,40x); b) Granulomatous inflammation (H&E,40x); c) Necrosis of alveoli (H&E,40x); d) Epithelioid histiocytes (Slipper shaped) (H&E,40x).



**[Table/Fig-7]:** Histological examination of Tuberculosis (TB) affected lungs showing; a) Langhans giant cell (Horseshoe shaped) (Z&N, 40x); b) Granulomatous inflammation (Z&N, 40x); c) Necrosis of alveoli (Z&N, 40x); d) Epithelioid histiocytes (Slipper shaped) (Z&N, 40x).

Name of author	Publication year	Specimen used	Gross findings	Microscopic findings	Sample size	Sex (if known)	Age groups
Tajiri T et al., [11]	2011	Multiorgan autopsy including lungs	Multiple millet-seed-like nodules (miliary pattern)	Granulomas with Langhans giant cells ± caseous necrosis	7 cases	1 male, 6 females	41-86 years
Bavikar R et al., [12]	2015	Autopsy (lungs + other organs)	Disseminated pulmonary and extrapulmonary involvement	Caseating granulomas; disseminated TB common; frequent HIV association	112 cases	M 63%, F 37%	Median 32 years
Gupta M et al., [13]	2016	Lung autopsy and surgically resected specimens	Caseation, consolidation, miliary nodules, cavities	Necrotising granulomas (82.5%); AFB positive in 57.5%	40 cases	Male predominance (92.5%)	Mean 41 years (20-75 years)
Selvambigai G et al., [14]	2016	Autopsy lung specimens	Consolidation, congestion, emphysema	Pneumonia most common; granulomatous lesions occasional	100 cases	Male predominance	11 to > 60 years
Kaur B et al., [15]	2017	Postmortem lung specimens	Congestion, pulmonary oedema, focal consolidation	Granulomatous inflammation with or without caseation; Langhans giant cells	100 cases	M: F ≈ 3:1	Mean 41.3±14.57 years
Al-Harbi A et al., [16]	2017	Lung biopsy and resection specimens (non autopsy)	Not emphasised	Necrotising (58%) and non necrotising granulomas (42%); TB commonest etiology	158 cases	Male (50%)	Mean age of 47±19 years;
Kaur M et al., [17]	2019	Medico-legal autopsy lung specimens	Not specifically described	Granulomatous inflammation; AFB-positive TB (6.1%); miliary TB (3.2%)	213 cases	M: F ≈ 2.5:1	Mean 34±4.2 years
Dhruv D et al., [18]	2020	Autopsy lung specimens	Congestion, pulmonary oedema, patchy discoloration	Granulomas with Langhans giant cells in TB cases	474 cases	M 73%, F 27%	9->60 years
Present study	2026	Cadaver lungs (dissection hall)	Apical involvement, cavitation, fibrosis, pleural thickening	Necrotising granulomas, epithelioid histiocytes, Langhans giant cells	30 lungs	Both	>18 years

**[Table/Fig-8]:** Comparison of gross and histopathological findings of pulmonary Tuberculosis (TB) in previous studies and the present study [11-18].

HIV:Human immunodeficiency virus;AFB:Acid fast bacillus

The Ziehl-Neelsen stain showed a Langhans giant cell with a distinct horseshoe-shaped arrangement of nuclei, indicative of granulomatous inflammation typical in TB. Epithelioid histiocytes with slipper-shaped nuclei, which are transformed macrophages central to the granulomatous immune response was also seen in TB [Table/Fig-7].

## DISCUSSION

This study reinforces the significance of thorough histopathological screening in cadaveric lung specimens as a valuable tool for identifying undiagnosed TB cases. The findings of the present study

are consistent with several autopsy-based investigations that have documented the characteristic gross and microscopic features of pulmonary TB [Table/Fig-8] [11-18].

## Limitation(s)

Single-centre study, embalming and prolonged storage may alter tissue architecture and potentially affecting histological interpretation and acid-fast bacilli detection. Histopathological evaluation is subject to interobserver variability, despite standardised staining and diagnostic criteria. Tissue processing-related artifacts arising during fixation, embedding, sectioning and staining may distort

cellular and architectural details, thereby interfering with accurate histopathological interpretation.

## CONCLUSION(S)

This study demonstrated that histopathological examination of cadaveric lungs is an effective method for detecting previously undiagnosed pulmonary TB. The identification of classical TB features highlights a substantial hidden disease burden not recognised during life. These findings support the routine inclusion of histological screening in postmortem and anatomy laboratory settings to enhance disease surveillance and strengthen public health and infection control measures.

**Authors' contribution:** MN: Concept, data collection, drafting; NY: Study design; NKG: Review; NS: Critical revision; JS: Data analysis; SKK: Histopathology support.

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