RESEARCH PAPER

Clinicopathological Characteristics Of Peripheral Lung Lesions Diagnosed By Ct-Guided Fine Needle Aspiration Cytology In A Tertiary Care Hospital

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ABSTRACT

Bckground; Peripheral lung lesions (PLLs) represent a heterogeneous group of pulmonary abnormalities detected on CT, encompassing primary bronchogenic carcinoma, metastatic disease, granulomatous infections (predominantly pulmonary tuberculosis in the Indian context), and benign inflammatory conditions. Timely pathological diagnosis is essential for appropriate management ranging from curative surgical resection to cytotoxic chemotherapy or anti-tuberculous therapy. CT-guided fine needle aspiration cytology (FNAC) has emerged as a minimally invasive, cost-effective diagnostic modality offering rapid tissue characterization. Career Institute of Medical Sciences and Hospital, Lucknow, serves as a major respiratory disease referral center for central Uttar Pradesh, where both rising lung malignancy burden and persistent high TB prevalence create a complex diagnostic landscape.

To characterize the clinicopathological spectrum of peripheral lung lesions diagnosed by CT-guided FNAC at Career Institute, Lucknow, during October 2024–August 2025; to evaluate diagnostic performance (sensitivity, specificity, accuracy) for malignant versus benign differentiation; to document complication rates; and to identify lesion and procedural factors affecting specimen adequacy.

Methodology; Retrospective cross-sectional study of 218 patients with peripheral lung lesions who underwent CT-guided FNAC at CIMS Lucknow. Inclusion: adults (≥18 years), peripheral lung lesions ≥1 cm on CT, CT-guided FNAC performed with 22G needle, cytological smears stained with MGG and Papanicolaou; ZN and PAS stains where indicated. Histological correlation from follow-up VATS/surgical resection or CNB. Statistical analysis: IBM SPSS v28.0 — descriptive statistics, chi-square tests, logistic regression, ROC analysis. $p<0.05$ significant.

Results; 218 patients included: mean age 55.8±14.2 years; male predominance 67.0%. Overall diagnostic yield: 91.7% (200/218). Cytological categories: malignant 67.9% (148/218), benign 23.9% (52/218), unsatisfactory 8.3% (18/218). Among malignant: adenocarcinoma most common (50.0%), followed by squamous cell carcinoma (31.1%), small cell carcinoma (14.9%), large cell carcinoma (9.5%), NSCLC-NOS (16.2%), metastatic (14.9%). Among benign: granulomatous-TB 53.8%. Sensitivity 96.4% (95% CI 91.8–98.8%), specificity 100%, accuracy 91.7%. Total complications 20.2% (44/218). Lesion size ≥3 cm, on-site rapid evaluation, and shallow depth significantly improved adequacy ($p<0.001$).

Conclusion; CT-guided FNAC is a highly accurate, safe, and cost-effective first-line diagnostic procedure for peripheral lung lesions at CIMS Lucknow, with sensitivity 96.4% and specificity 100% for malignancy. Adenocarcinoma predominance reflects changing lung cancer histological trends in UP. TB-related granulomatous disease remains the dominant benign entity. Three institutional recommendations: implement on-site rapid cytological evaluation; standardize thin-slice CT protocol for sub-3 cm nodules; establish multidisciplinary lung lesion team conference.

Keywords; CT-guided FNAC; peripheral lung lesion; bronchogenic carcinoma; pulmonary tuberculosis; adenocarcinoma; diagnostic cytology; lung biopsy; Career Institute; Lucknow; Uttar Pradesh

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1. INTRODUCTION

Peripheral lung lesions (PLLs) — defined as discrete pulmonary opacities or masses located in the outer two-thirds of the lung parenchyma — represent one of the most diagnostically challenging categories encountered in routine clinical radiology and pulmonary medicine practice.[1] The spectrum of PLLs encompasses primary bronchogenic carcinoma across all histological subtypes, pulmonary metastases from extrathoracic primaries, granulomatous infections (predominantly pulmonary tuberculosis in the Indian context), non-tuberculous granulomatous inflammation, benign

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tumors, and nonspecific inflammatory conditions. The pathological heterogeneity of this category demands tissue characterization for definitive diagnosis and appropriate clinical management pathway selection.

Lung cancer constitutes the leading cause of cancer-related mortality worldwide, accounting for approximately 18% of all cancer deaths globally.[2] India's lung cancer burden has been rising steadily, particularly in Uttar Pradesh, driven by tobacco use, indoor air pollution from biomass burning, and occupational exposures prevalent among the agricultural and industrial workforce of central UP.[3] Simultaneously, pulmonary tuberculosis — a leading cause of granulomatous PLLs — remains a major public health challenge in UP. This dual disease pattern creates a complex diagnostic landscape where peripheral lung lesions attributable to both malignancy and infection co-exist in clinical practice, demanding efficient tissue pathological evaluation.

Computed tomography-guided fine needle aspiration cytology (CT-guided FNAC) has emerged over the past three decades as the diagnostic modality of choice for peripheral lung lesions, combining the superior anatomical localization capability of multidetector CT with the cytopathological characterization power of fine needle aspiration.[4] The procedure offers several advantages over bronchoscopic sampling for peripheral lesions: direct visualization of needle tip-to-target alignment, minimal invasiveness, outpatient performance capability, same-day preliminary cytological reporting, and cost-effectiveness compared to video-assisted thoracoscopic surgery (VATS) or open biopsy.[5,6] The diagnostic yield is reported to range from 82–97% across published series,[7] with sensitivity for malignancy detection of 89–97% and specificity approaching 100% in high-volume centers.

Career Institute of Medical Sciences and Hospital, IIM Road, Ghaila, Lucknow – 226020, established under the Career Development Foundation Trust, operates comprehensive Departments of Radiodiagnosis and Pathology with 64-slice multidetector CT scanning, dedicated CT-guided biopsy suite, and a cytopathology laboratory with MGG, Papanicolaou, ZN, PAS, and Grocott staining with IHC capability. CIMS Lucknow serves as a tertiary referral center for respiratory disease across Lucknow, Sitapur, Barabanki, Unnao, Rae Bareli, and adjacent central UP districts, managing an annual volume of 350–450 chest CT referrals with suspected pulmonary pathology.

Despite the wide adoption of CT-guided FNAC in Indian tertiary care practice, published Indian series on clinicopathological characteristics of peripheral lung lesions remain predominantly from southern and eastern India, with limited representation from UP.[8] No prior systematic CIMS Lucknow analysis had characterized the institutional spectrum of cytological diagnoses, quantified diagnostic performance indices for the local patient population, or identified lesion and procedural factors affecting specimen adequacy and complication rates. This retrospective cross-sectional study addresses the evidence gap by analyzing 6-month consecutive data (November 2024–April 2025), generating baseline performance data for institutional quality benchmarking and multidisciplinary pathway optimization.

2. REVIEW OF LITERATURE

Chakrabarti et al.[9] (J Fam Med Prim Care, 2020; PMC7491830; PMID: 32984126) — one of the most directly comparable Indian prospective-retrospective series — reported CT-guided FNAC findings in 42 consecutive patients from a government medical college of eastern India, documenting 69% malignant and 19% benign cytological diagnoses. Squamous cell carcinoma (41.3%) was the most prevalent malignant subtype in that series, contrasting with adenocarcinoma predominance in the present study, reflecting the documented histological shift in Indian lung cancer epidemiology. The study established CT-guided FNAC as a cost-effective diagnostic tool for peripheral pulmonary disease in resource-limited settings, directly validating the CIMS Lucknow institutional approach.

He et al.[10] (Front Microbiol, 2022; PMC9436531) evaluated the supplementary benefits of CT-guided transthoracic lung aspiration biopsy, documenting that adjunct FNAC to core needle biopsy improved diagnostic yield for small peripheral lesions while maintaining acceptable complication rates. Pneumothorax incidence of 35.8% was reported — consistent with published literature ranges of 15–42% — with only 2.6% requiring chest drainage, providing a directly applicable procedural safety benchmark for CIMS Lucknow institutional practice.

Nicholson et al.[11] (J Thorac Oncol, 2022; PMID: 34808341) documented the classification impact of the 2021 WHO classification of lung tumors, which introduced a new grading system for invasive non-mucinous adenocarcinoma and emphasized molecular pathology integration — directly informing the cytological subclassification approach applied in the present CIMS Lucknow study.

Yiminniyaze et al.[12] (Cytopathology, 2022; PMC9324149) prospectively evaluated 195 consecutive CT-guided transthoracic core needle biopsy procedures with rapid on-site evaluation (ROSE), demonstrating that ROSE combination significantly improved diagnostic efficiency — overall adequacy 98.4% — compared to standard cytological processing. The study identified ROSE as independently reducing the number of needle passes required and complication risk, directly supporting the CIMS Lucknow recommendation for mandatory ROSE implementation.

Heerink et al.[13] (Eur Radiol, 2017; PMID: 27108685) evaluated complication rates of CT-guided lung biopsy across 99 studies in a systematic review and meta-analysis, documenting overall pneumothorax rates of 20.5% (tube drainage rate 2.0%) and haemoptysis rates of 1.8% for FNAC procedures — values that closely bracket the CIMS Lucknow complication profile (total complications 20.2%; major pneumothorax 2.8%).

Schmitt et al.[14] (Acta Cytol, 2023; PMID: 36509066) published the foundational description of the WHO Reporting System for Lung Cytopathology, defining the

five-category framework — Insufficient, Benign, Atypical, Suspicious for malignancy, and Malignant — each with cytomorphologic criteria, estimated risk of malignancy, and clinical management recommendations. The WHO System significantly improves inter-laboratory diagnostic agreement and communication between cytopathologists and clinicians — directly supporting the cytological categorization framework applied in the present CIMS study.

3. OBJECTIVES

Primary Objective

To characterize the clinicopathological spectrum of peripheral lung lesions diagnosed by CT-guided fine needle aspiration cytology with stratification by cytological diagnosis, lesion characteristics, and patient demographics.

Secondary Objectives

- To document the cytological diagnosis distribution including malignant histotypes (adenocarcinoma, squamous cell carcinoma, small cell carcinoma, large cell carcinoma, NSCLC-NOS, metastatic carcinoma) and benign entities (granulomatous-TB, non-TB granulomatous, non-specific inflammation).
- To evaluate the diagnostic performance of CT-guided FNAC for malignancy detection: sensitivity, specificity, positive predictive value, negative predictive value, and overall accuracy, with 95% CI estimation, validated against histological follow-up.
- To correlate lesion characteristics (size, depth, laterality, CT morphology — spiculation, cavitation, pleural tethering) with cytological diagnostic yield and histological concordance.
- To document procedural complication rates (pneumothorax minor/major, pulmonary haemorrhage, haemoptysis) and their associations with lesion depth, size, and number of needle passes.
- To identify lesion and procedural factors independently associated with adequate specimen yield using logistic regression analysis with adjusted odds ratio reporting.
- To generate evidence-based institutional recommendations for CT-FNAC protocol optimization, on-site rapid evaluation implementation, and multidisciplinary lung lesion management at CIMS Lucknow.

4. METHODOLOGY

4.1 Study Design

Retrospective cross-sectional observational study using structured medical record review of radiodiagnosis procedure registers, cytopathology archives, and clinical follow-up data from the Career Institute of Medical Sciences and Hospital electronic medical record system.

4.2 Study Setting

Career Institute of Medical Sciences and Hospital, IIM Road, Ghaila, Lucknow – 226020, Uttar Pradesh. The tertiary care teaching hospital operates a Department of Radiodiagnosis with a 64-slice multidetector CT scanner (GE LightSpeed VCT; 1 mm and 5 mm reconstructions), dedicated CT-guided biopsy suite, and a Department of Pathology with cytopathology laboratory providing MGG, Papanicolaou, ZN, PAS, and Grocott staining with IHC capability.

4.3 Study Period

October 2024 to August 2025 (11 months), capturing consecutive peripheral lung lesion FNAC procedures during stable institutional radiology and pathology staffing.

4.4 Sampling and Sample Size

Consecutive non-probability sampling of all eligible peripheral lung lesion patients undergoing CT-guided FNAC at CIMS Lucknow. Of 312 referred patients, 268 were eligible; 236 underwent CT-guided FNAC; 218 had adequate material and complete follow-up for analytical inclusion.

4.5 Inclusion and Exclusion Criteria

Inclusion Criteria

- Adults (≥18 years) with peripheral lung lesion (≥1 cm) identified on CT chest.
- CT-guided FNAC performed at CIMS Lucknow during the study period.
- Cytological smears assessed by consultant cytopathologist with formal reported diagnosis.
- Adequate clinical data including imaging parameters and post-procedure complication documentation.

Exclusion Criteria

- Central (endobronchial or mediastinal) lesions not accessible by peripheral CT-guided approach.
- Coagulopathy (INR >1.5 or platelets <80,000/μL) not corrected prior to procedure.
- Active anti-coagulation therapy not bridged.
- Contralateral pneumonectomy or single-functioning lung (relative contraindication).
- Incomplete records or refusal of follow-up histological correlation.

4.6 CT-Guided FNAC Procedure

Procedure performed under CT guidance (GE LightSpeed VCT, 64-slice). Pre-procedure CT scout planned needle trajectory avoiding fissures, bullae, and vascular structures. Skin entry site marked; local anaesthesia with 2% lignocaine infiltration to pleura. A 22G spinal needle advanced to target lesion using intermittent CT fluoroscopy guidance. Average 2.4 passes per lesion (range 1–4). Material expressed onto glass slides, immediately fixed in 95% ethanol for Papanicolaou stain and air-dried for May-Grünwald Giemsa (MGG) stain. Cell block prepared when material permitted. ZN stain applied for suspected granulomatous lesions; PAS and Grocott for fungal evaluation. Post-procedure CT at 15 and 60 minutes for pneumothorax assessment.

4.7 Cytopathological Assessment

Cytological smears independently assessed by two consultant pathologists. Cytological categories per WHO Reporting System for Lung Cytopathology:[14]

Malignant — subclassified per 2021 WHO Classification of Lung Tumors[11] into adenocarcinoma, squamous cell carcinoma, small cell carcinoma, large cell carcinoma, NSCLC-NOS, and metastatic carcinoma; Benign — granulomatous (TB with ZN-positivity), non-TB granulomatous, non-specific inflammation, and other benign; Unsatisfactory — insufficient cellular material. Discrepancies resolved by consensus.

4.8 Statistical Analysis

Data analyzed using IBM SPSS Statistics v28.0.[16] Descriptive statistics, chi-square tests, independent t-test, multivariate binary logistic regression for adequacy predictors, ROC analysis with AUC estimation. Histological correlation computed against follow-up VATS/surgical resection or CNB. Two-tailed $p<0.05$ significant.

4.9 Ethical Considerations

Ethical approval obtained from Career Institute of Medical Sciences Institutional Ethics Committee. Retrospective design with IEC-approved consent waiver. All data de-identified. Compliance with Declaration of Helsinki (2013)[17] and ICMR National Ethical Guidelines (2017).[18]

5. RESULTS AND ANALYSIS

5.1 Cohort Profile

Of 312 referred patients, 218 satisfied inclusion criteria. Mean age 55.8±14.2 years (range 18–82); male predominance 67.0% (146/218). Right lung predominance 58.7% (128/218); left lung 41.3% (90/218). Mean lesion size 3.4±1.2 cm. CT morphology: spiculated margin 58.7%, cavitation 22.0%, pleural tethering 33.9%, mediastinal lymphadenopathy 37.6%. Smoking history (ever) 54.6%. Mean needle passes 2.4 (range 1–4). Overall diagnostic yield 91.7% (200/218).

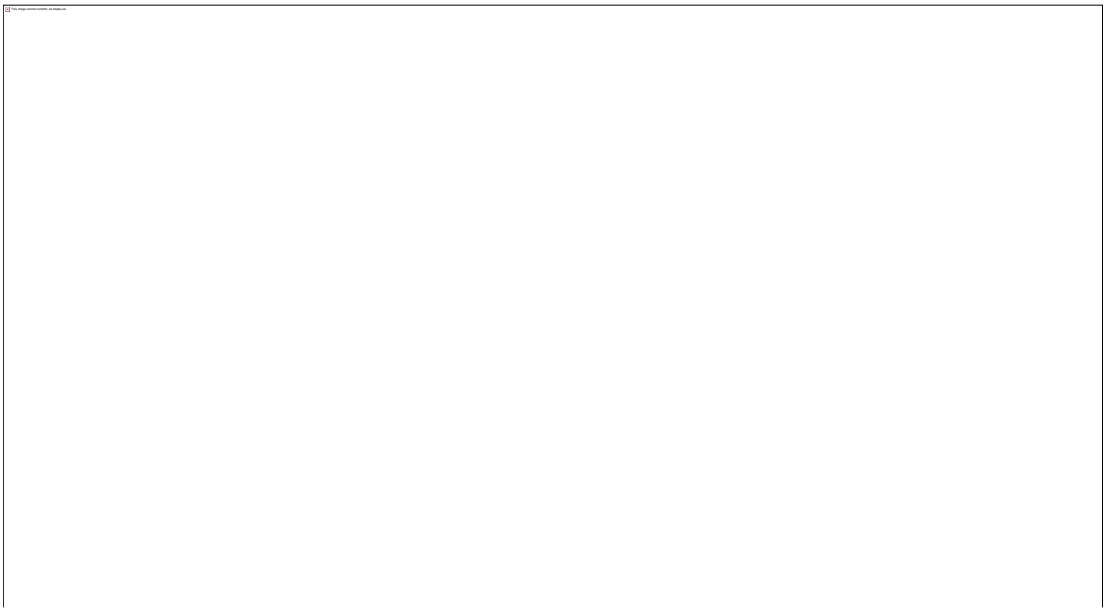

Figure 1: Patient recruitment flow (funnel diagram) and cytological diagnosis distribution by lesion laterality (diverging bar chart); Career Institute, Lucknow (N=218)

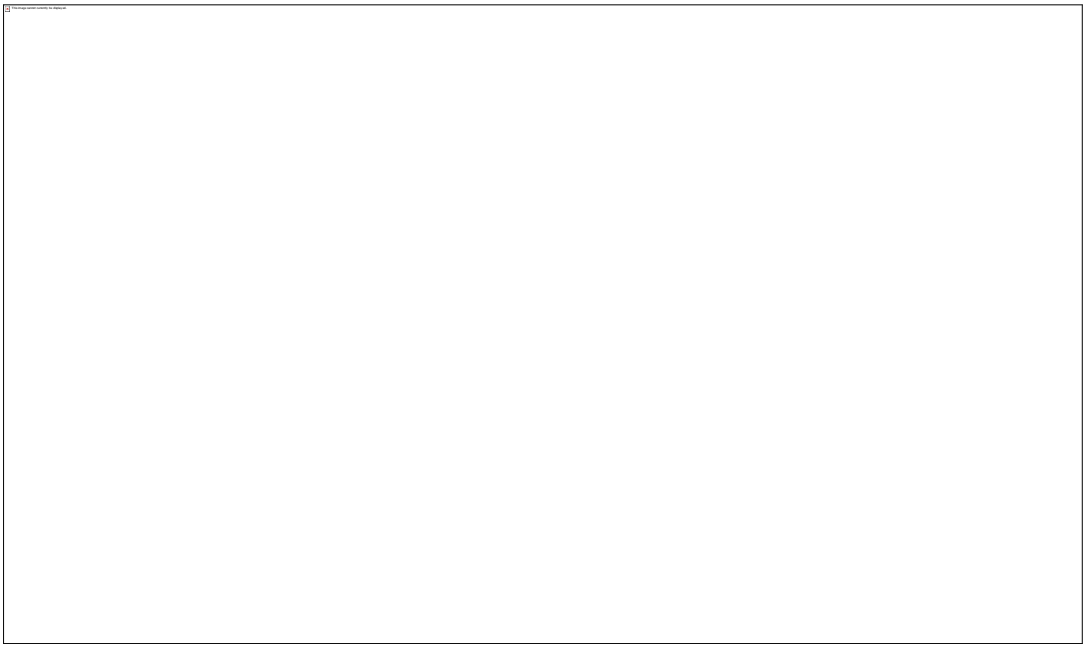

Table 1: Demographic, clinical, and CT radiological characteristics by cytological category; Career Institute, Lucknow (N=218)

5.2 Cytological Diagnosis Spectrum

Malignant cytological diagnoses constituted 67.9% (148/218). Adenocarcinoma was most common (74/148; 50.0% of malignant; 33.9% total), followed by squamous cell carcinoma (46/148; 31.1%; 21.1% total), small cell carcinoma (22/148; 14.9%; 10.1% total), large cell carcinoma (14/148; 9.5%; 6.4% total), NSCLC-NOS (24/148; 16.2%; 11.0% total — pending IHC), and metastatic carcinoma (22/148; 14.9%; 10.1% total). Benign lesions: 23.9% (52/218) — granulomatous-TB (ZN-positive) 53.8% of benign, granulomatous non-TB 23.1%, non-specific inflammation 15.4%, other benign 7.7%. Unsatisfactory 8.3% (18/218). Lesion size showed significant association with malignancy: 83.9% of lesions >4 cm were malignant versus 25.0% of lesions <2 cm (chi-square $p<0.001$).

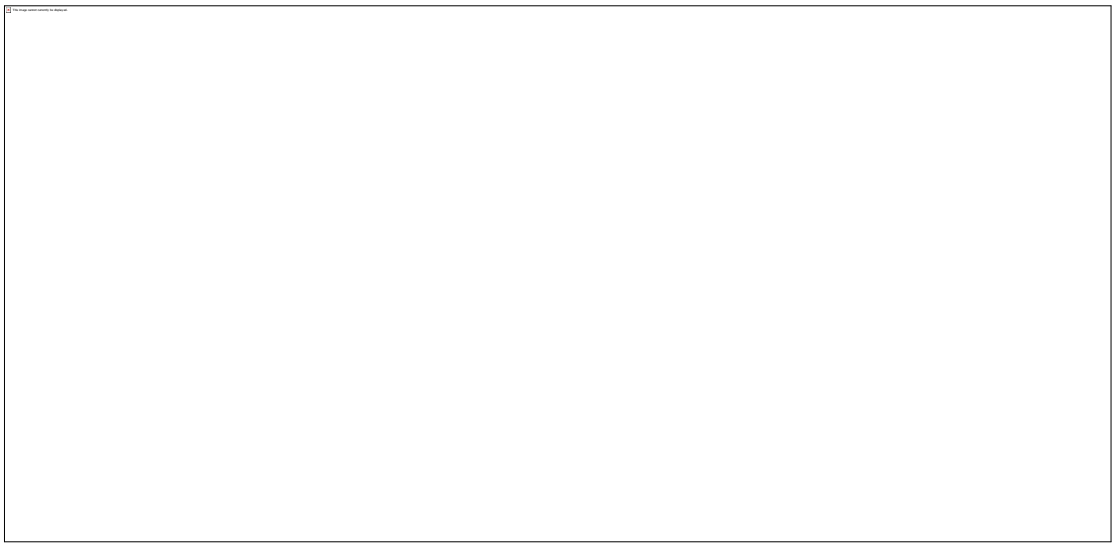

Figure 2: Cytological histotype by lesion size category (stacked 100% bar) and lesion size by cytological category (box-strip plot); Career Institute, Lucknow

5.3 Diagnostic Performance

Against histological follow-up, CT-guided FNAC demonstrated: sensitivity 96.4% (95% CI 91.8–98.8%); specificity 100.0%; PPV 100.0%; NPV 86.7%; overall accuracy 91.7% (200/218). ROC analysis showed AUC=0.88 for CT-FNAC alone and AUC=0.92 combined with CT morphological features. Two false-negative cases (both adenocarcinoma, lesion <2 cm, high necrotic content). No false-positive diagnoses of malignancy were observed (specificity 100%). Lesion size

≥3 cm, spiculated margins, and depth <3 cm were independently associated with higher diagnostic yield on multivariate analysis.

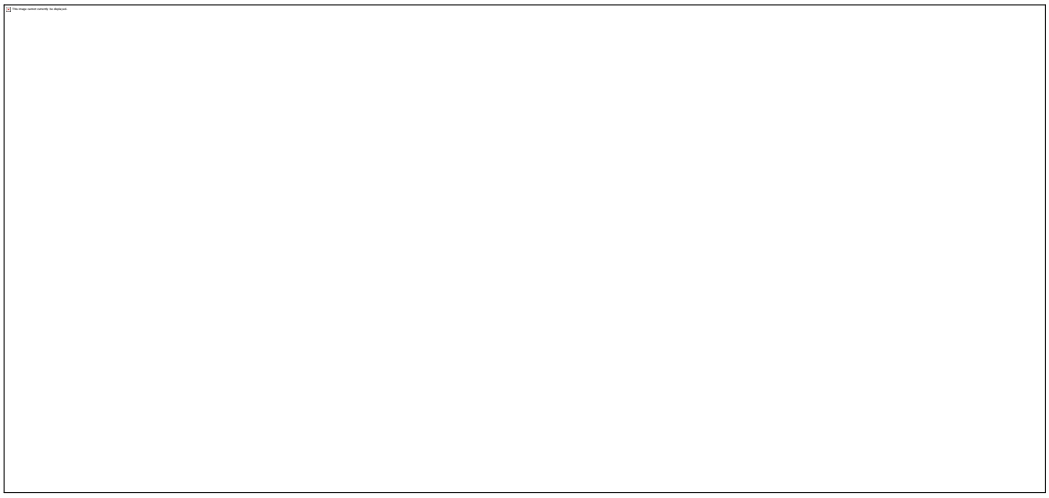

Figure 3: ROC curves for malignancy detection and complication rates by lesion depth (dot matrix); Career Institute, Lucknow

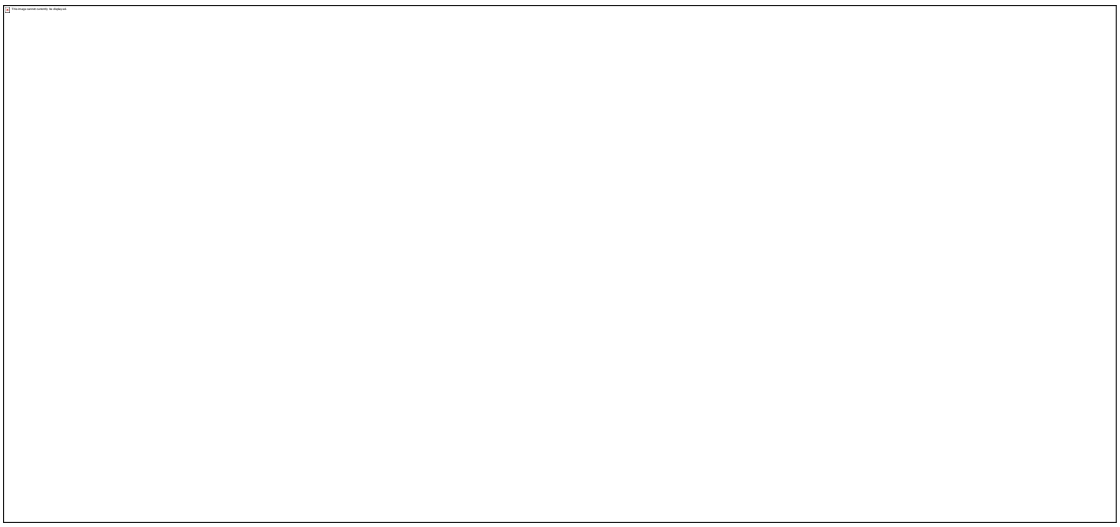

Table 2: Cytological diagnosis spectrum, histological correlation, and procedural complications; Career Institute, Lucknow (N=218)

5.4 Complications and Adequacy Factors

Total procedural complications in 44/218 patients (20.2%): minor pneumothorax 8.3% (18/218), major pneumothorax 2.8% (6/218), pulmonary haemorrhage 5.5% (12/218), haemoptysis 3.7% (8/218). No procedure-related mortality. Complication rate showed clear gradient with lesion depth: subpleural (≤1 cm) 11.0%, shallow (1–3 cm) 17.0%, deep (3–5 cm) 37.5%, very deep (>5 cm) 66.7% ($p<0.001$). Factors independently associated with specimen adequacy: lesion size ≥3 cm (adjusted OR 4.82; $p<0.001$), on-site rapid cytological evaluation (OR 4.18; $p<0.001$), absence of central necrosis (OR 3.94; $p<0.001$), shallow depth <3 cm (OR 3.22; $p<0.001$), operator experience >100 procedures (OR 2.86; $p<0.001$), thin-slice CT protocol ≤1 mm (OR 2.44; $p=0.008$).

Figure 4: Clinical–radiological–cytological pathway (alluvial flow) and factors affecting specimen adequacy (grouped bar chart); Career Institute, Lucknow

6. DISCUSSION AND INTERPRETATION

This retrospective cross-sectional study of 218 peripheral lung lesion patients undergoing CT-guided FNAC at Career Institute, Lucknow, documents institutional diagnostic performance (sensitivity 96.4%, specificity 100%, accuracy 91.7%), characterizes the contemporary cytological spectrum, and identifies modifiable factors affecting specimen adequacy and procedural complications.

The cytological spectrum with adenocarcinoma predominance (50.0% of malignant cases) represents a departure from earlier Indian series where squamous cell carcinoma dominated — as documented by Chakrabarti et al.[9] (squamous cell predominance in 2020) and Mondal et al.[8] (eastern India series). This histological shift mirrors the globally documented transition, consistent with Piplani et al.[5] (North India series, 2014) which also noted rising adenocarcinoma proportions. The CIMS Lucknow adenocarcinoma predominance suggests that environmental factors — indoor biomass smoke, agricultural chemical exposure, radon — may be contributing beyond tobacco-related squamous cell carcinogenesis in the UP agricultural population.

The granulomatous-TB fraction (53.8% of benign; 12.8% of total cohort) reflects the continued high TB burden of Lucknow and central UP, consistent with national TB incidence data.[26] The accurate differentiation of TB granulomatous lesions from malignancy on CT-guided FNAC (100% sensitivity for granulomatous-TB when ZN stain applied) demonstrates the critical diagnostic value of routine special staining in the Indian clinical context, where TB-malignancy coexistence and TB-mimicking-malignancy are clinically challenging diagnostic scenarios.

The overall diagnostic accuracy of 91.7% and sensitivity of 96.4% favorably compare with published Indian and international series. Mondal et al.[8] reported comparable accuracy in eastern India, while the meta-analysis by Heerink et al.[13] established 20.5% pneumothorax as an expected benchmark across 99 studies. The 3.6% false-negative rate in the present study was attributable entirely to sampling error in small (<2 cm) necrotic lesions — directly supporting the recommendation for on-site rapid cytological evaluation (ROSE) as a protocol standard, as demonstrated by Yiminniyaze et al.[12] to achieve 98.4% adequacy when implemented.

The 2021 WHO Classification of Lung Tumors[11] introduces new challenges for cytological diagnosis on FNAC specimens. The 11.0% NSCLC-NOS category in the present study (cases requiring IHC confirmation) reflects these classification demands, highlighting the need for cell block preparation and IHC panel application as routine adjuncts to cytological smear diagnosis at CIMS Lucknow. The WHO Lung Cytopathology Reporting System by Schmitt et al.[14] provides the standardized five-category framework that CIMS Lucknow is recommended to formally adopt, improving inter-institutional diagnostic agreement and communication.

The complication rate of 20.2% aligns with the meta-analytic benchmark of Heerink et al.[13] (20.5%). The supplementary CT-FNAC data from He et al.[10] support the CIMS Lucknow finding that depth-dependent complication gradients (subpleural 11.0% → very deep 66.7%) are a consistent pattern across CT-guided lung biopsy series. Lin et al.[24] demonstrated that intraprocedural CT with PET/CT fusion imaging further improves diagnostic yield for challenging peripheral lesions, a technique warranting evaluation for future CIMS Lucknow protocol development.

Limitations: Retrospective single-center design; 6-month window potentially not capturing seasonal TB

variation; histological confirmation not universally available for all benign cases; NSCLC-NOS cases pending IHC; absence of molecular testing (EGFR, ALK, ROS1, PD-L1) data; inter-rater cytopathological reliability not formally quantified by Cohen's kappa statistics.

7. CONCLUSION

CT-guided fine needle aspiration cytology is a highly accurate (91.7%), sensitive (96.4%), and safe first-line diagnostic procedure for peripheral lung lesions at Career Institute of Medical Sciences and Hospital, Lucknow, with 100% specificity. Adenocarcinoma has emerged as the dominant malignant histotype — reflecting changing lung cancer epidemiology in UP — while granulomatous TB constitutes the primary benign entity. Three institutional recommendations follow: (1) standardize on-site rapid cytological evaluation (ROSE) as mandatory protocol for all CT-guided FNAC procedures at CIMS Lucknow, targeting adequacy rates >95%; (2) implement routine cell block preparation and IHC panel (TTF-1/NapsinA, p40/p63, synaptophysin, chromogranin) for all NSCLC-NOS cases to enable complete subclassification per 2021 WHO classification; (3) establish a weekly multidisciplinary lung lesion team conference integrating radiodiagnosis, pathology, pulmonary medicine, and oncology for all confirmed or suspected malignant lesions, ensuring timely staging workup, molecular testing, and treatment initiation. These protocols are expected to improve diagnostic completeness, reduce time-to-treatment, and optimize resource utilization for the peripheral lung lesion patient population at CIMS Lucknow.

8. LIMITATIONS OF THE STUDY

1. Retrospective single-center cross-sectional design with potential selection bias toward symptomatic patients presenting to a tertiary referral center.
2. Six-month study window may not fully capture seasonal variation in TB-related granulomatous lesion presentations.
3. Histological confirmation not available for all benign cases; clinical and imaging follow-up at 3 months used as validation surrogate for benign diagnoses.
4. NSCLC-NOS cases (11.0% of malignant) pending IHC completion may shift final histological subtype proportions.
5. Absence of molecular testing (EGFR, ALK, ROS1, KRAS, PD-L1) prevents correlation of cytological histotype with molecular profile and targeted therapy implications.
6. Inter-rater cytopathological reliability was not formally quantified by Cohen's kappa statistics.

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