



Original Article

Role of Percutaneous Computed Tomography-guided Lung Biopsy in Non-resolving Consolidation and Identification of Clinical and High-resolution Computed Tomography Characteristics Predicting Outcome

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ABSTRACT

Objective: Non-resolving consolidation (NRC) with inconclusive sputum, bronchoscopy, and bronchoalveolar lavage results poses a diagnostic dilemma. This retrospective analytical study was conducted to evaluate diagnostic yield and complications of percutaneous computed tomography (CT)-guided lung biopsy (PCLB) in NRC. Assessment of clinical features and high-resolution CT (HRCT) characteristics was also done which may predict outcome.

Materials and Methods: Data of PCLB performed for lung consolidation from January 2010 to January 2019 were retrospectively evaluated. For the determination of diagnostic yield, a positive result from any one specimen obtained by PCLB (tissue core, aspiration cytology, or microbiology) was sufficient to considered procedure diagnostic if it was concordant with clinical features, imaging findings, response to treatment, and subsequent follow-up. Student's *t*-test and Fisher's exact test were used for statistical analysis.

Results: Out of total 56 patients, final diagnosis was achieved in 48 (19 malignant and 29 benign). Diagnostic yield was 69.6%. Complications were noted in 10 patients including mild hemoptysis and pneumothorax, which were managed conservatively. No clinical feature was having statistically significant association with final diagnosis. HRCT findings significantly associated with malignant outcome were larger size of consolidation, multiple contiguous lobe involvement, multiple air-filled cysts inside consolidation, and associated ground-glass areas or multiple ground-glass nodules. The absence of air bronchogram was more common in benign cases.

Conclusion: PCLB is a safe and useful method for obtaining specimen in NRC. Differentiation of benign from malignant outcome is not possible based on clinical findings; however, certain HRCT findings raise suspicion of malignancy.

Keywords: Adenocarcinoma, Computed tomography-guided biopsy, High-resolution computed tomography, Non-resolving consolidation

INTRODUCTION

The term non-resolving consolidation (NRC) or pneumonia is used for persistent radiological abnormality beyond an expected duration.^[1,2] In general, a consolidation patch is expected to resolve or improve after a course of antibiotic therapy. This expected duration has been described

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to vary from 4 to 12 weeks by different authors. There are numerous infectious and non-infectious causes of NRC. Although chest X-ray and computed tomography (CT) scan play an important role in localization of abnormalities, specific diagnosis cannot be made in many cases as many non-infectious causes such as malignancy, organizing pneumonia mimic typical pneumonia radiologically.^[3] Usually, the diagnosis in cases of NRC is made by sputum staining, sputum culture, and analysis of material obtained by bronchoalveolar lavage (BAL) and transbronchial biopsy. Fibro-optic bronchoscopy is very important in ruling out endobronchial lesion and obtaining BAL specimen for cytological and microbiological analysis.^[2] In selected cases, d-dimer testing, antinuclear antibodies, anti-neutrophil cytoplasmic antibodies, serum angiotensin-converting enzyme level, and CT angiography help in clinching the diagnosis.

However, despite these investigations, sometimes, the diagnosis remains uncertain. In such cases, percutaneous CT-guided lung biopsy (PCLB) plays a very important role.^[4] In large peripheral lesions, even ultrasound guidance can be used. The aim of the present study was to evaluate the diagnostic yield and complications of PCLB in cases of NRC with inconclusive results from sputum, bronchoscopy, and BAL. Assessment of clinical features and high-resolution CT (HRCT) characteristics was also done which may predict outcome.

MATERIALS AND METHODS

Data of PCLB performed for lung consolidation from January 2010 to January 2019 were retrospectively evaluated. Ethical clearance was taken from the institute ethics committee with waiver of consent. Procedure details and images were retrieved from the radiology records. All biopsies were performed with a 64-slice multidetector CT (MDCT) scanner (Brilliance CT, Philips Medical Systems, Cleveland, OH) or a 128-slice MDCT scanner (Somatom Definition AS, Siemens, Forchheim, Germany). Clinical, pathological, and microbiological records were obtained from the hospital information system and patient case sheets.

The patient preparation and basic considerations are similar to those described in earlier studies.^[4,5] All procedures were done using a coaxial technique. A quick core biopsy needle set (Cook, Bloomington, Indiana, USA) or Bard Mission Disposable Core Biopsy Instrument (BARD, Arizona, USA) was used. Length of the biopsy set was chosen depending on lesion depth. Mostly, a 20-gauge biopsy set was used; however, in a few cases, 18-gauge biopsy set was used. Larger pulmonary vessels, aerated bronchi, and ground-glass areas were avoided. Multiple tissue cores were obtained by slight tilting of the outer needle so as to sample different areas, usually 5–10 cores. Microbiology specimens were sent

whenever adequate material could be obtained, mostly for tuberculosis and in some cases for fungi. The tissue cores were placed in a formalin vial for histopathology and normal saline for microbiological analysis.

For the determination of diagnostic yield, a positive result from any one specimen obtained by PCLB (tissue core, aspiration cytology, or microbiology) was sufficient to be considered procedure diagnostic if it was concordant with clinical features, imaging findings, response to medication, and subsequent follow-up. A case with non-specific inflammatory histopathology picture was considered diagnostic if patient subsequently improved on antibiotics or follow-up imaging showed resolution of lesions. However, non-specific inflammatory histopathology picture was considered non-diagnostic, if another clinical diagnosis was made or patient responded to empiric antitubercular treatment or lost to follow-up. Inadequate specimen and technical failure were also categorized as non-diagnostic. Patients having a diagnosis from pathology or microbiology specimen, but not fitting with clinical feature, imaging findings, or other investigations were categorized as discordant.

Correlation of various clinical features and HRCT findings was done with final diagnosis to identify factors predicting the outcome. All CT images were reviewed by a radiologist having 9-year experience in pulmonary imaging. Extent of lung involvement was described as single segment, single lobe, multiple discrete segments, and multiple contiguous lobe involvement. Lung findings in addition to consolidation were also noted. The largest diameter of consolidation on axial image, density on non-contrast computed tomography (NCCT), enhancement on contrast CT, and margins were noted. Density of consolidation was categorized as isodense if its CT density was within 10 HU range of posterior spinal muscle. More than 10 HU above was categorized as hyperdense and <10 HU as hypodense. Enhancement of consolidation area was noted avoiding larger vessels. 10 HU or less post-contrast enhancement was classified as minimal enhancement, 11–20 HU as mild enhancement, more than 20 HU as moderate enhancement, and more than 40 HU as marked enhancement. Inside consolidation, the following features were noted; air bronchogram, air-filled cavitation, multiple air-filled cysts, rounded internal fluid pocket, calcification, and background vascular architecture. Any other finding inside the consolidated lung, presence of lymphadenopathy, and pleural effusion was also noted.

Statistical analysis

Statistical differences between benign and malignant groups were analyzed using the Student's *t*-test for continuous variables such as patient age and duration of chest symptoms. Statistical differences in clinical features and HRCT characteristics were analyzed using the Fisher's exact test. All

statistical testing were performed using statistical software (SPSS, version 17; SPSS, Chicago, IL, USA) with $P = 0.05$ or less considered statistically significant.

RESULTS

During the period of 9 years, 56 patients underwent PCLB procedure for lung consolidation [Figure 1]. Among these 56 patients, 39 were male and 17 females with the mean age of 50.1 years (range, 5–80 years). In three patients, PCLB was repeated as the first was not conclusive. Chest symptoms were present in 52 patients. Mean duration of chest symptoms was 6.6 months (range 1 week–48 months). Three patients had no chest complaints as lung lesions were detected incidentally, in one case during routine medical checkup, in two cases during work-up for central nervous system symptoms and splenomegaly, respectively. In one patient, detailed clinical history was not available. Cough was noted in 35, expectoration in 18, shortness of breath in 26, fever in 23, reduced appetite in 11, hemoptysis in 10, and chest pain in 18 patients. Weight loss was noted in 7, hoarseness of voice in 2, generalized weakness in 2, left axillary swelling in 1, and backache in 1 patient. Diabetes was the most common comorbidity in 11 patients, followed by hypertension in 5, bronchial asthma in 2, chronic obstructive pulmonary disease in 2, coronary artery disease in 1, congenital cardiac block in 1, and hypothyroidism in 1 patient. History of

alcoholism was noted in 2 and smoking in 4 patients. None of the patient was human immunodeficiency virus positive or on immunosuppression.

Sputum results were available in 26 patients. *Candida* was seen in 7, *Acinetobacter* and *Citrobacter* in 1, Gram-positive cocci in 1, tubercular bacilli in 1, and *Aspergillus* in 1 patient. In 15 cases, no organism was noted. Malignant cells were not seen in sputum of any case. In seven patients with *Candida* growth, four patients subsequently proven to be adenocarcinoma (including papillary and mucinous BAC), two as bacterial infection, one as tuberculosis, and one as organizing pneumonia. Patient with *Acinetobacter* and *Citrobacter* growth on sputum subsequently was proven to be bacterial abscess. Patient showed *Aspergillus* in sputum subsequently proven to be adenocarcinoma. In one patient showing tubercular bacilli in sputum, final diagnosis of tuberculosis was made. In sputum staining showed Gram-positive cocci, culture was negative and histopathology showed non-specific inflammatory changes, final diagnosis was not made due to lack of follow-up.

Fibro-optic bronchoscopy was done in 38 patients and was normal in 37 patients. In one patient, endobronchial mass was seen, but bronchoscopic-guided biopsy was inconclusive. Bronchoscopy was not done in 18 patients. BAL cytology results were available in 27 patients; no malignant cells were seen in any of these patients. Out of these 27 patients,

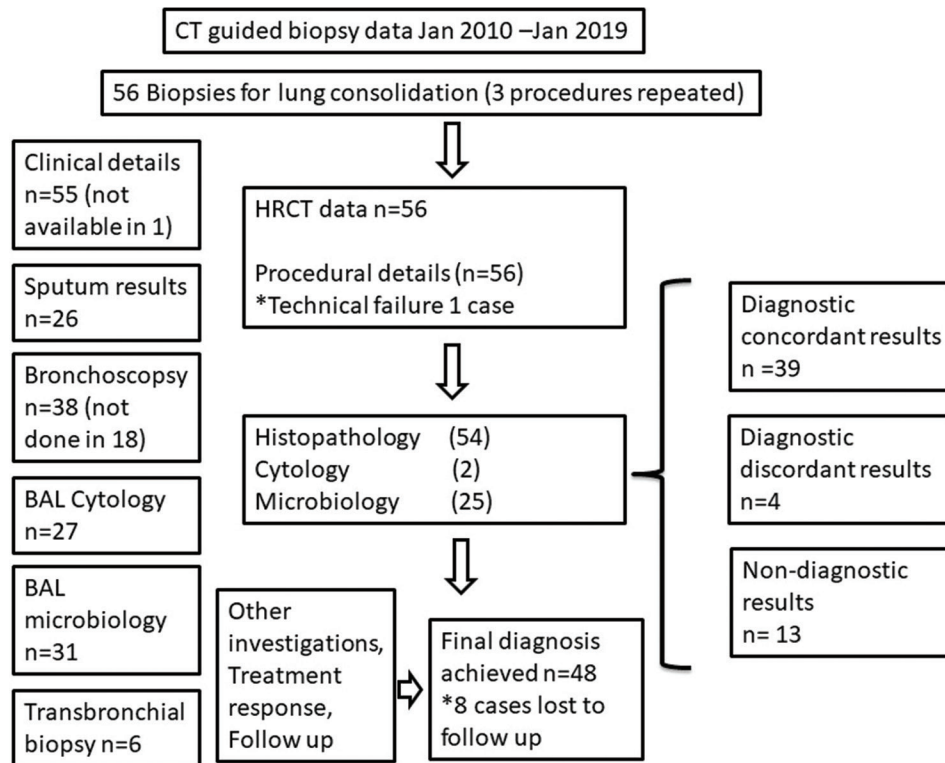


Figure 1: Results of percutaneous computed tomography-guided lung biopsy in lung consolidation in 56 patients.

12 subsequently proven to be malignant in nature. BAL microbiology results were available in 31 patients, the results of which are described in Table 1. Transbronchial lung biopsy was done in six patients and was inconclusive.

Extent of lung involvement on HRCT is described in Table 2. The mean maximum diameter of consolidation on axial CT image was 79.8 mm (range 30–160 mm). On NCCT, consolidation was isodense to posterior spinal muscles in 42, hypodense in 12, and hyperdense in 2 cases. Post-contrast enhancement was minimal in 21, mild in 15, moderate in 3, and could not be assessed in 17 cases. The consolidation margins were irregular in 34, ill-defined in 11, well defined in 4, and lobulated in 3 cases. In four

cases, consolidation margins could not be assessed as the entire lobe of involved and consolidation was outlined by pleura. HRCT findings inside consolidated lung were air bronchogram in 32, cavitation in 14 [Figure 2], multiple air-filled cysts in 6 [Figures 3 and 4], rounded internal fluid pocket in 6 [Figure 5], powdery calcification in 2 [Figure 6], preserved background vascular architecture in 26, distorted background vascular architecture in 8 (could not be commented 22 either due to unavailability of contrast images, internal cavitation, or liquefaction), lymphadenopathy in 10, and pleural effusion in 5 patients. Inside the consolidation, air-filled bronchiectasis was also noted in 1, mucus-filled prominent bronchi in 2, small pulmonary artery aneurysm

Table 1: BAL microbiology results in 31 patients with correlation with sputum and final diagnosis.

| BAL microbiology results | Sputum results | Final diagnosis |
|---|---|---|
| <i>Candida</i> (n=7) | <i>Candida</i> (2), no organism (1), not available (1) Not available (1) No organism (1) No organism (1) | Adenocarcinoma (n=4) Bacterial infection (n=1) Tuberculosis (n=1) Organizing pneumonia (n=1) |
| <i>Aspergillus fumigatus</i> (n=2) | No organism (1) <i>Aspergillus</i> (1) | ABPA Adenocarcinoma |
| <i>Aspergillus niger</i> (n=1) | No organism | Non-specific inflammation on histopathology, no follow-up |
| <i>Tubercular bacilli</i> on AFB staining (n=1) | Not available | Tuberculosis |
| <i>Mycobacterium tuberculosis</i> on BACTEC culture (n=1) | Not available | Sarcoidosis |
| <i>Pseudomonas</i> (n=1) | <i>Acinetobacter</i> and <i>Citrobacter</i> | Bacterial abscess |

BAL: Bronchoalveolar lavage, ABPA: Allergic bronchopulmonary aspergillosis

Tables 2: Details of extent of lung consolidation on HRCT in 56 patients.

| Extent of lung consolidation | Additional lung findings |
|---|---|
| Single segment (n=10) | Few well-defined nodules contralateral lung (1) Multiple medium size nodules both lungs (1) Small cavity contralateral lung (1) None (7) |
| Single lobe (n=22) | Few tiny nodules, other lobes or other lungs or both (3) Fibrocavitary lesion contralateral lung (1) Few tiny irregular nodules same lobe (2) Adjacent ground-glass opacity same lobe (1) None (15) |
| Multiple discrete segments in one (n=2) or both lungs (n=8) | Single thin-walled cavity contralateral lung (1) Septal thickening same lobe (1) Ground-glass halo (1) Multiple medium size nodules both lungs (1) None (6) |
| Multiple contiguous lobe involvement single lung (n=10) or both lungs (i=4) | Ground-glass opacities or ground-glass nodules other lobes of same or other lungs or both (5) Multiple medium size nodules other lobes of same or other lungs or both (6) Multiple cavitory nodules both lungs (2) Normal contralateral lung (1) |

HRCT: High-resolution computed tomography, ABPA: Allergic bronchopulmonary aspergillosis

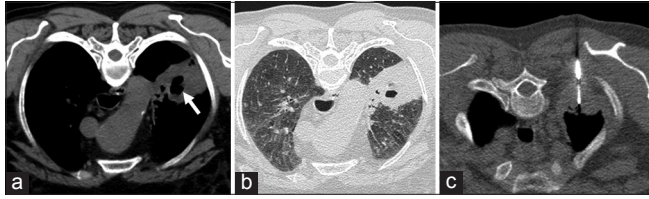


Figure 2: A 58-year-old female, incidentally diagnosed with the left upper lobe consolidation. (a and b) High-resolution computed tomography shows single segment consolidation with internal cavitation (arrow). (c) Needle inside lesion during biopsy. Histopathology was suggestive of granulomatous inflammation. Due to the absence of symptoms, she was kept on follow-up. Her sputum became positive for tubercle bacilli 2 months after biopsy and then antitubercular treatment was started.

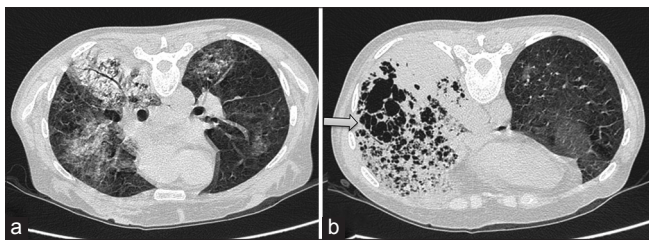


Figure 3: A 49-year-old female presented with cough, copious expectoration, and chest pain for 4 months. Sputum, bronchoalveolar lavage, and transbronchial lung biopsy results were inconclusive. (a and b) High-resolution computed tomography showed multiple contiguous lobe consolidation, air-filled cysts (arrow), air bronchogram, and ground-glass opacities both lungs. Final diagnosis was malignancy.

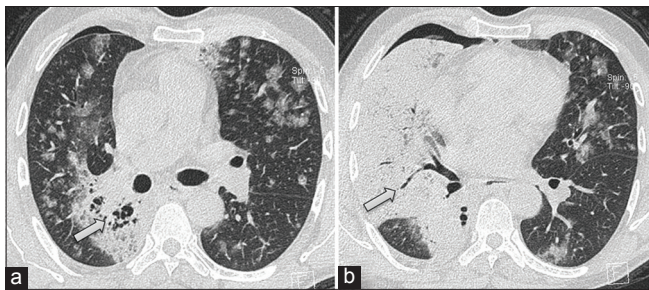


Figure 4: A 69-year-old male presented with shortness of breath, cough with expectoration, chest pain, fever, and loss of appetite for 9 months. Bronchoalveolar lavage reports were inconclusive. (a) High-resolution computed tomography showed multiple contiguous lobe consolidation with multiple ground-glass nodules in both lungs. Multiple air-filled cysts are seen inside (arrow). (b) Image at a lower level shows air bronchogram (arrow). Small post-procedural pneumothorax is also noted. Histopathology was adenocarcinoma.

in 1, heterogeneous enhancement in 3, and hyperdense bronchial mucus in 1 patient. One patient has fine nodular outline of consolidations. One patient with single lobe consolidation was having few tiny nodules in other lungs with peribronchovascular distribution. Raised diaphragm on the same side was noted in one patient.



Figure 5: A 50-year-old male presented with shortness of breath and fever for 1.5 months. Sputum was positive for *Acinetobacter* and *Citrobacter*. Bronchoalveolar lavage shows the presence of pseudomonas. (a-c) Computed tomography shows single lobe consolidation with large round internal fluid pocket. Biopsy yielded purulent material showing the presence of Gram-positive cocci. Culture was negative. The patient improved with antibiotics and metronidazole.

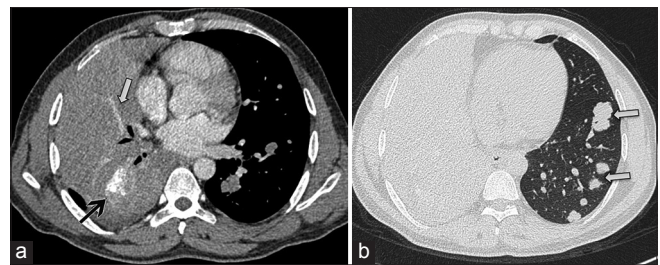


Figure 6: A 49-year-old male presented with dyspnea on exertion for 24 months. (a) Computed tomography shows consolidation of entire right lung with air bronchogram, preserved vascular marking (white arrow), and powdery calcification (black arrow) in the consolidated lung. (b) The left lung shows multiple solid nodules (arrow). Histopathology was suggestive of papillary adenocarcinoma.

PCLB was technically successful in all except one patient where biopsy could not be completed due to the development of pneumothorax and marked respiratory distress. Complications were noted in 10 patients including mild hemoptysis in 5 and pneumothorax in 5, which were managed conservatively. In 55 successful biopsies, specimens were sent for histopathology in 53 cases, for cytology in 1 case as only pus could be aspirated and in 1 case for both cytology and histopathology, results of which are described in Table 3.

Specimens were sent for microbiological examination in 25 cases, mostly for tuberculosis and fungi. Cartridge-based nucleic acid amplification test (GeneXpert assay) was introduced in our institute since 2017 providing rapid results which encouraged sending specimen for tuberculosis. Specimens were sent for bacterial staining and culture in two cases only. Routine culture was positive for tuberculosis in one case. Heavy growth of candida was seen in one case. Bacterial infection was identified on one case on staining. GeneXpert assay could detect tuberculosis in three cases while culture was negative on the same specimens.

Final diagnosis was achieved in 48 patients and 8 patients lost to follow-up [Table 4]. Results were diagnostic and concordant in 39 patients. Diagnostic yield in our study was 69.6% (39/56) patient wise and 66.1% (39/59) procedure wise. In this category, histopathology report was confusing in two cases (one interstitial lung disease and one vasculitis); however, microbiological report suggested correct diagnosis (bacterial abscess and tuberculosis, respectively).

Diagnostic and discordant results were obtained in four patients. In this category, two cases of bacterial pneumonia were diagnosed as organizing pneumonia on histopathology. One case of bacterial pneumonia with abscess was diagnosed as interstitial lung disease on histopathology. One case of sarcoidosis was diagnosed as non-specific inflammation on histopathology and BAL culture was positive for tuberculosis.

Table 3: Results of histopathology and cytology specimens.

| Specimen | Number of patients |
|---|--------------------|
| Histopathology (n=54) | |
| Adenocarcinoma (papillary variant 2, BAC 1) | 16 |
| Squamous cell carcinoma | 1 |
| Granulomatous inflammation | 7 |
| Tuberculosis | 3 |
| Vasculitis | 1 |
| Organizing inflammation and pneumonia | 3 |
| Eosinophilic pneumonia, suspicious of ABPA | 1 |
| Inflammatory lesion | 2 |
| Non-specific inflammation | 16 |
| Interstitial lung disease | 2 |
| Normal lung parenchyma | 1 |
| Inadequate | 1 |
| Cytopathology (n=2) | |
| Inflammatory lesion | 1 |
| Bacterial infection | 1 |

BAC: Bronchioloalveolar carcinoma, ABPA: Allergic bronchopulmonary aspergillosis

Table 4: List of various etiologies after final diagnosis.

| Final outcome | Number of cases |
|---|-----------------|
| Malignant (n=19) | |
| Adenocarcinoma | 16 |
| Squamous cell carcinoma | 1 |
| Lymphoma | 1 |
| Malignant etiology (not specified) | 1 |
| Benign (n=29) | |
| Tuberculosis | 11 |
| Bacterial abscess or pneumonia or both | 11 |
| Sarcoidosis | 3 |
| Organizing pneumonia | 2 |
| Atelectasis | 1 |
| Allergic bronchopulmonary aspergillosis | 1 |
| Uncertain | 8 |

However, despite anti-tuberculosis treatment intake, the lung lesions of this patient progressed and evolved in typical sarcoidosis. Results were non-diagnostic in 13 patients, as shown in Table 5.

Correlation of final diagnosis with clinical features is presented in Table 6. As history was not available in one patient, correlation could be done in 47 patients. No clinical feature was having statistically significant association with final diagnosis; however, the presence of fever and hemoptysis was more common in benign cases. Correlation of HRCT features with final outcome was done in 48 patients [Table 7]. Findings significantly associated with malignant outcome were larger size of consolidation, multiple contiguous lobe involvement, multiple air-filled cysts inside consolidation, and associated ground-glass areas or multiple ground-glass nodules [Figures 3 and 4]. Final diagnosis was not made in a case having ground-glass halo (non-specific inflammation on histopathology). The absence of air bronchogram was more common in benign cases. Rounded internal fluid pockets were mostly seen in bacterial abscess and tuberculosis. Powdery calcification was seen in two malignant cases only.

Heterogeneous enhancement was seen in one case of adenocarcinoma, squamous cell carcinoma, and tuberculosis each. Air-filled bronchiectasis was seen in one case of adenocarcinoma. Hyperdense bronchial mucus in consolidated lung was seen in allergic bronchopulmonary aspergillosis. One patient with multiple peripheral segmental consolidations with fine nodular outline proved to be a case of sarcoidosis. One patient with a single lobe consolidation and few tiny nodules in other lungs in peribronchovascular distribution also proved to be of sarcoidosis. Consolidation with few tiny nodules in the same lobe was seen in two patients; one was diagnosed as lymphoma and other tuberculosis.

DISCUSSION

Non-resolving pneumonia or consolidation poses a great diagnostic dilemma as a number of non-infectious conditions including malignancies may present in a similar way.^[3] Even the signs and symptoms are non-specific and overlapping in infectious and non-infectious causes. Certain malignancies such as adenocarcinoma and lymphoma may present as consolidation without bronchial obstruction.^[3,6] Bronchoscopy with BAL and often transbronchial biopsy is usually the first-line investigation for the evaluation of NRC. In cases, where these techniques are inconclusive or additional specimen is needed, PCLB is a promising technique.

Although results of lung biopsy involving different types of lesions have been reported extensively in literature, few series reports the results in pulmonary consolidation. Kiranantawat

Table 5: Analysis of non-diagnostic results.

| Results from biopsy specimen | Final diagnosis | Basis of final diagnosis |
|---|--------------------------|---|
| Technical failure (<i>n</i> =1) | Malignancy (1) | Bone scan revealed multiple bony metastases |
| Non-specific inflammation (<i>n</i> =11) | Uncertain (8) | Lost to follow-up |
| | Tuberculosis (2) | Response to empiric ATT |
| | Organizing pneumonia (1) | RA factor positive, response to steroid treatment |
| Inadequate (<i>n</i> =1) | Hodgkin lymphoma (1) | Biopsy from left axillary node |

ATT: Antituberculosis treatment, RA: Rheumatoid arthritis

Table 6: Correlation of age, gender, and clinical features with final diagnosis.

| Clinical features | Benign | Malignant | Total | <i>P</i> value |
|------------------------------------|----------------|----------------|-------|----------------|
| Gender | | | | 0.538 |
| Male | 21 | 12 | 33 | |
| Female | 8 | 7 | 15 | |
| Age (years) | 49.7 (SD 15.0) | 53.5 (SD 13.8) | 48 | 0.379 |
| Mean duration of symptoms (months) | 5.6 (SD 9.6) | 9.1 (SD 7.3) | 45 | 0.203 |
| Cough | | | | 0.766 |
| Absent | 10 | 7 | 17 | |
| Present | 19 | 11 | 30 | |
| Expectoration | | | | 1.000 |
| Absent | 18 | 11 | 29 | |
| Present | 11 | 7 | 18 | |
| Shortness of breath | | | | 1.000 |
| Absent | 14 | 9 | 23 | |
| Present | 15 | 9 | 24 | |
| Fever | | | | 0.070 |
| Absent | 12 | 13 | 25 | |
| Present | 17 | 5 | 22 | |
| Reduced appetite | | | | 1.000 |
| Absent | 22 | 14 | 36 | |
| Present | 7 | 4 | 11 | |
| Hemoptysis | | | | 0.225 |
| Absent | 23 | 17 | 40 | |
| Present | 6 | 1 | 7 | |
| Chest pain | | | | 0.753 |
| Absent | 19 | 13 | 32 | |
| Present | 10 | 5 | 15 | |

SD: Standard deviation

et al. reported diagnostic accuracy and safety of percutaneous transthoracic needle biopsy in the evaluation of 30 patients with pulmonary consolidation. Diagnostic accuracy was 83% in their series with minor complications in 13% including self-limiting hemoptysis and pneumothorax.^[4] Ferretti *et al.* reported the results of percutaneous CT-guided needle biopsy in 23 patients with non-resolving focal air space consolidations and negative fiberoptic bronchoscopy (FOB) results.^[7] Diagnostic yield of core needle biopsy was 78%. Immediate pneumothorax was noted in 47.8% of patients with 8.6% requiring pleural drainage. Diagnostic yield in our study was 69.6% (39/56). Complications were noted in 17.8% of patients including mild self-limiting

hemoptysis in 8.9% and pneumothorax in 8.9%, which were managed conservatively.

Sputum cytology is a simple and non-invasive test for the diagnosis of lung cancer. Muniyappa *et al.* reported 43.8% positivity of malignant cells in early morning sputum of lung cancer patients in South Indian population.^[8] They also observed that sputum cytology is highly sensitive for centrally located squamous cell carcinomas rather than peripherally located adenocarcinomas. In our study, malignant cells were not detected in sputum of any case. The reason for this could be that most of malignant cases in our study were adenocarcinomas. *Candida* and *Aspergillus* were detected in sputum of many cases, mostly in adenocarcinoma patients

Table 7: Correlation of HRCT features with final outcome in 48 patients.

| HRCT findings | Benign (n=29) | Malignant (n=19) | Total | P value |
|--|---------------|------------------|-------|---------|
| Largest dimension of consolidation (mm) | 72.89±21.79 | 99.63±33.77 | 48 | <0.05 |
| Single segment involvement | | | | NS |
| No | 20 | 18 | 38 | |
| Yes | 9 | 1 | 10 | |
| Single lobe involvement | | | | NS |
| No | 18 | 12 | 30 | |
| Yes | 11 | 7 | 18 | |
| Multiple discrete segments | | | | NS |
| No | 23 | 18 | 41 | |
| Yes | 6 | 1 | 7 | |
| Multiple contiguous lobes | | | | <0.05 |
| No | 26 | 9 | 35 | |
| Yes | 3 | 10 | 13 | |
| Air bronchogram | | | | <0.05 |
| Absent | 15 | 4 | 19 | |
| Present | 14 | 15 | 29 | |
| Internal cavitation | | | | NS |
| Absent | 20 | 15 | 35 | |
| Present | 9 | 4 | 13 | |
| Multiple air-filled cysts inside consolidation | | | | <0.05 |
| Absent | 29 | 13 | 42 | |
| Present | 0 | 6 | 6 | |
| Rounded internal fluid pockets | | | | NS |
| Absent | 24 | 19 | 43 | |
| Present | 5 | 0 | 5 | |
| Powdery calcification | | | | NS |
| Absent | 29 | 17 | 46 | |
| Present | 0 | 2 | 2 | |
| Background vascular architecture ^f | | | | NS |
| Preserved | 13 | 10 | 23 | |
| Distorted | 5 | 2 | 7 | |
| Lymphadenopathy | | | | NS |
| Absent | 23 | 16 | 39 | |
| Present | 6 | 3 | 9 | |
| Effusion | | | | NS |
| Absent | 25 | 18 | 43 | |
| Present | 4 | 1 | 5 | |
| Ground-glass opacity or ground-glass nodules | | | | 0.002 |
| Absent | 29 | 13 | 42 | |
| Present | 0 | 6 | 6 | |
| Multiple medium-sized solid nodules (other lobes or other lungs) | | | | NS |
| Absent | 26 | 13 | 39 | |
| Present | 3 | 6 | 9 | |
| Enhancement ^g | | | | NS |
| Minimal | 11 | 6 | 17 | |
| Mild | 8 | 6 | 14 | |
| Moderate | 2 | 1 | 3 | |
| Margins of consolidation | | | | NS |
| Ill-defined or irregular | 25 | 17 | 42 | |
| Well defined or lobulated | 4 | 2 | 6 | |
| Density (compared to posterior spinal muscles) | | | | NS |
| Hyperdense | 0 | 2 | 2 | |
| Hypodense | 6 | 5 | 11 | |
| Isodense | 23 | 12 | 35 | |

^fTotal 30 patients in this group, ^gTotal 34 patients in this group. HRCT: High-resolution computed tomography

likely due to colonization. Correct diagnosis was suggested on sputum examination in one case of bacterial infection and one case of tuberculosis.

BAL has been reported to have diagnostic yield of 83.67% in suspected cases of lung malignancy.^[9] However, in this series, most of malignancies were squamous cell or small cell carcinoma and were associated with bronchoscopically visible tumor. BAL cytology has not shown malignant cells in our series in subsequently proven malignant cases. The reason for this could be that only one case in our series had an endobronchial mass and most of malignant cases were due to adenocarcinoma. Similar to sputum, *Candida* and *Aspergillus* were noted in many cases on BAL, mostly in adenocarcinoma. A study was conducted by Chaudhuri *et al.* on non-resolving pneumonia with special reference to the role of FOB and CT-guided fine-needle aspiration cytology (FNAC).^[10] FOB was supplemented with BAL in all cases ($n = 56$). CT-guided FNAC was done in 11 patients. Both FOB and CT-guided FNAC were very useful for etiological diagnosis of non-resolving pneumonia with diagnostic yield of 85.7% and 91.6%, respectively. However, in our study, cases that remained inconclusive after sputum and bronchoscopy were subjected to CT-guided biopsy and we have no details of cases of NRC which were successfully diagnosed with the help of sputum and bronchoscopy.

In our study, no clinical feature was useful in differentiation of benign from malignant etiology. Many studies have been done to assess the role of CT features in differentiation of infectious pneumonia from bronchioloalveolar carcinoma (BAC).^[11-13] Aquino *et al.* in a retrospective study ($n = 40$) found that coexisting nodules and peripheral distribution of consolidation were significantly associated with consolidative BAC in adults with normal immunity.^[11] The presence of atelectasis and CT angiogram sign (preserved background vessels) was associated with infective pneumonia. In a similar study, Jung *et al.* found that CT findings favoring the diagnosis of BAC included an air-filled bronchus within the consolidation with stretching, squeezing, sweeping, widening of the branching angle, and bulging of the interlobar fissure.^[12] In our study, findings associated with malignant outcome were multiple contiguous lobe involvement, multiple air-filled cysts inside consolidation, and associated ground-glass areas or multiple ground-glass nodules. Cystic air spaces have been described in lung malignancies.^[14] Kim *et al.* have also described that the presence of bubble-like low-attenuation areas inside consolidation is associated with BAC.^[13] However, caution has to exercise in cases where there is coexistent emphysema or bronchiectasis.

In our study, we observed that the presence of ground-glass areas or ground-glass nodules was associated with malignant outcome, most of which were adenocarcinomas, whereas coexisting multiple solid nodules were seen in both

benign and malignant cases. Aquino *et al.* also observed that the presence of coexisting nodules is associated with BAC; however, they have not specified type of nodules. Invasive mucinous adenocarcinoma, formerly known as mucinous BAC, is characterized by its peripheral location and lepidic growth pattern (i.e. tumor growth along intact alveolar septa), and propensity to spread through airways and lymphatics.^[15] The spectrum of radiological findings in these cases includes consolidations, air bronchograms, multifocal solid or subsolid nodules or masses, cavitations, and persistent ground-glass opacities.^[6,15] In our study, the presence of air bronchogram was seen in both benign and malignant disease, whereas its absence was associated with benign outcome.

Our study highlights the emerging pattern of lung malignancy mimicking infective consolidation and utility of PCLB in such cases; however, there are many limitations. Our study is retrospective in nature, biopsies were conducted by multiple radiologists, and microbiological specimens were not sent in some cases. Eight cases were lost to follow-up which has led to a relatively low diagnostic yield. We believe that most of these cases had benign outcome and patients stop seeking medical attention.

CONCLUSION

PCLB is a safe and useful method for obtaining specimen in NRC with inconclusive reports on other investigations. Adenocarcinoma may present as NRC in many cases and malignant cells may not be detected on sputum or BAL cytology. Differentiation of benign from malignant outcome is not possible based on clinical findings due to overlapping features. However, the presence of multiple air-filled cysts in consolidations, multiple contiguous lobe involvement, and associated ground-glass opacities or ground-glass nodules on HRCT should raise suspicion of malignancy.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms.

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Conflicts of interest

There are no conflicts of interest.

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