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Position-Dependent Lung Shadow Movement

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ABSTRACT

A 73-year-old male presented with an abnormal chest x-ray revealing ground-glass opacity (GGO) in the left lower lung field, accompanied by elevated KL-6, SP-D, and GM-CSF antibody levels, indicative of autoimmune pulmonary alveolar proteinosis (PAP). Initial bronchoalveolar lavage and transbronchial lung biopsy revealed only nonspecific findings. During a CT-guided needle aspiration biopsy (CT-NAB), real-time imaging showed that GGO gradually moved and shifted with positional changes. Although PAP is not fully confirmed yet due to a lack of pathological findings, this case highlights several clinical suggestions for patients with atypical lung shadows, including those with suspicion of PAP. Further, this is the first report of lung shadow mobility during CT-NAB, emphasising the need for further studies to elucidate the pathophysiology of lung shadows and improve diagnostic accuracy.

1 | Introduction

Pulmonary alveolar proteinosis (PAP) is a rare pulmonary disease characterised by surfactant accumulation in alveoli [1]. Diagnosis can be challenging, particularly in the early stages, due to subtle/nonspecific imaging/pathological findings [1, 2]. We report a unique case with unilateral lung shadow, presumably attributable to autoimmune PAP, with positional changes in lung shadows observed during CT-guided needle aspiration biopsy (CT-NAB).

2 | Case Report

A 73-year-old Asian male was referred to our hospital following an abnormal chest X-ray at his annual health checkup. Medical history included pulmonary tuberculosis diagnosed in adolescence. The 2022 x-ray showed only old linear consolidation in the right upper lobe, consistent with previous tuberculosis. However, the 2023 X-ray revealed ground-glass opacity in the left lower lung field (Figure 1A), resulting in a referral for further evaluation in summer 2024. The patient took only olopatadine and montelukast prescribed for transient urticaria. He had a minimal smoking history and denied using supplements or illicit drugs. He was working at a supermarket and had no history of dust exposure.

Chest CT revealed patchy consolidation and ground-glass opacities with septal wall thickening, presenting a crazy-paving pattern in the left lower lobe, with shadow concentration on the caudal side (Figure 1B–E). Physical examination revealed no crackles, heart murmur, leg oedema, or signs of connective tissue disease. Laboratory results showed elevated Krebs von den Lungen (KL-6; 700 U/mL) and surfactant protein D (SP-D; 218.1 ng/mL). Other

parameters (C-reactive protein, lactate dehydrogenase, white blood cell count, and biochemistry) were normal. Tests for procalcitonin, beta-d-glucan, tuberculosis (interferon-gamma release assay), anti-Aspergillus antigen, immunoglobulin G4, autoimmune antibodies, and specific antigens were negative. Regarding tumour markers, CEA, SCC, and CYFRA were normal, but PRO-GRP (59.2 pg/mL) and SLX (41.7 U/mL) were slightly elevated.

Bronchoalveolar lavage (BAL) revealed a mildly cloudy appearance with a lymphocyte-dominant cellular profile of 84%. Random transbronchial lung biopsy (TBLB) showed nonspecific findings in the lung tissue, with subtle lymphocyte infiltration.

Laboratory and CT findings indicated PAP; however, the possibility of other lung diseases, including malignancy, remained. Therefore, we performed CT-NAB for diagnostic confirmation and to exclude malignancy. During CT-NAB in the prone position, the lung shadow in the left lower lobe shifted downward (Figure 2A–C), prompting a change in approach to the left lateral chest. Subsequently, the patient was repositioned supine, and further observations confirmed posterior shifting of the lung shadow with the crazy-paving pattern (Figure 2D–F). Unfortunately, the pathological results showed only nonspecific findings of lymphocyte infiltration. However, subsequent serological testing revealed elevated serum granulocyte macrophage colony-stimulating factor antibody (GM-CSF antibody) levels of 10.6 U/mL (reference: < 1.7 U/mL), leading to a diagnosis of possible autoimmune PAP due to the lack of pathological findings.

3 | Discussion

The CT-NAB findings of this case warrant discussion, as this is the first report describing short-term movements of lung shadows. In clinical practice, CT scans are rarely repeated, obscuring time-dependent changes in lung shadows.

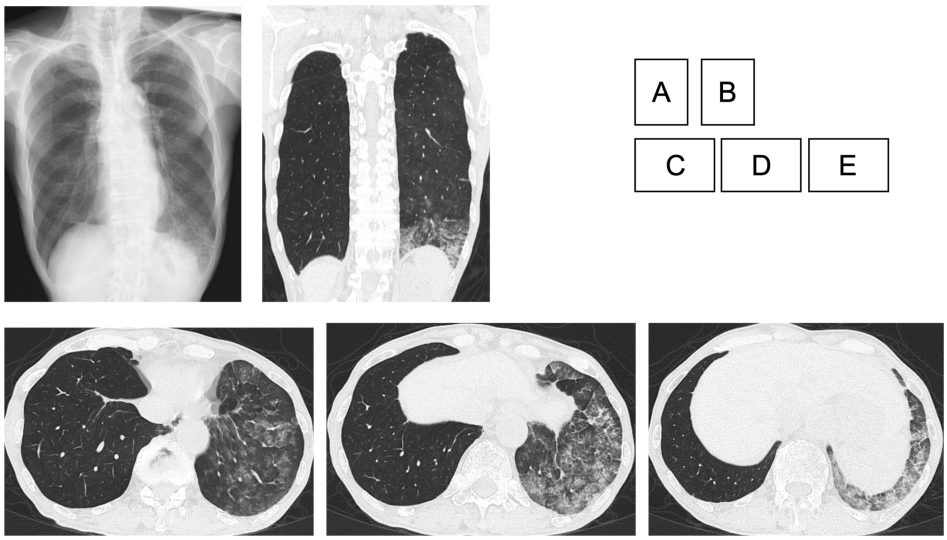

FIGURE 1 | Chest X-ray and CT findings. (A) The chest radiograph and (B–E) chest CT scans. CT images show patchy consolidations and ground-glass opacities with septal wall thickening, forming a 'crazy paving' pattern in the left lower lobe. CT = computed tomography.

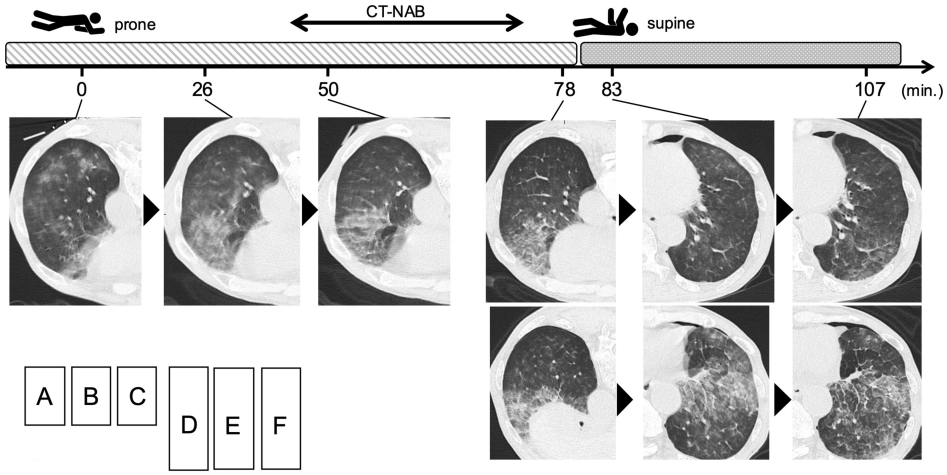

FIGURE 2 | Chronological changes in chest CT findings. (A–D) were obtained with the patient in the prone position during the CT-NAB procedure. Following this procedure, the patient was placed in the supine position (E and F). The horizontal axis represents the time (in minutes) from the prone position to the end of the observation period. CT = computed tomography; NAB = needle aspiration biopsy.

Several hypotheses may explain the phenomenon in the present case. First, anatomical characteristics, such as the interconnection of alveolar ducts leading to the respiratory and terminal bronchioles, and Kohn's pores between adjacent alveoli [3], combined with gravitational effects, may facilitate fluid movement. Moreover, pulmonary blood flow and alveolar ventilation vary significantly with body positioning. When upright, pulmonary blood flow per unit lung volume increases at the lung bases [4], while ventilation predominates at the lung apices [5]. Since CT scans are based on air–liquid density, this may contribute to the observed phenomenon, depending on positioning. However, these cannot fully explain the downward lung shadow shifting (Figure 2B–F), where the initially higher lung shadow gradually shifted downward over time. Further, lung shadows are often associated with pulmonary oedema. However, there were no signs of heart failure or valvular disease, nor any evidence of pulmonary embolism/vascular abnormalities. Follow-up CT and chest X-ray after several days/months showed no significant changes, suggesting a lower likelihood of pulmonary oedema.

Another hypothesis suggests that movement of the lung shadow could indicate early-phase PAP. As PAP is characterised by insoluble surfactant sediment accumulation [1], it is reasonable to assume that the surfactant exhibits lower turbidity in early stages. Therefore, reduced alveolar fluid turbidity may indicate early PAP, contributing to shadow mobility. However, this hypothesis requires further validation. Previous reports have indicated that statins could reduce alveolar fluid turbidity [6], raising the possibility of a reverse phenomenon, supporting our hypothesis.

The greatest limitation of this case is the failure to establish a definite diagnosis due to the lack of pathological findings. PAP has been reported to coexist with other diseases, including sarcoidosis and hypersensitivity pneumonitis (HP) [7, 8]. Given our patient's lymphocyte-dominant BAL fluid, a comorbid condition is possible. However, as the patient showed no pathological granuloma or relevant patient history for HP, none of the differential diagnoses is entirely conclusive. Therefore, we diagnosed this case as "possible PAP."

Nevertheless, this case raises two important considerations for respiratory physicians. First, clinicians should proactively consider GM-CSF antibody testing. Currently, PAP is not suspected unless BAL fluid appears turbid/milky, and GM-CSF antibody testing is not included in the diagnosis [2]. However, we propose that atypical features, including localised shadows, nonturbid BAL fluid, and inconsistent imaging findings, could indicate the possibility of early-phase PAP. If imaging raises suspicion, anti-GM-CSF antibody testing should be performed. Consequently, the prevalence of PAP may be higher than estimated [1, 2].

Second, clinicians must carefully select BAL and biopsy sites. These procedures are typically guided by preprocedural imaging; however, the lung shadow may shift once the patient is placed supine, increasing the risk of sampling errors and presenting diagnostic challenges. Such concerns are less significant in patients with lung cancer or interstitial lung disease, where lesions/masses are solid and stationary. In this case, although the GM-CSF antibody was positive, consistent with PAP, pathology was inconclusive, possibly due to the biopsy site. We performed random biopsies in segments 8 and 9 of the left lower lobe, positioned upward in the supine position. Considering the CT results, transbronchial lung biopsy may have resulted in sampling errors. Indeed, McCarthy et al. also reported low biopsy sensitivity in a patient with PAP [9], supporting our hypothesis. Recently, Azuma et al. reported that the combination of TBLB and BAL achieved a notably high diagnostic yield for PAP [10]. Additionally, transbronchial lung cryobiopsy is a useful diagnostic tool, particularly with coexisting interstitial lung disease [11]. These techniques enhance diagnostic accuracy; however, further studies must determine their applicability to lung shadows that migrate with positional changes.

In conclusion, this case highlights the positional effects of lung shadow with a crazy-paving pattern, presumably in early PAP phases, and underscores the need for further studies to improve diagnosis and management.

Author Contributions

T.B. wrote the manuscript. Y.S., W.K., and M.I. reviewed and edited the manuscript. K.W. was responsible for the pathological results. All authors reviewed and confirmed the contents of the final manuscript.

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Ethics Statement

The authors declare that appropriate written informed consent was obtained for the publication of this manuscript and accompanying images.

Conflicts of Interest

Tomohiro Bando reports honouraria for lectures from AstraZeneca and Boehringer Ingelheim Co. Ltd., outside of the submitted work. The other authors declare no conflicts of interest.

Data Availability Statement

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

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