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Oxygen As A Safety Lever: Accelerating Pneumothorax Resolution After Navigational Bronchoscopy Through Targeted Nitrogen Washout. Peer-Review.

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Abstract

Background: Pneumothorax is a common complication of navigational bronchoscopy for peripheral lung biopsies, occurring in 5–15% of cases. While high-concentration oxygen is known to accelerate resolution of spontaneous pneumothorax via nitrogen washout, its proactive intraoperative use as a mitigation strategy during bronchoscopy remains unexplored.

Case Summary: A 56-year-old woman with a history of breast cancer underwent navigational bronchoscopy for biopsy of a 6-mm right middle lobe nodule. High-concentration oxygen was administered throughout the procedure. A moderate post-procedural pneumothorax was detected on chest X-ray but resolved significantly within 3 hours and completely by 24 hours without chest drain insertion. Serial imaging confirmed full resolution at 21-day follow-up. ***Conclusion:*** This case suggests that intraoperative high FiO_2 may harness the nitrogen washout effect to rapidly resolve iatrogenic pneumothorax, potentially avoiding invasive intervention. We propose a risk-stratified framework to guide targeted use—positioning oxygen not merely as a ventilatory support, but as an active safety lever in bronchoscopic lung biopsy.

Keywords: navigational bronchoscopy; pneumothorax; nitrogen washout; high-concentration oxygen; peripheral lung biopsy; complication mitigation; FiO_2; case report

Introduction

Navigational bronchoscopy has transformed the diagnostic approach to peripheral pulmonary nodules, enabling biopsy of lesions previously accessible only via transthoracic needle aspiration or surgery [1]. However, this advance carries a trade-off: a 5–15% risk of pneumothorax, with 1–5% requiring chest drain insertion [2,3]. Current procedural protocols focus on lesion selection, navigation accuracy,

and operator training—but pay little attention to modifiable intraoperative factors that might mitigate complications once they occur.

One such factor is inspired oxygen concentration. High FiO_2 drives nitrogen washout from the pleural space by reducing the partial pressure gradient that normally impedes gas reabsorption [4]. This principle underpins conservative management of spontaneous pneumothorax [5], yet it is rarely applied proactively during bronchoscopy.

Instead, oxygen is administered passively—as part of anaesthetic maintenance—without explicit consideration of its potential therapeutic role in complication mitigation.

This represents a critical gap. If high FiO_2 can accelerate resolution of iatrogenic pneumothorax, then its use could reduce hospital stays, avoid chest drains, and improve patient experience. But indiscriminate application risks absorption atelectasis, particularly in patients with airway obstruction or emphysema [6]. Thus, a precision approach—identifying who benefits most—is essential.

We present a case where targeted high-concentration oxygen during navigational bronchoscopy was followed by unusually rapid resolution of a moderate pneumothorax. We contextualise this within current evidence and propose a novel, risk-based framework for oxygen use—repositioning it from background support to intentional safety intervention.

Methods

This report follows the CARE (CAse REport) guidelines [7] to ensure methodological transparency and clinical relevance.

A single adult patient was included. Written informed consent for publication of anonymised clinical details and imaging was documented in the medical record. No institutional ethics approval was required for single-case publication under UK Health Research Authority guidance, though the case was reviewed under local clinical governance.

The procedure was performed in a tertiary cardiothoracic centre as part of standard diagnostic workup for indeterminate pulmonary nodules in a patient with prior breast cancer. Pre-procedure imaging included contrast-enhanced chest CT and PET-CT. Intraoperative three-dimensional electromagnetic navigational planning guided transbronchial biopsy. Anaesthesia was delivered via a single-lumen endotracheal tube with FiO_2 maintained at ≥ 0.8 throughout the procedure, based on pre-procedure multidisciplinary agreement. Post-procedure monitoring included serial chest radiographs at 0, 3 and 24 hours, with clinical assessment of respiratory status.

Data were extracted from electronic health records and verified by two clinicians. Radiological findings were confirmed by a thoracic surgeon.

Case Presentation

A 56-year-old woman with a history of right breast cancer—but no significant comorbidities—was referred for navigational bronchoscopy following the incidental detection of multiple pulmonary nodules on staging imaging. Chest CT demonstrated bilateral nodules with associated atelectasis; subsequent PET-CT showed no FDG avidity. Intraoperative three-dimensional (3D) navigational planning identified a 6-mm peripheral nodule in the right middle lobe amenable to biopsy. Two additional nodules—a 2-mm lesion in the right upper lobe and a left lower lobe nodule adjacent to the descending aorta and vertebrae—were deemed non-accessible due to the absence of a direct airway path and proximity to critical structures, respectively, and were not sampled.

Following multidisciplinary discussion, including input from anaesthesia, the procedure was performed under general anaesthesia via a single-lumen endotracheal tube with administration of high-concentration supplemental oxygen ≥ 0.8 throughout. Multiple transbronchial biopsies were obtained from the right middle lobe (Figure 1).

Post-procedure chest radiography in recovery revealed a moderate right-sided pneumothorax (Figure 2). The patient remained haemodynamically stable, reporting only mild pleuritic discomfort, and was managed conservatively without chest drain insertion. Serial chest X-rays over the next 24 hours demonstrated rapid resolution: significant reduction was evident at 3 hours (Figure 3) and near-complete resolution by 24 hours (Figure 4). At outpatient follow-up 12 days later, chest imaging confirmed full resolution of the pneumothorax (Figure 5).

Discussion

The rapid spontaneous resolution of a moderate post-bronchoscopic pneumothorax in our patient—despite no chest drain insertion—raises important physiological and procedural considerations. Notably, the administration of high-concentration supplemental oxygen during the procedure likely accelerated pleural air reabsorption through the well-documented nitrogen washout effect [1]. Nitrogen constitutes ~78% of atmospheric air and is poorly soluble in blood; when pleural air contains a high nitrogen fraction, reabsorption is slow. By contrast, high inspired oxygen fractions (FiO_2 > 0.6) reduce alveolar and pleural nitrogen partial pressure, creating a diffusion gradient that enhances nitrogen clearance from the pleural space and accelerates pneumothorax resolution [1,2].

This physiological principle has long been applied in the conservative management of spontaneous pneumothorax [3], yet its prophylactic or intraoperative use during high-risk bronchoscopic interventions remains underexplored. Navigational bronchoscopy—particularly for peripheral lesions—carries a 5–15% risk of pneumothorax, with 1–5% requiring chest drain insertion [4,5]. Current guidelines (e.g., British Thoracic Society, American College of Chest Physicians) do not address intraoperative oxygen strategies to mitigate or accelerate resolution of procedure-related pneumothorax [6,7].

Our case illustrates a potential benefit of preemptive high FiO_2 in patients undergoing transbronchial biopsy of peripheral nodules. The pneumothorax, though moderate in size, resolved significantly within 3 hours and completely by 24 hours—far quicker than typical natural history (which may take 4–6 weeks for a 30% pneumothorax without intervention) [8]. This aligns with experimental models: in rabbit studies, 100% oxygen reduced pleural air volume by 50% within 2 hours, versus minimal change with room air [9].

However, this approach is not without controversy. Prolonged high FiO_2 can cause absorption atelectasis, particularly in dependent lung zones or in the presence of airway obstruction—a concern in patients with underlying atelectasis or mucus plugging, as seen in our case [10]. Yet, during brief procedural windows under controlled ventilation, such risks appear minimal, especially when weighed against the morbidity of chest drain insertion (pain, prolonged hospitalisation, infection risk) [11].

Critically, the literature lacks prospective data identifying which patients would benefit most from this strategy. We propose a risk-stratified framework:

1. **High-benefit candidates**:
    - Patients with peripheral, non-subpleural nodules requiring transbronchial biopsy with significant lung puncture (high pneumothorax risk);
    - Those with limited cardiopulmonary reserve, where even small Pneumothoraces could be poorly tolerated;
    - Individuals in resource-limited settings or for outpatient procedures where immediate chest drain access is impractical.
2. **Cautious or contraindicated use**:
    - Patients with significant bullous emphysema (risk of oxygen-induced bulla rupture);
    - Those with active oxygen-sensitive conditions (e.g., paraquat toxicity, certain chemotherapies);
    - Cases involving prolonged procedural times (>2 hours), where atelectasis risk rises [10].

Notably, our patient had no emphysema and underwent a relatively short procedure (<30 minutes), making her an ideal candidate. The presence of atelectasis on pre-procedure imaging did not impede resolution—suggesting that localized atelectasis may not negate the systemic nitrogen washout benefit.

This case also highlights a gap in procedural protocols: while navigational bronchoscopy increasingly incorporates real-time planning and robotic assistance, oxygen management remains an underutilised modifiable factor in complication mitigation. Future studies should prospectively evaluate FiO_2 titration (e.g., 60% vs. 100%) during bronchoscopic biopsies, with primary outcomes including pneumothorax incidence, size, time to resolution, and need for intervention.

Conclusion

High-concentration oxygen administration during navigational bronchoscopy may harness the nitrogen washout effect to accelerate resolution of iatrogenic pneumothorax, potentially averting invasive interventions. While not universally applicable, this strategy appears safe and effective in selected patients—particularly those without emphysema undergoing short-duration peripheral biopsies. We advocate for prospective validation of a risk-based oxygen protocol to optimise patient safety and procedural efficiency. Until then, clinicians should consider intraoperative high FiO_2 as a low-cost, physiologically sound adjunct in appropriate cases.

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Competing interests

None declared.

Patient consent

Written informed consent for publication of anonymised clinical information and images was obtained and is documented in the patient's medical record.

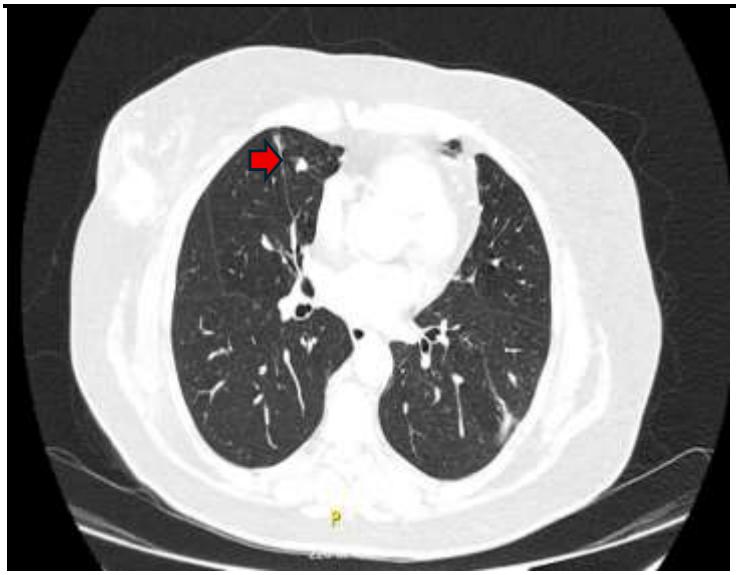

Figure 1Axial view of CT scan lung window, shows a small pulmonary nodule in the right middle lobe.

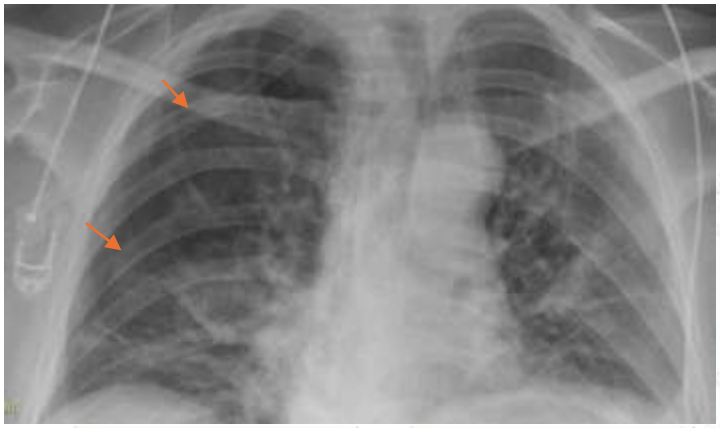

Figure 2 immediate postoperative

Figure 3 – (3 hours postoperative)

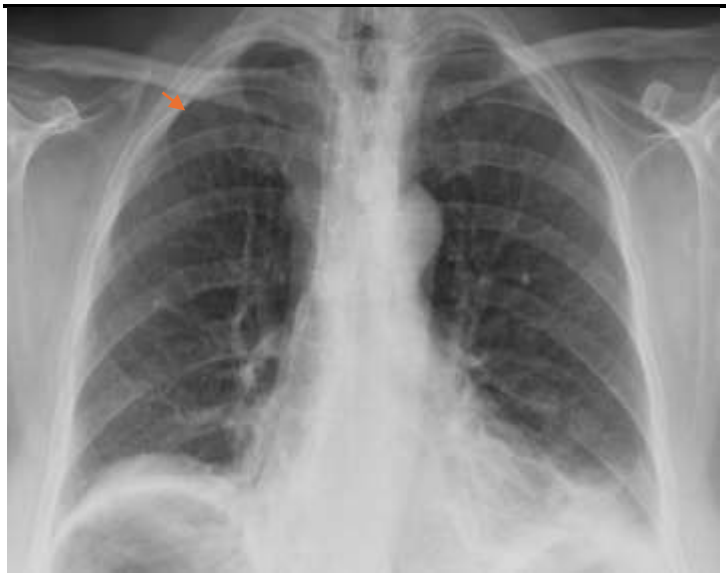

Figure 4 (24 hours postoperative)

Figure 5 (Outpatient 12 days postoperative)