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A Case of Persistent Air Leak Managed by Selective Left Main Bronchus Intubation in an Infant with Pulmonary Tuberculosis

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Data Interpretation D
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Conflict of interest: None declared

Patient: Male, 3-month-old
Final Diagnosis: Pulmonary tuberculosis
Symptoms: Respiratory distress
Medication: —
Clinical Procedure: Selective left main bronchus intubation
Specialty: Pediatrics and Neonatology

Objective: Unusual clinical course

Background: Persistent air leak, or persistent pneumothorax, is defined as a pneumothorax that persists beyond the first week, or air leak through a chest drain for more than 48 hours. The most common findings in pediatric pulmonary tuberculosis are parenchymal disease and mediastinal lymphadenopathy, but airway obstruction can cause emphysema and pneumothorax. A case is presented of persistent air leak in a 3-month-old infant with pulmonary tuberculosis that was managed by selective left main bronchus intubation.

Case Report: A 3-month-old boy presented with respiratory distress and fever. Imaging findings suggested pulmonary tuberculosis, and first-line anti-tuberculous treatment was initiated with isoniazid, rifampicin, pyrazinamide, and ethambutol (HRZE). He was discharged home after eight days, but was admitted four days later with respiratory distress. Chest X-rays showed a tension pneumothorax that required drainage and chest computed tomography (CT) showed right lung emphysema. Bronchoscopy found extrinsic obstruction of both main bronchi. Chest drains continued to leak air leak after 48 h. Right middle and lower lobectomy and drainage of multiple lymph nodes resulted in significant improvement. He developed pneumonia and acute respiratory distress syndrome, which prevented mechanical ventilation. The left main bronchus was selectively intubated to allow the air leak to heal and to ventilate the lung. He was extubated 10 days later and recovered completely.

Conclusions: This case highlights that when medical management of persistent air leak associated with tuberculosis is not effective, surgery, active ventilation, and selective main bronchus intubation should be considered.

MeSH Keywords: Pneumonectomy • Pneumothorax • Pulmonary Emphysema • Tuberculosis

Full-text PDF: <https://www.amjcaserep.com/abstract/index/idArt/920453>

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Background

Tuberculosis in neonates and children is an important public health issue, with an estimated incidence in Spain of 4.3 cases per 100,000 persons per year [1,2]. The diagnosis of pediatric tuberculosis can be challenging, as clinical and radiological signs can be variable, resulting in delayed treatment. In Europe, pediatric mortality due to tuberculosis is rare, but in cases with severe pulmonary or extrapulmonary disease, complications can result in increased morbidity and mortality [3].

The most common findings in pediatric pulmonary tuberculosis are parenchymal disease and mediastinal lymphadenopathy, but airway obstruction can cause emphysema and pneumothorax.

Following the diagnosis of pulmonary tuberculosis, medical treatment is the first-line treatment option. When emphysema results in pneumothorax and air leak, the management options include conservative treatment, drainage, or thoracotomy. Surgery is rarely performed and is usually reserved for pulmonary emphysema that results in persistent air leak [4]. Persistent air leak, or persistent pneumothorax, is defined as a pneumothorax that persists beyond the first week, or an air leak through a chest drain for more than 48 hours. A case is presented of persistent air leak in a 3-month-old infant with pulmonary tuberculosis that was managed by selective left main bronchus intubation.

Case Report

A 3-month-old male infant was admitted to our pediatric emergency department from a small local hospital in a neighboring town. He was in acute respiratory distress due to a mediastinal mass. His family explained that he had developed increasing difficulties in breathing and had a fever of up to 38.5°C during the previous five days. He had no remarkable past medical history. He was born at full-term, and newborn screening tests were negative. He had been asymptomatic from birth, and he had no previous infections. He had no syndromic features and had shown normal weight gain. He had received the first dose of the pediatric combination hexavalent vaccine (DTaP/HepB/IPV/Hib) containing diphtheria toxoid, tetanus toxoid, acellular pertussis, inactivated poliovirus, and recombinant hepatitis B virus (HBV) surface antigen. He had not received the Bacillus Calmette-Guérin (BCG) vaccine because it does not form part of the routine national vaccination schedule.

Chest X-rays performed at the primary care center showed lung hyperinflation and a left displacement of the trachea. Chest computed tomography (CT) showed collapse of the bronchus intermedius and air trapping in the right middle and lower lobes. Although he did not need respiratory support, it was decided to move him to our hospital, which had an intensive care unit.

On admission, he was admitted to the pediatric ward. A contrast-enhanced chest CT was performed, which showed findings suggestive of pulmonary tuberculosis (Figure 1).



Figure 1. Contrast-enhanced chest computed tomography (CT) imaging of a 3-month-old infant with pulmonary tuberculosis and persistent air leak. (A) Chest CT shows parenchymal lesions in the right upper lobe and the left lung. (B) There is emphysema in the right middle lobe and inferior right lower lobe and multiple mediastinal lymph nodes.

Laboratory tests showed microcytic anemia with a hemoglobin of 73 g/L, a mean corpuscular volume (MCV) of 76.5 fL, and an elevated C-reactive protein (CRP) of 4.2 mg/dL. Anemia was attributed to chronic inflammation and iron deficiency. Because the patient was hemodynamically stable, oral treatment with iron supplements was initiated. Three gastric aspirates were collected, and Ziehl–Neelsen staining for acid-fast bacilli was negative. The result of the interferon- γ release assay (IGRA) was positive, which supported a diagnosis of tuberculosis. The cerebrospinal fluid analysis was negative. A neutrophil oxidative burst assay for chronic granulomatous disease and a human immunodeficiency virus (HIV) test were negative.

However, because pulmonary tuberculosis was strongly suspected, first-line treatment with isoniazid, rifampicin, pyrazinamide, and ethambutol (HRZE) was initiated. After 48 hours of supplemental oxygen, the fraction of inspired oxygen in air (FIO₂) of 30% was delivered through a nasal cannula, and his respiratory distress resolved. The nasal cannula was withdrawn, and the chest X-ray confirmed no complications. Oral treatment was initiated and was well tolerated. The patient was discharged eight days later with no signs of respiratory distress.

However, four days later, he was readmitted to the small local hospital where he was initially treated for signs of respiratory distress and because vomiting made it impossible for his mother to manage his oral treatment. Chest X-ray showed pulmonary changes that raised the possibility of a reaction to medical treatment. He had signs of moderate respiratory distress, and so a high-flow nasal cannula was used, and his respiratory status improved. Anti-emetic treatment was also initiated, and the patient resumed oral treatment and remained stable for 11 days. On the 12th day of hospitalization, he presented with sudden worsening respiratory distress with desaturation and tachycardia, absent breath sounds over the right hemithorax, and severe respiratory acidosis. Chest X-ray showed a right tension pneumothorax. Needle thoracentesis was performed, and 100 cc of air was aspirated from the pleural space. However, there was no clinical improvement, and a chest tube was inserted. Because tachycardia, respiratory distress, and acidosis persisted, the patient was intubated nasally, and another chest tube was inserted (Figure 2). His condition improved, and he was transferred to our hospital.

During the next four days, he remained hemodynamically stable but had some episodes of respiratory failure due to recurrent pneumothorax that required manual aspiration through the chest tubes. Bronchoscopy was performed with a flexible fiberoptic bronchoscope, which showed extrinsic obstruction of both main bronchi, explaining the findings of emphysema. No endobronchial granulomas were seen. To prevent bronchial collapse during expiration, positive end-expiratory pressure (PEEP) was increased to 8 cmH₂O, and other ventilation

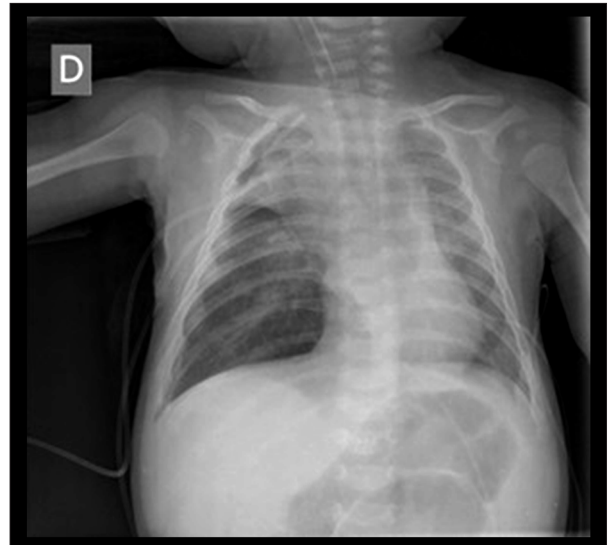


Figure 2. Chest X-ray imaging of a 3-month-old infant with pulmonary tuberculosis and persistent air leak. Chest radiographs show a right residual pneumothorax and partial collapse of the right upper lobe.



Figure 3. Chest computed tomography (CT) imaging of a 3-month-old infant with pulmonary tuberculosis and persistent air leak. Chest CT shows parenchymal emphysema in the right lung with compression of the left lung.

support modes were used. Lung ultrasound was performed daily to detect possible complications, and medical treatment with anti-tuberculosis drugs was maintained.

One week later, no improvement was seen, and chest tubes were still draining air, suggesting a persistent air leak that was maintained by high positive pressure. Further fiberoptic bronchoscopy showed worsening of the bronchial obstruction as

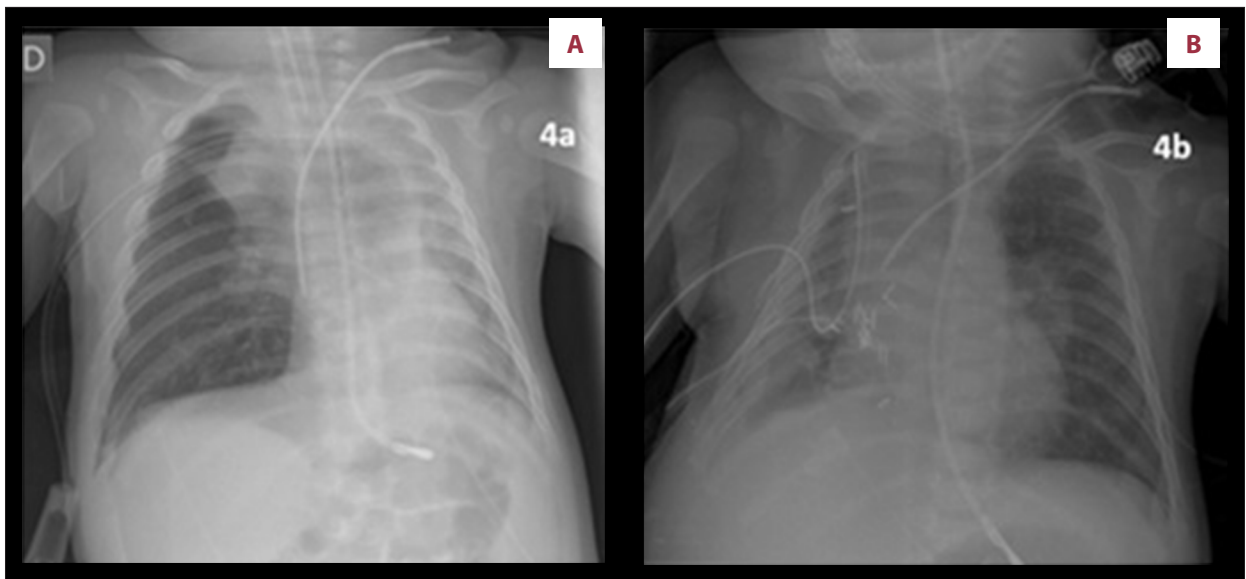


Figure 4. Chest X-ray imaging of a 3-month-old infant with pulmonary tuberculosis and persistent air leak. (A) Chest radiograph before surgery shows an anterior right pneumothorax and compression of the left lung. (B) Chest radiograph after surgery shows inflation of the right lung with no residual pneumothorax.

well as obstruction of the carina. Chest CT showed that the lymph nodes had decreased in size, but severe parenchymal emphysema in the right lung was compressing the contralateral lung (Figure 3). Despite the emphysema, as the lymph nodes had decreased in size, conservative management was maintained, followed by first-line treatment with isoniazid, rifampicin, pyrazinamide, and ethambutol (HRZE) and conventional ventilation.

On the 19th day of hospitalization, he presented with sudden respiratory failure with desaturation and bradycardia due to tension pneumothorax, requiring the FiO_2 of 100%, volume expansion, and continuous norepinephrine infusion (maximum dose, 0.6 mcg/kg/min) to maintain optimal mean blood pressure. Given the poor response to conservative treatment, urgent surgery was performed. The middle and lower right lobes were resected via a right thoracotomy. During surgery, caseating granulomas were found in the lymph nodes and in the lung parenchyma, and there were also multiple granulomas distributed locally in other areas of the lung parenchyma.

Acid-fast bacilli were detected, and cultures of the lymph nodes identified *Mycobacterium tuberculosis* complex. After surgery, his respiration improved (Figure 4). One week after surgery, fiber-optic bronchoscopy showed no airway compression or endobronchial lesions, and ventilatory support was reduced. However, after 24 hours, he developed further respiratory distress and fever. Laboratory tests showed leukocytosis, increased C-reactive protein (CRP) (19 mg/dL), and chest X-rays showed left-sided pneumonia (Figure 5). Tracheal, urinary and blood cultures were taken and treatment with meropenem and

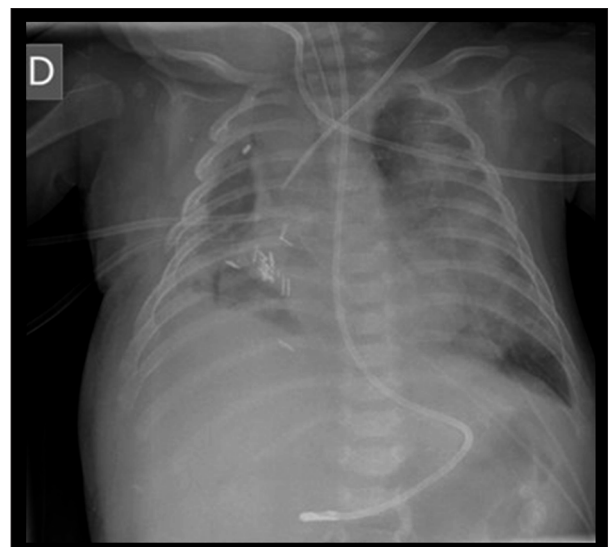


Figure 5. Chest X-ray imaging of a 3-month-old infant with pulmonary tuberculosis and persistent air leak. Chest radiograph shows the collapse of the right lung with parenchymal infiltrates in the left lung.

vancomycin was initiated. After 24 hours, *Klebsiella oxytoca* was detected in the tracheal cultures.

In the next few hours, he developed severe acute respiratory distress syndrome (ARDS), requiring high levels of positive end-expiratory pressure (PEEP) (12 cmH_2O) and FiO_2 up to 100% to maintain adequate ventilation and oxygenation. Norepinephrine infusion commenced (maximum dose, 0.7 mcg/kg/min). A tension pneumothorax appeared in the right hemithorax, requiring

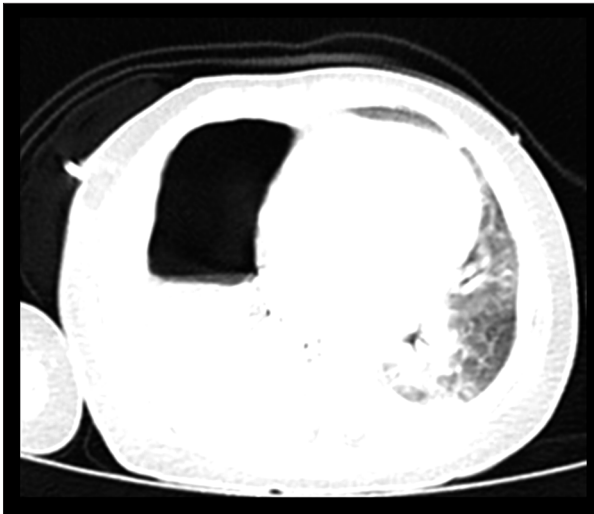


Figure 6. Chest computed tomography (CT) imaging of a 3-month-old infant with pulmonary tuberculosis and persistent air leak. Chest CT shows the collapse of the right lung and parenchymal infiltrates in the left lung.

another drainage tube. These measures failed to achieve adequate oxygenation, with a PaFi ($\text{PaO}_2/\text{FiO}_2$) <150 , and an oxygenation index of 24. A persistent air leak excluded the use of conventional mechanical ventilation. The patient was then managed with high-frequency oscillatory ventilation (HFOV) for 48 hours, with the maximum parameters including a mean airway pressure (MAP) of $23 \text{ cmH}_2\text{O}$, a frequency of 9 Hz, and an amplitude of 50%, but no improvement was seen.

To enable the left lung to be ventilated while allowing the persistent air leak in the right lung to resolve and the pleura to heal, the left main bronchus was selectively intubated with a 4 mm cuffed endotracheal tube. Volume-controlled ventilation PEEP of up to $14 \text{ cmH}_2\text{O}$ and tidal volumes of 5 ml/kg achieved adequate oxygenation and ventilation. As the contralateral lung was atelectatic, no problems with lung secretions occurred. Chest drains were kept in place, and PEEP was progressively reduced. Nine days after selective left main bronchus intubation, he was weaned off PEEP, and chest CT showed right lung collapse, left mediastinal displacement, and parenchymal infiltrates in the left lung (Figure 6). Given his clinical improvement, he was extubated 24 hours later but required a nasal cannula for the next 13 days. On the 69th day of hospitalization, the last chest tube was removed. The patient was discharged home 13 days later with no respiratory support. At this time, the patient is now 15 months old, and no complications have been observed during follow-up. He has not required respiratory support, and follow-up chest X-rays showed normal expansion of the right upper lobe.

Discussion

Tuberculosis and its complications can be much more severe in neonates and children than in adults, and the management of tuberculosis and its complications can be difficult. This report has shown that selective main bronchus intubation can be used to treat cases where conventional management fails to achieve adequate oxygenation. In this case, the diagnosis of tuberculosis was strongly suspected, and first-line treatment with isoniazid, rifampicin, pyrazinamide, and ethambutol (HRZE) was commenced. Ethambutol was included because of the high prevalence of isoniazid resistance in our part of Spain [2,5], and because the primary cause was initially unknown. Cultures of the gastric aspirate collected on the second day of hospitalization and the specimens collected during the first bronchoscopy were negative. *Mycobacterium tuberculosis* was isolated in the cultures from surgical lymphadenopathy specimens.

Because tuberculosis in children is often paucibacillary, *Mycobacterium tuberculosis* is isolated in only 20–40% of cases and failure to identify the pathogen can result in delayed treatment [1]. In this case, the diagnosis of tuberculosis was confirmed by both cultures and histologic findings of the resected lymph nodes. In this patient, the most challenging management issue was the persistent air leak. Most persistent air leaks resolve spontaneously, and the insertion of chest tubes are the initial treatment of choice. However, the best approach to persistent air leaks that do not heal remains controversial [4,6,7]. During the first days of hospitalization, severe airway obstruction due to enlarged mediastinal lymph nodes caused significant parenchymal emphysema and an air leak that could not be controlled with drainage tubes. Some cases of tuberculosis can lead to atypical or paradoxical findings when treatment is initiated, resulting in worse clinical or radiological findings [8,9]. Because conservative treatment is recommended in air leak in children, chest tubes and medical treatment were maintained and there were no other interventions. The patient was ventilated in both a volume-controlled mode and a volume support mode, with tidal volumes ranging from 6 mL/kg to 7 mL/kg , peak pressures of around $20 \text{ cmH}_2\text{O}$ to $25 \text{ cmH}_2\text{O}$, and plateau pressures around $12 \text{ cmH}_2\text{O}$ to $18 \text{ cmH}_2\text{O}$. Initially, PEEP was set at $5 \text{ cmH}_2\text{O}$, but it had to be increased to up to $8 \text{ cmH}_2\text{O}$ to avoid bronchial collapse at end-expiration and to prevent the bronchial occlusion and secondary emphysema. Increasing the PEEP did not increase the plateau pressures, which indicated that the risk of pneumothorax did not increase. However, when no improvement was seen, surgery was considered. Although mediastinal lymphadenopathy is common in pediatric patients with tuberculosis, particularly in children <4 -years-old, they rarely cause life-threatening airway compression, as they did in this case.

Goussard et al. [10] reported the findings from a study of a series of 250 children treated for pulmonary tuberculosis with life-threatening airway compression, where 86 required lymph node decompression, with urgent procedures performed in 25 children. As in the present case, the lymph nodes adhered to the surrounding structures and were difficult to remove, so they were aspirated, and all patients were successfully extubated and discharged home without ventilatory support [10]. Despite surgery, in the present case, the air leak persisted and was critically aggravated by ventilator-associated pneumonia and ARDS in the contralateral lung. At this point, it was impossible to achieve adequate oxygenation with conventional mechanical ventilation, but as there was a persistent air leak, the ventilation strategy was changed to high-frequency oscillatory ventilation (HFOV). Although HFVO has drawbacks, it is used as rescue therapy in cases of pulmonary air leak, pulmonary interstitial emphysema, and pneumothorax because it achieves adequate gas exchange without exposing the patient to changing pressures that can worsen the air leak. Poor management after the initiation of HFVO can lead to gas trapping, but PaCO₂ levels in this patient remained normal.

In this case, because HFOV had failed, more aggressive management was considered, with the main treatment options being selective left main bronchus intubation or occlusion of the main bronchus of the affected lung to prevent air from escaping through the bronchopleural fistula [4,6]. Several techniques have been used to occlude the bronchi, but none have been widely studied. Bronchial occlusion can have complications, such as necrosis, erosion of the bronchial wall or bronchial stenosis, airway perforation, and distal infection [11]. Lewis et al. [12] reported one of the first cases of selective bronchial occlusion in a 26-week preterm infant with hyaline membrane disease with a persistent air leak that was successfully treated using a Swan-Ganz catheter. There have been few previously reported cases of selective intubation of the main bronchus for persistent air leak. Hathorn et al. [11] evaluated six cases, including two cases with bronchopulmonary fistula, and four cases with intrapulmonary air leaks treated with endobronchial balloons. In this previous study, no complications occurred, and the treatment was successful in four cases [11].

Selective intubation of the main bronchus of the healthy lung is an option that has been widely reported in preterm infants with bronchopulmonary dysplasia that resulted in lung hyperinflation and tension pneumothorax. The technique of selective main bronchus intubation was first described by Brooks et al. [13], who reported selective intubation of the main right bronchus in four preterm infants with pulmonary emphysema. Jakob et al. [14] published a case series of nine preterm infants with emphysema with failed conservative therapy, including lateral decubitus positioning and HFOV for three days. Selective bronchial intubation was maintained

from 24 hours to seven days, and all but one of the patients were ventilated with HFOV [14]. Emphysema resolved in seven cases, and in the other two cases, pneumothorax recurred but was successfully managed conservatively [14]. Selective main bronchus intubation is also used as an intermediary measure for patients when ventilation of both lungs is very difficult. In these cases, the patient remains under selective intubation for hours or a few days until lobectomy or pneumonectomy of the affected lung is performed.

Another widely used treatment option for persistent air leak is pleurodesis. Chemical agents, including talc, doxycycline, or bleomycin, can be used to induce an inflammatory response to seal the pleural space [15], but this aggressive technique should be avoided in children. More recently, autologous blood patches have been used to induce pleurodesis for the treatment of persistent air leak [16–18]. In the patient described in this report, selective left main bronchus intubation was used to allow the air leak to heal and the contralateral lung (affected by ARDS) to be ventilated. The use of selective main bronchus intubation can have several challenges. Because very few cases have been reported in the literature and it was unclear whether the bronchopleural fistula would close in this case, it was difficult to determine when to extubate the patient. However, the remaining intubated lung was known to be at a high risk of tension pneumothorax. Also, high doses of multiple sedatives were required when the patient was selectively intubated. For example, the maximum doses of sedative drugs included midazolam (6 mcg/kg/min), propofol (4 mcg/kg/min), fentanyl (2 mcg/kg/h), ketamine (4 mcg/kg/h), and morphine (150 mcg/kg/h). The patient developed drug withdrawal that required treatment with methadone (maximum, 0.4 mg/kg/6 h), diazepam (maximum, 0.3 mg/kg/6 h), and clonidine (maximum, 5 mcg/kg/8 h).

A further difficulty, in this case, was the unavailability of a digital pleural drainage system, which required the use of a conventional chest drainage system until the air leak healed. Digital systems reduce interobserver variability and enable more continuous pressure than conventional devices [19], and using this technology throughout the period when chest tubes were in place might have improved the management of the air leak. This patient recovered completely. Currently, no complications have found at 12-month follow-up. However, close follow-up remains necessary to confirm the clinical outcome and to assess possible future complications.

Conclusions

This report presented a rare case of persistent air leak in a 3-month-old infant with pulmonary tuberculosis that was managed by selective left main bronchus intubation.

The management of this patient required a multidisciplinary approach to a potentially life-threatening condition and resulted in a successful outcome. This case highlights that when medical management of persistent air leak associated tuberculosis is not effective, surgery, active ventilation, and selective main bronchus intubation should be considered.

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Conflict of interest

None.