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Unilateral Lung Whiteout in Children

Four Cases and a Discussion of Management

Itaru Iwama, MD and Moriyasu Kohama, MD

Abstract: Unilateral lung whiteout is not a common pediatric chest radiograph finding, but when it is encountered, timely and accurate interpretations of the radiograph are required because life-threatening respiratory failure can be associated. Lung whiteout may result from several conditions, and the differential diagnosis has a broad range. We describe 4 pediatric patients with different etiologies of unilateral lung whiteout: a large pleural effusion, mainstem bronchial plugging with a large cast, a mediastinal tumor, and consolidation. The ultimate causal diagnosis may not be initially obvious, but valuable clues can usually be found in the conventional chest radiograph to assist with appropriate early management. Chest ultrasound provides additional information, and we recommend it as the second examination for such patients.

Key Words: unilateral lung whiteout, opaque hemithorax, chest radiograph, chest ultrasound

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CASES

Case 1

A 1-year-old boy who had been previously healthy came to the emergency department (ED) because of high fever and loss of appetite. He had not received antipneumococcal vaccine. Vital signs on arrival were heart rate (HR) of 170/min, respiratory rate (RR) of 68/min, temperature of 39.1°C, and SpO₂ of 84% in room air. Chest wall motion was decreased on the left side, and subcostal retractions were observed. Auscultation of the chest revealed decreased air entry and dullness to percussion on the left side. There was significant elevation of inflammatory markers (white blood cells, 45,100/μL; C-reactive protein 24.6 mg/dL). Chest radiograph showed unilateral whiteout of the left lung with an air bronchogram. The mediastinum was deviated to the right (Fig. 1A). Chest ultrasound and computed tomography (CT) scan revealed a large collection of pleural fluid surrounding the left lung (Fig. 1B). The patient was intubated, and a left-sided chest tube was inserted. A massive amount of purulent fluid was obtained. *Streptococcus pneumoniae* was detected in both the blood and pleural fluid cultures.

Case 2

A 2-year-old boy came to the ED with a chief complaint of dyspnea. He had rhinorrhea and a wet cough for several days. History was remarkable for several episodes of wheezing, but he had never been given a diagnosis of or treated for asthma. His parents

were both current smokers, and his mother had a history of asthma. Vital signs on arrival were HR of 178/min, RR of 42/min, temperature of 39°C, and SpO₂ of 85% in room air. Chest wall motion and breath sounds were both decreased on the left side. Venous blood gas showed metabolic acidosis but no hypercapnia (pH, 7.348; PCO₂, 39.5 mm Hg; HCO₃⁻, 21.1 mmol/L, and lactate, 3.5 mmol/L). Chest radiograph showed unilateral whiteout of the left lung with hyperinflation of the right lung. Disruption of air was noted in the left mainstem bronchus, and the mediastinum was deviated to the left (Fig. 2A). No pleural effusion was detected with chest ultrasound. He was admitted to the intensive care unit and started on high-flow nasal oxygen. Although the SpO₂ improved to 91% to 94%, his respiratory distress did not improve, and he was intubated 12 hours after arrival. Chest CT was obtained after tracheal intubation and showed total atelectasis of the left lung (Fig. 2B). His condition initially improved after tracheal intubation but then worsened on day 3. The presence of a bronchial cast was suspected, and flexible bronchoscopy was performed. A white mucus plug (Fig. 2C) was found in the left mainstem bronchus. Suctioning was carried out and resulted in the removal of the whole cast (Fig. 2D). His respiratory condition improved dramatically, and he was able to be extubated on the same day.

Case 3

A 2-year-old previously healthy boy presented with a week-long history of mild cough and wheeze followed by a rapid progression to severe dyspnea. He was taken to a nearby ED where he was urgently intubated. Even after tracheal intubation and manual ventilation, his respiratory condition did not improve. He was then transferred to our hospital for further management. Vital signs on arrival were HR of 130/min, RR of 36/min, temperature of 36.6°C, and SpO₂ of 99% in 6-L/min oxygen. Chest wall motion was decreased on the left side, and suprasternal and intercostal retractions were observed. Breath sounds were decreased on the left side. Venous blood gas showed extreme respiratory acidosis (pH, 6.722; pCO₂, 221 mm Hg; HCO₃⁻, 27.1 mmol/L). Chest radiograph after intubation showed unilateral whiteout of the left lung (Fig. 3A), with mediastinal and nasogastric tube deviation to the right. Air in the left mainstem bronchus was disrupted. Bronchoscopy was performed for an evaluation of the bronchial disruption, and obstruction of the left mainstem bronchus with extrabronchial compression was noted (Fig. 3B). His respiratory condition improved with mechanical ventilation under muscle relaxation. Chest CT showed a large anterior mediastinal mass (Fig. 3C). Open biopsy was performed and revealed T-lymphoblastic lymphoma. The size of the tumor decreased after prednisolone and chemotherapy were started, and he was able to be extubated on hospital day 8.

Case 4

A 13-year-old chronically bedridden, adolescent boy with a history of neonatal hypoxic ischemic encephalopathy, cerebral palsy, and epilepsy was admitted because of pneumonia. He was routinely fed by both nasogastric tube and oral feedings. History revealed several previous episodes of aspiration pneumonia. Antibiotics were initiated for the pneumonia, but

From the Department of Pediatrics, Okinawa Chubu Hospital, Okinawa, Japan. Disclosure: The authors declare no conflict of interest.

Reprints: Itaru Iwama, MD, Department of Pediatrics, Okinawa Chubu Hospital, 281 Miyazato, Uruma City, Okinawa 904-2293, Japan (e-mail: iwama_itaru@hosp.pref.okinawa.jp).

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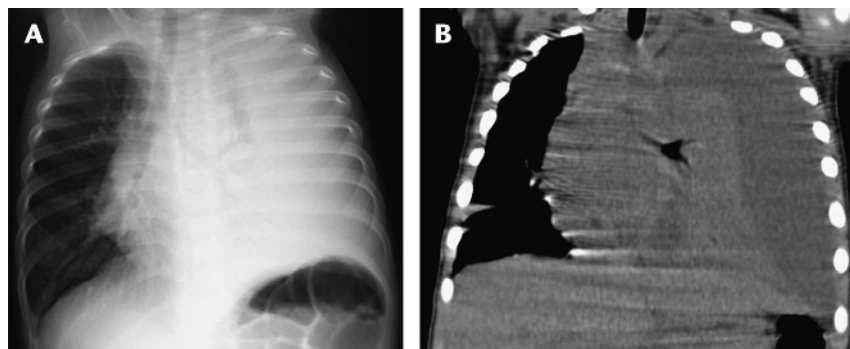


FIGURE 1. A, Chest radiograph showing whiteout of the left lung with contralateral mediastinal position. B, Chest CT scan demonstrating large pleural effusion surrounding the collapsed left lung.

he progressed to respiratory failure and was intubated on day 2. Postintubation chest radiograph showed a large right-sided pleural effusion. A chest tube was inserted, but drainage was poor due to the high viscosity of the fluid. Multiple intraoral indigenous bacteria were detected from the culture of the pleural fluid. He underwent decortication under video-assisted thoracic surgery on day 6 for the removal of mucinous exudates. Chest radiograph on day 10 showed unilateral whiteout of the right lung (Fig. 4A). Breath sounds were decreased, and crackles were heard on the right side. The position of the mediastinum stayed in the middle. No pleural effusion was detected, and consolidation was identified with chest ultrasound. Chest CT showed almost total consolidation of the right lung with only a small amount of residual pleural fluid (Fig. 4B). Mechanical ventilation

and antibiotics were continued for a month, the appearance of the chest radiograph gradually improved, and the patient recovered without any apparent sequelae.

DISCUSSION

Unilateral lung whiteout is caused by several conditions, and etiologies tend to vary according to age. To elucidate the etiologies, a review of the literature was performed using MEDLINE to search for articles published between January 1985 and December 2015. The search terms included “unilateral lung whiteout” and “opaque hemithorax.” The inclusion criteria for the search were articles written in English concerning patients with unilateral lung whiteout or opaque hemithorax. Exclusion

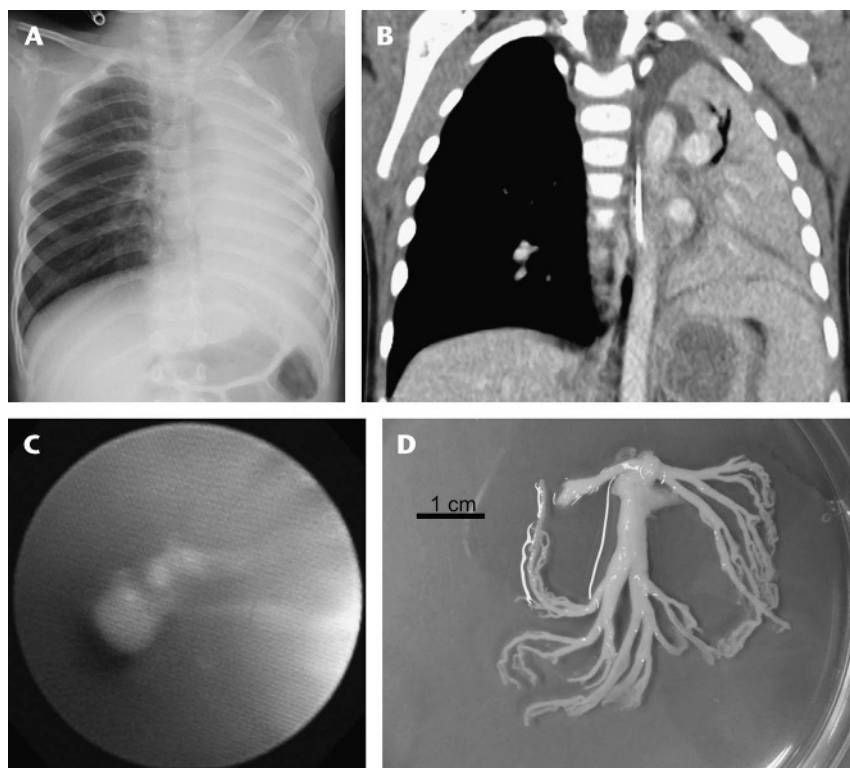


FIGURE 2. A, Chest radiograph showing whiteout of the left lung with ipsilateral mediastinal shift. B, Chest CT scan demonstrating total atelectasis of the left lung. C, Bronchoscopic view of the bronchial cast occluding the left main bronchus. D, Branching bronchial cast.

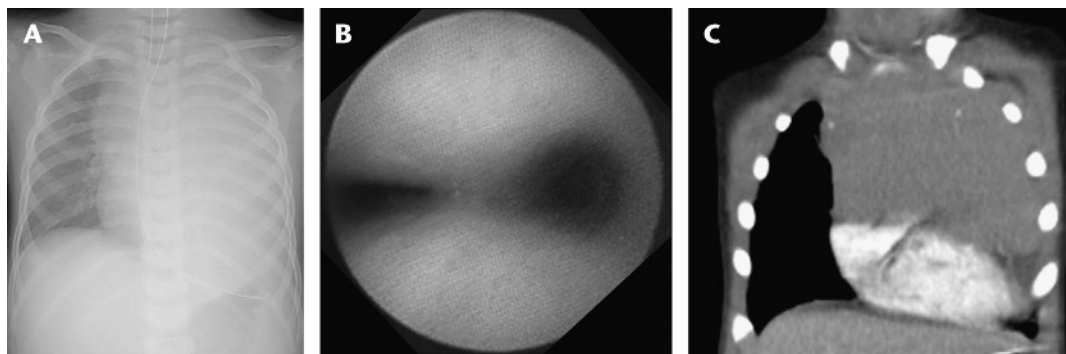


FIGURE 3. A, Chest radiograph showing whiteout of the left lung with contralateral mediastinal shift. Nasogastric tube and tracheal tube deviated to the right side. B, Bronchoscopic view of extrabronchial compression of the left main bronchus. C, Enhanced chest CT scan demonstrating a large homogenous tumor in the anterior mediastinum.

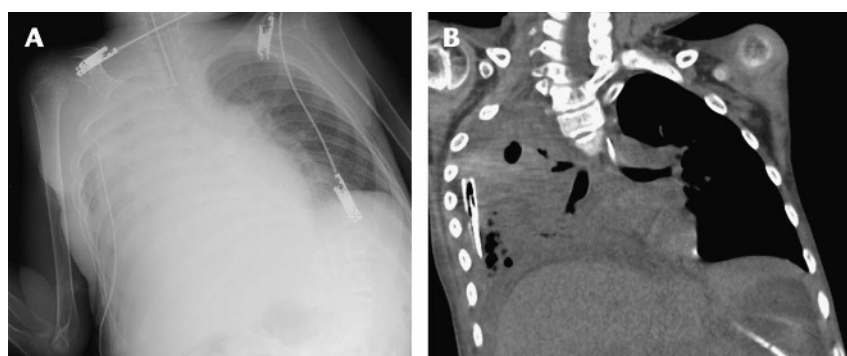


FIGURE 4. A, Chest radiograph showing whiteout of the right lung with central mediastinal position. B, Enhanced chest CT scan demonstrating total consolidation of the right lung.

criteria included case studies of unilateral lung whiteout or opaque hemithorax with no specific extractable data and articles written in a language other than English. Etiologies are summarized in Table 1. Five etiologies are the most common in all ages, but additional less common etiologies also occur, varying by age.^{1–20} In our case reports, we present patients with four of the most common etiologies. Table 2 provides a summary of these 4 cases.

A comparison of similarities and differences in clinical characteristics is worthy of discussion. In our first 3 cases, all of the patients were between 1 and 2 years old and presented with acute respiratory distress. All three had tachypnea, decreased oxygen saturation, decreased unilateral breath sounds, and decreased unilateral chest wall motion. Detailed physical examination of the chest, including not only auscultation but also inspection, palpation, and percussion, provided very helpful clues leading to elucidation of the type of intrathoracic pathology involved in the unilateral lung whiteout. Although the condition of patients presenting to the ED may be critical, physicians should make an effort to carry out a detailed physical examination. We cannot emphasize enough the importance of a focused physical examination.

The position and appearance of the mediastinum differed between cases and provided valuable clues to the underlying etiology. The mediastinum will shift to a contralateral position in the setting of a space-occupying entity such as the large pleural effusion in case 1 or the thoracic tumor in case 3. The mediastinum will shift to the ipsilateral side when volume reduction of the unilateral lung whiteout side occurs, such as in case 2 with atelectasis. Other important radiographic signs of volume reduction include

ipsilateral diaphragmatic elevation and crowding of the ribs. In settings where the volume of the unilateral lung whiteout does

TABLE 1. Etiologies of Unilateral Lung Whiteout

Causes common in all ages

1. Large pleural effusion^{1,2} (empyema,³ hemothorax, chylothorax)
2. Obstruction of the main bronchus (mucus plug,^{4,5} foreign body, endobronchial/extrabronchial mass, cardiomegaly,⁶ posttraumatic bronchial stenosis⁷)
3. Pneumonia affecting all lobes of a hemithorax⁸
4. Intrathoracic tumors (chest wall, pleura,^{2,3} lung parenchyma,³ mediastinum)
5. Pulmonary agenesis^{9,10}/aplasia¹¹/hypoplasia^{12,13}

Neonates: consider previously mentioned causes and

1. Congenital diaphragmatic hernia¹
2. Congenital large hyperlucent lobe¹
3. Congenital thoracic malformation¹

Adults: consider previously mentioned causes and

1. Unilateral pulmonary edema¹⁴
2. Postpneumectomy^{15,16}
3. Diffuse pleural soft tissue lesions⁸ (fibrothorax, malignant mesothelioma¹⁷)
4. Bronchial rupture⁸
5. Large intrathoracic cysts (aortic aneurysm^{18,19})
6. Destroyed lung (tuberculosis²⁰)

TABLE 2. Summary of the Cases

Case	1	2	3	4
Age, y	1	2	2	13
Sex	Male	Male	Male	Male
Pathology	Pleural fluid (empyema)	Atelectasis (bronchial cast)	Tumor (mediastinal lymphoma)	Consolidation (pneumonia)
Position of the mediastinum	Contralateral	Ipsilateral	Contralateral	Central
Bronchial obstruction	No	Yes	Yes	No
Intervention	Drainage	Bronchoscope	Steroid	Antibiotics, mechanical ventilation

not change, such as the consolidation seen in case 4, the position of the mediastinum will stay central. Sometimes, these conditions coexist in a single patient, such as in case 4 with the large effusion and consolidation. The appearance of the lung whiteout combined with the characteristics of the mediastinum can give valuable clues in determining the underlying cause of the patient's presentation.

Lung whiteout is, by definition, a radiologic diagnosis. A chest radiograph is the imaging study that leads to the initial recognition of the condition. The next examination typically will be a chest ultrasound. Evaluation of the lungs with ultrasound can provide valuable additional clinical information.^{21,22} Ultrasound is inexpensive and mobile and has almost no harmful effects because it is radiation free. Diagnosis of pneumothorax with ultrasound has been well established.²¹ The efficacy of lung ultrasound in diagnosing pneumonia in children has been demonstrated,^{23,24} and lung examination with ultrasound is also effective for diagnosing consolidations, atelectasis, and pleural effusions.²⁵ In 2015, Berant et al³ reported a case series in which lung ultrasound was used for the assessment of lung whiteout in children. Lung ultrasound was able to distinguish between consolidation, pleural effusion, and intrathoracic tumor, and, as a result, appropriate further management of these cases was facilitated. We performed chest ultrasound for three of our cases, but not for all four. A standard algorithm for the evaluation of unilateral lung whiteout has not yet been established at our institution so examinations differed between each case. What we learned from these cases and previous reports is that chest ultrasound is indicated early in the management of all children with unilateral lung whiteout.

If a large pleural fluid collection is detected with chest ultrasound, aspiration of the fluid or insertion of a drainage tube should

be considered. When no pleural effusion is observed with chest ultrasound, CT scan is recommended. Computed tomography scan can help further identify the etiology of most unilateral lung whiteouts. Enhanced CT is recommended for cases with intrathoracic tumors.²⁶ When endobronchial obstruction is suspected, bronchoscopy should be considered. It is helpful not only for diagnosis but also for treatment. It can be used for the removal of mucus plugs or foreign bodies. Most mucus plugs can be removed with suctioning through a flexible bronchoscope.²⁷ In Figure 5, we present a summary diagnostic flowchart for children with unilateral lung whiteout.

CONCLUSIONS

Chest radiograph is usually the initial imaging study that results in the identification of whiteout of the lung. The appearance of the whiteout, the position of the mediastinum, the presence or absence of diaphragmatic elevation, and the crowding of the ribs provide valuable clues to the underlying etiology of the whiteout. In addition, we recommend chest ultrasound as the second-line examination to gain further information without unnecessary radiation exposure.

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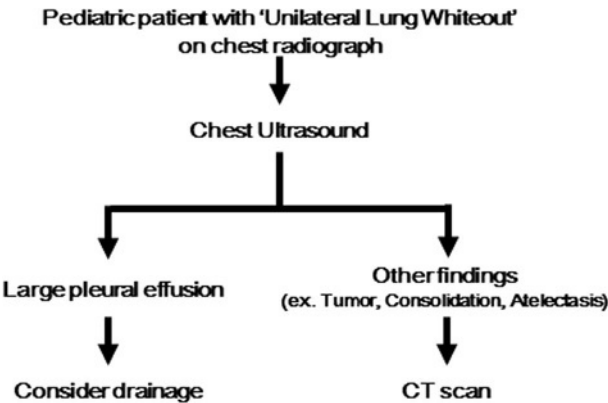


FIGURE 5. Diagnostic flowchart for children with unilateral lung whiteout.

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