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ORIGINAL ARTICLE

# Usefulness of Lung Ultrasound in the Diagnosis of Community-acquired Pneumonia in Children

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**Key Words**
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*Background:* Pneumonia is a life-threatening disease in children. With the current lack of universal diagnostic criteria, the diagnosis is usually made on clinical manifestations and findings from chest radiographs. Ultrasonography has recently been applied to the detection of pulmonary diseases. However, few data have been published showing its effectiveness in detecting pneumonia in children. The objective of this study was to determine the power of lung ultrasonography (LUS) for the diagnosis of pneumonia in children.
*Methods:* This retrospective study was carried out by reviewing medical records. Patients admitted to a pediatric ward with a diagnosis of pneumonia from June 1, 2010 to December 31, 2012 were enrolled in this study. Personal information, laboratory data, characteristics on LUS scan, and the results of chest radiography and LUS were collected. We compared the detection rate of pneumonia by chest radiography and LUS. LUS scans were followed up in 23 patients during the progression of their disease.
*Results:* A total of 163 patients was enrolled. Chest radiography was able to detect pneumonia in 152 patients, whereas LUS detected pneumonia in 159 patients. In LUS, the positive rates of the comet-tail sign, air bronchograms, fluid bronchograms, vascular pattern within the consolidation, and pleural effusion were 50.9%, 93.7%, 20.1%, and 28.9%, respectively. During follow

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up, the average size of the pneumonia patch in 23 patients decreased from 10.9 ± 8.7 $cm^2$ to 5.5 ± 8.2 $cm^2$, and finally to 2 ± 1.9 $cm^2$ on Day 1, Days 3–5 and Days 7–14, respectively.
*Conclusion:* LUS is a sensitive diagnostic tool with which to identify pneumonia in children. It is also useful in following up the progress of pneumonia. We suggest that LUS is a complementary tool to chest radiography in the diagnosis of pneumonia in children and that the follow up of pneumonia by LUS can reduce the exposure of children to ionizing radiation.


## 1. Introduction

Pneumonia is a major health threat worldwide and causes more deaths in children than AIDS, malaria, and measles.[1] In Taiwan, pneumonia is the 5th leading cause of death with a mortality rate of 24.8/10,000 people[2] and accounts for more than 0.65 million outpatient visits in medical settings each year; 50% of these patients are children.[3] In Taiwan, more than 70,000 children are admitted to hospital annually.[4] The lack of a worldwide consensus guideline for pneumonia means that the diagnosis is usually based on clinical signs and symptoms such as fever, cough, dyspnea, history-taking, and physical examination. The diagnosis of pneumonia is usually a new infiltrate seen on a chest radiograph. However, ionizing radiation may expose children to an increased risk of gene mutations and the development of cancer.[5] As an alternative, LUS has increasingly been used to detect pneumonia in children.[5,6] In many clinical settings, especially emergency departments and intensive care units,[7–9] LUS has been widely used as the primary diagnostic tool to detect pneumothorax, pulmonary consolidations, pleural effusion, acute respiratory distress syndrome, and pulmonary edema due to its ease of operation, provision of real-time images, and no risk of exposure to ionizing radiation.[8] Multiple studies have shown LUS imaging to be more accurate than chest radiography in some respiratory diseases in adults, such as pneumothorax, alveolar interstitial syndrome, pleural effusion, and pneumonia.[10–12] However, few studies have investigated the use of LUS in the diagnosis of pneumonia in children.[5,6,13] In our opinion, the small body size of young pediatric patients means that it is easier to detect pneumonia or other abnormalities with LUS. The purpose of this study was to demonstrate the characteristics of pneumonia in children on LUS and to evaluate the diagnostic power of LUS for pneumonia by comparison with conventional chest radiography.

## 2. Materials and methods

### 2.1. Patient selection

This retrospective study was conducted in Kaohsiung Medical University Hospital, Kaohsiung, Taiwan. We reviewed the medical records of patients who were admitted to the pediatric ward with a clinical diagnosis of pneumonia and who had both chest radiography and LUS examinations within 2 days. The diagnosis of pneumonia was in accordance with the British Thoracic Society guideline.[14] Community-acquired pneumonia in children can be clinically defined as the presence of signs and symptoms of pneumonia (such as fever, tachypnea, breathlessness, cough, wheeze, or chest pain) in a previously healthy child due to an infection acquired outside the hospital.[14]

A total of 316 patients were reviewed between January 1, 2010 and December 31, 2012. Of these, 153 patients were excluded due to congenital anomalies, undergoing chemotherapy or severe immunosuppression, >48 hours between LUS and radiography, unavailability of chest radiography results, unavailability of LUS results, or diagnosis other than pneumonia. The remaining 163 children were included in this study. History-taking, physical examination, laboratory tests (including complete blood count and level of C-reactive protein), chest radiography, LUS, and measurement of vital signs were performed for each patient. The final diagnosis was made by pediatricians based on clinical presentations. The protocol was approved by the Institutional Review Boards of the University Medical Center (KMUHIRB-20120062).

### 2.2. Chest radiography

Chest radiography was performed on every patient on the day of admission. Posterior–anterior chest radiography was performed on patients who were able to stand, whereas posterior–anterior radiography in the supine position was performed if the patients were unable to maintain a standing position. The film was initially read by the radiologist on duty and later confirmed by a second radiologist. The radiologists were both blind to the patients' clinical presentation and ultrasound findings.

### 2.3. Lung ultrasound

The thoracic wall consists of skin, subcutaneous tissue, muscles, and the ribs. On longitudinal scans the pleura appear as a horizontal line (the pleural line), which moves during breathing. Beyond the pleural line, the air in the lung further impedes visualization of the normal lung parenchyma. However, the large change in echogenicity results in horizontal artifacts called A-lines. A-lines are parallel lines and can be seen below the pleural line in an ultrasound scan of a normal lung. When the fluid content in the lung increases, B-lines are generated. B-lines are vertical, hyperechoic artifacts originating from pleural line and extending to the edge of the image. B-lines are also called the comet-tail sign and are commonly seen in lung