



Lung ultrasound features of complicated pneumonia in children

Ngo Minh Xuan

Department of Pediatrics, Pham Ngoc Thach University of Medicine, Ho Chi Minh city, Vietnam; Email: xuanlien62@pnt.edu.vn

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General Note



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ABSTRACT

Purpose: The aim of this study is to describe lung ultrasound findings of complicated pneumonia in children. **Methods:** We prospectively and prospectively analyzed patients under 16 years of age with complicated pneumonia evaluated at Children's Hospital I - Ho Chi Minh City from September 2018 to July 2019. At baseline and 48 hours after the beginning of treatment, history, clinical examination, laboratory testing, chest X-ray, and lung ultrasound were performed. **Results:** One hundred fifty children were enrolled in the study (20 with complicated pneumonia). The rate of complications of pneumonia on ultrasound: Lung collapse, pleural effusion, necrotic pneumonia are the most common complications in patients with pneumonia, with respectively 62.9%, 57.1 %, and 40%. Mean while only 11.4% of patients with pneumothorax complications and no patients with pneumonia with pulmonary abscess complication detected on lung ultrasound. **Conclusions:** Our study highlights that lung ultrasound is a good modality to evaluate of complicated pneumonia in children.

Keywords: pneumonia, chest X-ray, pneumothorax, lung ultrasound

1. INTRODUCTION

Pneumonia is a common disease in the world and is the leading cause of death in children under five years old. About 156 million new cases are contracted annually, of which mainly in developing countries; the number of pediatric deaths from pneumonia is 1.9 million (Rudan et al., 2008). Pneumonia is mild to severe. In severe cases, the disease can cause dangerous complications such as sepsis, lung abscess, pleural effusion, pneumothorax, necrotic pneumonia, and the possible result leading to death if not treated promptly (Chau, 2012; Kim, 2013). This is a complex disease with diverse clinical circumstances, depending on the etiologies of the disease, as well as the underlying lesions of the respiratory system and the underlying pathology of the patient. Mortality and complication rates depend on the cause groups.

In recent years, many authors have evaluated the role of ultrasound in the diagnosis of pneumonia as well as the complications of pneumonia and obtained certain positive results. The diagnostic ability of ultrasound in the above studies reaches a sensitivity of 95% - 97%, specificity 90% - 94%. Besides, lung ultrasound can be performed in bed, repeated many times, giving immediate results, and not being exposed to radiation (Cortellaro et al., 2012; Reissig et al., 2012; Chavez et al., 2014; Xia et al., 2016).

2. MATERIALS AND METHODS

Study population

The study population consisted of children age's birth to 15 diagnosed with pneumonia. The sample population is the above patients diagnosed with pneumonia in the Department of Respiratory and other departments at Children's Hospital I - Ho Chi Minh City from September 2018 to July 2019. Institutional review board of Children's hospital I approved this study with the reference number of 35/2018-CH1. Informed consent of patients was obtained.

Lung ultrasound examination

All patients underwent a bedside lung ultrasound in the first 12 h after chest X-ray. Lung ultrasound was performed using a Mindray-DC-T6 ultrasound machine equipped with a linear probe with frequencies ranging from 7.5 MHz to 12 MHz. LUS examinations were done according to the methodology described by Copetti and Cattarossi. To cover the whole lung surface, each hemithorax was divided into three areas: the anterior area delimited by parasternal and anterior axillary lines, the lateral area between the anterior and posterior axillary lines, and the posterior area delimited by the paravertebral and posterior axillary lines. Each region was scanned in the longitudinal and transverse plane, medial-lateral and up-down respectively. The anterior and lateral regions of the chest were examined while the infants in supine decubitus. The posterior region was examined in prone decubitus in infants while sitting position was used to scan the posterior wall in older patients.

Lung ultrasound was performed by a pediatrician with specific lung ultrasound expertise and un aware of the clinical, laboratory and radiographic data of the patients. The pediatrician has attended a 8-h lung ultrasound training session and supervised practical training.

An exploratory analysis was used in the first 30 patients to evaluate the sonographer inter-observer concordance between the pediatrician and a pediatric radiologist. The radiologist performed the lung ultrasound right after the pediatrician, being blinded to the results of the previous lung ultrasound and chest X-ray studies. Similarly, two pediatric radiologists independently reviewed the radiographic images of the same set of patients to evaluate the inter-observer concordance of the chest X-ray. The radiological images which were contradictory were re-evaluated by a senior radiologist to reach a final interpretation.

Statistical analysis

Data were analysed using the SPSS version 20.0 software package. For all the analyses, significance was accepted at $p < 0.05$.

3. RESULTS

A total 150 children with pneumonia were analyzed. Of these, there were 117 (78.0%) children under 5 years of age. Twenty cases of complicated pneumonia were found on ultrasound. In which, lung collapse, pleural effusion, necrotic pneumonia are the most common complications in patients with pneumonia, with respectively 62.9%, 57.1 %, and 40%. Mean while, only 11.4% of patients with pneumothorax complications and no patients with pneumonia with pulmonary abscess complications detected on lung ultrasound.

Most complications with pneumonia are common in both lungs, accounting for 57.6%. Besides, pneumonia has more common complications in the right lung than in the left lung (Table 1). Location of pleural effusion on ultrasound the proportion of patients with right-sided pneumonia is higher than left-hand pneumonia, with rates of 80% and 70%, respectively. In which 10/20 cases are

accounting for 50% with complications of pleural effusion in both lungs. Among 20 patients with pneumonia with pleural complications, the percentage of patients with moderate and low pleural effusion was the same and the highest, accounting for 45%, only 10% of patients with severe pleural effusion (Table 2).

Table 1 Location of complications on ultrasound

Location	Frequency(n=33)	Rate %
The right	9	27,3
Theleft	5	15,2
Both sides	19	57,6

Table 2 Degree of effusion on ultrasound

Degree of effusion on ultrasound	Number of patients (n=20)	Rate %
Little	9	45
Medium	9	45
Amount much	2	10

In 20 patients with pneumonia diagnosed with complications of pleural effusion on ultrasound (Figure 1), the nature of the fluid on the ultrasound image is the most homogeneous, accounting for 60% and mostly with fibrin 65% (Table 3). On ultrasound images show that the proportion of pneumonia patients with pneumothorax complications (Figure 2) is more common in the right lung than the left lung, with respectively 60% and 40%, no patients with pneumothorax complications in both lungs (Table 4).

Table 3 Properties and translation characteristics on ultrasound

Properties and translation characteristics on ultrasound		Number of patients (n=20)	Rate %
Characteristics	Homogeneous	12	60
	Heterogeneous	8	40
Fibrin	Yes	13	65
	No	7	35

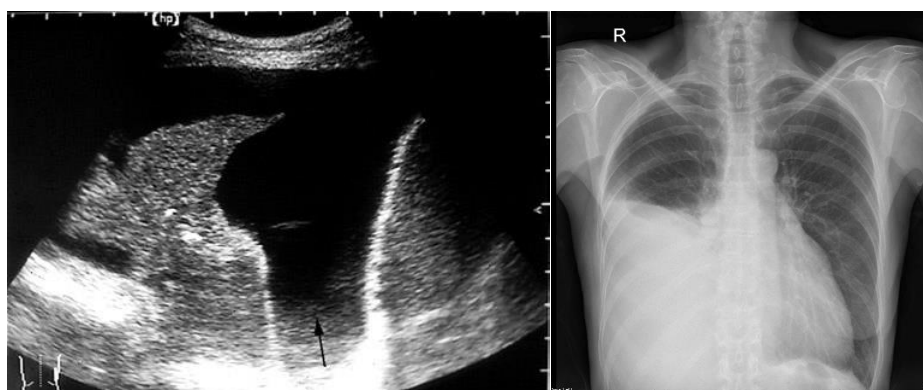


Figure 1 Pleural effusion on ultrasound and on chest X-ray

Table 4 The location of pneumothorax on ultrasound

Location	Number of patients (n=5)	Rate %
The right	3	60
The left	2	40
Both sides	0	0

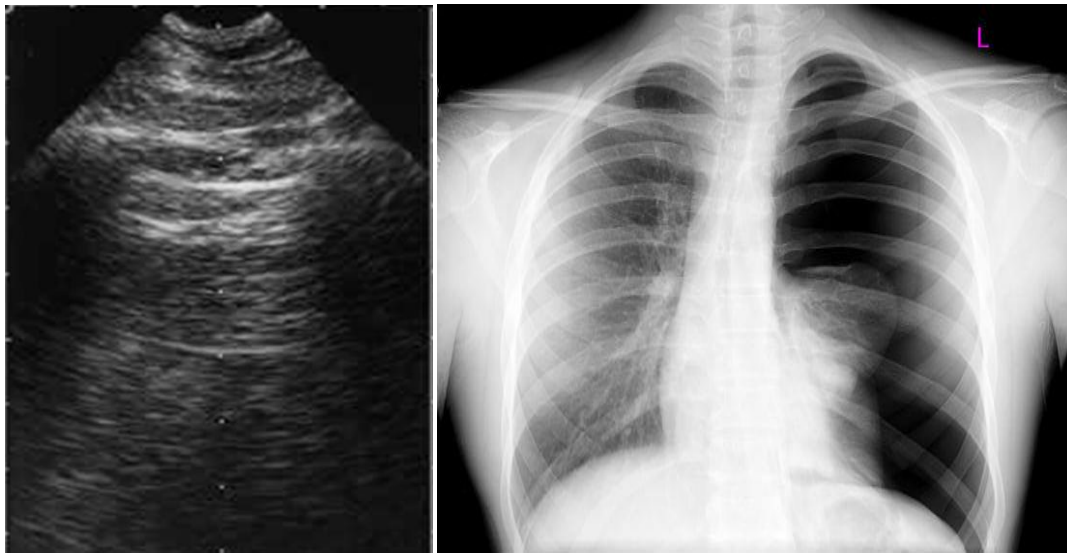


Figure 2 pneumothorax on ultrasound and on chest X-ray

Location of the collapsed lung on ultrasound: In 22 cases with collapsed lung defined on ultrasound, the proportion of patients with right collapsed lung was higher than left collapsed lung (Figure 3), with a rate of 77.3% and 54.5%, respectively. Of these, 7/22 cases accounted for 31.8%, with collapsed lung complications in both lungs.

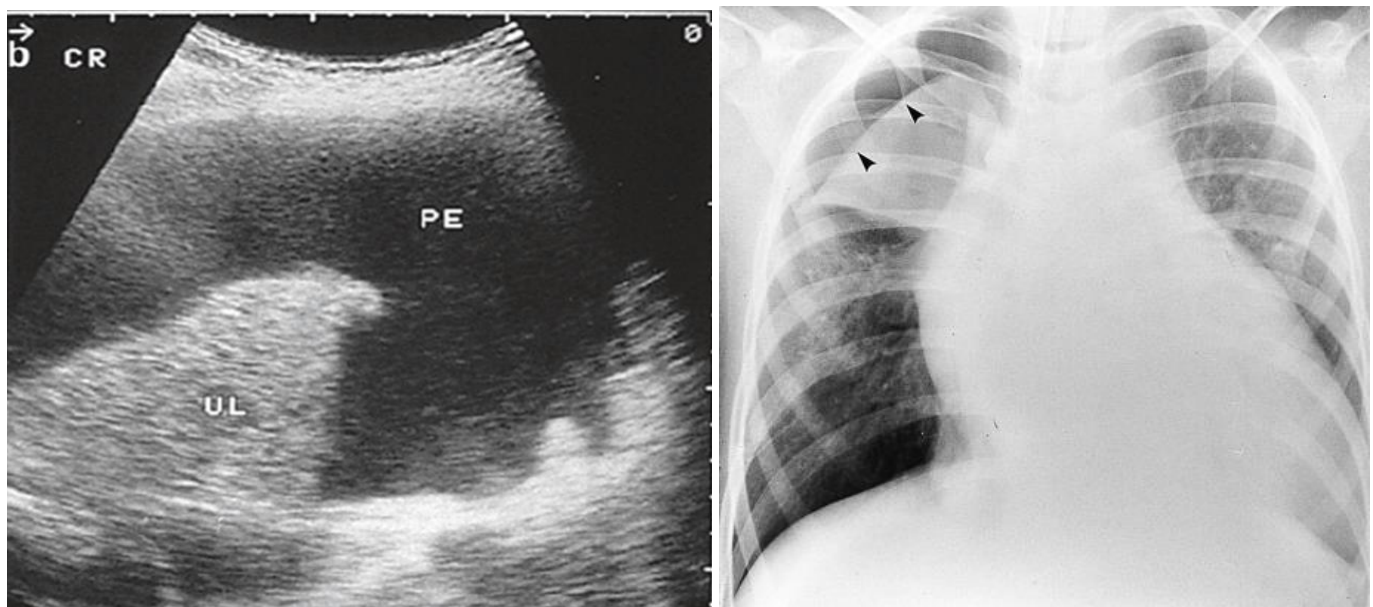


Figure 3 Collapsed lung on ultrasound and on chest X-ray

Among 14 patients with pneumonia with necrotic pneumonia identified on ultrasound, the proportion of patients with necrotic pneumonia in the right lung is higher than in the left lung (Figure 4), with a similar rate respectively, 85.7% and 21.4%. Of which only 1/14 cases accounted for 7.1% of pneumonia patients with complications of necrotic pneumonia in both lungs (Table 5).

Table 5 Locations of necrotic pneumonia on ultrasound

Location	Number of patients (n=14)	Rate %
The right	11	78,6
The left	2	14,3
Both sides	1	7,1

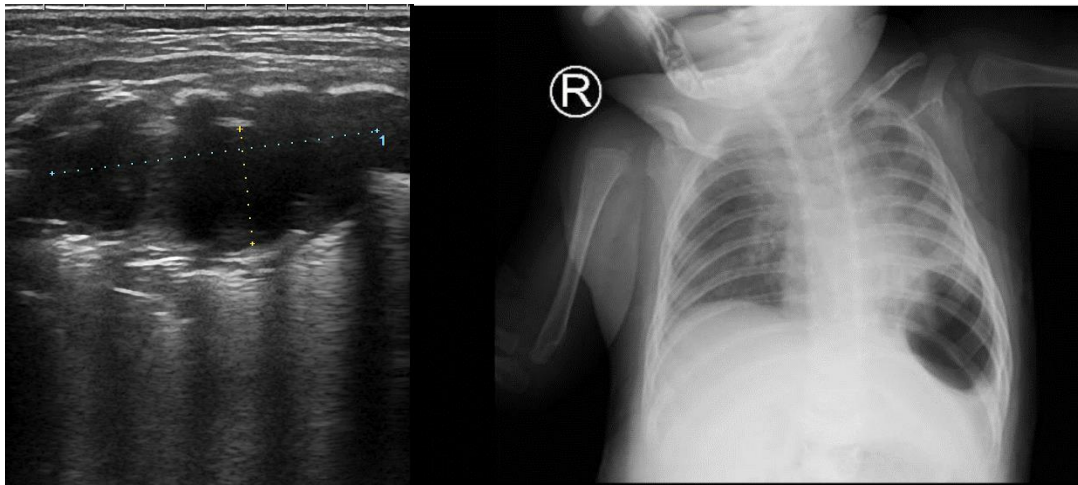


Figure 4 Necrotic pneumonia on ultrasound and chest X-ray

4. DISCUSSION

Pleural effusion is the phenomenon of more fluid than the normal physiological level in the pleural cavity, due to many causes and changes in clinical and laboratory. Usually, the amount of fluid in the pleural cavity is only about 10-15ml. This is one of the common complications in children with pneumonia. The study results of the author Reissig, the rate of pleural effusion in patients with pneumonia is 54.4% (Reissig et al., 2012). However, this result is higher than the research results of the authors Iuri (Iuri et al., 2009), the proportion of pneumonia patients with pneumothorax complications accounts for 46.9%, Cortellaro, the proportion of patients with pneumothorax with pleural complications determined on ultrasound was in 42% of the total 80 patients (Cortellaro et al., 2012) and Weinberg, studying ultrasound characteristics in 30 cases of pneumonia in children aged 6 months to 18 years old, the results were compared with X-ray, ultrasound detected pneumonia with complications of pleural effusion 30% (9/30) cases (Weinberg et al., 1986). According to author Parlamento the proportion of patients with pneumonia with pleural complications on ultrasound images accounted for 34.4% (Parlamento et al., 2009).

Pneumothorax is a condition in which air that enters between the pleura collapses the lungs, with complete and incomplete pneumothorax. The study results of the author Krenke, the rate of pneumothorax in patients with necrotic pneumonia is 6.25% (Krenke et al., 2015), and that of Onuki, the proportion of patients with pneumonia with pneumothorax complications is 4.5% (Onuki et al., 2017). Pulmonary collapse is a condition where a lung compression or blockage results in a decrease or loss of gas exchange capacity. It may affect part or all of the lungs. This is a common complication in children with pneumonia. A study of 46 patients with pneumonia, showed that the proportion of patients with collapsed lung was 50% and Touw, the rate of lung collapse in patients with pneumonia accounts for only 6.2% (Touw et al., 2018).

Necrotizing pneumonia is a severe form of lung pathology with the formation of small, small abscesses (<2cm) in the lung parenchyma, often without significant pleural damage. Lai's study, the study of ultrasound value in diagnosis and the ability to predict complications of necrotic pneumonia using color Doppler ultrasound to evaluate parenchymal perfusion lungs on 236 patients with pneumonia average age 5.53 ± 3.62 , ultrasound concluded that there were 80/236 (33.9%) cases of necrotic pneumonia (Lai et al., 2015). Thus, the above research results show that pleural effusion, necrotic pneumonia, and collapse are common complications in pneumonia patients. This is consistent with the research results of many other authors in the world.

According to the study of Tan, on 368 children with pneumococcal pneumonia found that 53% of cases of hospitalized pneumonia have pleural complications, pleurisy, gangrene, or abscess lungs (Tan et al., 2002). Several other studies also show that necrotic pneumonia, pleural effusion, and collapsed lung are common pulmonary complications in children (Sawicki et al., 2008; Lee et al., 2010). According to author Krenke, a study of 882 children with pneumonia found 32 children (accounting for 3.7%) had necrotic pneumonia. The average incidence of necrotizing pneumonia was 3% between 1995 and 1998 and then tended to increase after reaching 23% in 2003. This partly explains why the rate of complications of pneumonia in our study is higher than some of the above (Krenke et al., 2015).

The results of the study show that the complication of pneumonia is more common in the right lung than the left lung, with the proportion of 84.9% and 72.8%, respectively. For each type of complication of pneumonia (pleural effusion, pneumothorax, collapsed lung, and necrotic pneumonia), the research results also show the rate of complications of pneumonia in the Right lung is higher than the left lung. This result is similar to the research result of the author Khuong Quoc Dai, the rate of pneumonia

encountered in 69.6% (right lung pneumonia 32.1% and bilateral pneumonia). 37.5%), significantly higher than left pneumonia (44.6%) ($p < 0.05$) (Dai, 2017). In the study of author Ha Van Ngac, right lung damage encountered in 74.52%; left lung damage found in 20.75% of patients (Ngac, 1991). According to Sopena, the rate of right lung pneumonia was 79.2%, left pneumonia was 26.8% (Sopena et al., 1998).

All of the above studies show that the proportion of patients with pneumonia with complications in the right lung is higher than in the left lung, which is entirely reasonable with the pathophysiological mechanism of pneumonia. The right main bronchus is more sloping than the left one, so the risk of infection on the right is higher.

5. CONCLUSION

Through a study of 43 cases of pneumonia diagnosed at Children's Hospital from September 2018 to July 2019, we draw the following conclusions: Lung collapse, pleural effusion, necrotic pneumonia, and overflow pneumothorax is a common complication of pneumonia. For the most part, patients with complications in both lungs and lungs are more likely in the right lung than the left lung.

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This research received no external funding.

Conflict of Interest

The authors declare that they have no conflict of interest.

Informed consent

Informed consent was obtained from all individual participants included in the study. Additional informed consent was obtained from all individual participants for whom identifying information is included in this manuscript.

Ethical approval for study protocol

The study was approved by the Medical Ethics Committee of Children's Hospital I (ethical approval code: 35/2018-CH1).

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