RESEARCH ARTICLE

Correlation between chest radiographic findings and clinical features in hospitalized children with *Mycoplasma pneumoniae* pneumonia

Yeon Jin Cho1,2☯, Mi Seon Han3,4☯, Woo Sun Kim1,2,5*, Eun Hwa Choi3,4*, Young Hun Choi1,2, Ki Wook Yun3,4, Seunghyun Lee1,2, Jung-Eun Cheon1,2,5, In-One Kim1,2,5, Hoan Jong Lee3,4

1 Department of Radiology, Seoul National University College of Medicine, Daehak-ro, Jongno-gu, Seoul, Republic of Korea, 2 Department of Radiology, Seoul National University Hospital, Daehak-ro, Jongno-gu, Seoul, Republic of Korea, 3 Department of Pediatrics, Seoul National University College of Medicine, Daehak-ro, Jongno-gu, Seoul, Republic of Korea, 4 Department of Pediatrics, Seoul National University Hospital, Daehak-ro, Jongno-gu, Seoul, Republic of Korea, 5 Institute of Radiation Medicine, Seoul National University Medical Research Center, Daehak-ro, Jongno-gu, Seoul, Republic of Korea

☯ These authors contributed equally to this work.

* kimws@snu.ac.kr (WSK); eunchoi@snu.ac.kr (EHC)

Abstract

Background

Radiologic evaluation of children with *Mycoplasma pneumoniae* is important for diagnosis and management.

Objective

To investigate the correlation between chest radiographic findings and the clinical features in children with *Mycoplasma pneumoniae* pneumonia.

Materials and methods

This study included 393 hospitalized children diagnosed with *M. pneumoniae* pneumonia between January 2000 and August 2016. Their clinical features and chest radiographs were reviewed. Radiographic findings were categorized and grouped as consolidation group (lobar or segmental consolidation) and non-consolidation group (patchy infiltration, localized reticulonodular infiltration, or parahilar peribronchial infiltration).

Results

Lobar or segmental consolidation (37%) was the most common finding, followed by parahilar or peribronchial infiltration (27%), localized reticulonodular infiltration (21%) and patchy infiltration (15%). The consolidation group was more frequently accompanied by pleural effusions (63%), compared to the non-consolidation group (16%). Compared with patients in the non-consolidation group, those in the consolidation group were associated with a...
significantly higher rate of hypoxia, tachypnea, tachycardia, extrapulmonary manifestations, prolonged fever, and longer periods of anti-mycoplasma therapy and hospitalization. **Lobar or segmental consolidation** was significantly more frequent in children ≥5 years old (44%) compared with children 2–5 years old (34%) and <2 years old (13%). **Parahilar peribronchial infiltration** was significantly more frequent in children <2 years old (56%) compared with children 2–5 years old (32%) and ≥5 years old (18%).

**Conclusion**
The chest radiographic findings of children with *M. pneumoniae* pneumonia correlate well with the clinical features. Consolidative lesions were frequently observed in older children and were associated with more severe clinical features.

1. **Introduction**
*M. pneumoniae* is recognized as one of the most important pathogens causing lower respiratory tract infections [1]. The major burden of *M. pneumoniae* infection is in community-acquired pneumonia, which mainly affects young children and adolescents [2]. *M. pneumoniae* pneumonia accounts for approximately 10% to 40% of community-acquired pneumonia cases in children [2–4].

Chest radiography is frequently performed in children to diagnose pneumonia and assess its extent. In childhood pneumonia, chest radiography continues to be a valuable method of investigation, because radiographic findings are associated with clinical manifestations [5, 6]. Patients with consolidative pneumonia on radiography require more days of respiratory support, have an increased risk of treatment failure, and have a higher case fatality rate than those with other infiltrates [5, 7]. However, although there have been several studies investigating the relationship between radiologic findings in *M. pneumoniae* pneumonia and clinical course, most of these partially evaluated the clinical manifestations in a small study population [8–10].

The purpose of this study was to investigate the correlation between chest radiographic findings and the clinical features in children with *Mycoplasma pneumoniae* pneumonia in a large pediatric patient cohort.

2. **Materials and methods**
The Institutional Review Board approved this study, with a waiver of informed consent requirements (IRB No. H-1711-132-901).

2.1. **Study subjects**
This study included hospitalized children and adolescents under 18 years old who were diagnosed with *M. pneumoniae* pneumonia at our hospital between January 2000 and August 2016. The diagnosis of *M. pneumoniae* pneumonia was made on the basis of the presence of (i) symptoms and signs indicative of pneumonia, including cough, abnormal breath sounds on auscultation, and lung infiltration on chest radiographs; and (ii) a single anti-mycoplasma antibody titer of ≥1:640, a fourfold or greater rise in titers, a positive test result for *M. pneumoniae* by PCR, or *M. pneumoniae* isolated on culture of respiratory specimens. Children and adolescents in an immunocompromised state or those chronic lung disease were excluded from this study, because the underlying conditions may preclude diagnosing *M. pneumoniae*.
infection by serology and affect the auscultation and chest radiographic findings. We also excluded patients with asthma in this study because *M. pneumoniae* infection can exacerbate asthma and it may exaggerate the clinical and radiological presentations of mycoplasma pneumonia [11, 12].

**2.2. Clinical and laboratory data collection**

Medical records of the study population were retrospectively reviewed. Data on the patient’s age at diagnosis, clinical symptoms and signs, admission to the intensive care unit, laboratory examination results including the test results for *M. pneumoniae* infection, and the use of anti-mycoplasma antibiotics (macrolides in all patients and quinolones in 49 patients) were collected. Hypoxia was defined as when the room air pulse oximetry was <90% or the patient was assumed to be hypoxic and receiving supplemental oxygen [13]. Tachypnea was defined as a respiratory rate of >60 breaths per minute for children aged ≤2 months, >50 for children aged 2–12 months, >40 for children aged 1–5 years, and >20 for children aged >5 years. Tachycardia was defined as >205 beats per minute (bpm) for neonates, >180 bpm for infants, >140 bpm for children aged 1–3 years, >120 bpm for children aged 3–5 years, >118 bpm for children aged 5–10 years, and >100 for adolescents older than 10 years of age [14]. Patients were considered febrile when the axillary body temperature was 38˚C or above. The auscultation findings were described as crackles, wheezing, or decreased breath sounds. Extrapulmonary manifestations, such as rash, elevated liver enzyme levels, proteinuria, and arthralgia were evaluated during the hospitalization period [15]. Elevation of liver enzyme levels was defined as at least a twofold increase from the baseline level. Proteinuria was diagnosed when patients younger than the age of 2 years had a urine protein/creatinine ratio >0.5 or patients 2 years of age and older had a ratio >0.2.

**2.3. Chest radiographic findings and categorization**

The chest radiographs obtained during the course of illness were reviewed by two pediatric radiologists (30-year experience; W.S.K. and 6-year experience; Y.C.) in consensus. The radiologists were unaware of the clinical data associated with each chest radiograph. After analysis of the chest radiograph of each patient, the radiologic findings were categorized as follows: *lobar or segmental consolidation, patchy infiltration, localized reticulonodular opacity, and parahilar peribronchial infiltration* (Fig 1). *Lobar or segmental consolidation* was defined as homogenous dense opacity obscuring pulmonary vascular shadows and involving more than a pulmonary segment. *Patchy infiltration* was defined as a localized ill-defined increased-attenuation lesion or ground-glass lesion involving subsegmental areas. *Localized reticulonodular infiltration* was defined as a reticulonodular opacity involving less than half of one lung field. *Parahilar peribronchial infiltration* was defined as an extensive parahilar reticulonodular lesion involving larger than half of one lung field. For patients with multiple findings in a single chest radiograph, the most dominant finding was chosen (Fig 2). When patients had multiple chest radiographs taken, the radiograph showing the severest features was reviewed. The presence of accompanying pleural effusion was also reviewed. For further analysis, the radiologic findings were grouped as *consolidation group* (*lobar or segmental consolidation*) and *non-consolidation group* (*patchy infiltration, localized reticulonodular infiltration or parahilar peribronchial infiltration*).

**2.4. Chest radiographic findings and the age of patients**

We analyzed the age distribution of patients in the *consolidation group* and those in the *non-consolidation group*. To investigate the difference in radiographic findings according to the age
of the children, patients were divided into three age groups (<2 years, 2–5 years, and ≥5 years) and their chest radiographic findings were compared.

2.5. Diagnostic tests for *Mycoplasma pneumoniae*

Determining the presence of specific antibodies against *M. pneumoniae* was performed using an indirect particle agglutination test kit (SerodiaMycoII, Fujirebio, Tokyo, Japan). Antibody titers were tested in dilutions from 1:40 to 1:20,480, and a single titer of ≥1:640 or a fourfold or greater rise in titers was considered suggestive of *M. pneumoniae* infection, with reference to previously published data [16]. PCR analysis was performed on nasopharyngeal aspirate specimens that were obtained using mucus traps and catheters within 1–2 days after the patients’ visit to the hospital.

2.6. Statistical analysis

The chi-squared test or Fisher’s exact test was used to compare categorical variables, and the Mann-Whitney U test was used to compare continuous variables. Differences were considered
statistically significant when the $P$ value was below 0.05. SPSS version 23.0 was used to perform the statistical analysis.

3. Results

3.1. Clinical characteristics of *M. pneumoniae* pneumonia

A total of 393 patients were included in this study, and their median age was 5 years (IQR, 3–7 years). Among them, 381 patients (97%) had fever with a median duration of 10 days (IQR, 7–13 days). Eighty-nine patients (23%) presented with hypoxia and received supplementary oxygen therapy. Sixty-three patients of them had documented hypoxemia on pulse oximetry and remaining 26 patients were assumed to be hypoxic by clinicians. Tachypnea and tachycardia were noted in 63% and 79% of the children, respectively. On auscultation, crackles (53%) were predominantly heard, followed by decreased breath sounds (27%) and wheezing (10%). Extrapulmonary manifestations were observed in 30% of the patients. Liver enzyme level elevation (58%) and rash (55%) were the two most common findings, followed by proteinuria (9%) and arthralgia (8%). Among the patients, 2% were admitted to the intensive care unit due to respiratory failure. Three hundred and forty-six patients (88%) received anti-mycoplasma antibiotic treatment for a median duration of 13 days (IQR, 10–16 days). Beta-lactam antibiotics were co-administered in 183 (47%) patients as empirical therapeutics for other potential bacteria. The median hospitalization period was 6 days (IQR, 2–9 days).

3.2. Chest radiographic findings of *M. pneumoniae* pneumonia

The most common chest radiograph finding in *M. pneumoniae* pneumonia was lobar or segmental consolidation (37%), followed by parahilar peribronchial infiltration (27%), localized reticulonodular infiltration (21%), and patchy infiltration (15%) (Table 1). Multiple findings in a single chest radiograph were observed in 123 of 393 patients (31%). Pleural effusion was detected in 132 of 393 patients (34%) and was more frequently associated with lobar or segmental consolidation (63%) and patchy infiltration (25%) compared to localized reticulonodular infiltration (13%) or parahilar peribronchial infiltration (14%). The differences in the distribution of pleural effusion among the four different chest radiographic findings were statistically significant ($P < 0.001$) except that between the localized reticulonodular infiltration and parahilar peribronchial infiltration groups. Twelve of the 132 patients (9%) showed massive pleural effusion, requiring percutaneous catheter drainage.

3.3. Association between chest radiographic findings and clinical manifestations

The difference between the consolidation group and the non-consolidation group on chest radiographs in relation to clinical manifestations is shown in Table 2. The consolidation group

| Consolidation group | Non-consolidation group | $P$-value |
|---------------------|-------------------------|-----------|
| **Lobar or Segmental consolidation** | **Patchy infiltration** | **Localized reticulonodular infiltration** | **Parahilar peribronchial infiltration** |
| Patients, N (%) | 146 (37) | 57 (15) | 83 (21) | 107 (27) |
| Pleural effusion, N (%) | 92 (63) | 14 (25) | 11 (13) | 15 (14) | <0.001* |

* $P < 0.001$ for consolidation vs. other infiltrations and also when each one of the four categories were separately compared except for localized reticulonodular opacity vs. parahilar peribronchial infiltration.

https://doi.org/10.1371/journal.pone.0219463.t001
on chest radiographs had a longer median fever duration (12 days vs. 9 days, \( P < 0.001 \)) and were more likely to have hypoxia \( (P = 0.006) \), tachypnea \( (P = 0.001) \), and tachycardia \( (P = 0.010) \). The incidence of chest retraction showed no difference between both groups. Breathing sounds were decreased in the consolidation group \( (P < 0.001) \), whereas crackles were frequently heard in the non-consolidation group \( (P < 0.001) \). Extrapulmonary manifestations, such as rash and liver enzyme level elevation, were more frequently observed in the consolidation group \( (P < 0.001) \). The white blood cell count was higher in the non-consolidation than in the consolidation group \( (8.6 \times 10^3/\mu L \) vs. \( 7.7 \times 10^3/\mu L \), respectively, \( P = 0.006) \). However, the median level of C-reactive protein was higher in the consolidation group than in the non-consolidation group \( (5.3 \text{ mg/dL} \) vs. \( 2.6 \text{ mg/dL} \), respectively, \( P < 0.001) \). In the consolidation group, more patients received anti-mycoplasma antibiotics than in the non-consolidation group \( (95\% \) and \( 84\% \), respectively, \( P = 0.008) \), and the consolidation group required treatment with anti-mycoplasma antibiotics for a longer duration than the non-consolidation group \( (15 \text{ days} \) vs. \( 11 \text{ days} , P = 0.001) \). The median hospitalization period was longer in the consolidation group than in the non-consolidation group \( (8 \text{ days} \) vs. \( 5 \text{ days} , P < 0.001) \). There was no difference in the requirement of intensive care unit admission between the two groups. When the four categories of radiologic findings were separately analyzed, children with lobar or segmental consolidation showed the longest median fever duration \( (12 \text{ days} , P < 0.001) \) as well as the highest incidence of hypoxia \( (30\% \), \( P = 0.006), \) tachypnea \( (75\% , P < 0.001) \), tachycardia \( (86\% , P = 0.01) \), and decreased breath sounds \( (53\% , P < 0.001) \). Extrapulmonary manifestations were most commonly observed in the patients with lobar or segmental consolidation \( (47\% , P < 0.001) \). The median level of C-reactive protein was higher in patients with lobar and

### Table 2. Association between chest radiograph findings and clinical manifestations in children with *Mycoplasma pneumoniae* pneumonia.

| Clinical variables | Consolidation group (n = 146) | Non-consolidation group (n = 247) | P-value |
|-------------------|-------------------------------|----------------------------------|---------|
| Age, median (IQR) (y) | 5 (4–8) | 4 (3–7) | <0.001 |
| Clinical Signs | | | |
| Fever duration, median (IQR) (d) | 12 (9–14) | 9 (6–11) | <0.001 |
| Hypoxia | 30% | 18% | 0.006 |
| Tachypnea | 75% | 56% | <0.001 |
| Tachycardia | 86% | 74% | 0.010 |
| Chest retraction | 12% | 13% | 0.965 |
| Crackles | 38% | 62% | <0.001 |
| Wheezing | 6% | 12% | 0.071 |
| Decreased breath sound | 53% | 11% | <0.001 |
| Extrapulmonary manifestation | 47% | 19% | <0.001 |
| Rash | 25% | 11% | <0.001 |
| Liver enzyme elevation | 32% | 9% | <0.001 |
| Laboratory findings | | | |
| WBC count, median (IQR) \( (\times 10^3/\mu L) \) | 7.7 (5.9–10.3) | 8.6 (6.5–12.1) | 0.006 |
| CRP, median (IQR) \( (\text{mg/dL}) \) | 5.3 (2.1–11.4) | 2.6 (0.9–5.0) | <0.001 |
| ICU admission | 3% | 1% | 0.134 |
| Anti-mycoplasma antibiotics treatment | 95% | 84% | 0.008 |
| Duration, median (IQR) (d) | 15 (12–18) | 11 (7–14) | <0.001 |
| Hospitalization period, median (IQR) (d) | 8 (5–11) | 5 (2–7) | <0.001 |

Values are percentage unless otherwise stated.

Abbreviations: y, year; d, day; IQR, interquartile range; WBC, white blood cell; CRP, C-reactive protein; ICU, intensive care unit
segmental consolidation (5.3 mg/dL, *P* < 0.001) and these patents were treated with anti-myco-
plasmal antibiotics and hospitalized for the longest period (15 days, *P* < 0.001) among the four
radiologic category groups.

3.4. Chest radiographic findings and the age of patients

The median age of the consolidation group was higher than that of the non-consolidation group
(5 years vs. 4 years, *P* < 0.001) (Table 2). The radiographic features according to three different
age groups are shown in Table 3. Lobar or segmental consolidation was most frequently
observed in children aged ≥5 years (44%), followed by children aged 2–5 years (34%) and chil-
dren aged <2 years (13%); this difference was statistically significant (*P* < 0.001). In compari-
son, parahilar peribronchial infiltration was observed in 56% of children aged <2 years,
followed by 32% of children aged 2–5 years and 18% of children aged ≥5 years; this difference
among the age groups was statistically significant (*P* < 0.001). There was no difference in the
incidence of patchy infiltration or localized reticulonodular infiltration among the different age
groups.

4. Discussion

The chest radiographic examination is an essential part of the diagnosis of pneumonia includ-
ing *M. pneumoniae* pneumonia. Furthermore, chest radiographs play an important role in
assessing a patient’s current condition and prognosis, as well as in determining the treatment
plan. The radiographic findings of *M. pneumoniae* pneumonia in children are nonspecific and
variable and may include localized reticulonodular opacities, parahilar peribronchial infiltrations,
localized ground glass lesions, lobar consolidation, and mixed interstitial and focal air-
space pneumonia at multiple sites [17]. In addition, minimal or small pleural effusions and
hilar lymphadenopathy can be associated [17]. Typical radiographic findings of *M. pneumo-
niae* pneumonia were known to be focal reticulonodular opacification or peribronchial inter-
stitial infiltrates [9, 17, 18]. However, several authors have stated that patchy consolidation or
homogenous consolidation are common findings in *Mycoplasma pneumoniae* pneumonia [8,
19–21]. In previous studies of pediatric patients, the proportions of patients with consolidative
lesions were 33 to 70% [9, 17, 21].

The various and variable radiologic features can be understood through the pathophysio-
logical mechanism of mycoplasmal pneumonia. *M. pneumoniae* attach to the ciliated epithelial
cells on the respiratory tract through the P1 protein, further protecting the organism from
mucociliary clearance and producing local cytotoxic effects [22]. Therefore, the characteristic
histopathologic features are edematous and ulcerative bronchial and bronchiolar walls that are
infiltrated with macrophages, lymphocytes, neutrophils, and plasma cells. These findings
manifest as peribronchial infiltrates and nodular opacities on chest radiograph [23]. In severe pneumonia, the cell-mediated immune response is exaggerated, and interleukin levels are elevated, resulting in diffuse alveolar damage with fibrinous exudates within the alveolar lumens, appearing as consolidation on radiographs [24–26]. Several studies already noted that children with severe symptoms were likely to show consolidative features at the radiologic examination [8–10].

In this study, lobar or segmental consolidation (37%) was the most common finding in *M. pneumoniae* pneumonia. In a previous study with 42 patients which consisted of both outpatients and inpatients with *M. pneumoniae* pneumonia, the most common radiological finding was focal reticular opacity (62%). In their study, consolidation or pseudoconsolidation, which also included patchy opacities, were seen in 33% of patients [17]. The subjects of this study consisted of patients who visited and were hospitalized in a tertiary hospital; therefore, patients who had severe symptoms at the beginning of disease or persistent symptoms in spite of treatment at the primary or secondary hospital were more likely to be selected. This could also explain the relatively high incidence (34%) of pleural effusion in this study. The incidence of pleural effusion in *M. pneumoniae* pneumonia is estimated to range from 5% to 24% in other previous studies [17, 27, 28]. In this study, the incidence of pleural effusion was high, especially in patients with lobar or segmental consolidation (63%).

This study involving a large study population with *M. pneumoniae* pneumonia found that the chest radiographic findings correlated well with the clinical manifestations. In several previous studies on hospitalized children with mycoplasma pneumonia, children with lobar or segmental consolidation had a longer fever duration and longer hospitalization period compared with those with non-consolidative lesions [8–10]. In this study, children with lobar or segmental consolidation especially, exhibited the longest fever duration with the highest incidence of extrapulmonary manifestations.

In laboratory results, the C-reactive protein level was significantly higher in the consolidation group than in the non-consolidation group. This correlation between laboratory findings and radiologic findings is in keeping with the findings of previous studies [9, 10]. However, white blood cell (WBC) counts were higher in the non-consolidation group than in the consolidation group, although the clinical significance of this result is unclear. This study further assessed hypoxia, tachypnea, and tachycardia, which indicate severe pneumonia in children, and observed a higher incidence in patients with consolidation [29]. The background of this interrelationship between the symptoms of pneumonia and radiologic findings in *M. pneumoniae* pneumonia could be explained by the immune response as well as pathologic changes. As already mentioned, the cell-mediated immune response plays an important role in the development of *M. pneumoniae* pneumonia [30]. The excessive cell-mediated immune response of the host not only induces the formation of pulmonary consolidation, but also contributes to severe respiratory manifestations [30]. Considering the high proportion of extrapulmonary manifestations in this study, children with lobar or segmental consolidation especially may have an augmented immune response. From these findings, we could further conjecture that this specific subgroup might benefit from anti-inflammatory therapies besides anti-mycoplasma antibiotics.

Previous studies on *M. pneumoniae* pneumonia in children showed that consolidations were more frequently observed in older age, while interstitial changes were most commonly reported in young children [10, 19], which are consistent with the results of this study. In this study, children ≥5 years old were likely to show consolidations (44%), while only 13% of children <2 years old had consolidations. A possible explanation would be the more mature response of T lymphocytes to alveolar macrophages in older children, producing higher levels of cytokines and resulting in more severe pneumonia [26, 31, 32].
This study has several limitations. First, as the study was performed retrospectively, clinical information may have been limited to available medical records of the patients. Second, some radiographic findings are difficult to classify into the four different categories. Third, because this study was performed at a tertiary hospital, many patients had pneumonia severe enough to be referred from primary or secondary hospitals. Therefore, it may be difficult to apply the results of this study to general patient group. Fourth, although we excluded patients with asthma in study population, it is possible that the cases that had not been confirmed as asthma at the time of diagnosis of M. pneumoniae pneumonia could be included.

5. Conclusion

The chest radiographic findings in childhood M. pneumoniae pneumonia are variable and nonspecific. Common radiographic findings of M. pneumoniae pneumonia were lobar or segmental consolidation, parahilar peribronchial infiltration, localized reticulonodular infiltration, and patchy infiltration. The chest radiographic findings of children with M. pneumoniae pneumonia correlate well with the clinical features. The consolidation group was associated with severe clinical features. Lobar or segmental consolidation was more frequently observed in older children. The difference in chest radiographic findings in different age groups may provide guidance to clinicians for managing M. pneumoniae pneumonia in children.

Supporting information

S1 File. Dataset. Individual patient data of clinical and radiologic findings. (XLSX)

Author Contributions

Conceptualization: Yeon Jin Cho, Mi Seon Han, Woo Sun Kim, Eun Hwa Choi, Ki Wook Yun, Jung-Eun Cheon, In-One Kim, Hoan Jong Lee.

Data curation: Yeon Jin Cho, Mi Seon Han, Woo Sun Kim, Eun Hwa Choi, SeungHyun Lee, Jung-Eun Cheon, In-One Kim.

Formal analysis: Yeon Jin Cho, Mi Seon Han, Woo Sun Kim, Eun Hwa Choi, Young Hun Choi, SeungHyun Lee.

Funding acquisition: Eun Hwa Choi.

Investigation: Mi Seon Han, Woo Sun Kim, Eun Hwa Choi, Young Hun Choi, Ki Wook Yun, Jung-Eun Cheon, In-One Kim, Hoan Jong Lee.

Methodology: Yeon Jin Cho, Mi Seon Han, Woo Sun Kim, Eun Hwa Choi, Young Hun Choi, Ki Wook Yun, In-One Kim, Hoan Jong Lee.

Project administration: Woo Sun Kim, Eun Hwa Choi, Ki Wook Yun, Hoan Jong Lee.

Resources: Woo Sun Kim, Eun Hwa Choi.

Supervision: Woo Sun Kim, Eun Hwa Choi, Young Hun Choi, Jung-Eun Cheon, In-One Kim.

Validation: Eun Hwa Choi, Young Hun Choi, Ki Wook Yun, SeungHyun Lee.

Writing – original draft: Yeon Jin Cho, Mi Seon Han.

Writing – review & editing: Yeon Jin Cho, Mi Seon Han, Woo Sun Kim, Ki Wook Yun, Jung-Eun Cheon, In-One Kim, Hoan Jong Lee.
References

1. Cherry JD, Harrison GJ, Kaplan SL, Hotez PJ, Steinbach WJ. Feigin and cherry's textbook of pediatric infectious diseases: Elsevier/Saunders; 2014.

2. Jain S, Williams DJ, Arnold SR, Ampofo K, Bramley AM, Reed C, et al. Community-Acquired Pneumonia Requiring Hospitalization among U.S. Children. New England Journal of Medicine. 2015; 372(9):835–45. https://doi.org/10.1056/NEJMoai1405870 PMID: 25714161.

3. Principi N, Esposito S. Emerging role of Mycoplasma pneumoniae and Chlamydia pneumoniae in respiratory-tract infections. The Lancet Infectious diseases. 2001; 1(5):334–44. Epub 2002/03/02. https://doi.org/10.1016/S1473-3099(01)00147-5 PMID: 11878086.

4. Principi N, Esposito S, Blasi F, Allegra L. Role of Mycoplasma pneumoniae and Chlamydia pneumoniae in Children with Community-Acquired Lower Respiratory Tract Infections. Clinical Infectious Diseases. 2001; 32(9):1281–9. https://doi.org/10.1093/clinids/32.9.1281 PMID: 11303262.

5. Reynolds JH, Mcdonald G, Alton H, Gordon SB. Pneumonia in the immunocompetent patient. The British Journal of Radiology. 2010; 83(996):998–1009. https://doi.org/10.1259/bjr/31200593 PMID: 21088086.

6. Kelly MS, Crotty EJ, Rattan MS, Wirth KE, Steenhoff AP, Cunningham CK, et al. Chest Radiographic Findings and Outcomes of Pneumonia Among Children in Botswana. The Pediatric infectious disease journal. 2016; 35(3):257–62. Epub 2015/11/17. https://doi.org/10.1097/INF.0000000000000990 PMID: 26569190; PubMed Central PMCID: PMC4752380.

7. Yoon IA, Hong KB, Lee HJ, Yun KW, Park JY, Choi YH, et al. Radiologic findings as a determinant and no effect of macrolide resistance on clinical course of Mycoplasma pneumoniae pneumonia. BMC infectious diseases. 2017; 17(1):402. Epub 2017/06/09. https://doi.org/10.1186/s12879-017-2500-z PMID: 28592263; PubMed Central PMCID: PMC5463359.

8. Hsieh SC, Kuo YT, Chern MS, Chen CY, Chan WP, Yu C. Mycoplasma pneumonia: clinical and radiographic features in 39 children. Pediatrics international: official journal of the Japan Pediatric Society. 2007; 49(3):363–7. Epub 2007/05/30. https://doi.org/10.1111/j.1442-200X.2007.02363.x PMID: 17532837.

9. Youn YS, Lee KY, Hwang JY, Rhim JW, Kang JH, Lee JS, et al. Difference of clinical features in childhood Mycoplasma pneumoniae pneumonia. BMC pediatrics. 2010; 10:48. Epub 2010/07/08. https://doi.org/10.1186/1471-2431-10-48 PMID: 20604923; PubMed Central PMCID: PMC2810686.

10. Maffey AF, Barrero PR, Venialgo C, Fernandez F, Fuse VA, Saia M, et al. Viruses and atypical bacteria associated with asthma exacerbations in hospitalized children. Pediatric pulmonology. 2010; 45(6):619–25. Epub 2010/05/27. https://doi.org/10.1002/ppul.21236 PMID: 20503289.

11. Kassisse E, Garcia H, Prada L, Salazar I, Kassisse J. Prevalence of Mycoplasma pneumoniae infection in pediatric patients with acute asthma exacerbation. Archivos argentinos de pediatria. 2018; 116(3):179–85. Epub 2018/05/15. https://doi.org/10.5546/aap.2018.eng.179 PMID: 29756701.

12. Bradley JS, Byington CL, Shah SS, Alversen B, Carter ER, Harrison C, et al. The management of community-acquired pneumonia in infants and children older than 3 months of age: clinical practice guidelines by the Pediatric Infectious Diseases Society and the Infectious Diseases Society of America. Clinical infectious diseases: an official publication of the Infectious Diseases Society of America. 2011; 53(7):e25–76. Epub 2011/09/02. https://doi.org/10.1093/cid/cir531 PMID: 21880587.

13. Association AH, Pediatrics AAo. Pediatric Emergency Assessment, Recognition, and Stabilization. Provider Manual. eBook Edition. 2017.

14. Narita M. Classification of Extrapulmonary Manifestations Due to Mycoplasma pneumoniae Infection on the Basis of Possible Pathogenesis. Frontiers in microbiology. 2016; 7:23. Epub 2016/02/10. https://doi.org/10.3389/fmicb.2016.00023 PMID: 26858701; PubMed Central PMCID: PMC4729911.

15. Kim NH, Lee JA, Eun BW, Shin SH, Chung EH, Park KW, et al. Comparison of polymerase chain reaction and the indirect particle agglutination antibody test for the diagnosis of Mycoplasma pneumoniae pneumonia in children during two outbreaks. The Pediatric infectious disease journal. 2007; 26(10):897–903. Epub 2007/09/29. https://doi.org/10.1097/INF.0b013e318121e3e8 PMID: 17901794.

16. John SD, Ramanathan J, Swischuk LE. Spectrum of clinical and radiographic findings in pediatric mycoplasma pneumonia. Radiographics: a review publication of the Radiological Society of North America, Inc. 2001; 21(1):121–31. Epub 2001/02/07. https://doi.org/10.1148/rg.21.1.g01ja10121 PMID: 11158648.
Correlation between chest radiographic findings and clinical features in children with Mycoplasma pneumonia

18. Cameron DC, Borthwick RN, Philp T. The radiographic patterns of acute mycoplasma pneumonia. Clinical Radiology. 1977; 28(2):173–80. https://doi.org/10.1016/s0009-9260(77)80097-4 PMID: 870278

19. DeFilippis A, Silvestri M, Tacchella A, Giacchino R, Melioli G, Di Marco E, et al. Epidemiology and clinical features of Mycoplasma pneumoniae infection in children. Respiratory medicine. 2008; 102(12):1762–8. Epub 2008/08/16. https://doi.org/10.1016/j.rmed.2008.06.022 PMID: 18703327.

20. Putman CE, Curtis AM, Simeone JF, Jensen P. Mycoplasma pneumonia. Clinical and roentgenographic patterns. The American journal of roentgenology, radium therapy, and nuclear medicine. 1975; 124(3):417–22. Epub 1975/07/01. PMID: 1155679.

21. Güçkel C, Benz-Bohm G, Widemann B. Mycoplasmal pneumonias in childhood. Pediatric Radiology. 1989; 19(8):499–503. https://doi.org/10.1007/bf02389556 PMID: 2677945

22. Waites KB, Talkington DF. Mycoplasma pneumoniae and its role as a human pathogen. Clinical microbiology reviews. 2004; 17(4):697–728, table of contents. Epub 2004/10/19. https://doi.org/10.1128/CMR.17.4.697-728.2004 PMID: 15489344; PubMed Central PMCID: PMC523564.

23. Lee I, Kim TS, Yoon HK. Mycoplasma pneumoniae pneumonia: CT features in 16 patients. European radiology. 2006; 16(3):719–25. Epub 2005/10/11. https://doi.org/10.1007/s00330-005-0026-z PMID: 16215734.

24. Tanaka H. Correlation between Radiological and Pathological Findings in Patients with Mycoplasma Pneumonia Pneumonia. Frontiers in microbiology. 2016; 7(695). https://doi.org/10.3389/fmicb.2016.00695 PMID: 27242720

25. Narita M, Tanaka H, Yamada S, Abe S, Ariga T, Sakiyama Y. Significant role of interleukin-8 in pathogenesis of pulmonary disease due to Mycoplasma pneumoniae infection. Clinical and diagnostic laboratory immunology. 2001; 8(5):1028–30. Epub 2001/08/31. https://doi.org/10.1128/CDLI.8.5.1028-1030.2001 PMID: 11527824; PubMed Central PMCID: PMC96192.

26. Ding S, Wang X, Chen W, Fang Y, Liu B, Liu Y, et al. Decreased Interleukin-10 Responses in Children with Severe Mycoplasma pneumoniae Pneumonia. PloS one. 2016; 11(1):e0146397. Epub 2016/01/12. https://doi.org/10.1371/journal.pone.0146397 PMID: 26751073; PubMed Central PMCID: PMC4708966.

27. Ma YJ, Wang SM, Cho YH, Shen CF, Liu CC, Chi H, et al. Clinical and epidemiological characteristics in children with community-acquired mycoplasma pneumonia in Taiwan: A nationwide surveillance. Journal of microbiology, immunology, and infection = Wei mian yu gan ran za zhi. 2015; 48(6):632–8. Epub 2014/10/15. https://doi.org/10.1016/j.jmii.2014.08.003 PMID: 25311405.

28. Wang RS, Wang SY, Hsieh KS, Chiuo YH, Huang IF, Cheng MF, et al. Necrotizing pneumonia caused by Mycoplasma pneumoniae in pediatric patients: report of five cases and review of literature. The Pediatric infectious disease journal. 2004; 23(6):564–7. Epub 2004/06/15. https://doi.org/10.1097/01.inf.0000130074.56368.4b PMID: 15194841.

29. Scott JA, Wonodi C, Moisi JC, Deloria-Knoll M, DeLuca AN, Karron RA, et al. The definition of pneumonia, the assessment of severity, and clinical standardization in the Pneumonia Etiology Research for Child Health study. Clinical infectious diseases: an official publication of the Infectious Diseases Society of America. 2012; 54 Suppl 2:S109–16. Epub 2012/04/17. https://doi.org/10.1093/cid/cir1065 PMID: 22403224; PubMed Central PMCID: PMC3297550.

30. Miyashita N, Obase Y, Ouchi K, Kawasaki K, Kawai Y, Kobashi Y, et al. Clinical features of severe Mycoplasma pneumoniae pneumonia in adults admitted to an intensive care unit. Journal of Medical Microbiology. 2007; 56(12):1625–9. https://doi.org/10.1099/jmm.0.47119-0

31. Narita M, Tanaka H, Abe S, Yamada S, Kubota M, Togashi T. Close Association between Pulmonary Disease Manifestation in Mycoplasma pneumoniae Infection and Enhanced Local Production of Interleukin-18 in the Lung, Independent of Gamma Interferon. Clinical and diagnostic laboratory immunology. 2000; 7(6):909–14. PubMed PMID: PMC35984. https://doi.org/10.1128/cdli.7.6.909-914.2000 PMID: 11063497

32. Grigg J, Riedler J, Robertson CF, Boyle W, Uren S. Alveolar macrophage immaturity in infants and young children. The European respiratory journal. 1999; 14(5):1198–205. Epub 1999/12/22. PMID: 10596713.