

Small Airway Disease after Mycoplasma Pneumonia in Children: HRCT Findings and Correlation with Radiographic Findings¹

Jung-Eun Cheon, M.D.^{1,3}, Woo Sun Kim, M.D., In-One Kim, M.D.,
Young Yull Koh, M.D.², Hoan Jong Lee, M.D.², Kyung Mo Yeon, M.D.

Purpose: To assess the high-resolution CT (HRCT) findings of small airway abnormalities after mycoplasma pneumonia and correlate them with the findings of chest radiography performed during the acute and follow-up phases of the condition.

Materials and Methods: We retrospectively evaluated HRCT and chest radiographic findings of 18 patients with clinical diagnosis of small airway disease after mycoplasma pneumonia (M:F = 8:10, mean age: 8.3 years, mean time interval after the initial infection; 26 months). We evaluated the lung parenchymal and bronchial abnormalities on HRCT ($n=18$). In addition, presence of air-trapping was assessed on expiratory scans ($n=13$). The findings of HRCT were correlated with those of chest radiography performed during the acute phase of initial infection ($n=15$) and at the time of CT examination ($n=18$), respectively.

Results: HRCT revealed lung parenchymal abnormalities in 13 patients (72%). A mosaic pattern of lung attenuation was noted in ten patients (10/18, 56%), and air-trapping on expiratory scans was observed in nine (9/13, 69%). In nine of 14 (64%) with negative findings at follow-up chest radiography, one or both of the above parenchymal abnormalities was observed at HRCT. In four patients (27%), parenchymal abnormalities were seen at HRCT in areas considered normal at acute-phase chest radiography. Bronchiectasis or atelectasis was observed in eight (44%) and four (22%) patients, respectively, at HRCT. The CT features of Swyer-James syndrome such as a unilateral hyperlucent lung with reduced lung volume and attenuated vessels were noted in two patients (11%).

Conclusion: HRCT can clearly demonstrate lung parenchymal and bronchial abnormalities of small airway disease after mycoplasma pneumonia in children.

Index words : Bronchiolitis obliterans

Children, respiratory system

Computed tomography (CT), high-resolution

Lung, CT

Mycoplasma pneumonia

¹Department of Radiology, Seoul National University College of Medicine, Institute of Radiation Medicine, SNUMRC, Clinical Research Institute, Seoul National University Hospital

²Department of Pediatrics, Seoul National University College of Medicine

³Department of Radiology, Seoul Municipal Boramae Hospital

Received January 21, 2003 ; Accepted March 11, 2003

Address reprint requests to : Woo Sun Kim, M.D., Department of Radiology, Seoul National University Children's Hospital, 28 Yongon-dong, Chongno-gu, Seoul 110-744, Korea.

Tel. 82-2-760-3608 Fax. 82-2-747-5781 E-mail: kimws@radcom.snu.ac.kr

Pneumonia due to *Mycoplasma pneumoniae* is a common infection occurring primarily in children and young adults (1, 2), and its radiologic findings have been extensively described in the literature (3 - 7). The most common of these is a focal or bilateral reticulonodular pattern, and hazy or ground-glass consolidation is also frequent (3, 7). Most published reviews emphasize the benign course of the condition (1 - 7), though long-lasting impairment of small airway function after clinical and radiographic recovery has been reported in children (8, 9).

Obliterative bronchiolitis is a rare disease involving the respiratory bronchioles and characterized by sub-mucosal and peribronchiolar fibrosis (11 - 14). It occurs in various clinical settings. Because *Mycoplasma pneumoniae* involves the bronchial epithelium, where inflammatory host defense mechanisms are active, it is likely that the organism is one of causes of obliterative bronchiolitis (11 - 15). The diagnosis of small airway dis-

ease, including obliterative bronchiolitis, is usually based on radiological findings and abnormal pulmonary function testing rather than on the results of histologic examination, and in patients in whom obliterative bronchiolitis is suspected, high-resolution computed tomography (HRCT) plays a major role (11, 12). The purpose of this study was to determine the HRCT findings of children with clinically suspected obliterative bronchiolitis after mycoplasma pneumonia, and to compare these with their chest radiographic findings.

Materials and Methods

Eighteen children [8 boys and 10 girls; age, 3 - 14 (mean, 8.3) years] with a clinical diagnosis of obliterative bronchiolitis after mycoplasma pneumonia were referred for CT for the evaluation of lung parenchymal abnormality. The main clinical features were as follows: 1) initial clinical findings were consistent with acute lower

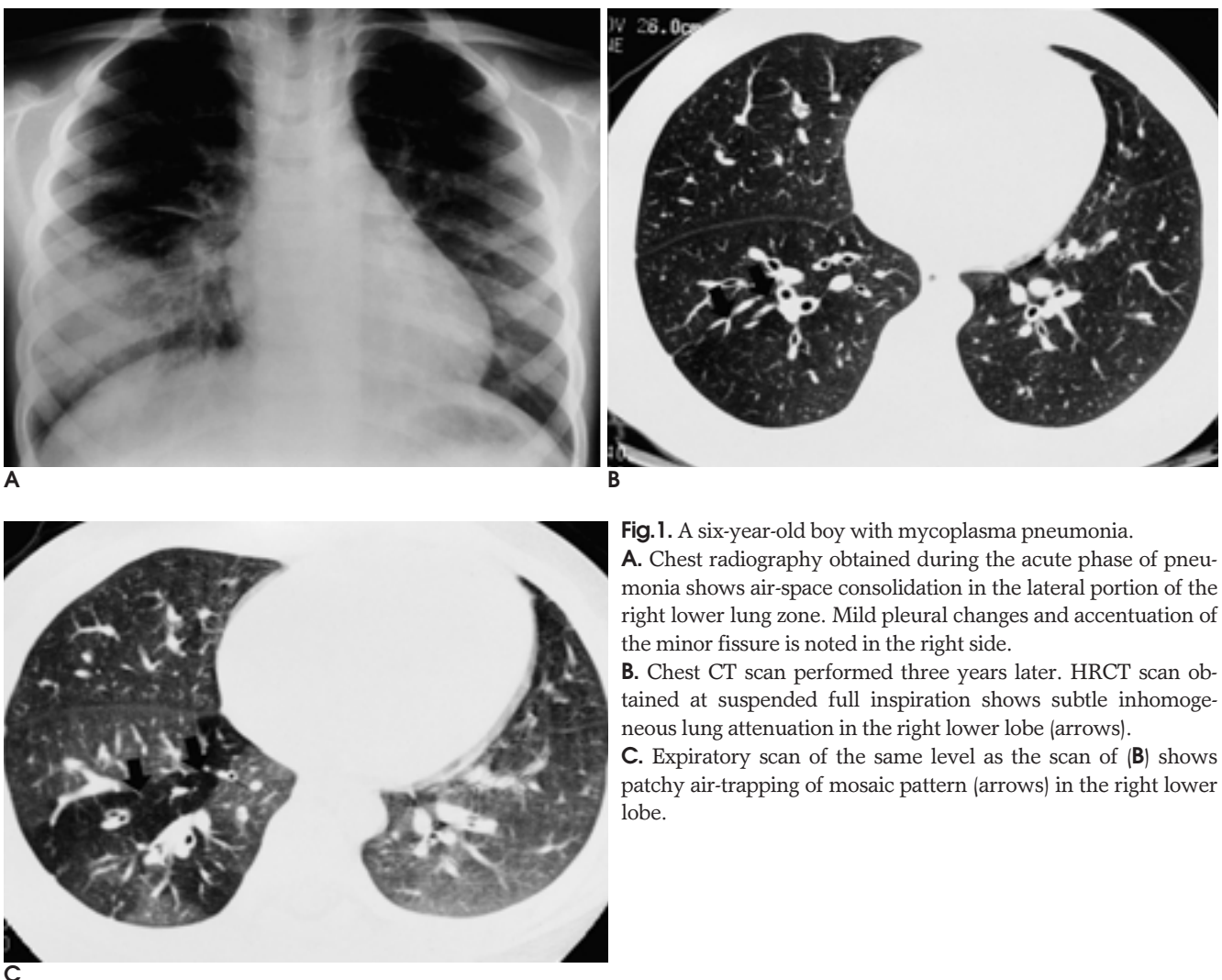


Fig. 1. A six-year-old boy with mycoplasma pneumonia.
A. Chest radiography obtained during the acute phase of pneumonia shows air-space consolidation in the lateral portion of the right lower lung zone. Mild pleural changes and accentuation of the minor fissure is noted in the right side.
B. Chest CT scan performed three years later. HRCT scan obtained at suspended full inspiration shows subtle inhomogeneous lung attenuation in the right lower lobe (arrows).
C. Expiratory scan of the same level as the scan of (B) shows patchy air-trapping of mosaic pattern (arrows) in the right lower lobe.

respiratory tract infection due to *Mycoplasma pneumoniae*, and mycoplasma pneumonia had been diagnosed after increased mycoplasma antibody titer ($>1:640$) or a four-fold or higher rise of titer between the acute and convalescent period; 2) respiratory symptoms, signs, or both [cough ($n=12$), wheezing ($n=4$), or crackles ($n=4$)] had persisted for months or years after the onset of illness; 3) the patients were previously healthy, with no specific antecedent illness, including asthma. In two of eight patients who underwent a pulmonary function test, mild

obstructive pattern (forced expiratory volume in 1sec [FEV1]/ forced vital capacity [FVC] less than 80%) was observed, though no specific abnormality was seen in the other six.

Chest radiographs obtained during the acute phase of pneumonia were available in 15 patients, regularly observed in our out-patient clinic for a mean period of 36 (3 - 54) months, and repeated chest radiographs were obtained during follow-up. For CT scanning, a HiSpeed Advantage System (General Electric Medical Systems,

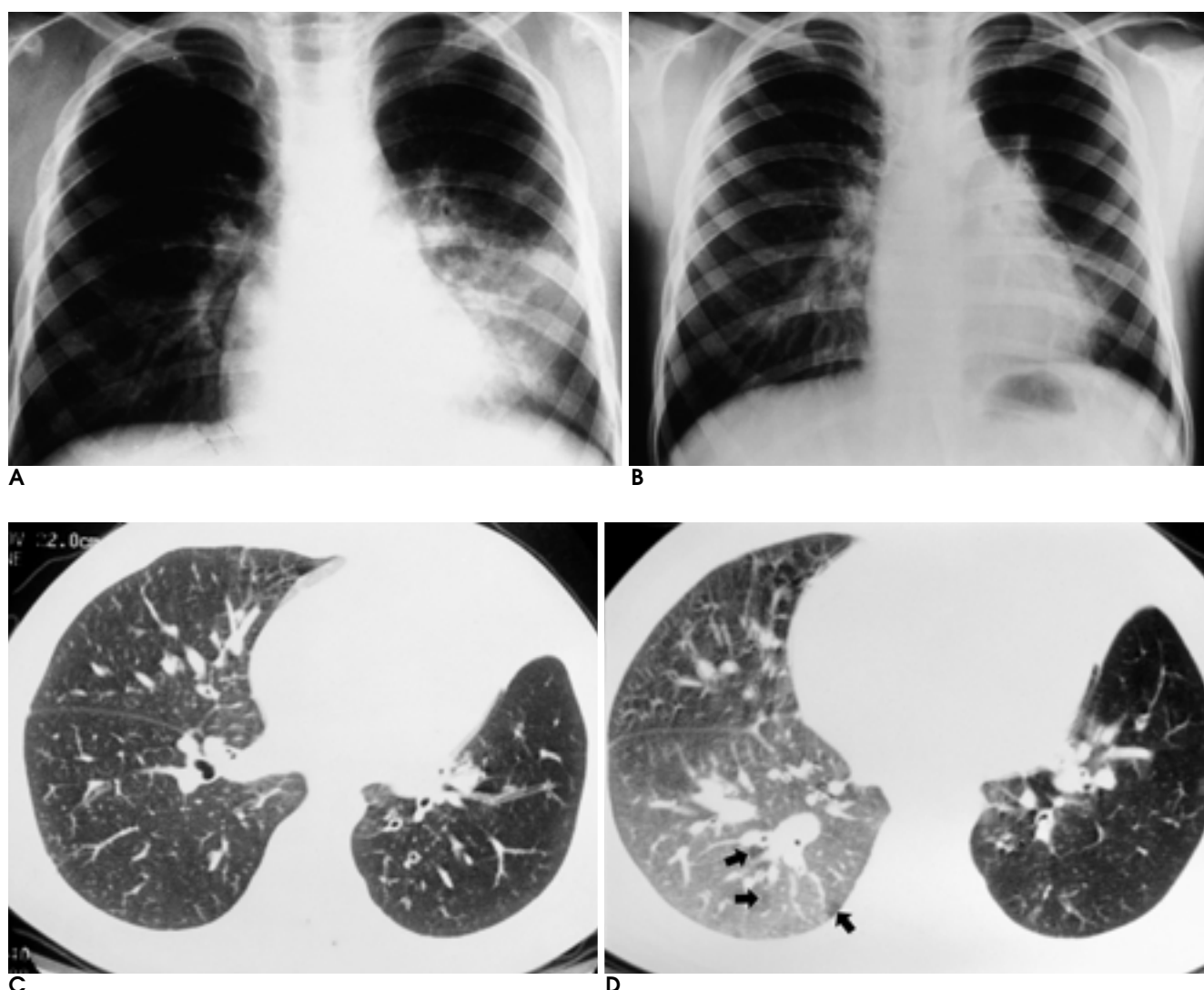


Fig. 2. A seven-year-old boy with left-sided Swyer-James syndrome after mycoplasma pneumonia.

A. Chest radiography obtained during the acute phase of pneumonia shows reticulonodular opacity mixed with patchy air-space consolidation in the left lower lung zone.

B. Follow-up chest radiography obtained six months later shows sparse vascular marking in left upper lung zone and generally reduced lung attenuation in the left lung. The heart is shifted to the left due to decrease in the left lung volume.

C. CT scan obtained at the level of lower lobes shows a small hyperlucent left lung with decreased pulmonary vascularity and a shift of the heart to the left.

D. Expiratory scan obtained at the same level as the scan of (C) shows loss of normal decrease of lung volume and loss of normal increase of lung attenuation in the left lung suggesting air-trapping. Multiple small areas of air-trapping are also seen in the right lower lobe (arrows).

Milwaukee, Wis., U.S.A.) set at 200 mA and 120 KVp was used. In all patients, HRCT scans with 1.5 mm-thick sections were obtained at 10 mm intervals and processed using a bone algorithm, and in 13, suspended full inspiratory and expiratory scanning was performed. In the remaining five, CT scans were obtained during quiet breathing. Filming was performed with a constant window setting (level -700, width 1500). The time interval between the initial episode of acute lower respiratory infection and CT examination ranged from 3 to 49 (mean, 26) months.

Chest radiographs and CT scans were analyzed by two radiologists (J-EC, WSK). The location, extent and pattern of parenchymal lesion revealed by chest radiographs obtained during the acute phase of pneumonia, and changes in lung volume and lung density seen on follow-up radiographs were reviewed. CT scans were

analyzed to determine the presence and extent of a mosaic pattern of lung attenuation on inspiratory scans or those obtained during quiet breathing, and of air-trapping on expiratory scans. A mosaic pattern was defined as a patchwork of regions of hypoattenuation on CT scans. Areas of less attenuated pulmonary parenchyma, especially where a less than normal increase in attenuation during expiration was observed, were considered to represent air-trapping (15, 16). Bronchiectasis or atelectasis was also assessed; the former was considered present when at least one CT scan in any given individual showed that the internal diameter of the bronchus was greater than that of the adjacent pulmonary artery, and tapering of the bronchial lumen was absent (15, 16). CT findings were correlated with the findings of chest radiography performed during the acute phase of infection ($n = 15$) and at the time of CT examination ($n = 18$).

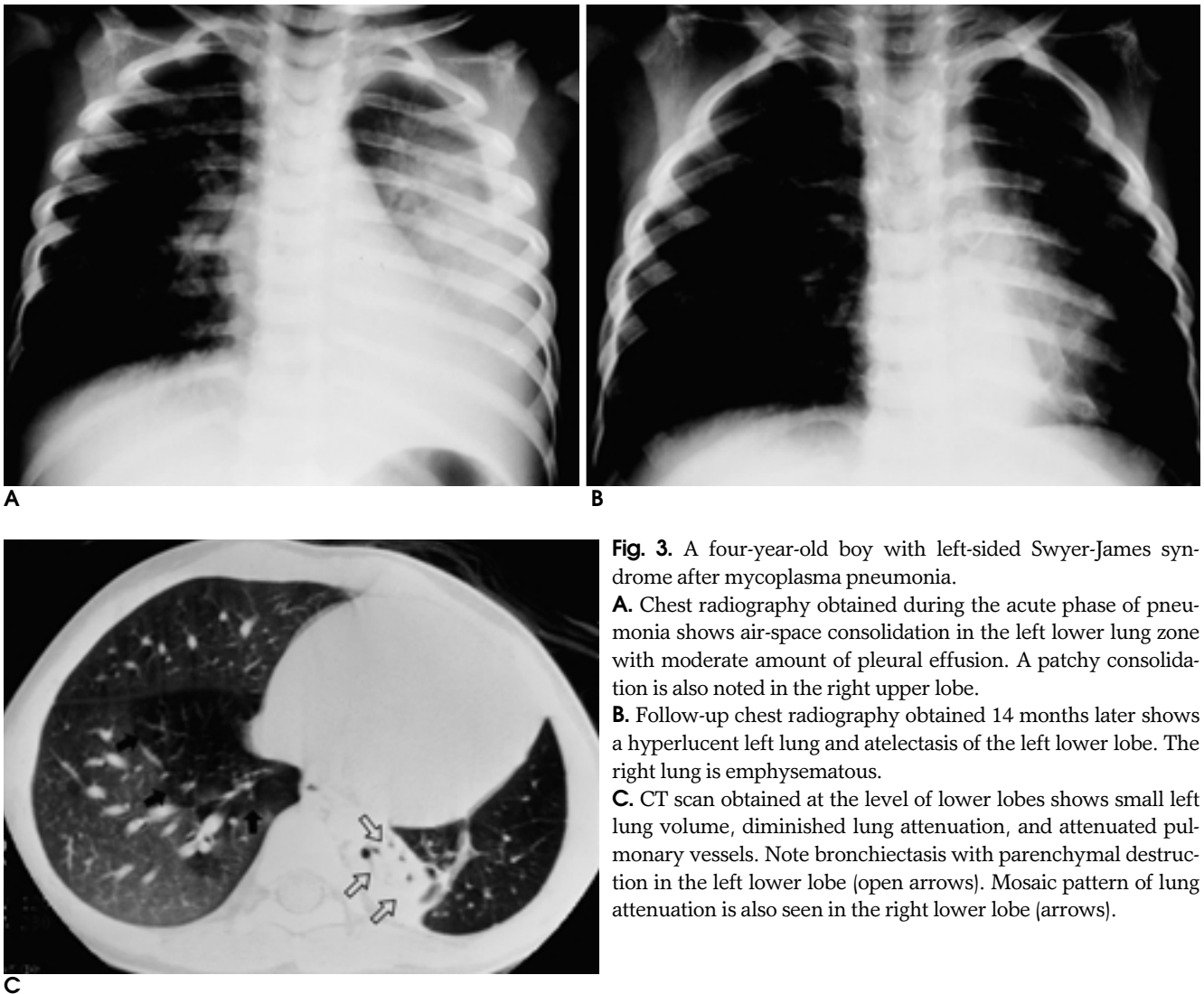


Fig. 3. A four-year-old boy with left-sided Swyer-James syndrome after mycoplasma pneumonia.

A. Chest radiography obtained during the acute phase of pneumonia shows air-space consolidation in the left lower lung zone with moderate amount of pleural effusion. A patchy consolidation is also noted in the right upper lobe.

B. Follow-up chest radiography obtained 14 months later shows a hyperlucent left lung and atelectasis of the left lower lobe. The right lung is emphysematous.

C. CT scan obtained at the level of lower lobes shows small left lung volume, diminished lung attenuation, and attenuated pulmonary vessels. Note bronchiectasis with parenchymal destruction in the left lower lobe (open arrows). Mosaic pattern of lung attenuation is also seen in the right lower lobe (arrows).

Results

Initial chest radiography ($n=15$) revealed air-space consolidation (Figs. 1A and 3A) in nine patients (60%), reticular or reticulonodular opacities in four (27%), and a mixed pattern (Fig. 2A) in two (13%). Parenchymal abnormalities were unilateral in eleven patients and bilateral in four. Zonal distribution was as follows: left lower lung ($n=10$), right lower lung ($n=5$), left upper lung ($n=2$), and right upper lung ($n=2$). Pleural effusion was noted in three patients (Fig. 3A).

Chest radiographs obtained at the time of CT ($n=18$) were normal in 14 patients (78%). The remaining four had unilateral emphysema ($n=2$) (Fig. 2B), localized emphysema of the left lower lobe ($n=1$), or atelectasis of the left lower lobe ($n=1$) (Fig. 3B).

HRCT ($n=18$) demonstrated lung parenchymal abnormalities in 13 patients (72%), with a mosaic pattern of lung attenuation in ten (56%) (Figs. 1B and 3C). The lesions were unilateral in six patients and bilateral in four; in each of the ten, the mosaic pattern involved one to four lobes (18 in total). At expiratory CT ($n=13$), air-trapping was observed in nine patients (69%), with unilateral ($n=6$) or bilateral ($n=3$) distribution (Figs. 1C and 2D). Air-trapping in the absence of inspiratory scan abnormalities was noted in three patients (23%). Bronchiectasis ($n=8$, 44%) and segmental or lobar atelectasis ($n=4$, 22%) were also present (Fig. 3C). Centrilobular nodules suggesting bronchiolar lesions were not found in any patients. The CT features of Swyer-James syndrome (reduced lung volume with hypoattenuation at the affected side, diminished vascular marking, bronchial dilatation, and air-trapping) were, however, seen in two patients (11%) (Figs. 2C, 2D and 3C). In four patients (22%), CT revealed no abnormality.

In ten of 15 patients (66%), the involved lobes seen at HRCT corresponded with the involved area depicted by chest radiographs obtained during the acute phase of pneumonia (Fig. 1). In four of the 15 (27%), CT revealed a mosaic pattern of lung attenuation or air-trapping in areas shown to be normal at acute-phase chest radiography (Figs. 2D and 3C). Nine of 14 patients (64%) with negative findings at chest radiography performed at the time of CT examination showed a mosaic pattern of lung attenuation and/or air-trapping at HRCT.

Discussion

Mycoplasma pneumonia is a community-acquired infection frequently encountered in clinical practice. Although clinically apparent pneumonia occurs in only 3 to 10 percent of infected persons, it probably accounts for up to 30 percent of all pneumonia in the general population (1, 2). The clinical course of mycoplasma pneumonia is typically benign and self-limiting. However, a follow-up study of 50 children undertaken by Mok et al. demonstrated persistent abnormalities of small airway function after mycoplasma respiratory illness (8). Sabato et al. (9) also demonstrated persistent pulmonary function abnormality, even in symptom-free children, at three-year follow-up. According to Kim et al. (10), a considerable proportion of children have abnormal HRCT findings after mycoplasma pneumonia, and younger age and higher antimycoplasmal antibody titer may be risk factors for sequelae.

HRCT is currently regarded as a useful adjunct to conventional diagnostic procedures including ventilation-perfusion scintigraphy and pulmonary function test in the evaluation of small airway disease (11, 12, 18 - 20). The CT findings of obliterative bronchiolitis are a mosaic pattern of lung attenuation, air trapping and bronchial dilatation, as well as centrilobular nodular or branching structures related to thickening of the bronchiolar wall. As the term "mosaic pattern of lung attenuation" is non-specific and refers to a pattern that occurs in a variety of lung diseases, paired inspiratory-expiratory CT scanning is useful for distinguishing small airway disease from other causes of a mosaic pattern of lung attenuation. In small airway disease, the hyperlucent area of the lung seen at inspiration will remain hyperlucent at expiration because of air trapping, showing no or minimal decrease in volume (18 - 20).

Swyer-James syndrome is a variant of postinfectious bronchiolitis obliterans and at radiography is characterized by a unilateral small lung with hyperlucency and air trapping (15, 21, 22). The CT findings of Swyer-James syndrome may include hyperlucent lung, reduced or normal lung volume, bronchiectasis, attenuated vascular markings, and air trapping at expiratory CT (21, 22). Swyer-James syndrome as a sequela of mycoplasma pneumonia has been reported in the literature (15).

From this preliminary experience of using HRCT for the evaluation of lung parenchymal change occurring af-

ter mycoplasma pneumonia, we have found that the modality is sensitive in detecting a mosaic pattern of lung attenuation and air trapping, and superior to radiography in showing its extent and distribution. HRCT is also excellent for the detection of bronchial abnormalities. We therefore believe that it can be a useful diagnostic modality for the detection of late sequelae of mycoplasma pneumonia, especially in patients without chest radiographic abnormalities in spite of the presence of respiratory symptoms. However, our study suffers certain limitations. First, because we did not collect data from a consecutive group of patients with mycoplasma pneumonia, we could not estimate the incidence of late parenchymal complications arising after mycoplasma pneumonia. Second, the possibility of subclinical infection other than mycoplasma pneumonia during the follow-up period could not be completely ruled out.

In conclusion, HRCT can clearly show lung parenchymal and bronchial abnormalities of small airway disease after mycoplasma pneumonia in children. Further study of the correlation between parenchymal changes observed at HRCT and clinical symptoms or pulmonary function abnormalities is required.

References

1. Mansel JK, Rosenow EC 3rd, Smith TF, Martin JW Jr. Mycoplasma pneumoniae pneumonia. *Chest* 1989;95:639-646
2. Cassell GH, Cole BC. Mycoplasmas as agents of human disease. *N Engl J Med* 1981;304:80-89
3. John SD, Ramanathan J, Swischuk LE. Spectrum of clinical and radiographic findings in pediatric mycoplasma pneumonia. *RadioGraphics* 2001;21:121-131
4. Guckel C, Benz-Bohm G, Widemann B. Mycoplasmal pneumonias in childhood. Roentgen features, differential diagnosis and review of literature. *Pediatr Radiol* 1989;19:499-503
5. Finnegan OC, Fowles SJ, White RJ. Radiographic appearances of mycoplasma pneumonia. *Thorax* 1981;36:469-472
6. Putman CE, Curtis AM, Simeone JF, Jensen P. Mycoplasma pneumonia. Clinical and roentgenographic patterns. *Am J Roentgenol* 1975;124:417-422
7. Reittner P, Müller NL, Heyneman L, et al. Mycoplasma pneumoniae pneumonia: radiographic and high-resolution CT features in 28 patients. *AJR Am J Roentgenol* 2000;174:37-41
8. Mok JY, Waugh PR, Simpson H. Mycoplasma pneumoniae infection. A follow-up study of 50 children with respiratory illness. *Arch Dis Child* 1979;54:506-511
9. Sabato AR, Martin AJ, Marmion BP, Kok TW, Cooper DM. Mycoplasma pneumoniae: acute illness, antibiotics, and subsequent pulmonary function. *Arch Dis Child* 1984;59:1034-1037
10. Kim CK, Chung CY, Kim JS, Kim WS, Park Y, Koh YY. Late abnormal findings on high-resolution computed tomography after mycoplasma pneumonia. *Pediatrics* 2000;105:372-378
11. Hartman TE, Primack SL, Lee KS, Swensen SJ, Muller NL. CT of bronchial and bronchiolar diseases. *RadioGraphics* 1994;14:991-1003
12. Müller NL, Miller RR. Diseases of the bronchioles: CT and histopathologic findings. *Radiology* 1995;196:3-12
13. Isles AF, Masel J, O'Duffy J. Obliterative bronchiolitis due to Mycoplasma pneumoniae infection in a child. *Pediatr Radiol* 1987;17:109-111
14. Prabhu MB, Barber D, Cockcroft DW. Bronchiolitis obliterans and Mycoplasma pneumonia. *Respir Med* 1991;85:535-537
15. Stokes D, Sigler A, Khouri NF, Talamo RC. Unilateral hyperlucent lung (Swyer-James syndrome) after severe Mycoplasma pneumoniae infection. *Am Rev Respir Dis* 1978;117:145-152
16. Austin JH, Müller NL, Friedman PJ, et al. Glossary of terms for CT of the lungs: recommendations of the Nomenclature Committee of the Fleischner Society. *Radiology* 1996;200:327-331
17. Stern EJ, Müller NL, Swensen SJ, Hartman TE. CT mosaic pattern of lung attenuation: etiologies and terminology. *J Thorac Imaging* 1995;10:294-297
18. Stern EJ, Webb WR. Dynamic imaging of lung morphology with ultrafast high-resolution computed tomography. *J Thorac Imaging* 1993;8:273-282
19. Johnson JL, Kramer SS, Mahhoubi S. Air trapping in children: evaluation with dynamic lung densitometry with spiral CT. *Radiology* 1998;206:95-101
20. Arakawa H, Webb WR, McCowin M, Katsou G, Lee KN, Seitz RF. Inhomogeneous lung attenuation in thin-section CT: diagnostic value of expiratory scans. *Radiology* 1998;206:89-94
21. Moore AD, Godwin JD, Dietrich PA, Verschakelen JA, Henderson WR Jr. Swyer-James syndrome: CT findings in eight patients. *AJR Am J Roentgenol* 1992;158:1211-1215
22. Marti-Bonmati L, Ruiz Perales F, Catala F, Mata JM, Calonge E. CT findings in Swyer-James syndrome. *Radiology* 1989;172:477-480

