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Pulmonary thin-section CT findings in acute *Moraxella catarrhalis* pulmonary infection

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Objective: *Moraxella catarrhalis* is an important pathogen in the exacerbation of chronic obstructive pulmonary disease. The aim of this study was to assess the clinical and pulmonary thin-section CT findings in patients with acute *M. catarrhalis* pulmonary infection.

Methods: Thin-section CT scans obtained between January 2004 and March 2009 from 292 patients with acute *M. catarrhalis* pulmonary infection were retrospectively evaluated. Clinical and pulmonary CT findings in the patients were assessed. Patients with concurrent infection including *Streptococcus pneumoniae* ($n=72$), *Haemophilus influenzae* ($n=61$) or multiple pathogens were excluded from this study.

Results: The study group comprised 109 patients (66 male, 43 female; age range 28–102 years; mean age 74.9 years). Among the 109 patients, 34 had community-acquired and 75 had nosocomial infections. Underlying diseases included pulmonary emphysema ($n=74$), cardiovascular disease ($n=44$) or malignant disease ($n=41$). Abnormal findings were seen on CT scans in all patients and included ground-glass opacity ($n=99$), bronchial wall thickening ($n=85$) and centrilobular nodules ($n=79$). These abnormalities were predominantly seen in the peripheral lung parenchyma ($n=99$). Pleural effusion was found in eight patients. No patients had mediastinal and/or hilar lymph node enlargement.

Conclusions: *M. catarrhalis* pulmonary infection was observed in elderly patients, often in combination with pulmonary emphysema. CT manifestations of infection were mainly ground-glass opacity, bronchial wall thickening and centilobular nodules.

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Moraxella catarrhalis is a Gram-negative, aerobic, oxidase-positive diplococcus that was first described in 1896 [1]. The pathogen, also known as *Micrococcus catarrhalis*, *Neisseria catarrhalis* and *Brahamella catarrhalis*, is a clinically important pathogen and is a common cause of respiratory infections, particularly otitis media in children and lower respiratory tract infection in elderly patients [2–5]. *M. catarrhalis* is considered to be the third most common and most important cause of broncho-pulmonary infections after *Streptococcus pneumoniae* and *Haemophilus influenzae* [6, 7]. In the Alexander project in Europe and the US between 1992 and 1993, *M. catarrhalis* was identified in 13.5% of bacterial isolates [8].

M. catarrhalis has also gained attention as a nosocomial respiratory pathogen and as a community-acquired pathogen. On the basis of epidemiological evidence, the spread of *M. catarrhalis* was suggested to occur within the hospital environment [9, 10]. McLeod et al [11] reported that 43 of 81 patients (53%) with *M. catarrhalis* infection were infected in a hospital and that the infection was associated with the proximity of the patient to other patients. Most nosocomial infections with *M. catarrhalis* involve the respiratory tract and outbreaks have been reported in respiratory units and paediatric intensive care units [10, 12].

M. catarrhalis infection has received increasing attention because it is an important factor in the acute exacerbation of chronic obstructive pulmonary disease (COPD). Acute exacerbation is a frequent event during the prolonged chronic course of COPD, which entails significant morbidity and mortality. The main aetiology for the majority of episodes is infection.

Al-Anazi et al [13] reported a CT image of pneumonia associated with *M. catarrhalis* in a haematopoietic stem cell transplant patient. However, to the best of our knowledge, no other English-language studies of pulmonary CT findings in patients with acute *M. catarrhalis* pulmonary infection have been published. Therefore, this study aimed to assess the clinical and pulmonary thin-section CT findings in acute *M. catarrhalis* pulmonary infection.

Methods and materials

Our institutional review board approved this retrospective study and waived informed consent.

We retrospectively identified 292 patients with acute *M. catarrhalis* pulmonary infection who had undergone pulmonary thin-section CT scans between January 2004 and March 2009 at four institutions. We excluded 72 patients infected with *S. pneumoniae*, 61 with *H.*

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influenzae, 37 with *Staphylococcus aureus*, 25 with meticillin-resistant *Staphylococcus aureus* (MRSA), 20 with *Pseudomonas aeruginosa* and some with other pathogens, who were diagnosed with concurrent infectious diseases by serological tests and clinical findings. Of the patients with concurrent infection, 44 were infected with more than one organism. Seven patients with pulmonary oedema, five with recurrence of malignancy and one with pulmonary haemorrhage were also excluded. Moreover, four cases with acute *M. catarrhalis* pulmonary infection were excluded because of poor image quality caused by motion artefacts, inadequate window level settings or for which hard copies of the CT film had been destroyed. Thus, the study group comprised 109 patients (66 male, 43 female; age range 28–102 years; mean age 74.9 years) with acute *M. catarrhalis* pulmonary infection. No patients with human immunodeficiency virus (HIV) infection or smoking-related diseases such as desquamative interstitial pneumonia or Langerhans cell histiocytosis were included in this study.

The diagnosis was established by isolation of *M. catarrhalis* from sputum in 100 patients, sputum from the trachea in 7 and bronchoalveolar lavage fluid in 2. A patient was considered to have community-acquired pneumonia if, at the time of hospital admission, he/she presented with cough (with or without sputum), fever, leukocytosis or leukopenia and had pulmonary infiltrates on chest radiographs. No patient had been admitted to or treated in a hospital 2 weeks prior to admission. Nosocomial pneumonia was defined as pneumonia that occurred 48 h or more after admission, which was not incubated at the time of admission [14]. Among the 109 patients, 34 had community-acquired and 75 had nosocomial infections.

The study group included 74 patients with pulmonary emphysema. In addition, patients with cardiovascular disease (n=44), post-operative status for malignant disease (n=41), diabetes mellitus (n=18) or liver disorders (n=16) were included in the study (Table 1).

An alcoholic was defined as an individual with an alcohol consumption of $\geqslant$80 g day^{-1} during the past 2 years [15]; a patient was considered to be a heavy smoker if he/she had smoked more than 10 pack–years. Overall, 25 patients were alcoholic, 47 were chronic smokers and 12 were both alcoholic and chronic smokers (Table 1).

Table 1. Patient characteristics and underlying conditions

Characteristic/condition	No. of patients (%)
Sex (male/female)	66/43
Pulmonary emphysema	74 (67.9)
Smoking habit	47 (43.1)
Cardiac disease	44 (40.4)
Alcoholic	25 (22.9)
Diabetes mellitus	18 (16.5)
Liver disorder	16 (14.7)
Collagen disease	6 (5.5)
Renal failure	4 (3.7)
Malignancy	41 (37.6)
lung cancer	15 (13.8)
gastric cancer	14 (12.8)
oesophageal cancer	10 (9.2)
colon cancer	2 (1.8)
Presenting symptoms	
cough	103 (94.5)
sputum	81 (74.3)
fever	73 (67.0)
dyspnea	19 (17.4)
general weakness	18 (16.5)

CT

Examinations

Thin-section CT examinations were performed at 4 institutions using a variety of scanners with 1-mm collimation (n=14) at 10-mm intervals from the apex of the lung to the diaphragm or volumetrically with a multidetector CT scanner (n=95) with 1-mm reconstruction. The scans were obtained with the patient in the supine position at full inspiration and images were reconstructed using a high spatial frequency algorithm.

Images were captured at window settings that allowed viewing of the lung parenchyma (window level −600 to −700 HU; window width 1200–1500 HU) and the mediastinum (window level 20–40 HU; window width 400 HU).

The pulmonary CT scan was performed within 1–6 days (mean 4.7 days) after the onset of respiratory symptoms. Intravenously administered contrast material was used in eight patients.

Image interpretation

Two chest radiologists (with 21 and 13 years of experience in chest CT image interpretation), who were aware of the underlying diagnoses, retrospectively and independently interpreted all CT images on workstations. Conclusions were reached by consensus. An average of two sessions per week was reserved to review the CT scans; about 50 sessions were carried out in total.

CT images were assessed for several radiological features: ground-glass opacity, consolidation, nodules, centrilobular nodules, bronchial wall thickening, interlobular septal thickening, intralobular reticular opacity, bronchiectasis, enlarged hilar/mediastinal lymph node(s) (>1 cm diameter short axis) and pleural effusion. Areas of ground-glass opacity were defined as hazy increases in opacity without obscured vascular markings [16, 17]. Areas of consolidation were defined as areas of increased opacity that obscured normal lung markings [16, 17]. Centrilobular nodules were defined as those present around the peripheral pulmonary arterial branches or 3–5 mm from the pleura, interlobular septa or pulmonary veins. Interlobular septal thickening was defined as abnormal widening of interlobular septa [17]. Intralobular reticular opacity was considered present when interlacing line shadows were separated by a few millimetres [16, 17].

The distribution of parenchymal disease was also noted. We also assessed whether the abnormal findings were located unilaterally or bilaterally. If the main lesion was predominantly located in the inner third of the lung, the disease was classified as having a central distribution. By contrast, if the lesion was predominantly located in the outer third of the lung, the disease was classified as having a peripheral distribution. If the lesions showed no predominant distribution, the disease

Table 2. Thoracic CT findings in 109 patients

Finding	No. of patients (%)
Ground-glass opacity	99 (90.8)
Bronchial wall thickening	85 (78.0)
Centrilobular nodules	79 (72.5)
Consolidation	53 (48.6)
Bronchiectasis	42 (38.5)
Intralobular reticular opacity	25 (22.9)
Interlobular septal thickening	10 (9.2)
Nodules	3 (2.8)
Pleural effusion	8 (7.3)
Lymph node enlargement	0 (0)

was classified as having a random distribution. In addition, zonal predominance was classified as upper, lower or random. Upper lung zone predominance was defined as most abnormalities being seen at a level above the tracheal carina, whereas lower zone predominance was defined as most abnormalities being below the upper zone. When abnormalities showed no definite zonal predominance, the lung disease was considered to have a random distribution.

Results

Clinical features

The patient characteristics and underlying conditions are summarised in Table 1. All patients had respiratory symptoms and most showed rapid progression of their respiratory symptoms. The most common presenting symptoms were cough (103 patients, 94.5%), followed by sputum (81 patients, 74.3%), fever (73 patients, 67.0%) and dyspnoea (19 patients, 17.4%).

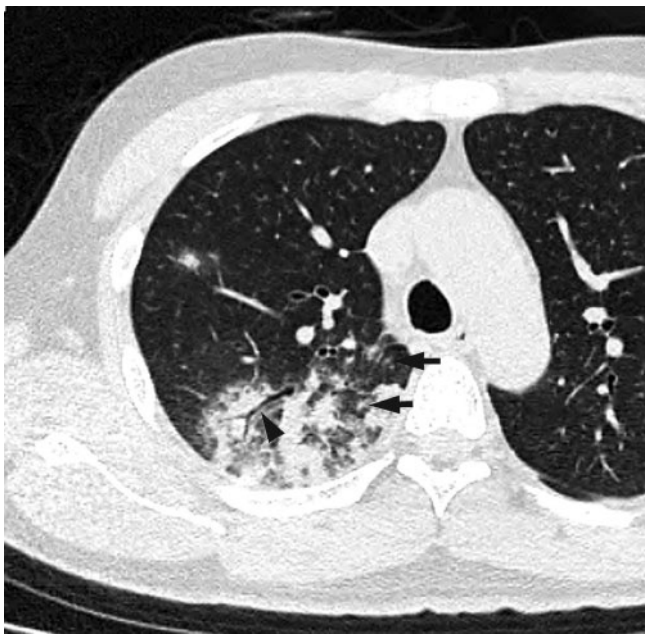

Figure 1. Acute *Moraxella catarrhalis* infection in a 42-year-old alcoholic male with diabetes mellitus, 2 days after onset of fever and cough with sputum. A transverse thin-section CT of the right upper lobe shows consolidation, ground-glass opacity, bronchial wall thickening (arrowhead) and centrilobular nodules (arrow).

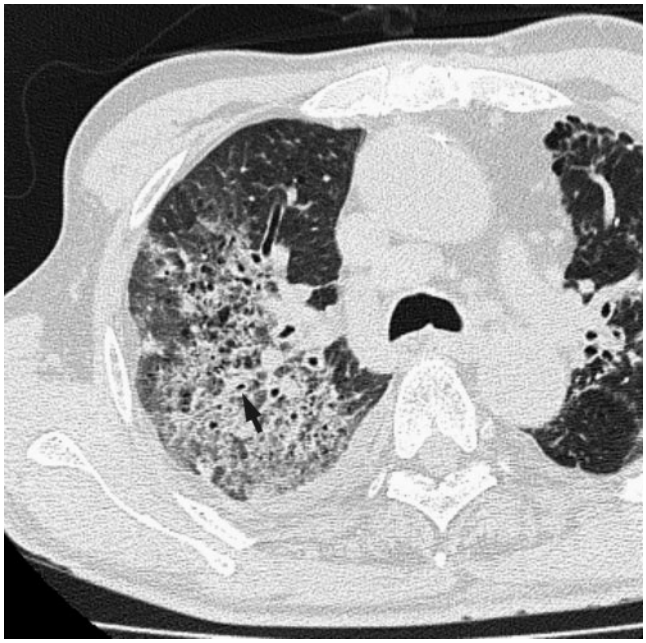

Figure 2. Acute *Moraxella catarrhalis* infection in a 75-year-old alcoholic male with pulmonary emphysema, 4 days after onset of fever, cough and dyspnea. A transverse thin-section CT of the right upper lobe shows consolidation, ground-glass opacity and bronchial wall thickening (arrow). Pleural effusion is also present.

CT patterns

Chest CT scans revealed abnormalities in all patients with *M. catarrhalis* pneumonia (Table 2). Among the 109 patients, ground-glass opacity (n=99, 90.8%) (Figures 1–4) was the most frequently observed abnormality, followed by bronchial wall thickening (n=85, 78.0%) (Figures 1–4), centrilobular nodules (n=79, 72.5%) (Figures 1 and 3),

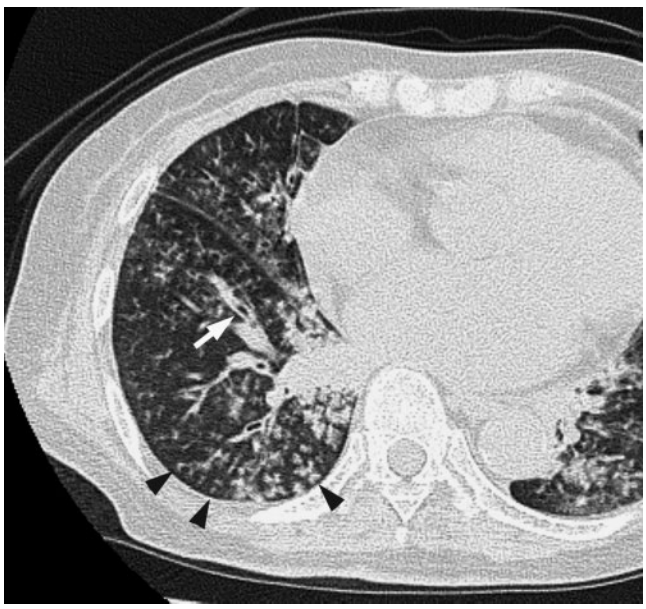

Figure 3. Acute *Moraxella catarrhalis* infection in a 72-year-old alcoholic female with cardiovascular disease and renal failure, 3 days after the onset of fever and cough with sputum. A transverse thin-section CT of the right lower lobe shows centrilobular nodules (arrowheads), bronchial wall thickening (arrow) and mild bronchiectasis.

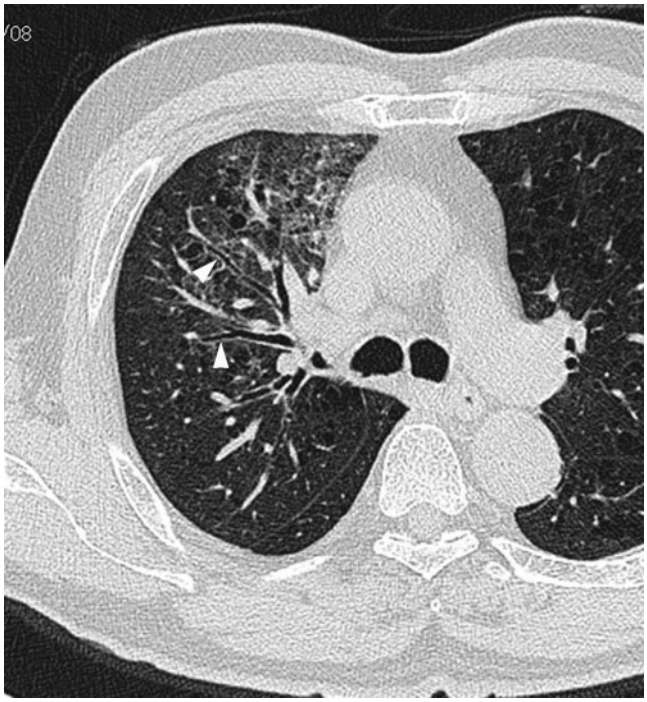

Figure 4. Acute *Moraxella catarrhalis* infection in a 76-year-old alcoholic male with pulmonary emphysema, 3 days after onset of fever and cough. A transverse thin-section CT at the tracheal carina level shows ground-glass opacity and bronchial wall thickening (arrowhead).

consolidation (n=53, 48.6%) (Figures 1 and 2) and bronchiectasis (n=42, 38.5%) (Figure 3). Intralobular reticular opacity (n=25, 22.9%) and interlobular septal thickening (n=10, 9.2%) were also observed. The most frequently observed combination was ground-glass opacity and bronchial wall thickening (n=80, 73.4%) (Figures 1–4), followed by ground-glass opacity and centrilobular nodules (n=71, 65.1%) (Figures 1 and 3) and bronchial wall thickening and centrilobular nodules (n=69, 63.3%) (Figures 1 and 3).

Disease distribution

Of the 109 patients with *M. catarrhalis* pneumonia, abnormal findings were found bilaterally in 63 patients (57.8%), unilaterally in 46 patients (42.2%) and in the periphery in 99 patients (90.8%) (Figures 1, 2 and 4). Ten patients showed a random distribution (9.2%) (Figure 3), no patients had a predominantly central distribution. The predominant zonal distribution was the upper zone in 21 patients (19.3%) (Figures 1, 2 and 4), lower zone in 60 patients (55.0%) (Figure 3) and of random distribution in 28 patients (25.7%).

Effusion and lymph nodes

Bilateral pleural effusions were found in two patients (1.8%) and unilateral pleural effusion was found in six patients (5.5%) (Figure 2) with acute *M. catarrhalis* infection. No patient had mediastinal and/or hilar lymph node enlargement.

Follow-up study

All 109 patients underwent antibiotic therapy. In 32 of 34 patients with community-acquired infections (94.1%), the abnormal findings improved on follow-up CT examinations or chest radiographs. In the remaining two patients (5.9%) with pulmonary emphysema and cardiac disease, however, abnormal findings such as ground-glass opacity and consolidation on follow-up CT worsened and the patients died. By comparison, in 70 of 75 patients with nosocomial infections (93.3%), the abnormal findings improved on follow-up CT or radiographs. In the remaining five patients (6.7%), which included four with pulmonary emphysema and one with cardiovascular disease and diabetes mellitus, the abnormal parenchymal findings and pleural effusions worsened and the patients died.

Discussion

M. catarrhalis is one of the most clinically important Gram-negative bacterial pathogens and is of great concern worldwide for several reasons: infections can exacerbate COPD, they can cause pneumonia (particularly in older adults) and *M. catarrhalis* is a nosocomial respiratory tract pathogen [18].

Exacerbation of COPD can be caused by many factors, including environmental irritants, heart failure or non-compliance with medication use [19]. However, most exacerbations result from bacterial or viral infections [20]. Bacterial infection is a factor in 70–75% of exacerbations; up to 60% are caused by *S. pneumoniae*, *H. influenzae* or *M. catarrhalis* [21].

The majority of respiratory isolates containing *M. catarrhalis* are from elderly patients [2, 22–24]. Wright et al [2] analysed the respiratory isolates obtained at one hospital in Texas and found that 81% of patients with *M. catarrhalis* infection were aged over 55 years. The authors also noted a high short-term mortality rate in elderly patients: 45% of patients died within 3 months of acquiring *M. catarrhalis* pneumonia. Most elderly patients who experience pneumonia as a result of *M. catarrhalis* infection have underlying cardiopulmonary diseases, including COPD, bronchiectasis, congestive heart failure or predisposition to aspiration. Other predisposing conditions associated with *M. catarrhalis* infection include corticosteroid therapy, diabetes mellitus and malignancies [22, 23, 25–28]. Factors contributing to the high incidence of respiratory infections in this age group include immunosuppression and enhanced adherence of *M. catarrhalis* to epithelial cells in elderly patients [29, 30].

Moreover, many nosocomial outbreaks of *M. catarrhalis* infections have been reported. Most of these outbreaks involved respiratory tract infections and some occurred exclusively in pulmonary units [10, 12, 31].

The average age of patients in our study with *M. catarrhalis* infection alone was 74.9 years, which is similar to that in previous reports [2, 22–24]. *S. pneumoniae*, *Klebsiella pneumoniae*, *Mycoplasma pneumoniae* and *Chlamydia pneumoniae* are also common pathogens involved in community-acquired or nosocomial pneumonia. The average age of patients with *M. catarrhalis* infection

tended to be greater than that of patients with pneumonia caused by other pathogens such as *S. pneumoniae*, *K. pneumoniae*, *M. pneumoniae* or *C. pneumoniae* (60 years, 61.5 years, 47.3 years and 57.7 years, respectively) [32–34]. Among the 109 patients with pulmonary infection caused by *M. catarrhalis* alone, pulmonary emphysema (67.9%) was the most commonly associated condition, followed by smokers (43.1%), cardiovascular disease (40.4%), malignant disease (37.6%), alcoholism (22.9%) and diabetes mellitus (16.5%). Underlying diseases such as pulmonary emphysema, cardiovascular disease or malignancy were more frequently seen in patients with *M. catarrhalis* than in patients with *K. pneumoniae* pneumonia alone (67.9% *vs* 17.7%, 40.4% *vs* 19.7% and 37.6% *vs* 18.2%, respectively) [33].

Among the 109 patients in this study, 34 had community-acquired and 75 had nosocomial infections; this observation is similar to that presented in an earlier report [11] and suggests that *M. catarrhalis* is a nosocomial respiratory pathogen and a community-acquired pathogen.

Regarding the presenting symptoms, all patients in the present study had several complaints such as fever, cough and sputum. There were no significant differences between patients with other pneumonias such as *K. pneumoniae*, *M. pneumoniae* or *C. pneumoniae* [33, 34].

In the present study, the mortality rate was 6.4% (7 of 109 patients), which was lower than in previous reports [2, 35]. However, this might be because most of the earlier studies were published in the pre-antibiotic era or in an era of minimal antibiotic use. In addition, no previous studies have evaluated patients with *M. catarrhalis* infection in the absence of any other pathogens. In the present study, one or more additional pathogens, such as *S. pneumoniae*, *H. influenzae*, *S. aureus* or MRSA, were identified in 183 of 292 patients (62.7%) with acute *M. catarrhalis* pulmonary infection; patients diagnosed with concurrent infectious diseases were excluded from this study. Therefore, the mortality rates in our patients with *M. catarrhalis* pulmonary infection might have been lower than those found in previous studies.

There are several case reports of patients with *M. catarrhalis* pulmonary infection [13, 35–37]; however, few included chest radiographs. Cheepsattayakorn et al [35] reported *M. catarrhalis* pneumonia in acquired immunodeficiency syndrome and reported that the chest radiographs showed patchy infiltration in both lower lobes with minimal pleural effusion. Al-Anazi et al [13] presented two cases of *M. catarrhalis* pneumonia in haematopoietic stem cell transplant patients. The chest radiograph of a 17-year-old female with acute myeloid leukaemia showed bilateral pulmonary infiltrates, which were more prominent on the left; the chest CT image showed nodular infiltration involving the left lower lobe and the lateral segment of the right lower lobe. In the other patient, a 50-year-old male with acute myeloid leukaemia, the chest radiograph showed bronchopneumonia. To the best of our knowledge, however, no other English-language studies of pulmonary CT findings in patients with acute *M. catarrhalis* pulmonary infection have been published.

We retrospectively evaluated the CT findings of 109 patients with acute *M. catarrhalis* pulmonary infection. The most common CT findings were ground-glass opacity followed by bronchial wall thickening, centrilobular nodules, consolidation and bronchiectasis. The abnormal findings were predominantly seen in the lower zone and in the peripheral lungs.

Nambu et al [32] reported that the CT findings in 41 patients with *S. pneumoniae* pneumonia consisted mainly of consolidation, reticular opacity and centrilobular nodules (90%, 39% and 32%, respectively). Previously, we have reported chest CT findings in 198 patients with acute *K. pneumoniae* pneumonia alone [33], in 42 patients with *M. pneumoniae* pneumonia alone [34] and in 40 patients with *C. pneumoniae* pneumonia alone [34]. The frequency of bronchial wall thickening with *M. catarrhalis* infection was higher than that with *S. pneumoniae*, *K. pneumoniae* or *C. pneumoniae* infection (78.0% *vs* 41%, 26.3% and 35.0%, respectively). Moreover, the frequency of centrilobular nodules with *M. catarrhalis* infection was also higher than that with *S. pneumoniae*, *K. pneumoniae* or *C. pneumoniae* infection (72.5% *vs* 56%, 4.0% and 7.5%, respectively). The frequencies of these features with *M. catarrhalis* infection were relatively similar to those with *M. pneumoniae* infection; however, the average age of patients with *M. catarrhalis* infection was significantly higher than for those with *M. pneumoniae* (74.9 years *vs* 47.3 years). The frequency of consolidation in patients infected with *M. catarrhalis* was lower than for those with *S. pneumoniae* or *K. pneumoniae* infection (48.6% *vs* 90% and 91.4%, respectively). In addition, intralobular reticular opacity was less frequently seen with *M. catarrhalis* infection than with *K. pneumoniae* or *C. pneumoniae* (22.9% *vs* 85.9% and 70.0%, respectively).

Bilateral pleural effusion was seen in two patients (1.8%) and unilateral pleural effusion in six patients (5.5%) with *M. catarrhalis* infection. The frequency of pleural effusions was lower than in patients with other pathogens such as *S. pneumoniae*, *C. pneumoniae*, *M. pneumoniae* or *K. pneumoniae* (20%, 25–30%, 9.5–20% and 53%, respectively) [32–34].

No patient in our present study had mediastinal and/or hilar lymph node enlargement. The frequency of lymph node enlargement was also lower than in patients with *S. pneumoniae*, *C. pneumoniae* or *M. pneumoniae* (36%, 5–33% and 7.1–10%, respectively) [32–34].

It should be noted that there are several limitations to our study. Firstly, this was a retrospective study and CT images were interpreted by consensus. Secondly, the thin-section CT images were obtained at several institutions using different protocols.

In summary, *M. catarrhalis* pulmonary infection was observed in elderly patients, often in combination with pulmonary emphysema. The CT manifestations in patients with *M. catarrhalis* pulmonary infection consisted mainly of ground-glass opacity, bronchial wall thickening and centrilobular nodules in the lung periphery; there was a low frequency of pleural effusion or lymph node enlargement.

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