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Detection failure rate of chest radiography for the identification of nursing and healthcare-associated pneumonia

Naoyuki Miyashita [a, *], Yasuhiro Kawai [a], Takaaki Tanaka [b], Hiroto Akaike [b], Hideto Teranishi [b], Tokio Wakabayashi [b], Takashi Nakano [b], Kazunobu Ouchi [b], Niro Okimoto [a]

[a] Department of Internal Medicine I, Kawasaki Medical School, Okayama, Japan
[b] Department of Pediatrics, Kawasaki Medical School, Okayama, Japan

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ABSTRACT

Aim: To clarify the detection failure rate of chest radiography for the identification of nursing and healthcare-associated pneumonia (NHCAP), we compared high-resolution computed tomography (HRCT) with chest radiography simultaneously for patients with clinical symptoms and signs leading to a suspicion of NHCAP.

Methods: We analyzed 208 NHCAP cases and compared them based on four groups defined using NHCAP criteria, patients who were: Group A) resident in an extended care facility or nursing home; Group B) discharged from a hospital within the preceding 90 days; Group C) receiving nursing care and had poor performance status; and Group D) receiving regular endovascular treatment.

Results: Chest radiography was inferior to HRCT for the identification of pneumonia (149 vs 208 cases, $p < 0.0001$). Among the designated NHCAP criteria, chest radiography identified pneumonia cases at a significantly lower frequency than HRCT in Group A (70 vs 97 cases, $p = 0.0190$) and Group C (86 vs 136 cases, $p < 0.0001$). The detection failure rate of chest radiography differed among NHCAP criteria; 27.8% in Group A, 26.5% in Group B, 36.7% in Group C and 5.8% in Group D. Cerebrovascular disease and poor functional status were significantly more frequent in patients in Groups A and C compared with those in Groups B and D.

Conclusions: Physicians may underestimate pneumonia shadow in chest radiographs in patients with NHCAP, and the detection failure rate of chest radiography differed among NHCAP criteria. Poor functional status may correlate with the low accuracy of chest radiography in diagnosing pneumonia.

1. Introduction

Pneumonia remains a significant cause of morbidity and death worldwide despite the availability of potent antibiotic therapies. In Japan, pneumonia is the third leading cause of mortality. Because 97% of patients who die due to pneumonia are elderly (≥65 years old), the Japan Respiratory Society (JRS) Guidelines documented a new pneumonia category – nursing and healthcare-associated pneumonia (NHCAP). This category is distinct from community-acquired pneumonia (CAP) and is relevant to the Japanese population, the Japanese healthcare insurance system, including the nursing-care insurance system, and the pattern of drug-resistant pathogens [1]. Among NHCAP patients, elderly patients who are receiving nursing care with an Eastern Cooperative Oncology Group performance status (PS) of 3 (capable of only limited selfcare, confined to bed or a chair for more than 50% of waking hours) or 4 (completely disabled, unable to carry out any selfcare, totally confined to bed or a chair) [2] were more often seen in hospitals [3–8]. The most frequent cause of NHCAP in Japanese people is thought to be aspiration pneumonia [3–11], which is associated with poor outcomes [3,5,10].

Patients with NHCAP often show a lack of respiratory symptoms such as cough, productive sputum, dyspnea, or chest pain [3].

* Corresponding author. Department of Internal Medicine I, Kawasaki Medical School, 2-1-80 Nakasange, Kita-ku, Okayama 700-8505, Japan. Tel.: +81 86 225 2111; fax: +81 86 232 8343.
E-mail address: nao@med.kawasaki-m.ac.jp (N. Miyashita).

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Frequently, family members or staff of the long-term care facility bring patients with NHCAP to the Emergency Room owing to melancholy, mental change, loss of appetite, or fever [3]. Chest radiography is regarded as essential to confirm the diagnosis. If physicians cannot detect any abnormal shadow by chest radiography, patients often receive a different diagnosis, which may lead to inadequate therapy. However, there are no data on the frequency that physicians underestimate pneumonia shadows in chest radiography. To clarify the detection failure rate of chest radiography in the identification of NHCAP, we compared high-resolution computed tomography (HRCT) with chest radiography simultaneously for patients with clinical symptoms and signs leading to a suspicion of NHCAP.

2. Patients and methods

2.1. Study populations

Patients with clinical signs and symptoms indicative of NHCAP (mental change, loss of appetite, nausea/vomiting, fever, cough, productive sputum, dyspnea, chest pain, hypoxemia or abnormal breath sounds) who visited Kawasaki Medical School, Kawasaki Hospital from January 2013 to September 2014 were enrolled in this study. NHCAP was defined as pneumonia acquired in the community with one or more of the following risk factors according to the JRS guidelines [1]: Group A) pneumonia diagnosed in a resident of an extended care facility or nursing home; Group B) pneumonia diagnosed in a person who had been discharged from a hospital within the preceding 90 days; Group C) pneumonia diagnosed in an elderly or disabled person who was receiving nursing care with PS of 3 or 4; Group D) pneumonia diagnosed in a person who was receiving regular endovascular treatment as an outpatient (dialysis, antibiotic therapy, chemotherapy or immunosuppressant therapy). All cases of pneumonia occurring more than 3 days after hospitalization were considered nosocomial. Informed consent was obtained from all patients, and the study protocol was approved by the Ethics Committee of Kawasaki Medical School.

2.2. Definitions

Aspiration pneumonia was defined in accordance with the Japanese Study Group on Aspiration Pulmonary Disease – pneumonia in a patient with a predisposition to aspiration because of dysphagia or swallowing disorders. Swallowing function was assessed using the water swallowing test, repetitive saliva swallowing test, simple-swallowing provocation test, and video fluorography [1,12]. When swallowing function was not assessed using these examinations, the presence of overt symptoms of dysphagia or a medical history of aspiration was determined as a swallowing disorder in the patient.

The severity of pneumonia was evaluated using predictive rules in accordance with the respective 5-point scoring systems for CAP in Japan proposed by the JRS – A-DROP (age, dehydration, respiratory failure, orientation disturbance, and low blood pressure) [13].

Microbiological tests, such as Gram stain, cultures, urinary antigen tests, and serological tests, were performed as described previously [3,14]. The microbial etiology was classified as “definitive”, “presumptive” or “unknown”, as reported previously [3,14].

2.3. Evaluation of radiologic findings

At the initial visit, all patients underwent a postero-anterior view and HRCT in a supine position during suspended end inspiration. Chest HRCT examinations were performed using an Aquilion 16 (Toshiba Medical Systems, Tochigi, Japan) with 1-mm collimation at 10-mm intervals. Images were obtained at lung parenchyma (level −700 HU; width, 1500 HU) and mediastinal (level 10 HU; width, 300 HU) levels. The time between clinical onset of pneumonia and radiographic examination ranged from 1 to 8 days (mean, 4.5 days).

Two observers (radiologists with 36- and 24-years experience, respectively) were blinded to the severity of symptoms as well as to findings obtained from the physical and laboratory examinations. They independently assessed the presence of opacity, loss of vascular marking, nodules, bronchial wall thickening, pleural effusion, and silhouette signs on chest radiographs, and consolidation, ground-glass attenuation, nodules, thickening of the bronchial wall, reticular or linear opacity, and pleural effusion on chest HRCT. The observers also evaluated if the pneumonia was unilateral or bilateral and identified the opacity pattern of pneumonia.

Consolidation was defined as air-space opacification with obscuration of the underlying vasculature. Ground-glass attenuation was defined as mildly increased attenuation without obscuration of the underlying vasculature. On chest radiographs, these two patterns were grouped together as opacity or loss of vascular markings. A centrilobular nodule was defined as a nodule identified around the peripheral pulmonary arterial branches or 3–5 mm away from the pleura, interlobular septa, or pulmonary veins. Bronchial wall thickening was defined as thickening identified over widespread areas not close to areas of ground-glass attenuation and/or consolidation. Interlobular septa thickening, intralobular interstitial thickening, and areas of irregular linear opacity were all classified as reticular or linear opacity. A reticular framework in ground-glass attenuation that was described as having a crazy-paving appearance was not classified as an area of reticular or linear opacity. The final decisions on the presence of each finding and the opacity pattern for each case were reached by consensus of the two radiologists.

In addition, these cases were classified into the following pneumonia patterns by HRCT: lobar pneumonia, bronchopneumonia, bronchitis, or pneumonia with interstitial changes. Lobar pneumonia (air-space pneumonia) was defined as non-segmental pneumonia showing homogenous consolidation that was relatively sharply demarcated from adjacent uninvolved parenchyma. The larger bronchi often remained intact and contained air. Bronchopneumonia was defined as pneumonia that had focal, peripheral, and peribronchiolar consolidation involving one or more segments of a single or several lobes. Consolidation involving the terminal and respiratory bronchioles, and adjacent alveoli, resulted in poorly defined centrilobular nodular opacities measuring 4–10 mm in diameter, or might extend to involve the entire secondary lobe. Bronchiolitis was defined as disease that showed a pattern of small centrilobular nodules and branching lines as a result of inflammation of the bronchiolar wall, and filling of the bronchiolar lumen by exudate. Pneumonia with interstitial changes had either a reticular or reticulonodular pattern.

2.4. Statistical analysis

Statistical analysis was performed using Stat View version 5.0. (SAS Institute Inc, Cary, NC, USA). The incidences of underlying conditions, clinical findings, and radiographic findings were analyzed using Fisher's Exact test. Mean age of patients and laboratory data were compared using Student's *t* test. For each radiological finding, kappa values were calculated between the observers. The evaluation of kappa as a measure of interobserver ratios was as follows: 0.01–0.19, poor agreement; 0.20–0.39, fair; 0.40–0.59, moderate; 0.60–0.79, substantial; and 0.80–1.00, almost perfect [15].