Percutaneous Needle Washing for the Diagnosis of Pulmonary Thin-walled Cavitary Lesions Filled with Air

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Abstract

Objective  It is difficult to obtain sufficient material from pulmonary thin-walled cavitary lesions filled with air by conventional percutaneous aspiration biopsy in order to make a diagnosis. In these cases, we performed percutaneous needle washing (PNW) and ascertained the diagnostic significance of this method.

Materials and Methods  PNW was performed on 27 patients with a pulmonary thin-walled cavitary lesion whose diagnosis could not be made by sputum and bronchoscopic examinations. Before centesis, the depth of the lesion was measured on CT scan. After the 22-gauge needle was inserted under X-ray fluoroscopic guidance, normal saline was injected into the cavity and aspirated. The aspirated material was examined cytologically and microbiologically. The procedure was carried out during one 30-second breath-holding.

Results  Upon performing PNW on 27 patients, malignant cells were detected in 10 patients and a bacterial or fungal pathogen was detected in 9 other patients [Aspergillus (4), Mycobacterium (3), Staphylococcus (1), Streptococcus (1)]. The diagnoses of 16 of the 17 patients who were negative for malignant cells on PNW, were ascertained as benign disease during their clinical course including 3 patients who were diagnosed as (or suspected of) having infectious disease clinically, while the diagnosis of one case was unknown. Therefore, the diagnostic sensitivity of PNW for malignant diseases was 91% (10/11), while that for infectious diseases was 69% (9/13). Mild pneumothorax was the only complication of PNW (2 cases).

Conclusion  PNW may be an appropriate diagnostic procedure for pulmonary thin-walled cavitary lesions whose diagnosis cannot be established by other techniques.

Key words: pulmonary coin lesion, thin-walled cavity, fine-needle aspiration, washings, diagnosis

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Definition of a pulmonary thin-walled cavitary lesion

We defined a ‘pulmonary thin-walled cavitary lesion’ as a cavitary lesion filled with air that had a thin wall along at least 75% of the circumference of the lesion, in which a ‘thin wall’ was defined as a wall thickness (W) of less than or equal to X, where X is the smaller value of 4 mm or 25% of the shortest diameter of the lesion (D) (Fig. 1).

Patients

Between September 2000 and August 2005, bronchoscopic procedures were performed on 2,993 patients in the Department of Respiratory Medicine, Himeji Medical Center, Himeji-City, Japan. Specimens obtained by transbronchial washing, brushing, curettage, bronchoalveolar lavage, or trans-bronchial needle aspiration were subjected to cytological and microbiological examinations. If biopsy specimens could be obtained, histological examination of biopsy specimens was performed. Among the 2,993 patients, 57 patients had a thin-walled cavitary lesion that satisfied our definition, and the lesions of 30 of the 57 patients could be diagnosed by sputum examination and bronchoscopic procedures. In the remaining 27 patients whose thin-walled lesions could not be diagnosed by these methods, PNW was performed. Each patient provided informed consent for PNW. This study was approved by the institutional ethics committee of National Hospital Organization, Himeji Medical Center, Japan.

Percutaneous needle washing technique

Before the aspiration procedure, the depth from the skin surface to the center of the cavity was measured on CT scans. The stopper of the 22-gauge needle was set at this depth. The volume of the cavity was estimated from the diameter of the cavity on CT scans. A 20-ml syringe containing normal saline of a volume of about two-thirds of the cavitary volume, was prepared. Just after the patient was instructed to hold his/her breath, the needle was inserted percutaneously into the lesion under local anesthesia with X-ray fluoroscopic guidance. Then, the syringe was attached to the needle and the piston was pulled slowly; we ascertained that the tip of the needle reached the cavity by easy inflow of air into the syringe. After the normal saline in the syringe was injected into the cavity, the needle was inserted a little deeper until the tip of the needle nearly reached the bottom of the cavity, and the saline was aspirated. Then, the needle was pulled out and the patient was allowed to breathe. The patient was required to hold his/her breath for about 30 seconds. The obtained specimen was immediately transported to the laboratory for cytological and microbiological examinations. To detect possible iatrogenic pneumothorax or other complications, fluoroscopic imaging of the chest was performed just after the procedure, and chest x-ray films were taken 1 hour after the procedure and again the next morning. If the aspirate was turbid and infectious disease was suspected, penicillin or clindamycin was administered intravenously to avoid spreading of the possible bacterial infection.

Results

Twenty-seven patients with a pulmonary thin-walled cavitary lesion filled with air underwent PNW. Upon cytological and microbiological examinations of PNW specimens from the 27 patients, malignant cells were detected in 10 patients (Cases 1-10) and a bacterial or fungal pathogen was detected in 9 other patients (Cases 11-19). Figure 2 shows the CT scans of the pulmonary lesions, the results of the cytological and microbiological examinations of the aspirates obtained by PNW, and the final diagnosis of the 27 patients. The final diagnosis of Cases 1 to 10 was a malignant neoplasm, and the final diagnosis of Cases 11 to 20 was active infectious disease. Case 20 was found to be infected by Mycobacterium and Streptococcus by surgery. The diagnoses of Cases 21 and 22 could not be definitively determined, but both were suspected of having an infectious disease; the pulmonary cavitary lesion in Case 21 resolved with treatment for tuberculosis and the lesion in Case 22 resolved spontaneously. Since a diagnosis could not be established, surgical resection was also performed in Cases 23 to 25, and

Figure 1. Tentative definition of a “pulmonary thin-walled cavitary lesion.” A pulmonary thin-walled cavitary lesion was tentatively defined as a pulmonary lesion filled with air that had a ‘thin wall’ along over 75% of the circumference of the lesion. A ‘thin wall’ was defined as a wall with wall thickness (W) of less than or equal to X, where X is the smaller value of 4 mm or one-fourth of the shortest diameter of the lesion (D). Apparent bullae were excluded from the thin-walled cavitary lesion.
Figure 2. CT scans of the pulmonary thin-walled cavitary lesions and results of the cytological and microbiological examinations of the specimens obtained by PNW in the 27 patients with a pulmonary thin-walled cavitary lesion. The CT scan image, age and gender of the patients are shown, grouped by their final clinical diagnosis. *Case 17: Complicated with lung carcinoma at the orifice of the right upper bronchus. † Case 20: PNW failed to detect any microorganisms, but the operative material revealed *Mycobacterium avium* and *Streptococcus intermedius* infection. ‡ Cases 21 and 22: The patients were clinically suspected of having infectious diseases. Adeno: adenocarcinoma cell type; Asp: *Aspergillus*; MAC: *Mycobacterium avium* complex; MRSA: methicillin-resistant *Staphylococcus aureus*; Ope: Surgical operation; PNW: Percutaneous needle washing; s/o: suggestive of; Squamous: squamous cell carcinoma cell type; Str: *Streptococcus*.

the diagnosis of the pulmonary cavitary lesion was a bronchogenic cyst in Cases 24 and 25, and old tuberculosis with bulla in Case 23. Case 26 had been followed for silicosis and a periodical check-up revealed a thin-walled cavitary lesion on X-ray, and in order to rule out malignant disease, tuberculosis and other diseases, PNW was carried out, which revealed no malignant cells nor microbiological pathogens. The diagnoses of Cases 1 to 26 were confirmed by either surgery or clinical follow-up of more than one year. The diagnosis of Case 27 could not be determined be-
caused by he died in a traffic accident three months after the PNW, which had revealed no malignant cells or microbiological pathogens.

Among the 27 patients, malignant cells were detected in 10 patients (Cases 1-10), and the diagnostic sensitivity of PNW for malignant diseases was 91% (10/11, where the “11” in the denominator included Cases 1-10 and 27 whose final diagnosis was unknown). In 9 cases (Cases 11-19), bacterial or fungal pathogens were detected by PNW, which were diagnostic. This procedure failed to detect microorganisms from the lesion of Case 20, who was subsequently found to be infected by *Mycobacterium* and *Streptococcus* by surgery as mentioned above. The sensitivity of PNW for infectious diseases was over 69% (9/13, where the “13” in the denominator included Cases 11-22 and 27). The diagnostic specificity of this method was 100% for malignant diseases, and 100% for active infectious diseases. The only complication of PNW was pneumothorax, which developed in two patients (Cases 3 and 20), but it resolved spontaneously in a few days without insertion of a drainage tube.

**Discussion**

The relationship between the thickness of the pulmonary cavity wall and its diagnosis had been reported. In 1951, Wigh and Gilmore reported that solitary pulmonary cavities with a wall thickness of 1-10 mm represented inflammatory abscesses and those with a wall thickness of 4-50 mm represented neoplastic cavities (4). Woodring et al reported that the thickness of the thickest part of the cavity wall gave good information that could be used to differentiate between benignancy and malignancy of pulmonary cavitary lesions among their 65 patients (5). In their study, all of the cavities with a wall thickness of 1 mm or less in their thickest part were benign; among lesions whose thickest measurement was 2-4 mm, 1/7 (14%) were malignant; among lesions whose thickest measurement was 5-15 mm, 16/33 (49%) were malignant; and among lesions whose thickest measurement was more than 15 mm, 19/20 (95%) were malignant neoplasms. The thickest measurement of the cavity wall of our 27 cavities ranged between 2-15 mm. According to these previous reports, our cases were at or near the borderline zone between benignancy and malignancy, and it was important to establish definitive diagnoses.

Several cases of malignant neoplasms with pulmonary thin-walled cavity have been reported (6-10). However, to the best of our knowledge, there is no clear definition of a “thin wall”. For this study, we established a tentative definition of “thin-walled cavity” on the basis of the estimated measurements of the lesions shown in chest X-ray and CT images in previous reports of malignant neoplasms with thin-walled cavity (6-10).

In 1974, Millard and Westcott reported three patients who underwent PNW for the diagnosis of cavitary lesions of the lung (3). Diagnostic specimens could not be obtained by the ordinary percutaneous needle biopsy technique from their patients because the specimen consisted only of necrotic material or the lesion was a thin-walled cavity. They reported that the washings were diagnostic of carcinoma in all three cases. A literature search revealed no other reports on PNW thereafter. The present method slightly differs from the method of Millard and Westcott (3). They injected normal saline under fluoroscopic vision until the cavity appeared to be filled or almost filled with saline, and they injected and aspirated normal saline a total of two or three times after centesis (3). On the other hand, we prepared a syringe containing normal saline of a volume of about two-thirds of the cavitary volume in advance of centesis, and we performed injection of normal saline and aspiration once in order to shorten the duration of the procedure and in an attempt to prevent the occurrence of pneumothorax. We thought that a volume of about two-thirds of the cavitary volume was appropriate because this volume of saline would be sufficient to wash more than half of the inner surface of the cavitary wall; in addition, using a volume of saline that is less than the cavitary volume would prevent excessive overflow of saline from the cavity into the bronchial tree. About 50 to 75% of the injected volume was obtained by aspiration, and this was sufficient for cytological and microbiological examinations. Our procedure of PNW requires breath-holding for about 30 seconds, and patients with severe pulmonary dysfunction may have difficulty in performing the breath-holding. However, our patients who could tolerate bronchoscopic procedures, did not have difficulty performing breath-holding for 30 seconds. In patients with fairly impaired pulmonary function, inhalation of 100% oxygen for 1 or 2 minutes before the breath-holding would assist these patients.

Several mechanisms of pulmonary cavity formation have been proposed (2, 8, 10-14): (a) central breakdown of solid lesions due to necrosis, detachment, abscess formation, enzymatic digestion, or thrombus followed by expectoration of the debris into the bronchial tree; (b) inflated focal cystic bronchiectasis; (c) cyst formation by the check valve mechanism induced by the narrowed airway; or (d) superimposition or invasion of the disease on the wall of a preexisting cystic structure such as a bronchogenic cyst or bulla. In patients with pulmonary cavities that formed by (a) central breakdown of solid lesions or (b) focal bronchiectasis, there are probably tight connecting routes between the cavity and the bronchi, and these cases are expected to be easily diagnosed by sputum examination and bronchoscopic procedures because cancer cells or microorganisms can easily be expectorated from the lesion through the wide connecting routes between the cavity and the bronchi. However, pulmonary cavities that formed (c) by the check valve mechanism or (d) from a preexisting cystic structure such as a bulla may have little connection with the bronchial tree, and the transbronchial technique may be less effective. PNW is thought to be especially effective for the diagnosis of pulmonary thin-walled cavitary lesions with little or no connection with the bronchial tree.
In the present study, PNW could detect malignant cells or microbiological pathogens in 19 of 27 patients, and the overall diagnostic sensitivity of this procedure was 70% (19/27). The remaining 8 cases whose diagnosis could not be established by PNW, included old tuberculosis with bulla (Case 23), bronchogenic cysts (Cases 24 and 25), and silicosis (Case 26), all four of which cannot be diagnosed by cytological and microbiological examinations. Considering that the subjects of this study were limited to patients whose diagnoses could not be established by other diagnostic procedures, the overall diagnostic yield of this method was thought to be acceptable. It is notable that in the 10 patients with malignancy, the cytological specimens of the aspirates obtained by PNW contained a much higher number of malignant cells compared with that in aspirates obtained by conventional aspiration of solid lesions, and this abundance would ensure the high diagnostic yield of this method. The high diagnostic sensitivity of PNW for Aspergillus infections may also be noteworthy. The success rate of microbiological or histopathologic detection of Aspergillus in bronchoscopic specimens obtained from patients with aspergillosis has been reported to be very low (15-17). However, in the present study, all four patients with Aspergillus infection (Cases 13-16) were positive for Aspergillus fumigatus on culture of the PNW specimens. Two patients with Aspergillus infection (Cases 14 and 15) underwent surgery and their resected materials revealed scattered distribution of Aspergillus in the cavity wall, and in Case 15 fungi were detected only on the inner surface of the cavity. These histological features might explain the diagnostic efficacy of PNW at least for these cases.

Only one minor complication of PNW occurred, that is, mild pneumothorax in two patients. One potential complication of PNW is that the infused normal saline could over-flow into the bronchial tree and cause severe coughing during the procedure, but in fact no patient in our study complained of cough. This might be due to the fact that the subjects were limited to patients whose diagnosis could not be established by sputum and bronchoscopic examinations, which would imply that the lesion had little communication with bronchi. Many reports have warned of the possibility of pleural dissemination and chest wall implantation of malignant cells in patients who undergo percutaneous biopsy (18, 19). However, Sawabata et al observed no significant correlation between the use of percutaneous biopsy and either recurrence or survival among lung carcinoma patients (20). Kjellberg et al reported that preoperative percutaneous needle biopsy had no influence on positivity for malignant cells in the intraoperative pleural lavage (21). As for complications of percutaneous needle aspiration of lung abscess, Pena Grinan et al reported that pyopneumothorax was not seen in any patient and 7 episodes of pneumothorax were the only complications among their 49 patients (22). These reports may support the safety of our method. None of our cases revealed invasion of the disease into the needle tract or local spread of the infection during the follow-up of more than one year.

Theoretically, PNW may be performed in patients who undergo CT-guided percutaneous needle aspiration and transbronchial needle aspiration. The present method had a reasonable diagnostic yield, had little risk of complications, and is thought to be a good maneuver for further examination of pulmonary thin-walled cavitary lesions whose diagnosis could not be made by sputum and transbronchial examinations.

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