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CHEST IMAGING
ORIGINAL ARTICLE

Percutaneous core needle biopsy for small (≤10 mm) lung nodules: accurate diagnosis and complication rates

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PURPOSE
To evaluate accurate diagnosis and complication rates of percutaneous core needle biopsy (PCNB) with an automated gun for small lung nodules that are 10 mm or less in diameter.

MATERIALS AND METHODS
Forty-two cases of small lung nodules with diameters ≤10 mm (mean diameter, 9 mm) that received a PCNB were included in this study. Imaging guidance was fluoroscopy in 30 cases and computed tomography (CT) in 12 cases.

RESULTS
Accurate diagnosis was achieved with the initial PCNB in 88.1% (37/42) of cases. Accurate diagnosis rates were 86.7% (26/30) with fluoroscopic guidance and 91.7% (11/12) with CT guidance ($P > 0.05$). The complication rate of PCNB was 7.1% (3/42), including hemoptysis (n=2) and pneumothorax (n=1). The complication rate was 6.7% (2/30) with fluoroscopic guidance and 8.3% (1/12) with CT guidance ($P > 0.05$).

CONCLUSION
PCNB with an automated gun is useful for the pathologically conclusive diagnosis of small lung nodules (≤10 mm in diameter) using fluoroscopic or CT guidance.

Key words: • *X-ray computed tomography* • *fluoroscopy* • *lung diseases* • *biopsy*

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Percutaneous core needle biopsy (PCNB) of the lung is a well-established method for the cytological diagnosis of pulmonary nodules (1, 2). PCNB is generally regarded as a safe procedure with limited morbidity and extremely rare mortality (2–5). Biopsies of pulmonary lesions as small as 3 mm in diameter have been reported (6, 7). Diagnostic accuracy rates of 90%–100% using computed tomography (CT) guidance have been documented for pulmonary lesions greater than 10 mm in diameter (3, 8). For smaller lesions, however, several studies have reported decreased diagnostic accuracy in the range of 52%–88% (3, 8, 9). Moreover, no study has reported a pathologically conclusive diagnosis of PCNB for small lung nodules using CT and fluoroscopy guidance.

The purpose of this study was to evaluate the accurate diagnosis and complication rates of PCNB using an automated gun for small lung nodules with diameters ≤10 mm.

Materials and methods

Patients

Between July 2004 and October 2011, 1467 consecutive percutaneous thoracic biopsies using automated biopsy devices or fine needle aspiration were performed at our institution. Of these cases, 81 extrapulmonary thoracic lesions, such as mediastinal (n=45), chest wall (n=21), and pleural (n=13) lesions were excluded. The remaining 1386 cases of PCNB were performed on pulmonary parenchymal lesions. The enrolled population consisted of 875 males (63.1%) and 511 females (36.9%). Patients' age ranged from 8 to 88 years (mean, 66.2 years). Using axial CT scan images, the largest transverse cross-sectional diameter of each nodule was measured on picture archiving and communication system workstations. The mean diameter of each nodule was considered as its size.

Of the 1386 evaluable cases, there were 52 cases of initial PCNB and 10 cases of fine needle aspiration for small nodules with diameters ≤10 mm. Of these cases, 42 patients receiving an initial PCNB were enrolled in this study. The enrolled group consisted of 24 males (57.1%) and 18 females (42.9%), and the ages ranged from 36 to 84 years (mean, 63.5 years). The mean diameter of these 42 nodules was 9 mm (range, 5–10 mm).

Procedure

A chest radiologist with seven years of PCNB experience performed all of the PCNBs. All patients underwent a diagnostic CT scan of the chest prior to biopsy. Imaging guidance was performed by fluoroscopy in 30 cases and CT in 12 cases. All PCNB cases were performed using either fluoroscopy (Axiom Artis FA, Siemens, Erlangen, Germany; Allura Xper FD 20/20, Philips Medical Systems, Best, Netherlands) or CT (Hispeed, GE Medical Systems, Milwaukee, Wisconsin, USA; MX 8000 IDT, Philips Medical Systems, Haifa, Israel) for imaging guidance. Selection of imaging guidance was based on theease of approach and good visibility of each lesion by fluoroscopy or CT. Contrast media were not used for fluoroscopy or CT. For fluoroscopic guidance, a magnification view of the same lesion was used. Fluoroscopy was favored over CT due to magnification of the lesion, especially for small peripheral lung lesions. For the basal lung lesions, fluoroscopic guidance was frequently used due to the relatively easy targeting during respiration holds. For the central lung lesions near the large vessels or mediastinal structure, CT guidance was favored. However, CT fluoroscopy was not used in this study.

The biopsy tool used was an automated biopsy gun (Magnum®, Bard, Covington, Georgia, USA) with an 18-gauge needle. Biopsy was also selected depending on the location, size, or character of each lesion. However, only biopsy cases were included in this study. All specimens were sent to the pathology department without the review of the cytologist on-site.

Prior to each procedure, the risks and benefits were explained to each patient, and informed consent was obtained. Procedures were performed with the patient in a prone, supine, oblique, or lateral decubitus position and the passage of the needle through the fissure was avoided. The number of needle passes was limited to a maximum of two attempts for each case in order to reduce the risk of complication. All patients were monitored for possible complications including pneumothorax and hemoptysis. An erect posteroanterior expiratory chest radiograph was obtained two hours after the PCNB to monitor the development of a potential pneumothorax. However, a post-PCNB CT scan was not performed for monitoring the potential pneumothorax. In practice, a small pneumothorax that is only visible on CT and not on chest radiograph usually does not evoke clinically significant problems. All cases of PCNB were retrospectively reviewed according to the institutional review board-approved protocols.

Analysis

The overall accurate diagnosis and complication rates of PCNB were determined. The criteria of accurate diagnosis included pathological or microbiological conclusion with clinical evidence. The accurate diagnosis and complication rates between CT guidance and fluoroscopic guidance were also compared. The pathological results of all cases of PCNB were reviewed. For the cases that were inaccurately diagnosed by PCNB, the final pathological results from subsequent analyses were also reviewed.

Data were analyzed with Statistical Analysis System (SAS, version 9.1, SAS Institute Inc., Cary, North Carolina, USA). Fisher's exact test was used for the statistical analysis. A P value less than 0.05 was considered statistically significant.

Results

The pathologically or microbiologically accurate diagnosis rate by initial PCNB for small (≤10 mm in diameter) lung nodules was 88.1% (37/42), which included 24 tumors (11 lung cancers, six hamartomas, five metastases, and two sclerosing hemangiomas), six cases of localized infection other than tuberculosis, four cases of tuberculosis, and three cases of fibrosis. The mean diameter of these 37 nodules was 9 mm. The initial PCNB did not result in an accurate diagnosis for the remaining five cases, which had a mean diameter of 9 mm. The pathological results of these five cases included three cases of atypical cells, one case of a few cells, and one case of necrosis with lymphocytes. Of the five cases without accurate diagnosis on initial PCNB, surgical biopsy was performed in four cases, and the PCNB was repeated in one case. Surgical biopsy of the four cases revealed three cases of lung cancer and one case of metastasis. The case of repeat PCNB was subsequently diagnosed with tuberculosis. The three cases of atypical cells found during the initial PCNB revealed two bronchogenic carcinomas and one metastasis. The case that demonstrated a few cells by the initial PCNB was found to have bronchogenic carcinoma based on the surgical biopsy. One case of necrosis with lymphocytes on the initial PCNB revealed tuberculosis based on the surgical biopsy. The pathological or microbiological results of the 42 cases of small lung nodules with diameters ≤10 mm are listed in Table.

Imaging guidance was performed with fluoroscopy in 30 cases and CT in 12 cases. The pathologically or microbiologically accurate diagnosis rates were 86.7% (26/30) with fluoroscopic guidance and 91.7% (11/12) with CT guidance (Figs. 1 and 2). There was no statistically significant difference in the accurate diagnosis rates between CT and fluoroscopy guidance ($P > 0.05$). The accurate diagnosis rates of PCNB were 87.5% (21/24) for male patients and 88.9% (16/18) for female patients ($P > 0.05$). The mean number of needle passes in the 42 cases was 1.2.

The complication rate for the initial PCNB was 7.1% (3/42), which included two cases of hemoptysis and one case of pneumothorax. None of the cases with complications required radiological intervention, such as catheter insertion or arterial embolization. One pneumothorax case and two hemoptysis cases developed with fluoroscopy-guided PCNB (6.7%, 2/30). One case of hemoptysis developed with CT-guided PCNB (8.3%, 1/12). There was no statistically significant difference in complication rates between the two modalities of imaging guidance ($P > 0.05$). The complication rates of PCNB were 4.2% (1/24) for male patients and 11.1% (2/18) for female patients.

Discussion

Transthoracic image-guided percutaneous fine needle aspiration biopsy has been a popular and reliable method for the cytological diagnosis of pulmonary lesions (1, 4). As imaging techniques and

Table. Pathological or microbiological results of 42 cases of small lung nodules that are 10 mm or less in diameter

Clinicopathological results	Initial PCNB	Repeat PCNB	Surgical biopsy
Bronchogenic carcinoma	11		3
Hamartoma	6		
Localized infection other than tuberculosis	6		
Metastasis	5		1
Tuberculosis	4	1	
Fibrosis	3		
Sclerosing hemangioma	2		
Total	37	1	4

PCNB, percutaneous core needle biopsy.

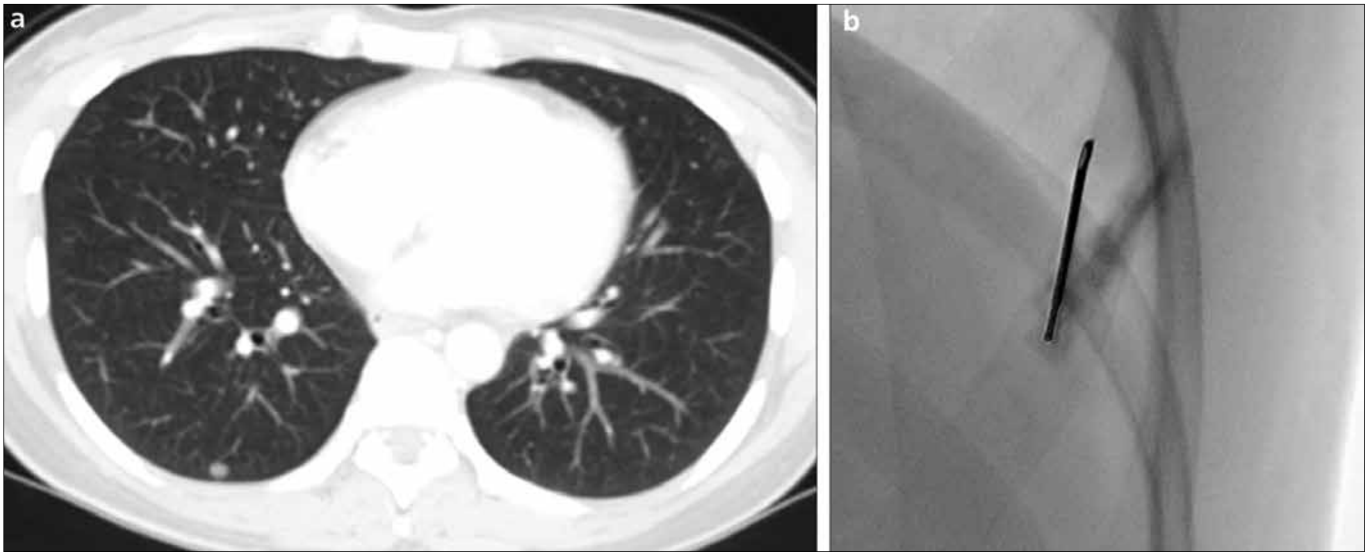

Figure 1. a, b. CT **(a)** shows a pulmonary nodule approximately 9 mm in diameter in the right lower lobe of a 38-year-old female. Fluoroscopy-guided percutaneous core needle biopsy of the solid nodule using an automated gun **(b)** revealed metastasis from a leiomyosarcoma based on pathological examination.

Figure 2. CT-guided percutaneous core needle biopsy using an automated gun of a pulmonary nodule approximately 10 mm in diameter in the right upper lobe of a 62-year-old female. The biopsy revealed a bronchioloalveolar carcinoma based on pathological examination.

technology improve the ability to detect smaller lesions, the definition of small pulmonary nodules continues to change (9). In several studies, investigators have reported a decline in the accuracy of percutaneous biopsy to less than 75% for lesions 1 cm or smaller (9). However, new techniques with respiratory gating and CT fluoroscopy have been used to improve success rates (10, 11).

Automated cutting biopsy devices are currently used for the diagnosis of lesions in many solid organs (12–14). A core biopsy technique in addition to fine-needle aspiration biopsy has been shown to increase the diagnostic accuracy for non-malignant lesions and aid the characterization of cell types in patients with carcinoma (15–18). In some reports, automated biopsy devices have provided a lower rate of false negative results (18). CT-guided lung biopsy has widespread acceptance as a preferred method of diagnosing lung nodules (16, 19), and its diagnostic accuracy has been reported to be as high as 81%–96% (7, 16, 19). For small lung nodules, the diagnostic accuracy of CT-guided PCNB has been reported to be 79%–88% (6, 9). Several studies have also reported decreased diagnostic accuracy in the range of 52%–88% for smaller lesions (3, 6–8). In this study, the diameters of the small nodules ranged between 5–10 mm and had a mean diameter of 9 mm. The pathologically or microbiologically accurate diagnosis rate of the PCNB was 88.1%. Our results were comparable with other studies that have reported on the use of PCNB for small nodules (3, 6–9). Automated gun biopsy with a core needle was used under fluoroscopy or CT guidance in this study. There was also no statistically significant difference in the accurate diagnosis rates between fluoroscopic and CT guidance ($P > 0.05$). Magnification of the small lesions was helpful for targeting the lesions, especially with fluoroscopy. However, identification of the needle tip and tract is usually superior on CT compared to fluoroscopy. In this study, CT-guided biopsy was usually used for perihilar or paramediastinal lesions abutting the large vessels in order to avoid injury to the large vessels or airways. For small peripheral lesions, fluoroscopy-guided biopsy was usually used with assistance of a magnification method. Furthermore, it might be possible to improve the accurate diagnosis rate for small pulmonary nodules by using CT fluoroscopy (3), but this modality was not used in this study.

During the biopsy procedure, maintenance of the needle in the middle of the lesion is an important factor for obtaining an accurate diagnosis. It is also important to select the appropriate biopsy tool and imaging guidance, depending on the location of the lesion. Constant and shallow respiration with the patient in a comfortable position is important for a successful biopsy. Importantly, by using these guidelines, a pathological diagnosis of small lung nodules using PCNB could be used more often without dependence on other methods, including surgery.

Pneumothorax is the most frequently encountered complication of PCNB, with an incidence of 21%–43% (6–8). Higher rates of pneumothorax development, up to 65%, have been reported for lesions 10 mm or smaller (6, 9). In this study, a pneumothorax occurred in one case (2.4%, 1/42) without the need for intervention, such as catheter insertion. A small pneumothorax that is only visible on a CT image and not on a radiograph usually does not have clinical significance. In this study, a CT scan was not used for monitoring the development of a pneumothorax, which may have masked the actual rate of pneumothorax development in this study. However, no statistically significant difference in the occurrence of a pneumothorax between the different biopsy tools or modes of imaging guidance was detected. It has been suggested that the rate of pneumothorax occurrence during a PCNB of smaller lesions could be minimized with the use of an appropriate biopsy tool, imaging guidance, or newer techniques. In addition, the risk of pneumothorax development may be lowered by avoiding fissures, emphysematous lung parenchyma, or bulla (3, 10, 20).

Hemoptysis occurred in two cases (4.8%, 2/42) in this study. The rate of hemoptysis was comparable to that reported in the literature for PCNB of small nodules (1–3, 12). In this study, there was no statistically significant difference in the development of hemoptysis between the different imaging guidance modalities. The risk of hemoptysis might be lowered by avoiding large vessels with the assistance of adequate imaging guidance and the selection of the appropriate route for needle passage.

Based on the pathological results of 42 cases of small nodules with diameters ≤10 mm, 16 cases (38.1%) were malignant lesions, including 11 bronchogenic carcinoma and five metastases. These findings suggest that active pathological confirmation for small lung nodules is necessary. In particular, the pathological evaluation of three cases of atypical cells from the initial PCNB revealed that all were malignant based on a repeat PCNB or surgical biopsy. These results suggest that pathological confirmation should be attempted in cases of atypical cells obtained from the initial PCNB. Furthermore, the help of an on-site cytologist might be helpful for improving the accurate diagnosis rate for small pulmonary nodules.

This study had several limitations. First, it was a retrospective study, which presents the possibility of selection bias. For some pulmonary nodules that were 10 mm or smaller, only surgical biopsy was performed without attempting a PCNB, and these cases were not included in this study. This might affect the rate of accurate diagnosis by PCNB. Complication rates might also be higher if the follow-up images were obtained by CT and not radiography. In this study, the routine follow-up protocol required chest radiography two hours after the PCNB. However, a scanty pneumothorax only detectable by CT usually has no clinical significance. Therefore, we used radiography instead of CT as a followup imaging modality. In addition, the study with only a small number of cases have limited statistical power for comparing different guiding images. Although this study had several limitations, we found that an accurate diagnosis of small lung nodules using PCNB with an automated gun was possible in most cases without the assistance of other diagnostic methods, including surgical biopsy.

In conclusion, PCNB with an automated gun was a useful diagnostic tool for lung nodules that were 10 mm or less in diameter. It is necessary to select the appropriate biopsy tool, imaging guidance, and route of approach based on the location and size of lesions in order to improve the success rate and lower the complication rate of PCNB for small lung nodules. Conflict of interest disclosure The authors declared no conflicts of interest.

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The authors declared no conflicts of interest.

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