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CT-Guided Percutaneous Fine-Needle Aspiration Biopsy of Pulmonary Lesions

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ABSTRACT

Background: *Transthoracic CT-guided percutaneous fine-needle aspiration biopsy (FNAB) has become a well- established diagnostic technique and been useful in differentiating malignant and benign pulmonary lesions.*

Materials and Methods: *505 patients (311 men and 194 women) aged 7-90 years old (mean age 56.2 years) with pulmonary lesions underwent CT-guided transthoracic fine-needle aspiration biopsy.*

Cytopathologic evaluation of FNAB samples was performed in all patients. In addition, each case was reviewed for complications, including pneumothorax and hemoptysis. Data were analysed using SPSS software for windows ver. 11.5.

Results: *FNAB samples were adequate for diagnosis in 410 (81.2%) of 505 patients. Two hundred and forty-nine lesions (60.7%0) were malignant, and 161 (39.3%) were benign or atypical. Thirty-four (6.7%) patients had pneumothorax out of which none of them required thoracostomy tube placement. Additionally, hemoptysis was noted in 9 (1.8%) patients and follow-up was carried out. No further complications were reported.*

Conclusion: *CT-guided FNAB of pulmonary lesions can yield well-established diagnoses and it can be useful in the management of patients with suspected lung cancer.* ***(Tanaffos 2006; 5(3): 37-44)***

Key words: *Lung, Biopsy , Computed tomography, CT-guided biopsy, Fine needle aspiration*

INTRODUCTION

Although the first reports of needle biopsy of the lungs were published in late 1800s (1, 2) it was not until Nordenstrom (3) introduced the technique of fine-needle aspiration biopsy (FNAB) of the lung that this technique became accepted as a useful and safe diagnostic tool in the evaluation of suspicious intrathoracic lesions. Since then, transthoracic image-guided percutaneous fine-needle aspiration biopsy has been a reliable means of differentiating benign and malignant pulmonary lesions. Success rates have been well-documented with diagnostic accuracy rates in excess of 93% and sensitivity rates in excess of 95% (4). However, the diagnostic efficacy of FNAB

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in the evaluation of benign pulmonary diseases is less impressive in comparison with malignant lesions which has been reported to be 9-91% (5-8) vs. 90-97% (9), respectively. In addition, the diagnostic rates for FNAB of the lung have been shown to be more sensitive than those for bronchoscopic techniques. (10)

Aside from pneumothorax (22-45%) (11) and thoracostomy tube insertion failures, reported complications like hemoptysis are uncommon and air embolism, needle track tumor seeding, and death remain extremely rare for image-guided FNAB (12-14).

Despite the accepted limitations of cytological analysis of FNA samples including the operator's ability to assess the adequacy of the sample visually, this method has become a widely used diagnostic tool in management of patients with suspected lung cancer (11). However, the inclusion of a cytopathologist to the biopsy team has further increased the utility of the procedure (15).

Studies to establish other factors that affect diagnostic yield have been limited, although there has been much more published studies on the factors affecting the incidence of pneumothorax (11).

We undertook this 3-year study to present our experience on patients referred to Masih Daneshvari Hospital. The factors affecting the frequency of pneumothorax were also studied.

MATERIALS AND METHODS

Patients

Between March 2001 and January 2004, 505 patients underwent percutaneous CT-guided lung biopsy at our center.

Patients with severe chronic obstructive pulmonary disease (COPD) (FEV1<11) or previous pneumonectomy, those unable to lie flat or suspend respiration and the very infirm cases were excluded. Clotting studies were performed before the procedure. An informed consent was obtained by the respiratory physicians and reiterated by the radiologist in charge of the procedure.

CT-scans from the time of biopsy were retrospectively reviewed all patients. Cytologic specimens were reviewed as well.

Procedure

An available CT-scanner (Siemens Somatom Plus) was used for biopsy. Patients underwent CT without contrast material enhancement in either the prone or supine position. In most situations, patients positioning was based on the shortest distance from the lesion to the visceral surface. Individual variables causing deviation from this practice included overlying skeletal structures and adjacent large pulmonary vessels in addition to potential fissures to be crossed.

Images were obtained through the region of interest by using a slice thickness of 10 mm, used by the operator to decide on a suitable approach to the lesion, and reviewed by using lung and mediastinal window settings.

One of the attending radiologists experienced in CT-guided biopsy performed all biopsies.

No routine breathing instructions were given during preliminary imaging or FNAB.

The chosen entry site was prepared and draped in a sterile fashion, and 2% lidocaine hydrochloride 5cc, was administered for local anesthesia.

Non-coaxial FNAB was performed in all patients by using 20 gauge Westcott needles (Kimal, Uxbridge, England). The depth from the skin to the lesion periphery was measured by using the CT images to choose the appropriate needle system length. After needle insertion, CT was used to confirm the correct position of the needle tip.

Samples were then obtained by using an aspiration technique with direct biopsy approach and then immediately sent to the pathology department for sample preparation and diagnosis.

CT-scans were obtained immediately after biopsy in all patients and evaluated by one of the radiologists. If pneumothorax was apparent on the CT-images after biopsy, 24 hours follow-up, chest x-ray and CT-scan were obtained. Pneumothorax rate was recorded.

Cytopathology samples were subsequently inspected by one of a number of pathologists and results issued to the respiratory staff managing the patient 3 to 5 days later.

Data collection and statistical analysis

Data were collected in five categories: patient demographics, details of the nature of the lesion, technical details regarding the procedure itself, details of complications that ensued and their treatment, and details regarding diagnostic yield.

The age and sex of patients were recorded. Lesion size, location (pleural, chest wall, lung based on affected lobe and mediastinum) and depth from the pleural surface were noted. The size of the lesion was measured as the maximum diameter (in cm) on the hard copy of CT images obtained in 10mm slices immediately pre-biopsy printed on mediastinal window setting. Depth of the lesion was measured from the pleural surface at the point of needle puncture, along the needle track, to the tip of the lesion.

Complications recorded were the presence of an immediate pneumothorax on the post-biopsy CT images, and hemoptysis, whether any treatment was required if pneumothorax was present or any other complications that ensued.

Diagnostic data included the results of biopsies divided into nine categories: insufficient, atypical cell, inflammation, reactive mesothelial cell, infection, anthracosis, necrosis, malignancy and metastasis. These details were obtained directly from the computer data base in the pathology department. Pneumothorax rate was compared for lesion size, location and depth. Appropriate statistical analysis was used to determine the significance of each result (p-value of less than 0.05 was considered significant). Data analysis was done using SPSS software for windows version 11.5.

RESULTS

Patients included 194 women and 311 men with a mean age of 56.2 years (age range 7-90 years). The average size of the lesions was 5.6 cm (range 2-18 cm) 302 lesions were contiguous with the pleural surface; the average depth of lesions from the pleural surface was 2.02 cm (range 1-6 cm).

Malignancy was identified in 249 (49.3%) of 505 patients. One hundred and sixty-one (31.8%) cases had benign or atypical findings.

Final pathologic diagnoses are listed in table 1.

Table 1. Final pathologic diagnoses

Final diagnoses	Number of cases (percent)
Malignant (including metastasis)	249 (49.3)
Atypical cell	22 (4.3)
Inflammation	74 (14.7)
Reactive mesothelial cell	2 (0.4)
Infection	33 (6.5)
Anthracosis	18 (3.6)
Necrosis	12 (2.4)
Insufficient	95 (18.8)

Samples did not enable diagnosis in 95 (18.8%) patients in whom non-diagnostic samples were obtained in 52 of 302 pleural-based lesions (≤ 1.0 cm from the pleural surface) and in 43 (45.3%) deep lesions.

A statistically significant relationship was noted between age advancing and malignancy ($p< 0.05$)

In addition, there was no significant difference between sex and benign or malignant lesions. (chi-square test).

Immediate pneumothorax on the post-biopsy CT images occurred in 34(6.7%) patients with no patient

requiring thoracostomy tube placement. The presence of immediate pneumothorax was recorded even when it represented only a very small, loculated pocket of air.

Higher rates of pneumothorax were encountered in those patients with deep lesions, lesions in the upper and lower lobes and lesions ≤ 5 cm in diameter (table 2).

Table 2. Pneumothorax rate based on lesion size, location and depth

Characteristic	No of patients	Pneumothorax rate (%)
1. Lesion size (cm)		
≤ 5	281	24 (8.54)
> 5	224	10 (4.46)
2. Lesion location (Lobe)		
Upper	191	11 (5.75)
Middle	51	2 (3.92)
Lower	191	19 (9.94)
3. Lesion depth		
Subpleural	302	6 (1.98)
Deep	191	28 (14.6) *

* significant ($p< 0.05$)

The higher rates of pneumothorax were statistically significant ($p<0.05$) in all of the above characteristics.

No patient with pneumothorax required thoracostomy tube replacement.

Nine patients (1.8%) in our study were documented to have small, self- limiting hemoptysis after the procedure. It is possible that other patients may have had similar symptoms without this being documented. No patients developed significant pulmonary hemorrhage after the procedure.

DISCUSSION

Patients with intrapulmonary masses of unclear etiology present clinicians with a diagnostic problem. The causes of such masses encompass a wide range of both benign and malignant processes with a diverse range of treatment options. Furthermore because of the wide spread availability of CT-scan, increasing numbers of small pulmonary nodules have been detected which are not visible on chest radiography, and ideally these too require definitive tissue diagnosis. The success rate in obtaining sufficient samples for cytohistologic evaluations (i.e. rate of adequate biopsy) has been reported to range from 80% to 100% and its diagnostic accuracy has been described to be high, 81- 96% (16-20). CT-guided percutaneous transthoracic biopsy has been at the forefront due to its accuracy and safety and is now accepted as being a crucial adjunct to fiber-optic bronchoscopy in the diagnosis of patients with lung cancer (11).

In the present study, 61.3% (n=302) of lesions were contiguous to the pleural surface, and the average depth of all other lesions from the pleural surface was 2.02 cm.

Lucidarme et al. (17) reported an average lesional depth of 2 cm, and Lopez et al. (21) of 3.1 cm, while Arakawa et al. (22) reported that 31% of all lesions biopsied were contiguous with the pleural surface. It must be mentioned that in centres, like ours, with more active pulmonologists and high number of sampling via bronchoscope, the probability of referring patients with more central lesions for CT-guided biopsy is less.

Pneumothorax is the most frequently encountered complication during CT- guided lung biopsy, with a frequency from 17.9% (16) to 54.3% (6). Higher pneumothorax rates up to 64% for lesions 1.0 cm or smaller have been reported.

Although pneumothorax is generally a complication without serious clinical consequences, it can cause delay in the treatment of the patients, an increase in hospitalization cost, and a risk for patients with impaired lung function.

Our brisk pleural puncture is a possible explanation of our low incidence of pneumothorax (6.7%). A brisk puncture at breath hold creates a pinpoint entry site, whereas a slow withdrawal of the Westcott guiding needle with a sharp pencil-tip configuration allows resilient lung tissue to seal the pleural hole. Other possible reasons for a low pneumothorax rate in our series may be a larger number of intrapulmonary lesions close to or abutting the pleural surface (61.3%) and a larger lung lesion size (mean size, 5.6 cm). No lesion was less than 2 cm in diameter.

In practice, there is no direct method for estimation of amount of immediate pneumothorax when the patients are still on the CT examination table (23). In direct conversion methods for pneumothorax estimated by supine chest radiography (24) and chest CT (25) may not be accurate because of variability in factors governing lung volumes between upright and supine positions. Our proposed CT grading of pneumothorax, although over simplified, may be used as a working guide to pneumothorax management.

We found that in patients who developed a pneumothorax post biopsy, the average lesion size was significantly smaller than in those who did not develop a pneumothorax. This follows other recent reports (20, 26, 27).

Cox et al. (26) reported pneumothorax rate of 40.4% of 356 biopsies while their pneumothorax rate for lesions 1 cm or smaller (n= 23) was 65%. The reason for this association is not entirely clear.

Miller et al. (28) have postulated that smaller lesions are more difficult to biopsy, and therefore, the dwell time within the lung may be longer; it has been suggested that movement during patient respiration may cause tearing of the lung parenchyma and by this mechanism longer dwell times may be the mechanism of increased incidence of pneumothorax.

However, Ko et al. (29) recently published data showing that an increased needle dwell time was not correlated with incidence of pneumothorax, thus apparently refuting this suggested mechanism. It could be postulated that larger lesions are more likely to be adjacent to the pleural surface and for this reason are associated with a lower risk of pnemothorax. In our opinion, the relationship between lesion size and incidence of pneumothorax may be explained by the procedural technique. It seems that the technique in FNA biopsies of moving the needle tip back and forwards within the lesion several times may also involve the needle track extending into the lung parenchyma during the biopsy of smaller lesions and thus increase the incidence of pneumothorax. Certainly, the relationship of increasing pneumothorax incidence with decreasing lesion size is reasonably well established.

The relationship between increasing lesion depth from the pleural surface and increasing incidence of pneumothorax was significant in our study. Patients developing pneumothorax had on average lesion depth of 1.37 cm compared with 0.68 cm in those who did not develop pneumothorax. This is in keeping with previous results (20, 26,27). The most obvious reason for these findings is the much lower incidence of pneumothorax after biopsy of lesions contiguous to the pleural surface; in our study only 1.9% of the 302 contiguous lesions developed pneumothorax.

When the data were further analysed to see if depth was correlated with incidence of pneumothorax when all contiguous lesions were excluded, no significant relationship was found. Therefore, we conclude that, as might be expected, CT- guided biopsies in which aerated lung is not traversed are associated with a very low incidence of pneumothorax; as soon as aerated lung is traversed, the risk rises considerable, but thereafter, the exact depth of the lesion is not a significant factor.

The majority of cases of pneumothorax developing after needle biopsy resolved spontaneously.

The frequency of chest tube placement was shown to range from 2.0% (27) to 15.0% (6) of all biopsy procedures and 6.7 % (33) to 33.3 % (20) of cases complicated by pneumothorax. In comparison, we observed no necessity for chest tube insertion.

The rate of hemoptysis in the present study was 1.8% (n=9). In Lucidarme et al. series, this rate was 10% (17), which was higher than ours. In addition, F. Laurent et al. (31) also showed the rate of hemoptysis to be 5.9 and 5.2% for small and larger nodules, respectively. Nevertheless, this complication did not require active treatment.

The low hemoptysis rate in our series may be related to a number of precautions taken by us. We used only a 20-gauge Westcott needle whose cutting mechanism does not cause a rapid forward movement into the surrounding lung parenchyma.

Klein et al. (6) and Lucidarme et al. (17) speculated that forceful forward throw of rapidly firing automatic cutting needle is a likely cause of increased incidence of pulmonary hemorrhage. In addition, we correct every needle trajectory before the lung is punctured. We perform minimal correction or manipulation of the needle path when the coaxial guiding needle is within the aerated lung.

From series of transthoracic needle biopsy with use of the CT-guided FNA technique reported in recent years, there appears to be a trend toward lower complication rates as experience increases. Pneumothorax rates range from 27-54% (5,6,17,30) to the recent rates of 9%- 19% (16,31,32). Chest tube insertion rates also decrease from the early 15% rates to the recent 3% rates, and hemoptysis rates range from the early rates of 10% to the recent rates of 4%-5%. Our complication rates of 6.7% pneumothorax, (with no need for chest tube insertion) and 1.8% hemoptysis are less than more recent reported series.

One main limitation of FNA biopsies is the operator's inability to assess FNA adequacy by visual inspection alone.

Austin et al. (15) showed that the presence of a cytopathologist at the time of FNA biopsy, with immediate assessment of the adequacy of samples, can significantly improve the diagnostic rate. However, like many other institutions, this facility is not available to us. It is difficult to compare this result with what is achieved elsewhere as no directly comparable data have been published.

Controversy exists about whether cytology or histology is more useful in the evaluation of lung nodules. However, histologic evaluation is more advantageous than cytology in making a specific diagnosis especially in benign lesions (18) or if an on-site cytopathologist is absent or a frozen section analysis can not be performed at the time of the biopsy. (34).

The use of core biopsies as the first-line technique for assessing diagnoses of pulmonary nodules is still debated. The Massachusetts group recommends that FNA should still be performed initially if a cytopathologist is available in the CT room and malignancy is suspected (36). If a malignant diagnosis is obtained on review of FNA, a core biopsy is not needed; however, if it is non- diagnostic or suggestive of a benign process, a core biopsy should then be performed (35).

In conclusion, CT-guided transthoracic fine needle aspiration biopsy is safe when factors and pathogenesis contributing to higher risk of complications are well understood. Because of its high accuracy rate for diagnosing both benign and malignant lung lesions, it may be used as an initial method for lung needle biopsy. However, attention should be paid to subpleural intrapulmoanry lesions,

which are associated with a higher risk of pneumothorax and deep lesions that are associated with a higher risk of pulmonary bleeding.

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