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Factors Contributing to Pneumothorax in Transthoracic CT-Guided Needle Aspiration Biopsy

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ABSTRACT

Background: *We studied pneumothorax as a complication of transthoracic CT-guided needle aspiration biopsy, and its correlation with different variables were determined.*

Materials & Methods: *This cross-sectional study was performed on 145 consecutive patients, aged 9-87 years (mean 55.3±17.6; M/F=1.6), during a 6-month period. We reviewed the pathology results of 150 biopsy specimens obtained from the cases, and assessed the effect of lesion size, depth, patient age and patient emphysema on pneumothorax rate.*

Results: *Lesion size ranged 1-18 cm (mean 6.5±3.4 cm). 95 lesions had zero distance from the chest wall, which were all taken into account in our calculations.Pneumothorax rate was 6 percent, and we found that lesion depth (p<0.05), lesion size (p=0.069), patient age (p=0.058,) and presence of emphysema (p<0.001) are significantly associated with increasing pneumothorax rate (CI=90%).*

Conclusion: *Lesion depth, lesion size, patient age, and emphysema significantly increase the rate of pneumothorax during transthoracic CT-guided needle biopsy*.***(Tanaffos 2002;1(1):15-21)***

Key words: *CT-guided needle biopsy, complications, pneumothorax, emphysema.*

INTRODUCTION

CT-guided transthoracic needle biopsy of the lung has been shown to be a relatively safe and accurate method for establishing the diagnosis of benign and malignant lesions of the chest (1). There have been reports on complications of the procedure; some of them such as systemic air embolism, pericardial tamponade, and seeding of malignant cells are rare but may be fatal (2-4); others, such as pneumothorax have been more frequent (5-10). The reported frequency of biopsy associated pneumothorax ranges widely from 5% to as high as 61% (5, 7, 11, 12). The frequency of complications appears to be higher for CT guidance (comparing with fluroscopically-guided biopsy), possibly because more difficult lesions are attempted, the procedure takes longer, and more pleural passes may be required (13,14).

In a recent study, Cox et al. discussed the significance of seven different variables -- lesion location, size and depth; number of pleural passes, needle size, presence of emphysema in the biopsied

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lobe, and the training level of biopsy performers--in increasing pneumothorax rate (14). It was concluded that among these variables, only small lesion size and presence of emphysema are significantly correlated with the occurrence of pneumothorax. In contrast to other studies (8, 10, 15), Cox et al. showed lesion depth to have no effect on pneumothorax rate. The latter conclusion is interesting, since Poe et al. showed lesion depth to have a significant effect on pneumothorax frequency even after excluding peripheral lesions from the analysis (5). Therefore, the present study was carried out over 150 consecutive CT-guided needle aspiration biopsies to evaluate the influence of these variables (lesion size, lesion depth, and presence of emphysema, as well as age, sex,…) on the frequency of pneumothorax.

MATERIALS AND METHODS

Over an eighteen-month period (July, 1999 through January, 2000), one hundred fifty consecutive percutaneous fine needle aspiration biopsies were performed at our institution.Cases consisted of patients in whom thoracic lesions were observed in their chest radiographs, but no specific diagnosis had been established after sputum culture,sputum and pleural fluid cytology and bronchoscopy. Meanwhile, those who had not been considered as suitable candidates for surgery, bronchoscopy, mediatinoscopy or thoracoscopy following the sputum and pleural fluid tests entered our study.

The study population included 93 men and 57 women with a mean age of 55.3 years (range; 9-87 years).

Level of needle entry site, lesion location (pulmonary, mediastinal, or pleural), lesion depth, and presence of emphysema were all determined in each case by reviewing preliminary scans obtained by Siemens Somatom Plus CT scanner (Frankfurt, Germany).To minimize the number of pleural surfaces crossed, the patient was positioned to make the most proximal surface of the lesion accessible.

Local anesthesia was administered by means of a subcutaneous injection of 1% lidocaine. All biopsies were performed by using a 13.97-cm 20-gauge Westcott needle (Becton Dickenson & Co., Rutherford, NJ) during patient breath holding by positioning the needle into the most accessible aspect of the lesion. Core biopsy specimens were submitted in 10% formalin, and aspiration specimens were spread on a slide for pathologic studies.

Frozen section or cytopathologic analysis was not available during biopsy although all tissue samples were sent for pathologic reports immediately after biopsy.

All biopsies were performed by one radiologist . Follow up CT scans were obtained in all patients immediately after biopsy, and 4 hours later to evaluate the pneumothorax.

In case of pneumothorax, the surgery department was consulted, and chest tube was placed if deemed necessary.

During management, there was no preference in assigning the patient to either the puncture-site-dependent or the puncture-site-nondependent recumbent positions.

In case of hemoptysis, after surgery consultation, the patient was assigned to the puncture-site-dependent recumbent position. After the procedure, patients were monitored for 4 hours under the supervision of a nurse. If pain, dyspnea, or hypoxemia was developed, chest radiographs were obtained in order to evaluate the pneumothorx .

Biopsies were repeated after one week in five compliant patients after pathology analysis had revealed that specimens were insufficient. Results were analyzed by using chi-square, Fisher's exact test, Mann-Whitney U test, and t-test with a 90% confidence interval (α=10%).

RESULTS

In 128 cases (85%), biopsy yielded sufficient tissue for pathologic studies. Among them, 22 lesions were benign, 61 were malignant, 28 were categorized as “nonspecific”, and 17 were suspicious for malignancy (Tables1-3).

Table 1. Benign diagnoses (*n*=22)

Benign Disorders	Number of Patients
Hydatid Cyst	3
G^+ Pneumonia	2
G^- Pneumonia	2
Aspergillosis	2
Tuberculosis	1
Granuloma	6
Anthracosis	3
Hamartoma	2
Mucin-producing cells	1
Cartilage	1
Thymoma	1

Table 2. Nonspecific Lesions (*n*=28)

Nonspecific Disorders	Number of Patients
Nonspecific Inflammation	23
Necrotic Tissue	4
Squamous Metaplasia	1

Lesions were most prevalent in the right lower lobe (28; 19%), right upper lobe (27; 18%) and left upper lobe (25; 17%). One hundred thirty-one (87%) were located in the lungs, 10 (7%) were mediastinal, and 9 (6%) were pleural. Lesion location frequencies are shown in Table 4. Complications arose in 12 cases (8%), including 9(6%) pneumothoraces and 3(2%) cases of hemoptysis. Nine cases of pneumothorax, just one required chest tube placement due to respiratory distress, however the others were managed conservatively and discharged after 24 hours. The patient discharged after 48 hours with a small chest tube (9 F) placed .

Table 3.Malignant Diagnoses (n=61)

Malignant Disorders	Number of Patients	
Small Cell Carcinoma	5	
Non-Small Cell Carcinoma	46	
Squamous Cell Carcinoma		19
Adenocarcinoma		13
Undifferentiated		7
PNET		2
Non-Hogkin Lymphoma		1
Carcinoid Tumor		1
Pancoast Tumor		1
Mesothelioma		1
Broncho-alveolar Cell Carcinoma		1
Methastasis	10	
Osteosarcoma		2
Scc of Cervix		2
Malignant Melanoma		1
Adenocarcinoma		1
Renal Cell Carcinoma		1
Hepatocellular Carcinoma		1
Adenoied Cystic Carcinoma		1
Femoral Liposarcoma		1

Table 4. Frequency of lesion locations

Location of Lesions		Number of Patients	
Pulmonary		131	
	RUL		27
	RML		17
	RLL		28
	LUL		25
	Lingula		10
	LLL		19
	Left Hemithorax		2
	Hilus		3
Mediastinal		10	
	Anterior		6
	Posterior		3
	Middle		1
Pleural		9	

Of the 145 patients 34(23%) had an emphysematous appearance in chest radiographs; where emphysema occurred at 8(89%) of 9 cases of pneumothorax. Indeed, pneumothorax rate was significantly greater in emphysematous patients (X^2=15.9, p<0.001).

Mean lesion size was 6.6±3.4 cm, ranging 1-18 cm. Patients with pneumothorax had mean lesion size of 3.6±1.0 cm, ranging 2.5-6 cm. Eventually, a significant difference was found between cases with lesions 3.5 cm or greater and cases with lesions smaller than 3.5 cm in terms of pneumothorax rate (p<0.068),(Table5). The distance of the lesion from the chest wall had a mean value of 0.6±1.0 cm, ranging 0-4.5 cm. Fifty-five lesions (26%) had at least 0.5 cm distance, whereas the remaining 95 (74%) were contacted to the chest wall. Six out of nine cases with pneumothorax had lesion distanced from the chest wall. Results have revealed a significant difference between peripheral and central lesions in terms of pneumothorax occurrence (*p*=0.055).Analysis by Mann-Whitney U-test has shown that the pneumothorax rate did increase with increasing distance of the lesion from chest wall. (X^2 = 4.35 , p< 0.05) (Table 6).

Table 5. Correlation of pneumothorax rate with lesion size

Lesion Size (cm)	Pneumothorax$^-$	Pneumothorax$^+$	Total	Pneumothorax Rate(%)
1-1.5	4	1	5	2
2-2.5	10	2	12	17
3-3.5	12	1	14	7
4-4.5	13	2	15	13
5-5.5	18	2	20	10
6-6.5	16	1	17	6
7-7.5	15	0	15	0
8-8.5	21	0	21	0
9-9.5	8	0	8	0
>10	23	0	23	0

Table 6. Correlation of pneumothorax rate with lesion distance from pleural surface

Distance from Pleural Surface(cm)	Penumothorax$^-$	Pneumothorax$^+$	Total	Pneumothorax Rate(%)
0	92	3	95	3
0-0.5	15	1	16	6
>0.5	34	5	39	13

Table 7. Correlation of pneumothorax rate with patient age

Age (years)	Pneumothorax$^-$	Pneumothorax$^+$	Total	Pneumothorax Rate (%)
<55	61	1	62	2
≥55	80	8	88	9

Considering the age, patients were divided into two groups of <55 years and ≥ 55 years. With a 90% confidence interval, there was a significant difference between the age groups in terms of pneumothorax rate (p=0.058) (Table 7).

DISCUSSION

Based on the study performed by Collings et al. which showed the puncture-site-down post biopsy position affecting neither the incidence of post biopsy pneumothorax nor the incidence of pneumothorax requiring chest tube placement (16). In case of pneumothorax, we had no preference in assigning the patient to either of the mentioned positions.

Sixty-three percent of cases had lesions adjacent to the chest wall. According to a recent study performed by Cox et al.(14),if no aerated lung is passed, the patient is not put at risk for pneumothorax; therefore, in statistical analysis, only the number of patients with lesions distanced from the chest wall rather than the total number of patients should be taken into account. Our data have suggested that the large size of lesions and the adjacency of two thirds of them to the chest wall may have been associated with very low (8%) pneumothoraxrate ; whereas three pneumothoraces developed in lesions adjacent to the chest wall, for which two reasons could be suggested. First, in some lesions, even adjacent to the chest wall, access was more feasible by passing a minimum amount of aerated lung. Second, some lesions were composed of an infiltration rather than a solid mass; therefore the biopsy needle had inevitably entered aerated lung during biopsy. As a result, all lesions (adjacent to or distanced from the chest wall) were taken into account in our analysis.

Controversy exists on whether the presence of emphysema increases the risk of pneumothorax or not. Some studies (9,10) have not found any correlation between abnormal pulmonary function test results and pneumothorax frequency, in contrast to others (5,7,8,14), which have Our findings support the latter (X^2=15.9, p<0.001). We found a significantly higher risk of pneumothorax in patients with emphysema (89% vs. 23% in those without emphysema). This may be due to reduced pulmonary reserve in emphysematous patients, the effect of dilated air spaces in preventing rapid sealing of air leaks, and the slower resorption of pneumothorax in these patients (14).

Prior investigators have assessed complication rate by categorizing lesions to greater and smaller than 1.5 or 2 cm (17,18); meanwhile, a strong correlation between pneumothorax rate and lesion size has been previously demonstrated (7, 10, 14). In our study, large lesion size resulted in dividing lesions into 3.5 cm or less, and greater than 3.5 cm. We have found a significant relationship between the two groups in terms of pneumothorax incidence (13% vs. 42%, X^2 = 3.3, p=0.069).

For lesions at a depth of 0-0.5 cm, the frequency of pneumothorax was 4%, however, for lesions that necessitated needle penetration was more than 0.5 cm, this figure approximated 13%.Our result support the finding of Poe et al. who found an increase in pneumothorax rate by increasing depth of needle penetration (5). Although comparison between Cox et al. findings and former study is difficult (due to the biopsies being performed by different techniques) and their findings contradict lesion depth being effective in increasing pneumothorax rate (14).Our data have been obtained by performing all biopsies by one single technique, and the results still confirm the significance of lesion depth.

Anderson et al. (9) found no correlation between patient age and pneumothorax rate. In our study, a significant increase in pneumothorax rate was shown in patients aged ≥55.

In conclusion, the only factors that altered the risk of pneumothorax were the lesion depth, lesion size, patient age, and the presence of emphysema.

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