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Orjinal Araştırma / Original Article

The Effect of The Number of Needle Maneuver in The Lung and The Number of Pleural Punctures on The Formation of Pneumothorax, A Complication of Lung Transthoracic Core Needle Biopsy

Akciğer İçindeki İğne Manevrası Sayısının ve Plevral Ponksiyon Sayısının, Akciğer Transtorasik Çekirdek İğne Biyopsisinin Bir Komplikasyonu Olan Pnömotoraks Oluşumuna Etkisi

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Abstract

Aim: This study sought to investigate the effect of the needle maneuver count and number of pleural punctures on pneumothorax in CT-guided transthoracic core needle biopsy.
Material and Method: Records of CT-guided core needle biopsy performed on patients were retrospectively reviewed. Demographic data, procedure reports, pathology reports, tomography images, follow-up examinations, and complications due to biopsy were examined. Next, the number of times the needle penetrated the pleura and the number of maneuvers in the lung were listed. The number of pleural punctures was recorded either as 1 or ≥2. The needle maneuver count was recorded either as 1, 2, or ≥3. All listed variables were statistically evaluated.
Results: A total of 393 patients were included in the study. Complications of pneumothorax occurred in 87 (22.1%) patients. A thorax tube application due to pneumothorax was required in 39 (9.9%) patients. When the needle maneuver count in the lungs during biopsy was greater than 3, the incidence of pneumothorax and the need for a thorax tube application were increased (p=0.001). As the size of the lesion decreased and the lesion-pleura distance increased, the needle maneuver count in the lung increased (p=0.001, p=0.008). Pneumothorax and thorax tube application rates were increased in 48 patients with pleural punctures ≥2 (p=0.001, p=0.001).
Conclusion: In CT-guided pulmonary transthoracic core needle biopsy applications, needle maneuver count and the number of pleural punctures constitute the major factors contributing to the risk of developing pneumothorax.

Keywords: Pneumothorax, lung cancer, transthoracic biopsy, lung biopsy

Öz

Amaç: Bu çalışmada BT eşliğinde transtorasik çekirdek iğne biyopsisinde, iğne manevrası sayısı ve plevral ponksiyon sayısının pnömotoraks üzerine etkisini araştırmak amaçlandı.
Gereç ve Yöntem: Hastalara uygulanan BT eşliğinde çekirdek iğne biyopsisi kayıtları retrospektif olarak incelendi. Demografik veriler, işlem raporları, patoloji raporları, tomografi görüntüleri, takip muayeneleri ve biyopsiye bağlı komplikasyonlar incelendi. Daha sonra, iğnenin plevraya kaç kez girdiği ve akciğerdeki manevra sayısı listelenmiştir. Plevral ponksiyon sayısı 1 veya ≥2 olarak kaydedildi. İğne manevra sayısı 1, 2 veya ≥3 olarak kaydedildi. Listelenen tüm değişkenler istatistiksel olarak değerlendirildi.
Bulgular: Toplamda 393 hasta çalışmaya dahil edildi. Pnömotoraks komplikasyonu 87 (%22,1) hastada oldu. Pnömotoraksa bağlı toraks tüpü uygulaması 39 (%9,9) hastada gerekli oldu. Biyopsi uygulama esnasındaki akciğerlerdeki iğne manevrası sayısının 3+ olduğu durumlarda, pnömotoraks insidansında ve toraks tüpü uygulama gereksiniminde artış saptandı (p=0,001). Lezyon boyutu azaldıkça ve lezyon plevra mesafesi arttıkça iğnenin akciğer içerisindeki manevra sayısı artmıştır (p=0,001, p=0,008). Plevra delinme sayısı ≥2 olan 48 hastada, pnömotoraks ve toraks tüpü uygulama oranları artmıştır (p=0,001, p=0,001).
Sonuç: BT eşliğinde yapılan pulmoner transtorasik çekirdek iğne biyopsisi uygulamalarında, iğne manevrası sayısı ve plevral ponksiyon sayısı pnömotoraks gelişme riskine katkıda bulunan ana faktörleri oluşturmaktadır.

Anahtar Kelimeler: Pnömotoraks, akciğer kanseri, transtorasik biyopsi, akciğer biyopsisi

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INTRODUCTION

Computed tomography (CT)-guided lung transthoracic needle biopsy (TTNB) is a well-known technique for the diagnosis of thoracic lesions.[1] It is an easily applicable and inexpensive alternative to more invasive surgical procedures.[2,3] The use of a coaxial system and a core needle in TTNB allows for the sampling of multiple tissues.[4-6] A high specific diagnostic rate for both benign and malignant lesions following biopsy were reported with the use of automated biopsy devices.[7,8]

Some complications may occur following CT-guided core needle biopsy. Pneumothorax (PTX), bleeding, air embolism, and tumor seeding through the needle tract are known biopsy complications. PTX is the most common complication of lung biopsy and was reported to occur in 17–26.6% of patients. A thorax tube application is required more rarely, in 1% to 14.2% of patients.[9-12]

Recently, risk factors that may increase PTX formation have been tried to be identified. Variables that could be risk factors included patient age, sex, smoking history, lesion size, external stabilizing needle size, whether a core biopsy needle or an automated needle gun system were used, and the depth of the parenchyma.[13] In other words, there are risk factors related to the lesion, patient, practitioner experience and method.[14,15] The risk factors associated with the lesion and patient (age, presence of emphysema, small lesion size, long needle path, etc.) cannot be altered. In the presence of these risk factors, the likelihood of developing PTX may be high. Practitioner experience is a variable factor, however. The procedure is very safe when performed by appropriately trained and experienced doctors.[16] The needle maneuver count and pleural punctures in the lung are among the practitioner-dependent variables. The effect of these variables on PTX has not been adequately evaluated in studies published to date. Proving that these variables are risk factors can lead to new studies on practitioner experience and technical methods. The aim of this study was to investigate whether the needle maneuver count in the lung and the number of pleural punctures constitute risk factors to the formation of PTX. In addition, the presence of factors associated with the lesion that could affect the needle maneuver count and pleural punctures, and that were not included in any of the studies published to date, were also evaluated.

MATERIAL AND METHOD

All procedures in the study were performed on human participants in accordance with national research committee standards, and ethical guidelines for the 1964 Helsinki Declaration and subsequent editions. The study was carried out with the permission of Necmettin Erbakan University Meram Faculty of Medicine Non-Pharmaceutical and Medical Device Research Ethics Committee (Decision No. 2019/2203). Treatment methods were performed according to approved guidelines. Permission was obtained from the institution for retrospective examination of the records. All patients were informed that their biopsy samples could be used forscientific research purposes and provided written consent before undergoing the procedure. Additional approval via telephone was obtained from patients whose images were used during manuscript preparation.

Study Plan and Patients

This study was jointly planned between Interventional Radiology and Thoracic Surgery Clinics. The records of patients who underwent CT-guided core needle biopsy between January 2017 and October 2019 were retrospectively screened. Demographic data, procedure reports, pathology reports, tomography images, follow-up examinations and complications due to biopsy were examined. CT images during and before the biopsy were obtained. The location of the lesion, lesion size, lesion-pleura distance and presence of emphysema were recorded. Emphysema was assessed using the Goddard classification, a visual scale that scores vascular impairment and low attenuation for each lung area. Patients with a history of ipsilateral surgery, bulla on the needle tract, a fissure that had to be passed, and a pleural-based lesion were excluded. All recorded sequential tomography images taken during the biopsy were screened by the interventional radiologist who performed the biopsy. This scan recorded the number of times the needle perforated the pleura and the needle maneuver count in the lung (**Figure 1**). Needle maneuver count in the lung, controlled progress and angle-shifting movements of the needle after crossing the pleura were listed (**Figure 2**). The number of pleural punctures was recorded either as 1 and ≥2. The needle maneuver count was grouped either as 1, 2 or ≥3.

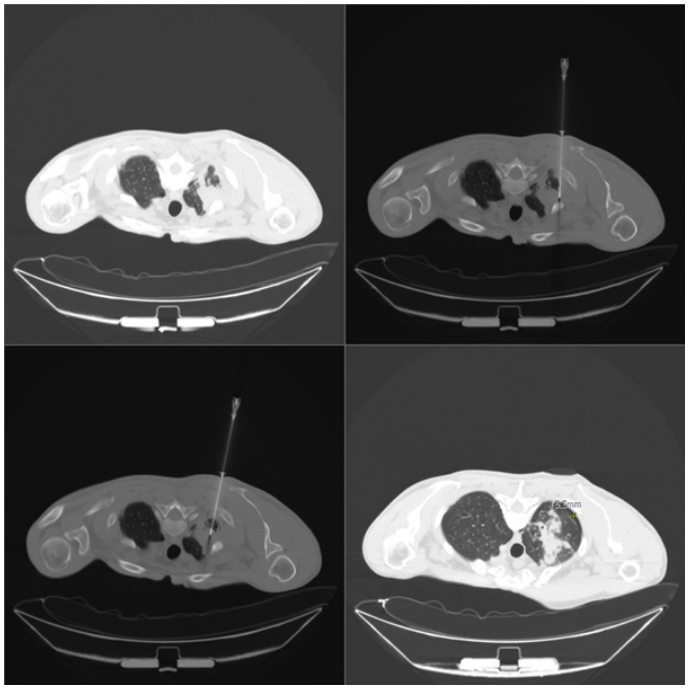

Figure 1. During the first puncture, the pleura was punctured twice because of misalignment of the coaxial needle angle. Subsequently, minimal pneumothorax occurred as a complication.

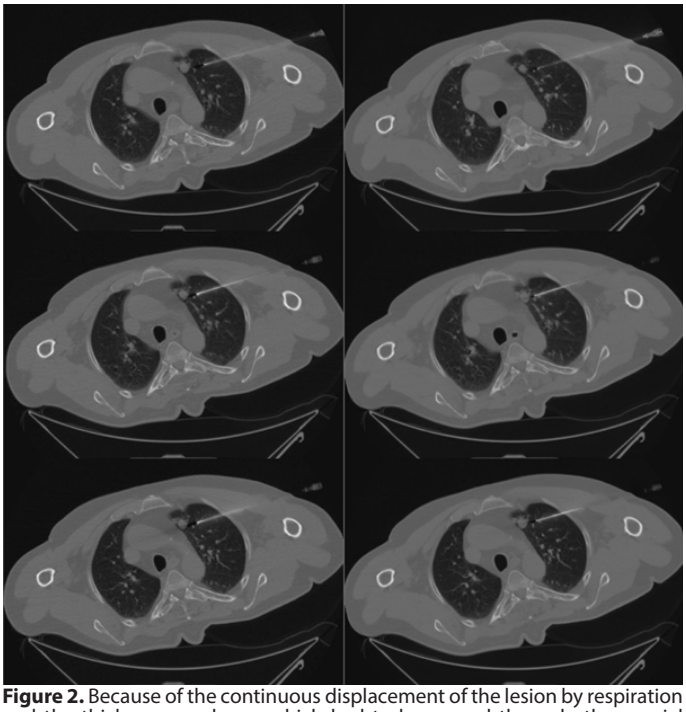

Figure 2. Because of the continuous displacement of the lesion by respiration and the thicker parenchyma which had to be passed through, the coaxial needle was maneuvered 6 times during biopsy. (20x15 mm irregular contoured lesion located in the anterior upper lobe of the left lung in the paramediastinal area; pathological diagnosis was adenocarcinoma)

Statistical Analysis

Data from the study was uploaded to the computer and evaluated by using "SPSS (Statistical Package for Social Sciences) for Windows 22.0 (SPSS Inc, Chicago, IL)." Descriptive statistics are presented as median (25%-75%), frequency distributions, and percentages. Visual (histogram and probability graphs) and analytical (Kolmogorov-Smirnov Test) methods were used to assess the conformity of the quantitative data to the normal distribution. A Pearson's chi-squared test was used to evaluate the number of pleural punctures, the needle maneuver count and the presence of emphysema with PTX and thorax tube placement variables. An independent samples test was used to evaluate the correlation between lesion size, lesion depth and PTX complications. The effects of lesion size and lesion-pleura distance on the number of pleural punctures were evaluated using a Mann-Whitney U test. The effect of increased lesion-pleura distance on needle maneuver count was evaluated using a Kruskal Wallis test and the effect of lesion size on maneuver count was evaluated using a one-way ANOVA test. The level of statistical significance was set at $p<0.05$.

Biopsy Procedure and Follow-up

Patients were informed by all medical practitioners about their possibility of disease and the reasons for which a biopsy should be performed. Written approval indicating the complications and the fact that information from the patients' file could be used for study purposes, were received. Routine bleeding parameters (INR<1.5, platelet count>50000) were assessed to minimize risks.

All biopsy procedures were performed by an interventional radiologist with at least 6 years of experience. All core needle biopsy procedures were performed under multidetector CT guidance (Somatom Emotion 6, Siemens, Erlangen, Germany). The technical parameters for CT are as follows: 120 mA; 100kVA; collimation 6x2 mm; slice thickness 2.5 mm; restructuring range 1 mm. A fully automatic coaxial system 20G, 15-20 cm core needle biopsy needle (estacore, Geotek Medical, Ankara, Turkey) was used for the biopsies. The coaxial needle used was a 19G needle. In our clinic, 20G needles have been used for the last 6 years since we have never encountered any problem obtaining adequate tissue. A breath holding technique was not used during patient biopsies. Initially, 10 cm tomography axial images were obtained. The most appropriate coaxial needle route was then determined. Skin antisepsis and local anesthesia were carried out. The coaxial system was carefully advanced. CT images were obtained after each maneuver to assess the accuracy of the needle tract. Approximately 3-4 pieces of tissue were taken with a core biopsy needle after visualization of the tissue was confirmed with tomography images showing that the coaxial needle had reached the lesion.

After the biopsy, CT images of the same region were taken while the patient was still on the table and assessed for the presence of any complications. Pulmonary radiographs were taken at the 6th and 24th hours of the follow-up period at the outpatient thoracic surgery service and evaluated by a thoracic surgeon. Patients who did not develop any complications were discharged. After the biopsy procedure, patients who developed PTX without a necessary intervention were closely monitored with nasal oxygen administration. A thorax tube was placed in patients with a large PTX (35% reaching below apical or hilus level), patients with progressing PTX on repeated radiographs, and symptomatic patients (severe pain or dyspnea) (**Figure 3**).

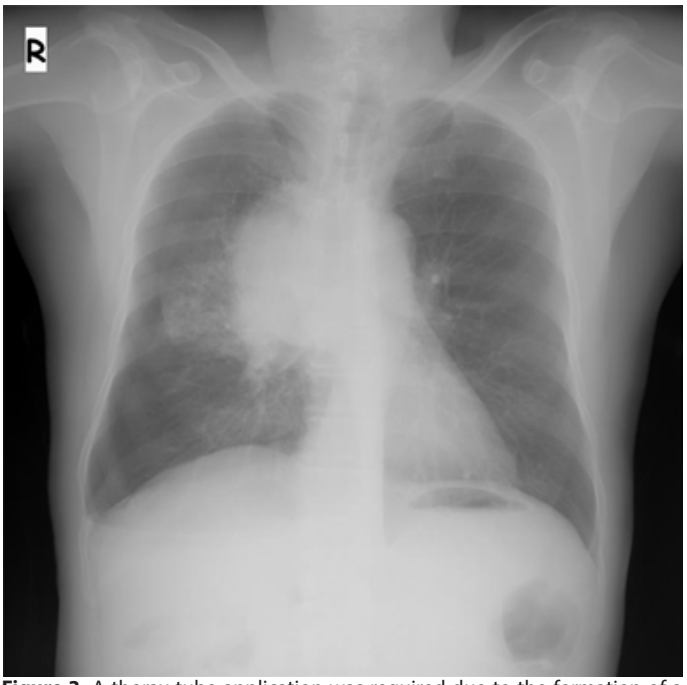

Figure 3. A thorax tube application was required due to the formation of a large pneumothorax on the posteroanterior chest X-ray at the 6th hour after the biopsy. (A biopsy was performed from the lesion located in the superior segment of the lower lobe of the right lung; the pathological diagnosis was high grade neuroendocrine carcinoma.)

RESULTS

A total of 393 patients (285 males and 108 females) were included in the study. The mean age of the patients was 58.4±12.1 years. Of all lesions, 208 were in the upper lobe, 41 in the middle lobe and 144 in the lower lobe. A total of 89 (22.6%) patients had PTX complications. Thorax tube application due to pneumothorax was required in 40 (10.1%) patients. Minimal pulmonary bleeding along the needle tract was seen in 48 (12.2%) patients. There were no severe pulmonary hemorrhage cases requiring treatment. Transient hemoptysis resolved spontaneously in 20 (5.08%) patients. No patient experienced air embolism or death. The diagnostic efficiency was 98.3% (**Table 1**).

Table 1. Descriptive and clinical characteristics of the performed biopsies.

	n=393 (100%)
Size (mm), mean±SD (min-max)	33.4±16.6 (7-110)
Lesion-Pleura Distance (mm), mean±SD (min-max)	30.5±12.8 (13-90)
Number of Parietal Pleura punctures, n (%)	
1	345 (87.8)
2	45 (11.4)
3	3 (0.8)
Needle Maneuver Count in the Lung, mean ± SD (min-max) w	1.8±1.0 (1-6)
1, n (%)	192 (48.9)
2, n (%)	130 (33.2)
3, n (%)	54 (13.7)
4, n (%)	5 (1.1)
5, n (%)	9 (2.3)
6, n (%)	3 (0.8)
Pneumothorax, n (%)	89 (22.6)
Thorax Tube Applications, n (%)	40 (10.1)
Pathology Result, n (%)	
Malignant	265 (67.5)
Benign	123 (31.2)
Insufficient Material	7 (1.7)
Diagnostic Efficiency Value, n (%)	98.3%

n: number of biopsy; **%:** column percentage; **mean:** mean value, **SD:** standard deviation

The mean lesion size was 34.5 (±19.9) mm in patients with PTX and 33.1 (±15.5) mm in patients without PTX. There was no significant difference in PTX rates between these two groups (p=0.969). The mean lesion-pleura distance was 34.7 (±13.4) mm in patients with PTX and 29.2 (±12.3) mm in patients without PTX. There was a difference in terms of PTX rates between these two groups (p=0.029). Emphysema was present in 62 patients in the lung lobe in which the biopsy was performed. PTX developed in 20 (35.2%) of the 62 patients with emphysema. This rate was 20.2% in patients without emphysema. The rate of PTX was higher in patients with emphysema (p=0.001).

The rates of PTX complications were similar between patients with a needle maneuver count of 1 and 2 in the lung. When the needle maneuver count in the lungs during biopsy was greater than 3, the incidence of PTX and the need for a thorax tube application were increased (p=0.001). As the size of the lesion decreased and the lesion-pleura distance increased, the maneuver count of the needle in the lung increased (p=0.001, p=0.008) (**Table 2**).

Table 2. Distribution of pneumothorax development and cases with thorax tube application according to the maneuver count of needle in the lungs.

	Maneuver Count Of Needle In The Lungs			p
	1 (n=192)	2 (n=130)	≥3 (n=71)	
Pneumothorax, n (%)	29 (15.1)	21 (16.1)	39 (54.9)	0.001
Status of Thorax Tube Application n (%)	13 (6.7)	7 (5.3)	20 (28.1)	0.001
Lesion-Pleura Distance mean (± SD)	27.3 (±9.8)	31.9 (±12.7)	36.3 (±17)	0.001
Lesion Size mean (± SD)	36.4 (±15.9)	31.7 (±15.4)	28.7 (±19.1)	0.008

n: number of biopsy, %: column percentage, mean: mean value, SD: standard deviation

There were 345 patients with 1 pleural perforation 1 and 48 patients with ≥2. In this group of patients with ≥2, the PTX ratio and necessity for a thorax tube application were significantly increased (p=0.001) (**Table 3**).

Table 3. Distribution of pneumothorax development with parietal pleura transition count and thorax tube application rate.

	Number of Parietal Pleura Punctures		p
	1 (n = 345)	≥2 (n= 48)	
Pneumothoraxn (%)	64 (18.5)	25 (52.0)	0.001
Status of Thorax Tube Attachment n (%)	23 (6.6)	17 (35.4)	0.001
Lesion-Pleura Distancemean(±SD)	30.3 (± 12.8)	31.5 (± 12.8)	0.391
Lesion Sizemean(±SD)	34.1 (± 16.7)	28.5 (± 14.8)	0.085

n: number of biopsy, %: column percentage, mean: mean value, SD: standard deviation

DISCUSSION

In this study, the risk factors contributing to PTX after lung TTNB and the conditions that might affect these risk factors were evaluated. In cases in which the number of coaxial needle maneuvers in the lung was greater than 3, there was an increase in the incidence of PTX occurrences and the need for thorax tube application. Similarly, the PTX rate and the need for thorax tube application were increased in patients with a pleural needle perforation count ≥2. As the size of the lesion decreased and the lesion-pleura distance increased, the number of needle maneuvers in the lung increased. These findings demonstrate the importance of practitioner experience.

Risk factors contributing to PTX complications have been evaluated in many studies. Each study has discussed the risk factors that they consider important. This limitation is natural since this issue is comprehensive. It may not be technically possible to discuss all risk factors in the studies. Heerink et al.[17] recently published a very interesting meta-analysis on this topic. They examined 32 core needle biopsy articles and 17 fine needle aspiration biopsy articles in their meta-analysis. They presented risk factors for biopsy complications and reported that factors such as larger needle diameter, smaller lesion size, and increased transverse lung parenchyma are risk factors for complications. The increased risk of transverse lung parenchyma, which is a risk factor, indirectly supports the hypothesis in this study. A long tract can increase the number of maneuvers and pleural punctures. There are also studies evaluating patient and lesion characteristics from risk factors applying univariate analysis.[18,19] These studies included factors such as patient age, sex, smoking history, localization of the site, lesion size, patient's lying position and size of external stabilizing needle. But, the number of needle maneuvers in the lung were not assessed.This factor can be improved with good planning before and during biopsy. Therefore, it is important to evaluate it. In this study, unlike the others, the needle maneuver count in the lung was assessed and its effect on PTX and thorax tube application rate was indeed studied. PTX complications were seen in 15.1% of patients with 1 needle maneuver number and 16.1% of patients with 2 needle maneuvers in the lung. PTX complication rates were similar in these two groups. However, the rate of pneumothorax increased dramatically in 54.9% of patients with ≥3 needle maneuvers. As a result of this study, when the maneuver count was ≥3, the incidence of PTX and the need for thorax tube application increased.

Lesion size and depth of placement are known to affect the incidence of pneumothorax after biopsy. There are studies examining the effects of lesion size and depth on PTX.[20-23] In fact, one of these studies described a pulmonary parenchyma with a thickness of 4 cm or more, through which the needle was passed, as a major risk factor for PTX formation.[20] Laurent et al.[21] examined the lesion size. There were no significant differences in the complication rate between the two patient groups with a size below or above 20 mm.[21] Heyer et al.[22] and Shiekh et al.[23] found the incidence of PTX to be significantly higher in smaller and deeper lesions. These three studies actually provided support for our theory, but did not elaborate on these factors. The greater distance between pleura and lesion means that the coaxial needle travels a longer way to reach the lesion. Access to this lesion is more difficult than to a nearby lesion. As a brief result of these studies, small sized and deeply located lesions can be defined as risk factors. However, the reasonsfor which these factors increase pneumothorax have not been evaluated in these studies. Small, deeply located lesions that are translocated by respiration are difficult to access. Therefore, it is clear that the number of maneuvers will be higher than in the others. In this study, the effect of lesion size and lesion-pleura distance variables on the needle maneuver count in the lung was evaluated. As the lesion size decreased, the number of needle maneuvers increased. As the lesion-pleura distance increased, the number of needle maneuvers in the lung increased significantly. According to the results of this study, the needle maneuver count in the lung was a risk factor for pneumothorax. In parallel with this information, the direction in which the lesion-pleura distance and lesion size increased the rate of pneumothorax was elucidated.

To the best of our knowledge, there is little work examining the number of pleural puncturesas a PTX risk factor.[24-26] Although the subject is partially included in these three studies, it has not been centrally examined. Geraghty et al.[24] found PTX complications in 27% of patients with a pleural perforation count of 1, in 29% of patients with a pleural perforation count of 2-3, and 30% of those with a pleural perforation count of 4 or more. They stated that there was no significant difference between these values (p=0.558).[24] Pleural punctures of two or more are abnormal. Comparison of the above-normal number of pleural punctures in different groups (2-3, ≥4) may have negatively affected their statistical results. Joseph et al.[25] noted in their study, whichincluded 356 patients, that there was no statistically significant correlation between PTX complication and the number of pleural punctures. In their evaluation, they listed all perforation counts as 1,2,3,4, and 5, without grouping them separately. The number of pleural punctures is higher than normal in the 2, 3, 4 or 5 groups. It can be predicted that there will be no significant difference when these 5 groups include 4 patients, since all of these have a number of pleural punctures. It is generally accepted that a pleural perforation number of 1 is the most appropriate count in biopsy applications. This is one of the main objectives in planning, but multiple punctures of the pleura may be required to reach small, deep-located lesions that are more displaced by respiration. In this study, the number of pleural punctures was divided into two groups, as having either 1 or ≥2 pleural punctures. In this way, statistics were carried out according to groupings. There was a significant increase in the rate of pneumothorax and the necessity of thorax tube application in patients with a pleural perforation count ≥2. In addition, this study provides evidence of the effect of pleural perforation on complications. It is considered that the observation period and the decreased need for additional treatment in contemporary medical care is just as important as providing quality health care. Therefore, it is important to know the factors affecting the rate of complications after percutaneous transthoracic core needle biopsy.

This study has some limitations. First, the evaluation was based on a monocentric retrospective analysis. Secondly, this resulted in insufficient smoking records. Third, the proportions of risk factors examined in this study may vary depending on practitioner experience. As a consequence, the results of studies across different centers may differ.

In conclusion, this study showed that the needle maneuver count and the number of pleura punctures in the lungs were risk factors for pneumothorax in the application of CT-guided lung core needle biopsy. A decrease in lesion size and an increase in lesion-pleura distance lead to an increase in the number of maneuvers, which constitutes a risk factor.

ETHICAL DECLARATIONS

Ethics Comittee Approval: The study was carried out with the permission of Necmettin Erbakan University Meram Faculty of Medicine Non-Pharmaceutical and Medical Device Research Ethics Committee (Decision No. 2019/2203).

Informed Consent: Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Status of Peer-review: Externally peer-reviewed.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

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Author Contributions: All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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