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Original Article *Özgün Araştırma*

DIAGNOSTIC ACCURACY AND COMPLICATIONS OF PERCUTANEOUS CT-GUIDED NEEDLE BIOPSY OF LUNG NODULES IN 161 PATIENTS

Akciğer Nodüllerinden BT Kılavuzluğunda İğne Biyopsisi Gerçekleştirilen 161 Hastada Tanısal Doğruluk ve Komplikasyonlar

Yunus YILMAZSOY [1]

[1] *Bolu Abant İzzet Baysal Üniversitesi Tıp Fakültesi, Radyoloji Bölümü, BOLU/TÜRKİYE*

ABSTRACT

Objective: Transthoracic needle biopsy is a diagnostic method that has proven its reliability in lung nodules and is frequently applied in daily practice. The diagnostic accuracy of biopsies performed with computed tomography navigation is quite high, even if the lesion sizes are smaller than 1 cm. We aimed to evaluate the diagnostic accuracy and complications of the computed tomography-guided percutaneous transthoracic needle biopsy procedure performed in our center.

Material and Methods: Patients who underwent computed tomography guided percutaneous transthoracic pulmonary nodule biopsy procedure between January 2017 and January 2020 were included in the study. The size and anatomic location of lesions, the distance between the pleura and the lesion, the angle of the needle with the pleura, the procedure time, the number of pathologic samples taken per patient, the total radiation dose, complications, and the pathological results of the lesions were analyzed from the patients' computed tomography images and patients' records.

Results: Among the 161 patients admitted for the transthoracic percutaneous needle biopsy procedure, 135 were male (mean age 64.3±11.1 years) and 26 were females (mean age 61.3±15.4 years). The pathological evaluation of 32 patients were reported as non-diagnostic. The diagnostic accuracy of computed tomography guided transthoracic biopsy was calculated as 80.1%. Major complications occurred in 10 patients (6.2%), and minor complications occurred in 60 patients (37.2%). The rate of procedure requiring chest tube insertion was 4.9%. The mean effective radiation dose of the patients per procedure was calculated as 5.26±3.25 mSv.

Conclusion: Computed tomography guided transthoracic biopsy procedure are a method with a high diagnostic accuracy rate, low rate of complications and can be preferred in all appropriate pulmonary nodules.

Keywords: *Solitary Pulmonary Nodule, Needle Biopsy, X-Ray Computed Tomography, Complications*

ÖZ

Amaç: Transtorasik iğne biyopsisi, akciğer nodüllerinde güvenilirliği kanıtlanmış ve günlük pratikte sıklıkla uygulanan bir tanı yöntemidir. Bilgisayarlı tomografi navigasyonu ile yapılan biyopsilerin tanısal doğruluğu, lezyon boyutları 1 cm'den küçük olsa bile oldukça yüksektir. Bu çalışmada merkezimizde yapılan bilgisayarlı tomografi eşliğinde perkütan transtorasik iğne biyopsisi işleminin tanısal doğruluğunu ve komplikasyonlarını değerlendirmeyi amaçladık.

Gereç ve Yöntemler: Ocak 2017-Ocak 2020 tarihleri arasında bilgisayarlı tomografi eşliğinde perkütan transtorasik pulmoner nodül biyopsi işlemi yapılan hastalar çalışmaya dahil edildi. Lezyonların boyutu ve anatomik yerleşimi, plevra ile lezyon arasındaki mesafe, iğnenin plevraya olan açısı, işlem süresi, hasta başına alınan patolojik örnek sayısı, toplam radyasyon dozu, komplikasyonlar ve patoloji sonuçları hastaların bilgisayarlı tomografi görüntüleri ile hasta kayıtlarından analiz edildi.

Bulgular: Transtorasik perkütan iğne biyopsi işlemine başvuran 161 hastanın 135'i erkek (ortalama yaş 64.3±11.1 yıl), 26'sı kadın (ortalama yaş 61.3±15.4 yıl) idi. 32 hastanın patolojik değerlendirmesi non-diagnostik olarak raporlandı. BT eşliğinde transtorasik biyopsi tanısal duyarlılığı %80.1 olarak hesaplandı. 10 hastada (%6.2) majör komplikasyon, 60 hastada (%37.2) minör komplikasyon gelişti. Göğüs tüpü takılmasını gerektiren işlem oranı %4.9 idi. Hastaların işlem başına aldıkları ortalama efektif radyasyon dozu 5.26±3.25 mSv (0.12-14.34 aralığında) olarak hesaplandı.

Sonuç: Bilgisayarlı tomografi eşliğinde transtorasik biyopsi prosedürü tanısal doğruluk oranı yüksek, komplikasyon oranı düşük ve uygun tüm pulmoner nodüllerde tercih edilebilecek bir yöntemdir.

Anahtar Kelimeler: *Soliter Akciğer Nodülü, İğne Biyopsisi, X-Ray Bilgisayarlı Tomografi, Komplikasyonlar*

Correspondence / Yazışma Adresi: **Dr. Yunus YILMAZSOY**
Bolu Abant İzzet Baysal Üniversitesi Tıp Fakültesi, Radyoloji Bölümü, BOLU/TÜRKİYE
Phone / Tel: +905325860513 **E-mail** / E-posta: yunusyilmazsoy@gmail.com
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INTRODUCTION

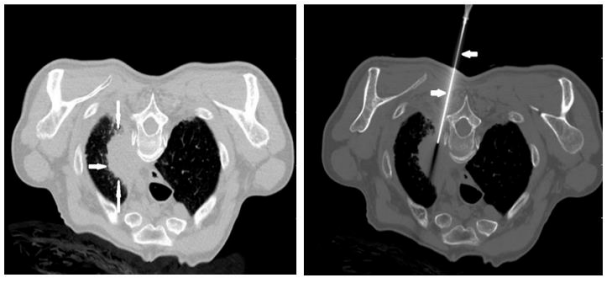
Transthoracic needle biopsy is a diagnostic method that has proven its reliability in lung nodules and is frequently applied in daily practice (1-4). The diagnostic accuracy of biopsies performed with computed tomography (CT) navigation is quite high, even if the lesion sizes are smaller than 1 cm (5,6). Lung nodule biopsy procedure can be performed from any region, including the mediastinal location. Transthoracic lung nodule biopsy can be performed with ultrasound, computed tomography, CT-fluor-oscopy, or cone-beam fluoroscopy. The advantage of biopsies performed with ultrasonography and fluoroscopy methods is that real-time imaging can be performed (7). However, radiation exposure of the practitioner is the main factor limiting the use in fluoroscopy methods. The diagnostic accuracy rate in transthoracic biopsies performed with computed tomography has been reported to be between 75% and 98% (8-10). The reasons for this difference can be explained by the technique used, the internal structure of the nodule and the algorithms in biopsy planning. In addition to increasing diagnostic accuracy, centers are developing new methods to overcome complications (11). Although pneumothorax is the most common complication in transthoracic lung biopsy procedure, hemo-thorax, hemoptysis, and air embolism are also among possible complications (12). In our study, we aimed to evaluate the diagnostic accuracy and complications of the computed tomography-guided percutaneous transthoracic needle biopsy procedure performed in our center.

MATERIALS AND METHODS

This study was performed in compliance with the principles of the Helsinki Declaration. Following the approval of the local ethics committee, 161 patients who underwent CT-guided percutaneous transthorac-ic biopsy (PCTTB) procedure between January 2017 and January 2020 were included in the study (The approval number: 221-276). Patients who did not accept the possible risks of the procedure and whose blood oxygen saturation value was below 80 % before the procedure were excluded from the study. Of the 161 patients, 135 were male (mean age 64.3±11.1 years) and 26 were females (mean age 61.3±15.4 years). Informed consent was obtained from all patients regarding the procedure and its complications.

Procedure

A multidetector computed tomography device was used to evaluate the lesion features and plan the procedure (Revolution EVO, GE healthcare, Waukesha, WI, USA). After the patient was placed in prone or supine position on the CT table, oxygen was administered by nasal cannula. A fingertip pulse oximeter reading device was used to monitor the patient's oxygen saturation. After setting the smallest possible field of view (FOV) for the localization of the lesion from the scout images, CT images were obtained with 2.5 mm slice thickness. From these images, the most appropriate access site for the lesion was evaluated and the optimal puncture site was marked on the patient's skin with a medical skin marker pen. After sterilizing the marked area, prilocaine was administered to provide local anesthetic effect. Then, under the guidance of CT images, the lesion was reached with a 17 G coaxial needle. After reaching the lesion, an automat-ed 18G tru-cut biopsy needle was advanced through the coaxial needle and biopsy samples were taken. Possible complications were evaluated by additional CT images. Necessary interventions were performed in the presence of complication. The patients were moved to the close observation area and followed-up within 4 hours. A control plain chest radiography examination was performed after 4 hours to detect latent complications of the procedure (Figure 1).



a b

Figure 1: a. A mass lesion in the upper lobe of the leftlung is seen in the patient lying in the prone position (white arrows). b. The lesion was reached with a coaxial needle (white arrows) and tru-cut biopsy samples was taken.

Data Analysis

In this retrospective study, the size and anatomic location of lesions, the distance between the pleura and the lesion, the angle of the needle with the pleura, the procedure time, the number of pathologic samples taken per patient, the total radiation dose, complications, and the pathological results of the lesions were analyzed from the patients' CT images and patients' records.

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Complications

Complications were divided into two groups as major and minor complications. Pneumothorax, transient hemoptysis and pulmonary hemorrhage, were considered as minor complications that do not require addition-al invasive procedures; pneumothorax and hemothorax requiring additional invasive procedures, air embo-lism, tract seeding, and death were considered as major complications (13).

Statistical analysis

Demographic data of the patients were calculated using descriptive statistical methods. The Shapiro wilk test was used to assess the normality of distribution between the groups. The statistical difference between the mean values and sub-groups was calculated using the students' T test. The relation between variables was calculated by using chi-square test, and linear-by-linear association. The Statistical Package for the Social Sciences (SPSS) software, Version 24.0 (IBM Corp., Armonk,NY.,USA) was used.

RESULTS

The characteristic features and related data of the lesions for which transthoracic biopsy procedure was performed are summarized in Table 1. The mean lesion size was 43.85±24.59 mm (range 10-144) and the distance to the pleura was 15.42±16.85 (range 0-70). The mean procedure time was measured as 20.95±7.30 min (range 10-52).

Table 1. Percutaneous Transthoracic Needle Biopsy procedure and patient records.

Characteristic	Value
Nodule size (mm)	43.85±24.59
Lesion to pleura distance (mm)	15.42±16.85
Lesion to hilus distance (mm)	28.16±24.84
Feature of lesion	
Solid	153
Ground glass	8
Density of Lesion (HU)	41.02±15.64
Emphysema in the lesion lobe	
Yes	72
No	89
Bullae or bleb in the needle trajectory	
Yes	6
No	155
Patient Position	
Supine	50
Prone	111
Number of pleural passes per lesion	1
Number of biopsies per patient	2.08±0.29
Needle angle to pleura	56.95±21.32
≥45º	108
<45º	53
Procedure Time (min)	20.95 ±7.30
Radiation Dose (mSV)	5.26 ±3.25
Tube Voltage (KV)	115.52±12.64
Tube Current (MaS)	267.88±130.11
DLP (mGy.cm)	435.25±234.88
CTDI (mGy)	124.92±93.24

DLP: Dose Length Product**; CTDI**: Computed Tomography Dose Index

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As a result of the pathological analysis of all cases, 112 (69.6%) were reported as malignant and 17 (10.6%) as benign. While 88 (78.6%) of the malignant cases were primary lung lesions, 24 (21.4%) were detected as metastases. The most common malignant lung tumor was adenocarcinoma (43.2%), followed by squamous carcinoma (39.7%). The pathological evaluation of 32 patients was reported as non-diagnostic. The diagnostic accuracy of CT-guided PCTTB was calculated as 80.1%. There was no statistically significant difference between lesion size and diagnostic accuracy (p=0.404), (Table 2).

Table 2. Analysis of Possible Factors Influencing Diagnostic Accuracy

Variable	Results		
	Positive Diagnosis (n=129)	**Negative Diagnosis (n=32)**	**P value**
Age [a]	63.52±11.95	64.53±13.41	0.679[b]
Sex			0.903[c]
Male	106	26	
Female	23	6	
Nodule size (mm)			0.589[c]
11-20	19	6	
≤ 20	110	26	
Pleural Distance			0.726[d]
0-20	88	22	
21-60	37	10	
61-120	4	0	
Nodule type			**0.029[c]**
Ground-glass	4	4	
Solid	125	28	
Necrosis- Cavitation			0.847[c]
Yes	50	13	
No	79	19	
Number of Sample			0.394[c]
≤2	119	28	
>2	10	4	
Location			0.402[c]
Upper and middle lobe	79	17	
Lower lobe	50	15	

[a]: Data are mean± SD, [b]: Student's T test, [c]: Chi-Square test, [d]: Linear by linear association

Major complications occurred in 10 patients (6.2%), and minor complications occurred in 60 patients (37.2%). The most common major complication was pneumothorax requiring tube insertion in 8 patients. The most common minor complication was parenchymal hemorrhage that spread to less than 1 segment observed in 38 patients (Figure 2).

Air embolism and mortality were not observed in our study. The rate of procedure requiring chest tube insertion was 4.9%. Angiography-guided embolization was performed in 2 patients due to prolonged bleeding and decreased blood hemoglobin levels. The passed parenchymal distance was determined as a risk factor for both pneumothorax and hemothorax. In addition, a significant correlation was found between the presence of emphysematous parenchyma in the needle tract and the development of pneumothorax (Tables 3 and 4).

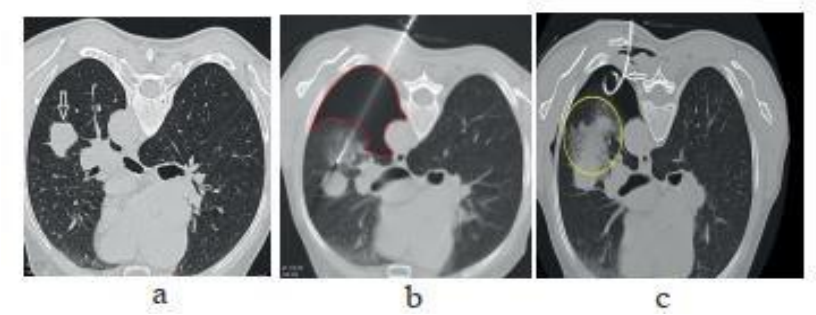

Figure 2: a. A mass lesion is shown in the lower lobe of the left lung (white arrow). b. Pneumothorax developing during the accession of the lesion with a co-axial needle is seen (red framed area). c. After the biopsy, a pleural drainage catheter placed due to pneumothorax (arrow) and pulmonary hemorrhage around the lesion is shown (yellow circle).

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Table 3. Analysis of Possible Factors Influencing Pneumothorax Rate.

Variable	Pneumothorax		P value
	Yes (n=32)	No (n=129)	
Age [a]	62.06±10.88	64.13±12.53	0.391[b]
Sex			0.251[c]
Male	24	108	
Female	8	21	
Nodule (mm)			0.268[c]
11-20	7	18	
≤ 20	25	111	
Pleural Distance			**0.023[d]**
0-20	16	94	
21-60	15	32	
61-120	1	3	
Nodule type			0.592[c]
Ground-glass	1	7	
Solid	31	122	
Location			0.440[c]
Upper and middle lobe	21	75	
Lower lobe	11	54	
Emphysema along the needle pathway			**0.008[c]**
Yes	21	51	
No	11	78	
Number of Sample			0.051[c]
≤2	32	115	
>2	0	14	
Needle angle to pleura			0.519[c]
≥45º	23	85	
<45º	9	44	
Procedure duration	26.96±8.50	19.45±6.15	**0.001[b]**

[a]: Data are mean± SD, [b]: Student's T test, [c]: Chi-Square test, [d]: Linear by linear association

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Table 4. Analysis of Possible Factors Influencing Parenchymal Hemorrhage Rate.

Variable	Parenchymal Hemorrhage		P value
	Yes (n=47)	No (n=114)	
Age [a]	63.08±11.38	63.99±12.58	0.670[b]
Sex			0.111[c]
Male	35	97	
Female	12	17	
Nodule (mm)			0.415[c]
11-20	9	16	
≤ 20	38	98	
Pleural Distance			**0.009[d]**
0-20	26	84	
21-60	18	29	
61-120	3	1	
Nodule type			0.184[c]
Ground-glass	4	4	
Solid	43	110	
Location			0.717[c]
Upper and middle lobe	27	69	
Lower lobe	20	45	
Number of Sample			0.504[c]
≤2	44	103	
>2	3	11	
Nodule Density	38.76±12.71	41.95±16.66	0.241[b]
Distance to Hilus			0.388[d]
0-20	17	50	
21-60	25	54	
61-120	5	10	

[a]: Data are mean± SD, [b]: Student's T test, [c]: Chi-Square test, [d]: Linear by linear association

In our study, the mean effective radiation dose of the patients per procedure was calculated as 5.26±3.25 mSv (range 0.12 to 14.34).

DISCUSSION

Fine-needle aspiration or tru-cut biopsy can be performed as a CT-guided lung needle biopsy procedure. While performing pathological analysis at the cellular level with aspiration biopsy, it may be easier to diagnose on a piece of tissue obtained with tru-cut biopsy technique. The diagnostic accuracy rate of percutaneous CT guided lung needle biopsy was calculated as 80.1 % in our study (14-15). A diagnostic accuracy rate of 75-98% has been reported in the literature, and this wide range may vary depending on the procedure method used, diagnostic algorithms and image processing methods (16). The biggest disadvantage of CT-guided lung biopsies is the inability to perform real-time imaging. In addition, if there is not enough distance between the gantry and the patient, the uncomfortable environment can make the procedure more difficult to perform.

The probability of lung nodules smaller than 8 mm to be malignant has been reported to be 1-2%. Groundglass pulmonary nodules are quite difficult to manage. The risk of malignancy is detected as 10-50% for ground-glass nodules larger than 10 mm and stable in size for 3 months (17). Malignant ground-glass opacity nodules usually show slow progression. Diagnostic accuracy rates of biopsies from ground-glass pulmonary nodules are similar to solid nodules (18). The diagnostic accuracy of CT-guided biopsy procedures applied to ground glass opacity nodules was found to be significantly lower in our study. We think that this is due to the fact that the number of ground-glass opacity nodules is only 8

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and insufficient to interpret. Pneumothorax rate was calculated as 19.8% and pleural drainage tube insertion rate as 4.9% (19-22). No correlation was found in terms of pneumothorax between technical features such as needle angle to pleura, sampling number and lesion characteristics as lesion size, location, lesion type. The presence of emphysema and the distance of the nodule from the pleura were found to be significant factors. There are studies showing that pneumothorax rate can be decreased by injecting the patient's own blood into the tract while withdrawing the coaxial needle (23). This can be explained by the fact that the alveolar structures damaged along the tract are filled with thrombus material and prevent air leakage. There are publications showing that the risk of pneumothorax incidence is lower in patients who develop pulmonary hemorrhage, even if this technique named 'blood patch' is not applied (24, 25). In our study, technically, blood patch was not used, and no statistically significant results were detected in patients with pulmonary hemorrhage in terms of pneumothorax.

In our study, pulmonary hemorrhage occurred in 29.1% of patients and hemoptysis in 12.4%, which is similar to previous studies (26,27). In addition, selective arterial embolization with angiography was required in 2 patients (1.2%). A statistically significant correlation was found between pulmonary hemorrhage and lesion-pleural distance. This can be explained by the increased risk of injury to vascular structures as the tissue thickness passed through the biopsy needle increases. Pulmonary hemorrhage is usually self-limiting. Laying the patient on the side with hemorrhage and transamine injection are among the methods used to limit hemorrhage (28).

In the study performed by Zhang et al., the mean effective radiation dose was calculated as 5.3±1.6 mSv, and the dose-length product (DLP) was 375.3±115.7 mGy.cm in lung biopsy procedures performed with standard protocol in 69 patients (29). In our study, the mean effective radiation dose was 5.26±3.25 mSv, DLP was 435.25±234.88 mGy.cm, and computed tomography dose index (CTDI) was 124.92± 93.24 mGy, which is similar to the literature data. In our study, computed tomography scans were performed in the pre-procedural, procedural and post-procedur-al phases. In order to reduce the radiation dose, the pre-evaluation of the biopsy is very important, and the detection of the lesion localization by methods such as measuring the distance of the lesion to the carina before the procedure may allow scanning of a small volume area and thus reducing the radiation dose. In addition, keeping the slice thickness and the number of slices optimal to the lesion size can be used as another dose reduction method. Although the radiation dose received by the patients is reduced by dose reduction methods, the number of additional scans and the total radiation dose increases in case of complication. In our study, the mean effective dose received by patients with complication was 6.30±3.75 mSv, while 4.45±2.56 mSv in patients without complication ($p<0.001$).

Not including pulmonary nodules less than 10 mm diameter, inability to evaluate possible differences between different biopsy techniques, and the low number of ground-glass nodules are the limitations of the study.

In conclusion, CT-guided PCTTB procedure are a method with a high diagnostic accuracy rate, low rate of complications and can be preferred in all appropriate pulmonary nodules.

Statements:

Ethics Committee Approval: The study was approved by the Ethics Committee of the University of Bolu Abant Izzet Baysal University (Date: 13.7.2021, Decision No: 2021/183).

Informed Consent: Written informed consent was obtained from all participants who participated in this study

Conflict of Interest Statement: The author has no conflicts of interest to declare.

Financial Disclosure: The author declares that this study has received no financial support.

Author Contributions: The author declares that he has participated in the design, execution, and analysis of the article and approved the final version.

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