doi: 10.53446/actamednicomedia.1744179

Acta Medica Nicomedia

Cilt: 9 (2026), 1-6 / Vol: 9 (2026), 1-6
https://dergipark.org.tr/tr/pub/actamednicomedia

Research Article | Araştırma Makalesi

DIAGNOSTIC VALUES OF TRANSTHORACIC FINE-NEEDLE ASPIRATION AND TRANSTHORACIC TRU-CUT BIOPSY IN NON-SMALL-CELL LUNG CANCER

KÜÇÜK HÜCRE DIŞI AKCİĞER KANSERİNDE TRANSTORASİK İNCE İĞNE ASPİRASYONU VE TRANSTORASİK TRU-CUT BİYOPSİSİNİN TANI DEĞERLERİ

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ABSTRACT

Objective: In this study, we aimed to evaluate the clinical feasibility of computed tomography (CT)-guided percutaneous transthoracic needle biopsy (PTNB) by analyzing its sensitivity, specificity, complication rates, and diagnostic utility in the histopathological characterization of thoracic malignancies.

Methods: Data on 864 patients who underwent transthoracic biopsy were analysed retrospectively. After excluding non-operated patients and those with insufficient data, a total of 279 procedures performed on 202 patients were analyzed. Age, gender, smoking status, comorbidity, lesion location, and dimension, needle entry distance, procedure duration, pneumothorax-hemothorax status, and pre- and postoperative pathology parameters were analysed.

Results: When the results of Tru-cut biopsy, fine-needle aspiration biopsy (FNAB), and the groups where both were performed together were compared with post-operative pathology results; the sensitivity and specificity were calculated separately for lung adenocarcinoma, squamous cell lung cancer, lung carcinoid tumor, undiagnosed benign cases, and large cell lung cancer. No significant difference was observed between the groups (p=0.807). Pneumothorax and pulmonary hemorrhage were the most frequently encountered complications. Pneumothorax occurred in 29.2% of patients, while pulmonary hemorrhage was detected in 73.8%.

Conclusion: Transthoracic biopsy remains a valid diagnostic tool today, with its high diagnostic rate, minimal invasiveness, short recovery time, and low complication rates. It will maintain its importance in lung cancer diagnosis until histopathology is obtained with less invasive methods.

Keywords: Lung cancer, computed tomography-guided percutaneous transthoracic needle biopsy, diagnostic values

ÖZ

Amaç: Bu çalışmamızda, bilgisayarlı tomografi kılavuzluğunda perkütan transtorasik iğne biyopsisinin özgüllüğünü, duyarlılığını, komplikasyonlarını, torasik malignitelerdeki histopatolojik tanı değerlerini inceleyerek klinik uygulanabilirliğini değerlendirmeyi amaçladık.

Yöntem: Transtorasik biyopsi uygulanan 864 hastaya ait veriler retrospektif olarak analiz edildi. Ameliyat edilmeyen veya verileri yetersiz olan hastalar dışlandıktan sonra toplam 202 hasta üzerinden 279 işlem analiz edildi. Yaş, cinsiyet, sigara içme durumu, eşlik eden hastalık, lezyon yeri ve boyutu, iğne giriş mesafesi, işlem süresi, pnömotoraks-hemotoraks durumu ve ameliyat öncesi ve sonrası patoloji parametreleri analiz edildi.

Bulgular: Tru-cut biyopsi, ince iğne biyopsisi ve her ikisinin de birlikte yapıldığı grupların sonuçları post operatif patoloji sonuçları ile karşılaştırıldığında; akciğer adeno kanseri, skuamöz hücreli akciğer kanseri, akciğer karsinoid tümörü, tanı konulmamış iyi huylu olgular, büyük hücreli akciğer kanseri için duyarlılıkları ve özgüllükleri ayrı ayrı hesaplanmıştır. Gruplar arasında anlamlı fark izlenmemiştir (p=0,807). Pnömotoraks ve pulmoner hemoraji sıklıkla görülen komplikasyonlardı. Hastaların %29,2'inde pnömotoraks ve %73,8'de pulmoner hemoraji saptanmıştır.

Sonuç: Transtorasik biyopsi, yüksek tanı oranı, minimal invazivliği, kısa iyileşme süresi ve düşük komplikasyon oranları ile günümüzde geçerli bir tanı aracı olmaya devam etmektedir. Daha az invaziv yöntemlerle histopatoloji elde edilene kadar akciğer kanseri tanısında önemini koruyacaktır.

Anahtar Kelimeler: Akciğer kanseri, bilgisayarlı tomografi kılavuzluğunda perkütan transtorasik iğne biyopsisi, tanı değerleri

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Submitted/Başvuru: 17.07.2025 • **Accepted/Kabul:** 02.04.2026 • **Published Online/Online Yayın:** 29.06.2026

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Introduction

Lung cancer is the most common cancer in the world[1], and although there have been positive developments in diagnosis, disease management, and treatment options, it remains the leading cause of cancer related deaths. About 25% of cancer related deaths are due to lung cancer.[2,3] There is a need for rapid and less invasive yet adequate diagnostic methods for this disease.

In light of recent developments in the fields of chemotherapy and immunotherapy, as well as the development of minimally invasive surgical procedures, interest in genetic studies has increased and the importance of rapid and safe diagnostic methods to obtain samples to be used in these studies has increased significantly. Computed tomography-guided percutaneous transthoracic needle biopsy (CT-PTTNB) has become a standard diagnostic modality for lung cancer owing to its high accuracy and reliability, as well as its minimally invasive nature compared with surgical procedures. However, in clinical practice, some physicians refrain from these procedures due to the delay in diagnosis and fear of possible complications. Alternatively, such procedures are performed in large health centers.

The objective of this study was to evaluate the specificity, sensitivity, complications, and management of CT-PTTNB. In addition, the study attempted to evaluate the superiority of two biopsy methods, namely transthoracic cutting needle (tru-cut) biopsies and fine needle aspiration biopsies (FNAB). Finally, the study sought to evaluate the clinical applicability of these biopsy methods by comparing their histopathological diagnostic values in thoracic malignancies.

Methods

The selection of patients and the localisation of lesions

Data on 864 patients who underwent transthoracic biopsy (TTBx) at the Kocaeli University Faculty of Medicine between 2010 and 2020 were analysed retrospectively. Patient information was obtained from the hospital information system, patient files, and the radiological imaging system. The following parameters were analysed: age, gender, smoking status, comorbidity, lesion location, and dimension, needle entry distance, procedure duration, pneumothorax-hemothorax status, and pre- and postoperative pathology parameters. Data from 202 patients were analysed after excluding non-operated patients and those with insufficient data. Patients were divided into three groups based on whether a tru-Cut biopsy, aspiration biopsy, or both were performed. A total of 279 procedures were performed on the 202 patients.

If both a tru-cut biopsy and an aspiration biopsy were performed, the postoperative pathology report was considered the definitive diagnosis if the interpretations differed.

Lesions located in the medial one-third of the hemithorax or associated with the mediastinal pleura were defined as central, while those in other locations were defined as peripheral. Following the biopsy procedure, the appearance of ground-glass, induced by the needle around the lesion, was considered pulmonary haemorrhage. Pulmonary haemorrhages around the lesion were categorised as either absent or minimal when measuring up to 1 cm in diameter; all others were classified as pulmonary haemorrhage.

Process

Bleeding time and hemogram tests were performed on all patients prior to the procedure. Imaging studies (CT and PET-CT) were examined to evaluate the location of the lung lesion and its relationship with vascular structures and organs. All biopsy procedures were performed using a 17-gauge coaxial needle and an 18-gauge Tru Cut gun on a 16-slice CT (Aquilion, Toshiba, Tokyo, Japan). The procedures were most commonly performed in the supine position, but prone or oblique positions were also used, depending on the lesion's location.

The puncture point was marked using CT, and local anesthesia was administered with 2% lidocaine, without crossing the pleura. We evaluated the distance of the needle to the pleura and other organs, as it crosses the pleura after puncture. After reaching the target lesion with the coaxial needle, fine-needle aspiration biopsy, and tru-cut biopsy procedures were performed. During some aspiration biopsy procedures, an "on-site" pathology examination was performed, during which the pathologist determined whether the material was sufficient. Considering the patient's tolerance of the procedure and adequacy of the specimen, at least two biopsy procedures were performed. Specimens obtained with a fine needle were spread on a microscope slide, and specimens obtained with a tru-cut gun were placed in 4% formaldehyde for fixation, and sent to the pathology laboratory. Patients who did not develop complications after the procedure were discharged. Those with complications were hospitalized for observation, and surgical intervention (tube thoracostomy) was performed if necessary.

Statistical Analysis

Statistical evaluation was performed using the IBM SPSS Statistics 20.0 (IBM Corp., Armonk, NY, USA) software package. Compliance with the normal distribution was evaluated using the Kolmogorov–Smirnov test. Numerical variables were presented as the mean ± standard deviation and the median (25th–75th percentile). Categorical variables were expressed as frequencies (percentage). As the normal distribution assumption was not met, the differences between the groups were analysed using Mann–Whitney U and Kruskal–Wallis tests. Dunn's test was used for multiple comparisons. The relationships between categorical variables were evaluated using chi-squared analysis.

When testing two-way hypotheses, $p<0.05$ was considered statistically significant.

Results

The mean age and gender distribution of the patients are shown in Table 1. No significant statistical difference was observed between the biopsy groups in terms of mean age (p=0.242) and gender distribution (p=0.675).
Mean lesion size, mean procedure time, and lesion location are shown in Table 2. No significant statistical difference was observed between the groups in terms of lesion size distribution (p=0.890), central-peripheral distribution (p=0.208), and location (p=0.058), but a significant difference was found in terms of procedure time ($p<0.05$).
Fifty-nine (29.2%) of patients developed pneumothorax, and 149 (73.8%) developed pulmonary haemorrhage after the procedure. No significant statistical difference was observed between the groups in terms of the development of pneumothorax (p=0.204) and pulmonary haemorrhage (p=0.846) (Table 3).

Table 1. Epidemiologic characteristics

	Total (202)		Group 1 Tru-Cut bx.		Group 2 Aspiration bx.		Group 3 Tru-Cut+Aspiration bx.		p value
	Quantity	Percent	Quantity	Percent	Quantity	Percent	Quantity	Percent	
Average age	202	60.4		61.78		59.66		59.71	0.242
Gender									0.675
Male	168	82.20	55	32.70	55	32.70	58	34.50	
Female	34	16.80	14	41.20	10	29.40	10	29.40	

Table 2. Characteristics of lesion size, location and procedure time

	Total (202)		Group 1 Tru-cut bx.		Group 2 Aspiration bx.		Group 3 Tru-Cut + Aspiration bx.	
	Quantity	Percent	Quantity	Percent	Quantity	Percent	Quantity	Percent
Location								
Left upper lobe	54	26.70	19	27.50	16	25	19	27.90
Left lower lobe	28	13.90	11	15.90	8	12.50	9	13.20
Right upper lobe	67	33.20	20	29	19	29.70	28	41.20
Middle lobe	8	4.00	2	2.90	4	6.30	2	2.90
Right lower lobe	40	19.80	17	24.60	17	26.60	6	8.80
Mediastinum	4	2	0	0	0	0	4	5.90
Place of settlement								
Center	12	5.90	7	58.30	3	25	2	16.70
Peripheral	189	93.60	62	32.80	61	32.30	66	34.90
Average processing time			17.93		28.08		19.01	
Average lesion size			36.61		34.31		35.79	

Table 3. Post operative complications and relationship between lesion size and location and pneumothorax

Variable	Total n (%)	Tru-cut n (%)	Aspiration n (%)	Tru-cut + Aspiration n (%)
Pneumothorax present	59 (29.2)	16 (27.1)	24 (40.7)	19 (32.3)
Pneumothorax absent	143 (71)	53 (77)	41 (63)	49 (72.0)
Hemorrhage present	149 (73.8)	49 (32.9)	49 (33.0)	51 (34.2)
Hemorrhage absent	53 (26.2)	20 (37.7)	16 (30.2)	17 (32.1)
Location	**Pneumothorax Yes (n)**		**Pneumothorax No (n)**	
Central	12		11	
Peripheral	57		132	
Size	**Patients (n)**		**Average lesion size (mm)**	
Pneumothorax available	59		31.03	
Pneumothorax not available	143		37.48	

When the relationship among lesion size, location, and postoperative pneumothorax was examined, a significant statistical difference was observed between the decrease in lesion size and the occurrence of postoperative pneumothorax. ($p<0.05$) No significant statistical difference was observed in the relationship between central and peripheral lesions and postoperative pneumothorax ($p=0.186$). (Table-3)

Biopsy types and pathology data are shown in Table 4.

Table 4. Preoperative and postoperative pathology comparisons between groups

Pathology	Total n (%)	Tru-cut n (%)	Aspiration n (%)	Tru-cut + Aspiration n (%)
Pre-op Adeno CA	40 (58.0)	40 (61.5)	40 (58.8)	
Pre-op Squamous cell CA	18 (26.0)	10 (15.0)	16 (23.5)	
Pre-op Carcinoid TM	2 (2.9)	3 (4.6)	3 (4.4)	
Pre-op Undiagnosed benign	8 (11.6)	10 (15.4)	9 (13.2)	
Pre-op Undiagnosed	1 (1.4)	2 (3.0)	0	
Post-op Adeno CA	120	40 (33.3)	40 (33.3)	40 (33.3)
Post-op Squamous cell CA	44	18 (40.9)	10 (22.7)	16 (36.4)
Post-op Carcinoid TM	8	2 (25)	3 (37.5)	3 (37.5)
Post-op Undiagnosed benign	6	1 (16.7)	4 (66.7)	1 (16.7)

Comparison of tru-cut biopsies and post-op pathologies;

When the pathologies diagnosed as lung adeno cancer (Ca) from tru-cut biopsies were compared with the pathologies diagnosed as post-op lung adeno Ca; tru-cut biopsy had a sensitivity of 0.875 95%Confidence Interval(CI) 0.785-0.931 and specificity of 0.964 (95%CI 0.881-0.990) in the diagnosis of adeno Ca, a sensitivity of 0.794 (95%CI 0.632-0.897) and specificity of 1 (95%CI 0.964-1) in the diagnosis of squamous cell ac Ca, a sensitivity of 0.8 (95%CI 0.376-0.964) and specificity of 1 (95%CI 0.972-0.1) in the diagnosis of ac carcinoid tumor, a sensitivity of 1 (95%CI 0.342-1) and specificity of 0.940 (95%CI 0.887-0.970) in the diagnosis of undiagnosed benign cases, The sensitivity was 0.333 (95%CI 0.061-0.792) and the specificity was 0.910 (95%CI 0.850-0.948) in the diagnosis of lung cancer (adeno Ca-squamous cell Ca differentiation) (Not Otherwise Specified (NOS)). The sensitivity was 0.4 (95%CI 0.168-0.687) and the specificity was 0.976 (95%CI 0.933-0.992) in the diagnosis of other tumours and metastases. The sensitivity was 0.5 (95%CI 0.095-0.905) and the specificity was 1 (95%CI 0.972-1) in the diagnosis of large cell lung cancer.

Comparison of aspiration biopsies and postoperative pathologies

When the pathologies of lung adeno CA from aspiration biopsies were compared with the pathologies of post-op lung adeno CA, the sensitivity of aspiration biopsy in the diagnosis of adeno Ca was 0.637 (95%CI 0.528-0.734), and specificity was 0.849 (95%CI 0.729-0.921). The sensitivity in the diagnosis of squamous cell CA was 0.615 (95%CI 0.425-0.776), and specificity was 0.971 (95%CI 0.921-0.990). The sensitivity in the diagnosis of undiagnosed benign lesions was 0.8 (95%CI 0.376-0.964), and the specificity was 0.828 (95%CI 0.753-0.884). Sensitivity 0 (95%CI 0-0.658) and specificity 0.847 (95%CI 0.776-0.899) in the diagnosis of lung CA without subgroup determination, sensitivity 0.1 (95%CI 0.018-0.404) and specificity 0.991 (95%CI 0.955-0.999) in the diagnosis of other tumours and metastases.

A histopathologic diagnosis could not be obtained in 0.99% of the patients who underwent the procedure. When the results of the patients who underwent tru-cut biopsy and aspiration biopsy together were compared with the postoperative pathology results, the sensitivity in diagnosing lung adeno Ca was 0.9 (95%CI 0.769-0.960), and the specificity was 0.964 (95%CI 0.823-0.994).

The sensitivity and specificity for squamous cell Ca were 0.812 (95%CI 0.570-0.934) and 0.980 (95%CI 0.899-0.997); the sensitivity and specificity for carcinoid tumour were 1 (95%CI 0.439-1) and 1 (95%CI 0.944-1), respectively, and the sensitivity and specificity for undiagnosed benign cases were 1 (95%CI 0.207-1) and 0.940 (95%CI 0.856-0.977), respectively. The sensitivity and specificity for the diagnosis of lung CA (adeno-CA-squamous cell CA differentiation,) for which no subgroup determination could be made, were 0 (95%CI 0-0.793) and 0.925 (95%CI 0.837-0.968), respectively. The sensitivity and specificity for the diagnosis of other tumours and metastases were 0.285 (95%CI 0.082-0.641) and 0.983 (95%CI 0.913-0.997), respectively.

No significant statistical difference was observed between the three groups regarding the distribution of postoperative pathology ($p=0.807$).

Discussion

In the present study, patients who underwent tru-cut bx, IIABx, and both procedures were evaluated, and no statistically significant difference was observed. However, the most favourable outcomes were observed in the cohort that underwent both procedures. The most prevalent complications were pneumothorax and pulmonary haemorrhage. It was observed that the risk of pneumothorax increased as the size of the lesion decreased.

CT-PTBI for the diagnosis of lung cancer was first performed in 1976 and has become very popular due to technological advances in tomography and biopsy equipment.[4] CT-PTBI is currently preferred because it is less invasive, safer, and has a shorter recovery time and lower complication rates than excisional biopsies[5]. In addition, its high diagnostic yield, low cost, and ease of reproducibility are among its other superior features.[6] In addition, percutaneous biopsies offer the opportunity for patients to enter surgery with a confirmed diagnosis and expedite the treatment process. In some patients who are not candidates for surgery, percutaneous biopsies help evaluate other treatment options. In our study, the effectiveness and applicability of this type of biopsy were investigated.

FNAB is mostly used for cytologic studies, while tru-cut needle sampling provides samples for histologic studies.[6] Adequate cell counts in aspiration biopsy or tru-cut biopsy samples do not affect the diagnosis, immunohistochemical studies, or genetic analysis.[7] The management algorithm is generally simple due to the low false-positive rate (0-0.2%) of TTAB in diagnosing malignancy. However, the accuracy of TTAB in diagnosing malignancy is limited.[8]

In the study by Yang et al., tru-cut and aspiration biopsies were compared, and although the positive diagnostic rates of aspiration biopsies for malignancies were close to the rates of tru-cut biopsies, there was a significant difference between the two groups in the determination of histologic cell type in favour of tru-cut biopsy.[9] In the study by Wattanasatesiri et al., the success rate of transthoracic needle biopsy for lung lesions was 77%-96% for aspiration biopsy and tru-cut biopsy, respectively.[10] In the study by Yang et al, when aspiration biopsies and tru-cut biopsies were compared with postoperative pathologies, the success rates for malignant tumors were reported to be 59%-97%, the success rates for benign tumors were 33% and 85%, respectively, while tru-cut biopsies had a diagnostic rate of 90% for benign lesions.[10] When aspiration biopsies were evaluated in our study, the specificity and sensitivity of aspiration biopsies were lower than those of tru-cut biopsies for both malignant and benign lesions. However, the best results were seen in patients in whom tru-cut and aspiration biopsies were performed and evaluated together. Especially for malignant lesions, the specificity and sensitivity were found to be very high. In the combined procedures of tru-cut biopsy and aspiration biopsy, the sensitivity for lung adeno Ca was 0.9 and the specificity was 0.964, the sensitivity for squamous cell Ca was 0.812 and the specificity was 0.980 (p=0.807). Although the number of benign lesions in our study was not very high, the diagnosis of benign lesions was as successful as that of malignant lesions. In our study, similar to the literature, the rates of obtaining a correct histopathologic diagnosis between the groups were close, but the specificity-sensitivity rates of the procedures were higher when tru-cut biopsy was performed, or both tru-cut and aspiration biopsy procedures were performed together, than when aspiration biopsy was performed alone (Table 5).

Table 5. Tru-cut and aspiration biopsiescompared with post-operative pathology.

Diagnosis	Tru-cut Specificity	Tru-cut Sensitivity	Aspiration Specificity	Aspiration Sensitivity
Adeno CA	0.964	0.875	0.849	0.637
Squamous cell CA	1.000	0.794	0.971	0.615
Ac carcinoid	1.000	0.800		
Undiagnosed benign tissue	0.940	1.000	0.828	0.800
NOS (sub-group assignment not possible)	0.910	0.333	0.847	0
Other tumors/metastases	0.976	0.400	0.991	0.100
Large cell lung CA	1.000	0.500		

Pneumothorax and pulmonary haemorrhage are the most common complications of TTAB.[10-13] In terms of the overall procedure, the rates of these two most common complications range from 22.2%-28.6% for pneumothorax and 13.4%-23.8% for pulmonary haemorrhage.[14,15] The rate of complications, such as emphysema, is affected by various factors such as lesion size, pleural lesion distance, needle size, number of samples obtained, needle pleural angle, and the experience of the radiologist performing the biopsy.[11] In our study, the pneumothorax rate was 29.2%, and the pulmonary haemorrhage rate was 26.2%, which is similar to that reported in the literature. It is generally reported that the rate of pneumothorax increases as the lesion size decreases.[13] Some studies have reported that lesions smaller than 2 cm require more needle passes to hit the lesion, thus prolonging the procedure time.[16,17] Similarly, in our study, the mean lesion size was 31 mm in patients with pneumothorax and 37 mm in patients without pneumothorax. There was a significant statistical difference between the two groups (p=0.037). When comparing the rates of pulmonary haemorrhage after the procedure, no difference was observed between tru-cut needles and needles used in fine needle aspiration, in terms of the development of pulmonary haemorrhage in recent studies.[6] In the study by Beşir et al, the occurrence rate was 8.8% after aspiration biopsy and 6.3% after tru-cut biopsy.[18] Similarly, no difference was observed between tru-cut and aspiration biopsy needles in terms of pulmonary bleeding in our study (p=0.846).

The limitation of our study was that it was single-centred and retrospective. However, our single location was also an advantage in that the patient results could be monitored from a single source.

In conclusion, transthoracic biopsy remains a valid diagnostic tool today, with its high diagnostic rate, minimal invasiveness, short recovery time, and low complication rates. It will maintain its importance in lung cancer diagnosis until histopathology is obtained with less invasive methods.

Compliance with Ethical Standards

Ethical approval for this study was obtained from the Kocaeli University Non-Interventional Clinical Research Ethics Committee in 2019 (Approval No. KÜ GOKAEK 2019/212).

Conflict of Interest

The authors declare no conflicts of interest.

Author Contributions

MFO, TS; Concept and design, Analysis and interpretation, MFO; Data collection, Manuscript writing, NZC; Critical revision. All authors read and approved the final version of the manuscript.

Financial Disclosure

None.

References

1. Thai AA, Solomon BJ, Sequist LV, et al. Lung cancer. *Lancet*. 2021;398(10299):535-554. doi:10.1016/S0140-6736(21)00312-3.
2. "Worldwide cancer data", World Cancer Research Fund. [Access: 28 June 2020. Access address: https://www.wcrf.org/dietandcancer/cancer-trends/worldwide-cancer-data]
3. Yüksel PDM, Balcı AA. *Göğüs Cerrahisi: Kırmızı Kitap*. Nobel Tıp Kitabevi; 2015.
4. Ahn JH, Jang JG. Initial experience in CT-guided percutaneous transthoracic needle biopsy of lung lesions performed by a pulmonologist. *J Clin Med.* 2019;8(6):821. doi:10.3390/jcm8060821
5. Tongbai T, McDermott S, Kiranantawat N, et al. Non-Diagnostic CT-Guided Percutaneous Needle Biopsy of the Lung: Predictive Factors and Final Diagnoses. *Korean J Radiol*. 2019;20(11):1515-1526. doi:10.3348/kjr.2019.0014.
6. Düzgün F, Tarhan S. Perkütan transtorasik akciğer ve kemik biyopsileri. *Turk Radyoloji Semin.* 2015;3(3):182-191. doi:10.5152/trs.2015.172
7. Küçük Hücreli Dışı Akciğer Kanseri İçin Moleküler Testler Tanı Rehberi. Türk Toraks Derneği; 2018.
8. Schreiber G, McCrory DC. Performance characteristics of different modalities for diagnosis of suspected lung cancer: summary of published evidence. *Chest*. 2003;123(1 Suppl):115S-128S. doi:10.1378/chest.123.1_suppl.115s.
9. Yang PC, Lee YC, Yu CJ, et al. Ultrasonographically guided biopsy of thoracic tumors. A comparison of large-bore cutting biopsy with fine-needle aspiration. *Cancer*. 1992;69(10):2553-60. doi:10.1002/10970142(19920515)69:10<2553::aidcncr2820691027>3.0.co;2-4.
10. Wattanasatesiri T, Puntu W, Vithitsuvanakul N. Influencing factors of pneumothorax and parenchymal haemorrhage after CT-guided transthoracic needle biopsy: single-institution experience. *Pol J Radiol.* 2018;83:e379-e388. doi:10.5114/pjr.2018.79202.
11. Huo YR, Chan MV, Habib AR, et al. Pneumothorax rates in CT-Guided lung biopsies: a comprehensive systematic review and meta-analysis of risk factors. *Br J Radiol*. 2020;93(1108):20190866. doi:10.1259/bjr.20190866.
12. Shiekh Y, Haseeb WA, Feroz I, et al. Evaluation of various patient-, lesion-, and procedure-related factors on the occurrence of pneumothorax as a complication of CT-guided percutaneous transthoracic needle biopsy. *Pol J Radiol.* 2019;84:e73-e79. doi:10.5114/pjr.2019.82837.
13. Leopardi CF, Patil VV. Gelatinous foam needle tract embolization during CT guided percutaneous transthoracic lung biopsy: A practical and cost effective approach in the community hospital setting. *Radiol Case Rep*. 2019;14(6):656-659. doi:10.1016/j.radcr.2019.01.009.
14. Heerink WJ, de Bock GH, de Jonge GJ, et al. Complication rates of CT-guided transthoracic lung biopsy: meta-analysis. *Eur Radiol.* 2017;27(1):138-148. doi:10.1007/s00330-016-4357-8.
15. Jang H, Rho JY, Suh YJ, et al. Asymptomatic systemic air embolism after CT-guided percutaneous transthoracic needle biopsy. *Clin Imaging*. 2019;53:49-57. doi:10.1016/j.clinimag.2018.09.004.
16. Covey AM, Gandhi R, Brody LA, et al. Factors associated with pneumothorax and pneumothorax requiring treatment after percutaneous lung biopsy in 443 consecutive patients. *J Vasc Interv Radiol*. 2004;15(5):479-83. doi:10.1097/01.rvi.0000124951.24134.50.
17. Yeow KM, Su IH, Pan KT, et al. Risk factors of pneumothorax and bleeding: multivariate analysis of 660 CT-guided coaxial cutting needle lung biopsies. *Chest*. 2004;126(3):748-54. doi:10.1378/chest.126.3.748.
18. Beşir FH, Altın R, Kart L, et al. The results of computed tomography guided tru-cut transthoracic biopsy: complications and related risk factors. *Wien Klin Wochenschr*. 2011;123(3-4):79-82. doi:10.1007/s00508-011-1538-y.