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ORIGINAL ARTICLE

Transthoracic Biopsy in the Diagnostic Approach to Mediastinal Masses: Diagnostic Performance, Imaging Guidance and Complication Profile

Mediastinal Kitlelere Tanısal Yaklaşımda Transtorasik Biyopsi: Tanısal Performans, Görüntüleme Rehberliği ve Komplikasyon Profili

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Highlights

- The findings of this study support the clinical utility of transthoracic needle biopsy (TTNB) as a highly effective and safe diagnostic tool in the evaluation of mediastinal lesions.
- Use of CT and USG as guidance tools allowed for safe navigation of the mediastinal anatomy, minimizing procedural complications and enhancing diagnostic accuracy.
- Transthoracic needle biopsy provides a high diagnostic yield with minimal complications when performed with careful patient selection and appropriate technique.

ABSTRACT

Aim: To evaluate the diagnostic efficacy, imaging modalities, and complication rates associated with transthoracic needle biopsy for mediastinal lesions, using either fine-needle aspiration biopsy or core needle biopsy under imaging guidance.
Materials and Methods: A total of 51 patients who underwent transthoracic needle biopsy for mediastinal masses were retrospectively analyzed. Biopsies were performed under Computed Tomography or Ultrasonography guidance, and the samples were evaluated cytologically or histologically.
Results: The diagnostic yield of transthoracic needle biopsy was 86.3% (44/51), with 13.7% (7/51) of procedures being nondiagnostic. The most frequently used needle type was 18G (86.3%). Imaging modalities included Computed Tomography (45.1%) and Ultrasonography (54.9%). Minor complications occurred in two patients: one developed a minor pneumothorax, and another experienced pneumothorax and subcutaneous emphysema. An 18G biopsy needle was used in these patients, and while one of them was performed under ultrasound guidance, the other was performed under Computed Tomography guidance. Pathological diagnoses included thymoma, lymphoma subtypes, metastatic malignancies, and rare benign conditions such as ectopic thyroid tissue and granulomatous inflammation.
Conclusions: Transthoracic tru-cut needle biopsy under imaging guidance is a safe and effective diagnostic approach for mediastinal lesions. Imaging features such as necrosis, contrast enhancement, and heterogeneity allow for optimal biopsy site selection, contributing to high diagnostic accuracy and low complication rates.

Keywords: Complications, diagnosis, image-guided biopsy, mediastinal neoplasms, transthoracic needle biopsy

ÖZ

Amaç: Bu çalışmanın amacı, görüntüleme rehberliğinde ince iğne aspirasyon biyopsisi veya tru-cut iğne biyopsisi kullanılarak gerçekleştirilen transtorasik iğne biyopsisinin mediastinal lezyonlardaki tanısal etkinliğini, kullanılan görüntüleme yöntemlerini ve işlemle ilişkili komplikasyon oranlarını değerlendirmektir.
Gereç ve Yöntemler: Mediastinal kitleler nedeniyle transtorasik iğne biyopsisi uygulanan toplam 51 hasta retrospektif olarak incelendi. Biyopsiler Bilgisayarlı Tomografi veya Ultrasonografi rehberliğinde gerçekleştirildi ve elde edilen örnekler sitolojik veya histolojik yöntemlerle değerlendirildi.
Bulgular: Transtorasik iğne biyopsisinin tanısal verimi %86,3 (44/51) olup, %13,7'si (7/51) tanısal değere ulaşmadı. En sık kullanılan iğne tipi 18G idi (%86,3). Görüntüleme rehberliği açısından işlemlerin %45,1'i BT, %54,9'u ise USG eşliğinde uygulandı. İki hastada minör komplikasyon gelişti; birinde minör pnömotoraks, diğerinde ise pnömotoraks ve subkütan amfizem birlikte izlendi. Bu olguların her ikisinde de 18G iğne kullanılmış olup biri Ultrasonografi, diğeri Bilgisayarlı Tomografi eşliğinde biyopsilerdi. Patolojik tanılar arasında timoma, lenfoma alt tipleri ve metastatik malignitelerin yanı sıra ektopik tiroid dokusu ve granülomatöz inflamasyon gibi nadir benign lezyonlar yer aldı.
Sonuçlar: Görüntüleme rehberliğinde yapılan transtorasik tru-cut iğne biyopsisi, mediastinal lezyonların değerlendirilmesinde yüksek tanısal doğruluk ve düşük komplikasyon oranları sunan güvenilir, etkili ve minimal invaziv bir tanı yöntemi gibi görünmektedir. Nekroz, kontrast tutulumu ve heterojenite gibi görüntüleme özelliklerinin dikkate alınması, biyopsi için en uygun bölgenin seçilmesine olanak sağlayarak işlem başarısını artırmaktadır.

Anahtar Kelimeler: Görüntüleme rehberliğinde biyopsi, komplikasyonlar, mediastinal neoplazmlar, tanı, transtorasik iğne biyopsisi

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Introduction

Mediastinal masses represent a diagnostically challenging group of lesions due to their heterogeneous etiology, varying from benign inflammatory conditions to aggressive malignancies. An accurate and timely diagnosis is essential not only for establishing the nature of the lesion but also for determining the optimal therapeutic strategy, which may include surgery, chemotherapy, or radiotherapy. Traditionally, surgical procedures such as mediastinoscopy and thoracotomy were considered the gold standard for obtaining diagnostic tissue samples. However, these approaches are invasive, costly, and associated with significant morbidity. As a result, image-guided percutaneous biopsy techniques have emerged as less invasive yet highly effective alternatives [1].

Transthoracic needle biopsy (TTNB), guided by imaging modalities such as Computed Tomography (CT) or ultrasound (US), allows for the sampling of mediastinal lesions with high precision. This technique can be performed using fine-needle aspiration biopsy (FNAB) to obtain cytological samples or core needle biopsy (CNB) to obtain tissue cores for histopathological evaluation. Core biopsies, in particular, provide architectural detail necessary for the diagnosis of lymphomas, thymic tumors, and metastatic lesions, which are common in the mediastinum [2, 3].

One of the key advantages of CT-guided TTNB lies in its ability to guide the biopsy needle to the most viable and diagnostic area of the lesion. By assessing radiological features such as contrast enhancement, necrotic regions, and internal heterogeneity, interventional radiologists can select optimal entry points and avoid necrotic or non-diagnostic areas. This imaging-based targeting significantly improves diagnostic yield and reduces the rate of repeat procedures [4-6].

The safety of TTNB has also been well-documented. While complications such as pneumothorax, hemoptysis, and subcutaneous emphysema can occur, their overall incidence remains low, especially when the procedure is performed by experienced hands under real-time imaging guidance. Moreover, the prompt identification and management of complications such as pneumothorax is facilitated when CT is used during and after the procedure [7-10].

In addition to its safety and accuracy, TTNB offers logistical advantages. It can often be performed on an outpatient basis, with minimal recovery time, making it a patient-friendly alternative to surgical interventions. Furthermore, the evolution of coaxial needle systems and improved imaging technology have made it possible to access even deep-seated or anatomically complex lesions within the mediastinum [11, 12].

Despite these advancements, challenges remain. Factors such as lesion size, depth, needle gauge, and the presence of comorbid pulmonary disease may influence both diagnostic yield and the risk of complications. Several studies have identified lesion characteristics and patient-related variables as significant predictors of post-biopsy complications such as pneumothorax and hemorrhage, particularly in CT-guided procedures [13, 14]. Understanding these factors is crucial for optimizing procedural planning and improving outcomes.

In this study, we aimed to retrospectively assess the diagnostic efficacy, complication rates, and clinical outcomes of transthoracic needle biopsy in patients with mediastinal lesions. We also sought to evaluate the role of imaging guidance in improving procedural accuracy and minimizing risk.

Materials and Methods

Study Design and Patient Selection

This retrospective study included 51 patients who underwent transthoracic needle biopsy for mediastinal lesions between January 2020 and December 2024 at a single tertiary care center. The study was approved by the institutional review board, and informed consent was obtained from all patients prior in order to the procedure. This study was approved by the Ethics Committee of the tertiary healthcare center on April 17, 2025 (Approval No: 2025-03/52).

Inclusion Criteria

• Patients aged ≥18 years

• Presence of a mediastinal mass detected on cross-sectional imaging (CT or US)

• Underwent image-guided transthoracic fine-needle aspiration biopsy or core needle biopsy

• Adequate clinical and pathological follow-up data available

Exclusion Criteria

• Patients with incomplete medical or pathology records

• Biopsies performed via other approaches (e.g., endobronchial, surgical)

• Severe coagulopathy or uncorrected bleeding disorders at the time of biopsy

• Lesions inaccessible via transthoracic route due to anatomic constraints

Biopsy Procedure

All biopsy procedures were performed under the guidance of either CT or US, depending on the lesion's location and accessibility. Parasternal approach was utilized for anterior mediastinal masses, while the paravertebral approach was preferred for posteriorly located masses. Needle selection (18G, 16G, or FNAB) was based on lesion characteristics and clinical indications. CT-guided procedures were conducted using a multislice CT scanner, with post-procedure scans obtained to assess for immediate complications such as pneumothorax or hemorrhage.

Data Collection

Patient demographics (age, sex), imaging modality used for biopsy (CT or US), type of biopsy needle, and

biopsy outcome (diagnostic vs. non-diagnostic) were recorded. Complications were categorized based on clinical and radiological findings immediately post-biopsy. Histopathological diagnoses were confirmed by an experienced pathologist.

Statistical Analysis

Statistical analyses were conducted using SPSS version 27.0 (IBM Corp., Armonk, NY, USA). Descriptive data were reported as mean ± standard deviation (SD) for normally distributed continuous variables, and as median with interquartile range (IQR: 25th–75th percentile) for non-normally distributed variables. Categorical variables were presented as frequencies and percentages. The Kolmogorov-Smirnov test was used to assess the normality of numerical data. A p value of <0.05 was considered statistically significant.

Results

A total of 51 patients who underwent transthoracic needle biopsy for mediastinal lesions were comprised in the study. The mean age of the patients was 48.5 ± 17.9 years. Of the total cohort, 29 patients (59.9%) were female and 22 (40.1%) were male.

47 of the 51 patients underwent core biopsy, while four of them underwent a fine needle aspiration biopsy. The majority of procedures were performed using an 18G core needle in 44 patients (86.3%), whereas 5.9% utilized a 16G needle and 7.8% were performed using fine-needle aspiration biopsy (Table 1).

Biopsies were conducted under imaging guidance, with ultrasound used in 28 cases (54.9%) and CT in 23 cases (45.1%) (Figure 1).

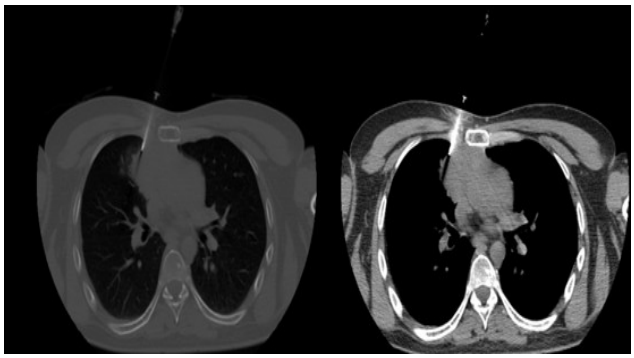

Figure 1: A CT-guided biopsy sample of a 45-year-old male patient's anterior mediastinal mass is shown. (arrow) The pathological diagnosis was Hodgkin Lymphoma.

The diagnostic yield of the procedure was 86.3% (n=44), while 13.7% (n=7) of biopsies were classified as nondiagnostic. In all 4 patients who underwent fine needle aspiration biopsy, the pathology result was stated as nondiagnostic (blood products). The diagnostic efficiency of the procedure was 93.6% (44/47) in patients who underwent core biopsy. A total of 47 patients underwent tru-cut biopsy, of which 23 were performed under CT guidance and 24 under ultrasonography guidance. CT-guided biopsies yielded in 22 diagnostic samples (95.7%), whereas US-guided biopsies yielded 22 diagnostic samples (91.7%). Although CT guidance demonstrated a numerically higher diagnostic success rate than US guidance, there was no statistically significant difference between the diagnostic rates of biopsies performed under CT and US guidance. (p>0.05)

Among the 47 patients who underwent core needle biopsy, an 18G needle was utilized in 44 procedures, yielding diagnostic samples in 41 cases (93.2%). A 16G needle was utilized in three procedures, all of which yielded diagnostic outcomes (100%). Although the diagnostic yield was numerically higher with the 16G needle, Fisher's exact test demonstrated that this difference was not statistically significant (p = 1.00). The absence of non-diagnostic samples in the 16G group and the small sample size likely limited the ability to detect a meaningful statistical difference.

Complications were observed in two patients (3.9%). A minor pneumothorax occurred in a 54-year-old female patient who was later diagnosed with small cell lung carcinoma. Another case, a 53-year-old woman diagnosed with thymoma, developed pneumothorax accompanied by subcutaneous emphysema (Table 1). 18G core biopsy needle was used in these two patients. No complications developed in patients who underwent fine needle aspiration biopsy or core biopsy using a 16G needle. In patients who developed complications, one biopsy was performed under ultrasound guidance, while the other biopsy was performed under computed tomography guidance.

Table 1: Age, gender, and data about biopsy procedures (n=51)

Age (mean±SD)	48.5±17.9
Gender (n/%)	
Female	29 (56.9)
Male	22 (43.1)
Imaging modality (n/%)	
USG	28 (54.9)
CT	23 (45.1)
Nondiagnostic/Diagnostic procedure (n/%)	
Nondiagnostic	7 (13.7)
Diagnostic	44 (86.3)
The needle used for biopsy (n/%)	
18G	44 (86.3)
16G	3 (5.9)
FNAB	4 (7.8)
Complication (n/%)	2 (3.9)
Minor pneumothorax	1 (1.9)
Pneumothorax and subcutaneous emphysema	1 (1.9)

Regarding clinical background, 26 patients (51.0%) had no known primary diagnosis prior to biopsy. Among those with known malignancies, primary diagnoses included breast cancer (9.8%), Hodgkin lymphoma (9.8%), diffuse large B-cell lymphoma (7.8%), and other rare malignancies such as nasopharyngeal carcinoma, follicular thyroid carcinoma metastasis, and osteosarcoma.

Histopathological evaluation of biopsy material revealed a wide spectrum of diagnoses. The most common findings included diffuse large B-cell lymphoma (13.7%), thymoma (11.8%) and Hodgkin lymphoma (9.8%). Other identified pathologies

included breast cancer metastasis, small cell lung carcinoma, neuroendocrine tumors, germ cell tumors, and rare benign conditions such as ectopic thyroid tissue and granulomatous inflammation (Table 2).

Table 2: Primary and pathologic diagnoses of patients (n=51)

Primary diagnosis (n/%)	
No primary diagnosis	26 (51.0)
Breast cancer	5 (9.8)
Hodgkin lymphoma	5 (9.8)
Diffuse Large B-cell lymphoma	4 (7.8)
Skin squamous cell carcinoma	1 (2.0)
Follicular thyroid carcinoma metastasis	1 (2.0)
Small cell lung carcinoma	1 (2.0)
Gastric metastasis	1 (2.0)
Multiple myeloma	1 (2.0)
Nasopharynx carcinoma	1 (2.0)
Osteosarcoma	1 (2.0)
Pancreas adenocarcinoma	1 (2.0)
Renal cell carcinoma	1 (2.0)
Primary refractory mediastinal B-cell lymphoma	1 (2.0)
T-Acute lymphoid leukemia	1 (2.0)
Pathological diagnosis of biopsy (n/%)	
Diffuse Large B-cell lymphoma	7 (13.7)
Thymoma	6 (11.8)
Hodgkin lymphoma	5 (9.8)
Breast cancer metastasis	4 (7.8)
Blood elements	4 (7.8)
Squamous cell carcinoma	3 (5.9)
T-Acute lymphoid leukemia	3 (5.9)
Small cell lung carcinoma	2 (3.9)
Neuroendocrine tumor	2 (3.9)
High-grade B-cell lymphoma	2 (3.9)
Fibrotic tissue	2 (3.9)
Adenocarcinoma metastasis	1 (2.0)
Germ cell tumor	1 (2.0)
Langerhans cell histiocytosis	1 (2.0)
Mixoid pleomorphic liposarcoma	1 (2.0)
Multiple myeloma	1 (2.0)
Renal cell carcinoma metastasis	1 (2.0)
Osteosarcoma metastasis	1 (2.0)
Ectopic thyroid tissue	1 (2.0)
Fibroadipose tissue	1 (2.0)
Granulomatous lymphadenitis	1 (2.0)
Casefying granulomatous inflammation	1 (2.0)

These results confirm that transthoracic core biopsy under imaging guidance provides a high diagnostic yield with a low rate of complications in patients with mediastinal masses.

Discussion

The findings of this study support the clinical utility of TTNB as a highly effective and safe diagnostic tool in the evaluation of mediastinal lesions. With a diagnostic yield of 86.3% and a low complication rate of 3.9%, our results are consistent with prior studies that have reported similarly high diagnostic success rates using image-guided biopsy techniques [2-3]. When only core biopsies are considered, the diagnostic yield increases to 93.6%, highlighting the importance of core tissue sampling in mediastinal mass evaluation. Although the diagnostic rate was 100% in biopsies performed with a 16G needle, no significant difference was found in terms of diagnostic accuracy between 16G and 18G needles due to the small number of patients in this group.

Given the limited diagnostic value of FNAB in this region, core biopsy appears to be the preferred initial approach. The ability to obtain histological architecture through core needle biopsy makes this approach invaluable in distinguishing lymphoproliferative disorders, metastatic disease, and primary mediastinal tumors.

The predominance of diffuse large B-cell lymphoma and thymoma in our pathological diagnoses aligns with the known epidemiological distribution of mediastinal masses in adults [15]. Furthermore, the use of CT and USG as guidance tools allowed for safe navigation of the mediastinal anatomy, minimizing procedural complications and enhancing diagnostic accuracy. The visualization of necrotic zones, heterogeneous components, and vascular structures prior to needle insertion is critical in avoiding non-viable tissue and optimizing sample adequacy [12].

Complication rates in our study remained low, with only two patients developing minor adverse events — a finding that reflects the improved safety of TTNB in experienced hands, particularly when supported by real-time imaging and meticulous technique [5,8]. Although parasternal and paravertebral approaches were preferred in our study, possible transpleural approaches may potentially be the cause of complications [16]. Lesion size and proximity to vital structures tend to be known contributors to complication risk, and careful patient selection was instrumental in reducing these risks in our cohort [13,14].

The small proportion of non-diagnostic samples (13.7%) may be due to the type of needle used in the biopsy, as well as necrotic tissue sampling or technically difficult lesion locations; these issues have been similarly emphasized in previous publications [17].

In our series, USG guidance was used slightly more frequently than CT, likely due to its portability and lack of ionizing radiation, especially in superficially located anterior mediastinal lesions. However, CT guidance offered superior spatial resolution and allowed post-procedural monitoring, particularly valuable in the early detection of pneumothorax or bleeding [18]. Early diagnosis of potential postbiopsy complications through CT scanning contributes to their resolution.

A particular strength of this study is the wide range of histopathological diagnoses obtained, demonstrating the versatility of TTNB in guiding treatment decisions across diverse clinical contexts—from hematological malignancies to metastatic disease and rare benign entities [19]. These results

emphasize the value of interdisciplinary collaboration among radiologists, pathologists, and oncologists in optimizing diagnostic performance.

However, several limitations must be acknowledged. The retrospective, single-center design may limit generalizability. The sample size is sufficient for primary outcomes, but limits subgroup analyses, particularly regarding predictors of complications and diagnostic yield by needle type or imaging modality used. Selection bias is also possible, as patients with inaccessible or high-risk lesions were excluded, potentially underestimating complication rates. Furthermore, incomplete follow-up in some nondiagnostic cases limited assessment of false-negative rates.

Conclusion

Ultimately, transthoracic core needle biopsy under imaging guidance appears to be a safe and reliable, effective, and minimally invasive diagnostic modality for mediastinal lesions. It provides a high diagnostic yield with minimal complications when performed with careful patient selection and appropriate technique. Integration of imaging characteristics into procedural planning enhances biopsy accuracy and improves clinical outcomes. Despite certain limitations, our findings further support the growing role of TTNB as a first-line diagnostic tool in the management of mediastinal masses.

Conflict of Interest

The authors declare no conflict of interest related to this study.

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Ethical Approval

This study was approved by the Ethics Committee of the tertiary healthcare center on April 17, 2025 (Approval No: 2025-03/52). All procedures performed in this study involving human participants were conducted in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments.

Informed Consent

Informed consent was obtained from all individual participants included in the study.

Author Contributions

All authors contributed equally to the study's conception, design, data collection, analysis, and manuscript preparation. All authors reviewed and approved the final version of the manuscript.

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References

1. Gupta S, Seaberg K, Wallace MJ, Madoff DC, Morello FA, Ahrar K, et al. Imaging-guided percutaneous biopsy of mediastinal lesions: different approaches and anatomic considerations. Radiographics. 2005;25(3):763–86.

2. Petranovic M, Gilman MD, Muniappan A, Hunsaker A, Halpern EF, Shepard JO, et al. Diagnostic yield of CT-guided percutaneous transthoracic needle biopsy for diagnosis of anterior mediastinal masses. AJR Am J Roentgenol. 2015;205(4):774–9.

3. Cesar DN, Torres US, D'Ippolito G, Souza AS. CT-guided transthoracic core-needle biopsies of mediastinal and lung lesions in 235 consecutive patients: factors affecting the risks of complications and occurrence of a final diagnosis of malignancy. Arch Bronconeumol (Engl Ed). 2019;55(6):297–305.

4. Zhang HF, Zeng XT, Xing F, Fan N, Liao MY. Diagnostic accuracy of CT-guided percutaneous core needle biopsy and fine needle aspiration in pulmonary lesions: a meta-analysis. Clin Radiol. 2016;71(1):e1–10.

5. Yeow KM, Su IH, Pan KT, Tsay PK, Lui KW, Cheung YC, 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.

6. Harter LP, Moss AA, Goldberg HI, Gross BH. CT-guided fine-needle aspirations for diagnosis of benign and malignant disease. AJR Am J Roentgenol. 1983;140(2):363–7.

7. Chami HA, Faraj W, Yehia ZA, Raphael M, El-Yazbeck A, El-Merhi F, et al. Predictors of pneumothorax after CT-guided transthoracic needle lung biopsy: the role of quantitative CT. Clin Radiol. 2015;70(12):1382–7.

8. Yamagami T, Nakamura T, Iida S, Kato T, Nishimura T. Management of pneumothorax after percutaneous CT-guided lung biopsy. Chest. 2002;121(4):1159–64.

9. Gohari A, Haramati LB. Complications of CT scan-guided lung biopsy: lesion size and depth matter. Chest. 2004;126(3):666–8.

10. Korkmaz B, Şara Hİ, Bakdık S. Relationship between different techniques and complications in CT-guided transthoracic lung biopsies: a single-centre comprehensive analysis CT-guided lung biopsy: techniques and associated complications. Pol J Radiol. 2025;90:e505-e518.

11. Westcott JL. Percutaneous transthoracic needle biopsy. Radiology. 1988;169(3):593–601.

12. Khan MF, Straub R, Moghaddam SR, Thalhammer A, Haddad M, Pache G, et al. Variables affecting the risk of pneumothorax and intrapulmonal hemorrhage in CT-guided transthoracic biopsy. Eur Radiol. 2008;18(7):1356–63.

13. Topal U, Berkman YM. Effect of needle tract bleeding on occurrence of pneumothorax after transthoracic needle biopsy. Eur J Radiol. 2005;53(3):495–9.

14. Greif J, Staroselsky AN, Gernjac M, Yigla M, Schneebaum S, Shapira Y, et al. Percutaneous core needle biopsy in the diagnosis of mediastinal tumors. Lung Cancer. 1999;25(3):169–73.

15. Priola AM, Priola SM, Cataldi A, Marci V, Lunghezza F, Fava C, et al. Accuracy of CT-guided transthoracic needle biopsy of lung lesions: factors affecting diagnostic yield. Radiol Med. 2007;112(8):1142–9.

16. Navin PJ, Eickstaedt NL, Atwell TD, Young JR, Eiken PW, Welch BT, et al. Safety and efficacy of percutaneous image-guided mediastinal mass core-needle biopsy. Mayo Clin Proc: Innovat Qual Outcomes 2021;5:1100–8.

17. Tsukada H, Satou T, Iwashima A, Souma T. Diagnostic accuracy of CT-guided automated needle biopsy of lung nodules. AJR Am J Roentgenol. 2000;175(1):239–43.

18. Weisbrod GL. Percutaneous fine-needle aspiration biopsy of the mediastinum. Clin Chest Med. 1987;8(1):27–41.

19. Linder J, Olsen GA, Johnston WW. Fine-needle aspiration biopsy of the mediastinum. Am J Med. 1986;81(6):1005–8.