Original Article

# Complications of pneumothorax in computed tomography-guided transthoracic needle biopsy and prognostic factors: study on patients with tumor-like lung lesions

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**Background:** Transthoracic biopsy has proven to be an effective procedure, especially for peripheral lung lesions, in obtaining samples that can definitively diagnose the underlying pathology. Despite its effectiveness, studies have demonstrated that it is associated with complications such as pneumothorax and hemoptysis. This study aims to evaluate the incidence of these complications and identify prognostic factors in patients who underwent a transthoracic biopsy.

**Methods:** This retrospective cohort analysis included adults from Thu Duc City Hospital, a sub-urban hospital who underwent transthoracic biopsy from 2017 to 2022. Complications that were evaluated included pneumothorax and hemoptysis. Separate logistic regression models estimated the association of pneumothorax or hemoptysis and selected baseline patient demographic and clinical characteristics.

**Results:** Among 221 patients who underwent transthoracic biopsy, 27.6% experienced pneumothorax complications, 19.9% had hemoptysis, and 5.4% had both. No air embolism was recorded. Most of the complications were mild and limited with medical management. Among patients who experienced pneumothorax, 6.6% (4/61) required chest tube drainage. Biopsy in tumors with a distance from chest wall to tumor edge of more than 20 mm and skin to tumor edge of more than 40 mm was associated with a higher risk of pneumothorax complication. Using the area under the receiver operating characteristic (AUROC) curve, a threshold of 23 mm for chest wall to tumor edge and 39.4 mm for skin to tumor edge could help predict pneumothorax with significant sensitivities and specificities.

**Conclusions:** This retrospective study demonstrated that approximately half of patients undergoing thoracic biopsy experienced complications. It was suggested that pneumothorax could be predicted by measuring the distance from the tumor edge to the chest wall and the skin to have better preoperation preparation and potentially mitigate the issue.

**Keywords:** Lung tumors; transthoracic biopsy; complications; risk factors; pneumothorax

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## Introduction

Lung cancer is among the leading causes of global cancer-related deaths (1). Lung cancer is on the rise in Vietnam; however, the majority of cases are detected in advanced stages, resulting in a significant fatality rate (2,3). Early detection and treatment of lung cancer are crucial as they dramatically decrease the associated mortality. However, in the context of the lungs, a lung tumor might present itself in many manifestations. Currently, there have been records of more than 80 different types of lung lesions. These include benign tumors, bronchial cancer, and metastatic cancer spreading from other parts of the body (4).

There are many methods of diagnosing tumor-like lesions, ranging from outdated methods such as sputum cell examination to invasive approaches such as biopsy via bronchoscopy or oesophageal endoscopy, transthoracic biopsy, or even surgical approach via mediastinoscopy and diagnostic thoracotomy (5). The selection of methods depends on the tumor's location, size, and the medical equipment accessible at the local facilities. Bronchoscopy is typically a safe and preferred procedure, particularly for malignancies located in the central regions. Nevertheless, transthoracic biopsy is a feasible alternative for tumors located at a distance from the central areas or those that are not observable by bronchoscopy (6,7). Transthoracic biopsy, also known as transthoracic sampling or transthoracic needle biopsy, has always been considered a relatively safe approach and has high diagnostic capability (8). Transthoracic biopsies would provide a tissue sample of adequate size that is appropriate for pathological diagnosis. These larger tissue samples, as opposed to those acquired using bronchoscopy, would improve the accuracy and precision of the diagnosis (52–91%) (9,10).

However, this technique would still encounter some complications, such as pneumothorax (26%) and hemorrhage (10%) (11). Pneumothorax is widely reported as the most common complication of transthoracic biopsy. This complication previously is diagnosed using a chest X-ray, but chest CT will be used in some undetermined cases and serves as the gold standard to detect even a small amount of air in the pleural space. In one study, the average time it takes for a pleural drain to complete in 33 patients with pneumothorax from complications of transthoracic biopsy is 3.8 days (1–9 days across all patients) (12).

At the Department of Internal Medicine, Thu Duc City Hospital, bronchoscopy must be the first diagnostic technique performed if there is a possibility of lung tumors. In situations where patients are unable to receive a histopathological diagnosis because no tumor is visible or the biopsy results are negative, it may be considered necessary to perform a transthoracic lung tumor biopsy using a coaxial needle. This decision would be made after carefully evaluating the indications and consultation with experts in challenging cases.

Despite the procedures being initiated and carried out for the past five years, the rates of local problems still need to be discovered. This study attempts to determine the incidence of complications such as pneumothorax, hemoptysis, and air embolism and identify potential predictors of these complications. We present this article in accordance with the STARD reporting checklist (available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-955/rc).

### Highlight box

**Key findings**

- Among 221 patients who underwent transthoracic biopsy, 27.6% experienced pneumothorax complications, 19.9% had hemoptysis, and 5.4% had both.
- Biopsy in tumors with a distance from chest wall to tumor edge of more than 20 mm and skin to tumor edge of more than 40 mm was associated with a higher risk of pneumothorax complication.
- Using the area under the receiver operating characteristic (AUROC) curve, a threshold of 23 mm for chest wall to tumor edge and 39.4 mm for skin to tumor edge could help predict pneumothorax with significant sensitivities and specificities.

**What is known and what is new?**

- Pneumothorax and hemoptysis are common complications in transthoracic biopsy.
- Tumors with diameter less than 2 cm are associated with increased risk of pneumothorax.
- A threshold of 23 mm for chest wall to tumor edge and 39.4 mm for skin to tumor edge could help predict pneumothorax complications.

**What is the implication, and what should change now?**

- Tumors with a diameter less than 2 cm, a chest wall-tumor edge more than 23 mm, and a skin-tumor edge more than 39.4 mm should be cautiously approach when performing transthoracic biopsy to mitigate the pneumothorax complications.

## Methods

### *Study population*

The study was conducted in accordance with the

Declaration of Helsinki (as revised in 2013). The study was approved by the Ethics Committee of Thu Duc City Hospital (No. 1455/QD-BV) and individual consent for this retrospective analysis was waived due to the retrospective nature of the study. We conducted a retrospective cohort study on 221 patients with tumor-like lung lesions admitted to the Department of Internal Medicine, Thu Duc City Hospital, Ho Chi Minh City, Vietnam, from January 1st, 2017, to December 30th, 2022. Thu Duc City Hospital is a suburban hospital with a capacity of 600 beds.

### *Inclusion criteria*

- ❖ Patients who were diagnosed with tumor-like lung lesions and pleural tumors via computed tomography (CT) scan and were unable to be diagnosed with other histology methods like bronchoscopy, transbronchial aspiration, cell study of bronchial lavage fluid.
- ❖ Patients who underwent transthoracic biopsy and consent to the procedure.

### *Exclusion criteria*

- ❖ Patients with coagulopathy, specifically patients with a platelet count less than 50 G/L or prothrombin rate less than 50%.
- ❖ The lesions had a high-risk possibility of angioma.
- ❖ The patient had emphysema or air bubble at the needle insertion site.
- ❖ The patients had uncontrolled coughing.
- ❖ The patients had undergone pneumonectomy in the opposite lung.
- ❖ The patients suffered from severe heart failure, arrhythmia, severe respiratory failure, hemodynamic instability, or assisted mechanical ventilation.
- ❖ The patients cannot cooperate with doctors.
- ❖ Patients with obstructive lung disease with a forced expiratory volume in 1 second (FEV1) less than 1 liter.
- ❖ Patients who cannot lie down.

### *Term definitions*

- ❖ Tumor center-chest wall distance: the distance from the chest wall to the center of the tumor (at the section where the tumor is at largest size).
- ❖ Tumor-chest wall distance: the distance from the chest wall to the edge of the tumor (at the section where the tumor is at largest size).
- ❖ Tumor-skin distance: the distance from the tumor edge to the skin (at the section where the tumor is at the largest size).
- ❖ Criteria for malignant diagnosis: sufficient evidence from histopathology to confirm cancer.
- ❖ Diagnosis criteria for benign: (I) tuberculosis is confirmed through histology, which shows evidence of a positive response to tuberculosis treatment; (II) indications of benign progression: lesions spontaneously resolve with specific therapies that are not cancer-associated; and (III) evidence from the histology report following the surgical procedure.

### *Study procedure*

All the patients were retrospectively collected as a convenience series. Patients who fulfilled the inclusion criteria and had no exclusion criteria underwent standard diagnostic procedures. In our institution, these criteria were based on the ATS guideline on transthoracic needle biopsy (13). All the patients had a first chest CT to facilitate tumor visualization and localization and determine the best route for bronchoscopy. All the measurements in the "Term definitions" section were done in this CT by radiologists. Bronchoscopy was the primary procedure for all patients. All patients with pulmonary tumor lesions on CT will be indicated for bronchoscopy. Bronchoscopic biopsy procedures include intrabronchial biopsy if tumors are seen, or blind transbronchial biopsy. After bronchoscopy, if no visible lesions that can be biopsied, no sample were collected, or the pathological results after biopsy are not consistent with the clinical presentation, we will conduct a consultation for the indication for transthoracic needle biopsy. The patients and their family received a detailed explanation of the transthoracic biopsy procedure, as well as the potential complications that may happen, such as pneumothorax, chest tube drainage if needed, hemorrhage, hemoptysis, and air embolism. Subsequently, the patients were requested to provide their signature on a written consent form, reaffirming their well-informed decision regarding the procedure. From this, we retrospectively review 221 patients in this study. CT scan was used to assist in performing all the biopsies and to determine post-op complications, such as pneumothorax, which was also confirmed by radiologists (detailed below).

CT-guided transthoracic needle biopsy procedure (14,15):

- ❖ All biopsies were performed by using our 32-slide


**Figure 1** Semi-automatic biopsy needle with coaxial (GSN1815/GSN2015, Geotek Medical, Ankara, Turkey).

conventional CT machine (Siemens, Erlangen, Germany). Operators (T.B.N. and T.N.A.T.) were both qualified for the procedures. To enable the shortest path for lung biopsy, patients were positioned either prone or supine, depending on the location of the lesion. CT images were acquired from the apex of the lungs to the diaphragm in order to identify the pulmonary lesion at the end of inspiration. The center of the lesion was determined at the CT landmark by placement of a radiopaque skin grid onto the patient's skin. A second set of CT images were acquired, and the location of the puncture point was identified by measuring the distance between the skin surface and the pleura, the length of the needle path, and the minimum angle formed by the vertical line and the needle. Routine disinfection and draping was carried out after marking the body surface puncture site, with the puncture site positioned at the center. Subsequently, the chest wall was anesthetized layer by layer using 2% lidocaine. After local anesthesia, all biopsies were performed with an 18- or 20-gauge semi-automatic biopsy needle with coaxial (GSN1815/GSN2015, Geotek Medical, Ankara, Turkey; *Figure 1*). An initial puncture was done without piercing the pleura. After this, CT scans were acquired to locate the exact position of the biopsy needle tip, and biopsies were performed while trying to avoid piercing the ribs, bullae, blood vessels, and fissures. If the lesion was located along the extended path of the needle track, the biopsy procedure was continued; otherwise, the site of puncture point was changed. Prior to rapidly advancing the needle towards the identified lesion, the patient was instructed to hold the breath. Subsequently, a CT scan was done immediately to verify that the needle tip has successfully reached the intended lesion. Then, sampling using the aforementioned semi-automatic biopsy gun was performed. Because our institution were a sub-urban hospital, we did not have Rapid Onsite Evaluation (ROSE) available in our institution, so around 4 to 8 tissue cores were obtained during the biopsy to facilitate further histopathologic diagnosis, molecular and immunohistochemistry analyses. Specimens were immediately immersed in 10% formalin solution and were sent to the pathologist for examination. Routine CT scan was performed right after the procedure to promptly identify any possible complications, such as pneumothorax, hemothorax...

### *Statistical analysis*

The data is imported and processed using the STATA 14.0 software, with descriptive statistics for the patients' baseline characteristics. The chi-squared test was used to determine related factors of pneumothorax complications, with statistical significance $P<0.05$.

We evaluate the prognosis threshold of pneumothorax complications via the measurement of tumors in patients and distances relative to tumors with the help of the ROC model with sensitivity and specificity as variables. The ROC model got the corresponding coordinates on the horizontal axis as the rate of false positives in the test, the vertical axis as the test sensitivity, and the area under the ROC curve (AUROC curve). The more the curve deviates upward and leftward, the more diagnostically relevant the test result is (16). We would collect the variables with AUROC ≥0.7 and use the sensitivity and specificity coefficient to determine the threshold of pneumothorax complication prediction.

 

## Results

### *Participants characteristics and complication rate of transthoracic biopsy*

Between January 1st, 2017 and December 30th, 2022, a total of 221 patients with lung tumors were indicated for transthoracic biopsy at Thu Duc City Hospital in Vietnam.

Demographic characteristics of the patients included 140 males (63.4%) and 81 females (36.6%) with a mean age of 59.7±11.9 years. The first-attempt sample collection rate is 95%, and 11 patients needed a second attempt at sample collecting (*Table 1*).

All 221 patients underwent a biopsy with the guidance of a CT scan; the shortest range is right at the chest wall, the longest distance from the chest wall is 63.2 mm, and the average distance recorded is 37.2 mm. Besides that, the average needle insertion range recorded is 57.4±8.8 mm, with the shortest range being 30 mm and the longest being 92.7 mm. The smallest tumor size is 10 $mm^3$, and the biggest recorded is up to 325 $mm^3$ (*Table 2*).

The study results showed no reported cases of air embolism and revealed that 44 out of 221 patients developed hemoptysis, representing a prevalence of 19.9%. The majority of the cases of hemoptysis resolved spontaneously within 24 hours. Out of 221 patients, 12 (5.4%) developed both hemoptysis and pneumothorax. However, all of these complicated cases gradually resolved on their own after the patients received supplemental oxygen. Out of the total of 221 patients, 61 individuals (27.6%) were detected to have pneumothorax. Among these cases, 4 patients required chest tube drainage (*Table 3*).

### *Prognosis factors of CT-guided transthoracic needle biopsy's complication*

The results show the relationship between the distances and complications of pneumothorax. Remarkably, of the 99 patients with chest wall to tumor edge distance equal to or more than 20 mm, the rate of pneumothorax is 51.5%. Meanwhile, in the less-than 20 mm group, that rate is only 8.2% with P<0.001. Similarly, regarding the skin to tumor

**Table 1** Patients' characteristics (n=221)

| Characteristics | Values |
|---|---|
| Gender | |
| Male | 140 (63.4) |
| Female | 81 (36.6) |
| Age group (years) | |
| 20 to 39 | 15 (6.8) |
| 40 to 59 | 93 (42.1) |
| 60 and above | 113 (51.1) |
| Age (years) | 59.7±11.9 |

Data are presented as n (%) or mean ± standard deviation.

**Table 3** Complications rate of transthoracic biopsy (n=221)

| Complications | Values, n (%) |
|---|---|
| Pneumothorax | 61 (27.6) |
| Hemoptysis + pneumothorax | 12 (5.4) |
| Hemoptysis | 44 (19.9) |

**Table 2** Tumor size and distances (n=221)

| Characteristics | Mean ± SD | Median [25–75% quartile] | Min | Max |
|---|---|---|---|---|
| Skin-chest wall distance (mm) | 19.8±1.2 | 19.8 [18.9–20.5] | 17 | 23.4 |
| Skin-tumor edge distance (mm) | 37.2±11.4 | 38 [29–46] | 17 | 63.2 |
| Chest wall-tumor edge distance (mm) | 17.5±11.3 | 18.5 [10.7–26.4] | 0 | 44.3 |
| Needle insertion range (mm) | 57.4±8.8 | 57.6 [51–62] | 30 | 92.7 |
| Chest wall-tumor center distance (mm) | 36.6±8.7 | 37.7 [30.8–42] | 9.6 | 71.5 |
| Tumor size ($mm^3$) | 101.5±338.6 | 21 [3.1–71.2] | 10 | 325 |

Skin-chest wall distance: the distance from the skin to the chest wall, skin-tumor edge distance: the distance from the chest wall to the edge of the tumor, chest wall-tumor edge distance: the distance from the chest wall to the tumor edge, chest wall-tumor center distance: the distance from the chest wall to the tumor center. All the distances were measured at the section where the tumor is at largest size. SD, standard deviation.

**Table 4** Relationship between pneumothorax and distances

| Characteristics | Pneumothorax, n (%) | | P value* |
|---|---|---|---|
| | Yes (n=61) | No (n=160) | |
| Chest wall | | | <0.001 |
| Tumor distance <20 mm | 10 (8.2) | 112 (91.8) | |
| Tumor distance ≥20 mm | 51 (51.5) | 48 (48.5) | |
| Skin | | | <0.001 |
| Tumor edge distance <40 mm | 10 (7.8) | 118 (92.2) | |
| Tumor edge distance ≥40 mm | 51 (54.8) | 42 (45.2) | |
| Tumor size | | | 0.04 |
| <2 cm | 59 (29.8) | 139 (70.2) | |
| ≥2 cm | 2 (8.7) | 21 (91.3) | |

Chest wall-tumor distance: the distance from the chest wall to the edge of the tumor, skin-tumor edge distance: the distance from the chest wall to the edge of the tumor. All the distances were measured at the section where the tumor is at largest size. *, Chi-square test.

**Table 5** Multivariate regression of prognostic factors for pneumothorax complications

| Distances | Coef. (95% CI) | z | P value |
|---|---|---|---|
| Skin-chest wall distance | −0.071 (−0.141 to −0.000) | −1.99 | 0.048 |
| Skin-tumor edge distance | 0.208 (0.127 to 0.289) | 5.09 | <0.001 |
| Skin-tumor center distance | 0.168 (−0.018 to 0.355) | 1.77 | 0.08 |
| Chest wall-tumor center distance | −0.109 (−0.297 to 0.077) | −1.16 | 0.25 |
| Tumor size | −0.075 (−0.148 to −0.003) | −2.07 | 0.04 |

Skin-chest wall distance: the distance from the skin to the chest wall, skin-tumor edge distance: the distance from the chest wall to the edge of the tumor, skin-tumor center distance: the distance from the chest wall to the tumor center, chest wall-tumor center distance: the distance from the chest wall to the tumor center. All the distances were measured at the section where the tumor is at largest size. Coef., coefficient; CI, confidence interval.

distance, of the 93 patients in the more-than-40 mm group, the rate of pneumothorax is 54.8%; in the less-than-40 mm group, that rate is only 7.8% with P<0.001.

We also found a correlation between the tumor sizes and the pneumothorax complications, specifically, if patients had tumors with a diameter less than 2 cm, they are proning to post-biopsy pneumothorax, with P=0.04 (*Table 4*).

The results of multivariate logistic regression analysis in *Table 5* showed that the most important prognostic factor of pneumothorax was the skin-tumor edge distance (95% CI Coef: 0.127–0.289; P<0.001). Another factor that was significant in the multivariate model was tumor size (P=0.04). These factors were further analyzed by the Area under the ROC curve to determine a specific cutoff in predicting complications (*Table 5*).

*Figure 2* represents the ROC for chest wall-tumor edge distance, the area under the curve is 0.8414, which reaffirms the reliability of these figures in prognosis for pneumothorax complications.

Analytical clearance for the cutoff threshold shows that if the chest wall-tumor edge distance exceeds 23 mm, it would have the highest accuracy, 78.18%, and sensitivity and specificity at 72.13% and 80.50%, respectively. Therefore, a distance ≥23 mm is considered the risk threshold for pneumothorax complications (*Table 6*).

*Figure 3* represents the data of ROC for skin-tumor edge distance, the area under the curve is 0.8396 which reaffirms the reliability of these figures in pneumothorax complications prognosis.

Analytical clearance for the cutoff threshold shows that

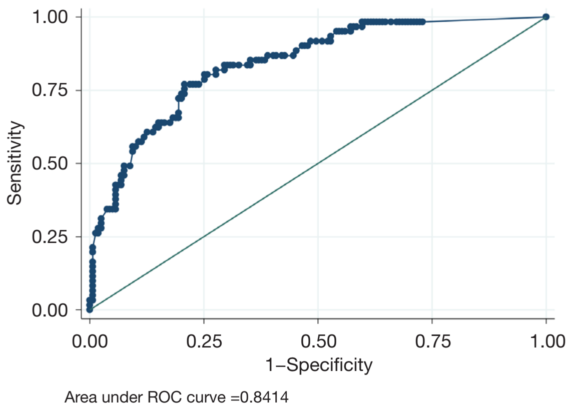


**Figure 2** AUROC curve of chest wall-tumor edge distance in prognosis for pneumothorax complications. ROC, receiver operating characteristic; AUROC, area under the receiver operating characteristic.

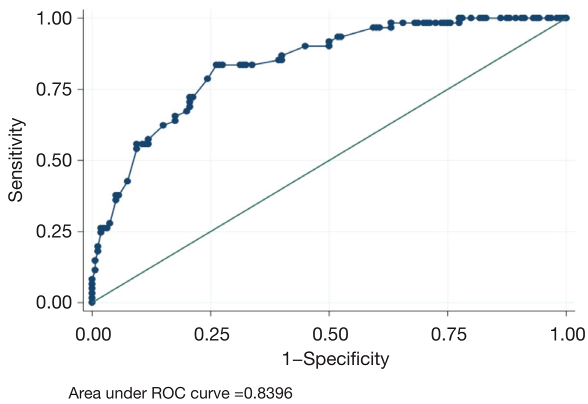


**Figure 3** AUROC curve of skin-tumor edge distance in prognosis for pneumothorax complications. ROC, receiver operating characteristic; AUROC, area under the receiver operating characteristic.

**Table 6** Sensitivity, specificity and accuracy rate of the chest wall-tumor edge distance in pneumothorax complication prognosis

| Cutoff threshold | Sensitivity (%) | Specificity (%) | Accuracy (%) |
|---|---|---|---|
| ≥10 mm | 98.36 | 32.08 | 50.45 |
| ≥16 mm | 83.61 | 72.50 | 75.57 |
| ≥20.3 mm | 83.61 | 70.44 | 74.09 |
| ≥23 mm | 72.13 | 80.50 | 78.18 |

**Table 7** Sensitivity, specificity and accuracy rate of the skin-tumor edge distance in pneumothorax complication prognosis

| Cutoff threshold | Sensitivity (%) | Specificity (%) | Accuracy (%) |
|---|---|---|---|
| ≥35.7 mm | 91.80 | 50.00 | 61.54 |
| ≥39.4 mm | 83.61 | 72.50 | 75.57 |
| ≥42 mm | 78.69 | 75.63 | 76.47 |

if the skin-tumor edge distance is greater than 42 mm, it would have the highest accuracy, at 76.47% and sensitivity and specificity at 78.69% and 75.63% respectively. Therefore, a distance ≥42 mm is considered the risk threshold for pneumothorax complications (*Table 7*).

*Figure 4* represents the data of ROC for skin-chest wall distance; the area under the curve is 0.5011, which shows the low reliability of this prognosis, and it didn't meet the prognosis standard.

*Figure 5* represents the data of ROC for skin-tumor center distance; the area under the curve is 0.6782, which shows the low reliability of this prognosis, and it didn't meet the prognosis standard (<0.7).

*Figure 6* represents the data of ROC for chest wall-tumor center distance; the area under the curve is 0.6721, which shows the low reliability of this prognosis, and it didn't meet the prognosis standard (<0.7).

*Figure 7* represents the data of ROC for tumor size; the area under the curve is 0.3087, which shows the low reliability of this prognosis, and it didn't meet the prognosis standard (<0.7).

## Discussion

### *Participants characteristics*

The average age of the individuals involved in the study is 59.7 years, within the range observed in previous transthoracic biopsy studies. The male percentage was double that of the female, with statistics of 63.4% and 36.6% respectively. This phenomenon is probably due to the fact that the prevalence of smoking among men is scientifically shown to be higher than that among women, and numerous studies have clearly shown that smoking is one of the primary factors responsible for lung cancers (17).

In our study, 11 participants underwent a second try at collecting samples. The successful first-time sample collection rate is 95%, with 210 out of 221 cases resulting in successful collection. Overall, our sample collection success rate is 100%, higher than the figures found by Harrison [81 out of 89 cases (91%)] (10). Our study's remarkably high success rate can be attributed to the utilization of CT assistance in virtually all cases, even those involving tumors

 

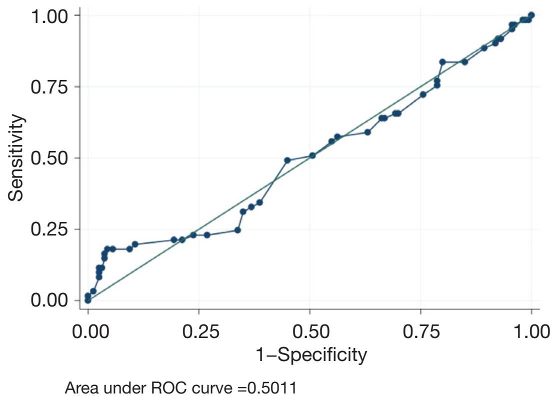


**Figure 4** AUROC curve of skin-chest wall distance in prognosis for pneumothorax complications. ROC, receiver operating characteristic; AUROC, area under the receiver operating characteristic.

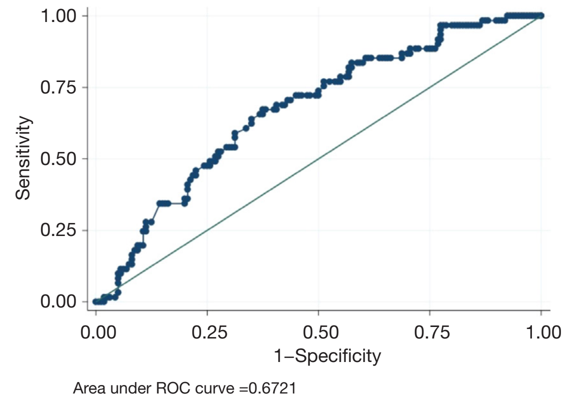


**Figure 6** AUROC curve of wall-tumor center distance in prognosis for pneumothorax complications. ROC, receiver operating characteristic; AUROC, area under the receiver operating characteristic.

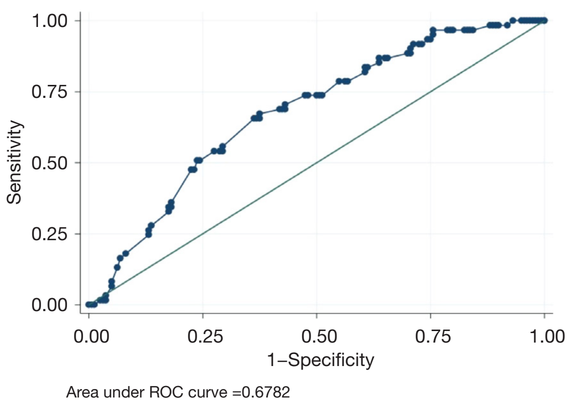


**Figure 5** AUROC curve of skin-tumor center distance in prognosis for pneumothorax complications. ROC, receiver operating characteristic; AUROC, area under the receiver operating characteristic.

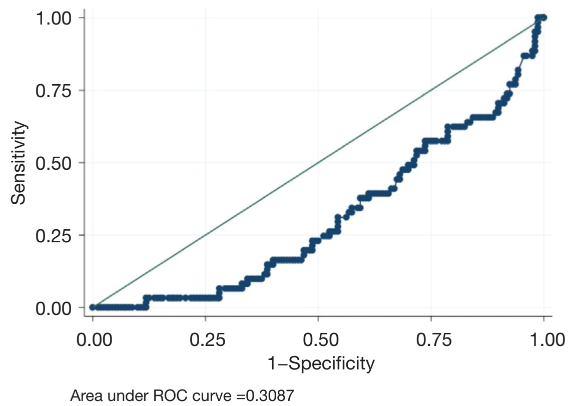


**Figure 7** AUROC curve of tumor size distance in prognosis for pneumothorax complications. ROC, receiver operating characteristic; AUROC, area under the receiver operating characteristic.

adjacent to the chest wall, and the excellent collaboration between patients and doctors. Utilizing CT-guided biopsy could significantly enhance the success rate and prevent the need for a second effort. Unsuccessful biopsies can be caused by factors such as patient movement, inability to hold their breath, or poor cooperation due to cognitive loss or senility in older patients (18).

### *Complication rate of transthoracic biopsy*

The incidence of pneumothorax in our study was 27.6%, with the corresponding number being 61 patients, and only 4 (1.9%) necessitated chest drainage. This proportion is lower than the figures shown in a meta-analysis, in which the rates for pneumothorax and chest drainage are 38.8% and 5.7%, respectively (19). Furthermore, our study indicates that patients' characteristics, such as gender and age, do not pose a risk factor for a higher rate of complications during a biopsy, aligning with the findings of Bozbaş *et al.* (20) and Tongbai *et al.* (21). However, Wiener *et al.* observed that individuals aged 60 to 70 years appear to have a higher likelihood of biopsy complications, contrasting with those above 80 years (22). We did document a correlation between the tumor size and the pneumothorax rate; specifically, the smaller the tumor diameter, the higher the risk of pneumothorax. This finding aligns with Wu *et al.*, who speculates that small lesion size also plays a role in the development of pneumothorax (23).

Approximately 20% of the overall population experiences complications related to hemoptysis, with the majority of cases being mild and self-limited. Previous studies have documented the correlation between pleura-tumor distance and the rate of hemoptysis following a biopsy (24,25). Our research indicates that a small proportion of cases, precisely 22.75%, had a pleura-tumor distance above 2.5 cm. Our investigation did not document any instances of air embolism. Encountering this problem is highly uncommon. Based on medical literature, the incidence of air embolism is approximately 0.2–1% (18,26).

### *Prognosis factors of CT-guided transthoracic needle biopsy's complication*

One of our new findings is the possible correlation between the incidence of pneumothorax complications and the distance between the tumor and the skin as well as the tumor and the chest, which is consistent with findings from earlier studies that have not yet clearly shown parameters such as sensitivity, specificity, and accuracy of a specific distance cutoff threshold (15,18,27). Additional risk factors for pneumothorax complications, as reported by other authors, include the puncture of needles into interlobar fissures, fibrotic lung areas, or emphysema (15,18). Meanwhile, at some medical centers, there is no statistically significant relationship between the number of biopsies and the rate of complications (26). Wu *et al.* mentioned that the risk of pneumothorax is higher with increased depth of the lesions from the skin or long needle path (>4 cm), consistent with our above findings (23).

Zhao *et al.*, in a study with a 31.4% pneumothorax rate, by using multivariable logistic regression, found that independent risk factors of pneumothorax include emphysema (P<0.001), no physical contact between lesions, and pleura (P<0.001), prone or side sleeping posture (P=0.002) and the number of needle insertions (P<0.001) (28). The pneumothorax prediction model's sensitivity, specificity, and accuracy figures are 56.8%, 79.6%, and 72.5%, respectively (28). While clinicians probably can somehow predict the posture and the number of needle insertions beforehand, our study, instead, focuses on the risk factor relating to the determined distance between a tumor and the chest wall, the tumor, and the skin, which can consistently and quickly be determined before the procedure. Both of our ROC curves have good AUC values. The first curve refers to the risk associated with the length of the chest wall tumor. A 23-mm or above length might be considered a significant threshold for pneumothorax complications. Regarding the second distance, which corresponds to the size of the skin tumor, a measurement of 42 mm or greater might indicate the possibility of pneumothorax complications. These two numbers can provide further information about the potential complications of a biopsy.

Various measures, nevertheless, can be adopted to mitigate the development of pneumothorax and minimize the number of pneumothoraces requiring chest tube placement. During and right after the procedure, clinicians should instruct patients not to move, talk rigorously, cough, or breathe deeply. Interlobar fissures should be avoided to reduce the number of pleural punctures. Careful discussion and planning are essential to minimize the traversal of aerated lung tissue without puncturing bullae or pneumatoceles, if feasible (23). In patients at high risk for developing pneumothorax, it may be suggested to use a procedure called needle track obliteration, or "patching", where 2–3 mL of the patient's blood is injected during the final withdrawal of the introducer needle (29). The efficacy of this technique remains controversial. Finally, after the biopsy, it is essential to position patients immediately with the puncture site facing downwards once the introducer needle has been removed (30,31). To facilitate the absorption of a pneumothorax, if it occurs, oxygen is delivered via a nasal cannula both during and after the procedure (32).

Our study also found no correlation between tumor sizes and biopsy complications, which aligns with the finding from Polat *et al.* (33). Remarkably, this study found that the depth of lesion measured from the pleura is 34.62±19.80 mm for patients with chest drainage and 22.81±17.82 mm for those without (P<0.01), which can be postulated that the length from the tumor to the pleura can correlate with severe pneumothorax complications. Polat *et al.* also conducted ROC analysis to estimate the probability of assisted drainage according to the distance of lesion calculated from the pleura surface. If the length exceeds 24 mm, the sensitivity would be 70.1%, and the specificity would be 64.5% (33). Similarly, our study found that a tumor-chest wall of more than 23 mm can be considered a threshold for risk prediction.

### *Study limitations*

Due to the retrospective nature of our study and ethical limits, we were unable to include control groups, although having an adequately large sample size. Furthermore, the data was not initially collected prospectively, meaning certain information may be missed. Therefore, the complication predictors identified in our studies should be cautiously adopted and cannot be generalized until a formal prospective is thoroughly conducted.

## Conclusions

Ninety-five percent first-attempt sampling rate among the patients, with the rate of pneumothorax complication being 27.6% (61/221 patients). Additionally, 19.9% showed signs of hemoptysis, and 5.4% showed both signs of pneumothorax and hemoptysis. All 221 patients underwent transthoracic biopsy, with the case with the longest distance from the chest wall being 63.2 mm and the average distance recorded being 37.2 mm. Moreover, the average needle insertion range recorded is 57.4±8.8 mm, with the shortest being 30 mm and the greatest being 92.7 mm. The smallest tumor was 10 $mm^3$, and the greatest was 325 $mm^3$.

In the figure for prognosis of pneumothorax complication, the chest wall-tumor edge distance has a value of area under ROC curve of 0.8414. A threshold of 23 mm shows that sensitivity, specificity, and accuracy are 72.13%, 80.5% and 78.18% respectively. The skin-tumor edge distance also shows a value of area under ROC curve of 0.8396. A threshold of 39.4 mm shows that sensitivity, specificity, and accuracy are 83.61%, 72.50%, and 75.57%, respectively. The skin-chest wall has a value of area under ROC curve of 0.5011, that of the skin-tumor center is 0.6782, and that of tumor size is 0.3087. The results found that there is a correlation between distances and pneumothorax complications. The rate of pneumothorax is 51.5% for patients with chest wall-tumor edge that is greater or equal to 20 mm; the rate is 8.2% for distances less than 20 mm (P<0.001).

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## Footnote

*Reporting Checklist:* The authors have completed the STARD reporting checklist. Available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-955/rc

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*Ethical Statement:* The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Ethics Committee of Thu Duc City Hospital (No. 1455/QD-BV) and individual consent for this retrospective analysis was waived due to the retrospective nature of the study.



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