

RESEARCH

Open Access



# The role of ultrasound-guided transthoracic Tru-Cut core biopsy in the diagnosis peripheral thorax lesion

Maha Fathy Mohamed<sup>1\*</sup> , Nabila Ibraheem Laz<sup>1</sup>, Khaled Mahmoud Kamel<sup>2</sup> and Raghda Yaser Mahmoud<sup>3</sup>

## Abstract

**Background:** The nature of opaque lesions such as effusions, atelectasis, masses, and consolidations can be clarified by sonography. This study investigated the sensitivity and accuracy of ultrasound-guided percutaneous core needle biopsy in different thoracic tumors (lung, pleural, chest wall, and mediastinal).

**Results:** Sixty patients underwent ultrasound-guided percutaneous transthoracic core biopsy of peripheral thoracic masses with a Tru-Cut needle with a big bore. Twenty masses were in the lung, seventeen lesions were in the pleura, ten masses were in the mediastinum, eleven were enlarged palpable lymph nodes, and two masses were in chest wall. The sensitivity, PPV, and accuracy for detection of chest tumors in the chest wall, mediastinum, lung, and pleura were 100% for all, and in LN 88.9, 100, and 90.9%, respectively. The overall diagnostic performance of sonar-guided Tru-Cut needle biopsy in diagnosis was 97.78% sensitivity, 98.18% accuracy, and 100% PPV.

**Conclusion:** Tru-Cut needle percutaneous transthoracic core biopsy is a convenient and sensitive process in obtaining samples under ultrasound guidance for exact histological diagnosis of thoracic tumors. The diagnostic efficiency is high, and the technique can also be used in outpatients, which is relatively simple.

**Trial registration:** NCT, [NCT04741958](https://clinicaltrials.gov/ct2/show/study/NCT04741958) Registered 5 February 2021, retrospectively registered,

**Keywords:** Ultrasound, Chest, Diseases, Core needle biopsy

## Background

Peripheral intrathoracic shadows are common presentation of different diseases of different origin (chest wall, pleura, pulmonary, and mediastinum); they are increasing in numbers, including peripheral lung cancer, tuberculosis, pneumonia, and atelectasis [1].

Thoracic masses with wall contact represent a frequent pathology that requires complex imaging studies and often interventional procedures, in order to reach the complete diagnosis. In most cases, after a thoracic lesion is found on a thoracic x-ray, the next step is to perform a CT and/or a bronchoscopy exam, but pleural

and pulmonary lesions often call for additional investigations.

Therefore, transthoracic ultrasonography (US) permits visualization of these lesions and their structural characterization, while offering suggestive elements for their malignant nature and for the differential diagnosis [2].

Sonography has the ability to clarify the opaque nature of lesions such as effusions, atelectasis, masses, and consolidations [3].

In recent years, the interest of chest physicians in transthoracic ultrasound has risen because it has the advantages of being available at the bedside, not requiring radiation, and allowing for guided aspiration of fluid-filled areas and solid tumors.

In addition, transthoracic US permits percutaneous guided biopsies, with lower risk than radiological guiding methods (fluoroscopy and CT) [2].

\* Correspondence: [mahafathy78@gmail.com](mailto:mahafathy78@gmail.com)

<sup>1</sup>Chest Diseases, Faculty of Medicine, Beni-Suef University, Beni-Suef, Egypt  
Full list of author information is available at the end of the article

Transthoracic US can substitute for other lung imaging methods and guide various processes for diagnosing and managing. In real time, US guidance increases significantly the success rate of transthoracic suction or biopsy (TNB) while the risk of complications is reduced significantly [4].

The goal of this work was just to measure ultrasound-guided percutaneous core needle biopsy sensitivity and accuracy in different thoracic tumors (lung, pleural, chest wall, and mediastinal).

## Methods

The current study is a case series study conducted on 60 patients that had radiographic evidence of thoracic mass suspected of malignancy and was selected from Chest Department, Kasr El-Aini Hospital and Beni-Suef University Hospital during the period from September 2020 to December 2020. [ClinicalTrials.gov](https://clinicaltrials.gov/ct2/show/study/NCT04741958) Identifier is NCT04741958 on 5/2/2021

## Inclusion criteria

1. Peripheral pulmonary masses that abutted on pleural surface
2. Pleural mass or diffuse pleural thickening
3. Patients with mediastinal tumor anterior, posterior, or at the site that has chest wall touch
4. An acoustic window to penetrate the ultrasound beam

This window appears to exist once the lesion is in direct contact with the parietal pleura or when the effusion or collapse takes place between the lesion and the chest wall, so that the ultrasound beam can transmit without being stopped by interposed air through the lesion.

5. Patients who have platelet count more than 100000 and normal prothrombin time

## Exclusion criteria

1. Patients not fulfilling the inclusion criteria
2. Cardiovascular instability
3. Arteriovenous malformation or aneurysm
4. Patients with uncontrolled convulsions

## All patients were subjected to:

- A. Pre-procedural monitoring:
  1. Consent:

Every patient received written informed consent, including the full explanation of the study and the right of the patient to withdraw at any time from the study during his or her participation. The consent also included the acceptance of the patient to use his or her data for

publication and presentation after masking his/her name.

Approval of ethical committee was taken.

2. Full history taking with particular attention to:
  - Epidemiological features (age, sex).
  - Smoking history.
  - Occupational history.
  - Duration of illness.
  - Medication used especially salicylates, antiplatelet, and oral anticoagulants drugs.
  - Associated illness such as liver and kidney disease.
3. A thorough clinical examination is performed, which includes a general and local chest exam.
4. Routine laboratory assessment.
5. Plain chest x-ray: postero-anterior view.
6. CT chest with contrast: CT chest was done for all patients prior to chest US to gain proper delineation of the target lesion and the surrounding anatomy.
7. Bleeding profile: pre-procedural prothrombin time and concentration (PT, PC, and INR) were checked to avoid possible post-procedural puncture site hematoma or bleeding and to correct any bleeding diathesis before procedure.
8. Transthoracic ultrasonography: transthoracic US was done using the machine Hitachi 5500 in the Diagnostic Ultrasound Unit, Chest Department, Kasr El-Aini Hospital (Figs. 1 and 2).

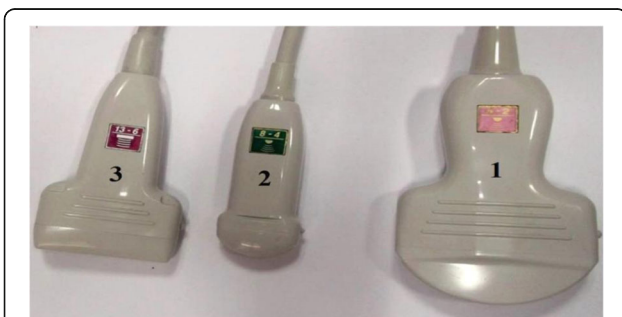
## B. Technique:

1. Patient position:
  - Position depends on the lesion site.
  - It is not preferred to perform the biopsy while the patient is standing to avoid syncope and vasovagal attacks.
  - 1.1. Sitting (dorsal and lateral images).
  - 1.2. Supine (ventral images).
  - 1.3. Right lateral position (dorsal and lateral images).
  - 1.4. Left lateral position (dorsal and lateral images).
    - Arms that rise and cross behind the head increase intercostal spaces and improve access.
    - The examiner is able to visualize the region behind the shoulder blade, if the patient puts his/her hand on the contralateral shoulder.



**Fig. 1** Photographic plate of Hitachi 5500 Transthoracic US machine.

2. A disposable antimicrobial wipe was used to clean the probe. The skin was kept clean, and water-based gel has been used to enhance the interface.
3. Scanning techniques that were used in transthoracic ultrasound:
  - Subcostal, intercostal, suprasternal, parasternal, infrasternal, and paravertebral approaches.
4. Biopsy with full aseptic technique should be performed in a clean area
5. Atropine intramuscular injection to prevent vasovagal attack.

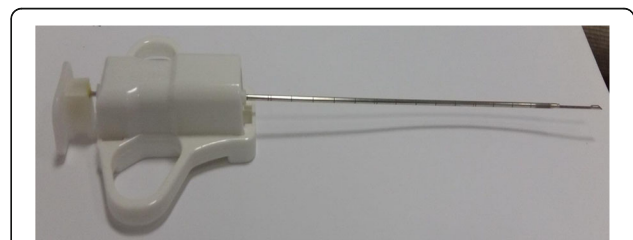


**Fig. 2** Photographic plate of the probes. (1) Convex probe 2–5 MHz. (2) Mini-convex probe 4–8 MHz. (3) Linear probe 9–13 MHz

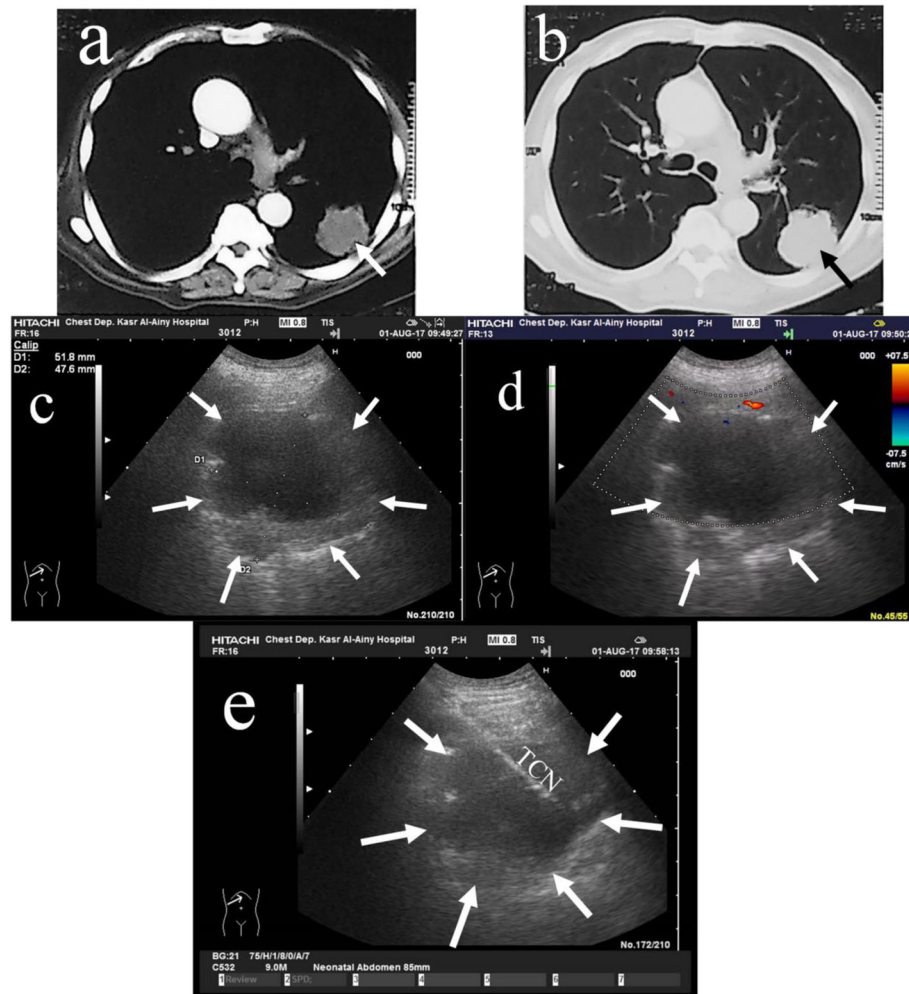
6. 5 cc lidocaine 2% was given as local anesthetic in the site of puncture.
7. Site of insertion.
  - i. Ultrasound was used to detect the lesion, assess a secure route for the needle placement, and therefore select the optimal position of the patient.
  - ii. To recognize surrounding vessels, color-coded Doppler imaging must be required. The entry site is also obtainable; the direction and the depth for the biopsy were achieved by accurate visualization and localization of the lesion with good accessibility using ultrasonography.
  - iii. The patient is then positioned according to the site of lesion to be biopsied—prone or setting for paravertebral lesions and supine for lateral or anterior lesions.
  - iv. There were two or more biopsies carried out at the same place with semi-automatic Tru-Cut needle 16 gauge (Figs. 3 and 4).
  - v. The Tru-Cut biopsy specimen was sent for pathologic examination. A specimen obtained by Tru-Cut biopsy was observed grossly and arbitrarily designated as inadequate if the specimen was smaller than  $2 \times 4$  mm in size. A Tru-Cut biopsy was repeated immediately before the histologic examination was performed. If a lymphoma or Hodgkin's disease was suspected, multiple biopsies were conducted to obtain at least two adequate specimens for both routine histological examination as well as immunohistologic studies to confirm the cell type

### III. Post-procedural monitoring:

1. The site was reviewed with the US immediately after the procedure.
2. Three hours of surveillance after intervention.



**Fig. 3** Tru-Cut needle



**Fig. 4** (a, b) CT chest mediastinal and pulmonary windows show left lower lobe rounded mass lesion with irregular margin (white and black arrows). (c, d) Linear probe ultrasonography and Doppler study show rounded hypoechoic lesion (white arrows) with poor vascularity. (e) Linear probe ultrasonography shows Tru-Cut needle (TCN) within the lesion to have a biopsy. Diagnosis: Poorly differentiated adenosquamous carcinoma

- All patients were subjected to routine assessment of vital signs as some patients develop vasovagal attacks during the procedure or develop tachypnea during or after the procedure.
- All patients were observed for occurrence of puncture site hematoma or bleeding which may cause hemodynamic instability [5].
- Sonographic inspection of the patient before discharge (pneumothorax? bleeding?) [6].

#### Statistic methodology

- The data collected has been revised, coded, and tabulated using SPSS Inc. (Chicago, IL, USA), version 22.0 (Statistical Package for Social Science). Data was presented and suitable.
- Analysis was done according to the type of data obtained for each parameter using:
  - Descriptive statistics:
    - Mean
    - Standard deviation ( $\pm$  SD)
    - Frequency and percentage of non-numerical data
  - Analytical statistics:
    - Sensitivity: a percent of patient with tumor correctly diagnosed as tumor by ultrasound-guided biopsy and results from equation "Sensitivity = (TP/TP + FN)"
    - Positive predictive values (PPV): depends on the prevalence of the disease in the population of interest and results from the equation "PPV = (TP/TP + FP)"
    - Accuracy or efficiency: the percentage of test results correctly identified by the test and result

from the equation “Accuracy = (TP + TN)/(TP + TN + FP + FN)”

- True positive result: the tumor is confirmed by a definite histopathologic diagnosis made by Tru-Cut core biopsy
  - True negative result: case not diagnosed as a tumor by ultrasound Tru-Cut core biopsy and this finding was confirmed by another modality for biopsy
  - False negative results: considered when an ultrasound-guided biopsy had not been diagnosed with the tumor and the tumor was stated with other modalities (CT-guided, thoracoscopic, or surgical biopsy)
4. Chi-square: the comparison test that has been used with qualitative variables. Statistically significant differences have been considered when *P* values were less than 0.05

**Results**

This study is conducted on 60 patients that had radiographic evidence of thoracic mass suspected of malignancy and aiming for measuring sensitivity and accuracy of ultrasound-guided percutaneous core needle biopsy in different thoracic tumors (lung, pleural, chest wall, and mediastinal). The patients’ ages ranged between 22 years and 85 years with 53.37 years mean age and 14.51 years standard deviations; they included 41 male patients with a percent of 68.33 and 19 female patients with a percent of 31.67. As regards the smoking state, 28 cases (46.67%) were current smokers, 9 cases (15%) were ex-smokers, both with 43.95 mean smoking index and 28.5 standard deviation. Twenty-three cases representing 38.33% were non-smokers. As regards the occupational and residence hazards status, it was found that 10 cases (16.66% of patient’s population) were exposed to occupational hazards of malignancies and 5 cases (8.33%) were exposed to residence hazards (Table 1). Chest x-ray, CT chest, and transthoracic ultrasound were performed to all patients. The descriptive data obtained of all patients included in the study from chest x-ray, CT scan, and transthoracic ultrasonography (TUS) are shown in Tables 2, 3, and 4, respectively. In the assessment of pulmonary nodules by US in comparison to CT (Table 5), it was found that they agreed in 3 cases for detection of pulmonary nodules, while CT was able to detect 9 cases and TUS failed to detect these 9 cases. This finding was found to be statistically significant (*p* value = 0.0246). Transthoracic ultrasound detected central masses in 12 patients only of the studied patients; those central masses were reaching the chest wall or had sonic window through effusion or collapse, and CT chest confirmed this finding and detected additional 21 cases which the ultrasound could not. The difference in this finding between transthoracic ultrasound and CT chest was found to be statistically

**Table 1** Patients demography

Variable	Value	
Age (mean/SD)	53.37	14.51
Sex (no., %)		
Female	19	31.67
Male	41	68.33
Smoking index (mean/SD)	43.95	28.5
Smoking status (no., %)		
Ex-smoker	9	15
Non-smoker	23	38.33
Smoker	28	46.67
Occupational hazards (no., %)		
No	50	83.34
Yes	10	16.66
Residence of hazards (no., %)		
No	55	91.67
Yes	5	8.33

No., number, SD standard deviation, % percent

significant (*P* value = 0.0001); while US detected 21 cases of parenchymal masses and CT detected 20 cases, this difference was statistically non-significant (*P* value = 1) (Table 6). Chest CT and US detected the same cases of unilateral pleural effusion (27 cases), and such results have been found to be statistically insignificant (*P* value = 1). Also, both modalities detected the same cases of bilateral pleural effusion (4 cases), and this finding was found to be statistically non-significant (*P* value = 1). US detected 19 cases with pleural thickening while CT detected 16 cases of them, and these results were found to be statistically non-significant (*P* value = 0.688). US was able to detect 7 cases as pleural nodules while CT detected 5 cases and was unable to detect 2 cases. These results were found to be statistically non-significant (*P* value = 0.762). Both CT and US had no difference in detection of pleural masses as both modalities detected 3 cases with pleural mass; this result was statistically non-significant (*P* value = 1) (Table 7). Both US and CT agreed in 6 cases for detection of rib erosion, while US was once capable to detect 2 cases of intercostal muscle

**Table 2** Radiological finding of patients

Variable	(No. = 60)	%
X-ray		
Right opacity	35	58.33
Left opacity	21	35
Bilateral opacity	4	6.67
Central opacity (mediastinal or hilar)	14	23.33
Peripheral opacity	46	76.67

No., number, % percent

**Table 3** Computed tomography findings

CT finding	No. of findings = 60)	%
(A) Pulmonary nodules	12	20
(B) Masses		
Central (mediastinal and hilar)	33	55
Parenchyma	20	33
(C) Pleurae		
Unilateral effusion	27	45
Bilateral effusion	4	6.67
Pleural thickening	16	2.67
Pleural nodules	5	8.33
Pleural mass	3	5
(D) LN		
Peripheral lymph node	6	10
(E) Chest wall		
Rib and intercostal erosion	6	10
Sternal erosion	3	5
Vertebral erosion	2	3.3

LN lymph node, CT computed tomography

invasion and CT failed to detect these 2 cases; these results were statistically non-significant ( $P$  value = 0.777). As regards vertebral erosion, it was found that CT was able to detect vertebral erosion in 2 cases while US failed to detect them, and this finding was found to be statistically insignificant ( $P$  value = 0.496). So, the total chest wall invasion detected by CT was 11 cases while total

**Table 4** Ultrasound findings

US finding	No. of findings	%
(A) Pulmonary nodules	3	5
(B) Masses		
Central	12	20
Parenchymal	21	35
(C) Pleurae		
Unilateral effusion	27	45
Bilateral effusion	4	6.67
Pleural thickening	19	31.67
Pleural nodules	7	11.67
Pleural mass	3	5
(D) LN		
Peripheral LN	11	18.33
(E) Chest wall		
Rib and intercostal erosion	8	13.33
Sternal erosion	2	3.33
Vertebral erosion	0	0

LN lymph node, US ultrasound

**Table 5** Assessment of pulmonary nodules by US in comparison to CT

CT finding	US positive	US negative	Total	P value
CT positive	3	9	12	0.0246 S
CT negative	0	48	48	
Total	3	57	60	

$P$  considered significant if  $< 0.05$

CT computed tomography, US ultrasound, S significant

chest wall invasion detected by ultrasound was 10 cases, and these results was found to be statistically non-significant ( $P$  value = 1) (Table 8). As regards the final diagnosis, 36 cases of the study population (60%) had extra-pulmonary tumors of which 3 cases were diagnosed as thymoma, 1 case as rhabdomyoma, 1 case as plasma cell tumor, 8 cases as mesothelioma, 2 cases as spindle cell tumor, 2 cases as neurofibroma, 5 cases as lymphoma, 3 cases as sarcoma, one case as schwannoma, and 10 cases as metastatic carcinoma; 19 cases (31.67%) had pulmonary tumor of which were 2 cases with small cell carcinoma, 3 cases with squamous cell carcinoma, 4 cases with large cell carcinoma, and 10 cases with adenocarcinoma; and just 5 cases (8.33%) had inflammatory lesion of which 3 cases were diagnosed as TB, one case was diagnosed as organizing pneumonia, and one was diagnosed as fibrosis (Table 9). The total non-malignant lesions were 10 cases; lesions with size 0.5–3 cm were 4 cases representing 40%, those with size 3–7 cm were 2 cases representing 20%, there was just one lesion with a size of 7–10 cm representing 10%, and there were 3 lesions of size above 10 cm representing 30%. In the same table, the total malignant lesions were 50 cases; 23 of them were of size 0.5–3 cm representing 46%, those with size 3–7 cm were 17 cases representing 34%, there was just one lesion with a size of 7–10 cm representing 2%, and there were 9 lesions of size above 10 cm representing 18%, this results was found to be statistically non-significant ( $P$  value = 0.426) (Table 10). All mediastinal and chest wall lesions were successfully diagnosed by histopathologic diagnosis made by Tru-Cut needle core biopsy giving 100% sensitivity, PPV, and accuracy, in 20 patients with lung lesions who had definite histopathologic diagnosis made by Tru-Cut core biopsy, of which 19 biopsies showed true positive results for tumor and one represented a true negative, and none showed false positive or false negative. The true negative case was diagnosed as organizing pneumonia, and this diagnosis was confirmed clinically and by a CT-guided biopsy from the lesion. So, the sensitivity, PPV, and the diagnostic accuracy of transthoracic core biopsy in the diagnosis of lung tumor were 100%, 100%, and 100%. All pleural lesions ( $n = 17$ ) had a definite histologic diagnoses made by Tru-Cut core biopsy, of which 15 biopsies showed true positive results for tumor, two showed true

**Table 6** Assessment of masses by US in comparison to CT

	CT finding	US positive	US negative	Total	P value
Central masses	CT positive	12	21	33	0.0001 S
	CT negative	0	27	27	
	Total	12	48	60	
Parenchymal masses	CT positive	20	0	20	1 NS
	CT negative	1	39	40	
	Total	21	39	60	

CT computed tomography, US ultrasound, S significant, NS non-significant

negative, and none showed false positive or false negative. The true negative cases were diagnosed as pleural TB, and the other case as pleural fibrosis. These true negative results were confirmed by thoracoscopic biopsy. So, the sensitivity, PPV, and the diagnostic accuracy of transthoracic core biopsy in the diagnosis of pleural tumor were 100%, 100%, and 100%. In the same table, in 11 patients with lymph node lesions who had definite histologic diagnosis made by Tru-Cut core biopsy, 8 biopsies showed true positive results for tumor, two showed true negative, one showed false negative, and none showed false positive. One of the true negative cases was diagnosed as TB, and this diagnosis was confirmed by surgical lymph node biopsy, while the other case showing true negative result was diagnosed as TB, and this finding was confirmed by CT-guided biopsy from vertebral lesion. The false negative case was diagnosed as sarcoma by surgical biopsy. So, the sensitivity, PPV, and the diagnostic accuracy of transthoracic core biopsy in the diagnosis of lymph node tumor were 88.9%, 100%, and 90.9%, respectively. The overall

diagnostic performance of sonar-guided Tru-Cut needle biopsy in diagnosis was 97.78% sensitivity, 98.18% accuracy, and 100% PPV (Tables 11 and 12). In our study, no complication was reported

### Discussion

This study was conducted on 60 patients that had radiographic evidence of thoracic mass suspected of malignancy aiming for measuring sensitivity and accuracy of ultrasound-guided percutaneous core needle biopsy in different thoracic tumors (lung, pleural, chest wall, and mediastinal). In this study, by regarding the overall sensitivity and accuracy of transthoracic US findings in relation to CT chest findings (Tables 3 and 4), it was found that both modalities agreed to each other in detection of pleural effusion, pleural mass, and superior vena cava obstruction. These results agree with the results of [7]. Using CT as a gold standard, study compared the diagnostic performance of TUS and bedside CXR for the identification of multiple pathological abnormalities in 200 critically ill patients. He found that the sensitivity,

**Table 7** Assessment of pleura by US in comparison to CT

	CT finding	US positive	US negative	Total	P value
Unilateral effusion	CT positive	27	0	27	1 NS
	CT negative	0	33	33	
	Total	27	33	60	
Bilateral effusion	CT positive	4	0	4	1 NS
	CT negative	0	56	56	
	Total	4	56	60	
Pleural thickening	CT positive	16	0	16	0.688 NS
	CT negative	3	41	44	
	Total	19	41	50	
Pleural nodules	CT positive	5	0		0.762 NS
	CT negative	2	53	55	
	Total	7	53	60	
Pleural mass	CT positive	3	0	3	1 NS
	CT negative	0	57	57	
	Total	3	57	60	

CT computed tomography, NS non-significant, US ultrasound

**Table 8** Assessment of chest wall by US in comparison to CT

	CT finding	US positive	US negative	Total	P value
Rib and intercostal erosion	CT positive	6	0	6	0.777
	CT negative	2	52	54	NS
	Total	8	52	60	
Sternal erosion	CT positive	2	1	3	1
	CT negative	0	57	57	NS
	Total	2	58	60	
Vertebral erosion	CT positive	0	2	2	0.496
	CT negative	0	58	58	NS
	Total	0	60	60	
Total chest wall invasion <sup>a</sup>	CT positive	8	3	11	1
	CT negative	2	47	49	NS
	Total	10	50	60	

<sup>a</sup>Total results of chest wall invasion = summation of results of (rib and intercostal erosion+ sternal erosion + vertebral erosion)  
 CT computed tomography, US ultrasound, NS non-significant

specificity, and diagnostic accuracy of TUS for pleural effusion were 100%, 100%, and 100%, respectively, and he concluded that TUS may be used as an alternative to thoracic CT for the diagnosis of common pathological disorders such as pleural effusion. In disagreement with our results regarding pleural mass detection, [8] while studying 60 patients with pleural effusion reported that

multi-detector computed tomography (100%,  $n = 12$ ) was superior to US which detected 66.6% ( $n = 8$ ) pleural masses with statistically significant difference.

As shown in Tables 5 and 6), CT chest was superior over TUS in detection of pulmonary nodule, central mass. As regards the assessment of pulmonary nodules by US in comparison to CT (Table 5), it was found that they agreed in 3 cases for detection of pulmonary nodules, while CT was able to detect 9 cases and TUS failed to detect these 9 cases. This finding was found to be statistically significant ( $P$  value = 0.0246). These agree with [9] who reported that there were 9 patients with pulmonary nodules which were detected by CT and missed by ultrasound, while studying the role of ultrasound in 84 pleural effusion patients in diagnosis and management at Alzahraa University hospital. As shown in Table 6, it was found that transthoracic ultrasound detected central masses in 12 patients only of the studied patients whose central masses were reaching chest wall or had sonic window through effusion or collapse, and CT chest confirmed this finding and detected additional 21 cases which the ultrasound could not detect. The difference in

**Table 9** Pathological diagnosis

Item	No.	%
A Extra-pulmonary tumor		
Thymoma	3	5
Rhabdomyoma	1	1.67
Plasma cell tumor	1	1.67
Mesothelioma	8	13.33
Spindle cell tumor	2	3.33
Neurofibroma	2	3.33
Lymphoma	5	8.33
Sarcoma	3	5
Schwannoma	1	1.67
Metastatic adenocarcinoma	10	16.67
B Lung tumor		
Small cell lung cancer	2	3.33
Adenocarcinoma	10	16.67
Squamous cell carcinoma	3	5
Large cell carcinoma	4	6.67
C Inflammatory		
TB	3	5
Organizing pneumonia	1	1.67
Pleural fibrosis	1	1.67

N number, TB tuberculosis bacilli

**Table 10** Lesion size in malignant and non-malignant by US

Lesion size (cm)	Tru-Cut diagnosis			
	Non-malignant		Malignant	
	N	%	N	%
0.5–3	4	40	23	46
> 3–7	2	20	17	34
> 7–10	1	10	1	2
Above 10	3	30	9	18
Total	10	100%	50	100%

US ultrasound, N number



**Table 11** Methods of histopathologic confirmation in the study population

	Transthoracic ultrasound-guided biopsy	Thoracoscopic biopsy	Surgical biopsy	CT-guided
Mediastinum ( <i>n</i> = 10)	10	0	0	0
Chest wall ( <i>n</i> = 2)	2	0	0	0
Lung ( <i>n</i> = 20)	19	0	0	1
LN ( <i>n</i> = 11)	8	0	2	1
Pleura ( <i>n</i> = 17)	15	2	0	0

LN lymph node, CT computed tomography

this finding between transthoracic ultrasound and CT chest was found to be statistically significant ( $P$  value = 0.0001). Also, these results agree with [10] who noted that US identified only 4 cases of mediastinal mass and CT identified 15 cases of mediastinal mass while studying the purpose of ultrasound in the diagnosis of chest disease in Kasr El-Aini University Hospital, Cairo, between 31 patients.

TUS was superior over CT chest in detection of parenchymal mass, pleural thickening and axillary, SCLN, and lower deep cervical lymph node. This is coinciding with the study done by [11] who stated that ultrasonography could distinguish pleural from parenchymal lesions, interpret ill parenchyma shaded by pleural effusion, and identify pleural septations and other pleural abnormalities. It also diagnoses pulmonary parenchyma conditions such as consolidation, atelectasis and tumor differentially.

According to Table 7, US detected 19 cases with pleural thickening while CT detected 16 cases of them, and these results found to be statistically non-significant ( $P$  value = 0.688). These findings of pleural thickening detection agree with [12] who mentioned that as regards pleural thickening recognition, US detected 100% ( $n$  = 24) and was significantly more sensitive than CT scan which detected 6.6% ( $n$  = 16), while studying the diagnostic role of thoracic ultrasonography in pleural effusion. According to Table 7 in the present study, US was able to detect 7 cases as pleural nodules while CT detected 5 cases and was unable to detect 2 cases. These results were found to be statistically non-significant ( $P$  value = 0.762). Furthermore, [12] reported superiority of US (13/32) over CT (5/32) in detection of pleural nodules with statically significant difference.

Regarding chest wall invasion, according to Table 8, total chest wall invasion detected by CT was 11 cases

while total chest wall invasion detected by ultrasound was 10 cases, and these results was found to be statistically non-significant ( $P$  value = 1). These results agreed with [13] who found that both CT and US agreed in 21 cases for detection of invasion of the lesions to chest wall, and while CT chest failed to detect that in 7 cases, this difference was statistically significant, in comparison of fine aspiration and Tru-Cut needle biopsy-guided ultrasonography in intrathoracic and chest wall lesions among 30 patients with peripheral intrathoracic shadows at Kasr El-Aini Hospital, Cairo University. Also, these results agree with [2] who performed a comparative evaluation of lung tumors in contact with the thoracic wall by transthoracic ultrasonography (US) and computed tomography (CT) among 131 patients with thoracic masses; they found that chest wall invasion detected by CT was greater than those detected by ultrasound, and they stated that the performance of US in diagnosing wall invasion is recognized (89–100%), being at least equal with that of CT (42–68%).

The results of this study showed that the majority of cases had extra-pulmonary tumors, followed by pulmonary tumors and just 8.33% of them had inflammatory lesion (Table 9).

In the current study, histopathological analysis of Tru-Cut biopsy revealed that 28.33% of diagnosed patients (17 cases) are bronchogenic carcinoma, followed by metastatic adenocarcinoma 13 cases (21.67%), then malignant mesothelioma 10 cases (16.67%), malignant lymphoma 5 cases (8.33%), thymoma 3 cases (5%), TB 3 cases (5%), sarcoma 2 cases (3.33%), neurofibroma 2 cases (3.33%), organizing pneumonia 1 case (1.67%), fibrosis 1 case (1.67%), rhabdomyoma 1 case (1.67%), plasma cell tumor 1 case (1.67%), and schwannoma 1 case (1.67%). This agreed with [14] who determined that the most common types of bronchogenic carcinoma

**Table 12** Sensitivity, PPV and accuracy of Tru-Cut biopsy for diagnosis as regarding the site of lesion

	Mediastinum <i>n</i> = 10	Chest wall <i>n</i> = 2	Lung <i>n</i> = 20	LN <i>n</i> = 11	Pleura <i>n</i> = 17	Total
Sensitivity	100%	100%	100%	88.9%	100%	97.78%
Accuracy	100%	100%	100%	90.9%	100%	98.18%
PPV	100%	100%	100%	100%	100%	100%

PPV positive predictive value, LN lymph node

among studied patients were squamous cell carcinoma and adenocarcinoma (30.2% each) followed by large cell carcinoma (28.3%) and SCLC (11.3%) while studying the usefulness of thoracic ultrasonography in diagnosis and staging of bronchogenic carcinoma .

In the current study, Fig. 1 showed that smoking was mainly linked to malignant diseases especially bronchogenic carcinoma. These results agree with [15] while evaluating the clinico-pathological profile of the bronchogenic carcinoma cases in the Chest Department, Cairo University, concluded that smoking still remains the major risk factor in the pathogenesis of bronchogenic carcinoma (Fig. 5).

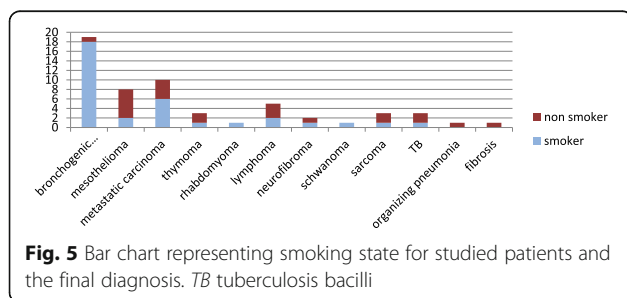
The current study results showed that occupational and residence hazards are risk factors in the pathogenesis of bronchogenic carcinoma and mesothelioma. These results agree with [16] who mentioned that factories influence a range area of ~5–7 km in radius, which clarifies the high rate of malignant pleuralmesothelioma (MPM) in people who live nearby to these factories. Individuals who worked since 1948 in the Egyptian asbestos organization Sigwart factories in greater Cairo (El-Maasara and Shubra El-Kheima) had an expanded hazard for MPM. In Egypt, the ministerial council decided to forbid asbestos imports in 2004 and the Sigwart plants were closed in November 2004. Therefore, along these lines, the anticipated rate of MPM in Egypt will achieve its peak around 2040.

The total non-malignant lesions were 10 cases; lesions with size 0.5–3 cm were 4 cases representing 40%, those with size 3–7 cm were 2 cases representing 20%, there was just one lesion with a size 7–10 cm representing 10%, and there were 3 lesions of size above 10 cm representing 30%. The total malignant lesions were 50 cases; 23 of them were of size 0.5–3cm representing 46%, those with size 3–7 cm were 17 cases representing 34%, there was just one lesion with size 7–10 cm representing 2%, and there were 9 lesions of size above 10 cm representing 18%. This result was found to be statistically non-significant (*P* value = 0.426). In both malignant and non-malignant lesions, the most abundant lesion size was 0.5–3 cm (Table 10). These results disagree with [2] who performed a comparative evaluation of lung lesions in

contact with the thoracic wall by transthoracic ultrasonography (US) and computed tomography (CT); they stated that between the patients with benign lesions and those with malignant lesions there are differences regarding the size of the masses, malignant lesions being significantly larger in size (*p* < 0.001).

In this study (Tables 11 and 12), all mediastinal and chest wall lesions were successfully diagnosed by histopathologic diagnosis made by Tru-Cut needle core biopsy giving 100% sensitivity, PPV, and accuracy, In 20 patients with lung lesions, there were 19 true positive tumor biopsies, one true negative biopsies, and no false positive or false negative biopsies among those who had a definite histopathologic diagnosis made by Tru-Cut core biopsy. The true negative case was diagnosed as organizing pneumonia, and this diagnosis was confirmed clinically and by CT-guided biopsy from the lesion. So, the sensitivity, PPV, and the diagnostic accuracy of transthoracic core biopsy in the diagnosis of lung tumor were 100%, 100%, and 100%. In the same context, in all pleural lesions (*n* = 17) having been definitely diagnosed histologically by Tru-Cut core biopsy, 15 biopsies have shown true tumor positive results, two have shown true negative results, and none have shown false positive or false negative results. True negative cases have been diagnosed as pleural TB, and the other as pleural fibrosis. Thoracoscopic biopsy confirmed the true negative results. Therefore, in the diagnosis of pleural tumors, the sensitivity, PPV, and the diagnostic accuracy of core transthoracic biopsy were 100%, 100%, and 100%. In 11 patients with lymph node lesions who had definite histologic diagnosis made by Tru-Cut core biopsy, 8 biopsies showed true positive results for tumor, two showed true negative, one showed false negative, and none showed false positive. One of the true negative cases was diagnosed as TB and this diagnosis was confirmed by surgical lymph node biopsy, while the other case showing true negative result was diagnosed as TB, and this finding was confirmed by CT-guided biopsy from vertebral lesion. The false negative case was diagnosed as sarcoma by surgical biopsy. So, the sensitivity, PPV, and the diagnostic accuracy of transthoracic core biopsy in the diagnosis of lymph node tumor were 88.9%, 100%, and 90.9%, respectively.

The overall diagnostic performance of sonar-guided Tru-Cut needle biopsy in diagnosis was 97.78% sensitivity, 98.18% accuracy, and 100% PPV. These results agree with [17] who stated that transthoracic US-guided lung biopsy had a specificity and sensitivity of 91.52%, while being a safe method, with a low complication rate of 8.47%, in a study of 89 patients with peripheral lung tumors, hospitalized at the Municipal Clinical Hospital Oradea. Also, these results agree with [18] who reported that the yield and safety of sonar-guided transthoracic



cutting-needle biopsies of thoracic lesions were very good with an overall diagnostic accuracy rate of 84% and a sensitivity of 85.5% for malignant lesions. Also, these results agree with [19] who mentioned that ultrasound can be helpful in guiding a percutaneous transthoracic core biopsy with a sizeable bore Tru-Cut needle. The diagnostic sensitivity in malignant thoracic tumors was up to 96% and accuracy was 97%.

Our study has several limitations. First, the number of the patients was small despite the observable variations regarding diagnosis, lesion size, and location. Second, there was a selection bias because only lesions that were in contact with pleural tissue were selected for biopsy. Further future study can be done on a large number of patients with peripheral lung lesions comparing the Tru-Cut needle with other types of needles.

## Conclusion

Percutaneous transthoracic core biopsy with a Tru-Cut needle under ultrasound guidance is a secure and sensitive way of obtaining specimens for accurate histological diagnosis of thoracic tumors. The diagnostic yield is significant, and the approach is simple enough to be used as an outpatient procedure. The limitations of this study include the following:

## Abbreviations

US: Ultrasonography; MPM: Malignant pleural mesothelioma; TB: Tuberculosis; SCLN: Scalene lymph node; TUS: Transthoracic ultrasonography; CT: Computed tomography; PPV: Positive predictive value

## Acknowledgements

All patients in this research have been thanked by the authors. The authors also thank their colleagues in the Departments of Chest, University of Cairo and Beni-Suef for their support.

## Authors' contributions

The work was actively participated by all the authors and all the authors read and agreed to present the manuscript. NL did the design of the studies, thoracentesis and pleural biopsy, data processing and analysis, manuscript design, and revision and approval of the final manuscript. KM did the design of the study, data acquisition and interpretation, thoracic and pleural biopsy performance, drafting manuscripts, review, and endorsement. RY did the plan, data acquisition and analysis, thoracentesis and pleural biopsy, drafting of manuscripts, reviews, and final approval research. MF did the design of the studies, data acquisition and interpretation, thoracentesis and pleural biopsy, handwriting, revision, and final approval

## Funding

This study did not obtain any specific grant from public, commercial, or non-profit funding agencies.

## Availability of data and materials

The data used and/or analyzed during the present study is accessible on reasonable request from the respective author.

## Declarations

### Ethics approval and consent to participate

Institutional research ethics committee, Faculty of Medicine, Beni-Suef University has approved this study by committees reference number FWA00015574/FMBSUREC/01092020/Mohamed. Written informed consent was obtained from all study participants before being enrolled in the study.

## Consent for publication

Written informed consent was taken from the patients for the disclosure of their details.

## Competing interests

The authors declare that they have no competing interests.

## Author details

<sup>1</sup>Chest Diseases, Faculty of Medicine, Beni-Suef University, Beni-Suef, Egypt. <sup>2</sup>Chest Diseases, Faculty of Medicine, Cairo University, Giza, Egypt. <sup>3</sup>Hospital of Chest Diseases, Beni-suef, Egypt.

Received: 29 September 2020 Accepted: 7 June 2021

Published online: 15 June 2021

## References

- Rivera MP, Detterbeck F, Mehta AC (2003) Diagnosis of lung cancer: the guidelines. *Chest* 123(1):129S–136S. [https://doi.org/10.1378/chest.123.1\\_suppl.129S](https://doi.org/10.1378/chest.123.1_suppl.129S)
- Chira R, Chira A, Mircea PA (2012) Intrathoracic tumors in contact with the chest wall—ultrasonographic and computed tomography comparative evaluation. *Med Ultrasonography* 14(2):115–119
- Balik M, Plasil P, Waldauf P, Pazout J, Fric M, Otahal M, Pachel J (2006) Ultrasound estimation of volume of pleural fluid in mechanically ventilated patients. *Intensive Care Medicine* 32(2):318. <https://doi.org/10.1007/s00134-005-0024-2>
- Tsai T-H, Jerng J-S, Yang P-C (2008) Clinical applications of transthoracic ultrasound in chest medicine. *J Med Ultrasound* 16(1):7–25. [https://doi.org/10.1016/S0929-6441\(08\)60002-8](https://doi.org/10.1016/S0929-6441(08)60002-8)
- Diacon AH, Theron J, Schubert P, Brundyn K, Louw M, Wright C, Bolliger C (2007) Ultrasound-assisted transthoracic biopsy: fine-needle aspiration or cutting-needle biopsy? *Eur Respir J* 29(2):357–362
- Chira RI, Chira A, Mircea PA, Valean S (2017) Mediastinal masses—transthoracic ultrasonography aspects. *Medicine* 96(49):e9082
- Agmy G, Mohamed S, Gad Y: Transthoracic chest ultrasound in critically ill patients: comparison with bedside chest radiography. *Eur Respir J* 2014, 44(Suppl 58):P4968.
- Bediwy AS, Badawy ME, Salama AA, Zayed HA (2015) The use of multi-detector computed tomography and ultrasonography for evaluation of pleural lesions. *Egypt J Chest Dis Tuberculosis* 64(1):161–168. <https://doi.org/10.1016/j.ejcdt.2014.09.001>
- Ahmed E, Abou Bakr S, Eid H, Shaarawy A, Elsayed W (2017) Role of ultrasonography in the diagnosis of pleural effusion. *Egypt J Bronchol* 11(2): 120–127. <https://doi.org/10.4103/1687-8426.203797>
- Amin H (2016) Role of transthoracic ultrasound in the diagnosis of some chest diseases. *Egypt J Chest Dis Tuberculosis* 65(4):851–858. <https://doi.org/10.1016/j.ejcdt.2016.03.007>
- Ferreira AC, Mauad Filho F, Braga T, Fanstone GD, Chodraui ICB, Onari N (2006) The role of ultrasound in the assessment of pleural effusion. *Radiologia Brasileira* 39(2):145–150
- Kamel K (2011) Abd El Hafeez A, Fathella W: Diagnostic role of thoracic ultrasonography in pleural effusion. *Egypt J Chest Dis Tuberculosis* 60(2): 283–293
- Elhadidy A KK, Mohammed R: Comparison of ultrasonography guided fine needle aspiration cytology and tru-cut needle biopsy in intrathoracic and chest wall lesions: cairo university; 2016.
- Hafez MR, Sobh ES, Elsayy SB, Abo-Elkheir OI (2017) The usefulness of thoracic ultrasonography in diagnosis and staging of bronchogenic carcinoma. *Ultrasound* 25(4):200–212. <https://doi.org/10.1177/1742271X17721264>
- Akl YM, Emam RH, Sabry IM, Ali AA (2013) Clinico-pathological profile of bronchogenic carcinoma cases presented to Chest Department, Cairo University in the last 10 years. *Egypt J Chest Dis Tuberculosis* 62(4):705–712. <https://doi.org/10.1016/j.ejcdt.2013.09.019>
- Madkour M, El Bokhary M, Awad Allah H, Awad A, Mahmoud H (2009) Environmental exposure to asbestos and the exposure-response relationship with mesothelioma
- Davidescu L, Dragnea D, Ulmeanu R, Olar D: Ultrasound-guided transthoracic biopsy of the peripheral lung tumors—why do we need it? In: *Eur Respiratory Soc*; 2016.

18. Schubert P, Wright CA, Louw M, Brundyn K, Theron J, Bolliger CT, Diacon AH (2005) Ultrasound-assisted transthoracic biopsy: cells or sections? *Diagnostic cytopathology* 33(4):233–237. <https://doi.org/10.1002/dc.20342>
19. Yang P-C, Luh K-T, Chang D-B, Wu H-D, Yu C-J, Kuo S-H (1992) Value of sonography in determining the nature of pleural effusion: analysis of 320 cases. *AJR* 159(1):29–33. <https://doi.org/10.2214/ajr.159.1.1609716>

### **Publisher's Note**

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

**Submit your manuscript to a SpringerOpen<sup>®</sup> journal and benefit from:**

- ▶ Convenient online submission
- ▶ Rigorous peer review
- ▶ Open access: articles freely available online
- ▶ High visibility within the field
- ▶ Retaining the copyright to your article

---

Submit your next manuscript at ▶ [springeropen.com](https://www.springeropen.com)

---