Safety and diagnostic yield of thoracic ultrasound-assisted transthoracic biopsy performed by a pulmonologist

Laila Ashour[a], Eman Ramzy[a], Mohamed El-Gharib[b], Rehab Maher[a], Dalia El-Embaby[a]

Background Transthoracic ultrasonography (US) is still not utilized to its full potential by respiratory physicians, despite being a well-established and validated imaging modality. It allows for an immediate and mobile assessment that can potentially augment the physical examination of the chest. This work aims to assess safety and diagnostic yield of thoracic US-assisted transthoracic biopsy performed by a pulmonologist.

Patients and methods The present study was conducted upon 75 patients who are referred to the Pulmonary Medicine Department, Ain Shams University Hospitals with radiological assessment that reveals pleural-based mass with or without pleural effusion, anterior mediastinal mass, peripheral lung lesions or chest wall lesions. The present study was conducted upon 75 (67 male and 8 female) patients with mean±SD age 58.8±15.64.

Results This study showed that 31 cases were presented by peripheral pulmonary mass, 29 pleural lesions, nine mediastinal and six chest wall lesions, 57 of them diagnosed by sonar guided biopsy, 51 of them were malignant and the remaining six were benign.

Conclusion Transthoracic US-assisted cutting-needle biopsy is an excellent first-line diagnostic tool for pleural-based lesions of at least 3 cm in diameter. It is a quick, low-cost, safe and well-tolerated tool in the hands of pulmonologists and has a high sensitivity for pleural-based malignancies.

Egypt J Bronchol 2018 12:427–432
© 2018 Egyptian Journal of Bronchology

Egyptian Journal of Bronchology 2018 12:427–432

Keywords: biopsy, chest, interventional, lung, mesothelioma, pleura, ultrasonography

Departments of, [a]Pulmonary Medicine, [b]Interventional Radiology, Faculty of Medicine, Ain Shams, University, Cairo, Egypt

Correspondence to Dalia El-Embaby, MB, BCh, MSC, 12 Abdallah Pasha Street, Matareyya, Cairo, 11211, Egypt. Mob: +201015104087; fax: +2022516500;
e-mail: dr.daliaelembaby333@gmail.com

Received 28 February 2016 **Accepted** 6 March 2016

Introduction

Transthoracic ultrasound (US) has many advantages that make it an ideal investigation in a healthcare system with limited resources, the most significant being its cost in terms of acquisition, maintenance and consumables. Furthermore it is mobile, utilizes no radiation and has a short examination time. Moreover, US-assisted biopsy can be performed by a single clinician with no sedation and minimal monitoring, even potentially outside of theatre [1].

US has found a firm place in chest medicine as an aid for assessing pleural effusions at the bed side. This development was facilitated by the advent of affordable, lightweight and mobile US units. Although less practiced by physicians, US can also visualize solid lesions arising from the pleura, chest wall and anterior mediastinum, and even lung tumors and consolidations are detected without difficulty provided they extend to the parietal pleura. US is an ideal tool to assist with biopsy procedures. It can frequently replace computed tomography (CT) guidance at much lower cost [2].

Firstly, large vessels and aerated lung parenchyma can easily be detected with US, which minimize the risk of pneumothorax and improve safety. Secondly, US can be performed at the bedside and in anybody position allowing for swift procedures with minimal distress even in patients in poor general condition. And lastly, the integration of US into a 'low-tech' procedure by chest physicians can reduce the need for more expensive radiological or surgical biopsy [3].

The usefulness of thoracic US rests with its immediate application. The US examination is integrated with the results of the physical examination and the clinical impression. There is no time delay, which is inherent to standard radiographic techniques, and the pulmonologist applies the results with full clinical knowledge of the patient, unlike the radiologist [4].

Patients and methods

The present study was conducted upon 75 patients who were referred to Pulmonary Medicine Department, Ain Shams University Hospitals with radiological assessment that revealed pleural-based lesions with

This is an open access article distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 3.0 License, which allows others to remix, tweak, and build upon the work noncommercially, as long as the author is credited and the new creations are licensed under the identical terms.

 DOI: 10.4103/ejb.ejb_11_16

or without pleural effusion, anterior mediastinal mass that were anterior in location and were in contact with the chest wall, peripheral lung lesion adjacent to and/or abutting the pleura, or chest wall lesions with an accessible 'US window' were enrolled in the study. The Research Ethics Committee at the Faculty of Medicine, Ain Shams University has approved the study (FMASU 1594/2013). Informed consent was obtained from all patients enrolled. The following variables were initially studied: age, sex, occupation, residence, chronic diseases, history of medications, smoking history, symptoms, general and local examination, laboratory investigations (complete blood picture, kidney and liver function tests, and bleeding profile), radiological evaluation (chest radiography and CT of the chest) to evaluate site, size, local extent of the lesion.

Technique

US examinations of thoracic structures are done with Mindray DP 1100, Mindray Bio-Medical Electronics Co., Shenzhen, China ultrasound machine using a 3.5C (bandwidth 2–5 MHz) convex phased array probe. The probe was placed horizontally and/or vertically along each intercostal space of (mid clavicular line, anterior axillary line, and posterior axillary line) on both sides. Transverse and longitudinal scans are used with intercostal, subcostal, suprasternal and parasternal, or paravertebral accesses.

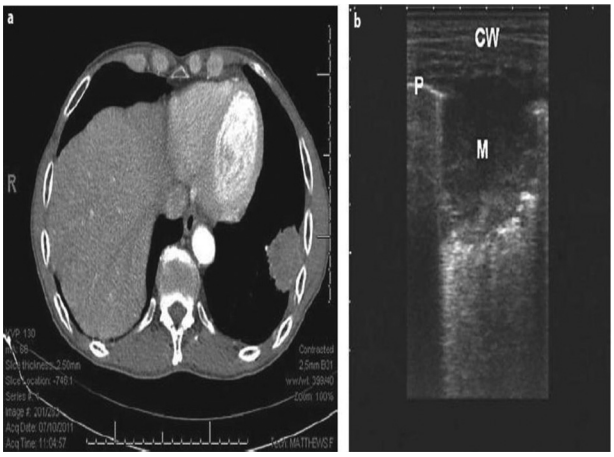
The patient can be examined in the supine, prone, lateral or seated position, depending on the area being examined, operator maneuverability, and patient comfort. The main objective in all cases is to find an acoustic window that allows adequate visualization of the lesion.

When the lesion had been identified and the patient positioned, the procedure began with the administration of a local anesthetic, which could be given subcutaneously or injected into the pleura. Depending on its caliber, the needle itself could be inserted with a free-hand technique or with the aid of a needle guide. Before the procedure careful planning (centering of the lesion, identify the pathway along which the needle would be advanced) shortens procedure time and reduces complications. When the lesion had been identified and the patient positioned, the procedure began with the administration of a local anesthetic, which could be given subcutaneously or injected into the pleura. Depending on its caliber, the needle itself could be inserted with a free-hand technique or with the aid of a needle guide. After the procedure all patients were hospitalized for 2-h to be adequately clinically monitored after the procedure. The specimen was sent for histopathological examination and radiological assessment using chest-radiography and chest US to detect any possible complication (Figs 1–3).

Results

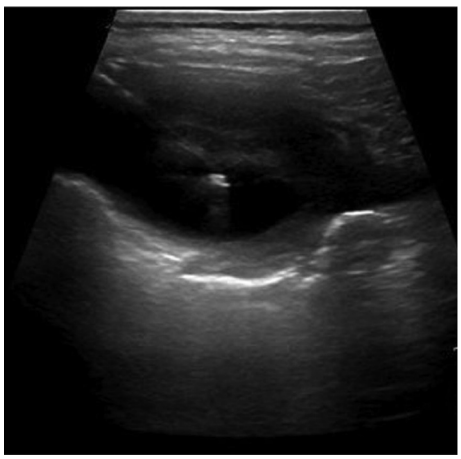
Seventy-five patients were included in this study; 67 were males and eight were females with a mean±SD age of 51.28±14.29 years. These 75 patients were having 31 peripheral parenchymal lesions, 29 pleural lesions, nine mediastinal lesions and six chest wall lesions. This procedure diagnose 57 lesions out of

Figure 1



High-frequency US image. It allows the determining of its full depth of lesion. Note the extension of the lung mass (M) beyond the pleura (P) into the chest wall (CW).

Figure 2



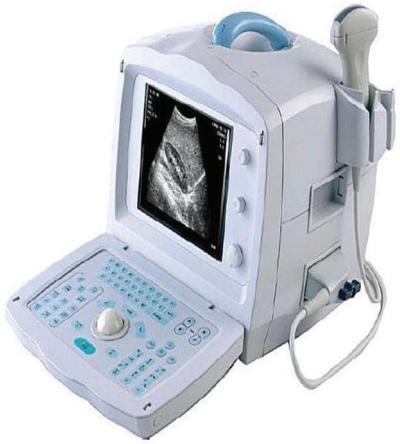
Biopsy of a metastatic pleural lesion in a patient with a history a squamous-cell carcinoma). The ultrasound image shows an expanding lesion on the pleural side.

the 75 (76%) patients; according to the final diagnoses of the 57 US diagnosed lesions, 51 (89.4%) lesions were malignant mostly non-small-cell lung cancer and mesothelioma and six (10.6%) lesions were benign, the other 18 (12 pleural and six peripheral parenchymal) cases were diagnosed either by fiberoptic bronchoscopy, thoracoscopy, CT guided biopsy or surgery. As regard the lesions diameter of peripheral parenchymal, mediastinal and chest wall lesions were ranged from 3 to 15 cm with a mean±SD of 5.39±2.01, while thickness of pleura were ranged from 2 to 4 cm with a mean of 3.18±0.72. Correlation between tumor size and diagnosis by chest US is shown in Table 1 which shows that there was highly statistically significant difference between diagnosed and undiagnosed lesions by US in relation to size of lesion. There was statistically positive correlation between size of lesion and diagnostic yield as increase of lesion size associated with increase diagnostic yield.

Correlation of lesion diameter and pleural thickness to complications is shown in Table 2 which shows that there was no statistically significant difference between complicated and noncomplicated cases according to size and site of lesion.

Out of the 29 pleural lesions; 24 was biopsied by Tru-cut needle and the other five by fine needle aspiration needle while the 31 peripheral parenchymal lesions 26 of them biopsied by fine needle aspiration needle while the other five by Tru-cut needle. The nine mediastinal lesions eight of them biopsied by fine needle aspiration needle while the other one by Tru-cut needle. All of chest wall lesions were biopsied by fine needle aspiration needle. Table 3 shows correlation of type of needle to diagnostic yield and confirmed that there was statistically significant difference between the type of needle and diagnostic yield, as diagnostic yield was increased in cases where fine needle aspiration was used.

Figure 3



Mindray DP 1100 ultrasound.

Table 1 Correlation between tumor size and diagnosis by chest ultrasound

	Diagnosed (*n*=57)	Nondiagnosed (*n*=18)	*t*	*P* value
Diameter of lesion (minimum–maximum) (cm)	2.5–15	2–4	5.35	0.0001**
Mean±SD	5.21±1.92	2.75±0.49		

**Highly significant.

Table 2 Correlation of lesion diameter and pleural thickness to complications

	Noncomplicated (*n*=57)	Complicated (*n*=18)	*t*	*P*
Lesion diameter (cm)	*N*=34	*i*=14	0.24	0.8
	5.44±1.48	5.28±3.02		
Thickness of pleura	*N*=23	*N*=4	0.2	0.8
	3.17±0.74	3.25±0.64		
Site of lesion [*n* (%)]				
Pleural	24 (42.1)	5 (27.8)	5.59	0.06
Parenchymal	18 (31.5)	13 (72.2)		
Mediastinal	9 (15.8)	0 (0)		
Chest wall	6 (10.6)	0 (0)		

Table 3 Correlation of type of needle to diagnostic yield

	Total (*n*=75) [*n* (%)]	Diagnosed (*n*=57) [*n* (%)]	Nondiagnosed (*n*=18) [*n* (%)]	*t*	*P*-value
Tru-cut needle	30 (40)	22 (73.3)	8 (26.7)	2.96	0.048703
Fine needle aspiration needle	45 (60)	35 (77.7)	10 (22.3)		

Table 4 shows that there was no statistically significant difference between the type of needle and complications.

Table 5 shows that there was statistically significant correlation between complications and each of the time of the procedure. Long time procedures were associated with more complications than short time procedures.

Eighteen cases were complicated; 10 by hemoptysis and improved with hemostatic measures, three by local Superficial hematoma improved by local ointment, two by chest pain improved with analgesics, two by pneumothorax, resolved with conservative measures and one case complicated by dyspnea and resolved spontaneously.

Discussion

As a guide to diagnostic procedures, US not only potentially increase the diagnostic yield, but also minimize risk compared to blind procedures. It is therefore ideal for image-guided chest wall, pleura, peripheral pulmonary and mediastinal interventions, including diagnostic thoracocentesis and biopsy [5]. The current study aimed to study the safety and diagnostic yield of thoracic US-assisted transthoracic biopsy performed by a pulmonologist.

For calculation of sensitivity and specificity, histological diagnosis of a specific neoplastic disease was accepted as true positive for malignancy. True negative for malignancy were lesions with nonmalignant histology if confirmed by surgical biopsy.

Depending on that scoring system, diagnosis of peripheral lung masses had a sensitivity of 80.6% and a specificity of 66%, with a positive and negative predictive value of 92 and 40%, respectively. While diagnosis of pleural lesions showed a sensitivity of 58.6% and a specificity of 75%, with a positive and negative predictive value of 85 and 42.8%, respectively. These results were in partial agreement with Diacon *et al.* [2] who worked on 90 patients with a sensitivity of 90% and a specificity of 100%, with a positive and negative predictive value of 100 and 57.7%, respectively. This was also agreed with Heilo *et al.* [6] who worked on 70 patients and had 80% sensitivity with specificity of 80% with a positive and negative predictive value of 90 and 45%, respectively.

The biopsy needle selected depends upon lesion characteristics, type/amount of tissue required, and operator preference as reported by Gong *et al.* [7] and Diacon *et al.* [2]. Fine needle aspiration and Tru-cut needle were used in the current study; 29 pleural lesions were biopsied, Tru-cut needle biopsy was used in 24 (82.7%) lesions with diagnostic yield in 16 (55.1%) lesions while was nondiagnostic in the other eight (27.6%) lesions, while fine needle aspiration biopsy used for the other five (17.3%) lesions with only one (3.4%) lesion diagnosed and the other four (13.9%) lesions were nondiagnosed.

Tru-cut needle biopsy was used more frequently in the pleural lesions as it is safe targets for it because they are not mobile on respiration and are not surrounded by lung tissue. Also it has much more diagnostic yield in comparison with fine needle aspiration biopsy; all of that was in agreement with Diacon *et al.* [2] who did fine needle aspiration biopsy with a significantly higher yield than Tru-cut needle biopsy in neoplastic disease (91 vs. 82%), mainly due to a higher yield in lung carcinoma; but in pleural lesions Tru-cut needle biopsy had much more superiority than fine needle aspiration biopsy.

Table 4 Correlation between type of complication and type of needle

	No complications (*n*=57)	Complications (*n*=18)	χ^2	*P*
Fine needle Tru-cut	37	7	3.24	0.07
	20	11		

	Chest pain (*n*=2)	Dyspnea (*n*=1)	Hemoptysis (*n*=10)	Pneumothorax (*n*=2)	Hematoma (*n*=3)	χ^2	*P*
Fine needle Tru-cut	0	0	5 (50)	0	1 (33.3)	1.86	0.7
	2 (100)	1 (100)	5 (50)	2 (100)	2 (66.7)		

Table 5 Correlations between complications and each of time of the procedure

Time of procedure [range (mean±SD)]	2060 min			32.53±12.2
	No complications (*n*=57)	Complications (*n*=18)	*t*	*P*
Time (minimum–maximum) (mean±SD)	20–40 (24.7±5.72)	20–60 (33.62±12.83)	2.77	0.007*

*Significant.

On the other hand, peripheral lung masses were biopsied mainly by fine needle aspiration biopsy in 26 (84%) lesions out of 31 lesions with diagnostic yield in 22 (71%) lesions while nondiagnosed in four (13%) lesions, the other five lesions biopsied by Tru-cut needle biopsy was diagnostic in three (9.6%) lesions and nondiagnostic in the other two (6.4%) lesions. Chest wall lesions and mediastinal lesions were all diagnosed by fine needle aspiration biopsy except one mediastinal lesion diagnosed by Tru-cut needle biopsy.

From above data most diagnoses were established with US-assisted fine needle aspiration biopsy in peripheral lung lesions, mediastinal and chest wall lesion while US-assisted Tru-cut needle biopsy was more effective in pleural lesions, this is in agreement with Diacon *et al.* [2]. It is reasonable to assume that fine needle aspiration biopsy causes less tissue damage than Tru-cut needle biopsy and is therefore an inherently safer procedure. While Diacon *et al.* [2] used both maneuvers in the same lesion for some cases, here in this current study we used only one maneuver for each lesion due to lack of materials and refusal of the patients themselves.

Thickness of pleural lesions in the 29 lesions ranged from 2 to 4 cm with mean±SD (3.18±0.72) while other 46 lesions diameters in peripheral lung masses, mediastinal masses and chest wall masses ranged from 2.5 to 15 cm with mean±SD (5.39±2.01). Fifty-seven lesions out of 75 lesions with diameter or thickness of at least 2.5–15 cm were diagnostic by either fine needle aspiration biopsy or Tru-cut needle biopsy. This was statistically significant results concomitant with Diacon *et al.* [8], Hayata *et al.* [9] and who reported that the diagnostic accuracy was higher for large (>2 cm) peripheral pulmonary carcinomas [90% (60 of 67 lesions)] than for small ones [75% (12 of 16 lesions)] while Li *et al.* [10] found that the diagnostic yield was lower for small (<1.5 cm in diameter) peripheral pulmonary nodules [74% (20 of 27 lesions)] than for large ones [96% (67 of 70 lesions)].

The biopsies were generally well tolerated with minor complications. Complications occurred in 18 (24%) patients the most common was hemoptysis (55.5%), followed by superficial hematoma in 16.8%, chest pain and pneumothorax 11.1% for each and finally dyspnea occurring in 5.5%.

Pneumothorax occurred with Tru-cut needle biopsy in lesion less than 3 cm in diameter which was not adherent to the parietal pleura in biopsing peripheral lung mass, but it was small pneumothorax and resolved without intervention. This incidence was much lower than the incidence of pneumothorax in patients undergoing transthoracic needle biopsy has been reported by Choi *et al.* [11] to be from 9 to 54%, with an average of around 20%. The other complications were mild and transitory hemoptysis which occurred in 10 patients, half of them in Tru-cut needle biopsy and other half during fine needle aspiration biopsy and all during biopsy of peripheral lung masses. It was self-limited and stopped by hemostatic measures. Focal hemorrhage may occur around the biopsied lesion or along the needle tract, and typically requires no intervention.

The incidence of hemoptysis was slightly higher than its incidence in literature (7%) as mentioned by Berquist *et al.* [12]. Regarding relation of lesion diameter and pleural thickness to incidence of complications it was found that US-assisted cutting needle biopsy performed by a pulmonologist is safe and effective in lesions of at least 3 cm in diameter abutting or involving the pleura; this lesion size was in variance with Diacon *et al.* [2] in whom biopsying lesions was safe in lesions of at least 2 cm in diameter as in current study lesion size was at least 2.5 cm, so no interventions was done in lesions 2 cm as in Diacon *et al.* [2].

The low rate of adverse events in the present study confirms that the lesion size, depth and selected needle types-fine needle aspiration biopsy were more available than the Tru-cut needle in this study were adequate, while selection of patients with no preexistent lung disease and nonselection of patients of old age were also causes of low complication rate. US has the inherent safety advantage of visualizing only lesions not shielded by air-containing tissue. Aerated lung is therefore not transverse with the biopsy device, which makes pneumothorax and air embolus unlikely when a closed cutting-needle system is used.

Mean procedure time was 32.5 min (range: 20–60 min). Complications occurred more in procedures with longer time of interventions around 33.6 min which was in the first half of study due to less experience that caused more consumption of time and more complications; while complications was of lower incidence in shorter periods around 24.7 min which was in last half of study due to acquired experience. Twelve complications occurred in the first half versus six in the second half of the series due to the explanations mentioned above. All of that was nearly in agreement with Diacon *et al.* [8].

The above results of the present study suggests that 'low-tech' US assistance might substitute CT guidance for lesions of at least 3 cm in diameter, irrespective of the presence of a pleural effusion.

Conclusion

Transthoracic US-assisted cutting-needle biopsy is an excellent first-line diagnostic tool for pleural-based lesions of at least 3 cm in diameter. It is a quick, low-cost, safe and well-tolerated tool in the hands of pulmonologists and has a high sensitivity for pleural-based malignancies.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1 Koegelenberg C, Bolliger C, Diacon A. Transthoracic ultrasound of the chest wall, pleura, and the peripheral lung. In: Bolliger CT, Herth FJ, Mayo PH, Miyazama TF, Beamis JF, editors. *Progress in respiratory research. clinical chest ultrasound*. Basel: Karger 2008. pp. 22–33.

2 Diacon A, Theron J, Bolliger C. Transthoracic ultrasound for the pulmonologist. *Curr Opin Pulm Med* 2007; **11**:307–312.

3 Herth F, Becker H. Transthoracic ultrasound. *Respiration* 2003; **70**:87–94.

4 Havelock T, Teoh R, Laws D, Gleeson F. Pleural procedures and thoracic ultrasound: British Thoracic Society pleural disease guideline. *Thorax* 2010; **65**:75–90.

5 Koegelenberg C, Bolliger C, Theron J. Direct comparison of the diagnostic yield of ultrasound assisted Abrams and Tru-Cut needle biopsies for pleural tuberculosis. *Thorax* 2010; **65**:857–862.

6 Heilo A, Stenwig A, Solheim O. Malignant pleural mesothelioma: US-guided histologic core-needle biopsy. *Radiology* 1999; **211**:657–659.

7 Gong Y, Sneige N, Guo M. Transthoracic fine-needle aspiration vs concurrent core needle biopsy in diagnosis of intrathoracic lesions: a retrospective comparison of diagnostic accuracy. *Am J Clin Pathol* 2006; **125**:438–444.

8 Diacon A, Schuurmans M, Theron J. Safety and yield of ultrasound assisted transthoracic biopsy performed by pulmonologists. *Respiration* 2005; **71**:519–522.

9 Hayata Y, Oho K, Ichiba M. Percutaneous pulmonary puncture for cytologic diagnosis: its diagnosticvalue for small peripheral pulmonary carcinoma. *Acta Cytol* 2000; **17**:469–475.

10 Li H, Boiselle P, Shepard J. Diagnostic accuracy and safety of ultrasound-guided percutaneous needle aspiration biopsy of the lung: comparison of small and large pulmonary nodules. *Am J Roentgenol* 1996; **167**:105–109.

11 Choi C, Um S, Yoo C. Incidence and risk factors of delayed pneumothorax after transthoracic needle biopsy of the lung. *Chest* 2004; **126**:1516–1521.

12 Berquist T, Bailey P, Cortese D. Transthoracic needle biopsy: accuracy and complications in relation to location and type of lesion. *Mayo Clin Proc* 1999; **55**:475–481.