Egyptian Journal of Chest Diseases and Tuberculosis (2014) 63, 1025–1034

HOSTED BY

The Egyptian Society of Chest Diseases and Tuberculosis

Egyptian Journal of Chest Diseases and Tuberculosis

www.elsevier.com/locate/ejcdt
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ORIGINAL ARTICLE

Study of the added value of transthoracic ultrasound in staging of lung cancer

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Received 10 March 2014; accepted 22 April 2014
Available online 3 June 2014

KEYWORDS

Lung cancer;
Staging;
Transthoracic ultrasound

Abstract *Introduction:* Lung cancer is one of the leading causes of cancer-related deaths in the world and early detection and proper staging are highly important for planning of treatment strategy.

Aim of the work: To study the possible added value of transthoracic ultrasound (TUS) in staging of lung cancer.

Patients and methods: The study was carried out at Chest Department, Kasr El-Aini hospital in the period from April 2012 to December 2012. TUS was carried out on 50 cases with primary lung cancer after revision of CT chest images.

Results: TUS was only able to detect pulmonary masses in 31 cases (they had an ultrasound (US) window to reach the tumor mass). The study found that TUS was more able to detect more cases with chest wall invasion than CT chest and it was able to differentiate between visceral and parietal pleural invasion. It was also not only more able to detect the presence of pleural fluid encystation than CT scan detection but also was more able to further characterize its type. Diaphragmatic mobility was also assessed by TUS. There was also a statistical significant difference between TUS and CT chest in detecting consolidation and/or collapse.

Conclusion: TUS is complementary and adding a value to both clinical and computerized tomographic diagnoses of lung cancer. It can help in staging of lung cancer and aid chest physicians in determining the modality of treatment in each patient depending on his/her stage.

Introduction

Lung cancer is one of the leading causes of cancer-related deaths in the world. Invasion of the parietal pleura, the visceral pleura, or the bony structure of the chest wall occurs in 5–8% of patients with non-small cell lung cancer who are undergoing surgical treatment, and alters the TNM classification, staging, and planned treatment approaches. Therefore, it is important to determine the extent of disease prior to surgery, as this will impact disease management and prognosis [1].

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Peer review under responsibility of The Egyptian Society of Chest Diseases and Tuberculosis.

0422-7638 http://dx.doi.org/10.1016/j.ejcdt.2014.04.004

Table1 Clinical characteristic of the study population.

No.	Age (mean ± SD)	Sex		Diagnosis	
		Male	Female	NSCLC	SCLC
50	58.52 ± 9.19	43	7	46	4

Table2 Assessment of chest wall invasion, visceral pleural invasion and parietal pleural invasion.

Total cases	Chest wall invasion by CT		Chest wall invasion by US		Visceral pleural invasion by US		Parietal pleural invasion by US	
31	No.	%	No.	%	No.	%	No.	%
	5	16.1	9	29	17	54.8	14	45.1

Table 3 Presence of effect (collapse and consolidation) by US & CT.

Modality	Effect			No Effect	Total	*P*-Value
	Collapse	Consolidation	Collapse & consolidation			
CT	8	1	0	41	50	$P < 0.001$*
TUS	13	2	4	31		

* Significant at $P < 0.001$.

Table 4 Detection of pleural fluid encystations by CT and TUS.

Modality	Free effusion	Encysted effusion	*P*-Value
CT	12	4	0.013
TUS	5	11	

Table 5 Diaphragmatic mobility in relation to elevated copula by CT.

		Elevated copula By CT chest		
		Yes	No	Total
Diaphragm mobility by US	Mobile	6	39	45
	Immobile	1	4	5
	Total	7	43	50

Table 6 Comparison between clinical detection and US detection of supraclavicular lymph node.

Modality	LN present	LN absent	Total	*P*-Value
Clinical detection	2	48	50	0.008
US detection	5	45		

Table 7 T Stage after US and before U/S.

		Before US T stage				
After US T stage		T2a	T2b	T3	T4	Total
	T2a	11	0	0	1	12
	T2b	2	5	1	0	8
	T3	5	2	17	0	24
	T4	0	0	0	6	6
	Total	18	7	18	7	50

In assessment of T Stage after US and before U/S there was no change in 39 cases with total agreement = (11 + 5 + 17 + 6) / 50 = 78%, 9 cases changed to a more advanced stage after TUS and 2 cases changed to a less advanced stage after TUS.
Down staging by US = 2/50 = 4%.
Up staging by US = (2 + 5 + 2)/50 = 18%.

Table 8 Overall Stage after US and before U/S in 50 patients.

		Before US stage						
After US stage		1b	2a	2b	3a	3b	4	Total
	1b	7	0	0	0	0	0	7
	2a	1	5	0	0	0	0	6
	2b	1	1	7	0	0	0	9
	3a	0	1	1	11	0	0	13
	3b	0	0	0	0	2	0	2
	4	0	0	0	0	0	13	13
	Total	9	7	8	11	2	13	50

In assessment of the overall Stage after US and before US there was no change in 45 cases with total agreement = (7 + 5 + 7 + 11 + 2 + 13)/50 = 90%.
Five cases changed to a more advanced stage after TUS due to the change of T stage.
Up staging by US = (1 + 1 + 1 + 1 + 1)/50 = 10%.

The pre-operative evaluation in patients who will undergo operative staging or resection for lung cancer is multidimensional and involves detailed history taking, physical examination and review of imaging studies. Two important elements of both staging and pre-operative evaluations include the evaluation of: [1] the pleural space for the presence of malignant pleural effusion and [2] the diaphragm for appropriate movement. At this point in time, the pleural space evaluation is being performed using CT scan which does not allow the acquisition of real-time cytological material from pleural effusions due to the fact that the CT scans are done in a diagnostic setting.

Malignant pleural effusion is recognized as a poor prognosticator in non-small cell lung cancer patients and has recently been upgraded from a T4 to an M1a status [2].

Also diaphragmatic movement/excursion is not currently being assessed pre-operatively and its impact on staging and post-operative pulmonary function is unknown. Recognizing the stage early allows for more precise prognostication of disease and can lead to precision and streamlining of treatment plans for thoracic surgeons and oncologists [3].

The role of ultrasonography in the diagnosis and management of different diseases is rapidly changing due to changes in technology in the competing modalities, such as computed tomography and magnetic resonance imaging.

Aim of the work

To assess the added value of transthoracic ultrasonography in staging of lung cancer.

Subjects and methods

A prospective study that was conducted at Chest Department, Kasr El-Aini hospital, Cairo University, in the period from April 2012 to December 2012. Fifty patients with confirmed diagnosis of primary lung cancer were involved in the study.

After assessment of the finding on CT chest, detailed transthoracic evaluation was carried out using ultrasound equipment model HITACHI EUB 7000 and ultrasound probes with different frequencies (Convex probe 2–5 MHz, Mini convex probe 4–8 MHz, Linear probe 9–13 MHz). As a coupling medium water soluble ultrasound transmission gel was applied to the skin.US examination was performed with the patient in the supine or sitting position, according to the site of the lesion. The lung and the pleura were evaluated through longitudinal and oblique intercostal transducer application.

Diaphragmatic motion was examined while the patient remained in supine position in the longitudinal semi-coronal plane from a subcostal or low intercostal approach using M-mode ultrasonography.

Diagnostic thoracocentesis was performed for cases with detected pleural effusion, using fine 20 gauge needles and the fluid was sent for chemical and cytological analyses.

Supraclavicular lymph nodes were examined while the patient was placed in a supine position with the neck hyperextended. Enlarged nodes were aspirated with fine 20 gauge needles or biopsied via true-cut 18 gauge needle.

Statistical analysis

Data were statistically described in terms of mean ± standard deviation (±SD), number of cases, and percentages when appropriate. Chi-square test/fisher exact test was used for comparing categorical data. Cases having the same stage were calculated as a percentage of the total cases examined, to detect the percentage of agreement. *P* value was significant if less or equal than 0.05. All statistical calculations were done using computer programs SPSS (Statistical Package for the Social Science; SPSS Inc., Chicago, IL, USA) version 15 for Microsoft windows.

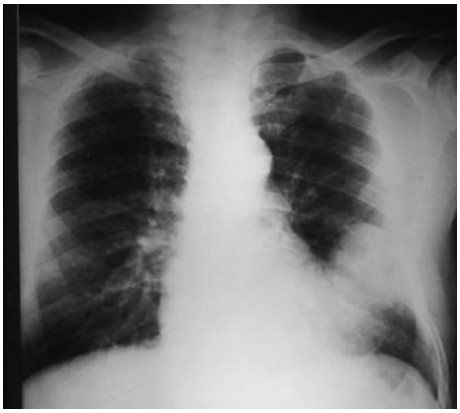
Results

Results are discussed in Tables 1–8.

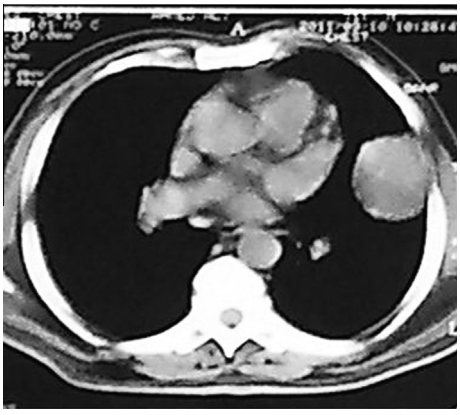
Case presentation

Case (1): Peripheral mass with intact visceral and parietal pleura

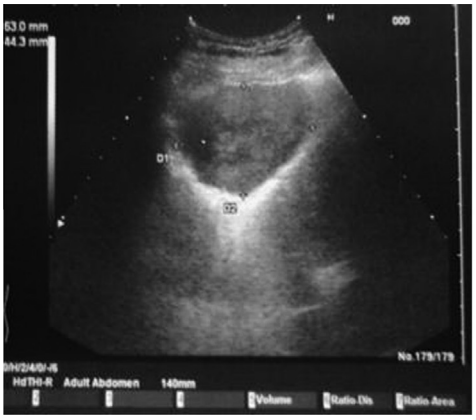
Chest X-ray: Fig. (1a)

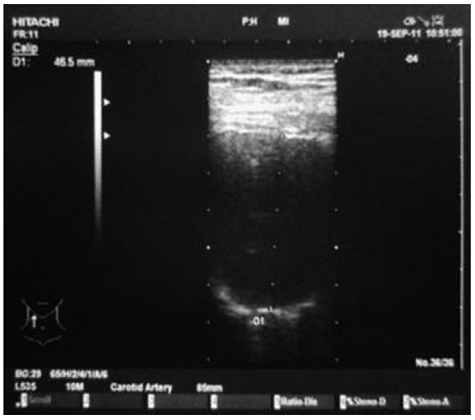


CT chest: Fig. (1b)



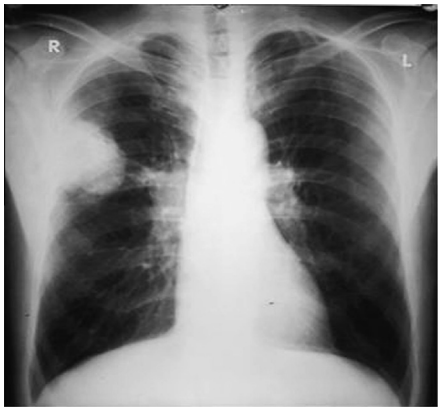
Transthoracic ultrasound: Fig. (1c)



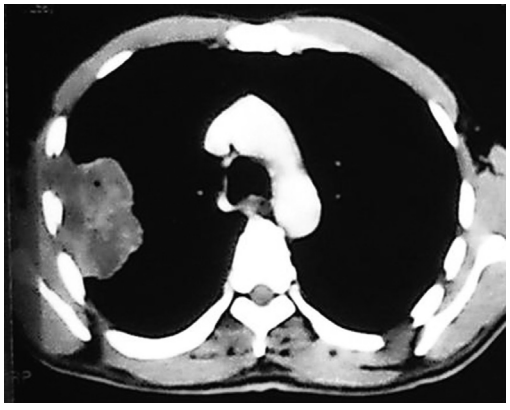


Case (2): Peripheral mass with chest wall invasion and rib erosion

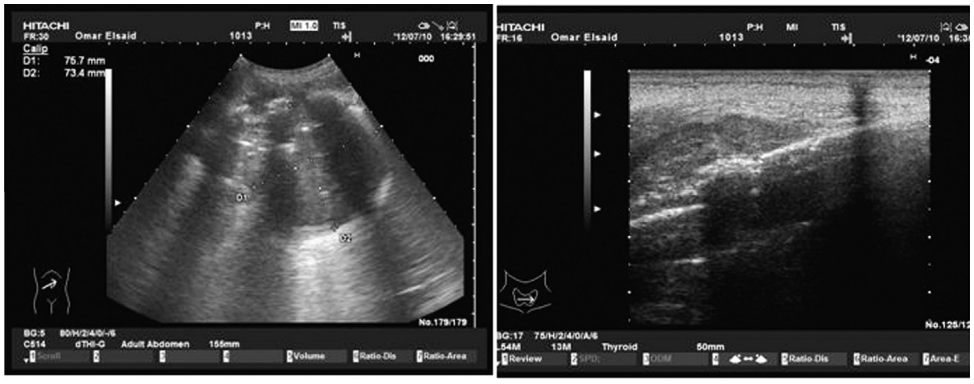
Chest X-ray: Fig. (2a)



CT chest: (Fig. 2b)

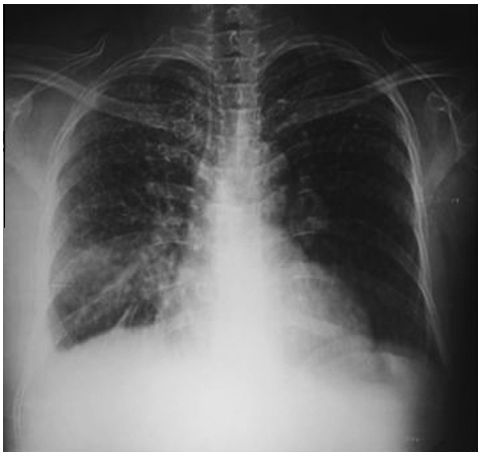


Transthoracic ultrasound: (Fig. 2c)

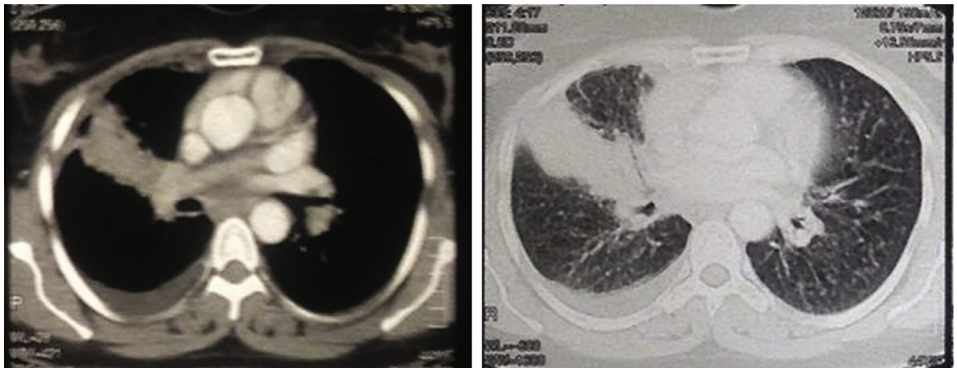


Case (3): TUS showing mass in the right mammary region and right pleural effusion with small right scalene LN

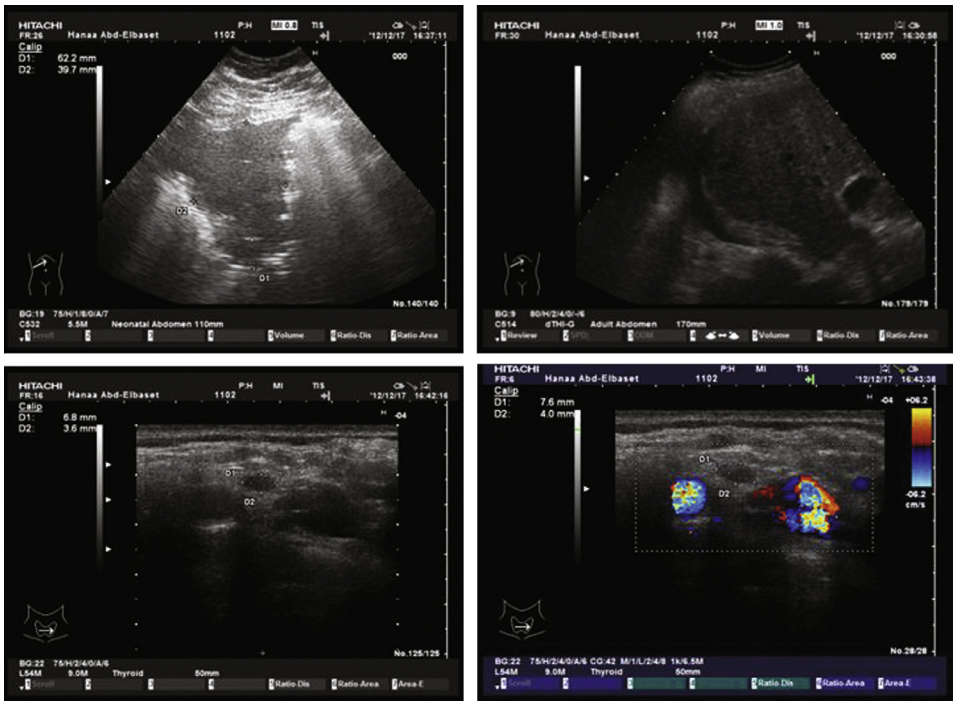
Chest X-ray: (Fig. 3a)



CT chest: (Fig. 3b)

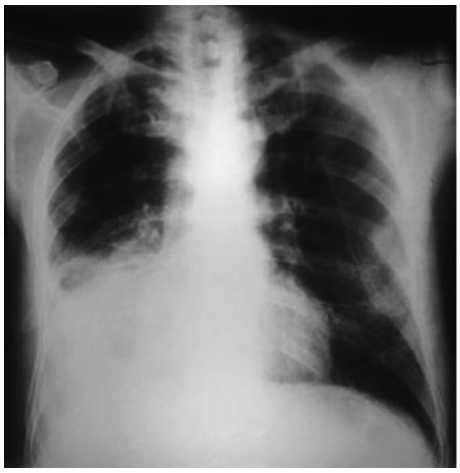


Transthoracic ultrasound: (Fig. 3c)

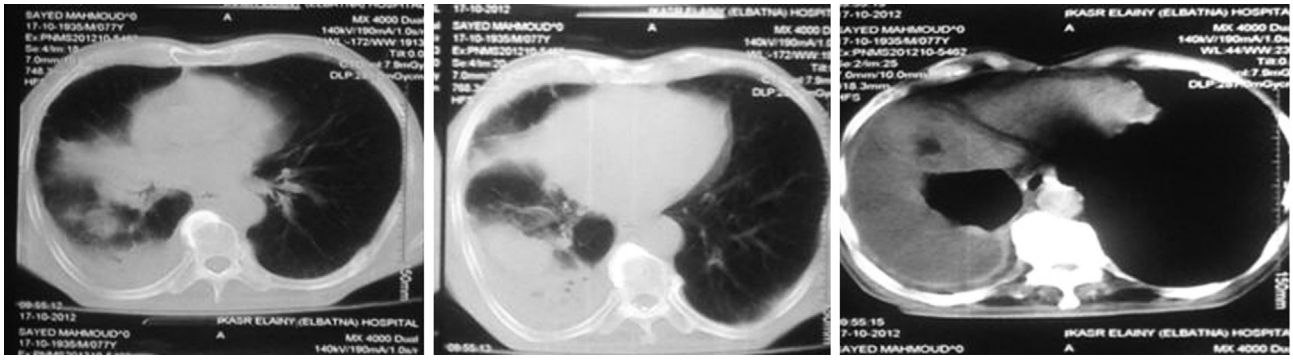


Case (4): TUS showing complex septated pleural effusion with underlying consolidation collapse of the lung and a diaphragmatic pleural nodule

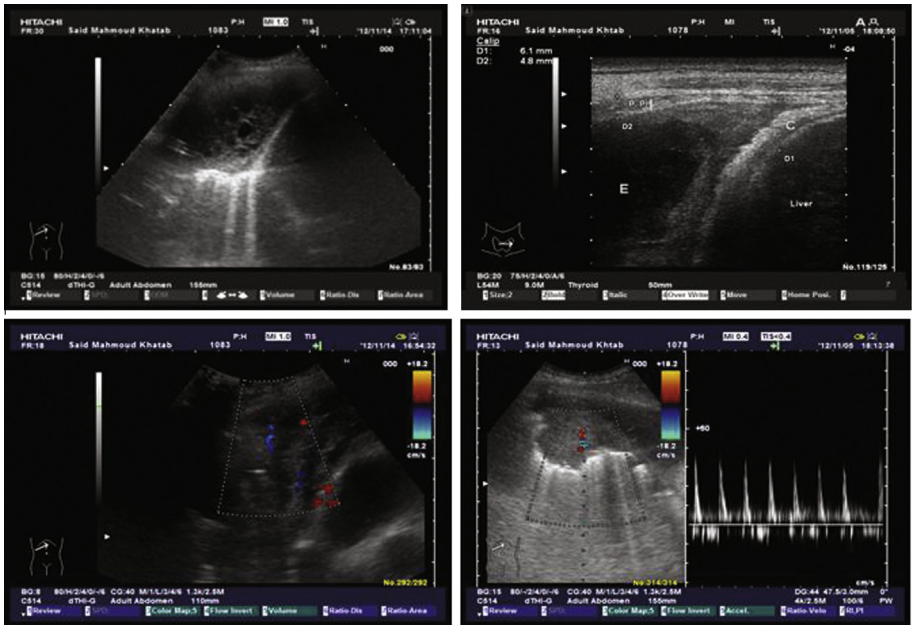
Chest X-ray: (Fig. 4a)



CT chest: (Fig. 4b)

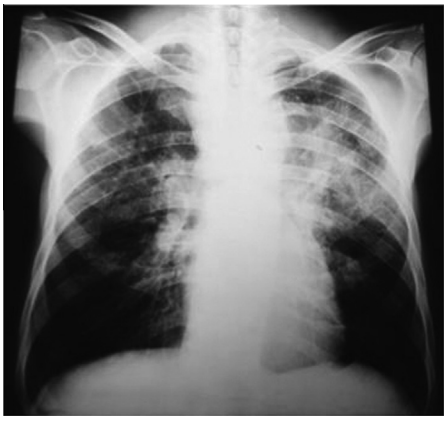


Transthoracic ultrasound: (Fig. 4c)

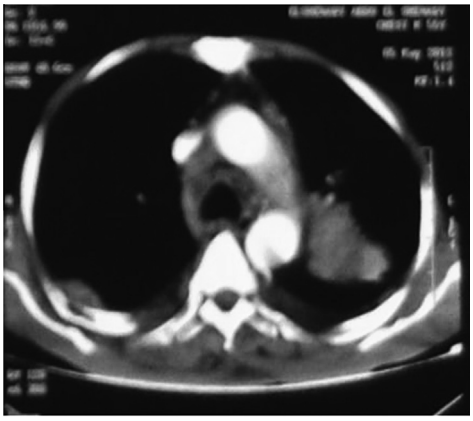


Case (5): Metastatic lung cancer with TUS showing right suprarenal mass and left scalene lymph node

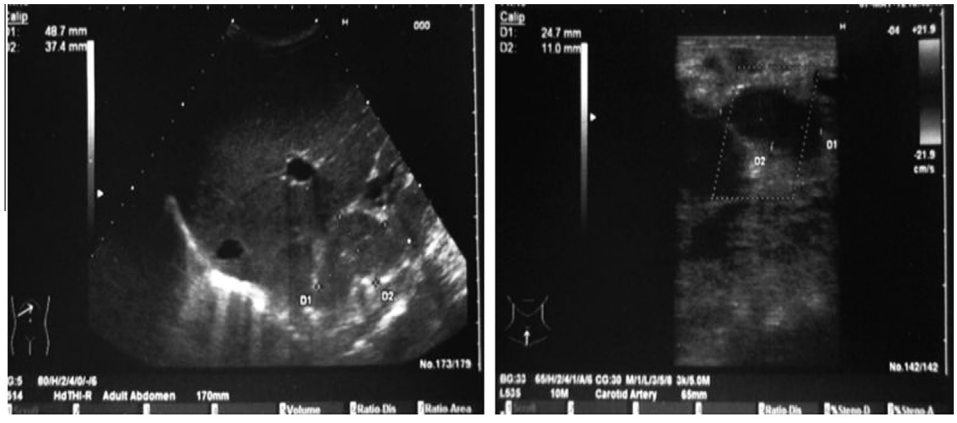
Chest X-ray: (Fig. 5a)



CT chest: (Fig. 5b)



Transthoracic ultrasound: (Fig. 5c)



Discussion

The study was carried out at Chest department, Kasr El-Aini hospital, Cairo University in the period from April 2012 to December 2012. It included fifty patients with confirmed diagnosis of primary lung cancer. TUS was performed for all cases after careful revision of CT images.

The clinical characteristics of the study population are shown in Table 1. Forty six cases were diagnosed as NSCLC and 4 cases as SCLC. The final pathological diagnosis was obtained in 30 cases via fiberoptic bronchoscopy, 17 cases via sonar guided biopsy from the lung mass,1 case via sonar guided biopsy from supraclavicular lymph node, 1 via CT guided biopsy, and 1 via thoracoscopic lung biopsy.

TUS was only able to detect pulmonary masses in 31 cases (62%) (they had an US window to reach the tumor mass) and there was no statistically significant difference between CT chest and TUS as regards the size of the mass (*P*-value: 0.155). The difference between the size detected by CT and TUS was due to the ability of US to differentiate the tumor from the surrounding lung consolidation and/or collapse. Also there was no statistical significant difference between CT chest and TUS as regards the shape, and the margin of the lesion with *P*-values 0.430 and 0.200 respectively.

The main finding of our study is that, TUS was able to detect more cases with chest wall invasion than CT chest and it was more able to detect visceral and parietal pleural invasion (Table 2).

Sugama et al. [4] found that the total accuracy of TUS in detection of pleura and chest wall invasion was 77% which was important regarding decisions of surgical interventions and stated that this approach could delineate cancerous invasion into the pleura and chest wall sufficiently well for staging of patients with lung cancer.

Bandi et al. [1] carried out a study to evaluate the role of ultrasound in determining chest wall involvement in lung cancer compared to CT scan and surgery and found that, ultrasound is more sensitive than CT scanning in the evaluation of chest wall invasion and compliments CT scan data and concluded that ultrasound has better sensitivity (89%) and specificity (95%) in assessing chest wall involvement by a lung tumor compared to CT scan examination (sensitivity, 42%; specificity, 100%).

Also Chira et al. [5] carried out a study to compare ultrasonographic and computed tomography in intrathoracic tumors in contact with the chest wall and concluded that, the sensitivity and specificity of US in diagnosing chest wall invasion of malignant lesions are superior to those of CT.

In our study, we found that TUS is more able to detect the presence of consolidation and/or collapse than CT chest with highly statistically significant difference (*P*-value < 0.001). This is particularly important as it has an impact on T stage of lung cancer (Table 3).

As regards assessment of pleural effusion, it was found that there was no statistical difference between TUS and CT in the detection of pleural effusion with P value = 0.534. In our study TUS and CT were well correlated in the detection of pleural effusion ($r = 0.792$) and in determining its amount ($r = 0.854$). However ultrasound is more able to detect the presence of encystation than CT scan detection with P value = 0.013 (Table 4).

Also TUS was helpful in characterization of the effusion. Free effusion was present in 8 cases, complex non-septated effusion in 8 cases, complex septated in 3 cases, and one case with anechoic effusion. There was a statistical significance difference between TUS and CT in characterization of pleural effusion ($P < 0.001$). This was in agreement with Kurian et al. [6] who stated that although chest ultrasound may be limited by its small field of view and shadowing of deep structures by overlying air, yet it was equally able to detect pleural fluid and loculation when compared with CT chest. TUS was superior to chest CT in its ability to resolve the internal components of pleural fluid including fibrin strands.

In assessment of diaphragmatic mobility, five cases were found to have diaphragmatic immobility which could not be detected by CT.

This was in agreement with a study done by Gerscovich et al. [7] to evaluate diaphragmatic motion by US and concluded that US is feasible and useful in evaluating diaphragmatic motion and that it could replace fluoroscopy as it has advantages over traditional fluoroscopy.

In assessing diaphragmatic mobility in relation to elevated copula by CT it was found that only 1 case out of 7 cases with elevated copula by CT had diaphragmatic immobility by US and the other 6 cases had freely mobile diaphragm as shown in Table 5.

Regarding the assessment of nodal involvement, TUS was used to assess only supra-clavicular lymph node (N3). It was detected clinically in 2 patients, and was detected by ultrasound in 5 patients (10% of cases) including the 2 cases detected clinically, with a significant statistical difference ($P = 0.008$) (Table 6). Pathological diagnosis of metastatic lung cancer was achieved in 1 case via true cut needle biopsy from the detected lymph node. Fultz et al. [8] stated that US-guided FNA of supraclavicular lymph nodes is a simple and safe procedure that can usually be performed by a single operator. Also Kumaran et al. [9] confirmed that Ultrasound guided FNAC is a promising, relatively non-invasive technique for the staging and diagnosis of patients with lung cancer. In agreement to our results, Overhagen et al. [10] stated that the sensitivity of palpation, CT, and neck US in detecting supraclavicular lymph node was reported as 33%, 83%, and 100%, respectively.

The impact of ultrasonography-guided fine needle aspiration of no palpable supraclavicular lymph nodes on diagnosis and staging in advanced lung cancer was also studied by Ozkan et al. [11], and confirmed that US-guided FNA is an easier, safer, and less invasive procedure than standard techniques used to diagnose lung cancer patients with enlarged mediastinal lymph nodes.

Table 7 shows the T stage before transthoracic ultrasound when compared to the T stage after transthoracic ultrasound in all 50 cases of the study group. Eighteen cases were in stage T2a before TUS; 2 cases were upstaged to T2b by changing the size of the mass and 5 cases were upstaged to stage T3; one case by detecting immobile diaphragm and 4 cases by detecting parietal pleura and chest wall invasion by TUS. Seven cases were found in stage T2b before TUS, after TUS 2 cases were upstaged to T3 by detecting parietal pleura and chest wall invasion and one case was downstaged to T2b by measuring a smaller size of the lesion. One case out of the 7 cases in stage T4 was downstaged to T2a after TUS as it could not detect bilateral nodules. The difference in the size of the lesion detected by CT to that detected by TUS could be explained by the change of the plane of viewing the image via TUS.

In assessment of the N and M stages in all 50 cases of the study group, no difference was detected after TUS with a total agreement of 100% with the following N stage; 31 cases (62%) were in stage N0, 7 cases (14%) were in stage N1, 10 cases (20%) were in N2 stage and only 2 cases (4%) were in N3 stage, and as regards the M stage; 37 cases (74%) were in M0, 5 cases (10%) were in M1a stage and 8 cases (16%) were in M1b stage.

The overall stage after TUS in all 50 cases of the study group showed that, five cases upstaged due to the change in the T stage where 2 cases in stage 1b were upstaged; one case to 2a, and another case to 2b, another 2 cases in stage 2a were upstaged; one case to 2b, and another one to 3a, also one case in stage 2b was upstaged to 3a.

Hoosein et al. [12] studied the importance of US in staging and gaining a pathological diagnosis in patients with lung cancer and reported that the use of ultrasound gives a rapid and less invasive method of diagnosing and staging lung cancer and has become introduced into the diagnostic pathway in patients with lung cancer.

According to our findings the use of TUS appears as an easy and safe diagnostic tool for cases with lung cancer and can be not only complementary to both clinical and computerized assessment, but with important added value.

The following limitations of the study worth attention; 1st, The necessity to have a rather large wall contact in order to completely analyze a lesion or to perform US guided biopsy is important. Also the accuracy of TUS in detection of tumor size and subsequently changing the T descriptor is questionable, because more advanced imaging modalities are superior in size determination. 2nd, accurate pleural and chest wall invasion should be confirmed by post-surgical staging,

And lastly, TUS was limited to assess only supraclavicular lymph node as mediastinal nodal involvement cannot be assessed by transthoracic ultrasound except if ultrasound window is available, taking into consideration that more advanced non-invasive methods can be used as PET and MRI or invasive techniques such as EUS and mediastinoscopy that were not used during staging.

Conclusion

Transthoracic ultrasound can help in staging of lung cancer and aid chest physicians in determining the modality of treatment in each patient depending on his/her stage and accordingly, it should be implemented in the diagnostic work up of patients with primary lung cancer.

Conflict of interest

None.

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