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Research Article

Multidetector CT Scan of the Chest Versus Transthoracic Ultrasound in Diagnosis of Pleural Diseases

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ABSTRACT

Pleural diseases (as pleural effusions, pleural masses, pleural plaques, diffuse pleural thickening and pleural tumors) affect over 3000 subjects per million populations each year. Diseases of the pleura can be broadly classified into benign and malignant. The incidence of malignant pleural mesothelioma is increasing worldwide. Imaging of the pleura can be challenging and it plays an important role in the diagnosis and subsequent management of patients with pleural diseases. This study aimed to compare the efficiency and reliability of Multidetector Computed tomography (MDCT) and Transthoracic Ultrasound (TUS) in diagnosis of pleural disease. Patients and Methods: This study included 71 patients with pleural disease. All patients were subjected to complete history taking, full clinical examination, MDCT chest and TUS examination. The patients included in the study were classified according to the pathology of the lesions into Group A (51 patients with malignant lesions) and Group B (included 20 patients with non- malignant lesions), The malignant patients included in the study were classified according to the pathology of the lesions into Group A_1 (24 patients with primary malignant lesions) and Group A_2 (27 patients cases with secondary malignant lesions).

Conclusion: MDCT scan of the pleura is less sensitive than TUS in detection of pleural nodules, masses, pleural thickening, adhesion and also in detecting lung masses. However TUS examination of the pleura – in the presence of adequate window –could suspect nature of lung mass by Dupplex study, Yet TUS examination of the pleura is a localized examination and can't be applied to whole chest without prior guidance by radiology either CXR or MDCT.

Keywords: Pleural diseases, Multidetector CT scan, Transthoracic ultrasound, Pleural nodules, Pleural masses

INTRODUCTION

The pleura is derived embryologically from the mesenchyme[1]. It serves an important role in lung function in that it acts as a cushion for the lungs and allows for smooth movement of the lungs within the chest cavity[2]. Pleural diseases (as pleural effusions, pleural masses, pleural plaques, diffuse pleural thickening and pleural tumors) affect over 3000 subjects per million populations each year. Diseases of the pleura can be broadly classified into benign and malignant. The incidence of malignant pleural mesothelioma is increasing worldwide[3]. Pleural plaques are deposits of hyalinized collagen fibers in the parietal pleura. They are indicative of asbestos exposure and typically become visible twenty or more years after the inhalation of asbestos fibers, although latency periods of less than ten years have been observed[4]. Imaging of the pleura can be challenging and it plays an important role in the diagnosis and subsequent management of patients with pleural diseases[5]. Contrast-enhanced Multidetector CT (MDCT) is an established modality for investigating suspected pleural disease by allowing thorough scrutiny of the various pleural surfaces within the thorax[6]. Pleural thickening, enhancement, effusions and other associated findings on MDCT help in further characterization of disease into a benign or malignant process. It reduces examination times presenting advantages, particularly in examinations where voluntary or involuntary patient motion is a problem[7]. Transthoracic ultrasound (TUS) is an ideal aid to the clinician, given its mobility, lack of irradiation and short examination time. TUS can locate the best pleural access point and also detect thick fibrous septation; it improves the accuracy of pleural puncture sites by 26%[8]. TUS also allows access in 88% of patients after unsuccessful clinically guided thoracocentesis and reduces complications[9]. Moreover, the volume of fluid, the presence of septation, pleural thickening, nodules and pleural based tumours can be accurately assessed[8]. This study aimed to compare the efficiency and reliability of Multidetector Computed tomography (MDCT) and Transthoracic Ultrasound (TUS) in diagnosis of pleural disease.

Subjects

The present study included 71 patients who were selected from the Chest Department inpatients, Kasr Alainy Hospital, Cairo University, Egypt in the period from February 2013 to July 2014. The selected patients had pleural effusion, pleural thickening, pleural nodules or pleural masses.

The included patients were divided into 2 subgroups according to the pathology of the lesions:

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Group A: included 51 patients with malignant lesions.
Group B: included 20 patients with non- malignant lesions.
The malignant patients included in the study were divided into 2 subgroups according to the pathology of the lesions:
Group A_1: included 24 patients with primary malignant lesions.
Group A_2: included 27 patients with secondary malignant lesions.

METHODS

All included patients were subjected to:
Written informed consent.
Full history taking (including residence, occupation and smoking history)
Detailed clinical examination
Chest X-rays PA and lateral views.
MDCT scan of the chest (using a 16 multidetector CT scanner) Patient's position: supine.
Helical volume data sets of the chest were acquired during single breath-hold inhalation with the following parameters: FOV: 25cm, collimation: 0.5 mm and rotation time 0.5 s.
which was used to detect the following:
Degree of thickness of pleura was assessed and classified into three grades: grade 1: 3-7 mm, grade 2: 7-10 mm, grade 3: > 10mm
The presence of pleural nodules (lesions <3cm in largest diameter) or pleural masses (lesions >3 cm in largest diameter).
Pleural fibrosis and pleural effusion (free or loculated).
The character of collapsed lung either *bulky collapse* (lung that didn't collapse totally under the effusion with no aeration and preserved some volume) or *healthy collapse* (lung that collapse totally under the effusion).
Transthoracic ultrasonographic study
(using Hitachi 7000). All cases were examined with curvilinear transducer (3.5 MHz) and linear array transducer (7.5 MHz). Screening of the patient's chest using the low frequency probe.
This was used to detect the following:
Degree of thickness of pleura was assessed and classified into three grades: grade 1: 3-7 mm, grade 2: 7-10 mm, grade 3: > 10mm
The presence of pleural nodules (lesions <3cm in largest diameter) or pleural masses (lesions >3 cm in largest diameter).
The character of collapsed lung either *bulky collapse* (lung that didn't collapse totally under the effusion with no aeration and preserved some volume) or *healthy collapse* (lung that collapse totally under the effusion).
The size of the effusion was documented as follows: *Mild* (if the space was greater than the costophrenic angle but still within the range of the area covered with a 3.5 MHz curvilinear probe), *moderate* (if the space was greater than one probe range but within a two probe range and *Massive* (if the space was larger than a two-probe range).
Statistical Analysis
Data were statistically described in terms of mean ± standard deviation (± SD), median and range, or frequencies (number of cases) and percentages when appropriate. Comparison of numerical variables between the study groups was done using Student t test for independent samples in comparing 2 groups when normally distributed and Mann Whitney U test for independent samples when not normally distributed. Comparison of numerical variables between more than two groups in the present study was done using Kruskal Wallis test. Within group comparison of numerical variables was done using paired t test in comparing 2 groups when normally distributed and Wilcoxon signed rank test for paired (matched) samples when not normally distributed. For comparing categorical data, Chi square ($\chi 2$) test was performed. Exact test was used instead when the expected frequency is less than 5. Comparison and agreement between the different diagnostic modalities was done using McNemar and kappa tests. Accuracy was represented using the terms sensitivity, specificity, +ve predictive value, -ve predictive value, and overall accuracy. p values less than 0.05 was considered statistically significant. All statistical calculations were done using computer program SPSS (Statistical Package for the Social Science; SPSS Inc., Chicago, IL, USA) release 15 for Microsoft Windows (2006).

RESULTS AND DISCUSSION

Pleural diseases (as pleural effusions, pleural masses, pleural plaques, diffuse pleural thickening and pleural tumours) affect over 3000 subjects per million populations each year. Diseases of the pleura can be broadly classified into benign and malignant. The incidence of malignant pleural mesothelioma is increasing worldwide[3]. Imaging of the pleura can be challenging and it plays an important role in the diagnosis and subsequent management of patients with pleural diseases[5]. Contrast-enhanced Multidetector CT (MDCT) is an established modality for investigating suspected pleural disease by allowing thorough scrutiny of the various pleural surfaces within the thorax[6]. Transthoracic ultrasound (TUS) is an ideal aid to the clinician, given its mobility, lack of irradiation and short examination time. TUS can locate the best pleural access point and also detect thick fibrous septation; it improves the accuracy of pleural puncture sites by 26 %[8]. This aim of the current study was to compare the efficiency and reliability of Multidetector Computed tomography (MDCT) and Transthoracic Ultrasound (TUS) in diagnosis of pleural disease.
The present study included 71 patients with pleural lesions forming the study population.
The study patients were classified according to the final histopathological results, into two groups; *Group A:* included 51 cases with malignant lesion (they were 24 males and 27 females with mean age of 57.2) and *Group B:* included 20 cases with non-malignant lesion (they were 6 males and 14 females with mean age of 49.479). The malignant patients included in the study (Group A) were further classified into *Group A_1:* included 24 cases

with primary malignant lesions (they were 13 males and 11 females with mean age of 58.3) and *Group A_2:* included 27 cases with secondary malignant lesions (they were 11 males and 16 females with an average age of 55.8).

Regarding site of lesions, MDCT chest revealed that 54.9% of cases had right sided lesions, 39.5% of cases had left sided lesions and 5.6% had bilateral lesions and TUS data revealed that 56.3% of cases had right sided lesions, 40.9% had left sided lesions and 2.8% of cases had bilateral lesions. (table 1). The current study agreed with *Enas et at.,*[10] found by CT chest that 70% of cases had right sided lesions and 30% had left sided lesions.

Regarding the comparison between MDCT chest and TUS in the ability of detection of pleural masses there were no statistical significant difference (table 2).

This study showed that TUS could be reliably used in detection of pleural masses. TUS still has some advantages over MDCT in detecting and diagnosing pleural masses: (1) Practically, some patients with pleural masses and pleural effusions often had complaints of dyspnea and chronic cough; therefore, it was difficult or impossible for these patients to lie in bed for a thoracic CT examination and CT-guided needle biopsies (2) detecting the pleural masses in real-time and making needle biopsies simultaneously[11].

Comparing the ability to detect pleural nodules, this study revealed that TUS was superior over MDCT scan of chest with statistical significant difference (p = 0.000) (table 2) (figure 1).

Comparing the ability to detect pattern of pleural effusion (free or loculated) this study revealed that both of them were close to each other, with no significant difference. (table 2) (figure 1).

Bediwy et al,[12] stated that in TUS diagnosed 83.3% of free pleural effusion lesions, 60% of encysted pleural effusion lesions and diagnosed all empyema lesions, however it was less sensitive in detecting pleural thickening and pleural nodules or masses**.**

Also *Sikora et al.,*[13] stated that transthoracic US serves as a more accurate imaging tool than chest radiography for the diagnosis of pleural effusions and allows discrimination of pleural effusions from other lung pathology that may appear similar on a chest radiograph. Furthermore, US can allow diagnosis of complicated pleural effusions, such as empyema that may be associated with a higher risk for drainage.

Comparing the ability to detect character of the collapsed lung (bulky or healthy collapse), this study revealed that TUS was superior over MDCT chest with statistical significant difference (p = 0.016) (table 2) (figure 1).

As TUS is a dynamic technique - and with the presence of adequate window - could visualize beyond visceral pleura and give an idea about nature of collapsed lung either compression collapse under effusion or obstructive collapse due to central obstruction causing distal collapse (this could be detected by the presence of fluid bronchogram).

Comparing the ability to detect character of the collapsed lung (bulky or healthy collapse) by TUS between primary malignant and secondary malignant cases, this study revealed that TUS was the best modality to detect bulkylung in secondary malignant cases with statistical significant difference (p = 0.024) (table 3) (figure 1).

Comparing the ability to detect lung mass by TUS between primary malignant and secondary malignant cases, this study revealed that TUS was the best modality to detect lung mass in secondary malignant group with statistical significant difference (p = 0.004) (table 4), while MDCT scan of chest revealed no significant difference between primary malignant and secondary malignant (table 4) (p = 0.0923).

The present study showed that TUS is superior over CT chest in detection of lung masses and bulky lung, as TUS had the ability to visualize beyond visceral pleura –if there is available interface- and could detect vascularity of lesion using Doppler wave and give an idea about its nature (benign, malignant).

There were no comparative studies assessing lung character by CT chest and TUS relative to each other.

Regarding the ability to detect pleural nodules by TUS (table 5), there were statistical significant difference (p = 0.025) between malignant (group A) and non-malignant groups (group B) but there were no significant difference (p = 1.00) between primary (group A_1) and secondary malignant cases (group A_2).

This study showed that pleural nodules detected by TUS in 66.2% of cases were malignant as confirmed histopathologically.

These results coincide with *Enas et al.,*[10] who stated that sonographic appearances of pleural nodules were mostly malignancy, as confirmed histologically.

Regarding the ability of TUS to detect pleural thickening (table 5), revealed that there were statistical significant difference (p = 0.05) between primary malignant and secondary malignant groups, there were no significant difference (p = 0.729) between malignant and non-malignant groups. (Figure 1)

On the other hand, *Bediwy et al,*[12] stated that in TUS was less sensitive than CT chest in detecting pleural thickening and pleural nodules or masses**.**

Comparing the ability to detect pleural Thickening, this study revealed that TUS was superior over MDCT with statistical significant difference (p= 0.0001) (table 6). (Figure 1)

Regarding the ability of TUS to detect grade of pleural thickening (table 6), it was found that Grade 3 (>10mm thickness) included 14 malignant cases compared to 2 non-malignant cases and difference between malignant and non-malignant groups was found to be statistical significant difference (p = 0.05) and there were no significant difference (p = 0.514) between group A_1 and group A_2.

Also *Qureshi et al.,*[14] were able to identify 73% of malignant effusions on US appearance alone, they found that pleural thickening >10 mm, pleural nodularity and diaphragmatic thickening >7 mm were highly suggestive of malignant disease.

Bugalho et al.,[15] stated that with regard TUS could detect pleural or diaphragmatic thickening, a total of 49 patients

Table 1: Site of lesions according to MDCT chest and TUS:

		Malignant			Non -malignant	Total
		Primary malignant	Secondary malignant	Total		
MDCT chest	Right	15(21.1%)	16(22.5%)	31(43.6%)	8(11.3%)	39(54.9%)
	Left	9(12.7%)	10(14.1%)	19(26.8%)	9(12.7%)	28(39.5%)
	Bilateral	0(0%)	1(1.4%)	1(1.4%)	3(4.2%)	4(5.6%)
	Total	24(33.8%)	27(38%)	51(71.8%)	20(28.2%)	71(100%)
TUS	Right	15(21.1%)	17(23.9%)	32(45%)	8(11.3%)	40(56.3%)
	Left	9(12.7%)	10(14.1%)	19(26.8%)	10(14.1%)	29(40.9%)
	Bilateral	0(0%)	0(0%)	0(0%)	2(2.8%)	2(2.8%)
	Total	24(33.8%)	27(38%)	51(71.8%)	20(28.2%)	71(100%)

Table 2: Comparison between MDCT chest and TUS in detection of (pleural masses, pleural nodules, pattern of pleural effusion and character of collapsed lung) among study patients: (4 patients didn't have pleural effusion)

MDCT masses		TUS masses			P value
		No	Yes	Total	
	No	64(90.1%)	2(2.8%)	66(92.9%)	0.546
	Yes	0(0%)	5(7.1%)	5(7.1%)	
	Total	64(90.1%)	7(9.9%)	71(100%)	
MDCT Nodule		TUS nodule			P value
		No	Yes	Total	
	No	10(14.1%)	53(74.6%)	63(88.7%)	0.000*
	Yes	0(0%)	8(11.3%)	8(11.3%)	
	Total	10(14.1%)	61(85.9%)	71(100%)	
MDCT Pattern of effusion		TUS Pattern of effusion			P value
		Free	Loculated	Total	
	Free	37(55.2%)	1(1.5%)	38(56.7%)	0.213
	Loculated	8(11.9%)	21(31.4%)	29(43.3%)	
	Total	45(67.1%)	22(32.9%)	67(100%)	
MDCT character of collapsed lung		TUS character of collapsed lung			P value
		Bulky	Healthy	Total	
	Bulky	5(7%)	0	5(7%)	0.016*
	Healthy	10(14%)	56(79%)	66(93%)	
	Total	15(21%)	56(79%)	71(100%)	

Table 3: Comparison between primary and secondary malignant cases regarding character of collapsed lung detected by TUS.

	Primary malignant	Secondary malignant	Total
Bulky	3(6%)	11(21.5%)	14(27.5%)
Healthy	21(41.1%)	16(31.4%)	37(72.5%)
Total	24(47.1%)	27(52.9%)	51(100%)
P-value	0.024*		

had >10 mm thickness in the malignant group (74.2%). In the non-malignant group 23 patients (34.3%) had pleural or diaphragmatic increased thickness but only 9 had a thickness of >10 mm. All cases of non-malignant thickness were related to infectious diseases.

Comparing the ability to detect character of thickened pleura (irregular or smooth), this study revealed TUS was superior over MDCT chest in detection of irregular thickening of the pleura with statistical significant difference (p = 0.003) (table 7).

Regarding the character of thickened pleura correlated to pathological diagnosis whether malignant or non-malignant: CT findings in malignant cases 15 (21.1%) cases had irregular thickened pleura, 7 (9.9%)cases had smooth thickened pleura, while in non-malignant cases 1 (1.4%) case had irregular thickened pleura and 6(8.6%) cases had smooth thickened pleura.

TUS findings in malignant cases 41 (57.7%) cases had irregular thickened pleura, 2 (2.8%) cases had smooth thickened pleura, while in non-malignant cases 10 (14.1%) cases had irregular thickened pleura and 6(8.6%) cases had smooth thickened pleura.

This study disagree with**,** *Raj et al.,*[16] who stated that CT chest allows detailed evaluation of the pleura and differentiation of benign from malignant pleural disease and also stated that Adequate enhancement of the pleura enables differentiation of the thickened pleura from adjacent effusion or aerated or collapsed lung.

Comparing the ability to detect grade of thickened pleura, this study revealed that TUS was superior over MDCT chest in detection of different grades of thickened pleura with statistical significant difference (p = 0.010) (table 7).

Regarding the grade of thickness of parietal pleura correlated to pathological diagnosis whether malignant or non-malignant: CT findings in malignant cases: Grade 1 (<3mm) was found in 10 (14.1%) cases, Grade 2 (3-7mm) was found in 7(9.9%), Grade 3 (>10mm) was

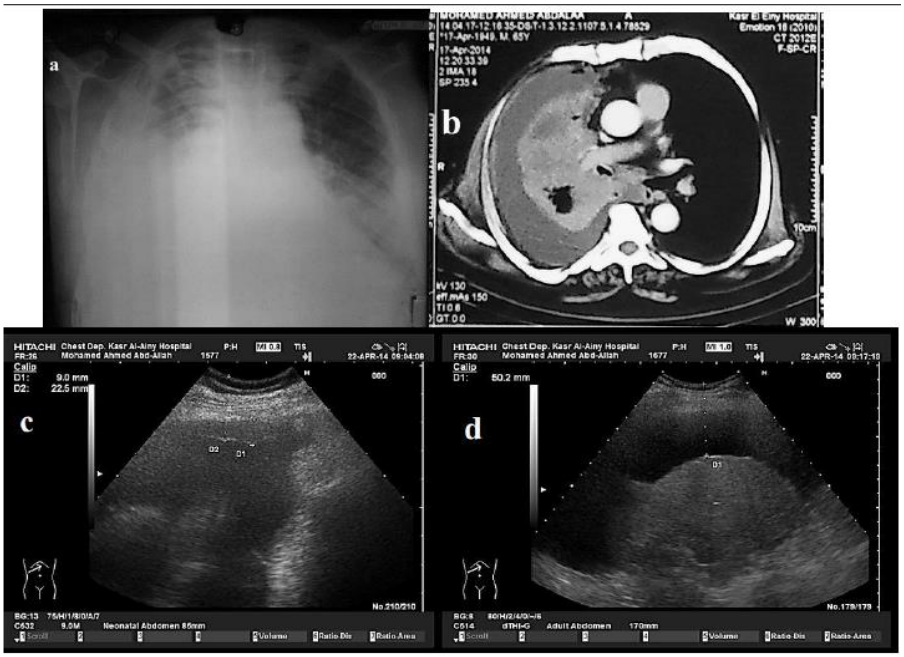

Figure 1: a) CXR-PA showing massive right sided pleural effusion, b) MDCT chest mediastinal window showing right sided pleural effusion and grade 1 pleural thickening and bulky collapse, c)TUS showing complex non septated pleural effusion with nodule over costal pleura and grade 2 pleural thickening d)TUS showing bulky middle lobe.

Table 4: Study the ability of MDCT chest and TUS to detect lung mass in malignant subgroups:

		Primary	Secondary	Total	P-value
MDCT	Yes	0(0%)	3(5.8%)	3(5.8%)	0.0923
	No	24(47.1%)	24(47.1%)	48(94.2%)	
	Total	24(47.1%)	27(52.9%)	51(100%)	
TUS	Yes	1(2%)	13(25.5%)	14(27.5%)	0.0004*
	No	23(45%)	14(27.5%)	37(72.5%)	
	Total	24(47%)	27(53%)	51(100%)	

Table 5: Study the ability of TUS to detect pleural nodules and pleural thickening among the study patients:

TUS nodules	Malignant			Non malignant	Total
	Primary	Secondary	Total		
Yes	22(31%)	25(35.2%)	47(66.2%)	14(19.7%)	61(85.9%)
No	2(2.8%)	2(2.8%)	4(5.6%)	6(8.5%)	10(14.1%)
Total	24(33.8%)	27(38%)	51(71.8%)	20(28.2%)	71(100%)
P-value	1.000				
P-value	0.025*				
TUS pleural	Malignant			Non malignant	Total
Thickening	Primary	Secondary	Total		
Yes	23(32.4%)	20(28.2%)	43(60.6%)	16(22.5%)	59(83.1%)
No	1(1.4%)	7(9.8%)	8(11.2%)	4(5.7%)	12(16.9%)
Total	24(33.8%)	27(38%)	51(71.8%)	20(28.2%)	71(100%)
P-value	0.05*				
P-value	0.729				

found in 5(7%) cases and CT chest didn't detect pleural thickening in 29(40.8%) cases, in non-malignant cases: Grade 1 was found in 5 (7%) cases, Grade 2 was found in 2(2.8%), Grade 3 was found in 0(0%) cases and CT chest didn't detect pleural thickening in 13(18.3%) cases.

TUS findings in malignant cases: Grade 1 (<3mm) was found in 17 (23.9%) cases, Grade 2 (3-7mm) was found in 12 (16.9%), Grade 3 (>10mm) was found in 14(19.7%) cases and TUS didn't detect pleural thickening in 8(11.6%) cases, in non-malignant cases: Grade 1 was found in 12 (16.9%) cases, Grade 2 was found in 2(2.8%), Grade 3 was found in 2(2.8%) cases and TUS didn't detect pleural thickening in 4 (5.6%) cases. Also TUS detected chest wall invasion among malignant cases and confirmed its absence in non-malignant cases, with statistically significant value (P-value= 0.015) (table 8), While MDCT chest couldn't detect any case with chest wall invasion. Regarding the ability of TUS to detect

Table 6: Comparison between MDCT chest and TUS in detection of pleural Thickening among the study patients and grading of pleural thickening detected By TUS among the study patients:

MDCT Pleural Thickening		TUS Pleural Thickening			P value
		No	Yes	Total	
	No	12(16.9%)	30(42.3%)	42(59.2%)	0.0001*
	Yes	0(0%)	29(40.8%)	29(40.8%)	
	Total	12(16.9%)	59(83.1%)	71(100%)	
TUS Grade of pleural Thickening	Malignant			Non malignant	Total
	Primary	Secondary	Total		
Grade 1	9(15.3%)	8(13.6%)	17(28.9%)	12(20.3%)	29(49.2%)
Grade 2	5(8.4%)	7(11.9%)	12(20.3%)	2(3.4%)	14(23.7%)
Grade 3	9(15.3%)	5(8.4%)	14(23.7%)	2(3.4%)	16(27.1%)
Total	23(39 %)	20(33.9%)	43(72.9%)	16(27.1%)	59(100%)
P-value	0.514				
P-value	0.05*				

Table 7: Comparison between MDCT chest and TUS regarding the character of pleural thickening and grade of pleural thickening among 29 patients detected by MDCT chest.

MDCT character of thickened Pleura		TUS character of thickened Pleura			P value	
		Irregular	Smooth	Total		
	Irregular	16(55.2%)	0(0%)	16(55.2%)	0.003*	
	Smooth	10(34.5%)	3(10.3%)	13(44.8%)		
	Total	26(89.7%)	3(10.3%)	29(100%)		
MDCT Grade of thickened Pleura		TUS Grade of thickened Pleura				P value
		Grade 1	Grade 2	Grade 3	Total	
	Grade 1	5(17.3%)	7(24.1%)	3(10.4%)	15(51.8%)	0.010*
	Grade 2	1(3.4%)	1(3.4%)	7(24.1%)	9(30.9%)	
	Grade 3	0(0%)	0(0%)	5(17.3%)	5(17.3%)	
	Total	6(20.7%)	8(27.5%)	15(51.8%)	29(100%)	

Table 8: Chest wall invasion and texture of visceral pleura as detected by TUS among the study patients:

Chest wall invasion By TUS	Malignant				Non malignant	Total	P-value
	Primary	Secondary	Total	P-value			
Yes	7(9.9%)	5(7%)	12(16.9%)	0.511	0(0%)	12(16.9%)	0.015*
No	17(23.9%)	22(31%)	39(54.9%)		20(28.2%)	59(83.1%)	
Total	24(33.8%)	27(38%)	51(71.8%)		20(28.2%)	71(100%)	
TUS texture of visceral pleura	Malignant				Non malignant	Total	
	Primary	Secondary	Total				
Irregular	10(14.1%)	10(14.1%)	20(28.2%)		1(1.4%)	21(29.6%)	
Smooth	14(19.8%)	17(23.9%)	31(43.7%)		19(26.7%)	50(70.4%)	
Total	24(33.9%)	27(38%)	51(71.9%)		20(28.1%)	71(100%)	
P-value	0.780						
P-value	0.004*						

texture of visceral pleura (table 8), there were statistical significant difference (p = 0.004) between malignant and non-malignant groups but there were no significant difference (p = 0.780) between primary malignant and secondary malignant groups.

CONCLUSION AND RECOMMENDATIONS

MDCT scan of the pleura is less sensitive than TUS in detection of pleural nodules, masses, pleural thickening, adhesion and also in detecting lung masses. However TUS examination of the pleura – in the presence of adequate window –could suspect nature of lung mass by Dupplex study, Yet TUS examination of the pleura is a localized examination and can't be applied to whole chest without prior guidance by radiology either CXR or MDCT.

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