How to Cite:
El Wahsh, R. A., El-Habashy, M. M., Saad, R. A., & Mahrous, A. H. (2022). Role of chest ultrasound in management of exudative pleural effusion. *International Journal of Health Sciences*, *6*(S6), 143–159. https://doi.org/10.53730/ijhs.v6nS6.9294

Role of chest ultrasound in management of exudative pleural effusion

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***Abstract*---**Background: During the planning and execution of diagnostic and therapeutic procedures, thoracic ultrasonography is an appropriate imaging tool for the interventional pulmonologist (IP). Aim of the work: to determine whether or not thoracic ultrasonography should be used in the management of exudative pleural effusion. Patients and Methods: One hundred patients with exudative pleural effusion were included in a prospective interventional analytical study. During this study, the patients underwent ultrasonographic examination and evaluation to guide various diagnostic manoeuvres. These manoeuvres included diagnostic thoracentesis, tru cut needle biopsy from pleural or underlying lung or mediastinal lesions, and thoracoscopic assistance. In addition to assisting in therapeutic operations (such as therapeutic thoracentesis, installation of pleural drains, and pleurodesis), ultrasound was also used for prognostic reasons (post-pleural drainage assessment, pleural drain follow up, non-expandable lung prediction, and pleurodesis success detection). Results: 70 patients underwent ultrasound-guided diagnostic procedures, including diagnostic thoracentesis in 19 patients, biopsy from pleural, lung, or mediastinal lesions in 30 patients, and thoracoscopic assistance in 21 patients in order to select the appropriate type of intervention, either medical thoracoscopy (MT) or video-assisted thoracoscopic surgery (VATS). These procedures were performed in order to determine whether the patients would benefit more from medical thoracoscopy (MT) or VATS. In 55 patients, ultrasound-assisted therapeutic procedures were performed (therapeutic thoracentesis in 13 patients, pleural drain placement in

27 patients and assisted pleurodesis in 15 patients). In addition, ultrasound was helpful for a number of prognostic objectives, including post-pleural drainage assessment in 28 patients, non-expandable lung prediction in 15 patients, pleural drain follow-up in 27 patients, and evaluation of pleurodesis success. Conclusion: In the management of exudative pleural effusion, transthoracic ultrasonography is a tool that is both feasible and safe for the interventional pulmonologist to use. It supports a variety of diagnostic, therapeutic, and prognostic goals.

***Keywords*---**chest ultrasound, pleural effusion, ultrasound guidance.

Introduction

Interventional pulmonologists now consider transthoracic ultrasonography (TUS) to be an essential part of their toolkit. There are a variety of diagnostic, therapeutic, and prognostic goals that may be supported by conducting a comprehensive and sophisticated examination utilizing transthoracic ultrasonography. (1) The TUS should be used as a standard of care prior to any pleural operations, as recommended by the 2010 Pleural Disease Guidelines published by the British Thoracic Society. (2) The treating physician may utilise it at point of care with no inherent delay between the ordering of an imaging investigation and the conduct of the study, and it does not use ionizing radiation. There is no clinical distinction between the physician who is providing treatment and the physician who is evaluating the imaging result. Management of pleural effusions and biopsy of pleural-based masses are common operations performed by the IP. At the point of care, the IP can identify the patient's condition, formulate a treatment strategy, and carry out the necessary procedures thanks to chest ultrasonography. (3)

Aim of the study: to determine whether or not chest ultrasonography is beneficial in the management of exudative pleural effusion.

Patients and methods

On 100 patients with exudative pleural effusion, a prospective interventional analytical analysis was conducted. Patients' informed written permission was acquired, as well as the approval of the Research Medical Ethics Committee. Between September 2019 and November 2021, the research was conducted at the ultrasonographic unit of the Menoufia University Hospital's chest department. The research excluded patients with a transudative effusion or bleeding problems. History taking, general and local examinations, laboratory investigation (complete blood count, liver function tests, serum LDH and protein, and bleeding profile), radiological evaluation (chest radiography and computed tomographic (CT) chest scan), and pleural fluid analysis (biochemical, differential cell count, culture & sensitivity and cytology) were all performed on all participants. Examination of the patients was performed with US equipment (Philips Affiniti 50 G, Germany) using a convex probe with a frequency range of 2-5 MHz to evaluate effusion, visceral pleura, and lung parenchyma, while a linear probe with a frequency range of 5-10

MHz was used to investigate the parietal pleura and chest wall. Using colour flow Doppler and M-mode ultrasound in addition to routine two-dimensional ultrasound, free-flowing pleural effusions demonstrate flow by colour Doppler, and by M-mode US, lung tissue could be seen moving within the pleural effusion to and from the chest wall, demonstrating the "sinusoid sign." (4) The results of the transthoracic ultrasound were recorded, and these results included the volume of pleural effusion, the echo-texture of the pleura, the location, distribution, and surface of pleural thickening, the location of pleural nodules and masses, and the presence of septations and thick adhesions. TUS guided a variety of diagnostic procedures, including diagnostic thoracentesis, thoracoscopic assistance (which provided information about effusion amount, presence and site of loculations not easily predictable on CT scan, presence of thick adhesions, localization of parietal nodules or other potential neoplastic lesions, so it facilitated the choice of the proper interventional approach, whether MT or VATS), and real time ultrasound-guided tru cut needle biopsy from pleural, lung, or mediastinal lesions using a semi-automated spring-loaded tru cut needle GTA [Quistello (MN), Italy] having a size of 16, 18-G, and a length of 10, 15, or 20 mm that is selected according to the size and distance of the lesion, as well as evaluation of possible complications such as active bleeding or pneumothorax after the procedure has been completed). (5) TUS assisted therapeutic procedures including therapeutic thoracentesis, small-bore pleural drain placement in loculated or small effusions, and pleurodesis (patients were examined to assess the presence of sliding sign, effusion amount, and presence of any loculations before pigtail insertion, chemical pleurodesis with doxycycline at a dose of 10 mg/kg diluted with lidocaine after complete drainage of effusion, follow up by TUS after 24 hours and after 3-4 weeks to detect successful pleurodesis and compare them with US findings before pleurodesis). TUS was also used for a variety of prognostic purposes, such as post-pleural drainage assessment, follow-up of pleural drain to determine when to remove it, non-expandable lung prediction (absence of sinusoidal respirophasic lung motion, also known as "absent sinusoid sign"), (6) and detection of pleurodesis success (the probe was positioned in intercostal spaces at 9 different predefined points to assess loss of sliding sign and pleural fluid volume; 2 on the midclavicular line "II and IV spaces," 3 on the midaxillary line "II, IV and VI spaces," and 4 posteriorly on the midline between the spine and the scapula "II, V, VII and IX spaces," pleurodesis was defined as excellent when it was confirmed in all 9 considered points, effective when it was confirmed in ≥ 6 points, poor when it was confirmed in < 6 points). The data was examined using the most recent version of the IBM SPSS software suite (IBM Corporation, Armonk, New York). The frequency and percentage of occurrence were used to characterise the qualitative data. The range, the mean, and the standard deviation were the expressions used for quantitative data, while the median and the interquartile range were used for discontinuous or nonparametric data.

Results

A prospective interventional analytical study was carried out on 100 patients with exudative pleural effusion. 64/100 (64%) were male while 36/100 (36%) were female. The ages of studied patients ranged between 22 and 77 years with a mean of 55.55 years ± standard deviation (SD) 12.66 years. 48 were non-smokers (48%),

21 were heavy smokers (21%), 25 were moderate smokers (25%) and 6 were mild smokers (6%). On studying the frequency of symptoms among the studied patients; dyspnea represented 86%, Chest pain represented 60%, cough represented 95%, constitutional manifestations represented 36%, and 21% of them had previously diagnosed malignancy (of bronchogenic, breast, colon, ovary, lymphoma or osteosarcoma origin).

By CT chest, most patients presented by moderate pleural effusion. Pleural thickening was found in 66 out of 100 patients. Among these 66 patients, pleural thickening was more in parietal than visceral pleura. Pleural nodules were found in 12 patients (12%). Among these 12 patients, all noticed nodules were in parietal pleura. Pleural masses were detected in 7 patients (7%), which were located mainly in costal pleura. The underlying lung parenchyma showed collapse in 71% of patients, consolidation in 25%, lung mass in 17%, and nothing in 6% of the studied patients. Mediastinal masses were found in only 2 patients (2%). (Table 1)

On patient examination by TUS, 54 patients presented with left pleural effusion, while the other 46 patients had right effusion. Most patients presented with moderate effusion (n=54, 54%). TUS discriminated type of effusion according to its echo-pattern into complex non-septated (64%), complex septated (28%), homogenously echogenic (5%), and only 3 patients had anechoic effusion (3%). Septations were present in 28 patients (28%) which were either movable or non-movable type. Thick adhesions were noted in 10 patients (10%). (Table 2)

As regard pleura, TUS revealed pleural thickening in parietal or visceral pleura or both in 75 patients. Among these 75 patients; 74 patients presented with costal pleural thickening (98.6%), 66 patients had diaphragmatic pleural thickening (88.6%), and 41 patients had visceral pleural thickening (54%). Pleural thickening distribution was diffuse in 54 out of 75 patients (72%) & focal in 21 patients (28%). The surface of pleural thickening was irregular in 41 patients (55%), and smooth in 34 patients (45%). Costal pleural thickening was measured and ranged between 2-15 mm with a mean of 6.51mm ± SD 3.36 mm. Pleural nodules were found in 33 patients which were located more in diaphragmatic pleura (n=31, 94%). US showed underlying parenchymal lesion whether collapse, consolidation, mass, or no parenchymal lesion (n=71, 71%; n=25, 25%; n=14, 14%; n=6, 6%) respectively. Mediastinal masses were found in 2 patients (2%). (Table 3)

Chest ultrasound supported diagnostic maneuvers in 70 patients including US-guided diagnostic thoracentesis in 19 patients (27%), US- guided biopsy in 30 patients (43%) from pleural ***(fig. 1)***, lung, or mediastinal lesions, and thoracoscopic assistance as a next/further diagnostic step in 21 patients (30%) where 11 patients were recommended for MT after TUS revealed criteria suggesting malignancy as significant pleural thickening or nodules and the other 10 patients were recommended for VATS due to presence of thick fibrous adhesions where non-expandable lung is predicted. Pre-MT ultrasound examination was done in 8 patients in whom MT was previously recommended where it helped to improve pleural access and pleural space evaluation. (Table 4)

Ultrasound assisted therapeutic procedures in 55 patients including therapeutic thoracentesis in 13 patients, pleural drain placement in 27 patients ***(fig. 2)*** and assisted pleurodesis in 15 patients. (Table 4)

Ultrasound also supported various prognostic purposes as post-pleural drainage assessment & follow up during medical treatment in 28 patients, non-expandable lung prediction in 15 patients ***(fig. 3)***, pleural drain follow up & removal in 27 patients and pleurodesis success evaluation in 15 patients. (Table 5)

Discussion

At the point of care, the IP is able to diagnose, formulate a treatment strategy, and carry out the operations thanks to chest ultrasonography. This calls for a paradigm change in the way that thoracic imaging is approached yet gives the IP the ability to more accurately identify disease processes. (3) The results of the chest CT and TUS examinations of the patients who were evaluated were documented in the study that is being presented here.

In terms of the amount of pleural effusion, the vast majority of patients (n = 54, or 54 percent) presented with moderate levels of pleural effusion. It has been observed that ultrasound and chest computed tomography did not disclose any differences in the assessment of the amount of pleural effusion. This is due to the fact that the majority of patients had a moderate to large effusion in both imaging methods. (Table 1 & 2)

According to the echo-texture of the effusion, ultrasonography was able to differentiate between the different types of effusion; 64 patients presented with complex non-septated effusion (64 percent), 28 patients had complex septated effusion (28 percent), 5 patients had homogenously echogenic effusion (5 percent), and only 3 patients had anechoic effusion (3 percent). (Table 2)

TUS uncovered additional characteristics such as septations, which were found in 28 cases with moveable or non-movable type. It is possible that the appearance of septae may be explained by the activation of the coagulation cascade during the process of either inflammation or cancer. In contrast to non-moveable septae, movable septae did not obstruct the drainage of pleural fluid during thoracentesis or US-guided installation of pleural drains. (Table 2)

According to the findings of Gorg et al. (7), the patterns of echoes inside the effusion and the proportion of instances with homogenously echogenic effusion were not different in patients whose exudate was benign or malignant. On real-time evaluation, complex septated effusions may be identified by the swirling of fine echogenic material inside the effusion. These effusions can be detected in infected exudative as well as malignant effusions.

In the research carried out by Kurian and Levin (8), transthoracic ultrasound was shown to be superior than chest CT in its capacity to identify the internal components of pleural fluid, such as fibrin threads, which may suggest the early organisation of an effusion.

In addition to showing thin fibrin septations, ultrasound demonstrated thick fibrous adhesions in 10 cases. It is generally accepted that the formation of adhesions is preceded by fibrinous septations being infiltrated by fibroblasts over the course of time, followed by the deposition of collagen. Because thick fibrous adhesions are seen as a contraindication for MT, VATS was suggested as the procedure of choice in these kinds of situations.

This is consistent with the findings of Hersh et al (9) and Shoukri (10), who stated that thick fibrous adhesions may prevent proper access and may prevent MT from properly assessing the pleural space. As a result, the diagnostic yield of MT may decrease, and the risk of associated complications may also increase.

These observations are also parallel to those found by the study carried out by Khalil et al (11), who stated that the discovery of thick fibrous adhesions and loculations has a significant impact on MT, either changing or modifying the plan of the operator. These observations are also similar to those found by the study carried out by Khalil et al (11). It is possible that thick adhesions may cause failure of post-MT lung expansion. This is a problem that might be predicted with US but not with CT.

When looking at pleural thickening, ultrasound found it in 75 individuals, either in the parietal or visceral pleura or both. Among these patients, 74 of them had costal pleural thickening, which accounts for 98.6 percent of the total, 66 of them had diaphragmatic pleural thickening, which accounts for 88.6 percent, and 41 of them had visceral pleural thickening, which accounts for 54 percent. (Table 3) On the other hand, CT chest was only able to identify pleural thickening in 66 of the patients, missing it entirely in the other 9 instances. (Table 1)

In the diagnosis of pleural effusions and pleural thickening, our findings concur with those found by Helala et al (12), who found that TUS is more sensitive than CT in these aspects.

This was in contrast to the findings that were obtained by Bandaru and Rachegowda (13), who stated that both focal and diffuse pleural thickening can be easily demonstrated by CT, but that TUS is less sensitive in detection of its extent unless the thickening is near one centimeter or more. This finding was in contradiction to their findings. They justified their findings by stating that the instances that were missed by TUS had a thickness of less than one centimeter, and they pointed out that the other research did not compare TUS and CT in terms of this assessment.

In terms of the surface and distribution of pleural thickening, there were 54 patients (72 percent) who had diffuse thickening, whereas 21 patients had focal thickening (28 percent). Its surface was irregular in 41 patients, which accounts for 55% of the total, whereas it was smooth in 34 individuals (45 percent). (Table 3) The pleural surface was smooth in nonmalignant instances (such as tuberculous pleurisy and pleuropulmonary infection), but it was uneven in malignant ones.

These findings are consistent with those of Kamel and El-Hinnawy (14), who demonstrated that transthoracic ultrasound has a very good predilection for the diagnosis of pleural thickening and for differentiating the etiology of pleural thickening as either malignant or nonmalignant.

According to Vorster et al (15), pleural thickening may be caused by a large variety of disorders of benign or malignant origin. It is possible for pleuropulmonary infections caused by either a particular organism as TB, or a nonspecific pathogen as in empyema, to result in benign pleural thickening.

US detected pleural nodules in 33 patients, most of which were located in the diaphragmatic pleura (n = 31, 94 percent of these cases), the costal pleura (n = 12, 36 percent), and the visceral pleura (n = 1, 3 percent), whereas CT chest only detected pleural nodules in 12 patients, all of which were located in the parietal pleura and missed the cases with diaphragmatic and visceral nodules (Table 1 & 3)

This is identical to the research that was carried out by Grondin and Dumoulin (16), who discovered that pleural US is a predictive tool for malignancy due to the fact that diaphragmatic pleural nodules or diaphragmatic pleural thickening are associated with a diagnosis of malignancy.

On the other hand, Bandaru and Rachegowda (13) found that pleural nodules were better spotted on CT compared to US. These results are in contrast to those that they observed and show that there is a discrepancy between the two sets of findings. This might be explained by the use of a CT scan with contrast, which enables greater vision throughout the various phases of contrast enhancement and makes it easier to identify tiny pleural lesions.

When it comes to pleural masses, they were identified in 7 individuals and were found mostly in the costal pleura. A CT chest examination also identified these masses. (Table 1& 3)

US indicated collapse, consolidation patches, mass, or no parenchymal lesion (n=71, 71 percent; n=25, 25 percent; n=14, 14 percent; n=6, 6 percent), accordingly, with reference to the underlying parenchymal lesion. Only two patients out of one hundred were discovered to have mediastinal masses (2 percent). (Table 3)

In all, 70 patients benefited from TUS for diagnostic reasons. It guided diagnostic thoracentesis in 19 patients, which is 27 percent of the total, and all 19 patients had successful procedures with no problems (Table 4). Doerschug and Schmidt (17) stated that pleural US indicates the depth of effusion and assists in determining an acceptable site for thoracentesis. These findings correspond with those reported by Doerschug and Schmidt. TUS monitors the effusion during the whole breathing cycle and provides the operator with assistance in determining whether or not the lung passes in the suggested needle path.

A total of 30 patients had biopsies conducted under US direction; the samples were collected from pleural (53 percent), lung (40 percent), or mediastinal abnormalities (7 percent). (Table 4 & fig.1)

The biopsy procedures were carried out successfully and without incident. The results of the histopathological examination showed 15 diagnosed cases out of a total of sixteen pleural biopsies, eleven diagnosed cases out of a total of twelve lung masses, and two diagnosed cases out of a total of two mediastinal lesions, with an overall diagnostic yield of 93 percent for US-guided tru cut needle biopsy for the thirty cases (Table 4). Despite positive cytology for malignant cells in the effusion in the case of the pleural biopsy and positive malignancy of lung adenocarcinoma diagnosed via fiberoptic bronchoscopy in the case of the lung biopsy, the negative pathology for malignancy in these two cases may be explained by the fact that the samples were taken from necrotic areas.

These findings are in line with those found by Sperandeo et al (18), who discovered that US-assisted core needle biopsy had a sensitivity of 85 percent up to 97 percent for lung tumours abutting the chest wall during his study of the role of TUS in pleural and pulmonary disease assessment.

These findings are also in agreement with Park et al (19), who found that US-guided percutaneous pleural needle biopsy (PCPNB) had high diagnostic accuracy for small pleural lesions. The diagnostic yield of US-guided PCPNB is greatest for lesions that show a nodular appearance on CT or TUS or that are diffuse but have a thickness on CT that is at least 4.5 mm.

According to Blank (20), ultrasound has a diagnostic yield that is higher than 90 percent, which is comparable to that of other imaging methods, CT in particular; however, the amount of time spent by the needle in the lesion is significantly less when using ultrasound, which also has a higher level of tolerability and fewer complications. In addition, ultrasound makes it possible to identify potential problems after a procedure, such as pneumothorax.

In their investigation of TUS guided biopsy of peripheral lung and mediastinal lesions, Cao et al (21) demonstrated certain barriers that inhibit the biopsy of mediastinal lesions under US guidance. These findings contradict what Cao et al (21) found in their study. When dealing with a parasternal tumour, it is important to locate the internal mammary arteries and stay away from them. When dealing with bigger masses, it is necessary to locate the aorta, the pulmonary artery, and the superior vena cava in order to prevent damaging them.

Twenty-one patients were given the advice to proceed with a thoracoscopy as the subsequent step in the diagnostic process; eleven patients (fifty-two percent), were given the advice to undergo MT because a thoracic ultrasound revealed criteria suggesting malignancy, such as pleural nodules or significant pleural thickening, which were not accessible for biopsy by chest ultrasound. In eight of these eleven patients, doing a pre-MT transthoracic US assessment was helpful in improving pleural access. On the other hand, 10 of these 21 patients (48 percent) were indicated for VATS as a subsequent management step owing to the presence of

septae and thick fibrous adhesions that may limit post-MT complete lung expansion. (Table 4)

This corroborates the findings of Andrew et al (22) who discovered that pre-MT ultrasonography has lowered the failure rate of single-port MT pleural access, which has led to a reduction in the number of additional operations and the need for artificial pneumothorax.

A total of 55 patients underwent therapeutic procedures with the assistance of chest ultrasonography. US guided therapeutic thoracentesis performance in 13 patients, which accounts for 24 percent of the total, assisted pleural drain placement in 27 patients, which accounts for 49 percent of the total, either in free or loculated effusions in cases of parapneumonic effusion, empyema, and before pleurodesis, and assisted pleurodesis in 15 patients, which accounts for 27 percent of the total, where it guided pleural drain insertion and follow up till adequate drainage to inject the sclerosing agent. (Table 4 & fig. 2)

According to Vetrugno et al. (23), who indicated that the installation of a pigtail may enhance respiratory mechanics, this finding is consistent with their findings. The operator is able to raise the success rate of the treatment and lower the hazards connected with it thanks to the US instructions.

In addition, Magdy and Hieba (24) found that US-guided completion of the procedure of pleurodesis in a single session with less time of pleural fluid drainage and shorter hospital stay is safer and more cost-effective than the traditional approach. This is highly suggested to replace the conventional method of maintaining the indwelling pleural drain for a few days until the cessation of pleural fluid re-accumulation.

Additionally, TUS was used for a variety of prognostic reasons. Post-drainage assessment and follow up during medical treatment were performed on a total of 28 patients. Of those patients, 24 (or 86 percent) did not require any further intervention and showed adequate drainage, while the remaining 4 patients (or 14 percent) required additional intervention in the form of re-tapping/aspiration or pigtail insertion after re-accumulation on the subsequent ultrasonographic assessment.

In the current investigation, ultrasonography correctly predicted the presence of non-expandable lung (NEL) in 15 patients; however, expandable lung was present in 56 individuals, and the other 29 patients did not reveal an underlying evident lung collapse from the beginning. NEL was predicted in patients with inflammatory processes involving the pleura with dense pleural loculations and pleural thickening or in cases with long-term malignancies where an indwelling pleural catheter is recommended rather than pleurodesis, which is not achievable if the two pleural layers can't be brought into apposition. (Table 5 & fig. 3)

These findings are in agreement with those that were discovered by Hassan et al (1) and Salamonsen et al (25), who supported the use of pleural ultrasound to identify malignant entrapped lung prior to effusion drainage. This could allow appropriate choice of definitive management (pleurodesis vs. indwelling catheter),

decreasing the number of interventions that are required to treat malignant pleural effusion.

The ultrasonographic follow up examination of patients who underwent pleurodesis helped to detect the success of the pleurodesis procedure, which was effective in 10 patients (67 percent), poor in 3 patients (20 percent), neither was excellent, and the other 2 patients were lost follow up. (Table 5)

These findings are consistent with those found by Awad et al (26), who advocated the use of ultrasound to determine whether or not pleurodesis was successful by seeing the absence of a sliding sign in successful pleurodesis patients.

In addition, Hassan et al. (1) and Magdy & Hieba (24) provided support for the role of ultrasound in determining whether or not pleurodesis was successful. They demonstrated that an ultrasound-derived absent sliding score could be used as early as day 1 and as late as day 15 to confirm pleural adherence and to anticipate pleurodesis outcome.

Conclusion

In the management of exudative pleural effusion, transthoracic ultrasound (TUS) is a noninvasive imaging tool that is both safe and cost-effective. It serves several diagnostic, therapeutic, and prognostic applications.

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Table (1): Distribution of studied cases according to CT chest findings (n=100).

Item		Frequency (n=100)	Percentage
Pleural effusion volume			
Large		17	17%
Moderate		54	54%
Small		17	17%
Loculated		12	12%
Pleural thickening			
Pleural Thickening	**Positive**	66	66%
	Negative	34	34%
Pleural thickening site **(n=66)**	➢ ***Parietal pleura***	66	100%
	➢ ***Visceral pleura***	34	52%
Pleural nodules			
Pleural Nodules	**Positive**	12	12%
	Negative	88	88%
Pleural nodule site (n=12)	• ***Parietal pleura***	12	100%
	• ***Visceral pleura***	0	0%
Pleural masses			
Pleural Masses	**Positive**	7	7%
	Negative	93	93%
Pleural masses site (n=7)	***Parietal pleura***	7	100%
	Visceral pleura	0	0%
Underlying lung parenchyma			
Collapse		71	70%
Consolidation		25	25%
Mass		17	17%
None		6	6%
Mediastinal masses			
Mediastinal mass	**Positive**	2	2%
	Negative	98	98%

Table (2): Distribution of studied patients according to ultrasonographic findings of pleural effusion (n=100).

Item		Frequency (n=100)	Percentage
Pleural effusion side	***Left***	54	54%
	Right	46	46%
Pleural effusion volume	**Large**	17	17%
	Moderate	54	54%
	Small	15	15%
	Minimal	2	2%
	Loculated	12	12%
Echo- texture	***Anechoic***	3	3%
	Complex non-septated	64	64%
	Complex septated	28	28%
	Echogenic	5	5%
Septations	**Present**	**28**	**28%**
	Absent	71	72%
Septation type (n=28)	***Movable***	15	54%
	Non-movable	13	46%
Thick adhesions	**Present**	10	10%
	Absent	90	90%

Table (3): Distribution of studied cases according to ultrasonographic findings of pleura and underlying lung parenchyma (n=100)

Item			Frequency (n=100)	Percentage
Pleural thickening				
Positive			75	75%
Negative			25	25%
Parietal costal pleural thickening (mm)				
Min-Max			2.0 – 15.0	
Mean ± SD			6.51 ± 3.36	
median (IQR)			6 (3 – 9)	
Site of pleural thickening (n=75)	**Parietal pleura**	***costal & dorsal***	74	98.6%
		diaphragmatic	66	88.6%
	Visceral pleura		41	54%
Distribution of thickening (n=75)	***Diffuse***		54	72%
	Focal		21	28%
Surface of thickening (n=75)	**Irregular**		41	55%
	smooth		34	45%
Pleural nodules				
Positive			33	33%
Negative			67	67%
Site of pleural nodules (n=33)	***Parietal pleura***	**Costal & dorsal**	12	36%
		Diaphragmatic	31	94%
	Visceral pleura		1	3%
Pleural masses				
Positive			7	7%
Negative			93	93%
Site of pleural masses (n=7)	***Parietal pleura***	***Costal & dorsal***	6	86%
		Diaphragmatic	1	14%
	Visceral pleura		0	0%
Underlying lung parenchyma				
Lung collapse			71	71%
Consolidation			25	25%
Mass			14	14%
None			6	6%
Mediastinal masses				

Present	2	2%
Absent	98	98%

SD: *standard deviation*

IQR: *Interquartile range.*

Table (4): Distribution of the studied patients according to TUS- guided management maneuvers (diagnostic & therapeutic purposes).

Ultrasound - guided Management Step		**No.**	**%**
Diagnostic (n=77)			
Diagnostic Thoracentesis & 1ry evaluation		**19**	**27%**
Biopsy		**30**	**43%**
↳ **Type *(n=30)***			
Pleural		16	53%
Lung		12	40%
Mediastinal		2	7%
↳ **Histopathology *(n=30)***			
Pleural	Epithelioid & spindle cell neoplasm	2	7%
	Caseating granuloma (T.B pleurisy)	2	7%
	Undifferentiated small cell carcinoma (metastatic)	1	3%
	Epithelial type neoplasm	4	13%
	Mesothelioma	4	13%
	Adenocarcinoma (metastatic)	2	7%
	Undiagnosed (inflammatory)	1	3%
Lung	Non -small cell carcinoma	2	7%
	Adenocarcinoma (metastatic)	1	3%
	Small cell lung cancer	2	7%
	Poorly differentiated carcinoma	1	3%
	Adenocarcinoma	2	7%
	Undifferentiated malignant neoplasm	3	10%
	Undiagnosed (necrotic)	1	3%
Mediastinal	Lymphoma	2	7%
Thoracoscopic assistance		**21**	**30%**
↳ **Type recommended *(n=21)***			
Medical (MT)		11	52%
VATS		10	48%
↳ **Pre-MT ultrasonographic guidance**		8	11%
Therapeutic (n=55)			
Therapeutic Thoracentesis		13	24%
Pleural drain Insertion		27	49%
Pleurodesis		15	27%

Table (5): Ultrasound-assisted pleural effusion management for prognostic purposes.

Ultrasound - guided Management Step		
Prognostic		
Post-drainage assessment & follow up during medical treatment (n=28)		
➢ **Result of assessment**		
Further intervention needed	4	14%
Further intervention not needed	24	86%
Pleural drain Follow up & removal (n=27)	27	100%
Non-expandable lung prediction (n=100)		
Expandable lung	56	56%
Un- expandable lung	15	15%
Not assessed	29	29%
Pleurodesis Success (n=15)		
Excellent	0	0%
Effective	10	67%
Poor	3	20%
Lost follow up	2	13%

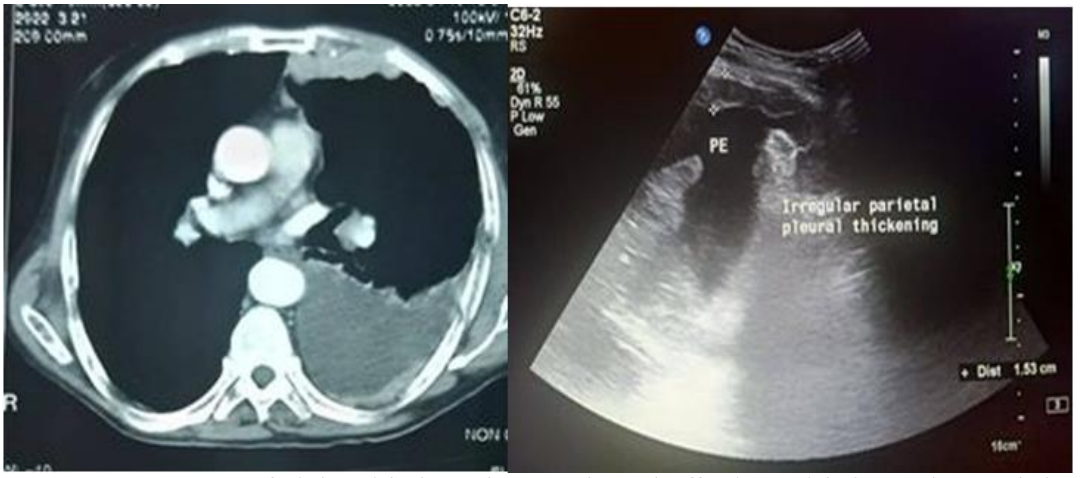

Figure (1)- A case of right-sided moderate pleural effusion with irregular nodular parietal pleural thickening seen in both CT and US. TUS-guided tru cut needle pleural biopsy taken & histopathological analysis result revealed undifferentiated small cell carcinoma (metastatic).

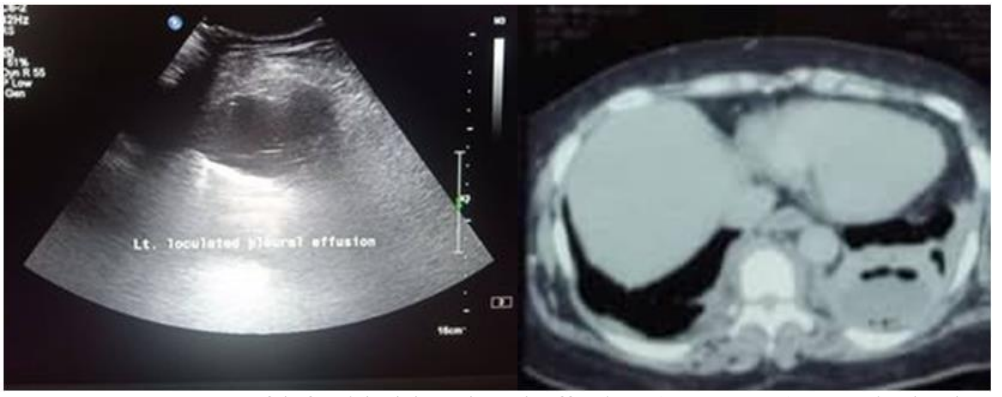

Figure (2)- A case of left-sided loculated effusion (empyema) seen in both CT and US. Us-guided placement of small-bore pleural drain/pigtail was done to drain pus.

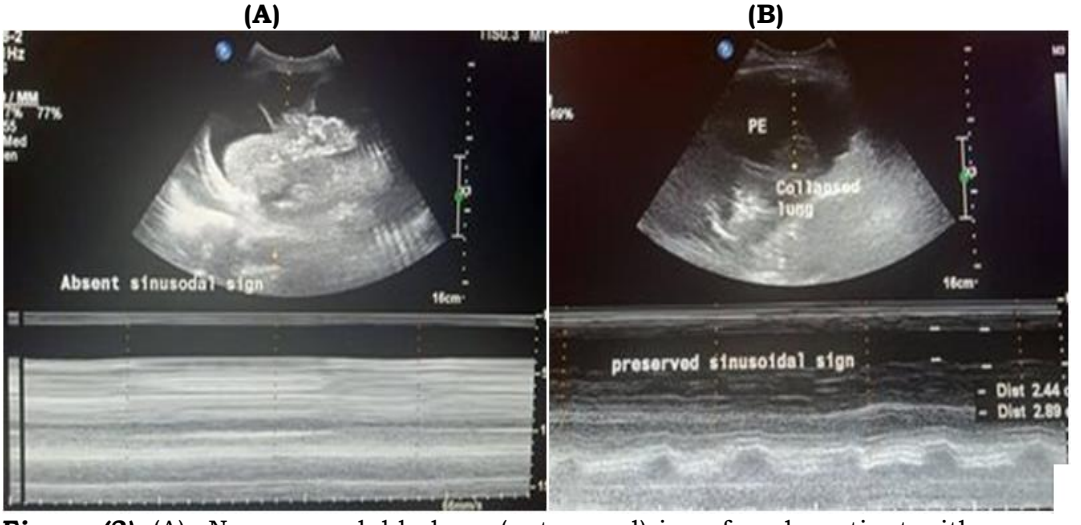

Figure (3). (A)- Non-expandable lung (entrapped) in a female patient with cancer ovary "absent sinusoidal sign" , so pleurodesis wasn't the choice of managemnt. (B)- Expandable lung "preserved sinusoidal sign" in a male patient with brochogenic carcinoma where pleurodesis was done.