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DIAGNOSTIC ACCURACY OF THORACIC ULTRASOUND IN DETECTING PLEURAL MALIGNANCY USING HISTOPATHOLOGY AS THE GOLD STANDARD

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ABSTRACT

Background: Pleural malignancy posses a major challenge regarding diagnosis because of the similarity of imaging with malignant pleural disease and benign pleural disease. Timely and proper management requires early and proper detection. The thoracic ultrasound is a non-invasive imaging technique that is both widely available and a radiation-free form of imaging that is used to examine pleural abnormalities and biopsy guide. Its diagnostics should be proven against histopathology.

Objective: To identify the accuracy of thoracic ultrasound in diagnosis of pleural malignancy, to establish the ultimate level as a gold standard, which is found in histopathology.

Materials and Methods: The present study was a descriptive cross-sectional study that occurred in the Department of Radiology, Lady Reading Hospital, Peshawar, in a period of four months, from December 24, 2025 to April 24, 2026. The sample of 241 patients with suspected pleural lesions aged 14-70 was selected as a result of consecutive non-probability sampling. Ultrasound results that indicated the possibility of malignancy were pleural nodularity, parietal pleural thickening of more than 1 cm, and pleural irregularity. Pleural biopsy was done using ultrasound guidance and histopathology was used as a reference. The computerized values included sensitivity, specificity, positive predictive value, and negative predictive value.

Results: Histopathology established the presence of pleural malignancy in 42.3. The sensitivity of ultrasound was 73.5, specificity 85.6, positive predictive value was 78.9 and negative predictive value was 81.5. The overall accuracy of diagnosing was 80.5%.

Conclusion: Thoracic ultrasound has excellent diagnostic quality and may be regarded as a valid first line imaging modality in suspected pleural malignancy, especially in resource constrained practices.

KEYWORDS. Biopsy, Pleura, Malignancy, histopathology, Ultrasound.

INTRODUCTION

Pleural lesions constitute a major diagnostic dilemma in clinical practice because of their diverse etiologies that are benign inflammatory diseases, primary and metastatic malignancies. Pleural diseases contribute to a significant respiratory morbidity in the world[1]. The incidence of pleural diseases is approximated as 23-3% in developed countries but could be as high as 30% in developing countries mostly due to infectious causes that include tuberculosis. Nevertheless, the malignant pleural involvement is an important issue to consider due to its correlation with adverse prognosis and systemic illness[2].

Malignant pleural disease usually takes place as a secondary event due to the metastasis of the primary tumors of the lung, breast, ovary, or gastrointestinal tract. Primary pleural malignancies, especially malignant mesothelioma are less common yet with high mortality. According to a recent study performed among United States Medicare beneficiaries, the prevalence of mesothelioma was reported to be between 8.8 to 31.3 per 100,000 individuals annually in 2016 to 2019 and annual incidence was between 4.5 and 12.6 per 100,000 individuals in 2016 to 2019, respectively (Bourne, 2019). These statistics indicate that pleural malignancies still have a clinical significance and that there is a necessity to use effective and timely diagnostic approaches[3].

Precise and descriptive diagnosis and description of pleural lesion is mandatory to inform management decisions, such as plans of biopsy, staging, and therapeutic interventions. Clinical manifestation can be rather general, and the patients

may tend to present themselves with dyspnea, chest pains, chronic cough, or frequent pleural effusion. Radiological assessment thus takes a leading position in distinguishing benign and malignant pleural diseases[4].

Despite its widespread use as a preliminary test, chest radiography has poor sensitivity and specificity to characterise pleural abnormalities. Computed tomography gives a better visualization of the pleural thickening and nodularity as well as the involvement of the mediastinum, but it is linked to radiation exposure, increased costs, and unavailability in resource limited locations. In addition, imaging is not a sufficient technique to make a definite diagnosis until histopathological confirmation is done[5].

Thoracic ultrasound has become a useful parameter of diagnostics in pleural disease. It is low cost, safe, radiation free and generally wide spread especially in tertiary care centres. The quick and easy examination of pleural morphology is done using ultrasound which is very sensitive in identifying any trace of pleural effusion. Certain sonographic findings including the presence of multiple pleural nodules, irregular or interrupted pleural thickening exceeding 1 cm, and pleural involvement of the parietal pleura have been noted to be suggestive of malignant pathology 7. Also, ultrasound is important in raising the pleural biopsies and this enhances diagnostic yield with the least possible complications[7].

In few studies, which have been carried out recently, the diagnostic value of thoracic ultrasound in the case of malignant pleural effusion have been evaluated. A meta analysis and a systematic review showed promising values and sensitivity and specificity, but there is variability in the studies, as there are differences in patient groups and sonographic criteria . New methods like the shear wave elastography have also revealed possibilities of enhancing diagnostic accuracy . Although these have been made, not much local information can be found on the diagnostic value of traditional thoracic ultrasound in the prediction of pleura malignancy in our population[8].

Pleural tissue histopathology is the best method of establishing the malignancy. Diagnostic features in some pleural tumors are characteristic borders like disorganized cellular structure, cell morphology: spindle or ovoid cell morphology, hypercellularity and hypocellularity in areas, cellular pleomorphism, hyalinized deposition of collagen, and branching hemangiopericytic type vasculature. It is therefore necessary to correlate the imaging results with histopathology to confirm the diagnostic accuracy of ultrasound in the diagnosis of possible pleural malignancy[9].

Despite the large usage of ultrasound in pleural assessment and biopsy guidance, there are relatively fewer studies that have conducted systematic research to determine the relationship between certain ultrasound features and the final histopathological outcomes. By creating this correlation, it would be possible to make diagnostic algorithms stronger and easier to make predictions of malignancy in earlier noninvasive stages, especially where we work in a resource limited healthcare setting[10].

The logic behind this study is to identify the percentage of the pleural lesions that exhibit malignancy in ultrasonography and that prove to be malignant in histopathological analysis. The lesions exhibiting irregular boundaries, nodular or solid structure, parietal pleural thickening more than 1 cm and break in pleural thickening are expected to have a higher probability of malignancy. On the other hand, lesions that seem to have smooth margins, homogenous appearance, and no pleural nodularity should have a greater association with benign pathology.

The proposed study will produce locally relevant evidence by comparing the diagnostic accuracy of thoracic ultrasound with histopathology as the reference standard. The results can help in enhancing clinical decision making, elements of biopsy strategy optimization, preventing unnecessary invasive processes, and patient management in suspected pleural malignancy.

MATERIALS AND METHODS

This descriptive cross-sectional study was conducted in the Department of Radiology at Lady Reading Hospital, Peshawar, over a period of four months, from December 24, 2025 to April 24, 2026 after approval of the research synopsis by the College of Physicians and Surgeons Pakistan and the institutional ethical review committee.

The sample size was calculated using OpenEpi. Based on previously published data reporting a mean prevalence of malignant pleural nodularity of 40%, sensitivity of 73%, and specificity of 91%, with an absolute precision of 8.9% and a 95% confidence level, the required sample size was determined to be 241 patients. Patients were recruited using consecutive non-probability sampling.[11]

The study population included all patients referred to the Department of Radiology for ultrasound-guided pleural biopsy due to suspected pleural lesions during the study period. Male and female patients aged between 14 and 70 years who underwent ultrasound-guided pleural biopsy for suspected pleural lesions were included in the study. Patients with simple pleural plaques and those whose pleural lesions did not demonstrate malignant characteristics on computed tomography and ultrasound were excluded.

A pleural lesion was considered malignant on ultrasound if one or more of the following features were present: multiple pleural nodules, parietal pleural thickening greater than 1 cm, or interruption or irregularity of pleural thickening. On histopathological examination, a lesion was labeled malignant if microscopic evaluation revealed disorganized cellular architecture without a definite pattern, spindle-shaped or ovoid cells, areas of hypercellularity alternating with hypocellularity, pleomorphic cells with hyalinized collagen, or a branching hemangiopericytic-type vascular pattern.

Diagnostic accuracy was determined by comparing ultrasound findings with histopathological results, which were taken as the gold standard. True positive cases were defined as lesions positive for malignancy on ultrasound and confirmed malignant on histopathology. True negative cases were those negative on ultrasound and confirmed benign on histopathology. False positive cases were lesions positive on ultrasound but benign on histopathology, while false negative cases were lesions negative on ultrasound but malignant on histopathology. Sensitivity was calculated as TP/(TP + FN) × 100, specificity as TN/(TN + FP) × 100, positive predictive value as TP/(TP + FP) × 100, and negative predictive value as TN/(TN + FN) × 100.

The study was conducted after obtaining ethical approval from the institutional review board of Lady Reading Hospital and the research evaluation unit of the College of Physicians and Surgeons Pakistan. Written informed consent was obtained from all participants after explaining the purpose, benefits, and potential risks of the study. Detailed demographic information including name, age, gender, medical record number, patient status, and date of procedure was recorded. Clinical history and physical examination findings were documented.

All patients underwent thoracic ultrasound examination performed by an experienced radiologist. Lesion characteristics were recorded on a predesigned proforma, including site of lesion, size and thickness, echogenicity, vascularity, associated pleural effusion, presence of lung lesion, and involvement of the chest wall, ribs, bones, or skin. Patients with suspicious malignant pleural lesions on ultrasound and/or computed tomography subsequently underwent ultrasound-guided pleural biopsy. Histopathological examination of biopsy specimens was carried out by experienced pathologists. Ultrasound findings were then compared with corresponding histopathological reports. All observations were verified under the supervision of a consultant radiologist to ensure data accuracy and uniformity.

Data were entered and analyzed using IBM SPSS Statistics. Categorical variables such as gender and ultrasound findings were expressed as frequencies and percentages, whereas quantitative variables such as age were expressed as mean ± standard deviation. A 2 × 2 contingency table was constructed to determine diagnostic accuracy parameters. Sensitivity, specificity, positive predictive value, and negative predictive value were calculated using the predefined formulas

Stratification of diagnostic accuracy measures was performed according to age and gender to control for potential effect modifiers.

RESULTS

A total of 241 patients were enrolled in the study. The mean age of the study population was 48.6 ± 12.4 years, with ages ranging from 14 to 70 years. Male patients constituted 57.3% (n = 138) of the study population, while females accounted for 42.7% (n = 103).

The detailed demographic characteristics of the participants are presented in **Table 1**.

Table 1: Demographic Characteristics of Study Population (n = 241)

Variable	Frequency	Percentage
Gender		
Male	138	57.3%
Female	103	42.7%
Age (years)		
14–30	38	15.8%
31–50	112	46.5%
51–70	91	37.7%
Mean ± SD	48.6 ± 12.4	—

As shown in Table 1, the majority of patients (46.5%) were in the 31–50 years age group, followed by 37.7% in the 51–70 years group. Only 15.8% of patients were younger than 30 years. This indicates that pleural disease was more frequently observed in middle-aged and older individuals in the present study

Ultrasound examination was performed in all patients to identify specific pleural characteristics suggestive of malignancy. The distribution of various ultrasound features is summarized in **Table 2**.

Table 2: Distribution of Ultrasound Findings (n = 241)

Ultrasound Feature	Frequency	Percentage
Multiple pleural nodules	78	32.4%
Parietal pleural thickening > 1 cm	89	36.9%
Interruption of pleural thickening	65	27.0%
Classified as malignant on ultrasound	95	39.4%
Classified as benign on ultrasound	146	60.6%

As illustrated in Table 2, parietal pleural thickening greater than 1 cm was the most frequently observed ultrasound feature (36.9%), followed by multiple pleural nodules (32.4%) and interruption of pleural thickening (27.0%). Based on predefined diagnostic criteria, 95 patients (39.4%) were categorized as having malignant pleural lesions on ultrasound, while 146 patients (60.6%) were categorized as benign.

Histopathological examination was used as the gold standard to confirm the final diagnosis. The distribution of histopathological findings is shown in **Table 3**.

Table 3: Histopathological Findings (Gold Standard) (n = 241)

Histopathological Diagnosis	Frequency	Percentage
Malignant pleural lesion	102	42.3%
Benign pleural lesion	139	57.7%

As demonstrated in Table 3, histopathology confirmed malignant pleural lesions in 102 patients (42.3%), whereas 139 patients (57.7%) were diagnosed with benign pathology. The proportion of malignancy confirmed by histopathology was slightly higher than that identified by ultrasound examination.

To evaluate the diagnostic performance of ultrasound, its findings were compared with histopathological results. The cross-tabulation of ultrasound diagnosis versus histopathology is presented in **Table 4**.

Table 4: Comparison of Ultrasound Findings with Histopathology (2 × 2 Table)

Ultrasound Findings	Histopathology Positive	Histopathology Negative	Total
Ultrasound Positive	75 (TP)	20 (FP)	95
Ultrasound Negative	27 (FN)	119 (TN)	146
Total	102	139	241

As shown in Table 4, ultrasound correctly identified 75 true positive cases and 119 true negative cases. However, 27 malignant cases were missed (false negatives), and 20 cases were incorrectly classified as malignant (false positives). These values were used to calculate the diagnostic accuracy parameters.

The calculated diagnostic indices of ultrasound in detecting pleural malignancy are summarized in **Table 5**.

Table 5: Diagnostic Accuracy of Ultrasound in Detecting Pleural Malignancy

Parameter	Value
Sensitivity	73.5%
Specificity	85.6%
Positive Predictive Value (PPV)	78.9%
Negative Predictive Value (NPV)	81.5%
Overall Diagnostic Accuracy	80.5%

Table 5 shows that ultrasound had a sensitivity of 73.5 and a specificity of 85.6 in identifying malignant lesions of the pleura. The positive predictive value stood at 78.9 and negativity predicted value was 81.5. The total diagnostic accuracy of ultrasound was 80.5 which is a good general performance especially in the elimination of malignancy.

Stratified Analysis

Stratification by gender showed some slight sensitivity and specificity in males (75.8% and 87.1) than in females (70.4% and 83.3) though not significantly.

Stratification according to age was slightly more sensitive in patients with age more than 50 years of age but did not attain statistical significance.

DISCUSSION

Pleural malignancy is still one of the major diagnostic and treatment dilemmas in clinical practice especially in areas that have high rates of benign pleural diseases like tuberculosis. Proper distinction of malignant and benign pleural lesion is the key to timely management, proper planning to treat and better patient outcome. The current research analyzed the accuracy performance of the thoracic ultrasound in the diagnosis of the pleural malignancy comparing the sonographic results with the gold standard of the histopathological analysis. The results indicate that ultrasound is a fairly reliable modality in the detection of malignant lesions of the pleura with a sensitivity of 73.5, specificity 85.6, positive predictive value of 78.9 and a negative predictive value 81.5[12].

This report shows that histopathology proved pleural malignancy in 42.3 per cent of the patients which is similar to the previous documented records of tertiary care centres where a high percentage of patients who undergo pleural biopsy are suspected of having malignant disease. The fairly high malignancy rate of our cohort is attributable to the referral characteristics of the institution, and the need to perform correct pre-biopsy imaging examination. According to the predetermined criteria (such as the presence of more than one nodule in the pleura, the presence of parietal

pleural thickening exceeding 1 cm, and the discontinuity of the pleural thickening), 39.4% of lesions were diagnosed with malignancy using ultrasound. These sonographic parameters were chosen on the basis of the earlier literature that indicated that they are closely related to the presence of malignant pleura[13].

The sensitivity that was observed in this study implies that ultrasound was able to identify the presence of the malignancy cases that are proven by the use of the microscope at the rate of about three quarters. The result is similar to other systematic reviews and meta-analyses which have found sensitivity of thoracic ultrasound to be between 70 and 90% in detecting malignant pleural effusion. The medium rate of false negative results in our research could be explained by the presence of small malignancies in early stages, low levels of pleural thickening, or lesions that do not have a strong nodular shape which could be difficult to identify sonographically. There is also the possibility of microscopic malignant infiltration which is not seen on ultrasound image because it lacks gross structural distortion[14].

The specificity of 85.6% that was found in this study reflects high capability of the ultrasound in recognizing benign lesions correctly. Our study could have had the false positive cases due to inflammatory or fibrotic pleural thickening that looks like malignancy. On imaging, nodular or irregular thickening appears due to chronic inflammatory pleural changes that can be and resemble malignancy in areas with a high prevalence of tuberculosis. This overlap highlights the need of histopathological confirmation in the face of suggestive imaging[15].

The positive predictive value of 78.9% indicates that around every 4 lesions that were found to be malignant on ultrasound were found to be historical. This supports the utility of ultrasound in the process of selecting the patients to undergo biopsy. The negative predictive value of 81.5% implies that the majority of the lesions that were classified as benign under ultrasound were non-malignant, however, a few cases of malignancy were missed. Clinically, this highlights the fact that a negative ultrasound result lowers the suspicions, but it does not completely rule out malignancy especially in high-risk patients having persistent symptoms or radiological suspicions on other modalities[16].

Stratified analysis showed that sensitivity was a bit higher in older patients and this could be due to higher prevalence of malignant pleura disease in the old age groups. Though the gender based variations were not found to be statistically significant, the marginally better diagnostic performance in males could be due to occupational exposure risk and prevalence of some malignancies being higher in the male patients. These differences were however not so significant so as to change clinical interpretation[17].

Provision of real-time image and lead pleural biopsy is one of the major strengths of thoracic ultrasound that were demonstrated in this research. In addition to the characterization of lesions, ultrasound helps to increase the accuracy of the procedure since the sites in which pleural abnormality is most pronounced are identified. The benefits of ultrasound over the computed tomography are that the technique is inexpensive, portable, and non-radiating. The above properties render ultrasound particularly handy as a diagnostic tool of choice in resource-constrained conditions.

The definition of operations applied in this research was based on some sonographic requirements. The occurrence of parietal pleural thickening above 1 cm, and more than one nodule of pleura showed a close relationship with malignancy. These findings can also be compared to the previous studies that indicated that the nodular pleural thickening and involvement of the diaphragm are very much indicative of the malignant pathology. Presence or absence of pleural thickening was also a predictive characteristic of importance. However, it was in non-nodular benign disease that single smooth thickening was more likely to be related to benign disease in our cohort[18].

Definitive diagnosis cannot be done without histopathological examination. Malignant transformation is confirmed by microscopic parameters of disorganized cellular structure, pleomorphism, spindle or ovoid cell structure, and typical vascular patterns. Imaging modalities such as ultrasound are more of a diagnostic adjuncts and procedural guides as opposed to a definite diagnostic tool. This idea is supported by the current study because it indicates that ultrasound plays an important role in suspicion and targeting, but it cannot substitute tissue diagnosis[19].

Comparing our results with those in the international literature, the level of diagnostic performance that we had in this research falls within reasonable limits. These minor differences might be due to variation in the study population, experience of the operators, resolution of the ultrasound equipments, and the criteria of identifying malignancy. One of the limitations of ultrasound is still operator dependency. Proper interpretation needs proper training and skills. The tests were conducted and monitored by trained radiologists in our research and could also be the reason why the diagnostic accuracy was satisfactory[20].

It has a couple of limitations that should be mentioned. Firstly, the study was conducted in a single tertiary care institution and it could limit the generalizability. Second, it could have been because of the bias of the selection since the lesions that were not malignant on both ultrasound and CT were excluded[21]. Third, the interobserver reliability was not assessed adequately. Irrespective of these drawbacks, the study may be regarded as a valuable source of local data and a reflection of clinical practice in the real world[22].

The clinical aspects of the results of this research are considerable. The use of thoracic ultrasound as an additional procedure to routine examination of the potential pleural malignancy can attract the successful and timely identification and, consequently, a superior organization of the biopsy and even the avoidance of the undesired

invasive procedures. Ultrasound is a resource constrained healthcare tool which can be applied as a screening tool before any other more sophisticated tests or surgery can be conducted.

The future research can take into account the implementation of the more contemporary approaches to ultrasound such as elastography or contrast-enhanced ultrasound to improve the degree of precision of the diagnosis. To be more persuasive, cross-sectional multicenter research involving more significant sample sizes can be used to establish standardized sonography grading systems that can be used to predetermine pleural malignancy.

CONCLUSION

Thoracic ultrasound demonstrates good diagnostic accuracy in detecting pleural malignancy when compared with histopathology as the gold standard. While it cannot replace tissue diagnosis, it serves as a valuable, noninvasive, and cost-effective tool for initial evaluation and biopsy guidance. Its implementation in routine clinical practice may improve diagnostic efficiency and optimize management strategies in patients with suspected pleural malignancy.

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