Pak. J. Chest Med. 2024;30(04)

Original Article

journal homepage: https:/www.pjcm.net/

Pakistan Journal of Chest Medicine

Official journal of Pakistan Chest Society

# Evaluation of Pleurodesis Success in Malignant Pleural Effusion Using Radiologic Modalities: The Role of Thoracic Ultrasound, CT, and Chest X-Ray

**Nadeem Gul, Farhan Sabir, Muhammad Taj, Raheel Shah** ✉

Department of Medicine, Kabir Medical College, Peshawar - Pakistan

**Corresponding Author:**
**Raheel Shah**
Department of Medicine,
Kabir Medical College,
Peshawar - Pakistan
Email: raheelshah98@gmail.com

**Article History:**

| | |
|---|---|
| Received: | Jun 01, 2024 |
| Revised: | Aug 29, 2024 |
| Accepted: | Nov 04, 2024 |
| Available Online: | Dec 02, 2024 |

**Author Contributions:**
NG conceived idea, FS drafted the study, MT collected data, RS did statistical analysis and interpretation of data, FS RS critical reviewed manuscript. Both approved final version to be published.

**Declaration of conflicting interests:**
The authors declare that there is no conflict of interest.

**How to cite this article:**
Gul N, Sabir F, Taj M, Shah R. Evaluation of Pleurodesis Success in Malignant Pleural Effusion Using Radiologic Modalities: The Role of Thoracic Ultrasound, CT, and Chest X-Ray. Pak J Chest Med. 2024;30 (04):492-500.

## ABSTRACT

**Background:** Malignant pleural effusion (MPE) is a frequent issue in advanced cancers. It leads to serious breathing problems and reduces the quality of life. Doctors often use chemical pleurodesis to prevent the fluid from returning. Assessing how well pleurodesis works is important for clinical decisions. Imaging methods like ultrasound, computed tomography (CT), and chest X-ray are key for checking results after the procedure.

**Objective:** To evaluate the effectiveness of pleurodesis in patients with malignant pleural effusion using thoracic ultrasonography, computed tomography, and chest radiography, focusing on the absence of pleural sliding as a sign of successful treatment.

**Methodology:** This study was performed at the Department of Medicine, Kabir Medical College, Peshawar. Fifty-four patients with malignant pleural effusion had intercostal chest tubes inserted, and then underwent chemical pleurodesis with bleomycin. Transthoracic ultrasound was done by researchers before the procedure, and again one month later to assess for the pleural sliding sign. Chest X-rays and CT scans also aided in determining the success of the pleurodesis.

**Results:** Out of the 54 patients, 43 (79.6%) had successful pleurodesis. This was signified with no pleural sliding on ultrasound, a lack of recurrence of pleural effusion on CT and X-ray. In the mammary and supra-mammary regions, 81.5% had loss of sliding. Axillary and posterior regions, 77.8% and 75.9% loss of sliding, respectively. There was no significant difference in the results based on the type of sclerosing agent employed in the procedure.

**Conclusion:** Transthoracic ultrasound is a trustworthy and effective non-invasive tool to evaluate the success of pleurodesis in malignant pleural effusion; the loss of the pleural sliding sign is associated with effective pleural adhesion. The CT and X-ray assessments support the ultrasound findings and use of sclerosing agent type did not significantly influence outcomes of pleurodesis.

**Keywords:** Malignant Pleural Effusion; Pleurodesis; CT; X-Ray

## Introduction

Malignant pleural effusion (MPE) is a frequent and worrisome complication in patients with advanced malignancies. Malignant pleural effusion is defined as fluid in the pleural space that accumulates due to cancer and is often manifested by significant symptoms such as shortness of breath, cough, and chest pain which compromises a patient's quality of life.[1] While presence of MPE indicates a generally poor prognosis, median overall survival is between 3 to 12 months depending on the type of cancer.[2] Common primary tumors leading to malignant pleural effusion include lung cancer, breast cancer, and lymphomas.[3]

The management of MPE mainly aims to relieve symptoms and prevent fluid buildup. One common treatment option is chemical pleurodesis. This procedure injects a sclerosing agent into the pleural space. The goal is to create inflammation and fibrosis. This process closes off the pleural cavity and stops further fluid accumulation.[4] Agents like talc, bleomycin, and doxycycline are often used. Talc is generally seen as the most effective agent. However, bleomycin is usually preferred for patients with weakened lung function because it poses a lower risk of causing acute respiratory distress syndrome.[5]

Traditionally, doctors evaluate the success of pleurodesis by looking for clinical improvement and by checking for reduced or absent fluid reaccumulation through imaging. Chest radiography has often been the first imaging method used for this assessment because it is widely available and affordable. However, it is not very sensitive for detecting small amounts of leftover fluid or for assessing the apposition of the pleura.[6] Computed tomography (CT) provides better spatial resolution and is more reliable in detecting remaining effusions, thickening of the pleura, or nodules. It also helps confirm that there is no pleural space, which indicates that pleurodesis has been successful.[7]

Thoracic ultrasonography (TUS) has become a highly sensitive, non-invasive, bedside tool for assessing pleural diseases. It can detect pleural effusions as small as 5 to 50 mL and allows for real-time evaluation of pleural surfaces. This capability makes it especially useful for guiding pleurodesis.[8] One key sign that TUS evaluates is the "pleural sliding sign." This sign indicates the movement of the visceral pleura against the parietal pleura during breathing. If the sliding sign is missing after pleurodesis, it suggests that the two pleural layers are stuck together. This situation indicates a successful pleural symphysis.[9]

TUS gives advantages such as repeatability, no radiation exposure, and dynamic functional information. Studies suggest that lack of pleural sliding on ultrasound is strongly related to pleurodesis success. This may potentially be an early, objective marker to identify pleural adhesion prior to any clinical or radiographic evidence appearing.[10]

While ultrasound may provide valuable insights into the outcome of pleurodesis, the field still exhibits variable application and interpretation of thoracic ultrasound. In addition, reports concerning ultrasound findings should be complemented by established imaging techniques including chest X-ray and computed tomography. If anything, this article emphasizes the need for studies determining the role of TUS in conjunction with other imaging modalities after pleurodesis.

The study described herein evaluated and compared the usefulness of transthoracic ultrasound, chest X-ray, and computed tomography in the assessment of pleurodesis success in patients with malignant pleural effusion. Specifically, the research focused on thoracic ultrasound assessment of the pleural sliding sign as a potential predictor of pleurodesis success.

## Objective

To assess the efficacy of pleurodesis in patients with malignant pleural effusion using thoracic ultrasonography, computed tomography, and chest radiography, with a focus on the absence of pleural sliding as a marker of successful intervention.

## Methodology

The present study was conducted in the Department of Medicine at Kabir Medical College in Peshawar, Pakistan, over a period of six months. In this study a total of 54 patients with malignant pleural effusion (MPE) were enrolled consecutively. To be included, patients had to be adults aged 18 and over, with cytologically or histologically confirmed malignant pleural effusion, and considered suitable candidates for chemical pleurodesis. Patients were excluded if they had a trapped lung, serious heart or lung issues, a known allergy to bleomycin, bilateral pleural effusions needing simultaneous treatment, or if they were unwilling or unable to give informed consent.

All enrolled patients had a thorough clinical assessment that included detailed history, physical examination, and baseline laboratory tests. Imaging workup involved chest X-rays and computed tomography (CT) scans to check for pleural effusion, pleural thickening, nodularity, and lung collapse. An intercostal chest tube (20 to 24 French) was inserted under clean conditions in each patient and linked to an underwater seal drainage system. The drainage was monitored daily. Pleurodesis was considered once the daily fluid output dropped to less than 100 ml and imaging confirmed full lung re-expansion.

Before the pleurodesis procedure, all patients had transthoracic ultrasonography (TUS) using a high-frequency (7.5-10 MHz) linear probe by an experienced radiologist. The main parameter assessed was the pleural sliding sign, which is the gliding movement of the visceral pleura against the parietal pleura during breathing. The

presence of pleural sliding showed that the pleural layers were not sticking together and confirmed that the patient was ready for pleurodesis.

Chemical pleurodesis was performed using bleomycin as the sclerosing agent. A total of 60 mg of bleomycin diluted in 50 ml of normal saline was put into the pleural cavity through the intercostal tube. After instillation, the chest tube was clamped for one to two hours. During this time, the patient was turned every 15 to 20 minutes to help distribute the agent evenly. The tube was then unclamped and reconnected to the underwater seal drainage system. The intercostal drain was removed within 24 to 48 hours if there was minimal output and no complications, such as fever, chest pain, or breathing problems.

One month after the procedure, all patients were re-evaluated in order to check the result of pleurodesis. The follow-up evaluation included a transthoracic ultrasound to assess the pleural sliding sign. The absence of any sliding sign on ultrasound indicated that pleura was adherent, and successful pleurodesis had taken place. Further, follow-up chest x-ray will usually be done in conjunction, or follow-up CT scan to check for any residual or recurrent effusion, along with pleural thickening and re-expansion of lung. All of them (ultrasound, x-ray and CT) together can give an overall evaluation of the outcome of pleurodesis.

The primary outcome measure for pleurodesis was defined as: no recurrence of pleural effusion, no pleural sliding on ultrasound at follow-up, and no further pleural procedure required within the one-month follow-up period. The secondary outcomes were: frequency of basal sliding sign noted on ultrasound studies before and after pleurodesis; and complications related to pleurodesis.

Data were entered and analyzed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were presented as means and standard deviations, while categorical variables were summarized as frequencies and percentages. The McNemar's test was used to compare paired categorical data (presence versus absence of the sliding sign before and after the procedure). A p-value of less than 0.05 was considered statistically significant.

The study received ethical approval (Ref. 101/KMC/2022-10) from the institutional review board of KMC prior to beginning. All participants gave informed written consent.

## Results

The study included 54 patients with confirmed malignant pleural effusion. The average age was 59.8 years, with a range from 37 to 81 years. There were 29 males (53.7%) and 25 females (46.3%) (Figure 1).

Most patients, 35 out of 54 (64.8%), reported chest pain, and 30 patients (55.6%) had a chronic cough. Every patient (100%) had dyspnea. Pleural nodules were found in 42 patients (77.8%), and pleural adhesions were

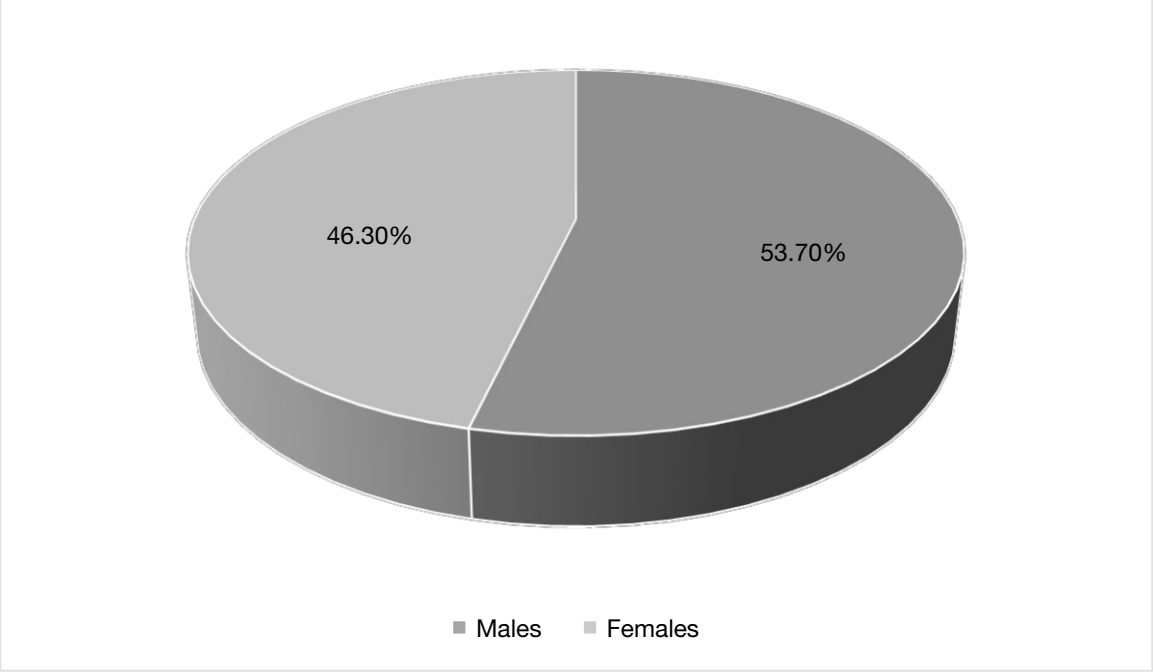


Figure 1. Gender based distribution of study cases

Table 1. Ultrasound Findings Pre- and Post-Pleurodesis by Chest Region (n = 54)

| Chest Region | Sliding Pre (%) | Sliding Post (%) | No Sliding Post (%) | P-value |
|---|---|---|---|---|
| Supra-mammary | 54 (100) | 9 (16.7) | 45 (83.3) | < 0.001* |
| Mammary | 54 (100) | 10 (18.5) | 44 (81.5) | < 0.001* |
| Infra-mammary | 54 (100) | 8 (14.8) | 46 (85.2) | < 0.001* |
| Upper axillary | 54 (100) | 11 (20.4) | 43 (79.6) | < 0.001* |
| Lower axillary | 50 (92.6) | 10 (18.5) | 40 (74.1) | < 0.001* |
| Supra-scapular | 54 (100) | 12 (22.2) | 42 (77.8) | < 0.001* |
| Interscapular | 54 (100) | 11 (20.4) | 43 (79.6) | < 0.001* |
| Infrascapular | 48 (88.9) | 15 (27.8) | 33 (61.1) | < 0.001* |

present in 9 patients (16.7%). The average body mass index (BMI) was 23.2 kg/m², with 20 patients (37.0%) having a history of smoking. CT scans of the thorax showed pleural effusion and lung collapse in all patients (100%). For pleurodesis agents, bleomycin was used in 35 patients (64.8%), doxycycline in 12 patients (22.2%), and tetracycline in 7 patients (13.0%). The most common diagnosis was metastatic adenocarcinoma (40.7%), followed by malignant mesothelioma (29.6%), lymphoma (11.1%), squamous cell carcinoma (7.4%), and other conditions (11.2%). Before pleurodesis, all patients showed the pleural sliding sign on transthoracic ultrasound in all areas of the chest wall. One month after the procedure, there was a notable decrease in pleural sliding across all areas. A total of 43 out of 54 patients (79.6%) showed no sliding sign, indicating successful pleurodesis. Conversely, 11 patients (20.4%) had persistent sliding, indicating pleurodesis failure ($P < 0.001$).

In the mammary and supra-mammary areas, the pleural sliding sign was absent in 44 patients, or 81.5%, after pleurodesis. This shows that pleural symphysis was effective in most cases. In the upper and lower axillary regions, 42 patients, or 77.8%, also showed no sliding sign after the procedure. This indicates a high success rate of pleurodesis in these areas as well. In the back of

Table 2. Pleurodesis Outcome According to Histopathology and Agent Used

| Variable | Successful (n=43) | Failed (n=11) | P-value |
|---|---|---|---|
| Bleomycin | 29 (67.4%) | 6 (54.5%) | 0.64 |
| Doxycycline | 10 (23.3%) | 2 (18.2%) | |
| Tetracycline | 4 (9.3%) | 3 (27.3%) | |
| Metastasis | 18 (41.9%) | 4 (36.4%) | 0.71 |
| Mesothelioma | 12 (27.9%) | 4 (36.4%) | |
| Lymphoma | 5 (11.6%) | 1 (9.1%) | |
| Squamous Cell Carcinoma | 3 (7.0%) | 1 (9.1%) | |
| Others | 5 (11.6%) | 1 (9.1%) | |

the chest, which includes the suprascapular, interscapular, and infrascapular regions, 41 patients, or 75.9%, had no pleural sliding, confirming effective pleural adhesion. Additionally, mild pleural effusion was seen in 10 patients, or 18.5%, and moderate effusion in 3 patients, or 5.6%, in these posterior regions. This suggests that a few cases had partial or incomplete pleurodesis (Table 1; Figure 1).

Out of 54 patients, 43 (79.6%) had successful pleurodesis. This was confirmed by the absence of pleural sliding on follow-up TUS and no signs of fluid reaccumulation on chest X-ray and CT. Pleurodesis failed in 11 patients (20.4%), all of whom showed the sliding sign and had varying amounts of residual or recurrent pleural fluid. Chest X-ray indicated moderate effusion in 12 patients (22.2%) after the procedure, while CT scans confirmed persistent pleural separation in 9 of these patients. There was no significant difference in pleurodesis success based on the type of sclerosant used (P = 0.64) or the histopathological diagnosis (P = 0.71), as shown in Table 2. Thoracoscopic findings, such as pleural thickening, nodularity, or adhesions, and the pre-procedural effusion volumes were also not significantly different between the successful and failed cases.

Following pleurodesis, regional thoracic ultrasound showed a significant reduction in the pleural sliding sign across all chest zones. In the mammary and supramammary areas, the sliding sign was absent in 44 patients (81.5%), confirming successful pleural adhesion. Similarly, in the upper and lower axillary regions, 42 patients (77.8%) showed no pleural sliding, indicating effective pleurodesis. Evaluation of the posterior zones, including the suprascapular, interscapular, and infrascapular areas, revealed an absence of the sliding sign in 41 patients (75.9%), further supporting positive results. However, among these, 10 patients (18.5%) had mild effusion, and 3 patients (5.6%) had moderate effusion, suggesting partial or failed pleurodesis in a small number of cases. Overall, 43 out of 54 patients (79.6%) achieved successful pleurodesis, while 11 patients (20.4%) experienced failure, as summarized in Figure 3.

## Discussion

This prospective study assessed how well pleurodesis worked in patients with malignant pleural effusion (MPE). We used transthoracic ultrasonography (TUS), computed tomography (CT), and chest X-rays. The lack of pleural sliding on TUS served as the main indicator for successful pleural fusion. Our findings showed that TUS is an effective, non-invasive method to evaluate pleurodesis results.

In our study, the average age of participants was 59.8 years, with a standard deviation of 11.3 years. There was

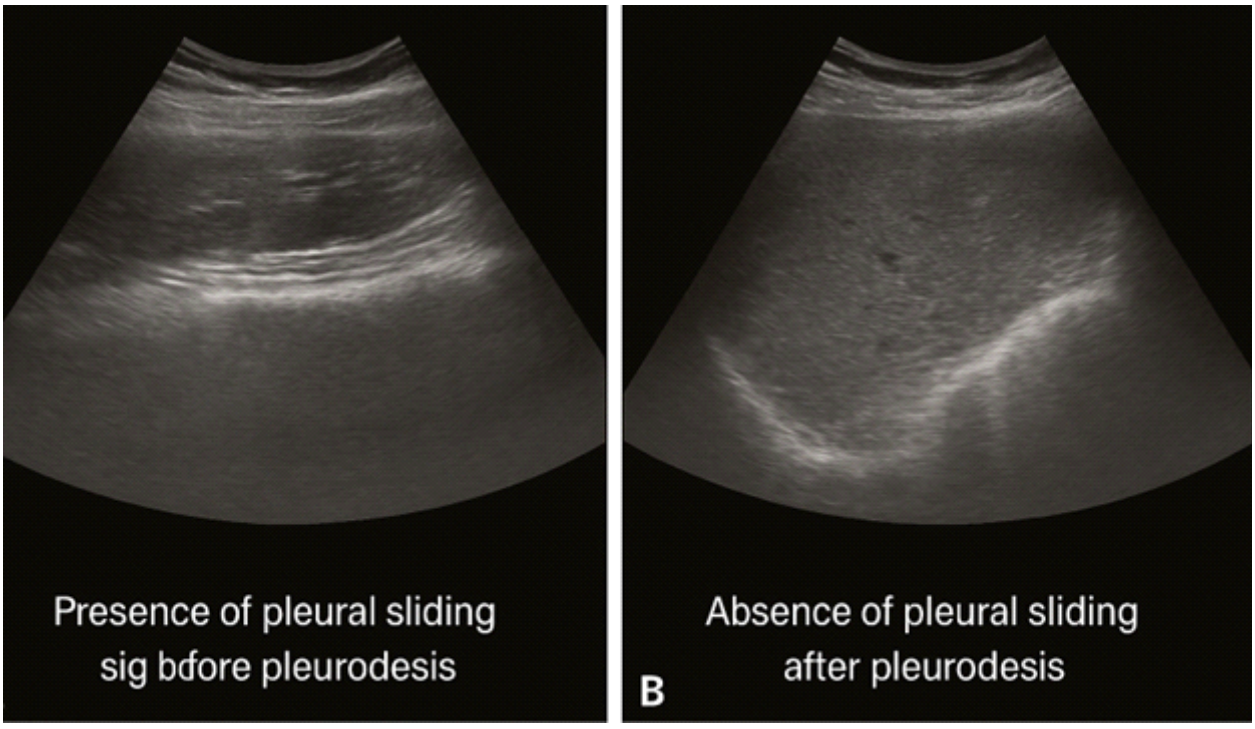


Figure 2. Ultrasound Images Pre- and Post-Pleurodesis. A: Presence of pleural sliding sign before pleurodesis. B: Absence of pleural sliding after pleurodesis.

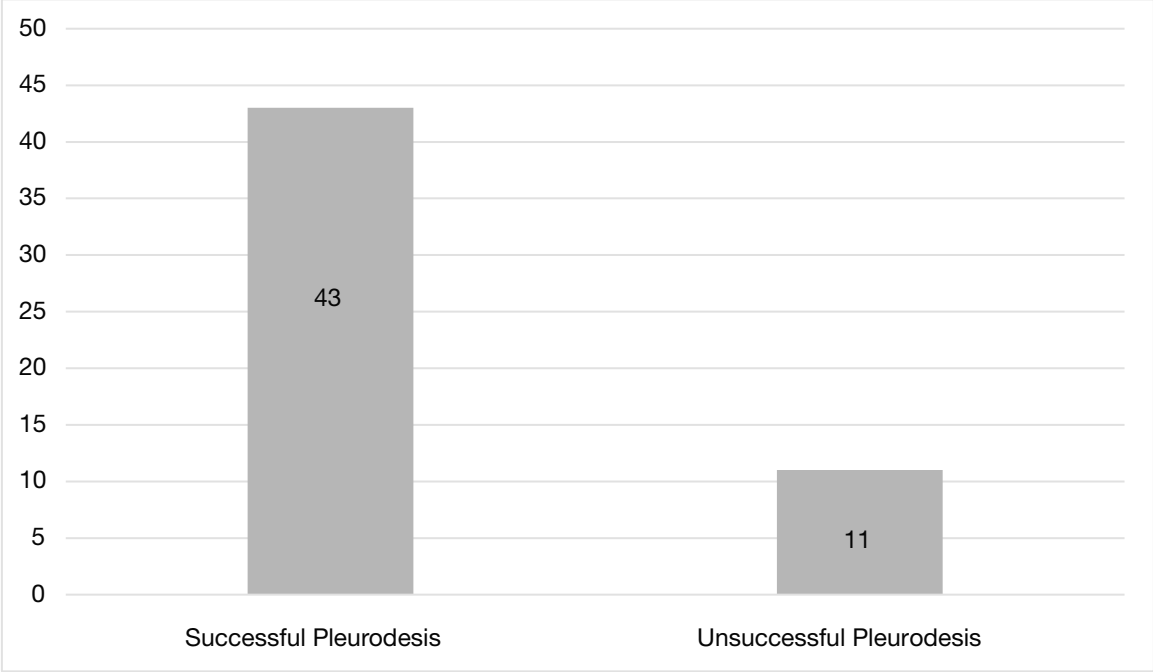


Figure 3. Overall Pleurodesis Outcome in Study Cohort

a slight male majority at 53.7%. This demographic pattern matches other studies, like El Hadidy et al., who found a mean age of 58.3 years with equal numbers of men and women among MPE patients undergoing pleurodesis.[11] Similarly, Martinez-Moragon et al. reported a mean age of 60 years in their group,[12] while Zimmer et al. studied a slightly older population with a mean age of 68 years.[13] The higher rates of lung and breast cancer in MPE, along with its common occurrence in older age groups, likely account for the similarities across these studies.

Regarding clinical presentation, all patients reported dyspnea, which is 100%. Chest pain occurred in 64.8% of patients, and 55.6% experienced cough. These findings show typical symptoms of MPE and match previous studies. Tsai et al. found dyspnea in 95% of patients with MPE.[14] Penz et al. and Dixit et al. also noted chest discomfort and cough in more than half of their patients.[15,16]

In our study, 77.8% of patients showed pleural nodularity on imaging, and 16.7% had adhesions. These findings are comparable with previous studies that identified pleural nodules in 70–90% of patients with mesothelioma or metastatic disease. El Hadidy et al. observed pleural nodules in 93.4% of their cases,[11] Seddik et al. reported nodularity in 82%,[17] and El-Sayed et al. found pleural nodules in 80% of their cohort.[18] The presence of adhesions, though lower in our study, is also supported by similar frequencies (10–20%) in the literature.

The most common histopathological finding in our study was metastatic adenocarcinoma at 40.7%. This was followed by malignant mesothelioma at 29.6%. Similar results were seen in studies by Manu et al., who reported metastasis in 61.9% of patients with malignant pleural effusion.[19] Magdy and Hieba found adenocarcinoma in 65% of cases, with half of those cases originating from the breast.[20] Martinez-Moragon et al. also reported that more than half of their patients had metastatic lung adenocarcinoma.[12] These results support the idea that most malignant pleural effusions come from metastatic sources, particularly lung and breast cancers.

The main outcome indicator, the absence of pleural sliding on ultrasound one month after pleurodesis, was seen in 79.6% of patients in our study. This is similar to the findings by Corcoran et al., who reported a pleurodesis success rate of 78% using TUS,[21] and by Agmy et al., who noted successful pleurodesis in 88% of their cases using pleural sliding scores.[22] El Hadidy et al. also observed successful pleurodesis in 71.4% of patients based on the absence of the sliding sign.[11] These results support the clinical use of the sliding sign in TUS as a trustworthy marker for pleurodesis effectiveness. The consistent results across studies highlight the diagnostic value of transthoracic ultrasound as a bedside tool for evaluating post-pleurodesis. Its non-invasive nature, real-time assessment, and high sensitivity make it a preferred method for tracking pleural adherence in cases of malignant pleural effusion.

In the mammary and supra-mammary areas, 81.5% of patients showed loss of pleural sliding. Seddik et al. also reported a significant decrease in the sliding sign in these areas after the procedure ($P<0.001$).[17] Agmy et al. pointed

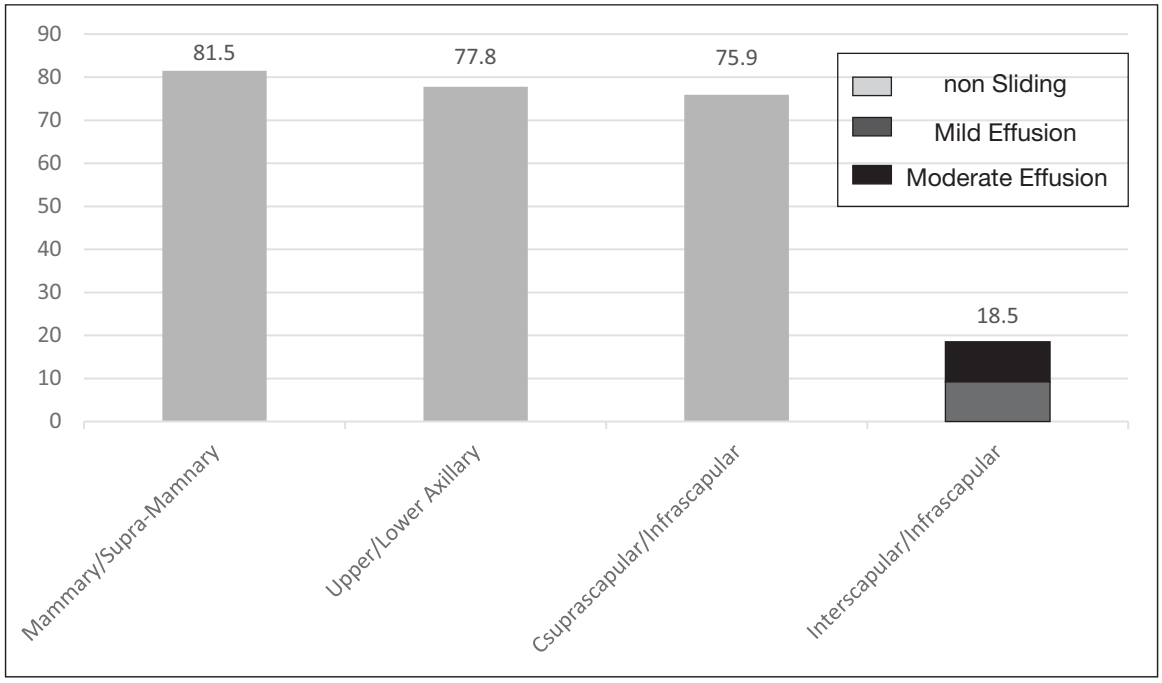


Figure 4. Pleurodesis outcome by region (n = 54)

out that the anterior thoracic zones are crucial for early detection of successful pleural adhesion. de Boer et al.[22] found that loss of the sliding sign in the anterior zones related to the completion of pleurodesis after surgical pleurectomy.[23] These findings support the idea that the anterior chest zones are good indicators for early detection of successful pleural symphysis. The repeated loss of the sliding sign in these areas suggests they should be prioritized in routine post-pleurodesis ultrasound checks.

In the axillary regions, 77.8% of patients had no sliding after pleurodesis. This finding is consistent with the research by El Hadidy et al., which showed that axillary areas had the highest rates of sliding sign disappearance.[11] Similarly, Seddik et al. and de Boer et al. reported significant changes in axillary ultrasound windows related to pleurodesis, supporting our results.[17,23] The axillary zones, because of their mobility and accessibility, seem to be especially sensitive to pleural changes after pleurodesis. Their reliable results across studies further confirm their importance as key ultrasound landmarks in post-procedural evaluations.

In the posterior regions (suprascapular, interscapular, and infrascapular), 75.9% of patients showed no pleural sliding. Meanwhile, 18.5% demonstrated mild effusion, and 5.6% showed moderate effusion. Our findings match those of Seddik et al., who saw a notable reduction in post-procedural effusion in posterior zones.[17]

Additionally, El-Sayed et al. found that posterior regions are good at detecting residual effusions with ultrasound. Corcoran et al. pointed out that these zones can indicate delayed or incomplete pleurodesis due to fluid buildup or technical issues.[21] These observations suggest that posterior regions may be important for spotting partial pleurodesis or early effusion recurrence. Including these areas in follow-up protocols could improve the detection of subclinical failures and lead to timely re-intervention.

The overall pleurodesis success rate of 79.6% seen in this study matches international data. For example, Martinez-Moragon et al. reported an 80% success rate with bleomycin,[12] while Chang et al. found success rates of 93.7% with Viscum and 96.0% with talc. In contrast, Agmy et al.[24] reported a lower success rate of 52.3%.[22] This difference may be due to variations in pleurodesis techniques or the sclerosing agents used. This range in success rates highlights how the choice of sclerosing agent and the procedural technique impact pleurodesis outcomes. Standardizing protocols and agent selection may help improve consistency and overall effectiveness in various clinical settings.

There were no significant differences in pleurodesis outcomes among the different sclerosing agents used in our study. Chang et al. found no difference in outcomes between talc and Viscum pleurodesis (P=0.225),[24] and Martinez-Moragon et al. reported similar success with tetracycline and bleomycin.[12] Walker-Renard et al. also concluded that while talc may be slightly better, other agents still yield satisfactory results.[25] These findings

indicate that choosing a sclerosing agent can be tailored to the patient's tolerance, availability, and the clinician's preference without compromising effectiveness. More randomized trials could clarify minor differences in safety and long-term outcomes among these agents.

Lastly, CT and chest radiography results in our group matched ultrasound findings. At the one-month follow-up, 79.6% of patients showed no return of effusion. These findings align with those of El-Sayed et al., who compared CT and ultrasound for spotting effusions and found a strong agreement between the two methods.[18] Zablockis et al. also showed that CT results add to ultrasound information when evaluating the response to pleurodesis.[26] This agreement underscores the importance of using different imaging methods for a thorough post-pleurodesis assessment. While ultrasound is convenient for bedside use, CT provides detailed anatomical confirmation, especially in cases with unclear or borderline results.

## Conclusion

This study shows that transthoracic ultrasonography, especially the assessment of the pleural sliding sign, is a reliable, non-invasive, and effective way to evaluate the success of pleurodesis in patients with malignant pleural effusion. The absence of pleural sliding one month after the procedure strongly links to radiologic signs of pleural adhesion and clinical improvement. While computed tomography and chest radiography provide useful confirmation, ultrasound offers the benefit of real-time, bedside monitoring without exposing patients to radiation. The type of sclerosing agent used did not significantly affect the pleurodesis outcomes, allowing for flexibility in agent selection based on the clinical situation. Overall, this study supports including thoracic ultrasound in routine follow-up for pleurodesis, improving patient care by enabling early detection of treatment success or failure.

## References


1. Roberts ME, Neville E, Berrisford RG, Antunes G, Ali NJ. Management of a malignant pleural effusion: British Thoracic Society Pleural Disease Guideline 2010. Thorax. 2010;65 Suppl 2:ii32–ii40. DOI: 10.1136/thx.2010.136994.
2. Thomas R, Cheah HM, Rajalingam V, D'Cruz A, Steinke K. Malignant pleural effusion – A review of current management strategies. Heart Lung Circ. 2022;31(5):683–693. DOI: 10.1016/j.hlc.2021.12.001.
3. Bielsa S, Porcel JM. Prognostic models in malignant pleural effusion. Curr Opin Pulm Med. 2014;20(4): 352–357. DOI: 10.1097/MCP.0000000000000072.
4. Fysh ETH, Lee YCG. Pleurodesis for malignant pleural effusions: improving success rate and patient outcomes. Curr Opin Support Palliat Care. 2013;7(4): 352–358. DOI: 10.1097/SPC.0000000000000012.
5. Rodriguez-Panadero F, Montes-Worboys A. Mechanisms of pleurodesis. Respiration. 2012;83(2):91–98. DOI: 10.1159/000329992.
6. Light RW. Pleural diseases. 6th ed. Philadelphia: Lippincott Williams & Wilkins; 2013. Chapter 11.
7. Hallifax RJ, Talwar A, Wrightson JM, Edey A, Gleeson FV, Rahman NM. State-of-the-art imaging of pleural effusions. Respirology. 2014;19(4):543–551. DOI: 10.1111/resp.12271.
8. Koegelenberg CFN, Diacon AH. Pleural ultrasound. Respiration. 2012;83(6):441–451. DOI: 10.1159/000335607.
9. Feller-Kopman D. Ultrasound-guided pleural procedures. Chest. 2013;144(6):1704–1713. DOI: 10.1378/chest.12-2712.
10. Salamonsen MR, Lo AK, Ng AC, Bashirzadeh F, Wang WY, Fielding DI. Novel use of pleural ultrasound can identify malignant pleurodesis failure. Chest. 2014;146(4):980–985. DOI: 10.1378/chest.13-2480.
11. El Hadidy AAEM, Kamel KM, Zaid AAAKA, Kamal E, Fayiad HESH, Hussein HZ. Role of chest ultrasound in detecting successful pleurodesis. Egypt J Chest Dis Tuberc 2017;66:279–283. DOI: 10.4103/0422-7638.211005.
12. Martínez-Moragón E, Aparicio J, Rogado MC, Sanchis J, Sanchis F, Gil-Suay V. Pleurodesis in malignant pleural effusions: a randomized study of tetracycline versus bleomycin. Eur Respir J 1997;10:2380–2383. DOI: 10.1183/09031936.97.10102380.
13. Zimmer PW, Hill M, Casey K, Harvey E, Low DE. Prospective randomized trial of talc slurry vs bleomycin in pleurodesis for symptomatic malignant pleural effusions. Chest 1997;112:430–434. DOI: 10.1378/chest.112.2.430.
14. Tsai TH, Wu SG, Chang YL, Wu CT, Tsai MF, Wei PF, et al. Effusion immunocytochemistry as an alternative approach for the selection of first-line targeted therapy in advanced lung adenocarcinoma. J Thorac Oncol 2012;7:993–1000. DOI: 10.1097/JTO.0b013e31825457a5.
15. Penz E, Watt KN, Hergott CA, Rahman NM, Psallidas I. Management of malignant pleural effusion: challenges and solutions. Cancer Manag Res 2017;9:229–241. DOI: 10.2147/CMAR.S111409.
16. Dixit R, Agarwal KC, Gokhroo A, Patil CB, Meena M, Shah NS, et al. Diagnosis and management options in malignant pleural effusions. Lung India 2017;34: 160–166. DOI: 10.4103/0970-2113.201316.

17. Seddik EKA, Awad NF, ElBalsha A-AM, Aly WE. Role of chest ultrasound in detecting successful pleurodesis in patients with malignant pleural effusion. Egypt J Hosp Med 2018;72:4443–4447. DOI: 10.12816/0048634.

18. El-Sayed I, Awad NF, Basiony FS, Salah El-Feshawy M. Chest ultrasound versus chest computed tomography for assessment of undiagnosed pleural effusion before medical thoracoscopy. Al-Azhar Med J 2022;51:2143–2156. DOI: 10.21608/amj.2022.272470.

19. Manu Mohan K, Ravindran C. Etiology and clinical profile of pleural effusion in a teaching hospital of south India: a descriptive study. Pulmon 2012;14:89–96.

20. Magdy KM, Hieba EG. Outcome of ultrasound-guided, single session pleurodesis in malignant pleural effusion. Egypt J Bronchol 2020;14:1–7. DOI: 10.1186/s43168-020-00002-y.

21. Corcoran JP, Hallifax RJ, Mercer RM, Yousuf A, Asciak R, Hassan M, et al. Thoracic Ultrasound as an Early Predictor of Pleurodesis Success in Malignant Pleural Effusion. Chest 2018;154:1115–1120. DOI: 10.1016/j.chest.2018.06.009.

22. Agmy G, Adam MF, El Sagheir SA, Mahmoud MA. Transthoracic sonographic scores in evaluating the success of different scelerosing modalities in patients with malignant pleural effusion. Egypt J Bronchol 2022;16:66. DOI: 10.1186/s43168-022-00128-7.

23. de Boer WS, Dinjens L, Stigt JA. The determination of pleurodesis using sonography after surgical pleurectomy for pneumothorax: a pilot study. J Thorac Dis 2023;15:3974–3978. DOI: 10.21037/jtd-22-1659.

24. Chang Y, Cho D, Cho K, Cho M. Viscum pleurodesis is as effective as talc pleurodesis and tends to have less adverse effect. Support Care Cancer 2020;28:5463–5467. DOI: 10.1007/s00520-020-05366-7.

25. Walker-Renard PB, Vaughan LM, Sahn SA. Chemical pleurodesis for malignant pleural effusions. Ann Intern Med 1994;120:56–64. DOI: 10.7326/0003-4819-120-1-199401010-00010.

26. Zablockis R, Danila E, Gruslys V, Cincilevi i t G. Systemic inflammatory response to different sclerosing agents as a predictor of pleurodesis outcome. In Vivo 2021;35:2391–2398. DOI: 10.21873/invivo.12496.