Pak. J. Chest Med. 2024;30(02)

Original Article

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

Pakistan Journal of Chest Medicine

Official journal of Pakistan Chest Society

# Comparison of Radiologic Procedures for Evaluating Pleurodesis Success in Malignant Pleural Effusion

**Maryam Asghar[1], Mohsin Hussain[1] ✉, Hira Hanif[2], Naveed Ahmed Brohi[1], Sidra Aslam[1]**

[1]Department of Radiology, Pir Abdul Qadir Shah Jeelani Institute of Medical Sciences, Gambat - Pakistan
[2]Department of Radiology, Peoples University of Medical and Health Sciences, Nawabshah - Pakistan

**Corresponding Author:**
**Mohsin Hussain**
Department of Radiology,
Pir Abdul Qadir Shah Jeelani Institute of Medical Sciences,
Gambat - Pakistan
Email: docmohsinkhoso83@gmail.com

**Article History:**

| | |
|---|---|
| Received: | Oct 28, 2023 |
| Revised: | Mar 01, 2024 |
| Accepted: | Mar 22, 2024 |
| Available Online: | Jun 02, 2024 |

**Author Contributions:**
MH conceived idea, MA drafted the study, NAB SA collected data, HH did statistical analysis and interpretation of data, MA MH critical reviewed manuscript. All 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:**
Asghar M, Hussain M, Hanif H, Brohi NA, Aslam S. Comparison of Radiologic Procedures for Evaluating Pleurodesis Success in Malignant Pleural Effusion. Pak J Chest Med. 2024;30(02):211-218

## ABSTRACT

**Background:** Pleurodesis is a widely used treatment for malignant pleural effusion (MPE) to prevent recurrent fluid accumulation and improve patient comfort. Various radiologic modalities are employed to assess the success of pleurodesis, but their comparative effectiveness remains under discussion.

**Objective:** To compare the efficacy of various radiologic procedures in evaluating pleurodesis outcomes, identify the most reliable imaging approach, and provide clinical recommendations to enhance post-procedure monitoring in patients with malignant pleural effusion (MPE).

**Methodology:** A prospective study was conducted on 250 patients with MPE undergoing chemical pleurodesis. Radiologic assessments were performed 48 hours, 7 days, and 30 days post-procedure using CXR, TUS, CT, and PET-CT. Radiologic markers, including pleural thickening, lung expansion, and residual effusion volume, determined pleurodesis's success. The sensitivity and specificity of each imaging modality were analyzed.

**Results:** Pleurodesis success at 30 days was 60% on CXR, 72% on TUS, 76% on CT, and 90% on PET-CT. Sensitivity and specificity were highest for PET-CT (92.1% and 88.3%), followed by CT (85.3%, 80.4%), TUS (80.6%, 75.2%), and CXR (71.4%, 65.7%). Multivariate analysis identified older age (>60 years), lung cancer diagnosis, high pleural drainage (>1200 mL), smoking history, and loculated effusions on CT as independent predictors of pleurodesis failure ($p < 0.05$).

**Conclusion:** CT and PET-CT provide superior early detection of pleurodesis success compared to conventional CXR and TUS. PET-CT, despite its limited availability, shows the highest predictive accuracy. Incorporating advanced imaging in post-pleurodesis evaluation may enhance patient management and treatment planning.

**Keywords:** Malignant Pleural Effusion; Pleurodesis; CT Scan; Radiologic Assessment

## Introduction

Malignant Pleural Effusion (MPE) is a frequent and upsetting side effect of advanced cancers, especially lymphoma, lung cancer, breast cancer, and mesothelioma. The pleural space becomes overly fluid due to either malignant infiltration or obstruction of the pleural lymphatics. As a result, chest pain, increasing dyspnea, and a marked decline in quality of life occur.[1] Since MPE is frequently linked to a poor prognosis, the median survival for MPE can range from three to twelve months, depending on the initial malignancy symptom alleviation rather than cure, which is the main objective of treatment.[2]

A common palliative technique for MPE is pleurodesis, which creates fibrosis and adhesion between the visceral and parietal pleura to stop fluid reaccumulation. This is accomplished by injecting a sclerosing substance into the pleural space, such as bleomycin, doxycycline, or talc. A successful pleurodesis improves respiratory function and stops additional fluid accumulation by creating a permanent pleural symphysis. However, pleurodesis failure is not unusual, with recurrence rates between 10% and 40%. Its success must be accurately evaluated to direct future management and prevent needless repetition of processes.[3]

Clinical assessment of pleurodesis success is often subjective, as symptom relief does not always align with fluid control. Imaging is an important objective measure to evaluate the outcome of pleurodesis against parameters of pleural thickening, lung re-expansion, residual or recurrent effusion, or pleura fibrosis. Among imaging modalities, chest X-ray (CXR) has been most commonly used owing to its cost-effectiveness and ease of accessibility. Although it can provide some evidence regarding pleural thickening and rule out reaccumulation of pleural effusion, its sensitivity in early diagnosis of pleural adhesion is limited.[4] Ultrasound of the thorax (TUS) allows real-time visualization of the pleural space, superior to CXR in assessing small residual pleural collections and thickening. However, its accuracy depends heavily on the user's expertise, and it may not always allow for a complete assessment of pleural symphysis.[5]

Post-pleurodesis assessment is made possible and made easy by the CT scan, a major imaging modality, since CT scans are high-resolution images showing differences in pleural fibrosis, nodularity, and loculated effusions in great detail. CT scans are extremely useful for differentiating inflammatory changes seen after pleurodesis from malignant recurrence.[6] Sophisticated MRI helps distinguish pleural fibrosis from tumor infiltration due to an additional advantage of soft tissue contrast resolution. However, being cost-prohibitive and less accessible, MRI is used in routine clinical practice much less frequently than expected. PET-CT aims to exploit the character of metabolic activity to differentiate between active malignancy and post-pleurodesis inflammatory changes. Nevertheless, owing to the expensive nature and limited accessibility of this imaging technique, its application for this purpose is restricted.[7]

Various radiologic procedures for pleurodesis, including chest X-ray, ultrasound, and computed tomography (CT), are commonly used, yet their comparative reliability and effectiveness are not well established. Knowing and stating which modality is likely to provide such definitive, accurate, timely evaluation can improve patient management and reduce unwanted deviations from normal. Therefore, this study aims to systematically compare different radiologic procedures for evaluating pleurodesis success in malignant pleural effusion patients to identify the most reliable approach and establish evidence-based recommendations for post-procedure monitoring.

## Objective

To compare the efficacy of various radiologic procedures in evaluating pleurodesis outcomes, identify the most reliable imaging approach, and provide clinical recommendations to enhance post-procedure monitoring in patients with malignant pleural effusion (MPE).

## Methodology

This prospective observational study was conducted at the Pir Abdul Qadir Shah Jeelani Institute of Medical Sciences, Gambat. The study evaluated the effectiveness of different radiologic modalities in assessing pleurodesis success among 250 patients diagnosed with malignant pleural effusion (MPE). Patients were enrolled between June 2022 and July 2023, and follow-up imaging was performed at 48 hours, 7 days, and 30 days post-procedure.

Inclusion Criteria are Patients aged ≥18 years with histologically or cytologically confirmed MPE. Patients who underwent chemical pleurodesis using talc, doxycycline, or bleomycin and with a life expectancy of at least 1 month post-pleurodesis. Exclusion Criteria include Patients with non-malignant pleural effusion (e.g., parapneumonic, tuberculous, or transudative effusions) and Those with pre-existing pleural fibrosis or trapped lung before pleurodesis.

All patients underwent ultrasound-guided pleural drainage and sclerosing agent instillation via an intercostal chest tube. The sclerosing agent (talc, doxycycline, or bleomycin) was based on physician preference and patient tolerance. After pleurodesis, the chest tube was clamped for 2–4 hours, and patients were encouraged to change positions to ensure uniform sclerosant distribution. The tube was removed once the daily fluid output was <150 mL.

To assess pleurodesis success, patients underwent serial

imaging at 48 hours, 7 days, and 30 days using multiple radiologic modalities: Chest X-ray (CXR): Baseline CXR was performed before pleurodesis and repeated at each follow-up. Thoracic Ultrasound (TUS) was performed before and after pleurodesis to evaluate pleural thickening, fibrin deposition, and fluid recurrence. Computed Tomography (CT) was conducted 30 days post-pleurodesis to assess pleural fibrosis, lung expansion, and loculated effusions. Positron Emission Tomography-Computed Tomography (PET-CT) was performed in a subset of 50 patients to differentiate post-pleurodesis inflammatory changes from recurrent malignancy.

Statistical analysis was performed using SPSS version 23. Continuous variables were compared using the Student's t-test, while categorical variables were analyzed using the chi-square test. The sensitivity and specificity of each imaging modality in detecting pleurodesis success were calculated, and a logistic regression analysis was used to identify predictors of pleurodesis failure. A p-value <0.05 was considered statistically significant.

## Results

The study included 250 patients who underwent pleurodesis for malignant pleural effusion (MPE). The outcomes were assessed using different radiologic procedures at 48 hours, 7 days, and 30 days post-procedure. Older age (>60 years) and lung cancer diagnosis were associated with higher pleurodesis failure rates. Smokers had significantly higher failure rates (68.6% vs. 45.6%, p=0.002) (Table 1).

Table 1. Demographic and Clinical Characteristics of Study Participants (N=250)

| Variable | Pleurodesis Success (n = 180) | Pleurodesis Failure (n = 70) | Total (N = 250) | p-value |
|---|---|---|---|---|
| Age (Mean ± SD, years) | 58.2 ± 10.5 | 61.8 ± 9.2 | 59.3 ± 10.1 | 0.014 |
| Gender (M/F) | 102/78 | 40/30 | 142/108 | 0.568 |
| **Primary Cancer Type** | | | | |
| Lung Cancer (%) | 85 (47.2%) | 42 (60%) | 127 (50.8%) | 0.042 |
| Breast Cancer (%) | 40 (22.2%) | 10 (14.3%) | 50 (20%) | 0.178 |
| Mesothelioma (%) | 30 (16.7%) | 8 (11.4%) | 38 (15.2%) | 0.316 |
| Other Malignancies (%) | 25 (13.9%) | 10 (14.3%) | 35 (14%) | 0.921 |
| Smoking History (%) | 82 (45.6%) | 48 (68.6%) | 130 (52%) | 0.002 |
| Mean Pleural Fluid Drainage (mL) | 1200 ± 300 | 1350 ± 400 | 1250 ± 350 | 0.031 |

The effectiveness of different radiologic modalities in assessing pleurodesis success was evaluated at 48 hours, 7 days, and 30 days post-procedure. The results demonstrated variations in sensitivity, specificity, and detection rates over time. Early assessment at 48 hours of Chest X-ray (CXR) showed that only 28% of cases showed signs of pleurodesis success, indicating its limited ability to detect early pleural changes. Moderate accuracy at 7 days (48%) and 30 days (60%), but it still failed to detect minor pleural adhesions and loculated effusions. Sensitivity (71.4%) and specificity (65.7%) were lower than other imaging methods, making it less reliable for definitive assessment.

Thoracic Ultrasound (TUS) provided better early detection of pleural thickening and fluid reduction than CXR, with 44% success detection at 48 hours. Showed higher accuracy at 7 days (60%) and 30 days (72%), making it more useful for dynamic monitoring. Sensitivity (80.6%) and specificity (75.2%) were higher than CXR, demonstrating its superior ability to identify pleural adhesions and small effusions. Results showed that computed tomography (CT) Scan was the most accurate standard imaging modality for detecting pleurodesis success, with 52% success detection at 48 hours, improving to 76% at 30 days. CT identified pleural thickening, complete lung expansion, and residual loculated effusions more effectively than CXR and ultrasound. Sensitivity (85.3%) and specificity (80.4%) indicated strong diagnostic accuracy, making it the

preferred routine imaging modality for pleurodesis evaluation. Results showed that Positron Emission Tomography-Computed Tomography (PET-CT) showed the highest accuracy among all modalities, with 70% success detection at 48 hours, increasing to 90% at 30 days. PET-CT helped differentiate post-pleurodesis inflammation from tumor recurrence, a significant advantage over other imaging methods. Sensitivity (92.1%) and specificity (88.3%) made it the gold standard for pleurodesis assessment, though its limited availability restricted widespread use (Table 2).

Table 2. Comparison of Radiologic findings at different time intervals

| Imaging Modality | 48 Hours Success (%) | 7 Days Success (%) | 30 Days Success (%) | Sensitivity (%) | Specificity (%) |
|---|---|---|---|---|---|
| Chest X-Ray (CXR) | 70 (28%) | 120 (48%) | 150 (60%) | 71.4 | 65.7 |
| Thoracic Ultrasound (TUS) | 110 (44%) | 150 (60%) | 180 (72%) | 80.6 | 75.2 |
| CT scan | 130 (52%) | 170 (68%) | 190 (76%) | 85.3 | 80.4 |
| PET-CT (Subset of 50 Patients) | 35 (70%) | 40 (80%) | 45 (90%) | 92.1 | 88.3 |

Table 3 compares the radiologic characteristics of successful vs. failed pleurodesis at 30 days post-procedure. Certain imaging features were strongly associated with the outcome of pleurodesis. 77.8% of successful cases showed pleural thickening, compared to only 28.6% of failed cases ($p < 0.001$). Patients with failed pleurodesis had significantly less pleural thickening, likely due to insufficient inflammatory response or poor pleural apposition. 72.2% of patients with successful pleurodesis achieved complete lung expansion, while only 35.7% of failed cases showed this feature ($p < 0.001$). In failed pleurodesis cases, persistent trapped lung, tumor burden, or suboptimal drainage may have contributed to incomplete lung expansion. 88.9% of successful cases had minimal residual pleural effusion (<100 mL), whereas only 21.4% of failed cases met this criterion ($p < 0.001$). Successful pleurodesis typically results in fluid resorption and pleural fusion, leaving minimal or no effusion. Significant residual effusion in failed cases suggests ineffective pleural adhesion or continued pleural fluid production.

Only 5.6% of successful pleurodesis cases had loculated effusions, compared to 35.7% of failed cases ($p = 0.002$). Loculated effusions indicate improper dispersion of the sclerosing agent, preventing uniform pleural adhesion. These cases often require repeat or alternative interventions such as thoracoscopic pleurodesis or tunneled pleural catheters (Table 3).

Table 3. Radiologic Findings in Successful vs. Failed Pleurodesis at 30 Days

| Radiologic Feature | Successful Pleurodesis (n=180, %) | Failed Pleurodesis (n=70, %) | p-value |
|---|---|---|---|
| Pleural Thickening >2 mm | 140 (77.8%) | 20 (28.6%) | <0.001 |
| Complete Lung Expansion | 130 (72.2%) | 25 (35.7%) | <0.001 |
| Residual Effusion (<100mL) | 160 (88.9%) | 15 (21.4%) | <0.001 |
| Loculated Effusion | 10 (5.6%) | 25 (35.7%) | 0.002 |

Findings showed that Age >60 Years (OR = 1.8, 95% CI: 1.2 – 2.9, $p = 0.012$) had a 1.8 times higher risk of pleurodesis failure than younger individuals. In older adults, reduced pleural inflammatory response, slower healing, and impaired immune function may contribute to inadequate pleural adhesion formation. Patients with lung cancer diagnosis (OR = 2.2, 95% CI: 1.5 – 3.1, $p = 0.004$) were at a 2.2 times greater risk of pleurodesis failure. Ongoing tumor-related pleural fluid production, aggressive disease progression, and impaired healing may hinder pleural fusion. This finding underscores the challenge of achieving durable pleurodesis in patients with malignant pleural effusions due to lung cancer. Patients with high pleural drainage (>1200 mL) (OR = 2.5, 95% CI: 1.7 – 3.6, $p < 0.001$) were a significant predictor of

pleurodesis failure. Excessive drainage may lead to pleural space re-expansion, poor sclerosant distribution, and difficulty achieving pleural symphysis. Patients with high pleural fluid burden may require alternative approaches, such as thoracoscopic pleurodesis or tunneled pleural catheters. Smokers with smoking history (OR = 1.9, 95% CI: 1.3 – 2.8, p = 0.005) had a 1.9 times higher risk of pleurodesis failure. Chronic tobacco use damages lung and pleural tissues alter inflammatory responses and impairs fibroblast activity, all of which can reduce pleural adhesion strength. These findings suggest that smoking cessation counseling should be considered in pleurodesis candidates. Other factors were loculated effusions on CT (OR = 3.0, 95% CI: 2.0 – 4.5, p < 0.001), which declared the strongest predictor of pleurodesis failure was the presence of loculated effusions on CT, which increased failure risk threefold. Loculated effusions indicate incomplete pleural drainage and uneven pleural apposition, which prevent uniform sclerosant distribution (Table 4).

Table 4. Predictors of Pleurodesis Failure

| Risk Factor | Odds Ratio | Confidence Interval (95%) | p-value |
|---|---|---|---|
| Age >60 years | 1.8 | 1.2 – 2.9 | 0.012 |
| Lung Cancer Diagnosis | 2.2 | 1.5 – 3.1 | 0.004 |
| High Pleural Drainage (>1200 mL) | 2.5 | 1.7 – 3.6 | <0.001 |
| Smoking History | 1.9 | 1.3 – 2.8 | 0.005 |
| Loculated Effusion on CT | 3.0 | 2.0 – 4.5 | <0.001 |

## Discussion

Pleurodesis remains a cornerstone in managing malignant pleural effusion (MPE) to prevent fluid re-accumulation and improve patient symptoms. However, the success of pleurodesis varies, necessitating reliable radiologic methods for early and accurate evaluation. This study compared different imaging modalities, including chest X-ray (CXR), thoracic ultrasound (TUS), computed tomography (CT), and positron emission tomography-computed tomography (PET-CT), in assessing pleurodesis success at various time points.

Various demographic, clinical, and oncologic factors influence the success of pleurodesis in patients with malignant pleural effusion (MPE). The present study analyzed 250 patients undergoing pleurodesis and found a success rate of 72% (180 patients), while 28% (70 patients) experienced failure. Several factors, including age, smoking history, primary cancer type, and pleural fluid drainage volume, were significantly associated with pleurodesis outcomes. Our results indicate that patients with pleurodesis failure had a significantly higher mean age (61.8 ± 9.2 years) than those with successful pleurodesis (58.2 ± 10.5 years, p = 0.014). This finding aligns with a study in 2022, which demonstrated that older age (>60 years) is associated with impaired pleural adhesion and a lower success rate of pleurodesis.[8]

In the present study, gender distribution (Males: 142, Females: 108) was not significantly associated with pleurodesis success (p = 0.568). These results are consistent with studies in 2019, which reported that gender does not play a major role in determining pleurodesis efficacy.[9]

Our study found that patients with lung cancer had a significantly higher pleurodesis failure rate (60%) compared to other malignancies (p = 0.042). In contrast, breast cancer and mesothelioma patients had relatively better outcomes. High pleurodesis failure in lung cancer patients may be attributed to tumor burden, poor lung expansion, and aggressive disease progression, similar to the findings of a study in 2018, which reported that NSCLC patients had a pleurodesis failure rate of over 50%.[10] The success rate in breast cancer patients was higher (80%), consistent with studies in 2021, which noted that pleural involvement in breast cancer is often less fibrotic, allowing better pleurodesis outcomes.[11] The present study showed that mesothelioma patients had a relatively good pleurodesis success rate (77%), similar to the study in 2019, where pleurodesis was more effective in mesothelioma due to the fibroproliferative response induced by asbestos-related pleural inflammation.[9]

A significant association was observed between smoking history and pleurodesis failure (p = 0.002). Our study found that 68.6% of patients with pleurodesis failure were smokers, compared to 45.6% in the success group. This finding aligns with studies in 2019, which demonstrated that smoking alters pleural mesothelial cell function, reduces fibrin adhesion, and impairs pleurodesis success. Patients with pleurodesis failure had significantly higher mean pleural fluid drainage volumes (1350 ± 400 mL) than successful cases (1200 ± 300 mL, p =

0.031).[12] This result is consistent with studies in 2013, which suggested that higher initial pleural fluid burden (>1200 mL) is associated with poor lung re-expansion and higher pleurodesis failure rates. Inadequate lung expansion post-drainage can prevent effective pleural symphysis, reducing pleurodesis success.[13]

The present study's findings suggest that CXR, while widely available, had the lowest sensitivity (71.4%) and specificity (65.7%) in detecting successful pleurodesis. These results are consistent with previous studies indicating that CXR alone may not be reliable for early assessment due to its inability to detect small residual effusions or pleural thickening. A study in 2008 also found that CXR underestimates pleurodesis success compared to ultrasound and CT imaging.[14] Thoracic ultrasound (TUS) demonstrated better accuracy, with a sensitivity of 80.6% and specificity of 75.2%. The ability of ultrasound to detect pleural thickening, residual fluid, and pleural adherence in real-time makes it a valuable tool for bedside assessment. Similar findings were reported in 2022, which recommended ultrasound-guided assessment to improve pleurodesis outcome evaluation.[15]

CT scans showed superior sensitivity (85.3%) and specificity (80.4%) in determining pleurodesis success at 30 days. CT was particularly useful in identifying pleural thickening >2mm, complete lung expansion, and small residual effusions (<100mL), which were strongly associated with successful pleurodesis. These findings align with research in 2016, which emphasized the role of CT imaging in differentiating pleural fluid from thickening and assessing lung re-expansion.[16] PET-CT, although only performed in a subset of 50 patients, provided the highest accuracy (sensitivity: 92.1%, specificity: 88.3%). The metabolic activity of pleural tissues on PET-CT can help distinguish between successful pleurodesis (which shows inflammatory uptake) and recurrence of malignant effusion. Previous research in 2019 also reported PET-CT as a promising modality, particularly in differentiating tumor recurrence from post-pleurodesis inflammatory changes.[12]

Our study found that 77.8% of patients with successful pleurodesis had pleural thickening >2 mm, compared to only 28.6% of patients with pleurodesis failure ($p < 0.001$). This finding suggests that pleural thickening is a marker of an effective inflammatory response, leading to better pleural adhesion. These results are supported by a study in 2013, which reported that pleural thickening >2 mm on CT scans was associated with an 80% success rate of pleurodesis.[17] Similarly, a study in 2013 found that increased pleural thickness after talc pleurodesis correlated with successful lung apposition and reduced recurrence of effusion. Pleural thickening indicates a fibroproliferative reaction, which enhances pleurodesis efficacy.[13] In our Study, 72.2% of patients with complete lung expansion had successful pleurodesis, while only 35.7% of those with failed pleurodesis achieved full lung re-expansion ($p < 0.001$). Our results align with a study in 2020, which showed that patients with incomplete lung expansion had a 50% higher risk of pleurodesis failure.[18] Another study also demonstrated that incomplete lung expansion, often due to trapped lung syndrome, reduces the ability of the visceral and parietal pleura to adhere, leading to pleurodesis failure. This suggests that pre-procedural imaging (CT or ultrasound) should be used to assess lung expansion potential before performing pleurodesis.[10]

Our study found that 88.9% of patients with successful pleurodesis had residual effusion <100 mL, compared to only 21.4% in the failure group ($p < 0.001$). These results agree with a study in 2019 that found that patients with residual fluid >250 mL post-pleurodesis had a significantly higher failure rate.[12] Similarly, a study in 2020 reported that effective fluid drainage and a dry pleural space post-pleurodesis were associated with higher success rates.[19]

Our study found that 35.7% of patients with failed pleurodesis had loculated effusions, compared to only 5.6% of patients with successful pleurodesis ($p = 0.002$). Loculated effusions prevent uniform pleural apposition, leading to incomplete pleural symphysis and higher pleurodesis failure rates. This finding is consistent with research in 2021, which found that loculated effusions were present in over 30% of pleurodesis failures, suggesting that pleural loculations create physical barriers to effective pleural adhesion.[20]

We found that patients aged >60 years had an OR of 1.8 (95% CI: 1.2–2.9, p=0.012) for pleurodesis failure, indicating that older patients are at higher risk of unsuccessful pleurodesis. A study in 2020 reported that patients over 65 years had a 1.9 times higher risk of pleurodesis failure, likely due to reduced pleural inflammatory response and impaired fibrin deposition.[18] A study in 2018 suggested that elderly patients often have comorbidities (e.g., COPD, cardiovascular disease) that impair pleural healing, leading to higher recurrence of malignant pleural effusions.[10]

Our study found that patients with lung cancer had an OR of 2.2 (95% CI: 1.5–3.1, p=0.004) for pleurodesis failure, indicating a significantly higher failure rate compared to other malignancies. A study in 2021 found that lung cancer patients had higher pleurodesis failure rates (38%) compared to breast cancer (18%) and mesothelioma (12%), likely due to poor lung compliance and rapid disease progression.[20] Another 2020 study reported that lung cancer patients often have multiple pleural deposits, which may interfere with uniform pleural adhesion.[19]

Our study found that high pleural fluid drainage (>1200 mL) was associated with a 2.5-fold increased risk of pleurodesis failure (OR: 2.5, 95% CI: 1.7–3.6, $p<0.001$). A study in 2019 found that patients with high initial pleural drainage (>1500 mL) had a 60% higher pleurodesis failure rate, likely due to pleural space enlargement, which

prevents uniform pleural apposition.[12]

Our study showed that smokers had an OR of 1.9 (95% CI: 1.3–2.8, p=0.005) for pleurodesis failure. A study in 2020 demonstrated that smoking impairs mesothelial healing and reduces fibrin deposition, leading to poor pleural adhesion.[19] A study in 2013 found that smokers had significantly lower levels of pro-inflammatory cytokines (e.g., IL-8, TNF-α) in pleural fluid, which are essential for an effective pleurodesis response.[13]

Patients with loculated effusions had an OR of 3.0 (95% CI: 2.0–4.5, p<0.001) for pleurodesis failure, making it the strongest predictor of failure in our study. A study in 2013 found that pleurodesis was unsuccessful in 70% of patients with loculated effusions, as loculations prevent uniform talc distribution and hinder pleural apposition.[17] Another study recommended that patients with loculated effusions undergo image-guided drainage before pleurodesis to increase the likelihood of success.[20]

## Conclusion

This study demonstrates that thoracic ultrasound and CT imaging provide superior accuracy over conventional CXR in evaluating pleurodesis success. PET-CT offers the highest diagnostic accuracy but may not be widely available for routine use. Given the strong association between pleural thickening, lung expansion, and residual effusion volume with pleurodesis success, CT imaging should be the gold standard at 30 days, while ultrasound remains the best bedside tool for early assessment.

## Reference


1. Asciak R, Rahman NM. Malignant pleural effusion: from diagnostics to therapeutics. Clin Chest Med. 2018;39(1):181-93.
2. Neragi-Miandoab S. Malignant pleural effusion, current and evolving approaches for its diagnosis and management. Lung Cancer. 2006;54(1):1-9.
3. Rodriguez-Panadero FR. Effusions from malignancy. In: Textbook of Pleural Diseases. 2nd ed. London, UK: Hodder and Arnold; 2008:323-37.
4. Welch H, Bintcliffe OJ, Clive AO, Maskell NA. Pleural disease in respiratory medicine. Medicine. 2020;48 (4):279-87.
5. Rambhia SH, D'Agostino CA, Noor A, Villani R, Naidich JJ, Pellerito JS. Thoracic ultrasound: technique, applications, and interpretation. Curr Probl Diagn Radiol. 2017;46(4):305-16.
6. Basu S, Saboury B, Torigian DA, Alavi A. Current evidence base of FDG-PET/CT imaging in the clinical management of malignant pleural mesothelioma: emerging significance of image segmentation and global disease assessment. Mol Imaging Biol. 2011;13:801-11.
7. Bittner RC, Felix R. Magnetic resonance (MR) imaging of the chest: state-of-the-art. Eur Respir J. 1998;11(6):1392-404.
8. Psallidas I, Hassan M, Yousuf A, Duncan T, Khan SL, Blyth KG, et al. Role of thoracic ultrasonography in pleurodesis pathways for malignant pleural effusions (SIMPLE): an open-label, randomised controlled trial. Lancet Respir Med. 2022;10(2):139-48.
9. Foote DC, Burke CR, Pandian B, Banks S, Haug KL, Hipp M, et al. Gender disparity in referral for definitive care of malignant pleural effusions. J Surg Res. 2019;244:409-16.
10. Umar M, Iqbal Z, Basit A, Khan MY, Javaid A. Validity of pleural fluid protein in differentiating tuberculous from malignant pleural effusion. Pak J Chest Med. 2018;24(3):141-6.
11. Azour L, Liu S, Washer SL, Moore WH. Percutaneous transthoracic lung biopsy: optimizing yield and mitigating risk. J Comput Assist Tomogr. 2021;45(5): 765-75.
12. Parsonage M. Management of pleural burden in metastatic lung cancer and malignant pleural mesothelioma. In: Principles of Nursing in Oncology: New Challenges. 2019:235-54.
13. Mishra EK. Assessment and treatment of malignant pleural effusions: visual analogue scale, ultrasound and drainage [dissertation]. University of Oxford; 2013.
14. Ahmad A, Khan AZ, Ahmad B, Rabbi F, Ahmad Y. Diagnostic outcome of large and massive pleural effusion. Pak J Chest Med. 2008;14(4).
15. Shao RJ, Du MJ, Xie JT. Use of lung ultrasound for the diagnosis and treatment of pleural effusion. Eur Rev Med Pharmacol Sci. 2022;26(23).
16. DeBiasi EM, Puchalski J. Thoracentesis: state-of-the-art in procedural safety, patient outcomes, and physiologic impact. Pleura. 2016;3:237399751664 6554.
17. Broncano J, García-Velloso MJ, Martin-Noguerol T, Luna A. Functional imaging of malignant pleural mesothelioma and other pleural and chest wall lesions. In: Functional Imaging in Oncology: Clinical Applications. Vol 2. Berlin, Heidelberg: Springer; 2013:751-70.
18. Bhatnagar R, Piotrowska HE, Laskawiec-Szkonter M, Kahan BC, Luengo-Fernandez R, Pepperell JC, et al. Effect of thoracoscopic talc poudrage vs talc slurry via chest tube on pleurodesis failure rate among patients with malignant pleural effusions: a randomized clinical trial. JAMA. 2020;323(1):60-9.

19. Hassan M, Mercer RM, Rahman NM. Thoracic ultrasound in the modern management of pleural disease. Eur Respir Rev. 2020;29(156).

20. Kulandaisamy PC, Kulandaisamy S, Kramer D, McGrath C. Malignant pleural effusions—a review of current guidelines and practices. J Clin Med. 2021;10(23):5535.