LITERATURE REVIEW

Improving Pulmonary Function and Functional Ability through Pulmonary Rehabilitation in Patients with Pleural Effusion: A Literature Review

Arnengsih Nazir[1*], Gabriella Anggraini[2], Brandon Clementius[3], Hana Athaya Nurhalizah[4], Agung Budi Sutiono[5]

[1]Department of Physical Medicine and Rehabilitation, Faculty of Medicine, Padjadjaran University/Dr. Hasan Sadikin General Hospital, Bandung, Indonesia.
[2]St. Borromeus Hospital, Bandung, Indonesia.
[3]Krida Wacana Christian University Hospital, Jakarta, Indonesia.
[4]Faculty of Medicine, University of Mataram, Mataram, Indonesia.
[5]Department of Neurosurgery, Keio University, Tokyo, Japan.

ARTICLE INFO

Article history:
Received 11 November 2024
Received in revised form
11 February 2025
Accepted 8 April 2025
Available online 31 May 2025

Keywords:
Dyspnea,
Exercise tolerance,
Human & health,
Pleural effusion,
Pulmonary rehabilitation.

Cite this as:
Nazir A, Anggraini H, Clementius B, *et al.* Improving Pulmonary Function and Functional Ability through Pulmonary Rehabilitation in Patients with Pleural Effusion: A Literature Review. *J Respi* 2025; 11: 191-200.

ABSTRACT

Introduction: Pleural effusion (PE) is characterized by reduced lung distensibility and expansion, resulting in decreased lung volume. Pleural effusion patients often experience respiratory symptoms that impair quality of life (QoL) and daily activities. Pulmonary rehabilitation (PR) has been developed to enhance functional capacity, alleviate symptoms, improve exercise tolerance, and reduce health service utilization. However, data on the specific implementation and benefits of PR in PE patients are limited.
Methods: This literature review synthesized data from a search using Public Medline (PubMed), Cumulative Index to Nursing and Allied Health Literature (CINAHL), and Google Scholar databases. The search was based on keywords relevant to study objectives and comprised various article types, ranging from review papers to original research. Articles with titles and abstracts relevant to the study objectives proceeded to a full-text evaluation.
Results: A narrative review discussing PE from pathology to rehabilitation management was formulated from 12 articles that elucidated various aspects of functional impairment in PE patients and 24 sources that discussed rehabilitation management.
Conclusion: Rehabilitation interventions, especially mobilization programs and lung expansion techniques, have shown effectiveness in improving pulmonary function and functional activities. Data regarding the role of inspiratory muscle training and aerobic exercise specific to PE remain limited. Given the functional impairments associated with PE, both before and after the removal of pleural fluid, PR programs are crucial in improving symptoms, pulmonary function, and overall functional ability in these patients.

INTRODUCTION

Pleural effusion (PE) is the abnormal fluid buildup in the pleural space and may result from various underlying conditions.[1] One-month and one-year mortality rates in PE patients were 22.6% and 49.4%, respectively, with higher mortality in patients with large, bilateral effusions and those with malignant or organ failure-related PEs.[2]

Pleural effusion can cause restrictive lung disease characterized by reduced lung distensibility and expansion. A further impact is decreased lung volume, especially reduced total lung capacity (TLC).[3] Pleural effusion patients experience respiratory symptoms, such as dyspnea, pain, and cough, which impair quality of life (QoL) and daily activities.[4,5]

The PE management goals are to reduce symptoms by removing fluid from the pleural cavity and treating the underlying disease.[6,7] Although thoracentesis can improve vital capacity (VC), the improvement in functional capacity is not comparable to fluid drainage.[8] A pulmonary rehabilitation (PR) program was developed to increase the patient's functional capacity and is expected to reduce symptoms, increase exercise

*Corresponding author: arnengsih@unpad.ac.id

Jurnal Respirasi, p-ISSN: 2407-0831; e-ISSN: 2621-8372.
Accredited No. 79/E/KPT/2023; Available at https://e-journal.unair.ac.id/JR. DOI: 10.20473/jr.v11-I.2.2025.191-200

expected to reduce symptoms, increase exercise tolerance and QoL, reduce the need for health services, and increase physical activity.[5,9,10]

Data regarding specific implementation and PR benefits in PE patients are limited, while most patients experience long-term functional impairments. Therefore, this literature review summarizes data from various literature regarding PR in PE patients. The topics were functional disorders caused by PE and rehabilitation assessment and management to improve pulmonary function and functional ability.

METHODS

The literature was searched using Public Medline (PubMed), Cumulative Index to Nursing and Allied Health Literature (CINAHL), and Google Scholar databases. The studies included in this literature review comprised various article types, ranging from review papers to original research, as long as they met the search criteria and addressed the study objectives. Additionally, textbooks and other relevant literature supporting the discussion were considered. Exclusion criteria included articles that were not in English or lacked full-text availability. Keywords used were "functional impairment," "dyspnea," "respiratory function," "lung function," "pulmonary function," "activity," "exercise," "pulmonary rehabilitation," "respiratory rehabilitation," "physical therapy," "functional ability," "pleural effusion," "restrictive lung disease," and "pleural procedure." The selection process involved an initial screening of article titles and a review of abstracts. Articles with titles and abstracts relevant to the study objectives proceeded to a full-text evaluation. Furthermore, references and citations from the selected articles were examined to enhance the comprehensiveness of the review.

RESULTS

The research objectives primarily guided the article search. Twelve articles (three reviews, eight original research, and one editorial) were identified as relevant for elucidating various aspects of functional impairment in PE patients, such as respiratory symptoms, lung compliance, respiratory muscle dysfunction, exercise limitations, and sleep or psychological disorders. Regarding rehabilitation, 24 sources (including 12 original research, nine review articles, one editorial, and two textbooks) were reviewed to discuss topics ranging from patient history to rehabilitation management. The findings were then summarized in a narrative review that offers a comprehensive discussion of PE, from its pathology to its rehabilitation strategies, with a particular focus on rehabilitation management (Table 1).

J. Respi. May 2025, Vol. 11 (02); 191-200

Table 1. Rehabilitation management in pleural effusion patients

Authors/Year/Study Design	Intervention	Outcome
Mobilization		
Dos Santos, *et al.*, 2019, randomized controlled trial[1]	Participants were given PAP and respiratory techniques while seated in a chair and walking a distance of 100 meters	The integration of PAP with respiratory techniques and mobilization reduced the duration of thoracic drainage, hospital length, pulmonary complications, antibiotic usage, and overall treatment costs
Dos Santos, *et* al., 2020, cross-sectional survey[11]	A survey study among physiotherapists on the rehabilitation techniques selected for patients with drained and non-drained PE	Deep breathing is the most commonly utilized lung expansion technique by chest physiotherapists for managing patients with both drained and non-drained PE, compared to other methods (mobilization by walking, incentive spirometry, and exercise with positive pressure)
Breathing Exercise		
Valenza-Demet, *et al*., 2014, randomized controlled trial[12]	Participants were given a PR program consisting of: • Mobilization: Limb exercises (i.e., passive, active assisted, or active) were performed in bed or a seated position, depending on medical advice Deep breathing program: Pursed lips breathing, active expiration, and incentive spirometry	The intervention group demonstrated a significant improvement from pre- to post-hospitalization in spirometric measurements (FVC and FEV1), radiographic severity, and a reduced length of hospital stay
Dos Santos, *et al*., 2020, cross-sectional survey[11]	A survey study among physiotherapists on the rehabilitation techniques selected for patients with drained and non-drained PE	Deep breathing is the most commonly utilized lung expansion technique by chest physiotherapists for managing patients with both drained and non-drained PE, compared to other methods (mobilization by walking, incentive spirometry, and exercise with positive pressure)
Positive Airway Pressure		
Dos Santos, *et al*., 2019, randomized controlled trial[1]	Active CPAP at 15 cmH_2O was administered through an oronasal mask connected to a bedside ventilation unit for 30 minutes while the patient remained seated in a chair	Incorporating positive pressure into mobilization and respiratory techniques reduced thoracic drainage duration, length of hospital stays, pulmonary complications, antibiotic consumption, and overall treatment costs
Dos Santos, *et al*., 2020, cross-sectional survey[11]	A survey study among physiotherapists on the rehabilitation techniques selected for patients with drained and non-drained PE	Deep breathing is the most commonly utilized lung expansion technique by chest physiotherapists for managing patients with both drained and non-drained PE, compared to other methods (mobilization by walking, incentive spirometry, and exercise with positive pressure)
Oliviera, *et al*., 2010, randomized controlled trial[13]	A physical therapist administered CPAP thrice a week for four weeks, utilizing a PEEP of 10 cmH_2O for 30 minutes. The procedure was performed in a seated position using a flow generator.	The intervention group exhibited a significantly greater reduction in PE volume and a lower final dyspnea index than the control group
IMT		
No study applied IMT in PE management		
Aerobic Conditioning		
Hanada, *et al*., 2020, systematic review[9]		Dyspnea scores improved following aerobic and breathing exercises. HRQoL also showed enhancement after aerobic exercise training, alone or in combination with breathing exercises. Additionally, aerobic training alone or combined with IMT or breathing exercises led to improved exercise capacity.
Tonelli, *et al*., 2017, prospective cohort[14]	Participants were given a PR program for 24 sessions, 6 days a week, once daily the first week and twice daily thereafter. Each session lasted at least 3 hours. The exercise program consists of: • Aerobic: Treadmill, stationary bikes, leisure walking • Resistance: Light weights, resistance bands • Breathing training: 2 sessions, 30 min/session, 4-5x/week. Breathing techniques = controlled and diaphragmatic breathing, pacing, and energy conservation The group education program consists of 3 sessions/week of education with the topics of medication and oxygen use, nutrition, panic control and relaxation techniques, psychosocial support and issues of palliation, and disease progression.	Exercise performance at peak load and submaximal effort, along with symptoms such as iso-time dyspnea and leg fatigue, showed significant improvement following PR. Additionally, SGRQ and MRC scores also improved significantly.

PAP: positive airway pressure; PE: pleural effusion; PR: pulmonary rehabilitation; FVC: forced vital capacity; FEV1, forced expiratory volume in one second; CPAP: continuous positive airway pressure; PEEP: positive end-expiratory pressure; IMT: inspiratory muscle training; HRQoL: health-related quality of life; SGRQ: St. George's respiratory questionnaire; MRC: medical research council

DISCUSSION

Functional Impairments in Pleural Effusion

Respiratory symptoms

Dyspnea, defined as the subjective sensation of breathing discomfort, is a prominent symptom encompassing the feeling of effortful breathing, chest constriction, and an intense need for air. It affects up to 80% of individuals with malignant pleurisy, and even more so in patients with heart failure-related effusions.[15] A large effusion in a patient with normal lungs, a moderate effusion with an underlying heart or lung disease, or a tiny effusion with severe cardiopulmonary diseases can all produce dyspnea.[15]

Approximately 25% of patients with malignant PE are asymptomatic and incidentally found on examination or radiography.[16] In symptomatic patients, dyspnea is the most common presentation, sometimes accompanied by chest pain and cough. Dyspnea is caused by decreased chest wall compliance, diaphragmatic depression, mediastinal shift, and reduced lung volume that enhances neurogenic reflexes. The effusion compresses the lung parenchyma, resulting in reduced chest wall compliance. Chest pain is usually associated with the involvement of the parietal pleura, ribs, and other intercostal structures. Instead of only fluid volume removal, improving these mechanics alleviates post-thoracentesis symptoms. Constitutional symptoms such as cachexia and weight loss, which are frequently related to the underlying malignancy, are also associated.[16]

There is an imbalance between defective ventilatory mechanics (decreased respiratory system compliance) and deficient inspiratory muscle performance in restrictive lung disease. The thoracic cage is displaced by a greater fluid accumulation, compromising inspiratory muscle function. Respiratory compliance and inspiratory muscle performance may be impaired differently depending on the effusion volume and the underlying disease. The amount of the effusion usually determines dyspnea, the patient's underlying cardiopulmonary reserve, and, potentially, the presence of anemia (whether inflammatory or secondary to chemotherapy). Dyspnea was more strongly linked to restricted lung inflation than to effusion volume.[4,15]

After the pleural cavity was emptied, the dyspnea sensation improved. At rest, dyspnea is mild and well-tolerated, but exerting even a modest amount of effort exacerbates the symptoms, resulting in a feeling of discomfort that makes even the most common daily activities difficult.[5] A larger PE may push the diaphragm inferiorly, impairing its ability to generate pressure and causing neuro-mechanical uncoupling. It has been proposed that the effect of a larger effusion on diaphragm function is a more important cause of dyspnea than restricted lung expansion.[4,17]

Decreased lung compliance

Pleural effusion induced a restrictive ventilatory defect, which decreased VC, functional residual capacity (FRC), and TLC. When the amount of fluid in the pleural space increases, the pleural pressure rises, causing the distending pressure on the chest wall and lungs to change. Assuming that the chest wall and lung compliance remain constant, the chest wall volume grows while the lung volume declines.[18]

Due to the PE, the lung and chest wall volumes were uncoupled and no longer equal. In addition to preventing complete expansion of the ipsilateral lung, the contralateral lung may be affected, and the ipsilateral chest wall is usually distended. The decrease in lung volume is outweighed by the small changes in airway function, causing the lungs to empty more quickly.[18,19]

Respiratory muscle dysfunction

The association between restricted lung inflation and reduced diaphragm movement could have several potential explanations. The diaphragm's contribution to lung expansion may be directly affected by the bulk effect of effusion on diaphragm movement. An enhanced mass effect of the effusion could cause restricted diaphragm movement and diminished TLC.[4,8,18,20] Since pleural fluid rests between the diaphragm and the lung, fluid accumulation causes the lung to be unable to expand effectively.[15] One study indicated that, on average, when diaphragm movement was impeded, PE was 86% larger than when diaphragm movement was normal.[4]

Breathing at a volume greater than usual for the chest wall results in shortened inspiratory muscles, which act on an unfavorable section of their length-tension curve. After the pleural fluid is removed, the chest wall's volume shrinks dramatically, especially in individuals with extensive pleural fluid accumulations and parenchymal pulmonary involvement, causing the lungs to become unnaturally stiff. The lengthening of the inspiratory muscles toward the end of exhalation is associated with a decrease in chest wall volume.[20]

Exercise and activity limitations

Dyspnea on exertion rather than rest is often the first complaint of a PE patient.[8] Along with PE, several factors must be investigated to explain physical limitations due to the underlying disorder. The leading cause is cancer, which causes systemic changes that can reduce exercise capacity, as well as tuberculosis (TB) and liver damage. The distance traveled before thoracentesis was about 27% shorter than expected in a healthy population with the same characteristics.[5] Pleural effusion can also affect sleep quality and efficiency.[8]

Removing an average of 1.5 L of pleural fluid increased walking distance by 11%.[5] After the procedure, the patient's exercise capacity improved but did not reach the predicted levels and maintained a 16% reduction.[5] Pleural effusion patients mainly report being unable to perform their routine tasks.[5] One study found that the level of pre-drainage functional impairment was similar to that of very severe and stable chronic obstructive pulmonary disease (COPD) patients, and the 6-minute walking distance (6MWD) was identical to that of COPD patients hospitalized for acute exacerbations.[21] The average post-drainage improvement in that study was 30 m, corresponding to the minimum clinically significant difference of 25 m commonly used in COPD studies.[21] Fluid drainage not only improved 6MWD but also improved the post-drainage Borg score both before and after the 6-minute walk test (6MWT). The improvement in 6MWD did not correlate with the improvement in symptoms. This suggests that other individual factors (such as comorbidity) may play a role in determining benefits.[21]

Sleep and psychological disorders

Impaired sleep quality and quantity in PE patients are caused by hypoxemia. Other psychological disturbances found in PE are anxiety and depression.[22] It was found that sleep quality and efficiency were poor in patients with large PE. Thoracocentesis increased total sleep time, efficiency (76% to 81%), and rapid eye movement (REM). No correlation existed between the volume of pleural fluid removed (mean 1.6 L) and improved sleep or shortness of breath scores.[8]

The mechanism of sleep disturbance is explained in several hypotheses. Patients with large PEs would experience oxygen desaturation during sleep, which might improve after thoracentesis. This initial hypothesis was based on observations of hypoxemia resulting from hypoventilation during sleep, particularly in the REM cycles of patients with kyphoscoliosis. This mechanical restrictive condition can also be observed in patients with large PEs with reduced chest wall motion. The reduced lung volume associated with PE can also reduce tracheal traction and collapse the upper airway.[8]

The presence of depression and anxiety is associated with decreased long-term survival and reduced adherence to therapy, causing a decrease in QoL. This occurs not only because of the effusion but also due to the underlying disease, especially malignancy.[22] Impaired function due to PE is schematically depicted in Figure 1.

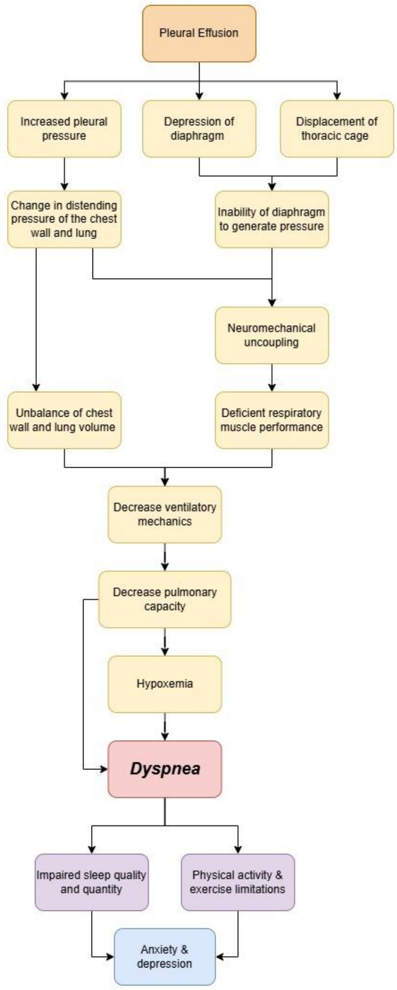

Figure 1. Functional impairments due to pleural effusions

Rehabilitation Assessment in Patients with Pleural Effusion

Anamnesis

Anamnesis is intended to determine the severity of symptoms, the course of disease or complications, and their impact on functional activities. The severity of symptoms can be assessed with assessment instruments such as the Visual Analogue Scale (VAS), dyspnea score-12 (D-12), and the Modified Borg Scale.[21,23] The VAS is a validated measurement tool for assessing shortness of breath in PE due to malignancy and has been used in studies after pleural drainage. Assessment is performed by asking the patient to describe how bad the degree of shortness of breath is by marking a scale between 0 and 100. The zero point indicates no tightness, while 100 indicates the worst tightness that cannot be tolerated.[21]

The D-12 questionnaire assesses the severity of shortness of breath with seven physical and five affective-related questions, each scored from 0 to 3. A maximum score of 36 points indicates the most severe level of shortness of breath. This questionnaire proved valid in patients with chronic lung diseases such as COPD, asthma, pulmonary fibrosis, and interstitial lung disease (ILD), as well as patients with chronic heart failure and pulmonary arterial hypertension.[21,24]

The Modified Borg Scale 0-10 is commonly used to assess shortness of breath before, during, and after exercise and 6MWT. The Scale consists of 12 points (0, 0.5, 1-10) according to the increasing shortness of breath. Patients were asked to mark the appropriate score and description of shortness of breath at rest and during activity.[23]

Pleural effusion can cause respiratory infections, pleuritic chest pain, and worsening of chronic diseases suffered by patients. Anamnesis is also aimed at assessing underlying chronic diseases, such as malignancy, autoimmune disease, heart disease, and TB, as well as their symptoms.[25,26]

Physical examination

In patients with severe dyspnea, accessory respiratory muscles such as the sternocleidomastoid, major pectoral, minor pectoral, anterior serratus, latissimus dorsi, and posterior superior serratus are involved asymmetrically.[27] Since shortness of breath causes changes in postural habit, the physical examination should include a posture examination.[28,29]

Pleural effusion does not directly cause a buildup of secretions. Secretions are usually associated with the underlying PE, such as TB. They are assessed for their viscosity, amount, and location.[29] Other physical functional abnormalities related to underlying diseases, such as signs of anemia and weight loss, also need to be considered.[29]

Supporting examination

Supporting examination data needs to be analyzed before providing PR interventions. The required laboratory data include routine hematology, hemoglobin, leukocytes, platelets, and blood gas analysis.[30] Other investigations are radiology and lung volume examination, which assess the extent of lung pathology and impaired lung function.[31]

Restrictive patterns are presented as reduced VC or forced vital capacity (FVC). These two parameters are used as the primary index of lung volume.[32] Another lung volume parameter is TLC and its components, such as FRC and residual volume (RV). Forced vital capacity, a combination of tidal volume, expiratory reserve volume (ERV), and inspiratory reserve volume (IRV), is measured by spirometry. Another index that can be assessed is forced expiration volume in 1 second (FEV1), FEV1 and FVC ratio (FEV1/FVC), and forced expiratory flow 25% to 75% of FVC (forced expiratory flow/FEF 25%-75%).[33,34] In addition, spirometry can also examine the components of the VC, namely, inspiratory capacity and ERV. However, measurement should be combined with other methods such as plethysmography, gas dilution, or imaging.[32]

Functional assessment in patients with pleural effusion

Respiratory muscle strength is often determined by measuring maximum inspiratory pressure (MIP) or PImax and maximum expiratory pressure (MEP) or PEmax. These pressures are measured using a Micro Respiratory Pressure Meter (MicroRPM) during maximal inspiration (Mueller's maneuver) or expiration (Valsalva maneuver) through the mouth. Maximum inspiratory pressure measurement is performed on residual volume, while MEP is on TLC and sitting. Respiratory muscle dysfunction is one of the main pathophysiologies caused by PE. However, no study has been conducted on respiratory muscle strength in PE patients.[35]

Cardiopulmonary exercise testing (CPET) is considered the gold standard for assessing cardiorespiratory fitness because it allows subjective assessment of cardiovascular and respiratory responses by evaluating the intensity of shortness of breath and leg muscle fatigue, as well as objective evaluation of cardiovascular response, respiration, and lung volume.[36,37] In PE patients, CPET is used to assess the effect of PE on exercise tolerance and the effect of thoracentesis on cardiorespiratory fitness. A study evaluating the effect of PE during maximum exercise using CPET found that maximum oxygen uptake (VO_2 max) decreased by 43% from baseline, and mean VO_2 max decreased by 37%.[31] After therapeutic thoracentesis (average 1.6 L), exercise tolerance, maximum workload, and VO_2 max were increased.[31] There is a good correlation between drainage and changes in VO_2 max, but no correlation has been found between the volume of fluid expelled and FEV1 or FVC.[31]

The impact of PE on functional activities can be assessed by assessing the QoL using a short-form 36-item (SF-36) questionnaire containing mobilization, daily life activities, and mental and social conditions.[38,39] No study was found to assess psychological disturbances in PE. However, one study assessed sleep quality in PE patients using the Pittsburgh Sleep Quality Index.[8] The Hospital Anxiety and Depression Scale was used to detect the presence of anxiety and depression.[22]

Rehabilitation management in patients with pleural effusion

Pulmonary rehabilitation in PE patients is known to accelerate fluid resorption and reduce the duration of drainage, respiratory system disorders, length of stay, and the incidence of pulmonary complications.[1] Pleural effusion patients are usually treated for shortness of breath. Shortness of breath can be bothersome. Hence, medical intervention or drainage is needed. Impaired functions in hospitalized patients include shortness of breath, which can be accompanied by coughing and chest pain. Other complaints related to underlying diseases, impaired mobility, reduced sleep quality, as well as anxiety and depression.[25]

The goals of inpatient PR management are weaning from the ventilator when the patient is admitted to the intensive care unit (ICU), returning to spontaneous breathing through airway clearance, reducing respiratory effort, improving respiratory function, and increasing lung inflation. Outpatient PR management aims to reduce symptoms, increase functional capacity, and increase patient participation.[1]

Physical therapy has been suggested as part of PE treatment and must be included as soon as possible in the management program. Enhancing functional capacity and reducing the hazards associated with intensive care and bed rest are two of the most significant goals of physical therapy in the context of hospitalization due to respiratory diseases, including PE. Including mobilization and breathing exercises can reduce musculoskeletal complications and improve respiratory function. Physical therapy interventions that induce intrathoracic pressure, such as deep breathing and incentive spirometry, may aid drainage and shorten the hospital stay.[12]

Mobilization

Walking on the first day following lung surgery appeared to have certain advantages, such as allowing the thoracic drainage tube to be removed sooner. Mobilization of patients after thoracic surgery seems to positively impact their functional recovery.[11] A randomized controlled trial involving 104 PE inpatients with or without an intercostal drainage tube found that adding breathing exercises and mobilization to other standard care reduced the severity of PE, as measured by blinded chest radiograph assessment.[1] These two interventions also cut the length of stay by an average of 12 days.[1]

Breathing exercise and incentive spirometry

Lung expansion techniques have been recommended as one group of interventions that could be utilized to speed up the drainage of a pleural fluid collection, reducing the risk of tube drainage problems. Its procedures, such as deep breathing, incentive spirometry, and positive airway pressure (PAP) exercises, are routinely used in drained or non-drained PE patients. One study found that most of the chest physiotherapists applied deep breathing exercises.[11] A combination of lung expansion techniques and walking was also used.[11]

Exercise combined with deep breathing is a low-cost and simple intervention. Deep breathing appears to have a better effect in individuals with cardiac surgeries and higher adherence to treatment than incentive spirometry.[11] A greater improvement in spirometric parameters, chest radiographs, and length of hospital stay in PE patients given respiratory physical therapy than in controls was found in a previous study where subjects were given standard physical therapy, pursed-lip breathing, active expiration, and incentive spirometry.[12]

Positive airway pressure

Positive airway pressure is a lung expansion technique that can help expand the lungs and facilitate drainage. It may be administered non-invasively through a face mask via non-invasive ventilation (NIV). Increased intra-pleural pressure would induce drainage and reabsorption of the pleural fluid collection, hastening the recovery of respiratory function, allowing earlier chest drainage removal, and shortening the length of hospital stay.[1]

One study found a significant improvement in PE size in the intervention group (83.5%) compared with the control group after four weeks of treatment with continuous PAP (CPAP).[13] One year following therapy with anti-TB medications, 50% of patients with pleural TB develop pleural thickening. Preventing pleural fibrosis is one of the goals of TB treatment. Pleural fibrosis is thought to be associated with a faster reduction in PE volume.[13]

The use of intermittent 15 cmH_2O CPAP in combination with mobilization and respiratory care reduces the duration of chest drainage, hospital stay, pulmonary problems, antibiotic use, and treatment expenses. Compared to CPAP of 4 cmH_2O, using 15 cmH_2O did not result in a higher rate of adverse events or lower tolerance (without therapeutic effect).[1]

Continuous positive airway pressure is typically considered a high-tech, hospital-based intervention, yet its application requires low-cost equipment. In addition, CPAP is widely available in outpatient healthcare units and home care settings. Complications associated with the use of NIV are rare. Gastric inflation at less than 30 cmH_2O, aspiration of gastric contents, and local complications such as skin abrasions from contact with the mask and conjunctivitis have all been documented in previous investigations.[13] These complications are preventable and curable.[13] Other limitations in using

PAP are the lack of familiarity with the technique and the risk of broncho-pleural fistula.[11]

Inspiratory muscle training

Although there is diaphragmatic dysfunction due to fluid accumulation in the pleural cavity, there is limited evidence of inspiratory muscle training in patients before and after the pleural procedure. There was an improvement in ventilation and respiratory volume on the side of PE in a study that used diaphragm exercises and pharmacological treatment twice a day for two weeks.[13]

Aerobic conditioning

No study has specifically examined the role of aerobic exercise in PE patients. However, there may be a developing body of evidence supporting aerobic exercise of PR as an essential intervention for patients with restrictive lung disease due to lung fibrosis. Patients with lung fibrosis must receive tailored exercise-based PR programs earlier. A previous study recommended that PR must be the primary management in patients with ILD of different severities.[14]

One systematic review and meta-analysis found that PR given through aerobic exercise or combined with breathing exercises or IMT led to significant improvements in exercise capacity, dyspnea, and health-related QoL.[9] Aerobic and breathing exercises, in combination, have a complementary effect on improving the dyspnea score. Aerobic exercise combined with IMT can be helpful since elevated inspiratory muscle strength can enhance the performance of the breathing muscle tissue required for ventilation. Increased exercise endurance can increase aerobic capacity and reduce ventilation load during exercise.[9]

Dyspnea scores improved after a combination of aerobic and breathing exercises. Improvement in symptoms was noted in response to repeated stimulation of high ventilation demands during exercise sessions, chest expansion during deep breathing exercises, and stretching of the chest muscles. These ventilation stimulations can contribute to more efficient breathing patterns, increased respiratory muscle strength, pleural elasticity, and compliance of lung tissue. This mechanism also decreases the perception of dyspnea after an exercise program. A combination of aerobic and breathing exercises improves health-related QoL scores.[9]

SUMMARY

In PE patients, the PR program can improve symptoms of dyspnea through mobilization programs and lung expansion techniques through deep breathing, incentive spirometry, and PAP. Data about the role of IMT and aerobic exercise specific to PE were limited. Based on the functional impairments found in PE, a PR program is needed to improve symptoms and enhance pulmonary functions and functional ability before and after the removal of pleural fluid.

LIMITATIONS OF THE STUDY

The limitations of this literature review include the restricted use of databases, specifically PubMed, CINAHL, and Google Scholar, which may lead to different results if additional databases were utilized. Future reviews are expected to be more comprehensive, evaluating relevant clinical studies and presenting protocols, outcome measures, and results more uniformly, allowing for a deeper analysis of the effectiveness of various rehabilitation interventions in managing patients with PE.

Acknowledgments

The authors would like to thank Padjadjaran University and Dr. Hasan Sadikin General Hospital for the opportunity to conduct this review and for facilitating the database.

Conflict of Interest

The authors declared there is no conflict of interest.

Funding

This study did not receive any funding.

Authors' Contributions

Conceptualization, drafting the manuscript, processed, and interpreted data: AN. Data collection: AN, GA, BC, HAN. Designed and finalized the manuscript: GA, BC, HAN. Reviewed the manuscript: ABS. All authors contributed and approved the final version of the manuscript.

REFERENCES

1. Santos EDCD, da Silva JDS, Filho MTTDA, *et al*. Adding Positive Airway Pressure to Mobilisation and Respiratory Techniques Hastens Pleural Drainage: A Randomised Trial. *J Physiother* 2020; 66: 19–26. [PubMed]
2. Markatis E, Perlepe G, Afthinos A, *et al*. Mortality among Hospitalized Patients with Pleural Effusions. A Multicenter, Observational, Prospective Study. *Front Med* 2022; 9: 828783. [PubMed]
3. Martinez-Pitre PJ, Sabbula BR, Cascella M. Restrictive Lung Disease. Treasure Island (FL), 2025. [PubMed]
4. Garske LA, Kunarajah K, Zimmerman PV, *et al*. In Patients with Unilateral Pleural Effusion, Restricted Lung Inflation is the Principal Predictor of

Increased Dyspnoea. *PLoS One* 2018; 13: e0202621. [PubMed]
5. Krishna R, Antoine MH, Alahmadi MH, *et al*. Pleural Effusion. Treasure Island (FL), 2025. [PubMed]
6. Addala DN, Kanellakis NI, Bedawi EO, *et al*. Malignant Pleural Effusion: Updates in Diagnosis, Management and Current Challenges. *Front Oncol* 2022; 12: 1053574. [PubMed]
7. Bintcliffe OJ, Lee GYC, Rahman NM, *et al*. The Management of Benign Non-Infective Pleural Effusions. *Eur Respir Rev* 2016; 25: 303–316. [PubMed]
8. Thomas R, Jenkins S, Eastwood PR, *et al*. Physiology of Breathlessness Associated with Pleural Effusions. *Curr Opin Pulm Med* 2015; 21: 338–345. [PubMed]
9. Hanada M, Kasawara KT, Mathur S, *et al*. Aerobic and Breathing Exercises Improve Dyspnea, Exercise Capacity and Quality of Life in Idiopathic Pulmonary Fibrosis Patients: Systematic Review and Meta-Analysis. *J Thorac Dis* 2020; 12: 1041–1055. [PubMed]
10. Holland AE, Cox NS, Houchen-Wolloff L, *et al*. Defining Modern Pulmonary Rehabilitation. An Official American Thoracic Society Workshop Report. *Ann Am Thorac Soc* 2021; 18: e12–e29. [PubMed]
11. Santos EDCD, da Silva JDS, Filho MTTDS, *et al*. Use of Lung Expansion Techniques on Drained and Non-Drained Pleural Effusion: Survey with 232 Physiotherapists. *Fisioterapia em Movimento*; 33. [Journal]
12. Valenza-Demet G, Valenza MC, Cabrera-Martos I, *et al*. The Effects of a Physiotherapy Programme on Patients with a Pleural Effusion: A Randomized Controlled Trial. *Clin Rehabil* 2014; 28: 1087–1095. [PubMed]
13. Oliveira JF, Mello FCQ, Rodrigues RS, *et al*. Effect of Continuous Positive Airway Pressure on Fluid Absorption among Patients with Pleural Effusion due to Tuberculosis. *Rev Bras Fisioter* 2010; 14: 127–132. [PubMed]
14. Tonelli R, Cocconcelli E, Lanini B, *et al*. Effectiveness of Pulmonary Rehabilitation in Patients with Interstitial Lung Disease of Different Etiology: A Multicenter Prospective Study. *BMC Pulm Med* 2017; 17: 130. [PubMed]
15. Porcel JM. PLEASE, Take a Deep Breath. *The European Respiratory Journal*; 55. Epub ahead of print May 2020. [PubMed]
16. Jacobs B, Sheikh G, Youness HA, *et al*. Diagnosis and Management of Malignant Pleural Effusion: A Decade in Review. *Diagnostics (Basel, Switzerland)*; 12. Epub ahead of print April 2022. [PubMed]
17. Umbrello M, Mistraletti G, Galimberti A, *et al*. Drainage of Pleural Effusion Improves Diaphragmatic Function in Mechanically Ventilated Patients. *Crit Care Resusc* 2017; 19: 64–70. [PubMed]
18. DeBiasi EM, Feller-Kopman D. Physiologic Basis of Symptoms in Pleural Disease. *Semin Respir Crit Care Med* 2019; 40: 305–313. [PubMed]
19. Kelly AM, Frauenfelder T. Diseases of the Chest Wall, Pleura, and Diaphragm. In: Hodler J, Kubik-Huch RA, von Schulthess GK (eds). Cham (CH), 2019, pp. 95–106. [PubMed]
20. Mentzer SJ, Tsuda A, Loring SH. Pleural Mechanics and the Pathophysiology of Air Leaks. United States, 2018. [PubMed]
21. Muruganandan S, Azzopardi M, Thomas R, *et al*. The Pleural Effusion and Symptom Evaluation (PLEASE) Study of Breathlessness in Patients with a Symptomatic Pleural Effusion. *Eur Respir J*; 55. Epub ahead of print May 2020. [PubMed]
22. Torres JR, Martos IC, López LL, *et al*. Psychological Distress at Hospital Admission is Related to Symptoms Severity and Health Status in Malignant Pleural Effusion Patients. *Eur J Cancer Care (Engl)* 2020; 29: e13212. [PubMed]
23. Matsuda Y, Yamaguchi T, Matsumoto Y, *et al*. Research Policy in Supportive Care and Palliative Care for Cancer Dyspnea. *Jpn J Clin Oncol* 2022; 52: 260–265. [PubMed]
24. Williams MT, Lewthwaite H, Paquet C, *et al*. Dyspnoea-12 and Multidimensional Dyspnea Profile: Systematic Review of Use and Properties. *J Pain Symptom Manage* 2022; 63: e75–e87. [PubMed]
25. Jany B, Welte T. Pleural Effusion in Adults-Etiology, Diagnosis, and Treatment. *Dtsch Arztebl Int* 2019; 116: 377–386. [PubMed]
26. Beaudoin S, Gonzalez AV. Evaluation of the Patient with Pleural Effusion. *CMAJ* 2018; 190: E291–E295. [PubMed]
27. Hashmi MF, Modi P, Basit H, *et al*. Dyspnea. Treasure Island (FL), 2025. [PubMed]
28. Gayen S. Malignant Pleural Effusion: Presentation, Diagnosis, and Management. *Am J Med* 2022; 135: 1188–1192. [PubMed]
29. Shaw JA, Diacon AH, Koegelenberg CFN. Tuberculous Pleural Effusion. *Respirology* 2019; 24: 962–971. [PubMed]
30. Liu W, Mu X, Wang X, *et al*. Effects of Comprehensive Pulmonary Rehabilitation Therapy on Pulmonary Functions and Blood Gas Indexes of Patients with Severe Pneumonia. *Exp Ther Med* 2018; 16: 1953–1957. [PubMed]
31. Light RW, Lee YCG. *Textbook of Pleural Diseases*. CRC Press, https://books.google.co.id/books?id=gm2mCwAAQBAJ (2016).
32. Lutfi MF. The Physiological Basis and Clinical Significance of Lung Volume Measurements. *Multidiscip Respir Med* 2017; 12: 3. [PubMed]
33. Ibitoye BO, Idowu BM, Ogunrombi AB, *et al*. Ultrasonographic Quantification of Pleural Effusion: Comparison of Four Formulae. *Ultrason (Seoul, Korea)* 2018; 37: 254–260. [PubMed]
34. Antonangelo L, Faria CS, Sales RK. Tuberculous Pleural Effusion: Diagnosis & Management. *Expert Rev Respir Med* 2019; 13: 747–759. [PubMed]

35. Schoser B, Fong E, Geberhiwot T, *et al*. Maximum Inspiratory Pressure as a Clinically Meaningful Trial Endpoint for Neuromuscular Diseases: A Comprehensive Review of the Literature. *Orphanet J Rare Dis* 2017; 12: 52. [PubMed]
36. Tran D. Cardiopulmonary Exercise Testing. *Methods Mol Biol* 2018; 1735: 285–295. [PubMed]
37. Adachi H. Cardiopulmonary Exercise Test. *Int Heart J* 2017; 58: 654–665. [PubMed]
38. Ersöz H, Dayılar Candan H. Evaluation of Quality of Life in Patients with Pleurodesis. *South Clin Istanbul Eurasia*; 30. Epub ahead of print 1 July 2019. [ResearchGate]
39. Sivakumar P, Saigal A, Ahmed L. Quality ofLife after Interventions for Malignant Pleural Effusions: A Systematic Review. *BMJ Support Palliat Care* 2020; 10: 45–54. [PubMed]