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Optimization of Airway Clearance in Pulmonary Tuberculosis Patients Through Chest Physiotherapy and Effective Cough Training: A Case Report

Winanda Diany[1] | Rycco Darmareja[2*]
[1,2] Faculty of Health Sciences, National Development University "Veteran" Jakarta
* Corresponding Author: ryccodarmareja@upnvj.ac.id

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ABSTRACT

Introduction: *Pulmonary tuberculosis remained a leading global cause of death despite various government programs. Ineffective airway clearance in patients could disrupt oxygenation, requiring appropriate therapeutic interventions.*
Objectives: *This study aimed to explore how chest physiotherapy and effective cough training could optimize airway clearance in pulmonary TB patients.*
Methods: *A case report was conducted on selected pulmonary tuberculosis patients, based on criteria established by the researcher. Data were collected through interviews, physical and supporting examinations, observations, and reviews of patient medical records. The application of evidence-based practice, in the form of chest physiotherapy and effective cough training, was observed in depth over five days of treatment to assess the optimization of the patients' airway clearance indicators, which were then recorded on the observation sheet provided.*
Results: *After the intervention, decreases were observed in respiratory frequency (toward normal), dyspnea scale (toward improvement), and areas with abnormal breath sounds, along with improvements in the patients' sputum characteristics.*
Conclusion: *Chest physiotherapy and effective cough exercises contributed to improved airway clearance. Nurses were encouraged to implement these interventions in patients with TB.*

Keyword: *chest physiotherapy, case study, effective cough, pulmonary tuberculosis*

Pendahuluan: *Tuberkulosis paru masih menjadi penyebab kematian tertinggi global. Banyak program yang dicanangkan pemerintah, namun prevalensinya masih tetap tinggi. Masalah keperawatan berupa bersihan jalan napas tidak efektif dapat mengganggu kebutuhan oksigenasi sehingga perlu dilakukan sebuah intervensi terapeutik.*
Tujuan: *Studi ini bertujuan untuk mengidentifikasi optimalisasi status bersihan jalan napas pada pasien TB paru melalui penerapan intervensi fisioterapi dada dan latihan batuk efektif.*
Metode: *Studi deskriptif kualitatif berupa case study di lakukan pada pasien Tb Paru terpilih, berdasarkan kriteria yang ditetapkan peneliti. Data di kumpulkan melalui prosedur wawancara, pemeriksaan fisik dan penunjang, observasi serta kajian pada rekam medis pasien. Penerapan evidance based practice berupa fisioterapi dada dan latihan batuk efektif di observasi mendalam selama lima hari perawatan untuk menilai optimalisasi pada indikator bersihan jalan napas pasien kemudian di catat pada lembar observasi yang disediakan.*
Hasil: *Setelah dilakukan intervensi diperoleh hasil bahwa terjadi penurunan frekuensi napas (ke arah normal), penurunan skala sesak (ke arah perbaikan), penurunan area dengan suara napas abnormal, serta perbaikan karakteristik sputum pasien.*
Kesimpulan: *Terapi dada dan teknik batuk terbukti memberikan dampak positif dalam memperbaiki tanda-tanda gangguan bersihan jalan napas. Oleh karena itu, diharapkan perawat mampu memaksimalkan penerapan intervensi ini sebagai strategi pada pasien tuberkulosis paru.*

Kata Kunci: *batuk efektif, fisioterapi dada, studi kasus, tuberkulosis paru*

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Introduction

Pulmonary tuberculosis was an infectious and contagious disease characterized by the entry of *Mycobacterium tuberculosis* into the functional lung tissue (parenchyma). The bacteria attacked the respiratory tract and multiplied within the lungs, triggering inflammation and tissue damage (Kurnia et al., 2021). Transmission occurred through air contaminated with droplets expelled by patients when coughing, sneezing, or speaking (Rahman, 2022). Afrina, (2023) added that poor housing conditions (such as limited

ventilation, inadequate lighting, and population density) were also contributing factors to the increasing prevalence of pulmonary TB.

Globally, in 2022 pulmonary TB remained the leading cause of death after COVID-19 as one of the major infectious agents. A total of 10.6 million TB cases were recorded worldwide. Eight countries accounted for the highest number of TB cases, with Indonesia ranking second (10%) after India (27%) (World Health Organization, 2023).

In Indonesia, pulmonary TB cases rose sharply from 397,377 in 2021 to 677,464 in 2022. By gender, 58% of patients were male and 42% were female, a pattern likely related to higher exposure to risk factors such as smoking, which was more common among men (Kementerian Kesehatan Republik Indonesia, 2023). Pulmonary TB was closely linked to smoking habits, which caused lung damage. Smokers had a 73% higher risk of developing pulmonary TB. Smoking weakened immune defenses and impaired the airway's mucociliary clearance (Ekawati et al., 2022).

Approximately 47% of pulmonary TB cases in Indonesia originated from three provinces with the highest burden: West Java, East Java, and Central Java (Kementerian Kesehatan Republik Indonesia, 2023). In addition, (Badan Pusat Statistik Provinsi DKI Jakarta, 2022) reported 26,854 pulmonary TB cases in Jakarta, distributed across East Jakarta (8,222 cases), Central Jakarta (5,008 cases), West Jakarta (4,956 cases), South Jakarta (4,812 cases), North Jakarta (3,819 cases), and the Thousand Islands (37 cases).

The government had implemented various national TB management programs, such as DOTS (Directly Observed Treatment Short-course), aimed at reducing mortality and preventing drug resistance (Fitri et al., 2018). Another program, TOSS TB (Find–Treat–Cure), focused on community empowerment to increase public awareness and support patients in completing their treatment (Sari & Rachmawati, 2019).

Early symptoms commonly experienced by pulmonary TB patients included productive coughing lasting approximately two weeks (Stephen et al., 2023). This condition indicated a strong relationship between pulmonary TB and the nursing diagnosis of ineffective airway clearance, defined as an inability to maintain a clear airway due to sputum accumulation which impaired optimal ventilation (Hanafi & Arniyanti, 2020). Puspitasari et al., (2021) stated that ineffective airway clearance also occurred when patients were unable to cough effectively. Nurses played a key role in managing this problem through effective coughing exercises to facilitate sputum expulsion, requiring minimal energy and reducing fatigue during coughing episodes.

In addition to effective coughing, the implementation of chest physiotherapy (including postural drainage, percussion, and vibration) was part of airway-clearance management. Chest physiotherapy helped mobilize secretions, improve impaired lung function, and promote airway patency (Subekti et al., 2023). Performing chest physiotherapy and effective coughing twice daily for five days had previously been shown to enhance airway clearance, reduce sputum volume, improve breathing patterns, and eliminate adventitious breath sounds indicative of airway obstruction (Fadhilah et al., 2023). These findings formed the foundation for conducting the present case study, which aimed to identify the application of chest physiotherapy and effective coughing to optimize airway clearance status among pulmonary TB patients.

Methods

This study employed a qualitative descriptive design with a single case study approach through the application of evidence-based nursing interventions for managing pulmonary tuberculosis with ineffective airway clearance. The participant was selected using purposive sampling based on the following criteria: individuals diagnosed with pulmonary TB, aged 17–65 years, who were willing to participate, had positive sputum smear results, and were unable to expectorate sputum effectively. The exclusion criteria were patients with Water Sealed Drainage (WSD), hemoptysis, or rib fractures. The study was conducted in a type A regional general hospital in Jakarta.

Data collection was carried out concurrently with the nursing care process for the pulmonary TB patient. Instruments used included nursing care documentation forms and daily observation sheets. Data were gathered through interviews, physical examinations, daily observations, supporting examinations, and a review of the patient's medical records. The data were then analyzed qualitatively using a descriptive approach. Throughout the study, ethical principles were upheld by respecting the patient, providing nondiscriminatory services regardless of ethnicity, religion, or social group, and ensuring that all interventions provided benefits without causing harm.

Focused observations in this study were directed at the implementation of chest physiotherapy and effective coughing exercises. Interventions were performed twice daily at 08:00 and 17:00 WIB for five consecutive days. The procedures followed the Standard Operating Procedures compiled from evidence-based nursing literature and were aligned with the standards applied in the study setting.

The interventions began with the nurse establishing a contract and obtaining informed consent from the patient, followed by equipment preparation. The intervention sequence included ensuring patient privacy, providing warm water, positioning the patient based on auscultation findings to match secretion locations (postural drainage), performing percussion and vibration on targeted lung segments, and concluding the session with effective coughing exercises. **This study has obtained ethical approval from the Health Research Ethics Committee of STIKes Bhakti Husada Mulia, Madiun, with ethical approval number 044/ E-KEPK/ STIKES/ BHM/ II/ 2026.** This indicates that the study has been declared to be in accordance with the principles of research ethics in accordance with applicable standards. The principles of health research ethics in human participants applied in this study are respect for human dignity, beneficence, non-maleficence, confidentiality, and justice.

Results and Discussion

Results

Description of Assessment Findings and Nursing Diagnoses

The assessment was conducted on Mr. A, a 49-year-old male working as a construction laborer. In 2022, he was diagnosed with pulmonary TB after assisting in caring for a neighbor who also had pulmonary TB (Mr. A was unaware that the disease was contagious). He had a smoking history of approximately 31 years (from age 16 to 47), consuming up to two packs of cigarettes per day. He also reported a 20-year history of alcohol consumption. The patient stated he had no history of diabetes, hypertension, heart disease, or stroke, although he had undergone surgery to remove kidney stones in 2022.

The patient reported having discontinued TB medications on four separate occasions. The first treatment interruption occurred after one month of taking anti-TB drugs, the second and third after two weeks, and the fourth after one week. He also stated that two of his children were currently undergoing the first month of TB treatment.

The patient developed shortness of breath and coughing for approximately two weeks and was hospitalized at a regional hospital in West Jakarta for four days. After returning home, he again experienced worsening shortness of breath, cough, fever, and nausea. Three days before being admitted to the hospital, he was taken to a regional hospital in Central Jakarta and was admitted to the pulmonary TB ward.

During assessment, the patient continued to complain of persistent coughing without clear triggers, described as a pulling sensation from the chest to the epigastric area. The cough was productive, but sputum was difficult to expel and occurred unpredictably. The main complaint was accompanied by shortness of breath rated at scale 6, worsening with activity (e.g., walking to the bathroom). The patient was fully conscious with a GCS score of 15 (E4, V5, M6) but appeared weak and frequently requested rest during the interview due to coughing and dyspnea. His body weight was 37.9 kg, height 165 cm, and BMI 13.9 kg/m^2 (underweight).

Physical examination showed normal nasal shape without lesions or bleeding, no nasal secretions, visible shortness of breath, and no nasal flaring or use of accessory respiratory muscles. However, breathing was rapid and shallow with a respiratory rate of 28 breaths/minute and dyspnea scale of 6. The sputum produced during coughing was yellow, slightly thick, and measured approximately 4 ml. Auscultation revealed dry rhonchi in the upper left lung lobe. Blood pressure was 114/87 mmHg, pulse 88 beats/minute, and temperature 36.2°C.

Laboratory results showed Hb 8.1 g/dl, leukocytes 14.29 $\times 10^3/\mu L$, platelets 456 $\times 10^3/\mu L$, albumin 2.4 g/dl, pH 7.520, pCO_2 27.1, and HCO_3 22.4. Chest X-ray results showed infiltrates in both lungs with suspected pneumonia or pulmonary TB. TB PCR (TCM) results indicated detectable pulmonary TB bacteria that remained sensitive to rifampicin.

Based on these findings, three nursing diagnoses were identified using the standards of the Indonesian Nursing Diagnosis System (Tim Pokja SDKI DPP PPNI, 2018): ineffective airway clearance (D.0001), nutritional deficit (D.0019), and nonadherence (D.0114). Although comprehensive nursing care was provided for all three diagnoses, this article focused on the ineffective airway clearance diagnosis, which aligned with the purpose of the study.

Outcome Determination and Care Planning

Outcomes and care plans were established based on the Indonesian Nursing Outcome Standards (SLKI) and the Indonesian Nursing Intervention Standards (SIKI) (Tim Pokja SIKI DPP PPNI, 2018; Tim Pokja SLKI DPP PPNI, 2018). The primary goal was to improve airway clearance (L.01001) within five days. Indicators included increased cough effectiveness, reduced sputum production, decreased rhonchi, decreased dyspnea, improved respiratory rate and pattern, and reduced difficulty speaking. Additional outcomes included improved gas exchange (L.01003), indicated by improved arterial PCO_2, PO_2, and pH levels.

To achieve these outcomes, the researcher implemented airway management interventions (I.01011), which consisted of monitoring respiratory patterns, adventitious breath sounds, and sputum quantity; applying therapeutic interventions such as semi-Fowler/Fowler positioning, warm water administration, and chest physiotherapy; providing education on effective coughing techniques; and collaborating in administering medications such as salbutamol tablets (3×2 mg), acetylcysteine tablets (3×2 mg), Pulmicort (3×1 mg), and 4 FDC (1×2.7 g). Additional interventions included respiratory monitoring (I.01014), involving observation of cough effectiveness, palpation of chest expansion, auscultation of breath sounds, monitoring oxygen saturation and arterial blood gas values, and documenting results accompanied by patient education on interpretation.

Implementation and Evaluation

After five consecutive days of implementing the interventions, improvements were observed from day one to day five, as shown in Table 1, which compared airway clearance indicators before and after chest physiotherapy and effective coughing.

Table 1. Comparison of Airway Clearance Indicators Before and After Chest Physiotherapy and Effective Coughing in a Pulmonary TB Patient

Indicator	Observation Time	Observation Results			
		Morning Intervention		Daytime Intervention	
		Before Intervention	After the Intervention	Before Intervention	After the Intervention
Respiratory Rate	Day 1	28	27	27	26
	Day 2	26	25	25	25
	Day 3	25	24	24	23
	Day 4	23	22	22	21
	Day 5	21	20	20	20
Dyspnea Scale (Borg Scale)	Day 1	6	6	6	6
	Day 2	6	5	5	5
	Day 3	5	4	4	3

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Indicator	Observation Time	Observation Results			
		Morning Intervention		Daytime Intervention	
		Before Intervention	After the Intervention	Before Intervention	After the Intervention
	Day 4	3	3	2	1
	Day 5	1	1	1	1
Adventitious Breath Sounds	Day 1 – 3	Ronchi on the left upper lobe	Ronchi on the left upper lobe	Ronchi on the left upper lobe	Ronchi on the left upper lobe
	Day 4 – 5	Reduced Ronchi in the left upper lobe	Reduced Ronchi in the left upper lobe	Reduced Ronchi in the left upper lobe	Reduced Ronchi in the left upper lobe
Sputum Characteristics	Day 1	Slightly thick yellow color with a fishy aroma ±4 ml	No sputum is produced	No sputum is produced	No sputum is produced
	Day 2	Slightly thick yellow color with a fishy aroma ±4 ml	No sputum is produced	Slightly thick yellow color with a fishy aroma ±4 ml	Slightly thick yellow color with a fishy aroma ±4 ml
	Day 3	Slightly thick yellow color with a fishy aroma ±4 ml	Slightly thick yellow color with a fishy aroma ±4 ml	Slightly thick yellow color with a fishy aroma ±4 ml	Slightly thick yellow color with a fishy aroma ±4 ml
	Day 4	Yellowish color mixed with a little white, slightly diluted, with a fishy smell, ±1.5 ml	Yellowish color mixed with a little white, slightly diluted, with a fishy smell, ±1.5 ml	Yellowish color mixed with a little white, slightly diluted, with a fishy smell, ±1.5 ml	Yellowish color mixed with a little white, slightly diluted, with a fishy smell, ±1.5 ml
	Day 5	Yellowish color mixed with a little white, slightly diluted, fishy smell, ±3.5 ml	Yellowish color mixed with a little white, slightly diluted, fishy smell, ±3.5 ml	Yellowish color mixed with a little white, slightly diluted, fishy smell, ±3.5 ml	Yellowish color mixed with a little white, slightly diluted, fishy smell, ±3.5 ml

Source: Primary Data

Table 1 shows that the respiratory rate on the first day, prior to the intervention, was 28 breaths per minute. Following five consecutive days of the intervention, the respiratory rate decreased to 20 breaths per minute. The dyspnea scale also gradually improved, with the patient initially scoring 6 on the first day before the intervention and decreasing to 1 by the fifth day. On the first day, auscultation revealed the presence of rhonchi in the upper lobe of the left lung. After chest physiotherapy and effective cough exercises, rhonchi were still audible but with reduced intensity.

Observations of sputum characteristics on the first day indicated yellow, slightly thick sputum measuring 4 ml with a fishy odor. On the first and second days, sputum could not be optimally assessed because the patient was unable to cough effectively and reported difficulty in expectorating. Gradually, by the second and third days, sputum could be expelled, and by the fourth and fifth days, changes were observed: the sputum was yellow mixed with white, slightly watery, measured 3.5 ml, and still had a fishy odor.

Thus, it can be concluded that the implementation of chest physiotherapy and effective cough exercises influenced changes in respiratory rate, dyspnea scale, breath sounds, and sputum characteristics in the pulmonary tuberculosis patient.

Discussion

Pulmonary tuberculosis was caused by the transmission of droplets containing *Mycobacterium tuberculosis* released by infected individuals through coughing, sneezing, or speaking, which were then inhaled and settled in the respiratory tract of healthy individuals (Platini et al., 2023). In this case, before being diagnosed with pulmonary TB, Mr. A had helped care for his neighbor who also had the disease, without adequate knowledge of its mode of transmission. In addition, Mr. A had a long history of smoking for 31 years, consuming up to two packs of cigarettes per day. A study by Suharmanto, (2024) showed that active smokers had a 4.718-times higher risk of developing pulmonary TB. Smoking reduced the effectiveness of respiratory defense mechanisms because cigarette smoke impaired ciliary movement and stimulated mucus production, which ultimately created a favorable environment for bacterial growth.

The symptoms experienced by the patient (including persistent cough, shortness of breath, and general weakness) were consistent with findings from previous studies on pulmonary TB. Mar'iyah and Zulkarnain, (2021) explained that TB patients commonly presented with coughing, dyspnea, and fatigue. Amiar and Setiyono, (2020) added that dyspnea in pulmonary TB occurred due to impaired lung development caused by parenchymal damage, which reduced lung expansion capacity and airflow to affected lung regions. Furthermore, Yulendasari et al., (2022) noted that coughing in pulmonary TB patients was a defense mechanism to expel secretions resulting from bronchial inflammation.

Management of health problems associated with pulmonary TB could be carried out through pharmacological and non-pharmacological approaches. Ningsih et al., (2022) categorized pharmacological therapy into two groups: Category 1 drugs for newly diagnosed pulmonary TB patients, and Category 2 drugs for those experiencing relapse, treatment failure, or treatment interruption. In the case of Mr. A, although he had interrupted treatment four times, he still received Category 1 therapy (4FDC: rifampicin, isoniazid, pyrazinamide, ethambutol). This was because his TB PCR (TCM) results indicated that *Mycobacterium tuberculosis* remained sensitive to rifampicin, thus standard Category 1 treatment was still appropriate (Direktorat Jenderal Pencegahan dan Pengendalian Penyakit Kementerian Kesehatan Republik Indonesia, 2020).

Inhalation therapy referred to the administration of liquid medications converted into aerosol form and delivered directly to the respiratory tract through the mouth, nose, airways, and lungs (Kristiningrum, 2023). The goals of inhalation therapy were to dilate the bronchial lumen, facilitate sputum expulsion, reduce bronchial hyperreactivity, and help manage infections (Ramadani, 2023).

This therapy is effective for delivering medication in aerosol form quickly and relatively safely compared to systemic therapy. The types of medication often administered are bronchodilators, mucolytics, and anti-inflammatories (Kristiningrum, 2023). Bronchodilators prevent obstruction and blockage of the airways by thinning mucus, thereby loosening the airways and reducing shortness of breath (Presditia et al., 2024). Thinner sputum can reduce inflammation, improve lung ventilation, and relax the respiratory muscles, thereby increasing the patient's functional activity (Sauqi et al., 2023).

The application of chest physiotherapy and effective coughing represented essential components of non-pharmacological management for pulmonary TB patients. Effective coughing exercises helped mobilize sputum with minimal energy expenditure, enabling patients to avoid fatigue while expelling secretions more optimally (Puspitasari et al., 2021). Meanwhile, chest physiotherapy functioned to mobilize airway secretions and improve lung function in both acute and chronic respiratory disorders (Subekti et al., 2023).

Chest physiotherapy provided multiple benefits for pulmonary TB patients. Syahfitri (2020) explains The application of chest physiotherapy can effectively clear the airways of pulmonary TB patients, thereby providing a sense of calm and comfort. Ningrum et al., (2022) reported that chest physiotherapy could increase sputum expulsion up to five to six times the normal rate. It also helped improve lung function and played an important role in managing respiratory diseases such as pulmonary TB (Purnamiasih, 2020). Fadhilah et al., (2023)

further emphasized that chest physiotherapy combined with effective coughing performed twice daily for five days produced measurable improvements in respiratory function.

The results of the intervention in Mr. A showed a reduction in dyspnea from scale 6 on the first day to scale 1 on the fifth day. This finding aligned with a study by Kurnia et al., (2021), which observed a decrease in dyspnea scale from 4 to 2 in pulmonary TB patients following chest physiotherapy and effective coughing interventions. Furthermore, the results of the data analysis conducted by Berutu et al. (2024) using the Wilcoxon test obtained a significant value of 0.000, which is below 0.005. The respiratory rate after therapy showed a better change than before chest physiotherapy. Before the intervention, the mean respiratory rate was 26.45, and after the intervention, the mean respiratory rate was 23.81.

There was also a notable decrease in respiratory rate, from 28 breaths per minute on the first day to 20 breaths per minute on the fifth day. This finding was consistent with the study by Fadhilah et al. (2023), which reported that respiratory rates initially above normal limits returned to normal by the fifth day after the application of chest physiotherapy and effective cough exercises. These improvements indicated that the intervention helped address impaired pulmonary ventilation.

Chest physiotherapy and effective coughing were also recognized as effective in facilitating sputum clearance from the respiratory tract (Jumriana et al., 2023). In this study, sputum characteristics improved from thick yellow secretions (4 ml) with a strong odor on the first day to thinner yellow-white sputum (3.5 ml) by the fifth day. According to Ningrum et al., (2022), thick yellow or green sputum indicated ongoing bacterial infection, and the ability to expel such sputum correlated with a reduction in adventitious breath sounds.

In line with the results of (Dewi et, (2017) study, the appropriate application of chest physiotherapy can significantly increase sputum volume in patients with pulmonary tuberculosis. The results of the paired sample t-test yielded a p-value of 0.001 ($p<0.05$), indicating a significant difference in sputum output before and after chest physiotherapy in pulmonary TB patients at the Makassar Community Lung Health Center (BBKPM).

Overall, the five-day evaluation of chest physiotherapy and effective coughing in the care of Mr. A demonstrated a positive clinical response, including reduced dyspnea, easier sputum expectoration, normalization of respiratory rate, and reduced rhonchi. Furthermore, these interventions were simple, cost-effective, and feasible for patients to perform independently.

Conclusion and Recommendations

The implementation of chest physiotherapy and effective cough exercises twice daily for five days in a pulmonary tuberculosis patient resulted in clinical improvements, including a reduction in respiratory rate toward normal, decreased dyspnea, diminished areas of abnormal breath sounds, and improved sputum characteristics. These findings indicated that the intervention contributed positively to the improvement of airway clearance indicators. The authors recommended that nurses optimally integrate this intervention into the care planning for pulmonary tuberculosis patients. Furthermore, it was suggested that patients, particularly Mr. A, continue these exercises independently at home to prevent symptom recurrence.

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