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Case Report

Rehabilitation in a Patient with Restrictive Lung Disease Due to Post Partial Right Inferior Lobe Resection with Phrenic Nerve Palsy: Case Report

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Abstract

The process of surgical resection is a complex procedure that raises several concerns after experiencing thoracic trauma. Injuries or cardiothoracic surgical interventions have the potential to give rise to phrenic nerve dysfunction, leading to diaphragmatic weakening, a reduction in inspiratory muscle capacity, and decreased lung volume. This impairs respiratory muscle endurance, ultimately manifesting as exertional dyspnea. A 19-year-old male patient with weaning ventilator failure following inferior lobe resection of the right lung and phrenic nerve palsy is the subject of the following case. After achieving stable hemodynamics in the patient, the pulmonary rehabilitation program within the intensive care unit was initiated. Therefore, this program was conducted to improve ventilation, lung volume, and capacity, as well as diaphragmatic excursion. Exercise capacity improved from a six-minute walking test, which covered 135 meters with a VO2 max of 10.04 and 2.87 metabolic equivalent (METs) before discharge. In the outpatient clinic setting, these values improved with the patient able to cover a distance of 294 meters, exhibiting a VO2 max of 13.17, and a METs value of 3.76.

Keywords: ***Thoracic trauma; Lung resection, Phrenic nerve palsy; Pulmonary rehabilitation.***

Introduction

Traumatic thoracic injury is a major cause of trauma-related mortality and accounts for 20 to 60% of all injuries. The majority of patients suffering from chest injuries often need less invasive procedures, such as the insertion of a chest tube, and in severe instances, surgical resection may be required [1].

Dysfunction of the phrenic nerve can result from trauma or cardiothoracic surgery [2]. Damage to the phrenic nerve leads to diaphragmatic paralysis, resulting in a decrease in inspiratory pressure and weakness of the diaphragm. This leads to a reduction in lung volume and inspiratory muscle capacity, contributing to diminished respiratory muscle endurance, ultimately culminating in exertional dyspnea [3].

Exercise tolerance improves among patients subjected to pulmonary rehabilitation after thoracotomy for resectable lung conditions. It is important to note that there may also be an increase in the perception of pain during the rehabilitation process [4]. However, there are few specific suggestions available for individuals with restrictive lung disease brought on by phrenic nerve palsy after partial right inferior lobe resection, such as positioning, breathing retraining endurance training, and airway clearance technique [5]. The case was a rehabilitation program for a 19-year-old male patient who had weaning ventilator failure following right inferior lobe resection with phrenic nerve palsy.

Case Description

A 19-year-old male patient consulted the Physical Medicine and Rehabilitation Department on two occasions, primarily due to difficulties in the weaning process from mechanical ventilation. The recent hospitalization occurred from July 19th to 28th, prompted by a stab wound sustained on the right posterior chest. On July 19, 2021, the patient was subjected to surgery at Cipto Mangunkusomo Hospital for inferior lobe resection of right lung segments 8 and 9. Subsequently, a re-thoracotomy was conducted on the same day due to persistent hemorrhaging. In the days leading up to hospitalization, increasing breathlessness was experienced. In the emergency room, chest X-rays were taken to show intrathoracic fluid before inserting water seal drainage (WSD). Due to the severity of the condition, the patient required endotracheal intubation and was admitted to the Intensive Care Unit (ICU). On the 6th and 9th days of the treatment, difficulties in the weaning process were experienced by mechanical ventilation, leading to unsuccessful extubation attempts.

On the 10th day of treatment, the patient was consulted by the physical medicine and rehabilitation department. The patient communicated non-verbally of not having shortness of breath but complained of discomfort in the throat and difficulty in expelling phlegm. The Richmond Agitation-Sedation Scale (RASS) score showed drowsiness (-1), using ventilator mode PS 10, PEEP 5 FiO2 40%. The chest wall movement exhibited a relative symmetry, with

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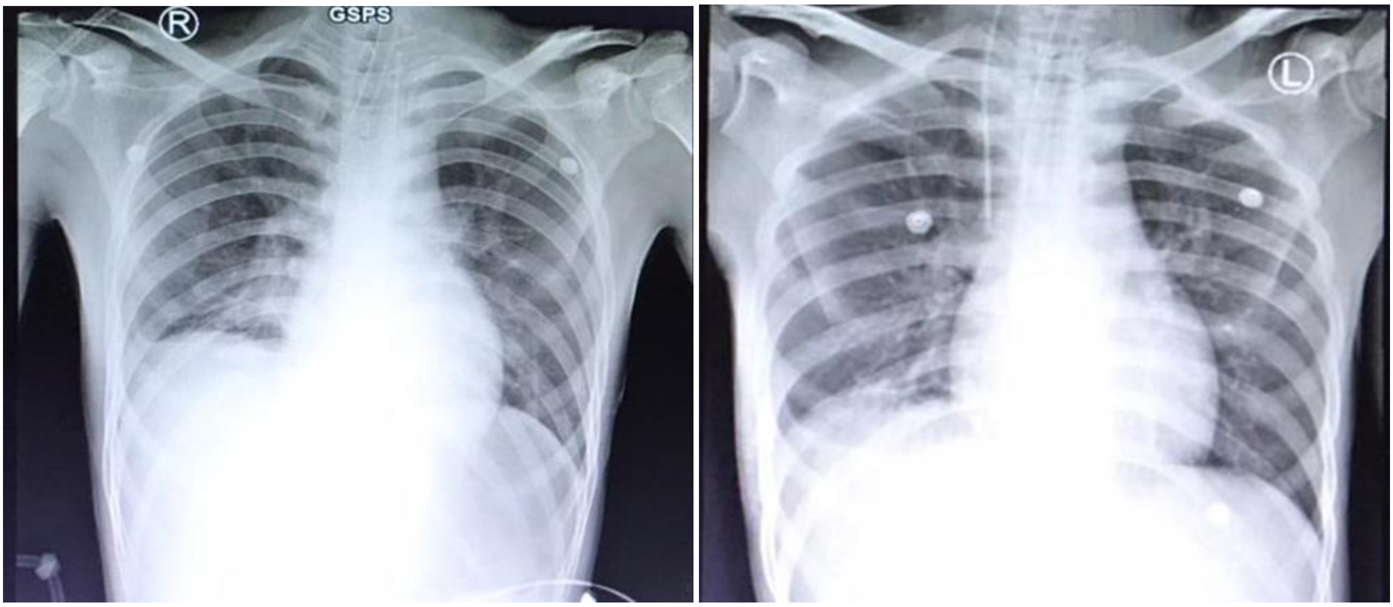
chest expansion wall excursion measuring 3 cm in the axilla, 3 cm at the xiphoid process, and 2 cm halfway between the xiphoid and umbilicus. There was a decrease in breath sounds in the right base, and the presence of phlegm (+) was observed. On the chest X-ray examination (**Figure 1**), a pleural effusion was identified on the right side with opacity in the basal region of the right lung, and fractures were reported in the clavicle and the tenth rib. Rehabilitation programs were administered, including a gradual transition from passive to active bed mobilization and daily breathing exercises including diaphragmatic and segmental techniques. The Active Cycle of Breathing Techniques (ACBT) and air stacking exercises were employed to optimize mucus clearance. Additionally, depending on the tolerance level of the patient, aerobic exercises were administered using an arm ergocycle.

The patient was subjected to a tracheostomy procedure on the fifteenth day of their treatment. Subsequently, the patient exhibited signs of improvement, evident three days after discharge from the ICU. During this time, the ability to stand beside their bed was reported for a duration of five minutes, maintaining a nasal oxygen consumption rate of 3 liters per minute. The chest expansion measurements showed excursions of 3 cm at the axilla, 3 cm at the xiphoid process, and 2 cm at half the distance between the xiphoid process and the umbilicus. Furthermore, the patient completed the "sit-to-stand test" six times within a 30-second timeframe. The rehabilitation programs included activities such as walking around the bed, with pauses mandated when the Borg Scale rating of perceived exertion (RPE) exceeded 13, or dyspnea and fatigue were rated higher than 4. The patient engaged in sit-to-stand and daily breathing exercises as part of the rehabilitation regimen. Furthermore, aerobic exercise was incorporated into the routine through the use of a leg ergo cycle, with the intensity adjusted to accommodate the tolerance levels.

On the 23rd day of treatment, the patient was improvement in mobility (**Figure 2**) and deemed fit for discharge. A six-minute walking test was administered, yielding results of 135 meters with a measured VO2 max of 10.04 and 2.87 METs. The patient showed the ability to perform the "sit to stand" exercise nine times within a 30-second duration, showcasing significant progress. The Barthel Index score reached 18 out of 20, indicating substantial improvement in functional abilities. After discharge, the patient was provided with a comprehensive set of home-based rehabilitation programs. These programs included aerobic exercise through daily 30-minute walks, with intervals of 10 minutes to be conducted 3-5 times a week. The target Borg scale for these sessions was set at 13-4-4 to ensure safe and effective training. The patient was instructed to engage in daily breathing exercises, including diaphragm and chest expansion exercises to support their recovery and respiratory function.

One week after discharge, the patient attended a follow-up appointment at the Physical Medicine and Rehabilitation outpatient clinic and there was no report of dyspnea or chest pain during the visit. Moreover, the walking capacity had improved, as evidenced by the results of the six-minute walking test, covering a distance of 294 meters. The VO2 max measured at an impressive 13.17, equivalent to 3.76 METs. As part of the rehabilitation plan, the patient received inspiratory muscle training to enhance respiratory function. Additionally, the aerobic exercise routine was continued, involving 30 minutes of daily walking for 3-5 times a week, with the same target Borg scale of 13-4-4 (**Figure 3**). Stair-climbing exercises were introduced, contributing to the physical improvement and endurance of the patient.



(a) **(b)**

Figure 1. Chest X-ray (a. pre-rehabilitation, b. 1 week after rehabilitation)

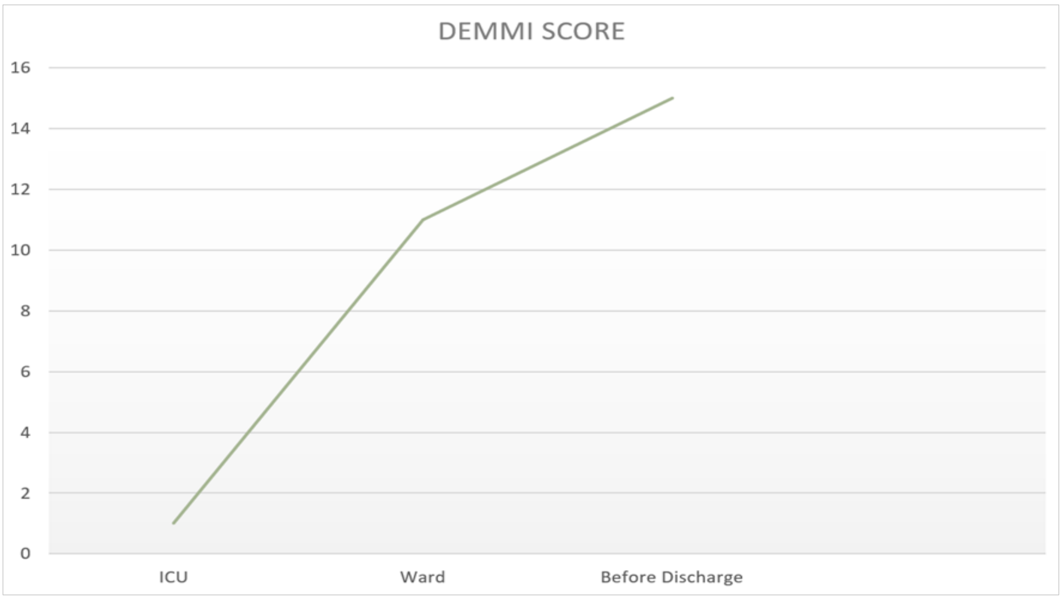


Figure 2. Changes in Mobility Index

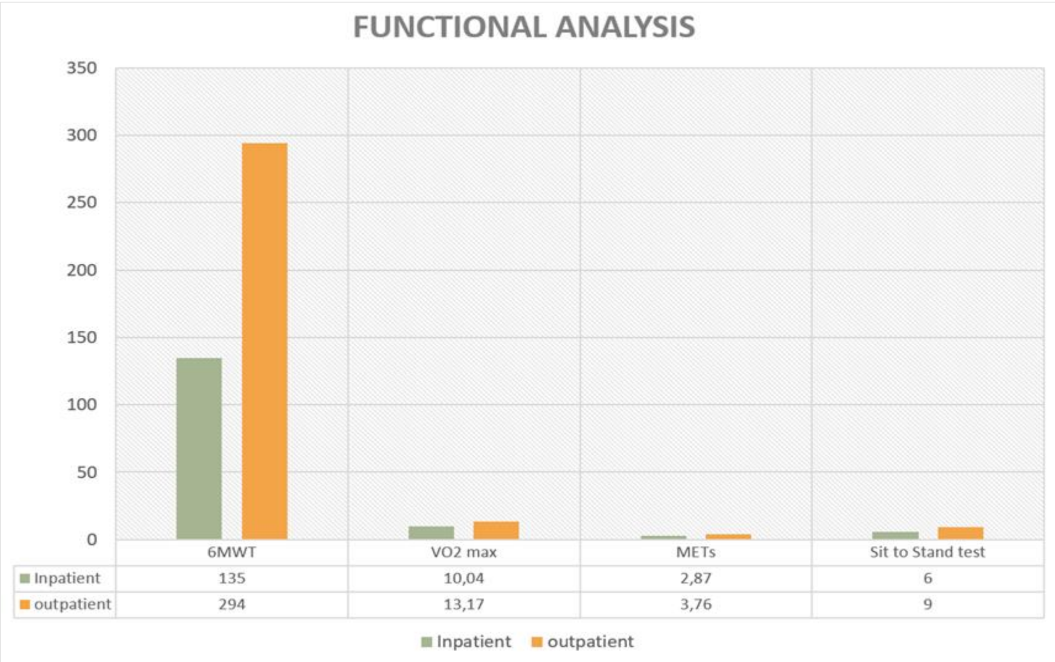


Figure 3. Functional Analysis from Inpatient to Outpatient

Discussion

Patients subjected to thoracic surgery commonly present with a range of postoperative pulmonary complications, categorized into infectious, such as pneumonia, or non-infectious, including atelectasis and respiratory failure. Additionally, other issues may manifest, including impaired airway clearance, frozen shoulder on the side of the thoracotomy, postural abnormalities, and persistent chest wall tightness. These concerns collectively constitute the primary challenges faced by individuals following thoracic surgical procedures [6].

Han et al found a patient subjected to surgery for diaphragmatic rupture and had reported experiencing persistent dyspnea for nine months [3]. Muscle fibrosis, fiber atrophy, and necrosis affect the diaphragmatic denervation, which should limit the paralyzed hemidiaphragm range of motion.7 The diagnosis of diaphragmatic paralysis is often subject to delayed recognition, primarily due to its symptomatic resemblance to diaphragmatic rupture. However, conservative management strategies, including interventions such as weight loss, exercise, and dietary modifications, have proven effective in alleviating the associated symptoms [3].

For patients who use prolonged mechanical ventilation, pulmonary rehabilitation with early mobilization has been suggested as a multidisciplinary method to support effective weaning. The benefits included an increase in functional status, length of spontaneous breathing trial, weaning rate, or even death. Therefore, comprehensive rehabilitation programs were advised for critically ill patients to improve functional recovery and lower the dependency on ventilators or difficult weaning [8].

To promote lung ventilation, the ideal position is an upright sitting position in or out of bed. The patient has the option to transition from bed rest to sitting in a chair while the endotracheal tube remains in place. This change in posture offers several benefits, including enhanced diaphragmatic excursion, improved ventilation, increased lung volume and capacity, reduced reliance on supplemental oxygen, and better forced expiratory flow [6].

The patient examination showed decreased chest expansion and mucus retention. The following treatments are specifically related to phrenic nerve rehabilitation: (1) Musculoskeletal limitations of the thoracic spine and rib cage, and (2) retraining of the neuromotor control of breathing [5]. These exercises include deep breathing, incentive spirometry, and inspiratory muscle training (IMT). This therapy aimed to improve lung expansion and increase lung volume and capacity. Deep breathing exercises play an important role in promoting substantial and prolonged enhancements in trans-pulmonary pressure. Consequently, these exercises lead to increased lung volume, improved ventilation, and enhanced oxygenation. Incentive spirometry serves as a visual feedback system designed to incentivize and motivate patients to actively engage in deep breathing practices and sustain maximal inspiration efforts [6]. Ventilatory muscle training programs enhance endurance and fortify neuroplasticity when the diaphragm exhibits consistent responsiveness [5]. A thorough airway clearance program, including assistive coughing methods, should be devised when the patient has a history of diminished capacity to clear lung secretions due to diaphragm weakness or paralysis [5]. To increase lung compliance and expansion, deep breathing, diaphragmatic breathing, segmental breathing, air staking, and chest mobility exercises were suggested. The patient also received active cycle breathing, coughing, and huffing to improve mucus clearance. The gradual weekly improvement in inspiration capacity shows the positive effects of exercise in the patient's situation.

In this case, post-rehabilitation functional status, as measured using DEMMI, showed significant improvement. Keng et all found DEMMI score had correlation with weaning success, hospital survival and 3-months survival after discharge [8]. After discharge, the patient should begin walking at a moderate level of effort approximately three times per day for five minutes, and a total of fifteen minutes per day. The total amount of walking time should be gradually increased by five minutes each week until the patient can walk for thirty minutes intermittently or continuously by the first month postoperatively. Patients with unilateral diaphragm palsy have reduced oxygen consumption (VO2) and decreased exercise tolerance. Therefore, aerobic exercise was prescribed by arm ergo cycle, leg ergo cycle, and walking exercise. The 6mwd and sit-to-stand tests showed that the functional capacity increased every week.

Conclusion

In conclusion, pulmonary rehabilitation was shown to be safe and enhance functional capacity in patients subjected to partial right inferior lobe resection with phrenic nerve palsy.

Ethics approval and consent to participate

Publication of this case report and accompanying images was waived from the patient's mother consent.

List of abbreviations

METs: metabolic equivalent
WSD: water seal drainage
ICU: Intensive Care Unit
RASS: The Richmond Agitation-Sedation Scale
ACBT: The Active Cycle of Breathing Techniques
RPE: rating of perceived exertion
IMT: inspiratory muscle training
VO2: oxygen consumption

Data Availability

Not applicable

Conflicts of Interest

The author(s) declare(s) that there is no conflict of interest regarding the publication of this paper.

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Authors' contributions

NL concepted, designed, collected the patient data and was a major contributor in writing the manuscript. SC, TF and PS supervision, analyzed and critical review. All authors read and approved the final manuscript.

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Not applicable

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