

Case Report

Influence of proprioceptive neuromuscular facilitation on pulmonary gas exchange in a mechanically ventilated class I obese patient with acute respiratory distress syndrome: a case report

Jayapriya, Om Prakash Palanivel*

Department of Cardio Vascular and Pulmonary Sciences, Saveetha College of Physiotherapy, Chennai, Tamil Nadu, India

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*Correspondence:

Dr. Om Prakash Palanivel,

E-mail: omprakash.scpt@saveetha.com

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ABSTRACT

Acute respiratory distress syndrome (ARDS) is a severe and life-threatening condition characterized by impaired oxygen exchange, reduced lung elasticity, and persistent hypoxemia, and although advances in mechanical ventilation have improved outcomes, oxygenation often remains suboptimal, necessitating supportive adjunctive therapies. This case report examined the effects of proprioceptive neuromuscular facilitation (PNF)-based respiratory physiotherapy in a 52-year-old male patient with ARDS associated with class I obesity on mechanical ventilation. Targeted PNF interventions, including anterior basal lifts and intercostal muscle stretching, were delivered over seven days, with oxygen saturation (SpO₂) monitored by pulse oximetry and arterial oxygen pressure (PaO₂) and PaO₂/FiO₂ (P/F) ratio measured through arterial blood gas analysis on the 3rd, 5th, and 7th days of ventilation. Progressive improvements in SpO₂, PaO₂, and P/F ratio were observed, reflecting enhanced pulmonary compliance and better gas exchange efficiency. These findings suggest that PNF-based respiratory physiotherapy may represent a valuable adjunct to conventional ARDS management in mechanically ventilated patients, though further research with larger samples is needed to validate its effectiveness in critical care.

Keywords: Acute respiratory distress syndrome, Proprioceptive neuromuscular facilitation, Mechanical ventilation, Oxygen saturation, Physiotherapy, Respiratory rehabilitation

INTRODUCTION

Acute respiratory distress syndrome (ARDS) is a critical condition that presents with sudden and severe breathing difficulties, often following direct or indirect injury to the lungs. Common causes include pneumonia, aspiration of stomach contents, sepsis, and physical trauma. As defined by the Berlin criteria,¹ ARDS is identified by bilateral opacities on chest imaging, a PaO₂/FiO₂ ratio of ≤300 mmHg, and the exclusion of elevated left atrial pressure as the primary cause. The central pathological feature of ARDS is damage to the alveolar-capillary membrane, which leads to fluid accumulation in the alveoli, decreased

surfactant levels, and lung collapse or atelectasis.² ARDS can be classified into mild, moderate, and severe forms, frequently requiring mechanical ventilation to support breathing. It also increases the risk of ventilator-induced lung injury (VILI), barotrauma, and prolonged ICU stay complications particularly prevalent among obese individuals due to altered respiratory mechanics, decreased lung compliance, and increased intra-abdominal pressure.³ Therefore, achieving a balance between adequate oxygenation and minimizing treatment-related harm is crucial, especially in obesity class I patients. To improve outcomes, various supportive treatments have been explored in recent years, including prone positioning,

extracorporeal membrane oxygenation (ECMO), and corticosteroids.⁴ While these interventions have shown promise, they often come with challenges like high resource demands, contraindications, and inconsistent effectiveness, which underscores the need for safe, accessible alternatives to complement standard ARDS care.⁴ In this context, physiotherapy has become an integral part of ICU management, especially for preserving lung function and reducing the risk of complications. One such technique, PNF, originally used to enhance neuromuscular coordination and strength, has shown promise in respiratory applications. By engaging accessory muscles and improving chest wall mobility, PNF techniques may help counteract common ARDS complications such as reduced lung volumes, alveolar collapse, and inefficient gas exchange. Through techniques like intercostal muscle stretching and anterior basal lifts, PNF may increase thoracic expansion and promote the opening of under-ventilated alveoli, thus supporting better oxygenation in ventilated patients.¹⁵ Previous investigations have shown that PNF not only supports individuals with chronic respiratory conditions such as COPD but also assists stroke survivors, where training of the accessory respiratory muscles contributes to improved chest wall expansion and enhanced breathing function.⁶ Furthermore, preliminary studies indicate that PNF may help improve oxygen levels in patients with acute respiratory issues, such as those caused by COVID-19.⁷ Moreover, systematic reviews have indicated that physiotherapy interventions in the intensive care setting, including chest physiotherapy and mobilization strategies, contribute to better respiratory outcomes and support recovery in critically ill patients.⁸ Clinical trials have demonstrated that introducing structured physiotherapy, such as early mobilization and functional training, in mechanically ventilated patients can shorten ventilation duration, reduce ICU-related complications, and promote long-term functional recovery.⁹ However, its application in ARDS remains a relatively unexplored area. This case study aims to bridge that gap by evaluating the effect of PNF on oxygenation in an ARDS patient receiving mechanical ventilation. Focusing specifically on intercostal stretching and anterior basal lift techniques, the study explores how PNF might improve lung mechanics, reopen collapsed airspaces, and enhance oxygen exchange. These findings contribute valuable insights into the role of physiotherapy as a supportive strategy in intensive care.

CASE REPORT

A 52-year-old male with a history of type 2 diabetes mellitus and hypertension on regular medication was admitted to the intensive care unit (ICU) for ARDS resulting from bacterial pneumonia and has a body mass index (BMI) of 34. At the time of ICU admission, the patient showed severe hypoxemia based on an oxygen saturation (SpO₂) of 77%, an arterial oxygen pressure (PaO₂) of 58 mmHg with a fraction of inspired oxygen (FiO₂ 1.0), and an arterial carbon dioxide pressure (PaCO₂)

of 53 mmHg. The patient was intubated with a 7.5 French polyvinyl chloride endotracheal tube (ETT) and hooked up to a Maquet mechanical ventilator in pressure-controlled ventilation (PCV) mode due to deteriorating respiratory status. The ventilator settings included a tidal volume of 4 mL/kg according to predicted body weight, a positive end-expiratory pressure (PEEP) of 14 cm H₂O, and a fraction of inspired oxygen (FiO₂) of 1.0. Oxygenation remained suboptimal despite 48 hours of mechanical ventilation and prone positioning. Clinical findings revealed restricted chest wall expansion, an elevated plateau pressure of 32 cm H₂O, and diffuse crackles upon auscultation. On the third day following intubation, the intensive care team commenced a structured physiotherapy program utilizing PNF techniques. The patient's primary relative provided informed consent prior to the initiation of therapy, which continued for seven days. The regimen comprised anterior basal lift techniques and intercostal muscle stretching techniques conducted on the 3rd, 5th, and 7th days of mechanical ventilation twice daily for 20 minutes per session. Generally, the anterior basal lift PNF technique is used to improve lung expansion and secretion movement in the lower front parts of the lungs. Hence, we place the patient in a semi-reclined or lying position and apply gentle pressure under the lower ribs during inhalation. This helps in lifting the chest wall and allowing better airflow into the lower lung zones. During exhalation, the pressure was slightly increased to help push out air and assist in clearing secretions. Intercostal muscle stretching PNF technique targets the muscles between the ribs to improve chest wall mobility and ease breathing. With the patient in a semi-recumbent position, stretch the side of the chest by applying firm, light pressure or a stretch during the inhalation phase. This helps loosen tight muscles, allowing the ribs to move more freely, support lung function, and improve breath. The sedation was carefully adjusted to facilitate optimal ventilator synchrony during PNF interventions. Baseline and pre-respiratory parameters were assessed, including SpO₂, PaO₂, and the PaO₂/FiO₂ (P/F) ratio. The initial assessment indicated a PaO₂ of 59 mmHg with an FiO₂ of 1.0 (SpO₂ 78%), resulting in a P/F ratio of 59, which confirms severe ARDS. On day five, PaO₂ increased to 86 mmHg with an FiO₂ of 0.75 (SpO₂ 88%), resulting in a P/F ratio of 114.7, which indicates moderate ARDS. On the seventh day of PNF intervention, PaO₂ increased to 101 mmHg on FiO₂ 0.5 (SpO₂ 96%), yielding a P/F ratio of 202, indicative of mild ARDS. The patient exhibited consistent clinical progress and was effectively transitioned to spontaneous breath mode. On the eleventh day of admission, the patient was liberated from the mechanical ventilator without complications, and on the same day, the patient was discharged from the ICU. This improvement in respiratory function marked a significant milestone in the patient's recovery journey. Following discharge, the patient continued to receive outpatient follow-up care to monitor lung function and ensure a full return to health.

DISCUSSION

Patients with ARDS on mechanical ventilation frequently encounter complications such as limited chest wall expansion, respiratory muscle weakness, and impaired gas exchange. These factors can impede recovery, prolong ICU duration, and increase the risk of long-term functional impairments. This case study demonstrates that PNF techniques resulted in significant improvements in oxygenation parameters, suggesting that PNF could serve as an effective intervention during the acute phase of respiratory rehabilitation for critically ill patients. Consistent with the findings of Bhakaney et al.⁷ Our study, which involved a 7-day intervention period, demonstrated significant improvements in SpO₂ (from 78% to 96%) and PaO₂ (from 59 mmHg to 101 mmHg), as well as an increase in the P/F ratio from 67 to 202. This alteration signifies a transition from severe to mild ARDS. The findings demonstrate that PNF intercostal muscle stretching and anterior basal lift techniques enhanced thoracic mobility, engaged under-ventilated lung areas, and facilitated improved alveolar ventilation. The case study demonstrated that PNF techniques, including intercostal stretching and diaphragmatic facilitation, improved oxygenation and reduced respiratory rate in a mechanically ventilated ARDS patient. These improvements are likely due to enhanced chest wall mobility and better ventilation-perfusion matching. The results align with findings from Rekha et al who showed that stretching respiratory accessory muscles in COPD patients improved chest expansion and reduced dyspnea.¹⁰ Although the current study involved a single ARDS patient, it suggests that PNF could be a valuable, low-cost, and non-invasive addition to ICU physiotherapy. However, more extensive studies are required to validate its clinical effectiveness across broader populations.¹⁰ Bhakaney and colleagues concentrated on the immediate effects of PNF in COVID-19 patients; however, our case study demonstrates that consistent application of PNF over several days can lead to sustained improvements. This comparison highlights the extensive applicability of PNF, indicating its relevance not only for immediate benefits but also for sustained recovery in critically ill, mechanically ventilated patients.⁷ Liu et al demonstrated improvements in FVC, FEV₁, and quality of life in COPD patients following PNF combined with aerobic exercise, which supports the current findings.⁵ Their emphasis on a chronic condition, coupled with the common objective of enhancing chest wall mobility and lung mechanics, is consistent with our study.⁵ The physiological principles of PNF are applicable in acute phase I rehabilitation, as demonstrated in this ARDS case, where PNF alone resulted in significant enhancements in respiratory function, despite the absence of aerobic training. Guidelines and expert consensus highlight that physiotherapy in intensive care, when applied with appropriate safety criteria, can enhance oxygenation, improve lung mechanics, and support early recovery in critically ill patients.^{11,12} The observed progress in our

patient from severe hypoxia to successful ventilator weaning highlights the crucial role of PNF in critically ill patients. However, some reports suggest that while physiotherapy and early mobilization benefit critically ill patients, the specific independent contribution of PNF techniques remains less well established.¹³ Improvements may be attributed to general mobilization rather than specifically to PNF. However, the systematic review by Gupta and Sharma emphasized the role of proprioceptive techniques in optimizing weaning outcomes and lung compliance, aligning with the physiological benefits observed in our case.¹⁴ Research on chest physiotherapy in ventilated patients has shown that targeted techniques can improve respiratory outcomes and may reduce complications such as ventilator-associated pneumonia, supporting its relevance to ICU rehabilitation.¹⁵ This adds evidence in favour of PNF-based approaches in ICU rehabilitation. A recent randomized controlled trial by Zhou et al demonstrated that the combination of proprioceptive neuromuscular facilitation and threshold inspiratory muscle training significantly enhanced inspiratory muscle strength, improved oxygenation, and facilitated successful ventilator weaning in neurocritical patients with weaning failure. These findings support the present case, highlighting the potential of PNF-based interventions to accelerate recovery and reduce ventilator dependency in critically ill patients.¹⁶ These findings reinforce the potential of PNF to contribute directly to ventilator weaning and functional recovery. This case study demonstrates the potential effectiveness of PNF techniques as an adjunct in phase I respiratory rehabilitation for critically ill patients, especially those with ARDS. These results are in line with the findings of Sasmitha et al who reported that pulmonary rehabilitation and respiratory muscle training improved oxygenation and functional capacity in ARDS patients.¹⁷ The consistency between both studies suggests that physiotherapy techniques whether manual or device-based can support lung recruitment and reduce respiratory workload in critically ill individuals. Although based on a single patient, this report highlights the potential role of PNF in ICU care. The observed enhancements in critical oxygenation metrics SpO₂, PaO₂, and the P/F ratio after systematic implementation of intercostal stretching and anterior basal lift techniques reveal a direct physiological advantage exceeding that of standard mobilization or patient handling. The implementation of PNF in this context is physiologically justified, with the objective of improving chest wall mechanics, facilitating the recruitment of under-ventilated lung segments, and optimizing gas exchange. Due to its non-invasive characteristics, ease of integration into existing physiotherapy routines, and minimal associated risks, PNF emerges as a valuable intervention for acute-phase respiratory care. This case study employs a single-subject design, limiting its generalizability. Further research, particularly randomized controlled trials, is essential to validate the efficacy, safety, and optimal implementation parameters of PNF in intensive care settings.

CONCLUSION

This case study examines the potential advantages of PNF techniques during the acute phase of respiratory rehabilitation for patients with severe ARDS. The observed improvements in oxygenation and ventilator weaning indicate that PNF could be a beneficial adjunct therapy to conventional physiotherapy. The findings of this study necessitate additional larger controlled studies to determine clinical efficacy and standardized application in critical care settings.

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