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Review Article

Effect of expiratory ribcage compression technique and respiratory neurofacilitatory techniques on lung function in mechanically ventilated patients: a review of literature

Shristi Das[1]*, Gitanjali Sikka[1], Prashant Kumar[2]

[1]College of Physiotherapy, Pt. B.D. Sharma University of Health Sciences, Rohtak, Haryana, India
[2]Department of Anesthesia, Pt. B.D. Sharma University of Health Sciences, Rohtak, Haryana, India

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***Correspondence:**
Dr. Shristi Das,
E-mail: shristi.dad12@gmail.com

ABSTRACT

Respiratory conditions pose significant challenges in critical care settings, particularly in managing patients who require mechanical ventilation in the intensive care unit (ICU). While mechanical ventilation is crucial for saving lives, it can also lead to complications such as impaired lung function and secretion retention. To address these issues, various physiotherapy techniques have been employed to enhance respiratory function and promote mucus clearance. These include manual techniques like expiratory rib cage compression (ERCC) and respiratory neuro-facilitative methods such as intercostal stretch (ICS), anterior basal lift (ABL), proprioceptive neuromuscular facilitation (PNF), and vertebral pressure (VP). A literature review was conducted, analyzing studies that evaluated the effectiveness of ERCC, ICS, ABL, PNF, and VP in patients on mechanical ventilation. The review focused on outcomes related to respiratory function, lung expansion, oxygen saturation, mucus clearance, and overall patient health. The data were collected, analyzed, and compared across different studies to assess the relative effectiveness of each technique. The review found that ICS, ABL, and VP significantly improved lung expansion and rib cage mobility, while PNF techniques, such as rhythmic initiation, enhanced respiratory muscle coordination and oxygen saturation. ERCC was particularly effective in promoting mucus clearance and improving respiratory mechanics in mechanically ventilated patients. The findings highlight the importance of personalized physiotherapy strategies in optimizing respiratory care for critically ill patients. Further research is recommended to refine these techniques and develop standardized protocols for their application in clinical practice.

Keywords: Respiratory physiotherapy, Critical care, Mucus clearance, Mechanical ventilation, Respiratory neuro facilitatory techniques

INTRODUCTION

In critically ill patients undergoing mechanical ventilation, airway secretions tend to increase due to the continuous application of positive pressure ventilation. Preventing these complications is a key objective in the care of such patients.[1] This review intent to assess and compare the effectiveness of various respiratory physiotherapy interventions, including manual techniques like expiratory rib cage compression or manual chest wall compression, and respiratory neurofacilitatory techniques such as intercostal stretch, anterior basal lift, and proprioceptive neuromuscular facilitation in critically ill patients. Expiratory rib cage compression (ERCC), also known as manually assisted coughing (MAC), quad cough, manual chest compression, or squeezing, is a technique proven to be effective in the treatment and prevention of lung collapse and is considered safe for critically ill patients.[2,3] The technique involves applying vigorous compression to the chest at the onset of spontaneous expiration or during

the expiratory phase of mechanical ventilation. The primary goal of ERCC is to stimulate coughing, one of the most effective mechanisms for airway clearance. By increasing expiratory flow and stretching the intercostal muscles through manual thoracic compression during exhalation, followed by a quick release at the start of inhalation, ERCC enhances mucus clearance and improves respiratory mechanics.[3] This technique is often combined with increased pressure support ventilation to further aid in secretion removal and improve lung function.[4] ERCC is commonly performed prior to procedures like endotracheal suctioning to increase their effectiveness.[5,6]

Intercostal stretch (ICS) is an effective respiratory neurofacilitatory technique helps in improving breathing pattern and respiratory muscle activity. This technique involves stretching of the intercostal muscles which targets nerve receptors of a muscle to extend its length futher improving lung expansion and breathing efficiency. The IC stretch enhances the chest wall elevation and increase chest expansion and diaphragm excursion to improve intrathoracic lung volume which contributes to improvement in flow rate percentage.[7] The anterior basal lift (ABL) technique is another respiratory neurofacilitatory technique which involves manual lifting of the anterior chest wall to aid in lung expansion, this helps in improving respiratory muscle activity and thereby improves intra-thoracic lung volume which contributes to improvement in flow rate percentage.[3]

Rhythmic initiation is a form of PNF technique used to stimulate diaphragm to shorten which improves breathing and oxygen saturation in mechanically ventilated patients.[8] Vertebral pressure involves applying manual pressure along the spine to facilitate deeper breathing which increases epigastric abdominal excursion over T2-T4.[9] Several studies have shown that ERCC and respiratory neurofacilitatory techniques improves lung functions in mechanically ventilated patients (Table 1).[1-9] this review aims to evaluate and compare the effectiveness of various respiratory physiotherapy techniques in improving respiratory function, and facilitating mucus clearance in critically ill patients.

METHODS

The systematic literature search began with databases like PubMed, MEDLINE, and the Cochrane library, using specific keywords related to various respiratory techniques such as "intercostal stretch," "chest compression," "ERCC," "mechanical ventilation," "PNF," "COPD," "ICU patients," "organophosphorus poisoning," and "manually assisted coughing." This search initially identified twenty studies. After a relevance screening, eleven studies were excluded for not meeting the inclusion criteria, leaving nine studies for further analysis.

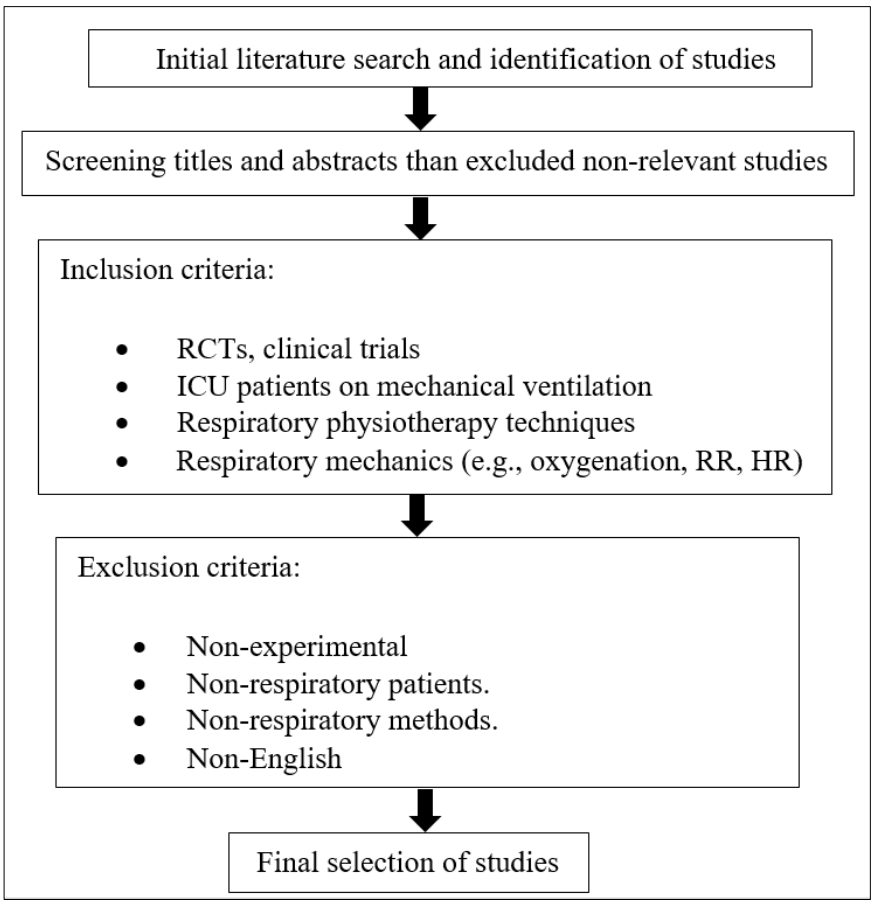

Figure 1: Identification of studies via databases and other methods.

Table 1: Summary of studies conducted on mechanically ventilated patients using expiratory rib cage compression and respiratory neurofacilitatory techniques.

Author, journal, year	Objective	Design	Characteristics of paraticipants sample size	Method	Outcome measures	Results	Limitation
Unoki et al, Respir Care, 2004[2]	They evaluated the effects of ERCC with and without endotracheal suctioning on heamodynamic changes, dynamic compliance of the respiratory system, and mucus clearance in rabbits with induced atelectasis	Different subject experimental	15 subjects	The study involved 28 female Japanese white rabbits with induced atelectasis, which were mechanically ventilated and anesthetized with sodium pentobarbital. They were divided into four groups: control, endotracheal suctioning alone, ERCC alone, and both ERCC and endotracheal suctioning.	Oxygenation, Ventilation, Dynamic Compliance of the Respiratory System (CRS), Mucus Clearance, Amount of Aspirated Artificial Mucus (secondary outcome)	ERCC, whether alone or combined with endotracheal suctioning, did not improve respiratory parameters and may exacerbate alveolar and airway collapse in mechanically ventilated rabbits with induced atelectasis.	Anatomic and physiologic differences between rabbits and humans limit the generalizability of the findings
Avena et al, J Bras Pneumol. 2008[3]	they assessed the effects of MAC on respiratory system mechanics and oxyhemoglobin saturation in sedated patients requiring full ventilatory support, and to determine the efficacy and safety of combining MAC with endotracheal aspiration in the removal of airway secretions.	Same subject experimental	16 subjects	The study involved 16 sedated patients on full ventilatory support (no active participation in ventilation). Respiratory system mechanics and oxyhemoglobin saturation were measured before and after MAC, as well as after endotracheal aspiration. Bilateral MAC was performed ten times on each patient, with three respiratory cycle intervals between each application.	Respiratory System Mechanics, SpO2	Results demonstrated a decrease in resistive pressure and respiratory system resistance, together with an increase in oxyhemoglobin saturation, after MAC combined with endotracheal aspiration. No evidence of alterations in peak pressures, plateau pressures or respiratory system compliance change was observed after MAC.	Small sample size
Gupta et al, International Journal of Health Sciences and Research, 2014[7]	of this study is to compare the efficacy of the ICS and ABL on respiratory rate, saturation of peripheral oxygen and heart rate.	Same subject experimental	30 subjects	30 patients from ICU were taken for the study who fulfilled the eligibility criteria and were systematically divided into Group A (IC stretch) and Group B (ABL). Patients were given the intervention according to their allocated group for 3 days and effects of these techniques on RR, SpO2 and HR parameters were observed. Data were taken at baseline and after 3 days of intervention.	Respiratory Rate (RR), Saturation of Peripheral Oxygen (SpO2), Heart Rate (HR)	The study found that the ICS technique significantly improved respiratory rate, heart rate, and oxygen saturation compared to the ABL in ventilated ICU patients	no follow up was done, small sample size.

Continued.

Author, journal, year	Objective	Design	Characteristics of paraticipants sample size	Method	Outcome measures	Results	Limitation
Naue et al, J Bras Pneumol. 2014[4]	The study aimed to assess the effectiveness of chest compression with a 10-cmH2O increase in baseline inspiratory pressure on pressure support ventilation (PSV) versus aspiration alone in patients on mechanical ventilation.	Same subject experimental	34 subjects	Study included 34 ICU patients who had been on mechanical ventilation for over 48 hours. Patients were divided into two groups: one receiving aspiration alone (control) and the other receiving chest compression with increased inspiratory pressure (intervention).	hemodynamic parameters, respiratory mechanics, and the amount of secretions removed.	The intervention group had significantly higher median secretions collected, increased mean expiratory tidal volume, and improved mean dynamic compliance. The study concluded that chest compression with increased pressure support significantly improved secretion removal, expiratory tidal volume, and dynamic compliance in mechanically ventilated patients	Small sample size
Bousarri et al Iranian Journal of Nursing and Midwifery Research, 2014[1]	This study evaluated the effect of expiratory rib cage compression before endotracheal suctioning on vital signs in mechanically ventilated patients.	Same subject experimental	50 subjects	The study included 50 patients from ICU. Patients were randomly assigned to receive endotracheal suctioning with or without rib cage compression, with at least a 3-hour interval between interventions. Rib cage compression was performed for 5 minutes before suctioning, and vital signs were measured 5 minutes before and 15 and 25 minutes after suctioning.	Hemodynamic and respiratory parameters	Significant differences in vital signs measured 5 minutes before compared to 15 and 25 minutes after suctioning with rib cage compression. Specifically, diastolic pressure did not significantly change 25 minutes after suctioning compared to baseline, but pulse and respiratory rates significantly differed 15 minutes after suctioning, with the effect on respiratory rate continuing up to 25 minutes. Comparisons between the two methods also showed significant differences in vital signs 5 minutes before and 15 minutes after suctioning.	short duration of observation
Guimarães et al, Respiratory Care, 2014[5]	This study assessed the acute mechanical effects and sputum clearance of ERCC in mechanically ventilated patients with pulmonary infection.	Same subject experimental	20 subjects	20 mechanically ventilated patients compared ERCC to normal ventilation without compression (CTRL), assessing sputum clearance and respiratory mechanics.	Sputum Clearance, Respiratory Mechanics, Expiratory Flow Parameters	ERCC increased sputum clearance by 34.4% and improved expiratory flow, but had minimal impact on respiratory mechanics and caused expiratory flow limitation in 30% of patients.	Small sample size

Continued.

Author, journal, year	Objective	Design	Characteristics of paraticipants sample size	Method	Outcome measures	Results	Limitation
Yaghoubi et al, IAJPS, 2017[6]	This study investigated the impact of ERCC during exhalation before tracheal suctioning on blood oxygen saturation in mechanically ventilated patients.	Different subject experimental	55 subjects	the study included 55 patients divided into control and intervention groups using convenience sampling. Blood oxygen saturation was measured 5 minutes before, and 15 and 25 minutes after, suctioning in both groups.	blood oxygen saturation	The oxygen saturation significantly increased in the intervention group that received ERCC before suctioning. The study concluded that ERCC during exhalation before suctioning improves blood oxygen saturation and is recommended for intubated patients.	Short Observation Period, the use of convenience sampling may introduce selection bias
Salve et al, International Journal of Health Sciences and Research, 2021[9]	The study investigated the effects of two PNF techniques, vertebral pressure and intercostal stretch, on respiratory parameters in ICU patients with organophosphorus poisoning on mechanical ventilation.	different-subject experimental	24 subjects	Twenty-four patients were divided into two groups: Group A received intercostal stretch, and Group B received vertebral pressure.	Respiratory Rate (RR), Tidal Volume (TV), Oxygen Saturation (SpO2), Heart Rate (HR)	Both techniques significantly improved HR, RR, tidal volume (TV), and SpO2. Improvements in TV, reductions in RR and HR, and increases in SpO2 were noted for both groups .PNF techniques, including intercostal stretch and vertebral pressure, are effective in enhancing respiratory parameters and oxygenation in patients with organophosphorus poisoning..	Same sample size
Zwoliński et al, Int J Environ Res Public Health, 2022[8]	This study examined the feasibility and effects of proprioceptive neuromuscular facilitation (PNF) techniques on vital signs in mechanically ventilated (MV) ICU patients.	different-subject experimental	61 subjects	Sixty-one adult patients were randomly divided into two groups, each receiving four 90-second manual breathing stimulations. Vital signs assessed included HR, systolic blood pressure (SBP), diastolic blood pressure (DBP), and SpO2.	Heart Rate (HR), Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP), Oxygen Saturation (SpO2)	No significant differences in HR, SBP, and DBP were observed between the two PNF techniques. A statistically significant improvement in SpO2 was observed in the rhythmic initiation technique group. Short-term PNF interventions are feasible in MV ICU patients and do not significantly impact vital parameters like HR, SBP, and DBP. However, the RIT technique may improve SpO2	Limited Sample Size, Lack of Control Group

DISCUSSION

The studies reviewed provide a considerable examination of different chest physiotherapy techniques, focusing on their effects on respiratory mechanics, gas exchange, and secretion clearance in impaired respiratory mechanics.

Unoki et al concluded that ERCC combined with endotracheal suctioning in rabbits with induced atelectasis might worsen oxygenation and ventilation parameters. Despite the purpose to enhance secretion clearance and improve lung mechanics, the study found that ERCC, whether alone or combined with suctioning, did not offer the expected benefits and could potentially exacerbate lung collapse. This result supports with the findings of Guimarães et al, who also observed no significant improvement in respiratory parameters with ERCC, although there was a notable improvement in secretion clearance. Conversely, Bousarri et al demonstrated that ERCC before endotracheal suctioning improved vital signs, specifically oxygen saturation. Yaghoubi et al further supported this by showing that this technique during exhalation before suctioning significantly increased blood oxygen saturation, suggesting its potential utility in clinical practice. Moreover, Naue et al studied the technique of chest compression with increased pressure support ventilation (PSV) showed positive results in secretion removal and improving respiratory mechanics. This technique, which involves a 10 cm H2O increase in baseline inspiratory pressure, appears to enhance the efficiency of secretion clearance and improve lung compliance, showing that it is a potentially beneficial intervention for patients with severe secretion retention.

Gupta et al studied the effect of ICS and reported significant improvements in respiratory rate, heart rate, and oxygen saturation in ICU patients. Additionally, as discussed by Zwoliński et al and Salve et al, the use of PNF & respiratory neuro facilitatory techniques further demonstrates potential benefits in mechanically ventilated patients, particularly in improving oxygenation and other vital signs without any adverse effect on hemodynamics. These findings suggest that these techniques could be a safe and effective in the management of mechanically ventilated patients. While some techniques like ICS and chest compression with increased PSV show benefits, or ERCC, may require careful use due to their potential to worsen respiratory parameters. Future research should focus on identifying the patient populations most likely to benefit from each technique, optimizing the timing and intensity of interventions.

LIMITATIONS

There are several key limitations for this review, the heterogeneity in study designs and patient populations, ranging from animal models to different ICU patients which complicates the direct comparisons and generalization of findings. Inconsistent methodologies and varying protocols across studies further limit the ability to draw definitive conclusions. Many studies focused on short-term effects with small sample sizes, which reduce statistical power and may introduce bias. Additionally, the studies included do not explore the long-term impact of these techniques. These limitations highlight the need for standardized, larger-scale, and longitudinal studies to better inform clinical practice.

CONCLUSION

The studies reviewed demonstrate the varying effectiveness of different respiratory physiotherapy techniques in critically ill patients. Techniques such as ERCC and MAC show potential for enhancing secretion clearance and optimizing oxygenation, though their effects on other respiratory parameters are inconsistent. Neuro-facilitative techniques, particularly intercostal stretch, have shown promise in improving key aspects of respiratory mechanics. The findings suggest that while some treatments offer significant benefits, others may have adverse effects, highlighting the importance of thorough patient assessments and personalized treatment plans. The variation in study outcomes underlines the need for further research to explore combinations of these techniques, identify the most appropriate conditions for their application, and optimize their use in clinical practice.

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