Efficacy of Peep-Zeep Manoeuvre, Ventilator Hyperinflation and Conventional Chest Physiotherapy on Ventilator-Associated Pneumonia: A Pilot Study

Dr. Vaishnavi Yadav [1*], Dr. Vishnu Vardhan [2], Dr. Sourya Acharya [3], Dr. Hemant Deshpande [4]

[1]Associate Professor, Department of Cardiorespiratory Physiotherapy, Ravi Nair Physiotherapy College, Datta Meghe Institute of Higher Education and Research (DU), Wardha, Maharashtra, India. Email: vaishnavi.cardiopt@dmiher.edu.in
[2]Professor, Department of Cardiorespiratory Physiotherapy, Ravi Nair Physiotherapy College, Datta Meghe Institute of Higher Education and Research (DU), Wardha, Maharashtra, India. Email: vishnu.vardhan@dmiher.edu.in
[3]Professor, Department of Medicine, Jawaharlal Nehru Medical College, Datta Meghe Institute of Higher Education and Research (DU), Wardha, Maharashtra, India. Email: souryaacharya74@gmail.com
[4]Associate Professor, Department of Emergency Medicine, Datta Meghe Medical College, Datta Meghe Institute of Higher Education and Research (DU), Wardha, Maharashtra, India. Email: hemsdesh1980@gmail.com

**Corresponding Author: Dr. Vaishnavi Yadav*

KEYWORDS

PEEP-ZEEP manoeuvre, Ventilator hyperinflation, Conventional chest physiotherapy, CPIS score

ABSTRACT

Ventilator-associated pneumonia is one of the major complications in patients submitted to a mechanical ventilator. Prevention and removal of pulmonary secretion, which is one of the primary causes of pneumonia, is a challenge for physiotherapists due to the presence of constant positive pressure. Conventional chest physiotherapy techniques, including suctioning, have certain disadvantages, such as no optimum intrapulmonary effect and effective flow bias generation, which is essential to propel secretions towards the central airway. Thus, the present study aims to evaluate the efficacy of PEEP-ZEEP manoeuvre, ventilator hyperinflation and conventional chest physiotherapy on ventilator-associated pneumonia. The objectives of the study are to evaluate and compare the effect of all the interventions on Clinical Pulmonary infection score (CPIS), oxygenation level (PaO2/FIO2), dynamic compliance, extubation day and length of ICU stay.

Method: 36 mechanically ventilated patients were randomly allocated to three groups for intervention. Group A chest physiotherapy with PEEP-ZEEP Manoeuvre, Grou B chest physiotherapy with ventilator hyperinflation and conventional chest physiotherapy.

Result: There was a significant difference in clinical pulmonary infection score (Group A p 0.002, Group B 0.000, Group C 0.00), Pao2/fio2 (Group A p =0.00, Group B p=0.000, Group C p 0.000), Fio2 (Group A p 0.002, Group B p= 0.00, Group C p= 0.0033), dynamic compliance (Group A p= 0.000, Group B p= 0.00, Group C p= 0.000), sputum (Group A p= 0.000, Group B p= 0.00, Group C p= 0.000) within the groups using t-test. There was no significant difference in clinical pulmonary infection score when pre-post difference scores were compared between the groups (Group A vs Group C p= 0.52, Group B vs Group C p=0.07, Group A vs Group B p= 0.096). There were no significant differences for Pao2/fio2 (p= 0.1), Fio2 (p= 0.5), dynamic compliance (p=0.9), sputum (p= 0.7) but significant difference for CPIS (p=0.04) between group using ANOVA.

Conclusion: Conventional chest physiotherapy and chest physiotherapy along with the ventilator manoeuvre is effective in improving oxygenation, respiratory mechanics and CPIS, i.e. ventilator-associated pneumonia recovery, but the superiority of any intervention needs further study.

1. Introduction and Background

The intensive care unit is the well-equipped specialized department in the hospital that provides specialized care for critically ill patients under the supervision of experts in various healthcare professions [1]. The objective of the sophisticated, structured I.C.U. is to maintain the normal physiology that has been hampered due to various life-threatening medical conditions. [2]Though mechanical ventilators are crucial, they are also associated with several factors that result in complications [3]. The prolonged ventilator support results in a high risk of developing infections and

dependency. It is more pronounced in comorbid and pre-existing respiratory diseases, neurologic insults, and emergency intervention. Critically ill patients require an additional invasive procedure that provides easy access to bacteria [4]. Ventilator pneumonia and ventilator-associated events, including pulmonary oedema, prolong the duration of the mechanical ventilator and poorly affect the patient outcomes [5]. Positive pressure inspiratory airflow, artificial airway management, and microbial biofilms are the primary routes for bacterial colonization [6]. The defence mechanism of the upper respiratory tract is bypassed by artificial airways, making bugs easy to enter and virulent. [7] VAP (Ventilator-associated pneumonia) is defined as pneumonia that occurs more than 48 hours after initiation of a mechanical ventilator [8]. There is an increase in morbidity, prolonged hospitalization, and an increased overall burden of health care costs. Early diagnosis and early intervention are the keys to improving patient outcomes in ventilator-associated pneumonia [5]. Mucociliary dysfunction is an inevitable effect of mechanical ventilators with varied causes that are direct and indirect [9]. The direct effects are those that are caused by the mechanical ventilator circuit and involve ETT-induced epithelial damage, anaesthesia, altered humidity and temperature, anaesthetics, and cough reflex impairment [10]. Cardiopulmonary physiotherapy plays a crucial role in airway clearance and early mobilization in critically ill patients. The appropriate choice of airway clearance techniques depends on the thorough assessment and evaluation of patients [11]. Prevention and Removal of airway secretion to maintain oxygen transport is the primary goal of cardiopulmonary physiotherapists, thus preventing atelectasis and collapse of the lungs [12]. Retention of pulmonary secretion enhanced by mechanical ventilator-associated complications provides growth media to bacteria, leading to infection, and the vicious cycle will continue. [13] Accumulated secretion in the airways, if extensive, starts a self-sustaining cycle of ventilation/perfusion mismatch, gas-exchange impairment, increased work of breathing, and subsequent augmented risk of mechanical ventilation-associated pulmonary infections [14]. There are small trials that have proven that conventional chest physiotherapy prevents VAP independently in mechanically ventilated patients, and a few studies have also found that conventional chest physiotherapy is not effective in the prevention of VAP. [15]

Shallow suctioning is usually performed, and deep suctioning is avoided to prevent trauma to the airways [16]. These factors somewhere favour the need to perform manoeuvres to mobilise pulmonary secretion from peripheral to central airways. The intervention used by physiotherapists for airway clearance in the ICU includes modified postural drainage position, manual hyperinflation, percussions, vibrations and shaking, followed by oral and airway suctioning [17]. As per the new findings in the last decade, expiratory flow bias performs a major role in clearing secretions [18]. Positive end-expiratory pressure is proven to lower the incidence of VAP and reduce the episodes of hypoxemia [19]. Several airway clearance techniques have been described, such as manual hyperinflation, ventilator hyperinflation, and the PEEP-ZEEP manoeuvre, which works on the generation of flow bias [20] [21]. Still, these have been mostly associated with short-term effects, in particular, improvements in lung compliance and oxygenation or an increased amount of secretions recovered after the manoeuvres. Manual Hyperinflation techniques involve disconnection from a mechanical ventilator, which increases the risk of respiratory infections. Therefore, the present study aims to evaluate the efficacy of the PEEP-ZEEP manoeuvre, ventilator hyperinflation technique, and conventional chest physiotherapy on clinical pulmonary infection score utilised for VAP.

2. Materials and Methods

A three-arm parallel pre-post study was conducted at the intensive care unit of Acharya Vinoba Bhave Rural Hospital, Sawangi Meghe Wardha. The permission was obtained from the institutional ethical committee of Datta Meghe Institute of Higher Education and Research (DU) (Ref. No.DMIMS(DU)/ IEC/2022/482 was registered with the clinical trial registry of India (CTRI/2023/04/065694). The consent for participation in the study was obtained from the patient's relatives. 36 participants were included in the study. Primary Outcomes, that is, Clinical pulmonary infection score (CPIS), Sputum and Oxygenation, were measured and evaluated at the initiation of the intervention and the time of extubation. Dynamic compliance was measured immediately after 10-15 minutes of intervention,

along with Weaning/ Extubation day and length of ICU stay.

Inclusion and Exclusion Criteria

Patients on mechanical ventilators for more than 48 hours with a Clinical pulmonary infection score greater than or equal to 6 and referred by a physician and intensivist were included in the study. Patients intubated outside the hospital setting, systolic blood pressure <90, chest trauma, pneumothorax, pleural effusion, intercostal drainage, and MODS were excluded from the study.

Procedure:

The participants were randomly allocated to three groups. Chest physiotherapy, including chest percussions, vibrations and positioning, was given to all three groups. Group A (Experimental) received Chest physiotherapy and PEEP-ZEEP manoeuvre followed by endotracheal, oral and subglottic suctioning. Group B received Chest Physiotherapy and ventilator hyperinflation followed by endotracheal, oral and subglottic suctioning. Group C received chest Physiotherapy and manual hyperinflation followed by endotracheal, oral and subglottic suctioning. Manual hyperinflation was given using a reusable manual resuscitator connected to sources of 100 % oxygen source to deliver the MH breath.The procedure was carried out for 10 minutes at the rate of 8 breaths/min. PEEP-ZEEP manoeuvre includes an increment of positive end-expiratory pressure to 15 cm H2O for five respiratory cycles and reduces to 0 cmH20. The procedure was carried out for 10 minutes, followed by the previous setting of baseline ventilator parameters. Ventilator hyperinflation was implemented by incrementally increasing Vt by 150 ml until the target volume (250% of initial) and Paw (35-40 cm of H2O) limit were reached. The manoeuvres were carried out under the guidance of an intensivist, and the intensivist made the necessary adjustments as per the protocol. The patients were monitored for 30 minutes for any adverse events related to haemodynamics, oxygenation and trauma. Clinical Pulmonary Infection Score (CPIS), Pao2, Fio2, and Pao2/Fio2 were measured pre- and post-treatment (Extubation). Sputum quantity was measured on day 1 post-treatment and Post extubation using a sterile collector connected to a suction catheter. Dynamic Compliance was measured Pre and post-treatment on day 1.

3. Results

36 participants enrolled in the study and data analysis was done. There is no significant difference among all the groups at the baseline level measured using ANOVA(Table 1). The paired t-test was used for the within-group comparison. The findings of the current study suggest significant differences in CPIS, Pao/Fio2, Fio2, Dynamic compliance and sputum quantity in all three groups,$p < 0.05$ (Table 2). The independent t-test was applied to compare the CPIS score pre-post difference (Table-4), Extubation day and length of ICU stay between the three groups, and no significant difference was observed (Table-3)

Table 1: Demographics and clinical characteristics

	Group A (n=12)	Group B (n=12)	Group C (n=12)	F	P - Value
Age	47 ± 8.4	45.7 ± 12.54	45 ± 10	0.19	0.822
BMI	23.4 ± 1.7	24 ± 1.27	23.83 ± 2.12	0.35	0.70
Gender					
Male	10	8	9	-	-
Female	2	4	3	-	-
Department					
Neurosurgery	2	4	5	-	-
Neurology	2	3	2	-	-
Medicine	6	5	1	-	-

	Group A (n=12)	Group B (n=12)	Group C (n=12)	F	P - Value
Cardiology	0	0	1	-	-
Others	0	0	3	-	-
Ventilator Parameter					
Mode	Volume Control	Volume Control	Volume Control		
Tidal Volume	437. ± 19.5	442 ± 18. 55	436 ± 20.59	0.315	0.732
PEEP	5.16 ± 0.38	5.1 ± 0.4	5.1 ± 0.39	0.164	0.84
Fio2	0.4 ± 0.04	0.4 ± 0.05	0.50 ± 0.09	0.63	0.53
Pao2	128 ± 12.37	24.08 ± 1.08	128 ± 19	0.021	0.9
Pao2/Fio2	273 ± 21.46	269 ± 25	254 ± 19	2.28	0.11
Dynamic Compliance	24 .33 ± 1.4	24.08 ± 1.08	24.2 ± 1.5	0.10	0.90
Baseline CPIS score	6.5 ± 0.51	6.5 ± 0.5	6.5 ± 0.67	0.33	0.71

Table 2: Comparison within the group

	Pre	Post	Mean SD	T	P- value
CPIS					
Group A (Chest Physiotherapy+ PEEP-ZEEP manoeuvre)	6.58 ± 0.51	2.66 ± 0.49	3.91 ± 0.66	20.29	0.002
Group B (Chest Physiotherapy+ Ventilator Hyperinflation)	6.5 ± 0.52	2.16 ± 0.57	4.08 ± 0.79	17.83	0.00
Group C	6.5 ± 0.67	3 ± 1.34	3.58 ± 0.90	13.78	0.00
Fio2					
Group A (Chest Physiotherapy+ PEEP-ZEEP manoeuvre)	0.47 ± 0.06	0.04 ± 0.00	0.07± 0.06	4.18	0.002
Group B (Chest Physiotherapy+ Ventilator Hyperinflation)	0.48 ± 0.05	0.04 ± 0.00	0.08 ±0.05	5	0.000
Group C (Chest Physiotherapy+ Manual Hyperinflation)	0.50 ± 0.09	0.04 ± 0.00	0.10 ± 0.099	3.76	0.003
Pao2/Fio2					
Group A (Chest Physiotherapy+ PEEP-ZEEP manoeuvre)	273.02 ± 21.46	330.62 ± 16	-57.59 ± 27.93	-7.143	0.000
Group B (Chest Physiotherapy+ Ventilator Hyperinflation)	269 ± 25.99	329 ± 14.93	-59.72 ± 34.87	-5.9	0.000
Group C (Chest Physiotherapy+	254.41 ± 19.93	318 ± 14.08	-63.91 ± 24.91	-8.88	0.000

	Pre	Post	Mean SD	T	P- value
Manual Hyperinflation)					
Sputum Quantity					
Group A (Chest Physiotherapy+ PEEP-ZEEP manoeuvre)	3.33 ± 0.49	1.75 ± 0.62	1.58 ± 0.66	8.204	0.000
Group B (Chest Physiotherapy+ Ventilator Hyperinflation)	3.16 ± 0.57	1.96 ± 0.28	1.25 ± 0.62	6.9	0.000
Group C (Chest Physiotherapy+ Manual Hyperinflation)	3.33 ± 0.65	2.16 ± 0.71	1.16 ± 0.57	7	0.000
Dynamic Compliance					
Group A (Chest Physiotherapy+ PEEP-ZEEP manoeuvre)	24.33 ± 1.43	28.0 ± 1.4	-3.66 ± 1.15	-11.00	0.000
Group B (Chest Physiotherapy+ Ventilator Hyperinflation)	24. ± 1.08	27.5 ± 1.73	-3.4 ± 1.62	-7.3	0.000
Group C (Chest Physiotherapy+ Manual Hyperinflation)	24.25 ± 1.54	27.7 ± 2.41	-3.5 ± 1.16	-10.3	0.000

Table 3: Comparison of variables between the groups

	Pre	Post	F	Sig
CPIS				
Group A (Chest Physiotherapy+ PEEP-ZEEP manoeuvre)	6.583 ± 0.51	2.66 ± 0.49	3.34	0.04
Group B (Chest Physiotherapy+ Ventilator Hyperinflation)	6.5 ± 0.5	2.16 ± 0.57		
Group C (Chest Physiotherapy+ Manual Hyperinflation)	6.5 ± 0.67	3.0 ± 1.34		
Fio2				
Group A (Chest Physiotherapy+ PEEP-ZEEP Manoeuvre)	0.47 ± 0.06	0.04 ± 0.00	0.63	0.5
Group B (Chest Physiotherapy+ Ventilator Hyperinflation)	0.48 ± 0.05	0.04 ± 0.00		
Group C (Chest Physiotherapy+ Manual Hyperinflation)	0.50 ± 0.09	0.04 ± 0.00		
Pao2/Fio2				

	Pre	Post	F	Sig
Group A (Chest Physiotherapy+ PEEP-ZEEP Manoeuvre)	273.02 ± 21.46	330.62 ± 16	2.288	0.1
Group B (Chest Physiotherapy+ Ventilator Hyperinflation)	269 ± 25.99	329 ± 14.93		
Group C (Chest Physiotherapy+ Manual Hyperinflation)	254.41 ± 19.93	318 ± 14.08		
Sputum Quantity				
Group A (Chest Physiotherapy+ PEEP-ZEEP Manoeuvre)	3.33 ± 0.49	1.75 ± 0.62	0.3	0.7
Group B (Chest Physiotherapy+ Ventilator Hyperinflation)	3.16 ± 0.57	1.96 ± 0.28		
Group C (Chest Physiotherapy+ Manual Hyperinflation)	3.33 ± 0.65	2.16 ± 0.71		
Dynamic Compliance				
Group A (Chest Physiotherapy+ PEEP-ZEEP Manoeuvre)	24.33 ± 1.43	28.0 ± 1.4	0.1	0.9
Group B (Chest Physiotherapy+ Ventilator Hyperinflation)	24. ± 1.08	27.5 ± 1.73		
Group C (Chest Physiotherapy+ Manual Hyperinflation)	24.25 ± 1.54	27.7 ± 2.41		
Extubation Day				
Group A (Chest Physiotherapy+ PEEP-ZEEP Manoeuvre)	9.8 ± 3.01		0.071	0.97
Group B (Chest Physiotherapy+ Ventilator Hyperinflation)	10.2 ± 2.4			
Group C (Chest Physiotherapy+ Manual Hyperinflation)	10.16 ± 3.12			
Length of ICU stay				
Group A (Chest Physiotherapy+ PEEP-ZEEP Manoeuvre)	13.9 ± 4.2		0.027	0.973
Group B (Chest Physiotherapy+ Ventilator Hyperinflation)	14.3 ± 4.16			
Group C (Chest Physiotherapy+ Manual Hyperinflation)	14.08 ± 4.7			

Table:4 Comparison of Pre-Post CPIS Score differences between groups

	Mean difference and SD (Pre -post difference)	t	p- value
CPIS Score			
Group A (Chest Physiotherapy+ PEEP-ZEEP Manoeuvre) Vs Group B Chest Physiotherapy+ Ventilator Hyperinflation)	3.9 ± 0.66 Vs 4.3 ± 0.49	-1.738	0.096
Group B Chest Physiotherapy+ Ventilator Hyperinflation) Vs Group C (Chest Physiotherapy+ Manual Hyperinflation)	4.3 ± 0.49 Vs 3.6 ± 1.15	1.840	0.079
Group A(Chest Physiotherapy+ PEEP-ZEEP Manoeuvre) vs Group C (Chest Physiotherapy+ Manual Hyperinflation)	3.9 ± 0.66 Vs 3.6 ± 1.15	0.649	0.52

4. Discussion

The result of the study shows significant improvement in clinical pulmonary infection scores after interventions within the groups. On comparison of pre-post CPIS differences, there is a no significant difference between all group.G.Ntoumenopoulus et al. studied the effect of chest physiotherapy on the prevention of ventilator-associated pneumonia by improved secretion clearance, thereby reducing the clinical pulmonary infection score in the interventional group [22]. Renu B. Pattanshetty et al. studied the impact of multimodal chest physiotherapy on ventilator-associated pneumonia in patients who were submitted to a mechanical ventilator and observed a reduction in clinical pulmonary infection scores. There was a reduction in VAP occurrence and overall mortality in the interventional group [23]. Antonio A.M. Castro et al. studied the effect of chest physiotherapy on lung infection. They concluded that the group that received chest physiotherapy care for 24 hours had a reduced rate of respiratory infection as compared to 6 hours per day, along with reduced days on ventilators and a mortality rate of [24]. H Zeng et al., in their study on the effect of chest physiotherapy on mechanical ventilator patients, observed a lower incidence of ventilator-associated pneumonia as compared to the control group and reduced immobilization-related complications [25].

The result of the study shows significant improvement in oxygenation and respiratory parameters after interventions within the groups. Savian et al. compared MHI vs VHI at different levels of PEEP on compliance and concluded improvement in compliance over time [26]. Ahmed et al., in their study on cardiac surgery, compared MHI and VHI and concluded that mean airway compliance improved in VHI [27]. Susan Berney et al. compared VHI and MHI and found no difference between the groups in terms of respiratory mechanics, but individually, there was a significant improvement in lung compliance [28]. A study by FRA Santos et al. (2009) on the effect of manual rib cage compression vs PEEP-ZEEP manoeuvre showed significant improvement in respiratory system compliance in mechanically ventilated patients [29]. A study by Cardozo et al. 2018 on neurological patients undergoing invasive mechanical ventilation stated that the PEEP-ZEEP manoeuvre improves respiratory compliance [30]. Paulus al. stated that there is a significant improvement in respiratory parameters after structured manual hyperinflation [31]. There is an improvement in partial pressure of oxygen, spo2 and pao2/fio2 in post-operative CABG patients. Blattener et al. concluded in their study that manual hyperinflation improves oxygenation, i.e. increases pao2, Pao2/fio2 and Spo2 in patients undergone cardiovascular [32]. Ahmed et al., in their study, found no significant difference in static and dynamic compliance, Paco2, Paco2 and Pao2/fio2 after comparing both manual and ventilator hyperinflation techniques, but dynamic compliance significantly improved in Ventilator hyperinflation [33]. A study by FRA Santos et al. (2009) on the effect of manual rib cage compression vs PEEP-ZEEP manoeuvre showed significant improvement in oxygenation in mechanically ventilated patients [29]. A study by Cardozo et al. 2018 on neurological patients undergoing invasive mechanical ventilation stated that the PEEP-ZEEP manoeuvre improves oxygenation [30]. A study by **TF de** Oliveira et al. compared bag squeezing and chest compression in mechanically ventilated cardiac

patients for improvement in oxygenation and found significant improvement [34]. According to the findings of Wang T et al., chest physiotherapy facilitates early extubation by decreasing extubation failure in mechanically ventilated patients [35]. Castrol et al. had identified the reduced hospitalization and length of ICU stay in mechanically ventilated patients [36]. In the present study, we have compared the extubation day between three groups, and there is no significant difference since all the groups received physiotherapy intervention along with ventilatory manoeuvres. Conventional chest physiotherapy and chest physiotherapy, along with ventilator manoeuvre, are effective in improving oxygenation and respiratory parameters and reducing clinical pulmonary infection scores.

5. Conclusion

The finding of the study suggests that chest physiotherapy with manual hyperinflation, ventilator hyperinflation and PEEP-ZEEP manoeuver improve clinical pulmonary infection score, thus facilitating recovery of ventilator-associate pneumonia by removing secretions. There is also improvement in oxygenation level and dynamic compliance that facilitates weaning thus chest physiotherapy along with ventilator manoeuvers i.e PEEP- ZEEP maneuver and ventilator hyperinflation should be incorporated as a part of daily physiotherapy routine.

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