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Effect of Perioral Stimulation, Vertebral Pressure, Abdominal Co-Contraction and Manual Pressure Techniques Along with Chest Physiotherapy on Ventilatory Parameters

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Abstract

Introduction: Ventilation is the essential part of life. The Intensive Care Unit (ICU) is a specialized department designed for patients with severe or life-threatening conditions, injuries or complications, offering focused management and care for these critical situation Patients on mechanical ventilation usually have larger amounts of pulmonary secretions due to impairment in mucociliary function and compromised mucus transport. Chest Proprioceptive Neuromuscular Facilitation (PNF) is one of the physiotherapy intervention in which proprioceptive and tactilestimuli are given externally to the patient, which produces reflex movement responses of respiration andregulate breathing.

Aim: To examine the effectiveness of Perioral Stimulation, Vertebral Pressure, Abdominal Co-Contraction, and Manual Pressure when combined with Chest Physiotherapy compared to Chest Physiotherapy alone and their efficacy in optimizing the weaning process for patients on SIMV mode

Procedure: A Randomized control Trial, single-blinded study was carried on 26 participants from Intensive Care Unit. They were then divided into two groups. In Group A participants were treated by PNF and chest physiotherapy and in Group B with chest physiotherapy alone. The interventions were given twice a day for 5 days. The effects on ventilatory parameters (Dynamic Compliance, HR, SpO2, RR, FiO2) were measured and compared from baseline day 1 to day 5.

Result: Post-intervention, there was Improvement in Dynamic Lung Compliance, Saturation of Oxygen, Heart Rate, Respiratory Rate, Fraction of Inspired Oxygen in both groups but on Comparing overall improvement, Group A was more effective than Group B.

Conclusion: The present study concludes that Perioral Stimulation, Vertebral Pressure, Abdominal Co-Contraction, and Manual Pressure with chest Physiotherapy are better and effective in improving Dynamic pulmonary compliance, saturation of oxygen, and reduction of Heart Rate, Respiratory Rate and FiO_2 and lead to early weaning of patients.

Keywords: Chest PNF; Perioral stimulation; Thoracic pressure; abdominal Co-contraction; Manual pressure; ICU; Mechanical Ventilation; SIMV.

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INTRODUCTION

Ventilation is the exchange of gases into and out of the lungs. It is the essential part of life.[1] There are numerous conditions due to which ventilation fails, including physiological changes such as lung parenchyma deterioration, disease conditions like Atelectasis or respiratory distress syndrome and excessive ventilatory demands for example: airway obstruction, medical or surgical procedures and other causes including head trauma, drug overuse and many more.[2] Bottom of Form

Patients with such critically ill conditions, are admitted to Intensive Care Unit (ICU), where constant monitoring and care is provided to them.[3] Almost around 30–60% of patients placed to the ICU required mechanical ventilation.[4]

Mechanical Ventilator (MV) is a useful and life-saving medical intervention designed to support patients with compromised respiratory function who are impotent to sustain the level of ventilation required to maintain the gas exchange.[5]

Synchronised Intermittent Mandatory Ventilation (SIMV) is a mode of Mechanical Ventilator in which the patient can inhale with unassisted spontaneous breaths between mechanically assisted breaths. Synchronized intermittent mandatory ventilation will provide a set number of breaths at a fixed tidal volume, but a patient can trigger a spontaneous breath with the volume determined by patient effort. SIMV mode achieves equilibrium by incorporating both breaths initiated by the patient and those assisted by the ventilator, fostering a respiratory rhythm that closely mirrors natural breathing patterns.[6]

There are many impediments associated with mechanical ventilation including pneumothorax, pneumonia, airway injury, alveolar damage, and reduction in cardiac output, disuse atrophy of diaphragm and oxygen toxicity, also causing biotrauma, barotraumas and volutrauma injuring the lungs and initiating a process called ventilator induced lung injury and the potential for respiratory muscle weakness.[7] The inactivity and immobility during Mechanical Ventilation in ICU have severe negative impacts on the body.[8] The Consequences of immobility are even more dreadful among the geriatrics and patients with chronic illness including chronic obstructive pulmonary disease (COPD) and congestive heart diseases (CHD).[9,10]

The Physiotherapist plays an indispensable role as a part of the multidisciplinary team within the ICU, dealing with the cardiorespiratory complications and preserving the functional abilities.[11] Chest Physiotherapy (CPT) in ICU is found to be beneficial to enhance patient pulmonary functions, promotes early recovery, reduces hospital stay and is cost effective therapy.[12] It focuses on preserving bronchial hygiene by employing techniques like positioning, percussion, vibration, mobilization, and endotracheal suctioning. Percussion, vibration and suction are commonly utilized techniques for mobilization and removal of secretions.[13] Positioning is implemented to increase the depth of ventilation.[14]

Chest Proprioceptive Neuromuscular Facilitation (PNF) is one of the physiotherapy intervention in which proprioceptive and tactilestimuli are given externally to the patient, which produces reflex movement responses of respiration and regulate breathing. It is the combination of techniques used for respiratory care of patients who are unconscious and ventilated.[15]

Unconscious patients can not engage in conventional treatment methods which require a significant amount of substantial voluntary effort, making chest care challenging. Therefore, Chest PNF techniques become even more important for patients who are on MV. PNF technique in ICU patient shows improvement in SpO_2, decrease in Respiratory Rate and Heart Rate and also helps in early weaning from mechanical ventilation.[16] ***Paulraj M, et al.*** **(2017)** concluded in his study that in COPD patients, the PNF of respiration was more effective and it also improves exercise capacity. They also enhance lung expansion, oxygenation, alters Respiratory rate and hemodynamics.[18] Chest PNF also improves the short term ventilation of patients with reduced consciousness following neurological injury.[19]

Among the six techniques of PNF, Anterior Basal Liftand Intercostal Stretch techniques have shown significant effect in early weaning from SIMV mode. However, there is a dearth of research on the other chest Proprioceptive Neuromuscular Facilitation techniques in patients undergoing SIMV.

The aim of this present study is to provide comprehensive analysis of the chest proprioceptive neuromuscular facilitation techniques like Perioral Stimulation, Vertebral Pressure, Abdominal Co-contraction and Manual Pressure along with chest Physiotherapy in SIMV patients by focusing on all the clinical evidences in order to see significant effect on Ventilatory parameters and early weaning.

NEED OF THE PRESENT STUDY

While existing research had an extensive examination of the efficacy of Chest Proprioceptive Neuromuscular Facilitation (PNF) techniques such as Basal lift and Intercostal stretches in facilitating early weaning for mechanically ventilated patients, particularly showcasing significant effects, a notable void was there in the literature regarding the application of other PNF techniques like Perioral Stimulation, Abdominal Co-contraction, Vertebral Pressure, and Manual Pressure in the context of patients under Synchronised Intermittent Mandatory Ventilation (SIMV) mode. Hence, there was a compelling necessity to investigate the impact of these additional PNF Techniques in combination with Chest Physiotherapy on the ventilatory parameters of individuals utilizing SIMV mode.

AIM OF THIS STUDY

To assess the impact of Perioral Stimulation, Vertebral Pressure, Abdominal Co-contraction and Manual Pressure in conjunction with Chest Physiotherapy on Patients undergoing Synchronised Intermittent Mandatory Ventilation.

OBJECTIVES

To evaluate the effect of Perioral Stimulation, Vertebral Pressure, Abdominal Co-contraction and Manual Pressure with chest physiotherapy on Patients in SIMV.

To examine the effectiveness of Perioral Stimulation, Vertebral Pressure, Abdominal Co-contraction, and Manual Pressure when combined with CPT compared to Chest Physiotherapy alone.

To assess the efficacy of Perioral Stimulation, Vertebral Pressure, Abdominal Co-contraction, and Manual Pressure along with CPT aiding in optimizing the weaning process for patients on SIMV mode.

HYPOTHESIS

Experimental Hypothesis (H_1) There may be significant effect of Perioral Stimulation, Vertebral Pressure, Abdominal Co-contraction and Manual pressure along with chest physiotherapy on Ventilatory Parameters.

Null Hypothesis (H_0): There may not be significant effect of Perioral Stimulation, Vertebral Pressure, Abdominal Co-contraction and Manual pressure along with chest physiotherapy on Ventilatory Parameters.

REVIEW OF LITERATURE

Chordiya SS, *et al.* ***(2017)*** did an experimental comparative study to see the "Effect of Respiratory PNF technique with Chest Physiotherapy in mechanically ventilated Organophosphorus poisoning patients." 30 participants with OP poisoning aging 15-85 years were included in the study. Group A received Chest Physiotherapy and Group B received Chest Physiotherapy and PNF technique. Lung compliance, Minute ventilation, Heart Rate, Systolic and Diastolic Blood Pressure were assessed on 1st, 2nd and 3rd day. Interventions were given for 15-30 minutes twice a day for 3 days. They concluded that combining chest physiotherapy with the PNF technique for managing mechanically ventilated patients with pulmonary complications was effective in preventing complications, facilitating the clearance of mucus secretions, and improving patient outcomes in patients with organophosphate poisoning.

Dr. Hardini Prajapati in 2016 did "an experimental study on the Effect of Neurophysiological Facilitation of Respiration on Ventilation of Mechanically Ventilated Patients". They took 10 mechanically ventilated SIMV/ CPAP modes patients of emergency ward of V.S. General Hospital, Ahmadabad to assess pre and post difference in RR, Vt, Ve and chest expansion. They applied intercostal stretch, abdominal co contraction and anterior stretch posterior basal lift. It was a onetime study to see short time effects. Therefore, there was significant improvement in all outcome measures after application of chest PNF techniques.

Castro AA, *et al.* in **2012** did a cohort study to assess "Chest physiotherapy effectiveness to reduce hospitalization and mechanical ventilation length of stay, pulmonary infection rate and mortality in ICU patients". 146 patients were enrolled for the study and differences between 2 hospitals were taken where in one 24 hours a day physiotherapy care was given to the patients while in other hospital it was only 6 hours a day. Through their study, they drew the inference that presence of a physiotherapist in the intensive care unit positively contributes in early recovery of the patient, reducing mechanical

ventilation support and length of hospitalization as well as the incidence of respiratory infection and mortality rate.[20]

Chang A, *et al*., (2002) conducted a research titled "Ventilatory effects of neurophysiological facilitation and passive movement in patients with neurological injury." with 13 intubated and high dependency patients having neurological injuries. The subjects were assessed under four conditions: no intervention (control), during periods of neurophysiological facilitation, passive movement, and sensory stimulation. Each condition was standardized to three minutes duration with all parameters (tidal volume, minute ventilation, respiratory rate and oxygen saturation) recorded before and after each intervention. The findings indicate that neurophysiological facilitation can enhance the short term ventilation in patients with impaired consciousness following neurological injuries.[21]

METHODOLOGY

An randomized control Trial, single-blinded study was conducted on 30 Subjects who were recruited from the ICUs at Shri Mahant Indresh Hospital, Patel Nagar, Dehradun. The subjects were selected on the basis of inclusion and exclusion criteria by Purposive Sampling method.

Including Both male and female participants, Aging between 20 – 80 years undergoing SIMV and Hemodynamically stable patients with Mean Blood Pressure (MAP) 70 – 110 mmHg. Excluding the subjects having body temperature above 38.3°C, Rib fracture, Chest Burn, Patients lacking the strength to fulfil the whole physiotherapy stimulation. The subjects whose Ventilator's operating mode changes during the study. Subjects with below 90% SpO_2, Respiratory rate below 12 and above 45 beat per minute, heart rate below 60 and above 120 beat per minute were also excluded.

OUTCOME MEASURES

Following outcome measures were used to evaluate respiratory function and patient's prognosis. Dynamic lung compliance (mL/cm H_2O), Respiratory rate (RR) (breaths/min), Oxygen saturation (SpO_2), Heart rate (HR), (breaths/min), Lastly, the fraction of inspired oxygen (FiO_2).

PROCEDURE

Subjects who fulfilled the inclusion and exclusion criteria, awritten consent was obtained from the their relatives. Comprehensive information about the study's purpose and methodology was communicated to the family members.

The subjects were then divided into two groups – an experimental group and a control group, each comprising 15 subjects each. To the subjects in Experimental group, Chest Proprioceptive Neuromuscular Facilitation techniques such as Perioral Stimulation, Vertebral Pressure, Abdominal Co-contraction and Manual Pressure along with Chest Physiotherapy was given. And to the subjects in Control group, only Chest Physiotherapy (Percussion, Vibration, Postural Drainage and Suctioning) was given. Each technique was repeated 10-12 times with 2-3 sets with 10 seconds of stimulus pressure and 10 seconds of rest. 2 sessions a day for 5 days.

Fig. 1: Diagrammatic presentation of abdominal co-contraction and percussion by the researcher

Fig. 2: Diagrammatic Presentation of Perioral Stimulation by the Researcher

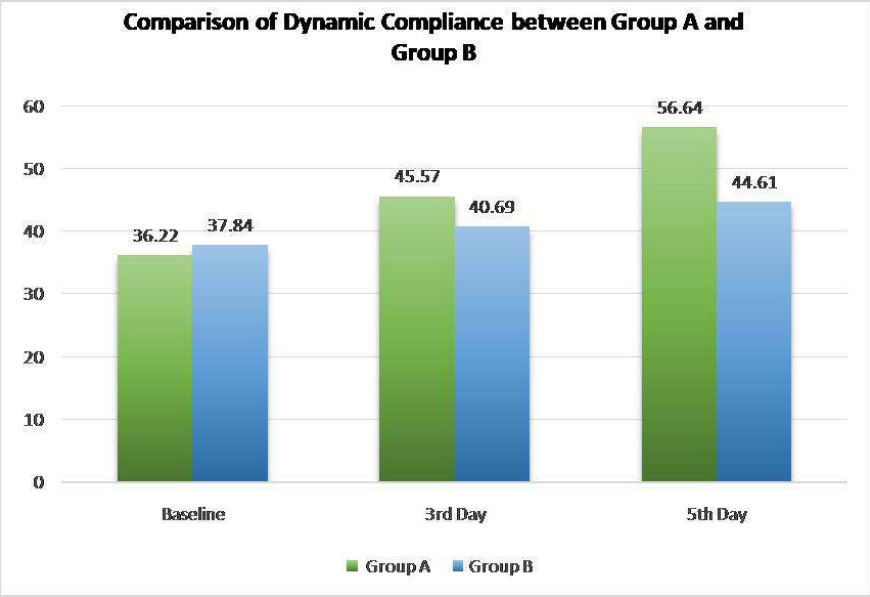
DATA ANALYSIS AND RESULT

The data was collected and Statistical analysis was carried out with statistical software SPSS 21 version. Various statistical measures such as mean, standard deviation, one way ANOVA test was utilized to analyze the difference of Dynamic Compliance, Heart Rate, FiO_2, SpO_2 and Respiratory rate, within Group A and Group B, and between the Group A and B. The level of Significance was set at $p<0.05$.

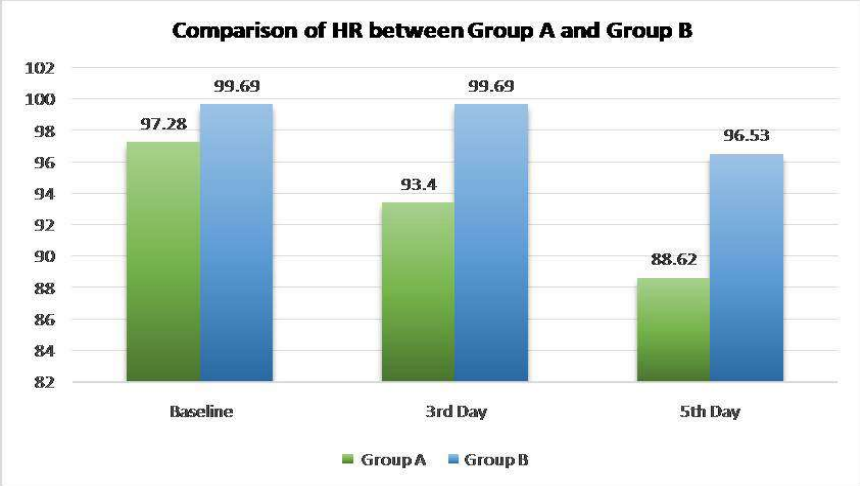
In the middle of the study 4 subjects dropped out Therefore, the study was carried out with 26 subjects. The Mean and Standard Deviation of Age in Group A is 55.3846 ±18.28175 and in Group B is 51.69231 ±19.65516.

In Group A, The Changes in Mean & SD values from baseline day 1, day 3 to day 5 of Dynamic Compliance (36.22 ±.10.64,46.66 ±.11.01 to 56.23 ±.13.55), Heart Rate (97.28±.15.39, 93.40 ±.11.78 to 88.621±.10.29), FiO_2 (0.5707 ±.0.223, 0.5133 ±.0.1954 to0.4308 ±.0.1855), SpO_2 (94.78 ±.2.359, 97.53 ±.1.721 to99.61 ±.6504). Lastly, Respiratory Rate (19.78 ±.6.26, 18.20 ±.5.51 to 16.40 ± 5.89).

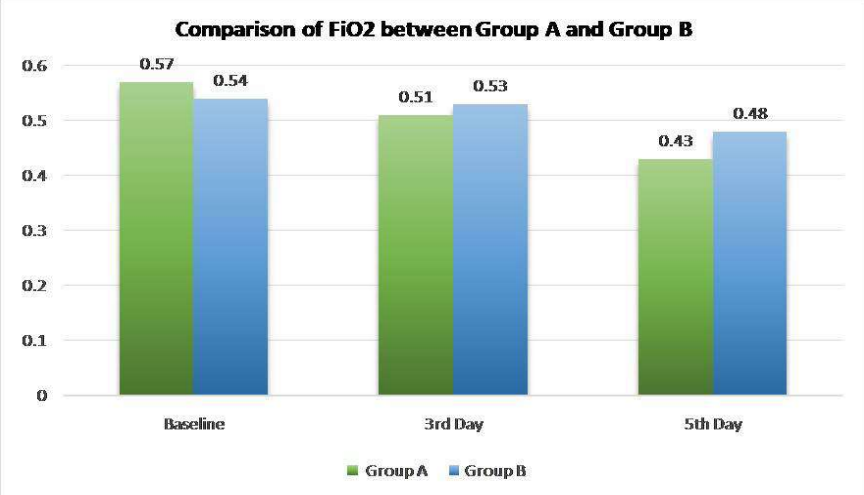
In Group B, The Changes in Mean & SD value from baseline day 1, day 3 to day 5 of Dynamic Compliance was 37.71 ±13.10, 40.20 ±14.26 to 47.00 ±13.14, Heart Rate 97.57±.23.38, 100.06 ±.20.80 to 93.50±.14.03. Values of FiO_2 0.5464 ±.0.1669, 0.5300 ±.0.1386 to 0.4810 ±.0.1565. SpO_2 97.85 ±.2.38, 97.60 ±4.38 to 98.60 ±.3.09 and Respiratory Rate (16.85 ±5.58, 17.46 ±5.20 to 16.40 ± 5.89).



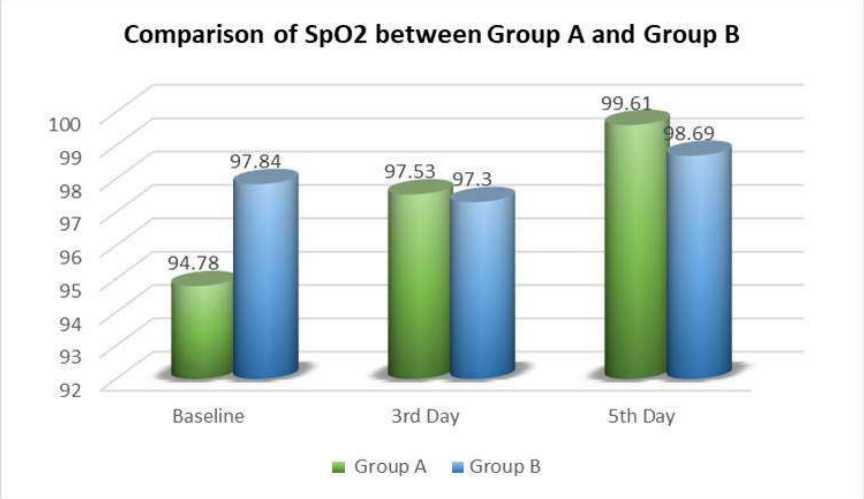
Graph 1: Graphical representation of mean difference of Dynamic compliance between group A and Group B in baseline, day 3 and day 5



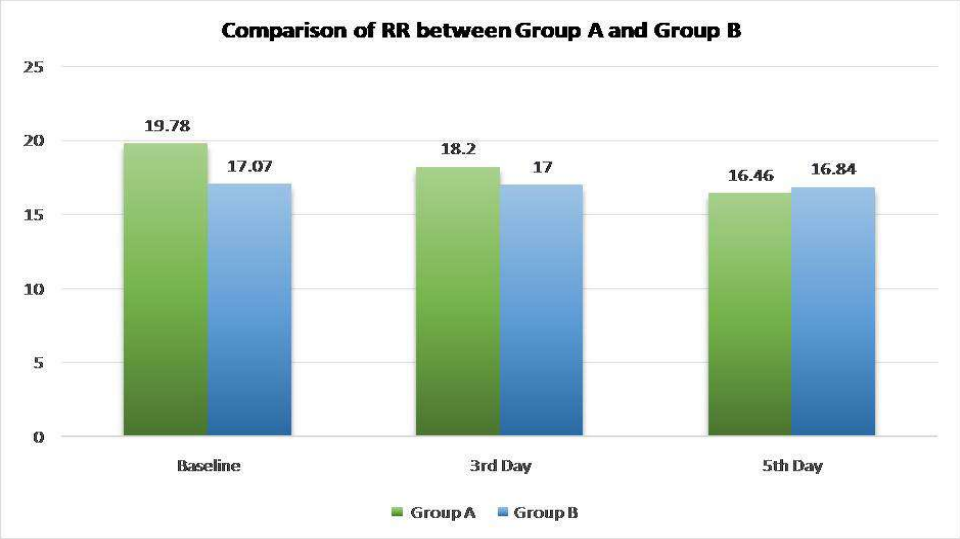
Graph 2: Graphical representation of mean difference of Heart Rate between group A and Group B in baseline, day 3 and day 5



Graph 3: Graphical representation of mean difference of FiO_2 between Group A and Group B in baseline, day 3 and day 5



Graph 4: Graphical representation of mean difference od SpO_2 between Group A and Group B in baseline, day 3 and day 5



Graph 5: Graphical representation of mean difference of RR between Group A and Group B in baseline, day 3 and day

DISCUSSION

Although, previous studies have extensively investigated the effectiveness of Chest Proprioceptive Neuromuscular Facilitation (PNF) techniques, such as Basal Lift and Intercostal Stretches, in promoting early weaning for mechanically ventilated patients with notable results, while there remained a significant gap in the literature regarding other PNF techniques impact on ventilatory parameters of patients on SIMV mode of mechanical ventilation. Specifically, techniques like Perioral Stimulation, Abdominal Co-contraction, Vertebral Pressure, and Manual Pressure were not studied in the context of patients on Synchronized Intermittent Mandatory Ventilation (SIMV) mode.

Therefore, this present study has focused on the effect of Perioral Stimulation, Vertebral Pressure, Abdominal Co-Contraction and Manual Pressure combining with Chest Physiotherapy on Dynamic Lung Compliance (Cdyn), Heart Rate (HR) Oxygen saturation (SpO_2), Fractional inspired oxygen (FiO_2) and the Respiratory Rate (RR) in subjects utilizing SIMV for early weaning. The study further aimed to compare the effect of PNF along with CPT with CPT alone which comprise of Vibration, Percussion, Postural drainage, and suctioning. 30 subjects were taken for the study from which 4 were dropped out. 3 because of the change in mode of mechanical ventilation. And 1 because of incompetency to continue the treatment. The study was done within the period of 5 months with the subjects aging between 20 to 80.

In Present study, it was found that there was significant improvement in Dynamic compliance while comparing from baseline day 1, day 3 to day 5, in the subjects treated with chest PNF along with chest Physiotherapy in Group A. Drawing the interpretation from statistical analysis, values of dynamic compliance were drastically enhanced from 36.22±10.64 on baseline day 1 to 56.23±13.55 on day 5 after PNF techniques along with CPT. Whereas in Group B we found that post CPT in group B, values went from 37.71±13.10 on day 1 to 47.00±13.14 on day 5, increasing marginally but there was no statistical significance ($p = 0.257$). The slight increase in values are the result of CPT (Postural drainage, vibration, percussion and suctioning) which plays important role in dynamic compliance as they might increase the more of homogeneous alveolar ventilation and reduces the risk of lung injuries induced by mechanical ventilation.[22] **Martinez,** *et al.* **in 2017** did a prospective physiological study to the changes in the value of static and dynamic compliance, resistive airway pressure, and peripheral oxygen saturation with four different positions of head. Supporting the present study, they also concluded that at head position of 30° in mechanical ventilated patients, highest dynamic compliance value was observed and the highest oxygenation value was observed at the head position of 0°.[23] On comparing Dynamic compliance between group A and B, Group A shows significant improvement than Group B. PNF techniques (Thoracic Vertebral Pressure, Abdominal co-contraction) positively influences the chest wall mobility, reducing stiffness, and

enhancing respiratory muscle functions. Thoracic vertebrae stimulates proprioceptive receptors in the spine and surrounding tissues while abdominal co-contraction can reduce overall respiratory system resistance and muscle fatigue by stabilizing the core and enhancing the mechanical capability of the thoraco-abdominal region. Therefore, increasing dynamic compliance as lungs can contract and expand liberally in response to ventilatory pressures. In support of this study, **Chordiya SS,** *et al.* **(2017)** also discovered that dynamic compliance was much improved with PNF combining with Chest physiotherapy compared to Chest Physiotherapy alone.

Although, Statically Insignificant result of Heart Rate was obtained (p = 0.221) in group A, while considering the values from Baseline day 1 (97) to Day 5 (88) a decrease in Heart Rate is perceived. In Group B, Values of HR from baseline day 1 (97) to day 5 (93) a slight decrease was seen but the statical insignificance was obtained (p=0.734). On comparing the values of HR between the Group A and Group B, it was learnt that PNF along with CPT was much better to decrease the heart rate. PNF techniques, Perioral Stimulation and Abdominal co-contraction may activate parasympathetic pathway inducing calming effect on the autonomic nervous system which may lead to a reduction and stabilization in heart rate. Abdominal Co-contraction by compressing the thoracic cavity may result in influencing venous return and cardiac output. On the other hand the effect of vertebral pressure **(Goerl, K.** *et al.* **2016)** and manual pressure **(Kroeling,** *et al.* **2011)** on HR depends on type and intensity of pressure.[24,25] **Abhinav Salve,** *et al*.**, in 2021** also did an experimental study on Effect of Vertebral Pressure Technique and Intercostal Stretch Technique on Respiratory Rate, Tidal Volume, SpO_2 and Heart Rate among Organophosphorus Poisoning Patients on 24 mechanical ventilated patients. He concluded that there was significant decrease in heart rate and respiratory rate while increase in Tidal volume and SpO_2 between pre intervention and post intervention.[26]

The Statical results for FiO_2 in the present study were insignificant in both Group A (p = 0.210) and Group B (p = 0.581). But while taking the values into account from the baseline day 1 (0.581) to day 5 (0.4308) in Group A and from Baseline day 1 (0.5423) to day 5 (0.4892) in Group B, a considerate decrease in FiO_2 is seen. Group A was found to be more effective than Group B. PNF Techniques like Perioral Stimulation may boost respiratory drive and enhance breathing coordination, which can result in more effective ventilation and improved gas exchange. Additionally, it could decrease the reliance on supplemental FiO_2 by helping the patient take deeper breaths and maintain sufficient oxygen levels. While activating the abdominal muscles by Abdominal Co-contraction can enhance diaphragm performance and overall respiratory mechanics. This could lead to increased tidal volume and improved ventilation efficiency, which may lower the need for supplemental FiO_2. Supporting the present study author ***Nitz J, et al*** in year 2003 did a research in facilitation of respiration in patients with may otonic dystrophy and found that PNF techniques were the main contributor in improvement of the ventilation.[27]

In our study the mean value of SpO_2 has been drastically increased within Group A from 94% on day 1 to 99% on day 5. Hence showing Significant result with p= 0.001. On contrary Group B shown statically insignificant results with p=0.773 but the mean value shows slight improvement of SpO_2 from 98% on day 1 to 99% on day 5. Hereby while comparing Group A and B, it is noticed that PNF along with CPT shows much better improvement in SpO_2 than CPT alone. Vertebral pressure might impact SpO_2 by reducing autonomic stress responses and improving ventilation-perfusion coordination. Another study by ***Thakkar N.B*** in 2006 further supports our findings, indicating that the PNF technique in ICU patients leads to improvements in their condition, including increased SpO_2, reduced respiratory rate, decreased heart rate, and facilitates earlier weaning from mechanical ventilation.[28] ***Reddy SV,*** *et al.* conducted a study in 2014 to determine the significance of proprioceptive neuromuscular facilitation technique with conventional chest physiotherapy in mechanically ventilated organophosphorus poisoning patients in 30 patients under 48 hours of ventilation. After giving conventional Chest Physiotherapy, PNF was given and then the values of pulmonary and hemodynamic parameters were compared. They suggested that PNF did not significantly enhance values of post CPT pulmonary & hemodynamic parameters in mechanically ventilated OP patients during acute management period. But a study was carried out by ***Chordiya SS,*** *et al.* in 2017, on 30 participants with OP poisoning to see the "Effect of Respiratory PNF technique with Chest Physiotherapy in mechanically ventilated Organophosphorus poisoning patients." The study concluded that, combining chest physiotherapy with the PNF technique for managing mechanically ventilated patients with pulmonary complications was effective in preventing complications,

facilitating the clearance of mucus secretions, and improving patient outcomes in patients.

Within group A, there was a decrease in mean RR from 19 on day 1 to 16 on day 5 but because p=0.32 it shows statical insignificance. In the same way statical insignificance was noted in group B with p=0.890 but there was a minimal decrease in mean of SpO_2 from 97 on day 1 to 98.69 on day 5. Comparing Group A and B, PNF with CPT is more reliable than only CPT. Chest PNF reduced the Respiratory Rate because respiratory drive is influenced by information from sensory receptors found in the airway, respiratory muscles and lungs along with central and peripheral chemoreceptors. Golgi Tendon Organs (GTOs) which are sensitive to muscle stretch, whether active or passive, regulates the contraction and relaxation of respiratory muscles. The stretch triggers the firing of muscle spindles, sending signals to the Central Nervous System via Alpha and Gamma motor neurons, which initiates muscle contraction.[29,30] **Bethune,** *et al.* in year 1975 did a study on 13 intubated, high dependency patients with neurological injuries in order to investigate the short term respiratory effects of PNF and passive movements on tidal volume, minute ventilation, respiratory rate and oxygen saturation. He proposed that PNF techniques contributes in increasing the depth of breathing and the arousal of unconscious patients as well as causes decrease in respiratory rate.

LIMITATIONS OF THE STUDY

Change in the mode of ventilation of the patient during the study period of 5 days was the main limitation of the present study.

Future research should be done with Chest PNF focusing on different Conditions of Patients undergoing SIMV mode of Ventilation.

CONCLUSION

This study demonstrates an improvement by the interventions in both groups but it is concluded that Perioral Stimulation, Vertebral Pressure, Abdominal Co-Contraction, and Manual Pressure along with chest Physiotherapy are better and more effective than chest physiotherapy alone, in improving Dynamic pulmonary compliance, saturation of oxygen, and reduction of Heart Rate, Respiratory Rate and FiO_2 and lead to early weaning of patients in SIMV.

Thus, our Experimental Hypothesis is Accepted. Therefore, These PNF techniques can be safely performed in Critical Areas for early weaning and minimizing hospital stays.

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