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Effect of Manual Hyperinflation & Expiratory Ribcage Compression on Oxygenation, Ventilation, Physiological Parameters and Airway Clearance in Mechanically Ventilated Patients-A Randomized Control Trial

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Abstract

Title: Effect of Manual Hyperinflation & Expiratory Ribcage Compression on Oxygenation, Ventilation, Physiological Parameters and Airway Clearance in Mechanically Ventilated Patients-A Randomized Control Trial

Background: In ICU physiotherapist plays an important role for treating the functional impairment especially patients who are on mechanical ventilation where you can prevent and reduce potential pulmonary complications such as hypoventilation, hypoxemia and infection. Manual hyperinflation also known as bag squeezing is given mechanically ventilated patients. Expiratory rib-cage compression is well known as “squeezing.” This technique mobilizes and helps to remove secretions, facilitates active inspiration hence, improves alveolar ventilation.

Objective: To study combined effect of manual hyperinflation and expiratory ribcage compression on oxygenation, ventilation, physiological parameters and airway clearance.

Methods: 30 mechanically ventilated subjects of >18 years old were included in this study. Subject’s demographic data was obtained and patients were randomly allocated into two groups. Experimental group received Manual Hyperinflation, Expiratory rib cage compression with conventional physiotherapy and Control group received only Conventional Physiotherapy. Treatment was given twice a day for five days a week. Outcome measures were taken before and after treatment.

Results: Both groups were similar in terms of baseline characteristic but significant difference was found in PaO2 when compared between the two groups where as no significant difference in PaCO2, Ventilation, Physiological parameters and Sputum volume when compared within the groups.

Conclusion: Present study suggested that experimental group showed better result as compared to control group when compared within group. Hence these techniques can be used as an integral part of chest physiotherapy in promoting patients recovery thus improving quality of life which can be used as a routine practice in ICU care.

Keywords: Manual hyperinflation, expiratory ribcage compression, mechanical ventilation, ICU.

Introduction: Normal function of the lung is to supply oxygen into the blood stream and take out the carbon dioxide from blood stream into the lungs. The aim of

ventilation is to maintain sufficient gas exchange in the lungs but patients with respiratory problem will increase CO_2 in the blood gases.CO_2 can be reduced by the airway clearance and or by mechanically increasing the respiratory rates.[1] The total compliance of both lungs together in normal adults human being about 200 milliliters of air per centimeter of water transpulmonary pressure where as every time the transpulmonary pressure increases 1 centimeter and lung volume will expand 200 milliliters.[2] An airway resistance(R_{AW}) increases due to accumulation of secretions within the lumen, thickening or contraction of airway wall, and reduce radial traction of lung interstitium.[3] It is assumed that by recruiting alveoli and improving lung volume, manual hyperinflation will improve lung compliance(C_L) and reduce R_{AW} in mechanically ventilated patients.[4] Manual hyperinflation (MH), also known as "bagging" or "bag-squeezing" is a frequently used maneuver in critically ill intubated and mechanically ventilated patients.[5] The aim of manual breathing assist technique is to increase tidal volume (VT), decrease the workload of breathing and improves airway clearance. In Japan, expiratory rib cage compression (ERCC) is commonly performed.[6] Expiratory Rib Cage Compression is suitable for use in a range of patient groups, including patients receiving Mechanical Ventilation (MV), and those with acute pneumonia, with postoperative respiratory complications, or chronic obstructive pulmonary disease.[7] ERCC is well known as "squeezing."This technique involves providing manually compression of the rib cage during expiration and releasing the compression at the end of the expiration which mobilizes and helps to remove pulmonary secretions, facilitates active inspiration, and hence improves alveolar ventilation.[8] Depending on the medical treatment administered in the acute stage, patients can be removed from mechanical ventilation; still there are patients who require mechanical ventilation over a month. Such patients frequently experience respiratory muscle weakening and decreased rib cage mobility. Consequently, it can become difficult for patients on MV to increase their expiratory flow rate and tidal volume, which are important factors in expulsion. The use of Expiratory Rib Cage Compression can increase tidal volume; as such, Expiratory Rib Cage Compression is an effective therapeutic technique for patients who cannot have their mechanical ventilator settings changed. However, it is necessary to be attentive of secondary osteoporosis, due to prolonged immobility.[9] These techniques helps to re-expansion of atelectatic lungs and increases pulmonary compliance and expiratory flow rate.[10]

Materials and Methods: Study was carried out in Intensive Care Unit at a tertiary care center, Belagavi, Karnataka for 12 months. Ethical clearance was approved from ethical committee. Informed consent was obtained from subjects before starting the treatment. 30 subjects were randomly allocated using envelope method into two groups. Inclusion criteria included both the genders with age above 18yrs, Subjects who have been on MV for at least 48hrs, GCS scale of above 8 and cardiovascular stability. Exclusion criteria were rib fracture, hemodynamic instability, undrained pneumothorax, pressure of chest tube and spinal cord injury above T8.Outcome measures were recorded such as partial pressure arterial oxygen (PaO_2) Partial pressure arterial carbon dioxide ($PaCO_2$), tidal volume, SpO_2, HR, RR and sputum volume

Procedure: Total 30 subjects were recruited in the study and the participants were randomly allocated into Group A(Control) and Group B(Experimental) respectively. Control group was given conventional chest physiotherapy such as chest percussion, vibrations and suctioning. Experimental group was given manual hyperinflation and expiratory rib-cage compression and conventional chest physiotherapy. Duration of treatment was 30 minutes and

intervention was given twice a day for five days. The two groups were as follows:

Intervention

Control group (Conventional Physiotherapy)

- Percussion: Percussion was performed with cupped hands over the lung segment which is to be drained. Frequency of percussion may be 100 to480 cycle/minute. The cupped hands striked the patient's chest wall in an alternating, rhythmic manner. Shoulder, elbows, wrist should be kept loose and mobile while performing the maneuver. Percussion is continued for several minutes. This procedure should not be painful or uncomfortable for the patients.[9,11]
- Vibration: Vibration was performed with the help of both the hands. It was directly applied on the chest wall over the area to be drained during the exhalation phase for several minutes. This procedure should not be painful or uncomfortable for the patients.[9,11]
- Airway Suctioning: Airway Suctioning was done using suction apparatus. Patient is in supine position and they were pre-oxygenated prior to the suctioning. It was made sure that there should be no suction pressure applied, while the catheter was being introduced suctioning pressure for adult. First kink the suction tube then slowly insert in endotracheal or tracheostomy tube until resistance is met and then slowly withdraw while gently rolling the catheter between finger and thumb. Then place the catheter in saline water to flush the secretion through the tube.[9, 11] Suctioning was done in both the group after the intervention was carried out.

Experimental group (Manual hyperinflation, Expiratory Rib Cage compression and chest physiotherapy)

The participants in this group received chest physiotherapy along with Manual hyperinflation using the self inflating resuscitation bag with 15L/min of fresh gas flow. Patient was disconnected from the mechanical ventilator and bag circuit was attached to the endotracheal or tracheotomy tube. With two hand techniques, hyperinflation breaths were delivered to the patients with 2-seconds inspiration and 2-seconds inspiratory pause followed by 1-second expiration, with a rate of 8 breaths/min for 3 minutes. Treatment session lasted for 15-30 minutes. Rib-cage compression is given over the part of the rib cage which will be most affected lung region from the end of inspiration to the end of expiration. Every rib-cage compression should be given throughout each expiratory phase with both spontaneously breathing and mechanically ventilated subjects, allows the patient to take inspiration. Care should be taken that compression should apply during the expiration. The duration treatment will be of 5 min.

Statistical Analysis: Analysis was done using SPSS version 21. The variables were assessed for normality using the Kolmogorov Smirnov test. Descriptive statistics included computation of means and standard deviations. The independent t test (for quantitative data within two groups) and paired't' test or dependent't' test (for quantitative data to compare before and after observations) were used in the study. The statistically significant p<0.058* was included in the study.

Results: Table: 1 Age Distribution

Group	Mean±SD	p-value
Control Group	51.53±16.15	0.97
Experimental Group	51.33±16.49	

Table 2: Gender Distribution

Gender	Control Group	%	Experimental Group	%	Total
Male	12	80	10	66.67	22

Female	3	20	5	33.33	8
Total	15	100	15	100	30
P=0.6802					

Table 3: Comparison between the Experimental Group and Control Group by using independent't' test

Outcome measures	Baseline p<0.05	Day 3 p<0.05	Day 5 p<0.05
PaO2	0.561	0.144	0.009*
PaCO2	0.856	0.491	0.678
Inspiratory tidal volume	0.699	0.750	0.601
Expiratory tidal volume	0.543	0.694	0.772
Sputum Volume	0.858	0.663	0.955
SpO2	0.753	0.429	0.829
HR	0.264	0.881	0.364
RR	0.331	0.267	0.447

Table 4: Comparison within Experimental Group and Control Group by using dependent't' test

Outcome measures	Control Group			Experimental Group		
	Baseline to Day 3	Baseline to Day 5	Day 3 to Day 5	Baseline to Day 3	Baseline to Day 5	Day 3 to Day 5
PaO2	0.120	0.447	0.299	0.633	0.664	0.266
PaCO2	0.282	0.268	0.794	0.692	0.453	0.311
Inspiratory tidal volume	0.027*	0.001*	0.008*	0.046*	0.016*	0.020*
Expiratory tidal volume	0.037*	0.003*	0.005*	0.014*	0.0007*	0.003*
Sputum Volume	0.462	0.041*	0.0002*	0.244*	0.017*	0.004*
SpO2	0.235	0.048*	0.024*	0.107	0.021*	0.167*
HR	0.876	0.187	0.099	0.104	0.669	0.050*
RR	0.5715	0.188	0.173	0.959	0.478	0.223

Discussion

Present study aimed to determine combined effect of manual hyperinflation & expiratory ribcage compression with conventional physiotherapy on oxygenation, ventilation, physiological parameters and airway clearance in mechanically ventilated patients.The study undertaken included a total number of 30 patients out of which 15 patients were included in control group (Group A) and 15 patients were in experimental group (Group B).

Present study included more male subjects than female subjects in control group where as 66.6% males and 33.3% females in experimental group. In contrast to present study results were found out in previous study where 7.2% men and 7.9% women were taken admission in ICU. There is high rate of mortality in female than in male which is because of estrogen level is decreased in women after the age of 50. Estrogen preserves the cardiovascular, immunological function and tolerance to severe hypoxia but after 50 yrs it lowers hence women are more prone for various diseases and mortality rate is higher and also had a higher readmission rate and longer length of ICU stay.[12]

Subject prevalence in present study based on age, where mean age in both the group was 51 yrs which explains that there are more respiratory impairments associated with mechanical ventilator male subjects in the middle aged category. Contrast to present study there was a study which suggested that old age (65-75yrs) and very old age (≥75 yrs) is more prone to ventilated associated pneumonia hence, prevalence and risk of mortality is less in middle age (45-64yrs). Considerably, the possible explanation could be due to exposure to antimicrobial use and risk of horizontal transmission of resistant pathogens as well-known risk factors for antimicrobial resistance in all age groups admitted to ICUs.[13]

A study conducted to determine the effects of rib-cage compression on airway-secretion removal, oxygenation, and ventilation in patients receiving mechanical ventilation. In general, forced expiration, which may increase expiratory flow rate, is likely to propel airway secretions. Patients received endotracheal suctioning with or without rib-cage compression, with a minimum 3 hour interval between the 2 interventions. The 2 measurement periods were carried out on the same day. There were no significant differences in the oxygenation or dynamic compliance of the respiratory system between the 2 periods.[14] Along with it there was no significant difference in airway-secretions removal. In present study there was improvement in the removal of secretions when compared

within the group. Possible explanation could be due to the sudden release or deflation of the resuscitation bag, the sputum present in the airways is dislodged and due to expiratory ribcage compression the secretions move from distal to proximal.

Present study showed that the use of simple techniques, performed twice a day for 5 days improved in oxygenation, tidal volume and in airway clearance. Present study used a combination of manual hyperinflation with expiratory rib cage compression and conventional chest physiotherapy (Percussion, vibration and suctioning) was being performed. Anyhow, some studies have reported that percussion is ineffective. In spite of MHI is extensively used in order to remove pulmonary secretions and treat atelectasis, there is no evidence to support its routine use in clinical practice.[15]This lack of evidence is due to the dearth of studies. Procedures either including or excluding the expiratory rib cage compression (ERCC) step are equally referred to as MHI. In addition, some studies do not clearly state whether the ERCC step was included in the MHI procedure. Present study included the ERCC step as it was originally described and because the ERCC step is proven effective in improving secretion clearance and alveolar ventilation.[16, 17]

A study evaluated the clinical effectiveness of respiratory physiotherapy in the prevention of pneumonia in 60 MV-dependent patients. Patients undergoing the physiotherapy protocol had a lower incidence of pneumonia, but present study did not evaluate the physiological effects of the techniques. Therefore, it is unclear whether the improvement of respiratory mechanics provided by the respiratory physiotherapy, as demonstrated in present study the cause of clinical improvement or is only associated with improvement.[18] Present study was not designed with that purpose in mind and does not have a sufficient sample power to evaluate relevant clinical outcomes, but it was able to demonstrate the ventilatory and hemodynamic changes triggered by a physiotherapy session.

Hence manual hyperinflation with expiratory rib cage compression can be used as an integral part along with conventional chest physiotherapy to enhance patient's recovery and improve quality of life.

Conclusion

Present study concluded that both manual hyperinflation and expiratory rib cage compression along with conventional chest physiotherapy are effective in improving oxygenation, ventilation, physiological parameters and sputum volume when compared within the group but was not effective between the groups. Hence the above technique can be used as an integral part of chest physiotherapy in promoting patients recovery thus improving quality of life which can be used as a routine practice in ICU care.

Conflict of Interests: None

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