Acta Scientific MEDICAL SCIENCES (ISSN: 2582-0931)

Volume 9 Issue 7 July 2025

Research Article

# Effectiveness of Manual Chest Compression and Decompression Technique on Lung Volumes and Pulse Oximetry in Mechanically Ventilated Patients: A Randomised Controlled Trial

**Manjima Chaudhuri, Sucheta Saha*, Koushik Ghosh and Suparna Gangopadhyay**

*Department of Neurorehabilitation, Institute of Neurosciences Kolkata, West Bengal, India*

***Corresponding Author:** Sucheta Saha, Senior Consultant, Department of Neurorehabilitation, Associate Director, College of Occupational Therapy and Physiotherapy, Institute of Neurosciences Kolkata, West Bengal, India.

**Received:** May 14, 2025

**Published:** June 24, 2025



## Abstract

**Introduction:** Intensive care unit (ICU) is a dynamic environment where physiotherapy is indispensable. There are various approaches of chest physiotherapy which were seen to be effective to improve lung health, which results early step down from ICU. Manual hyperinflation (MHI) and Manual chest compression and decompression maneuver (MCCD) are one of the inherent techniques of chest physiotherapy. The aim of the study is to find out the effectiveness of manual chest compression and decompression technique with MHI on lung volume and pulse oximetry in mechanically ventilated patients.

**Materials and Methods:** A randomized control trial was done in a single specialty tertiary care hospital. Among 156 patients screened, 106 were selected, 53 on each group (group-A and group-B). Group-A (control) received only conventional therapy (MHI) and group-B (experimental) received MCCD with conventional therapy. Data was taken before therapy, immediate post-therapy and 40-minute post-therapy.

**Results:** Overall, clinical improvement was shown on lung volume and oxygen saturation but the p-value was not significant ($p > 0.05$) on both the groups. Pearson's chi square test was used. There was neither significant improvement in conventional group nor significant difference was seen in both the groups.

**Conclusion:** Though there was no statistically significant difference between both the groups but minor improvement was observed in experimental group on lung volume and oxygen saturation. However, the long-term outcomes of multiple therapy sessions on selected patient population remains to be determined in future study. Larger sample can throw more light on statistical analysis.

**Keywords:** Intensive Care Unit (ICU); Manual Hyperinflation (MHI); Manual Compression and Decompression Technique (MCCD); Chest Physiotherapy; Lung Volumes

## Abbreviations

ICU: Intensive Care Unit; MV: Mechanical Ventilation; VALI: Ventilator Associated Lung Injury; VAP: Ventilator Associated Pneumonia; MHI: Manual Hyperinflation; MCCD: Manual Chest Compression and Decompression; ITU: Intensive Therapy Unit; SNOSE: Sequentially Numbered Opaque Sealed Envelopes; PEEP:

Positive End Expiratory Pressure; $SP_{02}$: Peripheral Capillary Oxygen Saturation; LRTI: Lower Respiratory Tract Infection; RR: Respiratory Rate; HR: Heart Rate; MAP: Mean Arterial Pressure; TV: Tidal Volume; ITV: Inspiratory Tidal Volume; ETV: Expiratory Tidal Volume; $P_{PLAT}$: Plateau Pressure; Peak P: Peak Pressure; VCV: Volume Control Ventilation

## Introduction

Intensive care units (ICUs) are special unit used to provide care for critically ill patients. The specialized practices which make them different from other units are uninterrupted artificial ventilators, neurological support, shock management, and renal dialysis using specialized equipment such as ventilators, multi-parameter monitors, among many others. Mechanical Ventilation (MV) and airway intubation reduces the normal clearance of airway secretion and enhances ventilation to the terminal alveoli. Mechanical ventilation causes many complications, like: pneumothorax, barotrauma or Ventilator Associated Lung Injury (VALI), alveolar damage, decreased cardiac output, pulmonary edema and Ventilator Associated Pneumonia (VAP), but Mechanical ventilation is always a lifesaving intervention [1-3].

To reduce the length of hospital-stay, role of chest physiotherapy is very much important. Chest physiotherapy also plays a big role to help in weaning from mechanical ventilation. There are various techniques of chest physiotherapy, such as: chest percussion, chest vibration, manual hyperinflation technique, suctioning, positioning of patients for postural drainage, chest compression and decompression technique and various assisted coughing techniques [1].

Chest physiotherapy helps to re-inflate the atelectatic lung with the help of postural drainage followed by chest percussion, chest vibration, manual chest compression and decompression, suctioning and improve ventilation perfusion ratio.[1] Other studies in the past have found that due to prolonged stay in intensive care unit, 82.6% of patients having complications of lobar atelectasis [1]. Lobar atelectasis can increase the risk of pulmonary infection and to prevent the occurrence, patient needs appropriate prophylaxis. For atelectasis, lung recruitment maneuvers should be implemented as early as possible [3-5].

One of the most common respiratory physiotherapy techniques is Manual Hyperinflation technique (MHI) for mechanically ventilated patients. It helps to clear airway secretion and alveolar recruitment. In 1968 it was described as a 'Bag squeezing' technique [6,7]. This maneuver is frequently used for critically ill intubated and mechanically ventilated patients [6]. MHI helps in alveolar recruitment and prevent airway plugging but this has limitation for application of respiratory failure patients [2,6]. MHI technique helps to deliver larger than baseline tidal volume (up to one- and one-half size of tidal volume delivered by ventilator) at a low inspiratory flow (attained by slow compression of manual hyperinflation bag, an inspiratory pause (to allow complete distribution of the inflated air among all the ventilated parts of the lung) and an expiration with a high expiratory flow. As we know that during manual chest compression and decompression technique (MCCD) we do not require to disconnect the patient circuit from mechanical ventilation. MCCD is a safe technique, it does not require high airway pressure therefore less chance of barotrauma [4,6]. Effectiveness of MCCD decreases the amount of carbon dioxide expired without promoting hemodynamic changes. These techniques are performed by compression of the ribcage during the expiratory phase and sustain the position until the first third of inspiratory phase and sudden release of compression. Bilateral manual pressure was given with the subject's breathing frequency. The therapist squeezed the ribcage with both hands while the patient was exhaling. So, there is a displacement of air and help in expansion of chest. As mentioned earlier this maneuver can be performed during mechanical ventilation and during spontaneous breathing. The chest compression maneuver constantly performed for 10 minutes [2,4].

Previous evidence suggests that MCCD maneuverer has physiological effect over recruitment of alveolar atelectasis and increase the functional residual capacity without any hemodynamic alteration [4]. So, the efficacy of MCCD has been proven. Aim of our study was to find out the efficacy of MCCD maneuver on lung volume and peripheral oxygen saturation over manual hyperinflation technique (MHI), in those patients who are in mechanical ventilation for more than 24 hours and has diagnosed lung complications, may be primary or secondary.

## Materials and Methods

The protocol of this prospective randomized controlled trial was approved by the internal ethical committee of the hospital. The proposed study was conducted at the Intensive Therapy Unit

(ITU) of the single specialty hospital. The study was undertaken as an investigator initiated academic project. Data analysis and archival of the study documents were done by department of Neuro-rehabilitation of the above-mentioned hospital. It was a single blinded, mono-centric study. The sample size was calculated based on the primary objectives of our study using the software nMaster version 2 (Department of Biostatistics, CMC Vellore). We obtained an evaluable sample size of 47 in each group to appreciate a mean difference of 100 ml (SD 150 ml) tidal volume between 2 groups. The alpha error and power were considered 5 and 90% respectively. After considering a 10% drop out rate we estimated that 53 patients should be recruited in each of the intervention group. Randomization was done using computer generated Random Number Table using the software mentioned below.

https://www.sealedenvelope.com/simple-randomiser/v1/lists

Allocation concealment was achieved by using standard method of sequentially numbered opaque, sealed envelopes (SNOSE). Sequentially numbered 107 envelopes were prepared before recruitment by an unblinded person who was not a part of the study team. He/she used to keep a paper slip inside the envelope mentioning the group allocation as per randomization. For our study the potential cases were taken from Intensive Therapy Unit of the hospital. The patients, who were critically ill and were in mechanical ventilator (MV) for more than 24 hours, were fulfilling the criteria of our study.

Written consent was taken from the family members of those patients who fulfilled the inclusion criteria of the study, for accepting to participate in this study. We have taken patients between the age group of 18-80 years and both genders were included in the study. The patients, those who were more than 24 hours in mechanical ventilator in volume control mode. Ramsey Sedation Scale between 4 and 6 levels. After 24 hours chest radiograph was done and if there were evidence of changes in chest radiograph, then we have taken the subjects for our study. We have checked the hemodynamic stability like: Heart rate, Respiratory rate, Mean arterial pressure pre and post therapy. The exclusion criteria consist of: Intracranial hypertension >30 mmHg, pneumothorax, Hemodynamic instability and no osteoarticular lesion (rib fracture, unstable thorax, any severe chest deformity.

## Study procedure

The Randomized controlled trial was conducted on one hundred six participants (n = 106). During therapy session we were always aware of all Serious Adverse Event (SAE), that were monitored by the other Physiotherapists. The position of the patients was supine with head end elevated at $30^{o}$ angle. For those who were having unilateral lung pathology, affected side of the lung positioned upper most. According to the area of lung pathology, positioning was modified. There were two group - Control group (Group-A) and Experimental group (Group B). All the patients received bronchial hygiene therapy (chest percussion, vibration and suctioning). One Physiotherapist delivered manual chest percussion and vibration on the chest wall and suction by another physiotherapist. Standard Laerdal resuscitation bag was used for MHI maneuver (delivered 15 L/minute of oxygen as per current clinical practice) and a manometer was attached in the circuit so that the peak airway pressure delivered will be 40 $cmH_2O$. Sustaining the pressure was not less than 2 seconds at end of the inspiratory phase. Expiration is always passive and the same Positive End Expiratory Pressure (PEEP) was applied during expiration as that was applied via the patient's ventilator. There were four sets of eight breaths per minute. Airway suctioning was done immediately after the treatment. On completion of the suction process, 10 ml of sterile saline was used to flush through the suction tubing to clear any secretions in the catheter. Pre and post therapy and 40 minutes following the procedure, value of lung volume and oxygen saturation was measured. The following variables was monitored: tidal volume, inspiratory tidal volume, expiratory tidal volume, minute volume, plateau pressure, peak pressure and peripheral oxygen saturation ($SpO_2$), respiratory rate, heart rate and mean arterial pressure.

The experimental group got the same MHI treatment as mentioned above. Then manual chest compression and decompression (MCCD) was performed for 10 minutes bilaterally in the right hemi thorax and in the left hemi thorax. The patients were placed in $30^{0}$ semi fowlers, supine position. During the procedure of manual chest compression technique, the ribcage was compressed during the expiratory phase and held in place until the first third of the inspiratory phase, at that point compression had to release suddenly. Bilaterally, manual pressure was given with the subject's breathing frequency; we squeezed the rib cage with both hands while the patient was exhaling. The air was displaced when the chest pressure altered and chest expands. This way the manual

chest compression maneuver was constantly carried out for 10 minutes. After performing the two procedures (MHI and MCCD), immediate airway suctioning done. Pre-therapy value was taken then immediate post therapy and 40minute post therapy value was documented. The same ventilator parameter was maintained until the last data was recorded.

### Statistical methods

- Continuous variables are expressed as Mean, Median and Standard Deviation and compared across the groups using Mann-Whitney U test.
- Categorical variables are expressed as Number of patients and percentage of patients and compared across the groups using Pearson's Chi Square test for Independence of Attributes.
- The statistical software SPSS version 22 has been used for the analysis.
- An alpha level of 5% has been taken, i.e. if any p value is less than 0.05 it has been considered as significant.

## Results and Discussion

A total 156 patients of lobar atelectasis and lower respiratory tract infection (LRTI) were screened according to inclusion and exclusion criteria. Among them 50 were excluded 106 were randomized selected for the study. 53 participants were selected for each group, Control group / Group A (n = 53) and Experimental group/ Group B (n = 53), for the study.

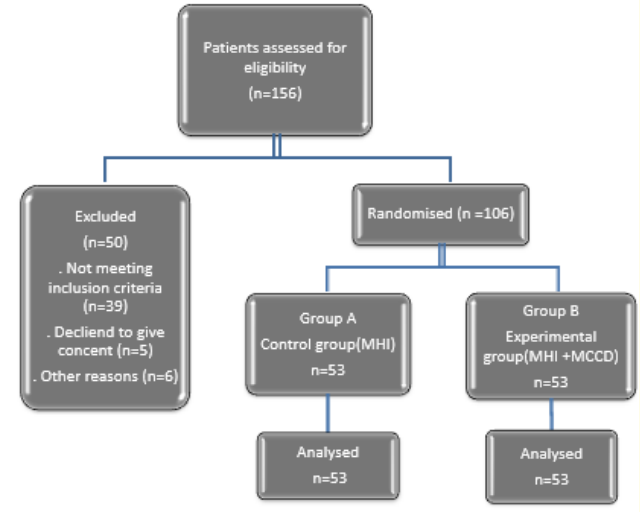


**Figure 1:** Consort Flow Chart.

All demographic and pre-training variables did not differ significantly among the two groups. So, both the groups were comparable at the baseline.

- **Age:** The mean age of Group A was 52.415, whereas in Group B mean age were 53.3. The p-Value of the age variables were 0.681.
- **Sex:** Total of 106 subjects 53 has been taken in Group A and 53 has been taken in Group B. In Group A among 53 subjects 14 subjects were female and 39 were male, whereas in Group B among 53 subjects 16 were female and rest of 37 subjects were male. p-Value were 0.666.

We completed all therapy sessions in all patients. There was no SAE.

### Respiratory rate (RR)

The mean base line RR were similar in two treatment groups however, while respiratory rate significantly increased immediate post therapy, this increased rate was not maintained after 40-minute post intervention. It has been analyzed even after 40-minute post treatment the mean base line of RR value was higher than the pre-treatment values, though statistically not significant ($p > 0.05$).

### Heart rate (HR) and mean arterial pressure (MAP)

Mean base line heart rate and mean arterial pressure values were similar in both the groups for the two-post therapeutic measurement and no significant difference has been detected ($P > 0.05$).

### Tidal volume (TV), Inspiratory tidal volume (ITV), Expiratory tidal volume (ETV)

Though there was no difference in Tidal volume mean base line between both the groups post therapy. Tidal volume mean base line value was same as all the subjects were in volume control mode of ventilator setting. In case of both Inspiratory tidal volume and expiratory tidal volume were increased in group-B, even after 40 minute of post therapy but statistically it was not significant. It was noted that in both the groups, the value of ITV and ETV has been increased immediate after therapy and was maintained till 40 minute of observation period.

### Plateau pressure (Pl P) and peak pressure (Peak P)

The Peak pressure and Plateau pressure of both the groups were remain same though there was mild variation initially after

treatment. In group-B immediate after treatment there was mild increased of Plateau pressure and decreased in peak pressure which was not noted in group-A.

### Minute volume (MV)

There was mild increase of minute volume in both the groups initially and was maintained 40-minute post therapy, but statistically that was not significant.

### Pulse oximetry

The mean base line of pulse oximetry value ($SpO_2$) in two treatment group was similar. However initial post intervention the value was little increased in group-A, while in group-B increased value was noted 40 minutes after treatment. Although statistically not significant, $SpO_2$ remain higher than base line for up to 40 minutes after each intervention.

| Clinical variables | Time | Group A | Group B | p- Value |
|---|---|---|---|---|
| RR (per minute) | Pre | 20.83 | 20.79 | 0.938 |
| | Post | 25.83 | 24.68 | 0.583 |
| | 40 min post | 21.19 | 21.06 | 0.606 |
| HR (per minute) | Pre | 82.68 | 79.98 | 0.431 |
| | Post | 93.83 | 89.55 | 0.202 |
| | 40 min post | 83.66 | 76.58 | 0.057 |
| MAP (mmHg) | Pre | 87.94 | 89.74 | 0.571 |
| | Post | 89.28 | 90.64 | 0.624 |
| | 40 min post | 88.57 | 89.45 | 0.721 |
| TV (ml) | Pre | 436.32 | 438.38 | 0.851 |
| | Post | 436.32 | 438.38 | 0.851 |
| | 40 min post | 436.32 | 438.38 | 0.851 |
| ITV (ml) | Pre | 452.49 | 452.53 | 0.740 |
| | Post | 484.85 | 479.60 | 0.546 |
| | 40 min post | 461.98 | 480.43 | 0.353 |
| ETV (ml) | Pre | 412.92 | 426.68 | 0.288 |
| | Post | 471.06 | 476.49 | 0.932 |
| | 40 min post | 432.09 | 468.81 | 0.101 |
| PIP (cm $H_2O$) | Pre | 21.30 | 20.77 | 0.887 |
| | Post | 20.43 | 21.49 | 0.383 |
| | 40 min post | 21.28 | 21.55 | 0.756 |
| PP (cm $H_2O$) | Pre | 27.40 | 26.74 | 0.716 |
| | Post | 26.70 | 24.57 | 0.181 |
| | 40 min post | 27.08 | 25.87 | 0.500 |
| MV (L/min) | Pre | 8.73 | 8.22 | 0.236 |
| | Post | 9.44 | 9.23 | 0.411 |
| | 40 min post | 9.53 | 9.27 | 0.555 |
| SpO2 (%) | Pre | 98.11 | 98.23 | 0.457 |
| | Post | 99.51 | 97.85 | 0.944 |
| | 40 min post | 99.30 | 99.17 | 0.387 |

**Table 1:** Clinical Variables for Group A and Group B.

This study shows that the addition of manual chest compression-decompression (expiratory ribcage compression) with manual hyperinflation technique does not provide further beneficial effect on lung volume and pulse oximetry ($SpO_2$) but if we see as a whole, definite improvement was seen.

As we all know that patients with pulmonary atelectasis and lower respiratory tract infection may need mechanical ventilation. Respiratory complications occur due to direct lung injury or indirect lung injury. Pulmonary complications can happen due to any neurological disorder, cardiac conditions or post abdominal surgery. The presence of atelectasis or bronchopneumonia can increase the risk of infection in lung field so; we should select the appropriate prophylaxis to prevent the recurrent infection and severity of lung disease [1,8,9].

According to the literature, manual chest compression and decompression facilitate to increase lung or pulmonary tidal volume followed by increased elastic forces in the ribcage that cause more negative pleural pressure. So, trans pulmonary pressure has increased. So, result is inspiratory flow and inspiratory volume increased [3,5,8,10].

Changes in heart rate (HR) and mean arterial pressure (MAP) are variables with manual hyperinflation and a longer inspiratory pause at the end of inspiration may be deleterious in acutely ill patients due to potential effects on cardiovascular system. The analysis of the present study showed there were no significant changes in respiratory rate (RR) and mean arterial pressure in both the group. There were no significant changes in all three-assessment period of (pre, post and 40-minute post therapy). So, it is indicated those physiotherapy maneuver did not affect the hemodynamic status of the patient. Hence it is proved that these maneuvers are safe in case of mechanically ventilated conditions.

If we select to start the patient on Volume Control Ventilation (VCV) the ventilator will always deliver the same amount of volume and generated pressure will be dependent on lung compliance. If compliance is poor the pressure will be high and barotrauma could ensue [3,5]. On the other hand, if we decide to start the patient on pressure control ventilation, the ventilator will always deliver the same pressure during respiratory cycle. In this study there are no changes in tidal volume though there are no significant changes in inspiratory and expiratory tidal volume, small improvement had been seen in Group B than Group A after immediate post therapy and it was sustained even up to 40 minutes post therapy. This minute changes proved that experimental group showed more improvement than conventional group in case of lung volume. So, Manual Chest Compression and Decompression (MCCD) maneuver can be used as a supplement to conventional mechanical ventilation with Manual Hyper Inflation (MHI) technique to improve oxygenation for lung injury patients [1,8,11-13].

In our study, no such changes had been observed in peak pressure and plateau pressure. As we have discussed earlier that there was improvement of inspiratory and expiratory tidal volume during and after the maneuver (MHI + MCCD) so, stability in peak pressure and plateau pressure was expected. It shows that MHI and MCCD helps in recruitment of alveoli that helps in trans-pulmonary collateral circulation that results in recruitment of atelectatic lung region, clearance of secretions and improvement in ventilation perfusion matching. Elevated peak and plateau pressure always indicates problem in lung compliance. In our study peak and plateau pressure was maintained in normal range.

Though there were no statistically significant changes in minute volume and $SpO_2$ in both the groups but improvement had been seen clinically. The SpO2 was maintained on higher side for both the groups even 40 minutes post therapy, that indicates effectiveness of both the maneuver.

In previous study it was seen that MCCD maneuver did not produced significant changes on mechanically ventilated patients. On other studies MHI also did not show any positive impact on mechanically ventilated patients. In our study we had tried to find out whether the combination of MCCD and MHI gives any better impact on mechanically ventilated patients with bronchopneumonia and lobar atelectasis. We had concluded that although there were no statistically significant variations in both the groups, minimal improvement had been seen in Group B in respect of lung volume and pulse oximetry ($SpO_2$).

## Limitations

- The sample size of the study was small (n = 106), so subgrouping was not done. We included all patients with X-ray changes randomly.
- In the study only one therapy session was applied. Lack of long term follow up is a major limitation.

- Observation period was short, so estimation of cumulative effect was not possible.
- Post therapy chest radiographs were not performed for all the patients.
- More advanced chest physiotherapy techniques, manual as well as mechanical applications, could have been given.

## Conclusion

The present study concludes that both manual hyperinflation and manual chest compression - decompression combined with manual hyperinflation techniques are equally good and effective in improving tidal volume and oxygenation level. It helps in early extubation of patients. Further it states that there is no significant difference between MHI and both combined with MHI and MCCD maneuver. However, the long-term outcome of multiple therapy sessions and on selected patient population by manual hyperinflation (MHI) and combined of MHI and rib cage compression (MCCD) remain to be determined.

## Conflict of Interest

None.

## Bibliography

1. Bhoir TV., *et al*. "Acute response of manual hyperinflation versus ventilator hyperinflation in addition to chest physiotherapy on critically ill mechanically ventilated patients". *International Journal of Multidisciplinary Research and Development* 4.6 (2017): 51-56.
2. Genc A., *et al*. "The effects of manual hyperinflation with or without rib-cage compression in mechanically ventilated patients". *International Journal of Physiotherapy* 1 (2011): 48-54.
3. Salahudeen M and Parthasarathy S. "Coastal Critical Care Patients: Effect of Manual Chest Compression to Decrease Lung Disability Among Vulnerable Patients on Mechanical Ventilator". *Journal of Coastal Life Medicine* 11 (2023): 227-235.
4. Via FD., *et al*. "Effects of manual chest compression and decompression maneuver on lung volumes, capnography and pulse oximetry in patients receiving mechanical ventilation". *Brazilian Journal of Physical Therapy* 16 (2012): 354-359.
5. Stiller K., *et al*. "Acute lobar atelectasis: a comparison of two chest physiotherapy regimens". *Chest* 98.6 (1990): 1336-1340.
6. Paulus F., *et al*. "Benefits and risks of manual hyperinflation in intubated and mechanically ventilated intensive care unit patients: a systematic review". *Critical Care* 16.4 (2012): 1-1.
7. Hodgson CL., *et al*. "An investigation of the early effects of manual lung hyperinflation in critically ill patients". *Anaesthesia and Intensive Care* 28.3 (2000): 255-261.
8. Dias CM., *et al*. "Bronchial hygiene technique with manual hyperinflation and thoracic compression: effectiveness and safety". *Revista Brasileira de Terapia Intensive* 23 (2011): 190-198.
9. Dennis D., *et al*. "Ventilator versus manual hyperinflation in clearing sputum in ventilated intensive care unit patients". *Anaesthesia and Intensive Care* 40.1 (2012): 142-149.
10. Patroniti N and Pesenti A. "Low tidal volume, high respiratory rate and auto-PEEP: the importance of the basics". *Critical Care* 7 (2003): 105-106.
11. Lofrese JJ., *et al*. "Physiology, Residual Volume". StatPearls Publishing, April 29, (2020).
12. Silva PL and Rocco PR. "The basics of respiratory mechanics: ventilator-derived parameters". *Annals of Translational Medicine* 6.19 (2018).
13. Choi JS and Jones AY. "Effects of manual hyperinflation and suctioning on respiratory mechanics in mechanically ventilated patients with ventilator-associated pneumonia". *Australian Journal of Physiotherapy* 51.1 (2005): 25-30.