

## Acute Response of Manual Hyperinflation In Addition To Standard Chest Physiotherapy on Critically Ill Mechanically Ventilated Patients

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### Abstract:

**Background:** Physiotherapists use manual hyperinflation (MHI) as a treatment for the recruitment of collapsed lung and mobilization of excess pulmonary secretions .Purpose: To investigate the acute effect of manual hyperinflation (MHI) on oxygenation and volume of secretions cleared in mechanically ventilated patients.

**Subjects and Methods:** Manual hyperinflation was delivered in 30 medically stable, mechanically ventilated patients . patients were randomly selected from Cairo university hospitals (critical care department). Their ages ranged from 50 to 60 years .The study group A received both manual hyperinflation and standard chest physiotherapy while control group B received standard chest physiotherapy only. Oxygenation parameters were recorded before and after 30 minutes of treatment while secretion volume was recorded after 30 minutes of treatment.

**Results:** The results of this study revealed statistically significant improvement in oxygenation parameters and the amount of drained chest secretions in patients of both groups which was highly significant in favor of study group A with P value  $\leq 0.05$ .

**Conclusion:** Use of manual hyperinflation in combination with standard chest physiotherapy is a beneficial method to clear lung secretions and improve oxygenation parameters in mechanically ventilated patients .

**Key words:** Oxygenation; Chest physiotherapy; Mechanical ventilation.

### I. Introduction

Patients receiving mechanical ventilation may have an increased risk of sputum retention, atelectasis, and pneumonia, making ventilation weaning more difficult and resulting in excess morbidity and mortality <sup>2</sup>.

The cost of maintaining patients on prolonged ventilation in the ICUs of acute care hospitals is high. Thus, every effort should be made to determine which patients can be rapidly extubated so as to keep the weaning period to a minimum.<sup>1</sup>

Physiotherapists are pivotal members in the multi-specialty medical team where intensive care is a collaborative environment in which they provide a vast array of services ranging from acute respiratory care to rehabilitation<sup>3,4</sup>.

Many services provided by physiotherapists to ICU patients include: positioning, mobilization, exercises, airway clearance techniques, manual and ventilator hyperinflation techniques for a successful weaning from the ventilator<sup>5</sup>.

The purpose of this study was to investigate the acute response (after 30 minutes) of manual hyperinflation (MHI) on the oxygenation parameters and amount of chest secretions for critically ill mechanically ventilated patients .

### II. Patients, instrumentations and procedures

#### [1]. Patients

Thirty patients were recruited randomly in this study. The study group (A) composed of 15 patients , Their ages ranged from 50 to 60 years with a mean of  $48.9 \pm 3.7$  years (80% male and 20% female) and control group (B) composed of 15 patients their ages ranged from 50 to 60 years with a mean of  $49.6 \pm 4.01$  years (70% male and 30% female) . All subjects were mechanically ventilated . The patients in study group A were received both manual hyperinflation and chest physiotherapy but the patients in control group were received traditional chest physiotherapy only.

#### Inclusion Criteria:

All patients were mechanically ventilated for 3 to 7 days and hemodynamically stable with positive end expiratory pressure (PEEP) not exceeding 5 cmH<sub>2</sub>O.

### **Exclusion Criteria:**

Patients were excluded from the study if they had one of the following criteria:

- Fraction of inspired oxygen ( $FiO_2$ ) > 0.6. Positive end expiratory pressure (PEEP) > 10 cm H<sub>2</sub>O to avoid barotraumas.
- Pulmonary pathology where lung hyperinflation was contra-indicated (e.g. acute respiratory distress syndrome, Undrained pneumothorax or exacerbation of chronic obstructive pulmonary disease and acute pulmonary oedema.
- Raised intracranial pressure<sup>6,7</sup>.

### **Withdrawal Criteria**

Patients were subjected to be withdrawn from the study if they had unstable cardiovascular status such as systolic blood pressure reading from 100-180 mmHg, mean arterial pressure from 60-110 mmHg, arrhythmias or arterial oxygen saturation ( $SaO_2$ ) less than 90%.

### **[2]. Equipment**

#### **Evaluation Equipment:**

Arterial blood oxygenation assessment using arterial blood gases analyzer:

1.  $SO_2$  (oxygen saturation)
2.  $PaO_2$  arterial oxygen pressure
3.  $PaO_2/FiO_2$  (Ratio of partial oxygen pressure and fraction inspired oxygen)

#### **Training Equipment:**

1. Bag valve resuscitation circuit locked at pressure = 45 cm H<sub>2</sub>O
2. Oxygen supply 15 L/min attached to the Bag valve resuscitation circuit.

### **[3]. Procedures**

#### **Procedure of manual hyperinflation technique:**

Each patient was positioned into an appropriate position for treatment and disconnected from the mechanical ventilator. Manual hyperinflation technique MHI was performed by applying a larger than normal volume at a low inspiratory flow followed by an inspiratory pause of approximately 2-3 seconds and expiration with a high expiratory flow where inspiratory: expiratory ratio of approximately 1/2 was followed by an uninterrupted expiration during which the bag was held compressed then a 'quick release' of the bag<sup>8,9</sup>.

At the end of procedure, patient should be reconnected to the ventilator to recheck patient's tidal volume, respiratory rate and respiratory pattern, any signs of distress (tachypnea, cyanosis, tachycardia), and position of the endotracheal tube or tracheostomy were also observed. The monitor also indicated that the cardiovascular system was stable and the oxygen saturation was within the normal limits for each patient<sup>10</sup>.

#### **Procedure for chest physiotherapy**

Chest physiotherapy in the form of percussion, vibration, and postural drainage was applied for 15 min for all patients in both groups<sup>4,5</sup>.

## **III. Results**

### **Assessment of the results:**

Study variables was done before starting physiotherapy sessions on both groups and at the end of the study, study variables include oxygenation parameters ( $PaO_2$ ,  $SaO_2$  %, and  $PaO_2/FiO_2$ ) and sputum amount.

#### **Data analysis**

Statistical analysis was performed on the data obtained from 30 patients. All statistical analysis was performed using SPSS for Windows 16.0; paired t-test was carried out to determine the significance of the outcome measurements pre and post-study in the two groups, unpaired t-test was carried out to determine the significance difference between groups. P-value of less than 0.05 was used to determine the significance of the outcome measurements between the two groups for oxygenation parameters and sputum amount.

The study group (A) composed of 15 patients their ages ranged from 50 to 60 years with a mean of  $48.9 \pm 3.7$  years (80% male and 20% female). The control group (B) composed of 15 patients their ages ranged from 50 to 60 years with a mean of  $49.6 \pm 4.01$  years (70% male and 30% female), there is no significant difference between both groups regarding to age with (P value ; 0.607).

-The obtained results in this study revealed no significant difference when comparing the pre-treatment mean values of the two groups regarding the three measured oxygenation parameters, as the p-value for  $PaO_2$ ,  $SaO_2$ % and  $PaO_2/FiO_2$  were 0.9, 0.15 and 0.97 respectively.

-Table (1) and figure (1) showed significant improvement in the mean values of the three measured oxygenation parameters (PaO<sub>2</sub>,SaO<sub>2</sub>% and PaO<sub>2</sub>/ FiO<sub>2</sub>) in the study group (A) at the end of treatment when compared with the corresponding mean values before treatment (P; 0.0001),with percent of improvement 12.13 %,1.17 %,12.1 % respectively .

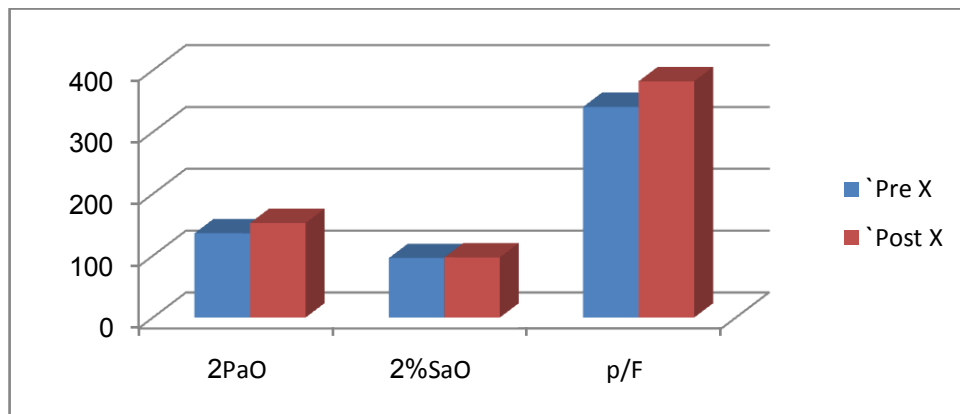
**Table (1)** Pre and post-treatment mean values and mean difference of PaO<sub>2</sub>,SaO<sub>2</sub>% and PaO<sub>2</sub>/ FiO<sub>2</sub> for the study group (A)

Variable	Pre X̄	±SD	Post X̄	±SD	Mean Difference	t-value	p-value	Percentage of improvement
PaO <sub>2</sub>	136.33	11.4	152.87	10.3	16.5	11.2	0.0001	12.13 %
SaO <sub>2</sub> %	96.2	0.64	97.33	0.48	1.13	9.13	0.0001	1.17 %
paO <sub>2</sub> /FiO <sub>2</sub>	340.8	28.5	382.17	25.8	41.33	11.2	0.0001	12.1 %

X̄: Mean

±SD: Standard deviation

P-value: Level of significance



**Figure (1)** Pre and post-treatment mean values and mean difference of PaO<sub>2</sub>,SaO<sub>2</sub>% and PaO<sub>2</sub>/ FiO<sub>2</sub> for the study group (A)

-Table (2) and figure (2) showed significant improvement in the mean values of the three measured oxygenation parameters (PaO<sub>2</sub>,SaO<sub>2</sub>% and PaO<sub>2</sub>/ FiO<sub>2</sub>)in the control group (B) at the end of treatment when compared with the corresponding mean values before treatment (P ;0.0001), with percent of improvement 4.1 %, 0.83 %, 4.11 % respectively .

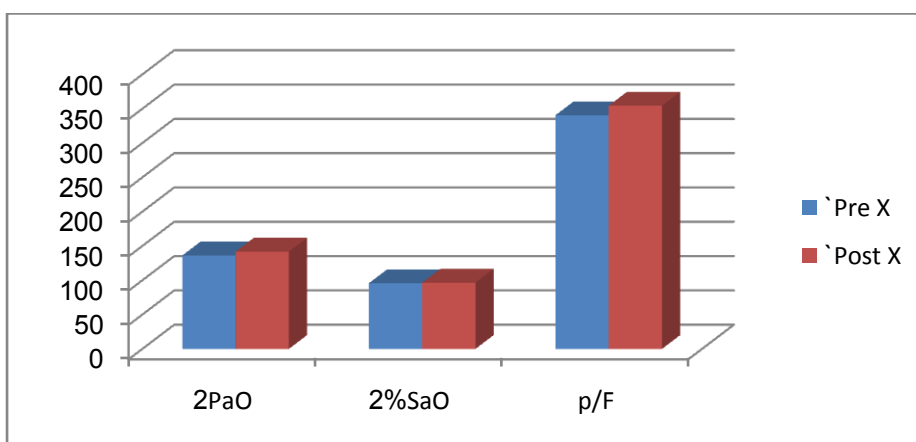
**Table (2)** Pre and post-treatment mean values and mean difference of PaO<sub>2</sub>,SaO<sub>2</sub>% and PaO<sub>2</sub>/ FiO<sub>2</sub> for the study group (B)

Variable	Pre X̄	±SD	Post X̄	±SD	Mean Difference	t-value	p-value	Percentage of improvement
PaO <sub>2</sub>	136.2	10.3	141.8	10.1	5.6	7.12	0.0001	4.1 %
SaO <sub>2</sub> %	95.7	0.6	96.5	0.7	0.72	6.18	0.0001	0.83 %
paO <sub>2</sub> /FiO <sub>2</sub>	340.5	25.9	354.5	25.2	14	7.12	0.0001	4.11 %

X̄: Mean

±SD: Standard deviation

P-value: Level of significance

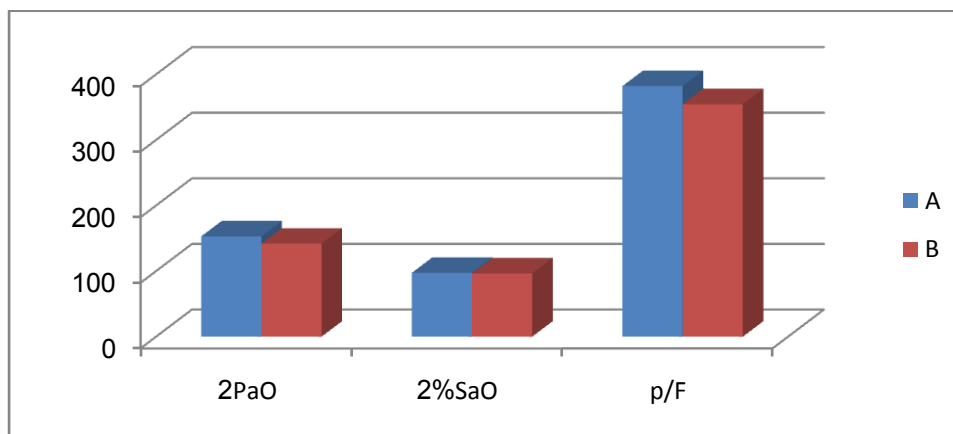


**Figure (2)** Pre and post-treatment mean values and mean difference of PaO<sub>2</sub>,SaO<sub>2</sub>% and PaO<sub>2</sub>/ FiO<sub>2</sub> for the study group (B)

-Un paired T- test was used to reveal the difference between the mean values post treatment in study and control groups. results showed that there was a significant difference between mean values post treatment in group A and group B for PaO<sub>2</sub> , SaO<sub>2</sub>% ,and PaO<sub>2</sub>/ FiO<sub>2</sub>, improvements is more higher in group A than B in the measured oxygenation parameters . Table ( 3)and figure (3)The mean difference of PaO<sub>2</sub>, SaO<sub>2</sub>% and PaO<sub>2</sub>/ FiO<sub>2</sub> between study group (A) and control group (B) post treatment .

**Table ( 3 )** The mean difference of PaO<sub>2</sub>, SaO<sub>2</sub>% and PaO<sub>2</sub>/ FiO<sub>2</sub> between study group (A) and control group (B) post treatment

Variable	T-value	p-value	Mean Difference	Significance
PaO <sub>2</sub>	2.9	0.0061	11.06	significant difference
SaO <sub>2</sub> %	3.3	0.002	0.74	significant difference
PaO <sub>2</sub> / FiO <sub>2</sub>	2.9	0.0061	27.6	significant difference

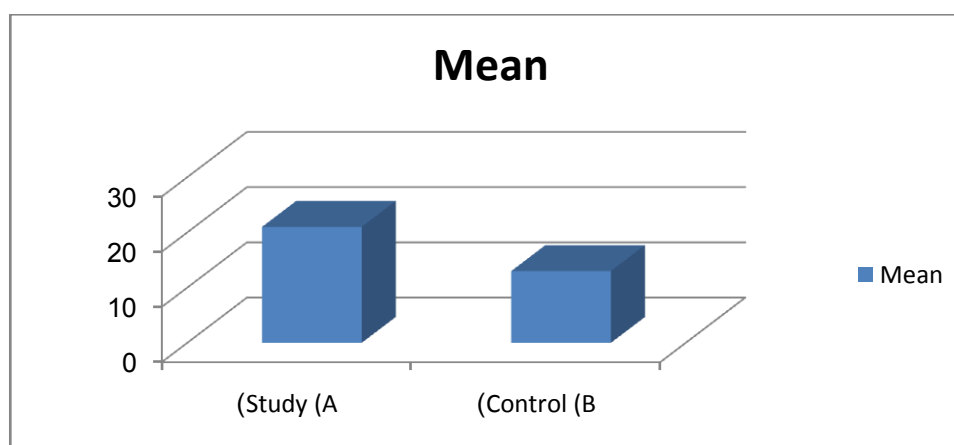


**Figure (3)** The mean difference of PaO<sub>2</sub>, SaO<sub>2</sub>% and PaO<sub>2</sub>/ FiO<sub>2</sub> between study group (A) and control group (B) post treatment .

Table (4) and figure (4). showed the mean value of the amount of sputum post treatment in both groups (p-value<0.0006) ,while its mean value in study group is higher than control group.

**Table (4).** The mean difference of the amount of sputum post treatment for the study (A)and control group (B).

Group	Mean	T-value	p-value	Significance
Study (A)	21	3.8	<0.0006	significant difference
Control (B)	13			



**Figure (4).** The mean difference of the amount of sputum post treatment for the study (A)and control group (B).

#### IV. Discussion

Medical ICUs are dedicated hospital areas where health professionals may properly and specifically care for these population of patients, including the good physiotherapy programs done to these patients , thus increasing their chance to be weaned from mechanical ventilation<sup>13</sup>

Although advances in critical care and mechanical ventilation over the past decades have resulted in the increased survival of patients who are critically ill. Patients requiring mechanical ventilation for along time are frequently deconditioned because of respiratory failure precipitated by the underlying disease, the adverse effects of medications, and a period of prolonged immobilization. Patients requiring mechanical ventilation often have substantial weakness of the respiratory and limb muscles that further impairs their functional status and health-related quality of life<sup>11</sup>

Atelectasis is a common clinical problem in the intubated and ventilated patient and, if prolonged, may lead to hypoxemia, pulmonary infection and fibrosis . In addition, loss of lung volume and atelectasis lead to a progressive reduction in pulmonary compliance making ventilation more difficult . Recruitment maneuvers such as manual hyperinflation have been shown to improve both atelectasis and static pulmonary compliance<sup>12</sup>

The general aims of any physiotherapy program in the critical areas is to apply advanced, cost-effective therapeutic modalities to decrease the patient's dependency on ventilator, improve residual function, prevent the need for new hospitalizations and to improve the patient's quality of life .

The aim of manual hyperinflation is to re-expand atelectasis ,mobilize secretions and prevent or reduce the incidence of nosocomial pneumonia in intubated patients.<sup>12</sup>

**Maxwell And Ellis , 2003**<sup>14</sup> stated that manual hyperinflation is sometimes used as a supplement to conventional mechanical ventilation to transiently improve oxygenation of patients with lung injury.

Our present investigation was designed to investigate the acute effect of manual hyperinflation on oxygenation parameters and sputum amount in critically ill mechanically ventilated.

The results in the present investigation revealed statistically significant improvement in oxygenation parameters ( $\text{PaO}_2$ ,  $\text{SaO}_2$  %, and  $\text{PaO}_2/\text{FiO}_2$ )and sputum amount .but the improvement was significant higher in the study group A than control group B . these benefits might have resulted from recruitment of alveoli by manual hyperinflation which could theoretically recruit atelectatic lung regions and facilitate secretion mobilisation and improvement in gas transfer in lung and improvement in the ventilation perfusion matching.

The study made by **Patman** et al., 2000<sup>15</sup> revealed that when we used manual hyperinflation alone versus no hyperinflation on 100 intubated patients ,the study results showed greater improvement in  $\text{PaO}_2 / \text{FiO}_2$  ratio and alveolar –arterial oxygen gradient in all cases of the MHI group, similar results are found in our study which showed improvement in the oxygenation and improvement of  $\text{PaO}_2 / \text{FiO}_2$  in all cases of the study group after MHI.

**Hodgson** et al., 2000<sup>15</sup> stated that when we used manual hyperinflation versus positioning on 18 mechanically ventilated patients, results show the great improvement in  $\text{O}_2$  saturation of these patients ,like our study revealed that the improvement in all cases received MHI.

**Jeffrey Lipman**, 2002<sup>16</sup> investigated the effects of MHI on the arterial oxygen to fraction of inspired oxygen ratio ( $\text{PaO}_2 / \text{FiO}_2$ ) and the alveolar-arterial oxygen tension difference (A-a)  $\text{PO}_2$  in 100 medically stable, mechanically ventilated subjects .results: After four minutes of MH there were significant improvements in  $\text{PaO}_2 / \text{FiO}_2$  and (A-a)  $\text{PO}_2$  with values remaining above baseline measures at 60 min post-intervention. The mean improvement was 56 mmHg for  $\text{PaO}_2 / \text{FiO}_2$  (approximately 17%) and 29 mmHg for (A-a)  $\text{PO}_2$  (approximately 17%) immediately post-intervention. No significant changes in mean  $\text{PaO}_2 / \text{FiO}_2$  or (A-a)  $\text{PO}_2$  were seen in the non-MHI group. Their findings were similar to results of our study ,in our study we used MHI to mechanically ventilated stable patients and resulted in great improvement in oxygenation parameters ( $\text{PaO}_2$ , $\text{SaO}_2$ % and  $\text{PaO}_2/ \text{FiO}_2$ ) in all cases of study group A with percent of improvement 12.13 %,1.17 %,12.1 % respectively ,compared to control group B 4.1 %, 0.83 %, 4.11 % respectively.

**Stiller** et al., 2004<sup>17</sup> used fourteen mechanically ventilated patient's with Unilateral lung pathology of acute lobar atelectasis and were taken chest physiotherapy regimens for treatment. Treatment in group 1 comprised positioning, vibrations, hyperinflation, and suction, and in group 2, treatment consisted of positioning, vibrations and suction alone. Treatment in either group was given hourly for six hours. Patients in group 1 had a significantly higher mean percentage resolution of their atelectasis and gases exchange  $\text{PaO}_2/\text{FiO}_2$  (mean value, 60.1 %), as seen on chest X ray, after one treatment intervention than patients in group 2 (mean 0.6 percent;  $p < 0.006$ ). After the intensive six-hour treatment period, the difference between the groups was marginally statistically significant, still favoring group 1 over group 2 ( $p < .055$ ). These results suggest that, at least initially in the course of acute lobar atelectasis, positioning and vibrations add to the efficacy of a treatment by manual hyperinflation and suction.

In contrast to the abovementioned positive findings, an investigation executed by **Paratz Lipman** , 2006<sup>18</sup> established that when MHI was performed to seven mechanically ventilated patients with septic and

cardiogenic shock arterial blood gases were recorded, these limited Results showed that there were no significant changes in PaO<sub>2</sub>/FiO<sub>2</sub> this may be due to the hemodynamic instability of the cases. in our study we were selected the haemodynamics stable cases only so the results was so better than that study.

#### **Clinical implications:**

Our findings indicate that a simple and inexpensive manual hyperinflation using resuscitation bag with oxygen delivery show significant improvement in oxygenation and sputum clearance on mechanically ventilated patients, these results, together with the observations of other trials, suggest that manual hyperinflation safe intervention that can be considered for mechanically ventilated critical ill patients, and it can help in weaning from the ventilator and decrease the time spent in intensive care unit also decrease morbidity of these cases.

Also our findings indicate that we should select the most hemodynamic stable cases to gain more benefit from MHI .

The improvement was showed in both group but it was high in the study group in all oxygenation parameter (PaO<sub>2</sub>, PaCO<sub>2</sub>, SaO<sub>2</sub> %, PaO<sub>2</sub> / FiO<sub>2</sub>)

#### **V. Conclusion**

Use of manual hyperinflation in combination with standard chest physiotherapy is a beneficial method to clear lung secretions and improve oxygenation parameters in mechanically ventilated patients.

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