Arterial Oxygenation Response to Manual Hyperinflation as an Added Procedure to Chest Physiotherapy in Critically Ill Mechanically Ventilated Patients

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ABSTRACT

Background: *Manual hyperinflation as a component of physiotherapy program is commonly applied but its value and its early use in treatment of mechanically ventilated remain unclear.* ***Objective:*** *to investigate the effect of manual hyperinflation on arterial oxygenation in mechanically ventilated patients.* ***Methodology:*** *forty mechanically ventilated patients were assigned to the study, the patients' age ranged from 40-60 years with mean age (52.5±7.6),they divided into 2equal groups of 20 patients for each. Study group patients received manual hyperinflation and chest physiotherapy as three sessions daily for three successive days, control group patients received chest physiotherapy only. Oxygen saturation was assessed before and after treatment program.* ***Result:*** *The results of this study revealed that there was statistically significant changes in oxygen saturation in patients of study group in comparison to which of patients in control group.* ***Conclusion:*** *The use of manual hyperinflation in combination with chest physiotherapy is recommended to improve the arterial oxygenation in mechanically ventilated patients.*

INTRODUCTION

A primary goal of mechanical ventilation is to improve arterial oxygenation. Improvement is achieved partly through the use of endotracheal intubation to ensure the delivery of oxygen to the airway and partly through an increase in airway pressure. Satisfactory oxygenation is easily achieved in most patients with airway obstruction. The main challenge arises in patients with alveolar-filling disorders[7].

Ventilator is associated with a number of complications, which increase morbidity and mortality that include: mucus plugging, e.g. (atelectasis, occlusion of the endotracheal tube), ventilation-associated pneumonia (VAP) and nosocomial infection, barotrauma, e.g. (pneumothorax, subcutaneous emphysema), hypotension[14].

The concentration of O_2 in arterial blood (CaO_2) can be defined by combining Equation by using the SO_2 and PO_2 of arterial blood (SaO_2 and PaO_2). $CaO_2 = (1.34 * Hb* SO_2) + (0.003 * PaO_2)$. There are approximately 200 mL oxygen in each liter of arterial blood, and only 1.5% (3 mL) is dissolved in the plasma. The oxygen consumption of an average-sized adult at rest is 250 mL/min, which means that if we were forced to rely solely on the dissolved O_2 in plasma, a cardiac output of 89 L/min would be necessary to sustain aerobic metabolism. This emphasizes the importance of hemoglobin in the transport of oxygen[11].

Physiotherapy intervention is regarded as an important component in the management of patients in intensive care and has demonstrated to provide both short and medium-term benefits[4].

The main indications for physical therapy for patients in intensive care units (ICUs) are excessive pulmonary secretions or atelectasis. Timely physical therapy interventions may improve gas exchange and reverse pathological progression, thereby curtailing or avoiding artificial ventilation[15].

The manual hyperinflation protocol is to be used by physiotherapists, which aims to manually inflate an intubated patient's lungs, via an endotracheal tube or tracheostomy tube with resuscitation bag circuit with pressure lock. Volumes delivered are greater than those given by the ventilator or achieved by the patient. It is used to reinflate areas of atelectasis, Mobilise secretions and for Patients who are unable to achieve 1 liters tidal volumes on deep inspiration on the ventilator Assessment tool[6].

Manual hyperinflation is defined as inflating the lungs using oxygen and manual compression to provide a tidal volume (Vt) exceeding baseline Vt, and using a Vt that is 50% greater than that delivered by the ventilator, requiring a peak inspiratory pressure of ranged from 20 to 40 cm H_2O[9].

The MHI technique was initially designed to enhance clearance of airway secretions[8].

Manual hyperinflation is used by physiotherapists to improve lung volume and mobilise secretions and has been shown to increase lung compliance in our patients with ventilator-associated pneumonia[2].

In addition, MHI produced no adverse events in the experimental group, as none of the patients experienced pneumothorax, suffocation, or hypotension during or following MHI[5].

METHODOLOGY AND PROCEDURES

Subjects

Forty patients were involved in this study, were divided randomly into two groups:

- Study group (twenty patients) received both manual hyperinflation and chest physiotherapy.
- Control group (twenty patients) received traditional chest physiotherapy only.
- All patients were mechanically ventilated for 3 to 7 days by Bennett ventilator.
- The age ranged from 40 to 60 years.
- All patients were on Positive end expiratory pressure (PEEP) not exceed 10 cmH_2O.
- All patients were hemodynamically stable (vital signs) temperature, heart rate and blood pressure.

Evaluation Equipment

- Arterial blood oxygenation assessment using arterial blood gases analyzer:
- O_2% (oxygen saturation) normal range from 92-100%.
- PaO_2/FiO_2 (percent of partial oxygen pressure and fraction inspired oxygen) normal range more than 400-500.

Training Equipment

- Bag valve resuscitation circuit locked at pressure = 40 cmH_2O.
- Oxygen supply 15 L /min attached to the Bag valve resuscitation circuit.

Procedures

1- Attach the resuscitation circuit to the oxygen flow meter and set the oxygen to 15 L/minute. any less than 15 L/minute increases the time of bag reinflation which can lead to a delay in giving the next breath.

2- Disconnect the patient from the ventilator, attach the resuscitation circuit to the filter and attach to the patient airway (endotracheal or tracheostomy).

3- The hyperinflation breaths had a slow inspiration for three seconds duration; A three second end inspiratory pause (hold) was followed by an uninterrupted expiration during which the bag was held compressed. hold the breath for three seconds at end of inspiration then a "quick release" of the bag. Slow deep breaths and hold, maximizes collateral ventilation. The "quick release" increases the expiratory phase to mobilize secretions up the bronchial tree and stimulate cough.
4- Reconnect the patient to the ventilator.
5- The manual hyperinflation treatment time was 15 minutes for each session three time/day for three days for the study group.

Chest physiotherapy

Chest physiotherapy in the form of percussion, vibration, and positioning, suction and postural drainage were applied for all patients in both groups.

Data analysis

The mean, standard deviation and the range will be calculated for all subjects. Paired "t" test will be used to determine the mean value of arterial blood gases for each patients before and after treatment program and to compare the changes with each group.

RESULTS

This study was comprised of forty patients, age of the patients ranged from 40 to 60 years old. All patients were mechanically ventilated.

Statistical analysis of data by using paired t-test to find the significance level, mean and standard deviation to detect the effect of manual hyperinflation on selected arterial blood gases of these subjects.

Subjects were divided into two groups:

- Study group (twenty patients) received both manual hyperinflation and chest physiotherapy. The patients' ages ranged from 40 to 60 years with a mean of 52.5±7.6 years.
- Control group (twenty patients) received chest physiotherapy only. The patients' ages ranged from 41 to 60 years with a mean of 51.8 + 6.5 years.

1- Partial arterial oxygen pressure (PaO_2) between the study group and control group:

Table (1) and fig.(1) show The comparison of PaO2 between the study group and control group before MHI revealed that there was no significant changes, it was (94.7±8.33) versus (90.55±10.74) (P : 0.2). But after MHI there was significant changes between both groups,it was (143.8 ± 41.39) versus (90.8± 7.47) (P : 0.0001) these results show the great difference done when we used manual hyperinflation. Also fig. (2) Show the % of improvement of PaO_2 between the study group and control group after treatment.

Table (1): The mean value and standard deviation of PaO_2 between the study group and control group.

Parameter \ Group	**Study** Group	**Control** Group	P-value	significance
Pre PaO_2	94.7±8.33	90.55±10.74	0.2	P>0.05**
Post PaO_2	143.8±41.39	90.8± 7.47	0.0001	P<0.05 *
% of change	34.1 increase	0.3 Increase		

Level of significance at P<0.05 * = significant ** = non significant

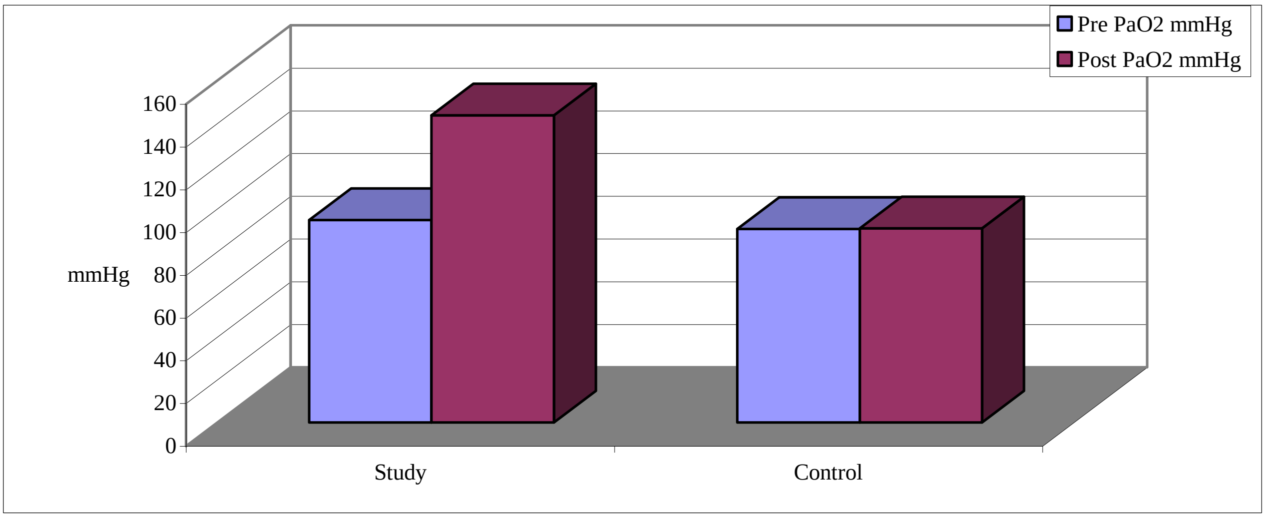

Fig. (1): The mean value and standard deviation of PaO_2 between the study group and control group.

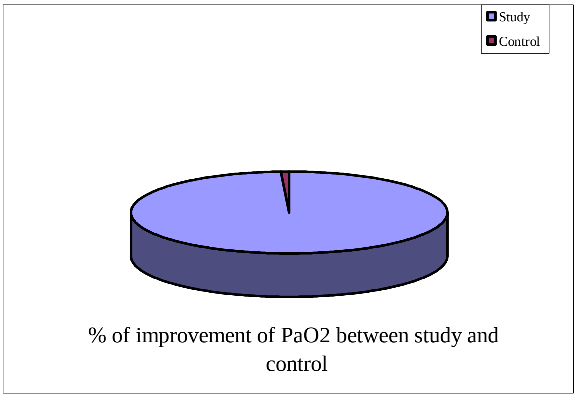

Fig. (2): The % of improvement of PaO_2 between the study group and control group after treatment.

2- Oxygen saturation (SaO2 %) between the study group and control group:

Table (2) and fig. (3) show the comparison of SaO_2% between the study group and control group before MHI revealed that there was no significant changes, it was (94.86 ± 2.49) versus (93.9±3.2) (P; 0.4), But after MHI there was significant improvement between both group, it was (98.48 ± 1.09) versus (96.7±1.7) (P; 0.007), these results showed the great difference done when we used manual hyperinflation. Also fig. (4): show the % of improvement of SaO_2 between the study group and control group after treatment.

Table (2): The mean value and standard deviation of SaO_2 between the study group and control group.

Parameter \ Group	**Study** Group	**Control** Group	P-value	Significance
Pre SaO_2%	94.86±2.49	93.9±3.2	0.4	P>0.05**
Post SaO_2%	98.48±1.09	96.7± 1.7	0.007	P<0.05 *
% of change	3.6 increase	2.8 increase		

Level of significance at P<0.05. * = significant.** = non significant

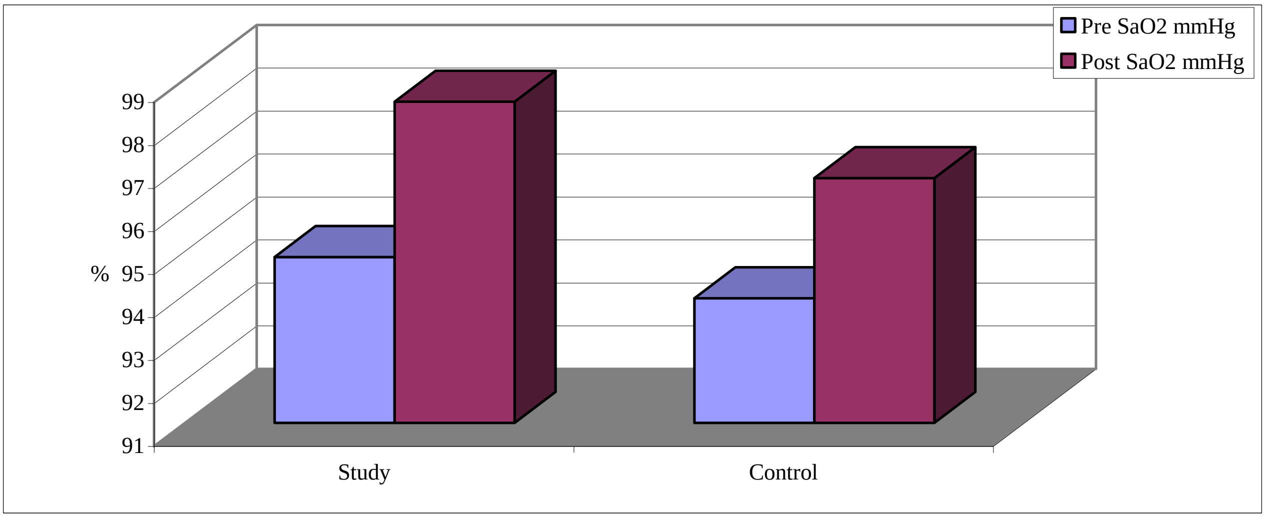

Fig. (3): The mean value and standard deviation of SaO_2% between the study group and control group.

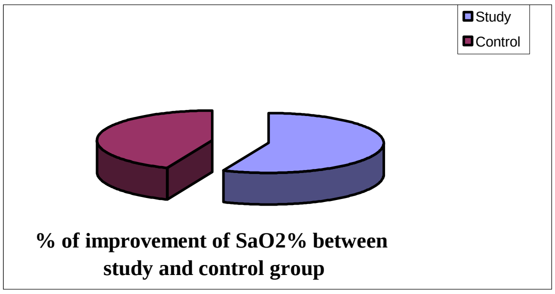

Fig. (4): The % of improvement of SaO_2% between the study group and control group after treatment.

3- (PaO2/FiO2) between the study group and control group:

Table (3) and fig. (5) show the comparison of (PaO_2/FiO_2) between the study group and control group before MHI revealed that there was no significant changes, it was (227.8 ± 50.1) versus (226.1±29.3) (P; 0.88), But after MHI there was significant changes between both group, it was (346.9±93.7) versus (227.2±26.8) (P;0.0001) these results showed the great difference done when we used manual hyperinflation. Also fig. (6): show the % of improvement of PaO_2/FiO_2 between the study group and control group after treatment.

Table (3): The mean value and standard deviation of PaO_2/FiO_2 between the study group and control group.

Group / Parameter	**Study** Group	**Control** Group	P-value	significance
Pre PaO_2/FiO_2	227.8±50.1	226.1±29.3	0.88	P>0.05**
Post PaO_2/FiO_2	346.9±93.7	227.2±26.8	0.0001	P<0.05 *
% of change	34.3 increase	0.48 increase		

Level of significance at P<0.05 * = significant ** = non significant

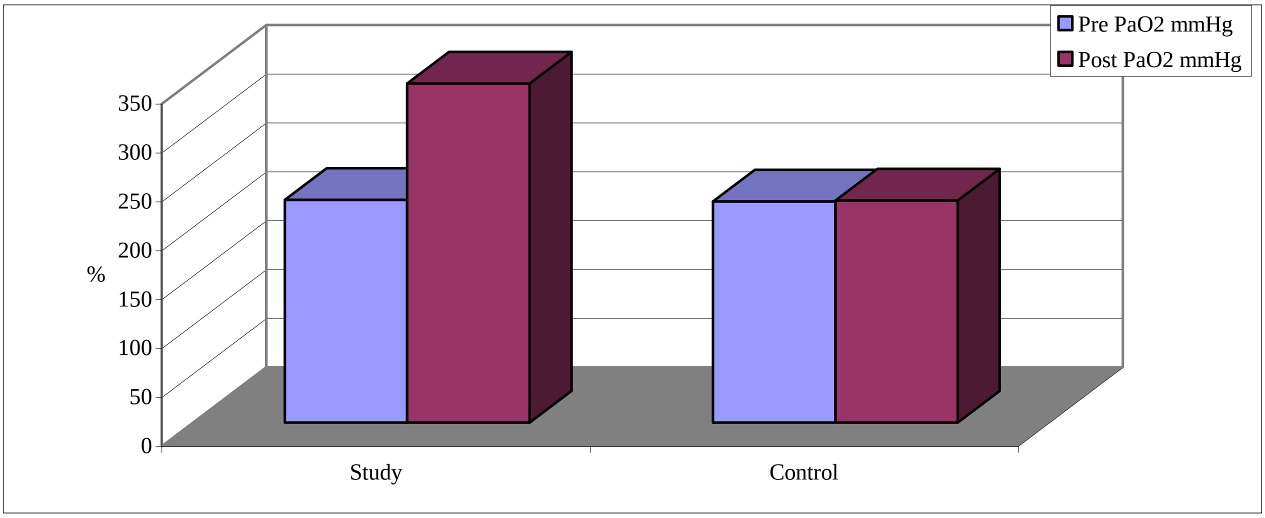

Fig. (5): The mean value and standard deviation of PaO_2/FiO_2 between the study group and control group.

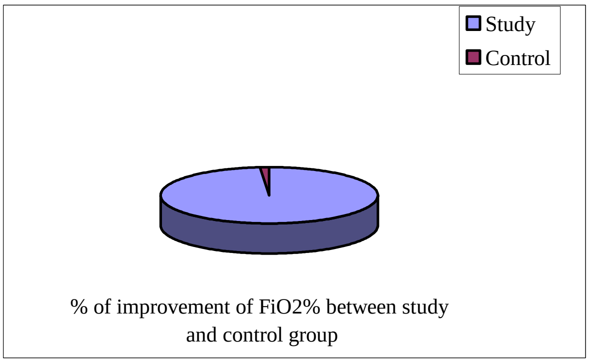

Fig. (6): The % of improvement of PaO_2/FiO_2 between the study group and control group after treatment.

DISCUSSION

The deleterious effects of prolonged immobilization affect the heart, vascular system, musculoskeletal system, skin, and kidneys. Effects may also occur in the respiratory system such as Nosocomial pneumonia, pulmonary thromboembolism, and hypoxemia may increase the patient's morbidity and mortality. Another pulmonary complication of immobility is atelectasis[12].

Mechanical ventilation is indicated in respiratory failure and patients receiving mechanical ventilation may have an increased risk of sputum retention, atelectasis, and pneumonia, making ventilator weaning more difficult. Thus, every effort should be made to determine which patients can be rapidly extubated so as to keep the weaning period to a minimum[5].

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[1].

Atelectasis is a common clinical problem in the intubated and ventilated patient. Recruitment maneuvers such as manual hyperinflation have been shown to improve both atelectasis and static pulmonary compliance[3].

The general aims of any physiotherapy program in the critical areas is to restore his/her respiratory and physical independence, thus decreasing the risks of bed-rest associated complications. Physiotherapy treatment when started early helps prevent weaning delay, limited mobility and total dependence on the ventilator[13]. The aim of lung hyperinflation is to re-expand atelectasis, mobilize secretions and prevent or reduce the incidence of nosocomial pneumonia in intubated patients[3].

The results in the present investigation revealed statistically significant changes in selected arterial blood gases (PaO_2, $PaCO_2$, SaO_2%, PaO_2/FiO_2) that showed improvement in both groups, but the improvement was significant in the study group. These benefits might have resulted from recruitment of alveoli, Manual hyperinflation opens collateral channels within the lungs, which could theoretically recruit atelectatic lung regions and facilitate secretion mobilisation, improvement in gas transfer in lung and improvement in the ventilation perfusion matching.

In contrast to the above mentioned positive findings, an investigation executed by Paratz Lipman, (2006)[10] established that when MHI was performed to seven mechanically ventilated patients with septic and cardiogenic shock. Diastolic and mean arterial pressure, pulmonary artery occlusion pressure, dynamic compliance, and arterial blood gases were recorded, these limited Results showed that there were no significant changes in pulmonary artery occlusion pressure, mean arterial pressure, or PaO_2/FiO_2 and arterial blood gases this may be due to the heamodynamic instability of the cases. in our study we were selected the haemodynamics stable cases only so the results was so better than that study.

Conclusion

The data obtained in the present study revealed statistically significant changes in selected arterial blood gases (PaO_2, SaO_2%, PaO_2/FiO_2) that showed a improvement in both group, but the improvement was high statistically significant in the study group.

Traditional chest physiotherapy was sufficient to result in positive changes in the arterial blood oxygenation (PaO_2, SaO_2%, PaO_2/FiO_2) but this improvement was increased with the use of manual hyperinflation plus traditional chest physiotherapy for mechanically ventilated patient.

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الملخص العربي

دراسة مدى استجابة تهوية الدم الشرياني للتنفيخ اليدوي كإضافة للعلاج الطبيعي للصدر لدى مرضى جهاز التنفس الصناعي

الهدف من البحث هو دراسة تأثير التنفيخ اليدوي على مدى تشبع الدم بالأكسجين لدى مرضى جهاز التنفس الصناعي . أجريت هذه الدراسة على أربعين مريض من مرضى جهاز التنفس الصناعي تتراوح أعمارهم ما بين أربعين إلى ستين عاما و تم تقسيمهم إلى مجموعتين متساويتين: المجموعة الأولى التي تلقت التنفيخ اليدوي لمدة 15 دقيقة مع العلاج الطبيعي للصدر لمدة 15 دقيقة ، والمجموعة الثانية وهى المجموعة الضابطة والتي تلقت العلاج الطبيعي للصدر لمدة 15 دقيقة . وكانت مدة الجلسات ثلاث جلسات في اليوم لمدة ثلاث أيام . تم قياس معدل تشبع الدم الشرياني قبل بدأ العلاج وبعد الانتهاء منه . وقد أظهرت النتائج وجود تحسن ملحوظ في معدل أكسجين الدم الشرياني لدى المجموعتين ولكن هذا التحسن مع وجود تغيرات ذات دلالة إحصائية عالية في المجموعة الأولى التي تلقت التنفيخ اليدوي مع العلاج الطبيعي للصدر ، لذلك يوصى بإضافة التنفيخ اليدوي مع العلاج الطبيعي للصدر لدى مرضى جهاز التنفس الصناعي .