To Evaluate the Effect of Manual Hyperinflation on Lung Compliance and PaO2/FIO2 Ratio on Stable Ventilated Post Coronary Artery Surgery (CAS) Patient using Laerdal Circuit

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Abstract: ***Background & objectives**: The aim of this study was to assess the effect of Manual Hyperinflation on lung compliance and PaO2/FIO2 ratio on stable ventilated post coronary artery surgery (CAS) patient using laerdal circuit. **Patients and Methods**: Total number of 90 participants of both the gender with age group between 55 to 77 years, post - operative CABG patients were to be divided in to two groups i. e. group A (experimental group) and group B (control group). Study duration was 6 Months. Sampling techniques was Simple random sample techniques. All patients who consented to the study were ventilated post - operatively on ventilator. Postoperative data were collected, and the commencement of the study was done within 1 - 2 hours of the patient received in recovery room. Manual hyperinflation was delivered via laerdal circuit with attached self - inflating bag of 1.6 litre. A pressure cuff manometer was incorporated to ensure the pressure maintained below 40 cmH2O Patient was positioned supine with bed flat and suction was done to ensure there is no secretion present in the central airway, as this may interfere in the study results. Set of baseline measurement of dependent variable is taken and lung compliance is measured alongside ABG sampling. **Results**: There were improvement in Within group in both the groups for all the outcome measures between - group analysis showed that the experimental and control groups were different statistically in PaO2/FiO2 ratio and lung compliance with $F = 24.030$, $p<0.001$ and $F = 8.096$, $p < 0.001$. **Conclusion**: These results, together with observations of both groups, suggest that manual hyperinflation registers significant improvement in lung compliance and PaO2/FiO2 ratio.***

Keywords: Manual hyperinflation, lung compliance, and PaO2/FIO2 ratio, coronary artery surgery

1. Introduction

Coronary artery bypass graft (CABG) was first introduced in 1968. It is done in patients with severe coronary heart disease (CHD). [1] On a global scale, approximately 17.3 million people died of cardiovascular disease per year. A study conducted by WHO showed that approximately 80% of death in low income countries occurred due to cardiovascular disease and diabetes. [2]The ultimate broad goals of cardiopulmonary physical therapy treatment in the ICU includes prevention from any cardiopulmonary complications, having patient alert and oriented to person, time, and place, to make patient return to premorbid functional level to the greatest extent possible and to reduce morbidity, mortality and length of hospital stay. [3]Pulmonary dysfunction is a ubiquitous consequence of cardiac surgery [4]. Alterations in mechanical properties of the lung lead to reductions in pulmonary compliance [5] as well as vital and functional residual capacity (FRC) [6, 7] in the first days after surgery. these patients remain sedated and are nursed in a supine position for several hours, while they are rewarmed and weaned from mechanically ventilation. This may reduce mucociliary transport, and as such retention of sputum [8, 9]

Bronchopulmonary complications are very common challenge faced by physiotherapist after CABG. Most respiratory dysfunction occurs at 48 hours and are partially recovered by fifth day. [10] The changes in lung volumes, capacities, oxygen saturation and arterial blood gases are seen in intubated patients. [11] The lung capacities are reduced by 30 - 60% and remain reduced by 12% for up to one year. [12, 13]. The etiology behind the worsening of pulmonary function after CABG has multiple factors such as reduction in rib cage expansion capacity, poor coordination in chest wall motion, [14] phrenic nerve injury that leads to diaphragmatic dysfunction, accumulation of pleural fluid and basal atelectasis. [15] Dysfunction of respiratory muscles is also the contributing factor for pulmonary function reduction. After CABG, the patient must be intubated until the condition is stabilized. The intubated patients are at higher risk of mucus retention in airways due to presence of endotracheal tube, administered drugs, muscle weakness, body positioning, less humidification of respiratory gases and immobility of patient. [16, 17] The retention of these secretions leads to serious respiratory complications. [18]

In our setting, a frequently performed intervention as part of airway management of intubated and mechanically ventilated patients is manual hyperinflation (MH) [19 - 21]. MH aims at mobilization of retained airway secretions in intubated and mechanically ventilated patients, thereby preventing atelectasis [22]. With MH the patient is disconnected from the mechanical ventilator, after which the lungs are inflated via a resuscitation bag. The technique consists of several factors, including the application of a larger than normal breath (to 150% of the tidal volume delivered by the mechanical ventilator), the use of a slow inspiratory flow rate (achieved by a slow compression of the resuscitation bag), an inspiratory pause (allowing complete distribution of the inflated air among all the ventilated lung parts) and a high peak expiratory flow achieved by the rapid release of the resuscitation bag. It is imaginable that a higher expiratory than inspiratory flow promotes the outwardly directed motion of airway secretions [23]. Although mobilization of airway secretions and prevention of sputum plugging [24, 25], and improved alveolar recruitment [26] are cited as potential benefits of bagging, the evidence supporting its efficacy is lacking.

Despite the widespread use of the technique (Hodgson et al 1999, 2000) and many studies which have described both beneficial and detrimental effects of MH (Buchananand Baun 1986, Eales 1989, Eales et al 1995, Enright 1992, Jones et al 1992b, Ntoumenopoulos et al 1998, Paratz and Burns 1993, Singer et al 1994), a standardised regimen for delivery of MH has not been defined.

As some studies have reported detrimental effects from MH, such as barotrauma or haemodynamic instability, it is important to investigate the effects of the technique and its ability to achieve desired objectives.

Using a randomized controlled trial and a patient population of medically stable, ventilated post coronary artery surgery (CAS) patients, this study investigated whether MH achieved the objective of improving the lung function of intubated patients. Specifically, the study examined the effects of MH on lung compliance (CL) and pao2/fio2 ratio.

2. Materials and Methods

It was randomized control trial with sample size of 90 post - operative CABG patients. Study duration was 6 Months. Sampling techniques was Simple random sample techniques. Inclusion criteria was Intubated, hemodynamically andvitally stable both males and females with age range of 55 - 77 years. Exclusion criteria was any past medical history included conditions that may have influenced lung compliance, severe asthma, severe chronic airflow limitation (CAL), any diagnosed pulmonary pathology and patient with post - operative complications e. g pulmonary hypertension, prolonged bypass time and sepsis. Withdrawal criteria was any subject who have unstable cardiovascular status (systolic blood pressure [SBP] <100 or >180 mmHg or mean arterial pressure [MAP] <60 or >110 mmHg), arrhythmias which compromise cardiovascular function, presence of a pneumothorax, excessive blood loss from subcostal catheters (>100 ml/hour), high levels of respiratory support (fraction of inspired oxygen [FIO2] > 0.7 and positive end expiratory pressure [PEEP] >7.5 cmH20).

3. Procedure

All patients who consented to the study were ventilated post - operatively on particular ventilator PHILIPS V200. Postoperative data were collected, and the commencement of the study was done within 1 - 2 hours of the patient received in recovery room. Patient was positioned supine with bed flat and suction was done to ensure there is no secretion present in the central airway, as this may interfere in the study results. Set of baseline measurement of dependent variable is taken and lung compliance is measured alongside ABG sampling.

Intervention Group: A was then under - went, application of manual hyperinflation using laerdal circuit, after completion of which patient was reconnected to the ventilator on the pre requisite settings. Measurement of the dependent variable was taken immediately after the completion of the maneuver and 1 hour post the manure completion. The control Group: B had the same measurements of the dependent variables but did not receive MH or other physiotherapy intervention. They were maintained on same ventilator settings as they were prior for the same duration of manual hyperinflation.

Manual hyperinflation was performed in standardize manner as follows:

1) Throughout the measurement period patient was positioned supine with bed flat position.
2) Manual hyperinflation was carried out on same fio2 as it was on ventilator.
3) Manual hyperinflation was delivered via laerdal circuit with attached self - inflating bag of 1.6 litre. A pressure cuff manometer was incorporated to ensure the pressure maintained below 40 cmH2O.
4) MH was performed with an inspiratory pause of approximately two to three seconds and inspiratory to expiratory ratio of approximately 1: 2 utilizing a both - handed technique for around 3 - 4 cycle.

Outcomes measurement

Outcomes parameters i. e. Static compliance: were calculated using formula (Vt/Pplat - PEEP) and arterial oxygen to fraction of inspired oxygen ratio (PaO2/FIO2) were measured on baseline (before intervention), immediate after intervention and after 1 hours of intervention.

Statistical Analysis and Results

All statistical analyses were performed using the SPSS™ version 20.0. The comparisons were made between two groups, based on two outcome measurements at the Baseline, Immediate after intervention and post 1 hour after intervention. The present study is randomized controlled clinical trial with 2 different group (Group –A Experimental and Group - B Control). Data were presented as mean with standard deviation (SD). Descriptive statistics were used to summarize patient characteristics. Differences in PaO2/FiO2 and Static compliance at the different time points were compared by analysis of variance (ANOVA) for repeated measurements.

Eighty - five patients undergoing CAS surgery completed the study. The 85 patients were divided into intervention group of 42 and leftover 43 in control group. Five subjects were withdrawn from the study on the basis of withdrawal criteria (3 were extubated in OT and 2 were due to haemodynamic instability).

The comparison of change in PaO2/FiO2 at baseline,

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immediate after intervention and 1 hour after intervention between the group A and group B. The sample size for both group A (n=42) and group B (n=43).

Table 1: Descriptive Statistics of the Study

Variables	Group A	Group B
Gender	10 (F) and 32 (M)	14 (F) and 29 (M)
Age (MEAN)	63.35	58.97

Table 2: Within - Group Comparison Results with Interaction

Outcome Measure	F	P - value	Effect Size (Partial Eta Squared)
PaO2/FiO2	110.984	< 0.001	.572
Lung compliance	51.654	< 0.001	.384

Within group analysis shows improvement in both the groups for all the outcome measures. P value is <0.001 for all. It proves that PaO2/FiO2 ratio and lung compliance improve in both group with $F = 110.98$, $p<0.001$ and $F = 51.65$, $p < 0.001$.

Table 3: Between Group Comparison of Result

Outcome Measure	F	P - value	Effect Size (Partial Eta Squared)
PaO2/FiO2	24.030	< 0.001	.225
Lung compliance	8.096	< 0.001	.089

Between - group analysis showed that the experimental and control groups were different statistically in PaO2/FiO2 ratio and lung compliance with $F = 24.030$, $p<0.001$ and $F = 8.096$, $p < 0.001$.

4. Discussion

Manual hyperinflation is a commonly used technique in the management of critically ill, mechanically ventilated and intubated patients [19]. Mechanical ventilation causes movement of secretions from smaller to larger airways [33, 34], resulting in removal of secretions with airway suction [19]. The current study was conducted to determine the the effects of manual hyperinflation on lung compliance and pao2/fio2 ratio on stable ventilated post CAS patient using laerdal circuit.

We conducted a study to evaluate the effects of manual hyperinflation on lung compliance and pao2/fio2 ratio on stable ventilated post CAS patient using laerdal circuit.

There was significant improvement seen in lung compliance (CL) as seen in other studies (**Patman et al** 2000). the variation in result may be due to differences in the dose of MH applied (as there is no standardize dose of application of manual hyperinflation) and the type of MH circuit (laerdal circuit in this study), operator technique and operator characteristics, and patient type.

Improvement in lung compliance in the MH group may have been secondary to recruitment of more functioning alveolar units. The application of MH may utilize intercommunicating channels, or collateral ventilation within the lungs, to facilitate the mobilization of secretions and the recruitment of atelectatic lung units (**Anderson et al** 1979), thereby improving FRC.

Delivering an increased tidal volume via MH may generate adequate trans - pulmonary pressure gradients to overcome alveolar collapse. Maintenance of this gradient for an appropriate length of time, via an inspiratory hold during MH, may influence the distribution of ventilation, allow time for alveolar inflation or enlargement, as well as the recruitment or unfolding of interdependent collapsed alveoli.

The results in the present investigation revealed statistically significant change in selected oxygenation parameter PaO2/FiO2 value. The study carried out by **Patson et al.** also shows the improvement in spo2/fio2 ratio in 100 intubated patients. One more study by **Hodgson et al.** Results demonstrated significant improvement for Manual hyperinflation treatment in gas exchange (PaO2/FIO2 and PaCO2). These results go in hand to our results and signifying that MHI added to standard physiotherapy has a great effect on improvement of oxygenation.

In contrast to the above - mentioned positive findings, an investigation executed by **Paratz and Lipman** shows that there were no significant changes in pulmonary artery occlusion pressure, mean arterial pressure, or PaO2/FiO2 and arterial blood gases this may be due to the heamodynamic instability of this cases, in contrast to our study we selected the haemodynamicaly stable cases only so the results were so different than the above study.

The significant improvement than baseline is only seen at immediate calculation post intervention which gets subsided post 1 hour of calculation, where there is no significant change between two groups. Lung compliance improvements did not sustain might be due to the returning of the patients on the pre requisite ventilator settings providing same tidal volume.

5. Conclusion

This study was conducted to evaluate the effect of Manual Hyperinflation on lung compliance and PaO2/FIO2 ratio on stable ventilated post coronary artery surgery (CAS) patient using laerdal circuit.
These results, together with observations of both groups, suggest that manual hyperinflation registers significant improvement in lung compliance and PaO2/FiO2 ratio.

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