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Effects of Manual Hyperinflation and Suction on Lung Compliance in Ventilated Patients in Different Positions

[1]*Eslam H. Abd El-Rhman,* [2]*Mohamed A, Shendy and* [3]*Ahmed H, Abd El- Rhman*

[1]Department of Physical Therapy Benha Insurance Hospital, Benha, Egypt
[2]Department of Physical Therapy for Cardiopulmonary Disorders and Geriatrics,
Faculty of Physical Therapy, CairoUniversity, Giza, Egypt
[3]Department of Anesthesia & Intensive Care Unit,
Faculty of Medicine, Benha University, Benha, Egypt

Abstract: Ventilated patients have a high risk of developing ventilator associated Pneumonia through aspiration of contaminated secretions into the lower airway or by bacterial colonization of the airways. Lung compliance is considered an important clinical parameter in ventilated patients and may also be a clinical predictor of mortality in patients with significant respiratory failure. The aim of the current study was established to show the efficacy of manual hyperinflation (MHI) and suction on Lung compliance in ventilated patients in different body positions. Fifty ventilated patients their age ranged from 30-65 years old. The subjects were divided into three groups, group A formed of 20 patient received manual hyperinflation only in different position, group B formed of 20 patient received suction only in different position and group C formed of 10 patient received manual hyperinflation with and without suction in different position. The mean values of lung compliance (LC) in group A and group B were non –significant between different position. But in group C the mean values were significantly increased from (35.65±7.43) to (45.89±4.52) at supine and from (37.85±4.91) to (50.61±6.33) in head down position. It is suggested that applying manual hyperinflation plus suction produce significant improvement in static lung compliance with head down position rather than manual hyperinflation alone and there was non-significant improvement in static lung compliance after suction alone in different body position.

Key words: Manual Hyperinflation · Lung Compliance · Suction · Positions

INTRODUCTION

Manual hyperinflation (MH) is one of a number of techniques which provides a greater than baseline tidal volume to the lungs. It is frequently used by physiotherapists in the treatment of intubated mechanically ventilated patients. With the aim of increasing alveolar oxygenation, recruiting atelectasis or mobilizing pulmonary secretions [1]. Physiotherapists use manual hyperinflation as a treatment for the recruitment of collapsed lung mobilization of excess pulmonary secretions [2]. Intubated and ventilated patients usually require regular respiratory physiotherapy to minimize secretion retention, maximize oxygenation and reexpand atelectic lung segments [3]. Respiratory physiotherapy is used in mechanically ventilated patients, for both those who are intubated and those with tracheostomies. It consists of a set of techniques for mobilizing and eliminating pulmonary secretions as a means of providing improved conditions for adequate pulmonary ventilation. This is through re-expansion of pulmonary atelectasis, increased pulmonary compliance and expiratory flow rates and reduced pulmonary complications [4]. Secretion clearance is an important outcome of MHI. Flow rates generated during MHI are also of significance as they influence secretion clearance. As MHI delivers increased tidal volumes (TVs) it may cause large fluctuations in intrathoracic pressure and could potentially cause significant haemodynamic changes [5]. Respiratory physiotherapy is designed to enhance sputum clearance and reduce the occurrence of lung complications [6]. Frequent removal of sputum from the airways via tracheal suctioning is mandatory in critically ill intubated and mechanically ventilated

Corresponding Author: Eslam Hamdy Abd El-Rhman, Benha Insurance Hospital, Benha, Egypt.
E-mail: dr_semsem_2001@yahoo.com.

patients. Under normal conditions, mucociliary transport clears the smaller airways of airway secretions. Secretions that are transported from the smaller airways into the bronchi and trachea then are removed by coughing. Critically ill patients, however, are frequently sedated and nursed in a supine position, potentially reducing mucociliary transport and promoting retention of airway secretions [7]. The extent to which the lungs will expand for each unit increase in transpulmonary pressure (if enough time is allowed to reach equilibrium) is called the lung compliance. The total compliance of both lungs together in the normal adult human being averages about 200 milliliters of air per centimeter of water transpulmonary pressure. That is, every time the transpulmonary pressure increases 1 centimeter of water, the lung volume will expand 200 milliliters [8]. The elastic behavior of the lung is often analyzed in terms of compliance, which is the inverse of elastance. Thus, compliance is expressed as change in lung volume divided by the change in pressure required to cause the increment in volume (or the decrease in pressure that is accompanying a decrement in volume). Normal lung compliance is around 0.2 to 0.3 L/cm H2O [9]. Lung compliance is considered an important clinical parameter in ventilated patients and may also be a clinical predictor of mortality in patients with significant respiratory failure [10]. Static lung compliance was calculated by use of the formula VT / IP – PEEP, where VT is tidal volume, IP is inspiratory pressure and PEEP is positive end expiratory pressure [11]. Positioning means the use of body position as a specific treatment technique. Positioning for ICU patients can be used with the physiological aims of optimizing oxygen transport through its effects of improving ventilation/perfusion (V/Q) matching, increasing lung volumes, reducing the work of breathing, minimizing the work of the heart and enhancing mucociliary clearance [12]. A specific body position, the duration of time within a body position, or body position change can adversely affect oxygen transport in patients, particularly those who are very young or old, obese, or critically ill. Thus, body position and body position changes need to be considered to enhance oxygen transport and oxygenation and moving secretions [13].

MATERIALS AND METHODS

Subjects Characteristics and General Experimental Design

Study Subjects: Fifty patients (both sexes) selected from Benha insurance hospital (intensive care unit), their age ranged from 30-65 years. All patients were hemodynamically stable; temperature (36.2-37.5) 0C, heart rate (60-100) pulse/minute, blood pressure (120-140/60-90) mmHg and respiratory rate (12-20) breath/minute. All patients recruited to this study were ventilated by DRAGER "evita 2dura" ventilator. Measurement of static compliance is accomplished at zero flow; all patients received the same technique in changing position. Patients were to be withdrawn from the study if they suffered cardiovascular compromise during the treatment as defined by the variables.

Evaluated and Training Parameters: A mechanical ventilator DRAGER "evita 2dura", made in Germany detect static lung compliance (LCs) directly, Manual resuscitation bag (circuit locked at pressure = 40 cmH2o) and Suction Apparatus used during the procedure.

Patients were divided to three groups, group A formed of 20 patients received manual hyperinflation only in different positions, group B formed of 20 patients received suction only in different positions and group C formed of 10 patients received manual hyperinflation with and without suction in different positions. Conservative physical therapy program (Circulatory exercises, Percussion and vibrations) was done for five minuets to all patients.

Manual Hyperinflation and Lung Compliance: At morning, the patient placed in supine, five readings of lung compliance (CL) Collected, the average calculated before starting. The resuscitation circuit was attached to the oxygen flow meter and set the oxygen at 10L/min. We ensured the circuit would not be faulty. The patient was disconnected from the ventilator, the resuscitation bag circuit attached to the filter and attached to the patient endotracheal airway. The hyperinflation breaths with a slow inspiration for three seconds duration, three seconds end inspiratory pause (hold); during which the bag was compressed, slow deep breaths and hold maximizes collateral ventilation followed by uninterrupted expiration; quick release of the bag increases the expiratory phase to mobilize secretions up to the bronchial tree [14]. The patients was received 10 minutes at rate of 8 to 13 breaths/min of manual hyperinflation as one shot using bag valve resuscitation circuit connected to a flow of 10 L/min and was used to deliver an inspiratory pressure of 40 cmH2O. Five readings of lung compliance Collected then the average calculated. The previous procedure was done in the second and third day after the patient was put in side lying and head down tilt position for 20 minutes respectively.

Suction and Lung Compliance: At morning the patient placed in supine five readings of lung compliance (CL) Collected and the average calculated before intervention. Making suction from the endotracheal tube and upper airways, the average of lung compliance (CL) calculated at this position. The previous procedure was done in the second and third day after the patient was put in side lying and head down tilt position for 20 minutes respectively.

Manual Hyperinflation with Suction Procedure: Manual hyperinflation followed by suction was done in supine and head down positions on 10 patients as the previous procedures.

Statistical Analysis: The mean values of LC obtained before and after the procedure in all groups were compared using the paired ''t'' test. ($P < 0.05$). And repeated measure ANOVA and Post hoc test was done within the group to detect significance difference between variables.

RESULTS

The study involved 50 mechanically ventilated patients their mean age (50.60±10.68) years. They were divided to three groups, group A formed of 20 patient were received MHI only in different position, group B formed of 20 patient were received suction only in different position and group C formed of 10 patient were received MHI with and without suction in different position in order to show the efficacy of MHI and suctioning on LC in different positions. in group A (Table1) detect the group means and Std. Deviation for LC and (Table2) represented significant difference in LC before (37.23±4.87) and after MHI in supine (45.89±4.52), side lying (44.90±4.02) and head down position (46.69±3.96) and there was non significance difference in LC after MHI between different positions as p-value was ($P>0.05$).

In group B (Table 3) detect the group means and Std. Deviation for LC and (Table 4) represented non-significant difference in LC before (35.16±9.25) and after suction in supine (36.16±8.80), side lying (37.53±9.27) and head down position (38.06±8.76).

Table 1: Mean and SD of LC after MHI.

	Lung compliance *(mL/CmH2o)*					
	N	Minimum	Maximum	Mean		SD
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
Before MHI	20	28.60	45	37.23	1.09	4.87
MHI in supine	20	36	53.2	45.89	1.01	4.52
MHI in side lying	20	36.5	50.6	44.90	0.89	4.02
MHI in head down	20	39.45	52	46.69	.0.88	3.96

Table 2: Post hoc test of the lung compliance before and after MHI in different body positions

Comparison	Mean Difference(+)	t-value	P-value	S
Before MHI vs. MHI in supine	8.66	5.8	0.0000010	S
Before MHI vs. MHI in side lying	7.67	5.4	0.000003	S
Before MHI vs. MHI in head down	9.46	6.7	0.0000006	S
MHI in supine vs. MHI in side lying	0.99	0.73	0.468	NS
MHI in supine vs. MHI in head down	0.8	0.59	0.554	NS
MHI in side lying vs. MHI in head down	1.79	1.4	0.163	NS

P-value: Probability Level NS: Non significance S: significance

Table 3: Mean and SD of LC after suction

	Lung compliance *(mL/CmH2o)*					
	N	Minimum	Maximum	Mean		SD
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
Before suction	20	20	55.7	35.16	2.06	9.25
suction in supine	20	23.5	56	36.16	1.96	8.80
suction in side lying	20	25	58	37.53	2.07	9.27
suction in head down	20	26.5	58.5	38.06	1.95	8.76

Table 4: Post hoc test of the lung compliance before and after suction in different body positions.

Comparison	Mean Difference(+)	t-value	P-value	S
Before suction vs. suction in supine	0.16	0.35	0.72	NS
Before suction vs. suction in side lying	2.37	0.80	0.42	NS
Before suction vs. suction in head down	2.90	1.07	0.31	NS
suction in supine vs. suction in side lying	1.37	0.47	0.63	NS
suction in supine vs. suction in head down	1.9	0.68	0.49	NS
suction in side lying vs. suction in head down	0.53	0.18	0.85	NS

Table 5: Mean and SD of LC after MHI with and without suction

	Lung compliance *(mL/CmH2o)*					
	N	Minimum	Maximum	Mean		SD
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
After MHI only in supine	10	24.5	50.2	35.65	2.35	7.43
MHI+ suction in supine	10	32.5	60	43.94	2.83	8.97
After MHI only in head down	10	29.5	45	37.85	1.55	4.91
MHI+ suction in head down position	10	40.5	63.5	50.61	2.0	6.33

Table 6: Post hoc test of the lung compliance before and after MHI+ suction in different body positions

Comparison	Mean Difference(+)	t-value	P-value	S	% of Improvement
After MHI only in supine vs. MHI+ suction in supine	8.29	2.24	0.03	S	19.06 %
After MHI only in head down vs. MHI+ suction in head down	12.76	5.03	0.00009	S	25.21 %

In group C (Table 5) detect the group means and Std. Deviation for LC after manual hyperinflation with and without suction. And (Table 6) reported a significant Improvement between LC after MHI only (35.65±7.43), (37.85±4.91) and after MHI with suction (43.94±8.97), (50.61±6.33) in supine and head down position respectively.

DISCUSSION

The aim of this study was to evaluate the efficacy of MHI and suction on LC in mechanically ventilated patients in different positions. The mean values of LC were significantly increased in group A with non significant between positions. Also in group B mean values were non significant with suction in different positions but in group C the results revealed significant increase of mean values of LC between MHI only and after applying MHI plus suction within all subjects in different positions. The aim of lung hyperinflation was to re-expand atelectatic lung to mobilize secretions and to prevent or reduce the incidence of nosocomial pneumonia in intubated patients [15].

These results supported by Jones [16] who found that Static lung compliance (CL) improved immediately after manual hyperinflation and the improvement has been maintained at 30 minutes after intervention. The mean CL of the respiratory system has increased by 22% immediately after manual hyperinflation plus suction from 35.2 (SD 4.9) to 43.1 (SD 6.4) ml/cmH2O. This has been maintained at 30 minutes after intervention. In fact, post suctioning CL changes have not been significant, since there was no difference in CL between the group pre-intervention levels. But the CL immediately and at 30 minutes after manual hyperinflation plus suction has been significantly higher than suction. Improvement by 22% in CL is comparable to those of 16 % [7, 18] and 30% [15] reported by other workers in mechanically ventilated patients.

Another study supported this research found that Static pulmonary compliance improved significantly following manual hyperinflation with addition of a head-down tilt to physiotherapy treatment. Static pulmonary compliance was measured before and immediately following physiotherapy treatment. There was a significant increase in peak expiratory flow ($p < 0.001$) in the head-down tilt position. Static pulmonary compliance improved significantly following physiotherapy treatment ($p = 0.003$). The mean difference and 95% confidence intervals pre- and post-treatment for static pulmonary compliance were 5.18 (2.14 to 8.22) ml/cmH2O. So, Berney et al. [19] suggested that addition of a head-down tilt to physiotherapy treatment, including manual hyperinflation, in patients who were intubated and ventilated, increased sputum production and improved peak expiratory flow.

Patman *et al*. [18] found that lung compliance improved remarkably immediately after intervention by 6.29ml/cmH2O (16%) in the MHI group. Compliance improved by 3.07 ml/cmH2O (8%) at 15 minutes in the MHI group, but remained above baseline by 3.07 ml/cmH2O (8%) at 60 minutes after intervention, while varying very little over time in the non-MHI group. The improvement recorded at one hour after intervention in the MHI group was 2.09 ml/cmH2O (5%).Significant difference in lung compliance has been found between groups. However, the changes in lung compliance over time were not significant. Compared to a baseline, a mean improvement of approximately 6ml/cm H2o (15%) has been produced after MHI.

Lung compliance increased when inspiratory time was prolonged during mechanical ventilation and a sustained deep inflation 'likely to occur during bagging' might cause re-expansion and an increased compliance. The application of manual hyperinflation with a larger than normal tidal volume breath together with an inspiratory pause adopted in this study may have facilitated collateral ventilation and effective recruitment of alveoli, thereby improving the time-dependent elastic behaviour of the lung. There was also a possibility that the manual hyperinflation technique was effective in Mobilizing of pulmonary secretions from peripheral to central airways, which were subsequently removed with suctioning, thereby leading to further recruitment of more functional alveolar units [19].

These findings are in agreement with Choi and Jones [20] suggested that tracheal suction alone was not accompanied by adverse effects and manual hyperinflation plus suction improved lung compliance by more than 20%. These improved respiratory mechanics suggest manual hyperinflation plus suction may be an effective intervention to improve the lung function of patients. This during their study on group of patients with ventilator associated Pneumonia.

CONCLUSION

In summary, Applying manual hyperinflation plus suction produce significant improvement in LC with head down position rather than manual hyperinflation alone and there was no improvement in static lung compliance after suction alone in different body position.

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