International Journal of Multidisciplinary Research and Development
Online ISSN: 2349-4182, Print ISSN: 2349-5979, Impact Factor: RJIF 5.72
www.allsubjectjournal.com
Volume 4; Issue 6; June 2017; Page No. 51-56

Acute response of manual hyperinflation versus ventilator hyperinflation in addition to chest physiotherapy on critically ill mechanically ventilated patients

[*1] Dr. Tejashree V Bhoir, [2] Dr. Atharuddin Kazi, [3] Dr. Akshaya shetty, [4] Dr. Sambhaji Gunjal, [5] Dr. Maria W Lamuvel, [6] Dr. Sneha Chordiya

[1, 6] Postgraduate Student, Department of Cardio-Respiratory Physiotherapy, Dr. A.P.J Abdul Kalam College of Physiotherapy, Loni, Maharashtra, Indiap

[2] Associate Professor, Department of Cardio-Respiratory Physiotherapy, Dr. A.P.J Abdul Kalam College of Physiotherapy, Loni, Maharashtra, India

[3] Associate Professor, Intensivist, Critical Care Incharge, Pravara Institute of Medical Science, Loni, Maharashtra, India

[4, 5] Assistant Professor, Department of Cardio-Respiratory Physiotherapy, Dr. A.P.J Abdul Kalam College of Physiotherapy, Loni, Maharashtra, India

Abstract

Background: Mechanically ventilated patients usually present with larger amounts of pulmonary secretions because of impairment in mucociliary function and mucus transport. This can lead to pulmonary complications.

Aims: To assess the acute response of MHI versus VHI in addition to chest physiotherapy on PaO2, PaCO2, PaO2/FiO2 ratio, and Compliance and sputum quantity in critically ill mechanically ventilated patients.

Methods and Material: An experimental prospective comparative study was done. 30 participants between age groups of 20-60 years were included in the study and divided into two groups: Group A received MHI and chest physiotherapy & Group B received VHI and chest physiotherapy. Data was recorded in which sputum quantity was taken immediately after intervention and PaO2, PaCO2, PaO2/FiO2 ratio, Compliance were measured after 20 min of intervention and analyzed by paired t test and Kolmogorov Smirnov test.

Results: The result showed that there was significant difference within the group but no significant difference (p=0.08) between the groups in the PaO2, PaCO2, PaO2/FiO2 ratio, and Compliance value after 20 min of intervention and there was no significant difference (p=0.08) in sputum quantity immediate after the intervention.

Conclusion: The present study concludes that both manual hyperinflation and ventilator hyperinflation along with chest physiotherapy are equally better and effective in improving oxygenation, PaO2/FiO2 ratio, pulmonary compliance and lead to early extubation of patients. Further it states that there is no significant difference between MHI and VHI.

Keywords: chest physiotherapy, manual hyperinflation (MHI), ventilator hyperinflation (VHI), PaO2, PaO2/FiO2 ratio, and compliance.

Introduction

Intensive care is a dynamic environment where physiotherapists are vital members of the multidisciplinary team providing a spectrum of care from acute respiratory to rehabilitation [1]. The definition of critical illness has been approached by investigators and clinicians from a number of perspectives. The clinician recognizes the patient with critical illness from a broad clinical view as a patient who has survived acute critical illness or injury but has not yet recovered to the point of liberation from life sustaining therapies. The patient is weak, deconditioned, usually delirious or comatose, and receiving prolonged mechanical ventilation (PMV) [2]. Advances in the management of intensive care unit (ICU) patients have improved outcomes and survival rates for this population. However, as patients survive acute illness, long-term complications are more apparent [3]. A feasible approach to prevent complications is the use of physical therapy techniques in these critically ill patients [4].

In most hospitals, in the developed countries, physiotherapy is seen as an integral part of the management of patients in ICUs. The precise role that Physiotherapists play in the ICU varies considerably from one unit to the next, depending on factors such as the country in which the ICU is located, local tradition, staffing levels, training and expertise. The referral process is one example of this variation, whereby in some ICUs, Physiotherapists assess all patients, whereas in other ICUs, patients are seen only after referral from medical staff [5]. The most common techniques used by Physiotherapists in the ICU are modified positioning, mobilization, manual hyperinflation (MHI), percussion, vibrations, suctioning, coughing and various breathing exercises [6–12]. Some Physiotherapists routinely treat most, if not all, ICU patients with a combination of these techniques, regardless of the patient's underlying pathophysiologic condition, with the intention of preventing pulmonary complications, whereas other Physiotherapists use such techniques selectively when they believe they are specifically indicated [5].

Manual hyperinflation is most commonly used as a treatment technique in the management of intubated patients [13]. It is performed by delivering a large tidal volume combined with an inspiratory plateau and a fast release of the resuscitation bag [14]. The effectiveness of MHI in improving oxygenation and pulmonary compliance, re-expanding areas of atelectasis, and clearing pulmonary secretions has been widely demonstrated [1, 15]. However, there is controversy in whether patients ventilated on high levels of positive end-expiratory pressure (PEEP) should be disconnected from the ventilator to receive MHI, because disconnection would cause loss of functional residual capacity (FRC), decrease in oxygenation and shear stress of distal lung units [16-18]. To prevent adverse effects of disconnection, the ventilator may be used to deliver increased tidal volume, a technique called ventilator hyperinflation (VHI).

Ventilator hyperinflation was originally described by Berney and Denehy as an alternative to manual hyperinflation, involving manipulation of ventilator settings, specifically respiratory rate, tidal volume and inspiratory flow, wave form and inspiratory pause to achieve a peak airway pressure of 40 cm H_2O, for six sets of six breaths.[1] Subsequent clinical studies have demonstrated that ventilator hyperinflation is safe with minimal risks and as effective as manual hyperinflation in sputum clearance and other respiratory parameters such as lung compliance and oxygenation [1, 19, 20-23]. However, VHI is not widely used and the lack of training is the most common barrier [23].

Chest physiotherapy is one of the most frequently performed interventions in the intensive care units. There are many physiological reasons that a patient in ICU may benefit from physiotherapy treatment. These include mucociliary dysfunction, altered lung volumes when patients are mechanically ventilated, increased pulmonary shunt, the effects of neuromuscular weakness on respiratory flows, increased risk of nosocomial pneumonia. So far, chest physiotherapy has been recognized as an important aspect to achieve successful weaning from the ventilator [24]. Indeed, lack or reduction of the cough reflex in an intubated patient may be associated with retention of bronchial secretions and the risk of pulmonary infection [8, 25]. The use of devices to increase the clearance of bronchial secretions are generally not considered in the early phase of treatment, as these techniques require substantial co-operation from the patient [26].

There was a research done on the acute response of manual hyperinflation in addition to standard chest physiotherapy on critically ill mechanically ventilated patients and they concluded that 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 [30]. In another study carried out on the comparison of the effects of manual and ventilator hyperinflation on static lung compliance and sputum production in intubated and ventilated intensive care patients and they concluded that, hyperinflation as part of a physiotherapy treatment can be performed with equal benefit using either a manual resuscitation circuit or a ventilator. Both methods of hyperinflation improve static pulmonary compliance and clear similar volumes of pulmonary secretions [31]. Therefore the present study has been under taken to evaluate acute response of manual hyperinflation versus ventilator hyperinflation in addition to chest physiotherapy on critically ill mechanically ventilated patients.

Materials and methods

An Experimental Prospective Comparative study was conducted on thirty participants (n=30, 25 male and 15 female) using simple random sampling. Ethical approval was obtained from Institutional Ethical Committee Ref.no. PIMS/CPT/ICE/2016/16557. Participants who were critically ill mechanically ventilated with the age group of 20-60 years were included according to inclusion and exclusion criteria and were allotted to group A (MHI and Chest PT) and group B (VHI and Chest PT) respectively. The intervention was given daily. The session period lasted for 30-45 min for each participant. Manual hyperinflation technique and ventilator hyperinflation technique along with chest physiotherapy were given for the respective group.

The inclusion criteria included both male and female participants, aged between 20 to 60 years, and those who were critically ill and mechanically ventilated. In Exclusion criteria, participants excluded were those with haemodynamically instability, having acute respiratory distress syndrome, Chest trauma, undrained pneumothorax or acute exacerbation of chronic obstructive pulmonary disease, acute pulmonary oedema and with fraction of inspired oxygen (FiO_2) > 0.8 and Positive end expiratory pressure (PEEP) > 10 cm H_2O.

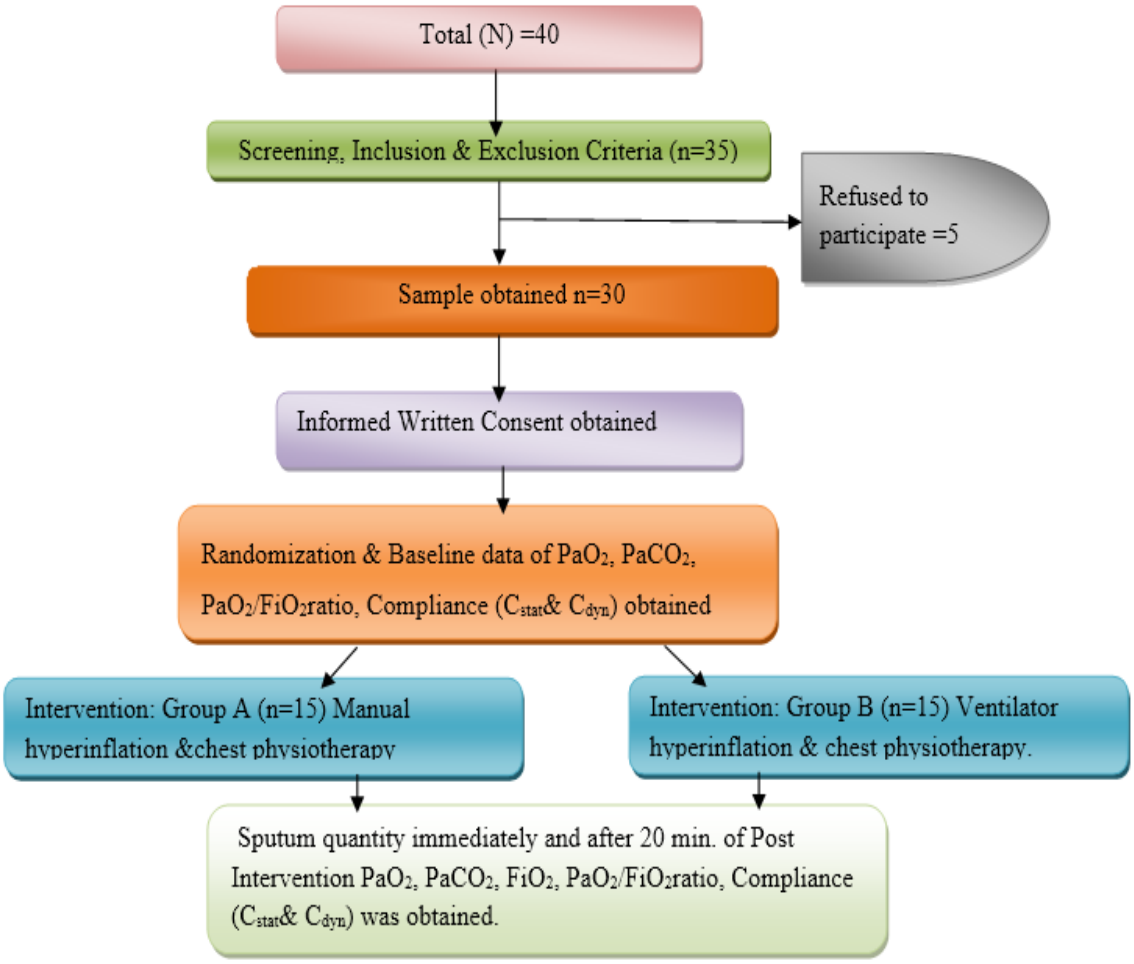

Fig 1: Flow chart representing the procedure.

Outcome Measures

1. Arterial blood gases: Partial pressure arterial oxygen (PaO_2), Partial pressure arterial carbon dioxide ($PaCO_2$),
2. Partial pressure arterial oxygen/ Fraction of inspired oxygen(PaO_2/FiO_2 ratio)
3. Compliance:

A. Static compliance (C_{stat}): Normal static compliance is 50-100 ml/cm H_2O.

$$C_{stat} = \frac{V_T}{P_{plat} - PEEP}$$

B. Dynamic compliance (C_{dyn}): Normal dynamic compliance is 50-80 ml/cm H_2O.

$$C_{dyn} = \frac{V_T}{PIP - PEEP}$$

4. Sputum quantity:

Data analysis and results

Data collected was analysed using SPSS version 20 (IBM SPSS Statistics Inc., Chicago, Illinois, USA) of Windows software program. The variables were assessed for normality using the Kolmogorov Smirnov test. Descriptive statistics included computation of means and standard deviations and $p < 0.05$ is considered as level of significance. Student's Paired' test and Unpaired' test was applied to analyze the data.

Arterial blood gases were calculated using post intervention data in both the groups (Table & Fig no.2)**.** The mean difference for PaO_2 and $PaCO_2$ in group A and group B after intervention was 131.13±38.88 and 123.66±40.85, 32.66±6.33 and 42.33±18.84, respectively.

PaO_2/FiO_2 ratio was calculated using post intervention data in both the groups (Table & Fig no.2)**.** The mean difference for PaO_2/FiO_2 ratio in group A was 337.80±112.60 and group B was 306.07±117.07.

Compliance was calculated using post intervention data in both the groups (Table & Fig no.2)**.** The mean difference for C_{stat} and C_{dyn} in group A and group B after intervention was 131.13±38.88 and 123.66±40.85, 32.66±6.33 and 42.33±18.84, respectively.

Sputum Quantity was calculated using post intervention data in both the groups (Table & Fig no.3)**.** The mean difference for sputum quantity in group A was 23.6±3.39 and group B was21.86±1.64

Discussion

The result of the present study suggests that, the ABGs values (PaO_2, $PaCO_2$), Compliance (C_{stat} & C_{dyn}) & PaO_2/FiO_2 ratio

were highly significant in pre and post intervention within the group. But, there was no significant difference in ABG values (PaO_2, $PaCO_2$), Compliance (C_{stat} & C_{dyn}), PaO_2/FiO_2 ratio taken after the 20 min of intervention and sputum quantity taken immediately between the group when post intervention values were compared of group A and B.

Arterial blood gas values (PaO_2, $PaCO_2$) and PaO_2/FiO_2 Ratio

The results in the present investigation revealed statistically significant changes in selected oxygenation parameters (PaO_2, $PaCO_2$, PaO_2/FiO_2 ratio). These benefits might have resulted from recruitment of alveoli, manual hyperinflation and ventilator hyperinflation which opens collateral channels within the lungs, which could theoretically recruit atelectatic lung regions and facilitate secretion mobilization, improvement in gas transfer in the lung and improvement in the ventilation perfusion matching.

The study conducted by Patman *et al*., revealed that when manual hyperinflation alone was used as an intervention versus no hyperinflation on 100 intubated patients, the study results exhibited great enhancement in PaO_2/FiO_2 ratio and alveolar-arterial oxygen gradient in all cases of the MHI group [27] and Maxwell And Ellis, concluded that manual hyperinflation can be used as a supplement to conventional mechanical ventilation to transiently improve oxygenation of patients with lung injury,[28] similar results were found in the present study which shows improvement in the oxygenation and improvement of PaO_2/FiO_2 in all cases after MHI intervention in critically ill mechanically ventilated patients.

Lung compliance

There is no significant difference between the groups. It states that the lung compliance was same in group B as compared to group A. Lung compliance escalated when inspiratory time was prolonged during mechanical ventilation and a sustained deep inflation 'likely to occur during bagging', it might cause re-expansion and an increased in compliance. The application of MHI and VHI with a larger than normal tidal volume breath together with an inspiratory pause, adopted in this study, may have facilitated the collateral ventilation and effective recruitment of alveoli, thereby improving the time-dependent elastic behavior of the lung. There is also possibility that the MHI and VHI technique was effective in mobilizing pulmonary secretions from peripheral to central airways, which were subsequently removed with the suctioning, thereby leading to further recruitment of more functional alveolar units [29].

Sputum quantity

Sputum quantity the mean difference of these two groups after the intervention confirmed that there is no significant difference between the groups. It states that the sputum quantity was same in group B as compared to group A.

The study done by Berney S *et al*. On comparison of the effect of manual and ventilator hyperinflation on static lung compliance and sputum production in intubated and ventilated intensive care patients and the study results showed that both the method of hyperinflation improve static pulmonary compliance and clear similar volumes of pulmonary secretions.[31] In the present study same effects were found in static pulmonary compliance and sputum quantity in both groups of MHI and VHI in critically ill mechanical ventilated patients.

The study conducted by Dennis D *et al*. On ventilator versus manual hyperinflation in clearing sputum in ventilated intensive care unit patients revealed that there was no difference in wet weight of sputum cleared using ventilator hyperinflation or manual hyperinflation (mean 3.2 g, p=0.989). Further, no difference in compliance (p=0.823) was detected. Physiotherapy using ventilator hyperinflation cleared a comparable amount of sputum and was as safe as manual hyperinflation.[20] Similar results are found in the present study which showed that there was no difference in compliance and sputum quantity after VHI and MHI in addition to chest physiotherapy techniques in critically ill mechanical ventilated patients.

Conclusion

The present study concludes that both manual hyperinflation and ventilator hyperinflation along with chest physiotherapy are equally better and effective in improving oxygenation, PaO_2/FiO_2 ratio, pulmonary compliance and it lead to early extubation of patients. Further it states that there is no significant difference between MHI and VHI.

Limitation of Study

The study has considered only the immediate effect of manual hyperinflation and ventilator hyperinflation.

Suggestion for future research

Future research should be done with more focus on the long term effect of manual hyperinflation and ventilator hyperinflation along with chest physiotherapy.

Table 1: Data represent comparison of post-procedure parameter of the groups A & B

	Groups	Mean	Std. Deviation	Mean differences	p value and Results
PaO_2(mmHg)	A	131.13	38.88	7.46	0.61(Not significant)
	B	123.66	40.85		
$PaCO_2$(mmHg)	A	32.66	6.33	9.66	0.07(Not significant)
	B	42.33	18.84		
PaO_2/FiO_2	A	337.8	122.06	31.73	0.47(Not significant)
	B	306.06	117.07		
C_{stat} (ml/H_2O)	A	35.33	16.64	1.1	0.84(Not significant)
	B	36.46	14.36		
C_{dyn} (ml/H_2O)	A	27.53	13.705	0.06	0.98(Not significant)
	B	27.46	8.64		

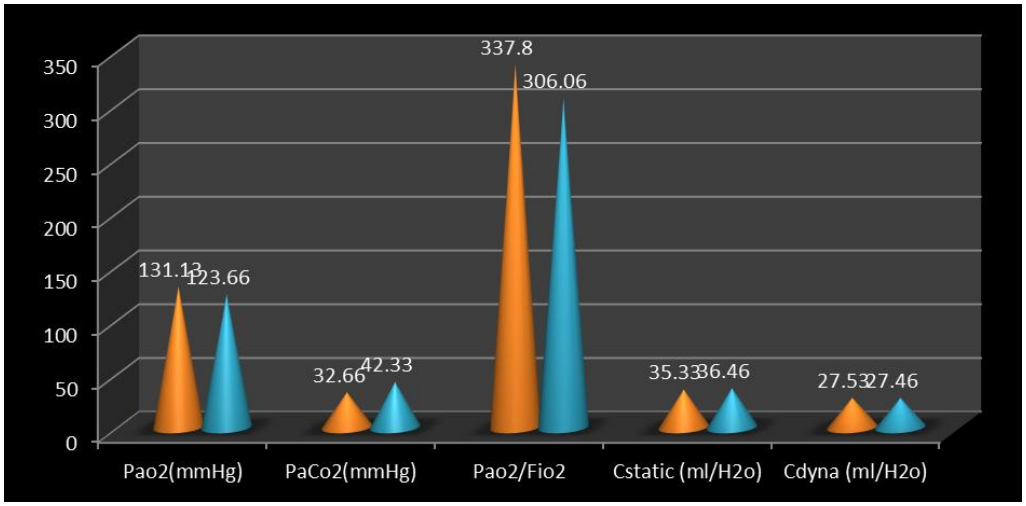

Fig 2: Represent comparison of post-procedure parameter of the groups A& B.

Table 2: Data represent sputum quantity-between the groups A & B

Groups	Mean	Std. Deviation	Mean differences	P value and Results
A	23.6	3.39	1.73	0.08 (Not significant)
B	21.86	1.64		

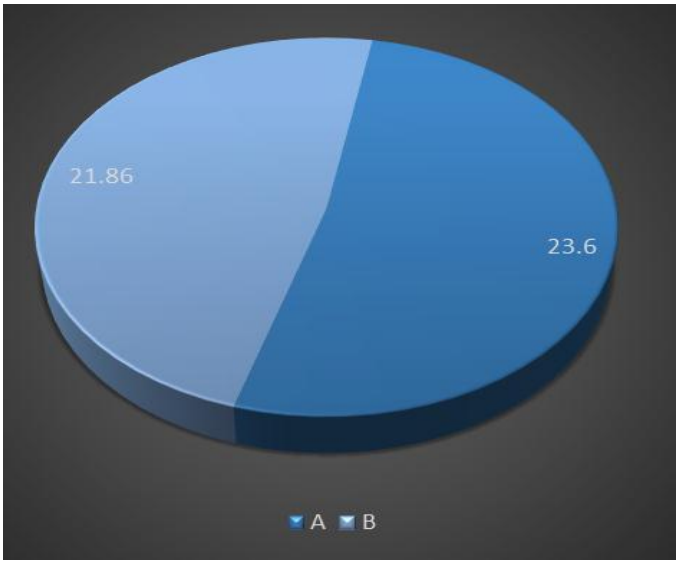

Fig 3: Represent Sputum quantity-between the groups A & B

References

1. Denehy L, berney S. physiotherapy in intensive care unit Physical Therapy Reviews. 2006; (11):49-56.
2. Carson S, Definitions and Epidemiology of the Chronically Critically Ill, Respiratory care, 2012; 57(6):848-56.
3. Schweickert W, Pohlman M, Pohlman A. Early physical and occupational therapy in mechanically ventilated, critically ill patients. The Lancet. 2009; 373:1874-82.
4. Bailey P, George T, Vick S. Early activity is feasible and safe in respiratory failure patients. Crit Care Med 2007; 35:139-45.
5. Van Aswegen H, Potterton J. A pilot survey of the current scope of practice of South African Physiotherapists in Intensive Care Units. South Afr J Physiother 2000; 61(1):17-21.
6. Jones AYM, Hutchinson RC, Oh TE. Chest physiotherapy practice in intensive care units in Australia, the UK and Hong Kong. Physiother Theory Pract. 1992; 8:39-47.
7. Daber SE, Jackson SE. Role of the physiotherapist in the intensive care unit. Intensive Care Nurs. 1987; 3:165-171.
8. Judson MA, Sahn SA. Mobilization of secretions in ICU patients. Respir Care. 1994; 39:213-226.
9. Singer M, Vermaat J, Hall G *et al*. Hemodynamic effects of manual hyperinflation in critically ill mechanically ventilated patients. Chest. 1994; 106:1182-1187.
10. Ciesla ND. Chest physical therapy for patients in the intensive care unit. Phys Ther. 1996; 76:609-625.
11. King J, Crowe J. Mobilization practices in Canadian critical care units. Physiother Can. 1998; 50:206-211.
12. Hodgson C, Carroll S, Denehy L. A survey of manual hyperinflation in Australian hospitals. Aust J Physiother. 1999; 45:185-193.
13. Tan I, Oh T. Mechanical ventilatory support. In: Oh T, ed. Intensive Care Manual. 4th Ed. Oxford, Butterworth Heinemann, 1997, 246.
14. Clement A, Hubsch S. Chest physiotherapy by the bag squeezing method: a guide to technique. Physiotherapy. 1968; 54(10):355-9.
15. Paratz J, Lipman J, McAuliffe M. Effect of manual hyperinflation on hemodynamics, gas exchange, and respiratory mechanics in ventilated patients. J Intensive Care Med. 2002; 17(6):317-24.
16. Hedenstierna G, Tokics L, Lundquist H, Phrenic nerve stimulation during halothane anesthesia. Effects of atelectasis. Anesthesiology. 1994; 80(4):751-60.
17. Lindberg P, Gunnarsson L, Tokics L. Atelectasis and lung function in the post-operative period. Acta Anaesthesiol Scand. 1992; 36:546-53.
18. McCann UG, Schiller HJ, Carney DE. Visual validation of the mechanical stabilizing effects of positive end-expiratory pressure at the alveolar level. J Surg Res. 2001; 99:335-42.
19. Savian C, Chan P, Paratz J. The effect of positive end-expiratory pressure level on peak expiratory flow during manual hyperinflation. Anesth Analg. 2005; 100:1112-6.
20. Dennis D, Jacob W, Budgeon C. Ventilator versus manual hyperinflation in clearing sputum in ventilated intensive

care unit patients. Anaesth Intensive Care. 2012; 40(1):42-149.
21. Anderson A, Alexanders J, Sinani C, Hayes S, Fogarty M. Effects of ventilator vs manual hyperinflation in adults receiving mechanical ventilation: a systematic review of randomised clinical trials. Physiotherapy. 2015; 101(2):103-10.
22. Ahmed F, Shafeeq AM, Moiz JA, Geelani MA. Comparison of effects of manual versus ventilator hyperinflation on respiratory compliance and arterial blood gases in patients undergoing mitral valve replacement. Heart Lung. 2010; 39(5):437-443.
23. Hayes K, Seller D, Webb M, Hodgson CL, Holland AE. Ventilator hyperinflation: a survey of current physiotherapy practice in Australia and New Zealand. New Zealand Journal of Physiotherapy. 2011; 39(3):124-130.
24. Stiller K. Physiotherapy in intensive care: towards an evidence-based practice. Chest. 2000; 118:1801-13.
25. Pryor J. Mucociliary clearance. In: Ellis E, Alison J, editors. Key issues in cardiorespiratory physiotherapy. Oxford, UK: 1992. Butterworth-Heinemann; 1992, 105-30.
26. Enrico Clinia, Nicolino Ambrosino b. Early physiotherapy in the respiratory intensive care unit. Respiratory Medicine. 2005; 99(9):1096-1104.
27. Patman S, Jenkins S, Stiller K. Manual hyperinflation--effects on respiratory parameters. Physiother Res Int., 2000; 5(3):157-71.
28. Maxwell L, Ellis E. The effect of operator performance during manual hyperinflation on pattern of ventilation and wet weight sputum cleared in intubated patients. Aust J Physiother, 2003; (49):31-38.
29. Berney S, Denhey L, Pretto J. Head down tilt and manual hyperinflation enhance sputum clearance in patients who are intubated and ventilated. Aust J. Physioter. 2004; (50):9-14.
30. Berney S, Denhey L. comparison of the effect of manual and ventilator hyperinflation on static lung compliance and sputum production in intubated and ventilated intensive care patients. Physiother. Res. Int. 2002; (2):100-89.
31. Mohamed A, Ibrahiem A. Acute Response of Manual Hyperinflation In Addition To Standard Chest Physiotherapy on Critically Ill Mechanically Ventilated Patient. IOSR Journal of Nursing and Health Science (IOSR-JNHS), 2015; 4(1):33-38.