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Minute Ventilation and Peak Airway Pressure Response to Diaphragm Stretch in Intubated Patients

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Abstract : This study evaluated the minute ventilation and peak airway pressure response to diaphragm stretch in intubated patients. Thirty patients participated in this study were divided randomly into two groups, study group (fifteen patients) received both diaphragm stretch and traditional chest physiotherapy and control group (fifteen patients) received traditional chest physiotherapy only. Mechanical ventilator was used to assess minute ventilation and peak airway pressure. Results showed that the two groups were similar in terms of the baseline characteristics. There were no significant differences between the control and study groups regarding the minute ventilation and peak airway pressure. Conclusion: use of diaphragm stretch had no effect on improving minute ventilation and peak air way pressure in intubated patients.
Key words: Diaphragm Stretch - minute ventilation - peak airway pressure.

Introduction

Mechanical ventilation was initially conceived as symptomatic treatment for pump failure. The failing muscular pump is assisted or substituted by an external pump. Because of technological limitations in the early days, substitution was the only choice. Today, technological advances allow mechanical ventilators to be used as sophisticated assistants of the respiratory pump. Positive pressure ventilation can also be very effective in primary lung failure. The safe management of mechanical ventilation requires precise information about altered respiratory mechanics in the individual patient, in order to tailor a strategy that protects the respiratory system from further damage (ventilator associated lung injury - VALI), and provide an environment that promotes lung healing. In the most severe cases with extreme mechanical derangements, these objectives can be difficult to achieved[1].

Selection of mode is based on the clinician’s familiarity, experience and the institutional preferences. Some modes guarantee a constant volume (volume-targeted or volume controlled) with each machine breath, whereas other modes guarantee a constant pressure (pressure-targeted or pressure-controlled)[2].

In less severe cases, when there is no independent indication for intubation, the initial support can be performed with pressure support ventilation (PSV) delivered by mask. In more severe cases and when mask ventilation fails, intubation is necessary and support will be initiated with volume controlled ventilation (VCV) or pressure controlled ventilation (PCV). The traditional initiation with VCV is not essential. When mask ventilation is successful, maintenance involves continuous or intermittent PSV by mask[3].

Invasive mechanical ventilation is used routinely in ICUs to treat acute respiratory failure. Although this treatment is essential for survival, it has a major disadvantage: the passive state of the respiratory muscles under mechanical ventilation leads to rapid atrophy of the diaphragmatic muscle fibers, which reduces the diaphragm's ability to generate force. This condition is termed 'ventilator induced diaphragmatic dysfunction' [4]. The onset of ventilator-induced diaphragmatic dysfunction is rapid, with the atrophy starting to occur within hours of commencing mechanical ventilation[5]. This atrophy is caused by an imbalance between protein synthesis and proteolysis, and is accompanied by a remodeling of the diaphragmatic muscle tissue [6]. Furthermore, the contractility of the muscle decreases, reducing the efficiency of the surface area of muscular fibers in the diaphragm for the same size of action potential[7]. These changes lead to a large reduction in the inspiratory pressure generated by the diaphragm. Moreover, the extent of the changes is correlated to the duration of mechanical ventilation [8]. It is therefore generally accepted that ventilator induced diaphragmatic dysfunction contributes to poorer outcomes such as delay in weaning from mechanical ventilation and increased risk of mortality in the ICU [9].

Chest physical therapy is used in the intensive care unit (ICU) to minimize pulmonary secretion retention, to maximize oxygenation and to re-expand atelectatic lung segments. The treatment techniques used in the ICU are postural drainage, percussion, vibration, limb exercises and continuous passive motion (CPM), coughing, suctioning, breathing exercises, patient mobilization and manual lung inflation [10]. Stretching of respiratory muscles, myofascial release, and soft tissue massage are included in what is known as thoracic manual therapy. The aim of most of these techniques is to increase movement in the rib cage and the spine in order to improve lung function and circulation [11].

The diaphragm is recognized as the primary muscle of respiration that plays an important role in breathing and physiological regulation. Dysfunction of the diaphragm can cause poor breathing patterns, disrupt physiological balance, and have detrimental effects on the interrelation among body systems [12].

This study aimed to investigate the effect of diaphragm stretch on weaning from mechanical ventilation.

Materials and Methods

Subjects Characteristics and General Experimental Design

Study Subjects:

Thirty patients were selected from Beni-suef University Hospital (critical care department) with body mass index (BMI) ranged from 22 to 38.1 kg/m^2, their age ranged from 53 - 73years. All participants provided their informed consent after receiving a detailed explanation of the study. The ethics committee of research in Faculty of Physical Therapy, Cairo University approved the study.

Evaluated Parameters

Mechanical Ventilator: to assess minute ventilation and peak air way pressure.

Patients Were Divided Randomly into Two Groups:

Study group received diaphragmatic stretch and traditional chest physiotherapy; control group received traditional chest physiotherapy only. The program was applied once daily for five days for both groups. All sessions were supervised and applied by same physiotherapist. All patients were mechanically ventilated, their positive end expiratory pressure (PEEP) did not exceed 10 cmH_2O and the patients were hemodynamically stable (vital signs). Patients were excluded from the study if they had one of the following: Fraction of inspired oxygen (FiO_2) > 0.6, positive end expiratory pressure (PEEP) > 10 cmH_2O to avoid barotraumas, unstable cardiovascular condition as defined by a mean arterial pressure (MAP) < 75 mmHg, arterial oxygen saturation (SaO_2) < 90% and any surgery in the abdomen, un-drained pneumothorax, high peak airway pressures, low blood pressure (systolic < 80 mm Hg) and severe bronchospasm. Patients would be withdrawn from the study if they suffered cardiovascular compromise during the treatment as defined by the above variables. The detailed training regimen was as follows:

Diaphragm stretch procedure was applied to patients in the study group. The Patient was supine on the bed with the operator standing at the side. Operator's fingertips contact the inferior surface of the diaphragm below the costal arch on the opposite side. Operator's other hand stabilizes the lower anterior rib cage of the opposite side. Operator maintained cephalic pressure on the inferior aspect of the diaphragm. Inhalation was resisted and exhalation encouraged. Fingertips compression was maintained until diaphragm was released. The treatment session was maintained 5 minutes for each side.

Traditional chest physiotherapy including percussion, vibration, positioning, suction and postural drainage were applied for all patients in both groups for 30 minutes once daily for five days.

Statistical Analysis:

The mean values of minute ventilation and peak air way pressure obtained for five days in both groups was compared using the factorial ANOVA test.

Results

The Study Involved Thirty Patients:

Their age ranged from 53 - 73years. The subjects were divided into two equal groups: the study group (9 males & 6 females) received diaphragm stretch procedure and traditional chest physiotherapy. The control group (6 males & 9 females) received traditional chest physiotherapy only once daily for five days. Table 1 represented non-significant difference between both groups. Table 2 represented the mean values of minute ventilation were non-significant from 10.2 to 10.0 in control group and from 10.2 to 10.3 in study group, the mean values of peak airway pressure were non-significant from 23.7 to 24.1 in control group and from 21.6 to 21.4 in study group.

Discussion

The aim of this study was to evaluate the effect of diaphragmatic stretch on minute ventilation and peak airway pressure in intubated patients. The mean values of minute ventilation and peak air way pressure were non significance in both groups. Also, there was a non-significant difference between the groups after treatment.

Table (1) anthropometric characteristics of patients in both groups (T-Test)

	Control/study	N	Mean	Sig. (2-tailed)
Age	Control	15	63.27	.348
	study	15	65.53	
BMI	Control	15	28.173	.458
	study	15	27.180	
ICU stay at 15 days from beginning P T	Control	15	7.13	.551
	Study	15	7.87	

Table (2) Analysis of minute ventilation and peak airway pressure between patients of both groups before and after treatment

		Groups		P1	P2	P3
		Control	Study			
		Mean	Mean	Time	Group	Interaction
VE	1st day	10.2	10.2	0.755	0.990	0.687
	5th day	10.0	10.3			
Peak airway pressure	1st day	23.7	21.6	0.833	0.310	0.327
	5th day	24.1	24.4			

There is increasing evidence to show mechanical ventilation itself may adversely affect the diaphragm's structure and function, which has been termed ventilator-induced diaphragmatic dysfunction. The combination of positive pressure ventilation and positive end-expiratory pressure may unload the diaphragm therefore subjecting it to changes in myofibrils length, which may account for its rapid atrophy. In addition, patients who undergo prolonged periods of ventilation demonstrate a decrease in respiratory muscle endurance and are at risk of respiratory muscle fatigue [13].

The efficacy of chest physical therapy can be determined by a reduction in the incidence of pulmonary infection or an improvement in pulmonary function. The mortality rate from nosocomial pneumonia remains high and ranges from 30% to 60%. Other benefits of chest physical therapy may include decreased duration of mechanical ventilation and prevention of tracheostomies benefits that reduce cost and shorten hospital stays [14].

The present study was in opposite direction to Sharon Wendy Hosking et al.,[15] osteopathic manipulative techniques applied to anatomical attachment areas of the diaphragm had a beneficial effect on diaphragm movement and spirometric measurements.

Ntoumenopolous and colleagues [16]compared physiotherapy treatment versus a sham treatment in 60 intubated and ventilated critically ill patients. Physiotherapy treatment comprised chest wall vibrations and specific positioning (no MH). The authors found that the incidence of nosocomial pneumonia was 31% less in the group who received physiotherapy, although no difference in time on mechanical ventilation or time in the ICU stay was found. This is the first study to compare outcomes for patients of receiving physiotherapy treatment in the ICU.

A systematic review of 10 randomized trials showed that inspiratory muscle training has important clinical benefits in patients who are weaning from mechanical ventilation in the ICU. These benefits included a significantly shorter weaning period, reduced risk of weaning failure (i.e., return to mechanical ventilation after extubation), and reduced length of ICU and hospital stay [17].

The current study was early supported by Engel and Vemulpad[18] who did not find substantial improvements in spirometry measures after manual therapy in normal asymptomatic individuals.

On other hand Berney and Denehy [19] found that chest physiotherapy including ventilator hyperinflation in side-lying did not significantly increase VO2 in 20 intubated adult ICU patients.

Limitations:

Our study has some limitations, such as the small sample size. Another limitation is the weaning of some patients from mechanical ventilation during the application of the study.

Conclusion:

In summary the present study showed that there was non-significance difference between study group and control group regarding to minute ventilation and peak airway pressure; further studies evaluating the effectiveness of chest physiotherapy in ICU patients on mechanical ventilation can provide additional evidence.

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