Effect of Manual Expiratory Rib Cage Compression on Blood Gases in Mechanically Ventilated Patients

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ABSTRACT

Background: expiratory rib cage compression technique is one of the most practiced chest physiotherapy technique in mechanically ventilated patients in intensive care unit. **Purpose:** this study was conducted to detect the effect of manual rib cage compression on blood gases in mechanically ventilated patients. **Subjects &methods:** forty adult mechanically ventilated patients participated in this study , their ages ranged from 40 to 50 years old and randomly distributed into two equal groups (A and B). Group (A): twenty mechanically ventilated patients received traditional physiotherapy (positioning, percussion, vibration and suctioning). Group (B): twenty mechanically ventilated patients received manual expiratory rib cage compression technique in addition to the same traditional treatment. Each patient in both groups assessed before treatment and reassessed after three successive days of treatment with a rate of two sessions per day regarding ABG parameters (PaO2, and PaCo2). **Results:** there were significant increase after treatment in PaO2 compared to before-treatment within control group and study group. Study group improved higher PaO2 than control group .But, no significant differences ($P>0.05$) between before and after treatment in PCO2 within control group and study group. And Between both groups indicated no significant differences ($P>0.05$) at before and after treatment in PCO2, PO2, between control group and study group. **Conclusion:** Addition of manual rib cage compression technique to traditional chest physiotherapy show positive clinical effects on PaO2 but has no effect on PaCO2.

Key words: intensive care; mechanical ventilation; chest physiotherapy; manual rib cage compression; expiratory rib cage compression.

INTRODUCTION

Intensive Care Units (ICUs) are special units used to provide care for critically ill patients, Critical patients might need invasive ventilatory support for different reasons.

Invasive mechanical ventilation is not an easy to decision to take for some patients, but it is a method of keeping patients alive by adequate tissue oxygenation to support the body during the treatment course in the ICU (1).

Also Invasive mechanical ventilation (MV) considered to be the cornerstone in the treatment of the critically ill patients, it had a deleterious effects caused by Tracheal intubation which seriously impairs cough reflex and mucociliary escalator function leading to sequestration and impaction of secretions in the lower airways. (2)

Respiratory or chest physiotherapy is a part of the multidisciplinary care of critically ill patients Particularly in intubated, sedated, and MV-dependent patients because of pulmonary complications resulting from the depression of the cough reflex, reduction in mucociliary clearance, and the increase in the bronchial mucus production. (3)

Expiratory rib cage compression (ERCC) or squeezing is one the most frequently used airway clearance techniques among adult critical patients, and it is found to be safe for critically ill patients, compared to percussion or vibration. (4)

ERCC consists of a manual thoracic compression applied during exhalation, followed by a sudden release at the end of exhalation, aiming to increase expiratory flow, thus expanding the gas-liquid interaction and mobilizing secretions from peripheral to central regions, favoring their removal (4)

Chest wall percussion and vibration were used by up to 80% of physiotherapists, based on the assumption that applying an external force to the chest wall to loosen the mucus facilitates airway mobilization and clearance (5)

Frequent positioning in bed helps to increase lung volume, mobilize and remove secretions from the airway with the help of gravity, improve the V/Q ratio, reduce the work of breathing, minimize myocardial work. (3)

Arterial blood gases are measured to determine the percentage of hemoglobin saturated with oxygen (Sao2), amount of oxygen dissolved in the blood (PaO2), the amount of carbon dioxide dissolved in the blood (PaCO2) and the amount of acid in the blood (PH). The oxygen measure used to determine if the patient needs oxygen therapy. The carbon dioxide used to give an idea about lung function. (6) with spastic diplegic CP.

Materials and Procedures

Study design:

This was a randomized controlled study. Participants were recruited from kasr al Ainy hospitals, Cairo, Egypt from November 2019 to February 2021.

Ethical considerations:

Ethical considerations: Human use analysis has complied with all applicable national regulations and institutional policies, followed the human use study. The tenets of the Helsinki Declaration and the acceptance of the ethical declaration physical therapy faculty of committee, Cairo University, Egypt

Participants:

Forty adults mechanically ventilated patients from both sexes participated in this study, their age ranged from 40 to 50 years old

Patients were randomly assigned into two equal groups in number (20 patients for each group A and B) , Their relatives were fully informed by the physiotherapist and all signed a written informed consent form.

INCLUSION CRITERIA:

All the patients had the following criteria:

1. Age ranged from 40 to 50 years old.
2. Mechanically ventilated patients more than 48 hours.
3. . Medically stable patient.
4. Semiconscious.
5. Patient with neck circumference more than or equal 35.5 in men and more than or equal 32 in women

EXCLUSION CRITERIA:

Patient presenting any of the followings excluded:

1. Patient with hemodynamic instability.
2. Patient with acute respiratory distress syndrome.
3. Inotropic support.
4. Untreated pneumothorax.
5. Rib fracture or lung damage.
6. Recent pulmonary embolism, cardiac arrest, AF, MI.

Measurements procedures:

Arterial blood gases (ABGs):

1. PaO2
2. PaCo2

Treatment procedures:

Control group (A): 20 mechanically ventilated patients that received traditional physiotherapy methods (percussion, vibration and positioning) twice per day, total time of the session was ranged from 20-30 minutes followed by suction. The treatment started 48 hours after mechanical ventilation, they received treatment daily for three successive days.

Study group (B): 20 mechanically ventilated patients that received first traditional physiotherapy (percussion, vibration and positioning) for 20-30 minutes then bilateral manual expiratory rib cage compression technique for 5 min followed by suction.

The treatment started 48 hours after mechanical ventilation, and done 2 times per day for three successive days.

Data analysis:

Data were screened, for normality assumption test and homogeneity of variance. Normality test of data using Shapiro-Wilk test was used, that reflect the data was normally distributed ($P>0.05$) after removal outliers that detected by box and whiskers plots. Additionally, Levene's test for testing the homogeneity of variance revealed that there was no significant difference ($P>0.05$). So, the data are normally distributed and parametric analysis is done. The statistical analysis was conducted by using statistical SPSS Package program version 25 for Windows (SPSS, Inc., Chicago, IL). Data are expressed as mean and standard deviation for demographic data (age and neck circumference). Multivariate analysis of variance (MANOVA) used to compare the tested major variables of interest at different tested groups and measuring periods. Mixed design 2 x 2 MANOVA-test was used, the first independent variable (between subject factors) was the tested group with 2 levels (control group and study group). The second independent variable (within subject factor) was measuring periods with 2 levels (before and after treatment). Bonferroni correction test was used to compare between pairwise within and between groups of the tested variables which F was significant from MANOVA test. All statistical analyses were significant at level of probability less than an equal 0.05 ($P \leq 0.05$)

Results

In the current study, a total of 40 patients participated and they were randomly distributed into 2 groups (20 patients/group). No significant differences (P>0.05) in demographic data for age (P=0.460) and neck circumference (P=0.622) between control group and study group (Table 1).

Table 1: Demographic data comparison between group A and group B.

Items	Groups (Mean ±SD)		*P*-value
	Control group (n=20)	Study group (n=20)	
Age (year)	46.65 ±3.25	46.10 ±3.37	0.460
Neck circumference (cm)	35.49 ±1.65	35.30 ±1.86	0.622

Data are expressed as mean ± standard deviation (SD) P-value: probability value P-value >0.05: non-significant

The statistical analysis using 2x2 mixed design MANOVA (Table 2) indicated that there were significant differences (F-value=3.347; P=0.014; P<0.05) of the tested groups (the first independent variable) on the all tested dependent variables (PCO2 and PO2). In addition, there were significant differences (F-value=17.264; P=0.0001; P<0.05) of the measuring periods (the second independent variable) on the tested dependent variables. However, no significant (F-value=1.459; P=0.224; P>0.05) due to the interaction between the two independent variables, which indicates that the effect of the tested group (first independent variable) on the dependent variables was not influenced by the measuring periods (second independent variable).

Table 2: Main effects of independent variables by 2 x 2 MANOVA test for dependent measuring variables.

Source of variation	Wilk's Lambada value	F-value	P-value
Groups effect	0.845	3.347	0.014*
Period effect	0.514	17.264	0.0001*
Groups x period effect	0.926	1.459	0.224

P-value: probability value * Significant (P-value <0.05)

Multiple pairwise comparison tests within each group for PCO2 and PO2 variables (Table 3) showed that there were significantly increased after treatment in PO2 (P=0.0001; P<0.05) compared to before-treatment within control group and study group. Study group improved higher PO2 (46.85) than control group (39.65). But, no significant differences (P>0.05) between before and after treatment in PCO2 within control group and study group. Multiple pairwise comparison tests between both groups for PCO2 and PO2 variables (Table 3) indicated no significant differences (P>0.05) at before and after treatment in PCO2 and PO2, between control group and study group.

Table 3: Inter- and intra-group comparison for PCO_2 and PO_2 variables

Variables	Items	Groups (Mean ±SD) Control group (n=20)	Study group (n=20)	Mean difference	*P*-value
PCO_2	Before-treatment	34.80 ±7.30	32.92 ±7.76	1.88	0.337
	After-treatment	35.90 ±5.42	35.90 ±2.93	0.00	1.000
	Mean difference	1.11	2.98		
	Improvement %	3.16%	9.05%		
	95% CI	-2.77 – 4.98	-0.89 – 6.86		
	P-value	0.572	0.129		
PO_2	Before-treatment	100.21 ±26.51	106.20 ±25.99	5.99	0.543
	After-treatment	139.94 ±28.45	155.95 ±40.61	16.01	0.106
	Mean difference	39.73	49.75		
	Improvement %	39.65%	46.85%		
	95% CI	20.22 – 59.23	30.24 – 69.25		
	P-value	0.0001*	0.0001*		

Data are expressed as mean ± standard deviation (SD) CI: confidence interval P-value: probability value * Significant (P<0.05)

Discussion

The present study was designed to study the effect of manual expiratory rib cage compression on blood gases in mechanically ventilated patients. Forty mechanically ventilated patients assigned into two groups, each group consisted of twenty patients. The first group was the group (A) who received traditional physiotherapy; the second group was the group (B) who received traditional physiotherapy and manual expiratory rib cage compression for three successive days

The results of this study proved that there were significant increase in PaO2 and SaO2 after treatment compared to before-treatment within control group and study group. Study group improved higher PO2 and SaO2 than control group.

But, no significant differences between before and after treatment in pH and PCO2 within control group and study group.

And No significant differences at before and after treatment in pH, PCO2, PO2, and SaO2 between control group and study group.

In agreement with **Santos et al.,** who stated that both manual expiratory rib cage compression and PEEP-ZEEP showed a statistically significant difference in tidal volume, static compliance and dynamic compliance but In relation to oxygenation, in the group of manual rib-cage compression, peripheral oxygen saturation increased with significant difference **(7)**

Consistent with randomized controlled trial of **berti et al., 2012** whose result show that he use of expiratory rib cage compression with manual hyperinflation had a positive effect on the duration of MV, as accelerated the weaning process and in turn the ICU discharge rate and Murray score. **(8**

In contrast to the above **Unoki et al., 2005**, reported that rib-cage compression prior to endotracheal suctioning does not improve airway-secretion removal, oxygenation, or ventilation after endotracheal suctioning in this unselected population of mechanically ventilated patients **(9)**

In addition to **Guimaraes et al. 2014**. Who found in his study that ERCC increases expiratory flow but it has no clinical relevant effects on improving the sputum production and respiratory mechanics in hyper secretive mechanically ventilated patients. The maneuver can cause also EFL in some patients. **(10)**

Unlike **Mase et al,** whose study support that expiratory rip cage compression promote the expiration and increase the tidal volume, however the lung volume didn't increase beyond the end inspiratory levels at rest **(11)**

Conclusion

Addition of manual rib cage compression technique to traditional chest physiotherapy show positive clinical effects on PaO2 in mechanically ventilated patients but has no effect on PaCO2.

Disclosure statement

No author has any financial interest or received any financial benefits from this research.

Conflict of interest

The authors state no conflict of interest

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