Novelty Journals

ISSN 2394-7330

International Journal of Novel Research in Healthcare and Nursing
Vol. 7, Issue 3, pp: (119-130), Month: September - December 2020, Available at: www.noveltyjournals.com

Effect of Chest Percussion and Squeezing on Respiratory Status for Mechanically Ventilated Patients

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Abstract: **Chest physiotherapy is one aspect of bronchial hygiene and plays an important role in management of mechanically ventilated patients; it is considered one of the most frequently performed intervention in ICU and is widely used among mechanically ventilated patients for both those who are intubated and tracheostomized .Chest Percussion and squeezing are the techniques of chest physiotherapy which are most frequently recommended for mechanically ventilated patients who have impaired cognition or poor coughing ability. Chest percussion and squeezing are used to enhance mucociliary clearance from both central and peripheral airway, and both techniques are more effective in mobilizing secretions that are adherent to the bronchial walls.**

Materials and Methods: A convenience sample of 60 adult mechanically ventilated patients who were admitted to the ICU and required continuous invasive mechanical ventilation for more than 48 hours were included in the study. These patients were divided randomly into two groups 30 patients each, the control group who were subjected to the routine care applied by nursing staff in the study settings and intervention group who had chest percussion and squeezing applied by the researcher.

Results: Chest percussion and squeezing can improve the oxygenation parameters as the Pulmonary oxygenation capacity index (PaO2/FiO2 readings), SpO_2, PaO_2 and FiO2. There was highly statistical significant difference between the control and intervention groups regarding tidal volume, amount and viscosity of excretory secretions, respiratory inspection and auscultation in favor to the intervention group.

Conclusion: The chest percussion and squeezing are applicable and effective maneuvers for mechanically ventilated patients, it improve alveolar ventilation, gas exchange, decrease the force of breathing, and promote airway patency and oxygenation by removing airway secretions

Keywords: **chest physiotherapy, airway and mucociliary clearance, expiratory rib cage compression, chest squeezing, chest percussion.**

I. INTRODUCTION

Approximately one third of all critically ill patients who enter the intensive care unit (ICU) require mechanical ventilation which is a mainstay of treatment for respiratory failure and the most frequent indication for acid-base imbalance, hypoxemia, hypercapnea or to relieve ventilator work which are the most common indications for admission to ICU(Hariedy, Mohamed, Mohamed, Abdel-Aziz & Morsy, 2015).

However these mechanically ventilated patients have an increased risk of developing complications such as chest infection, lung collapse which complicated by pneumonia and may progress to respiratory failure or acute respiratory distress syndrome resulting in prolong mechanical ventilation period and increase mortality to 33% -71% (Pattanshetty & Gaude, 2011).

Additionally, mechanically ventilated patients are also at risk for retained airway secretions causing impaired of airway clearance from a myriad of causes including endotracheal intubation that disrupts the mucociliary escalator and irritates the respiratory mucosa, the mucus-producing goblet cells, and increases the volume and tenacity of mucus resulting in increased mucus production and the amount of mucus as consequence (Pozuelo-Carrascosa et al., 2018).

On the other hand endotracheal tubes damage cilia and impair ciliary function and predispose the patients to infection, relative immobility, atelectasis and retained secretions. Muscle weakness associated with prolonged ICU stay may also contribute to secretion retention. Also, fluid status particularly fluid restriction in the mechanically ventilated patients, may contribute to thickened secretions (Kohan, Rezaei-Adaryani, Najaf-Yarandi, Hoseini & Mohammad-Taheri, 2014).

Moreover, mechanically ventilated patients generally have lower level of consciousness, which reduces their clearance of airway secretions because the cough reflex is decreased or because of impaired cough mechanism, this is due to either the presence of the tube itself or the suppression of the cough reflex by sedation or analgesia, Therefore, these patients lose the ability to cough and secretions tend to pool (Hariedy et al., 2015; Pozuelo-Carrascosa et al., 2018).

These accumulation of secretions causes an increase in airway resistance and partial or total airway obstruction, resulting in alveolar hypoventilation, atelectasis, hypoxemia, and increased work of breathing, as well as creating a favorable environment for the proliferation of bacteria and the development of pneumonia leading to impaired gas exchange which reflects upon arterial blood gases parameters, difficult and failed ventilator weaning trials, prolonged mechanical ventilator periods, increased length of hospital stay, increased cost of care and worsen patients prognosis ,resulting in excess morbidity and mortality (Oliveira, Lorena, Gomes, Amaral & Volpe, 2019).

Therefore, airway management is an important aspect of nursing care for mechanically ventilated patients to maintain airway patency and improve gas exchange, which is achieved through sufficient systemic fluid therapy, hydration, air humidification, tracheal suctioning, manual lung inflation, coughing, breathing exercises, patient mobilization ,application of aerosol, incentive spirometry, forced expiratory techniques, bronchodilators, mucolytic agents, and chest physiotherapy (CPT) (Yousefnia-Darzi, Hasavari, Khaleghdoost, Kazemnezhad-Leyli & Khalili, 2016).

Chest physiotherapy is one aspect of bronchial hygiene and plays an important role in management of mechanically ventilated patients; it is considered one of the most frequently performed intervention in ICU and is widely used among mechanically ventilated patients for both those who are intubated and tracheostomized (Borges, Saraiva, Saraiva, Macagnan & Kessler, 2017).

Chest physiotherapy is used for mechanically ventilated patients for several reasons include to minimize pulmonary secretions retention, clearing airway, maximize oxygenation, re-expand atelectasis, recruit collapsed distal lung units , optimize the matching of ventilation and perfusion(V/Q), improve respiratory efficiency, promote expansion of the lungs , strength respiratory muscles and help them to breathe more freely and to get more oxygen into the body and improve oxygenation by the indirect removal of mucus from the patient ,s airway. Moreover, it can improve changes in breath sounds, vital signs, facilitate early weaning and rapid recovery, reduce ICU stay and decrease hospital cost (Active Health Management Medical Management Guidelines, 2016).

Chest physiotherapy has several techniques and modalities which should be considered for its indication as functional diagnosis, the impact on pulmonary function, difficulty of expectoration, the mechanically ventilated patients' level of cooperation and performance status, the most effective and less harmful intervention, the operational cost and the mechanically ventilated patients' preference (Gupta & Gupta, 2018), these techniques such as positioning, postural drainage, kinetic therapy, mobilization, suction, humidification, techniques to stimulate a cough as manual hyperinflation, in addition to techniques which require external application of force on the chest as chest vibrations, chest percussion and chest squeezing (Spapen, De Regt & Honoré, 2017; Morrow, 2019).

Chest Percussion and squeezing are the techniques most frequently recommended for mechanically ventilated patients who have impaired cognition or poor coughing ability. Chest percussion and squeezing are used to enhance mucociliary

clearance from both central and peripheral airway, and both techniques are more effective in mobilizing secretions that are adherent to the bronchial walls (Berra et al., 2012).

Despite several studies have been conducted to study chest physiotherapy effect on mechanically ventilated patients' outcomes, up till our knowledge there was no study investigates specifically the effects of chest percussion and squeezing. Hence, this study was conducted to determine the effect of chest percussion and squeezing on respiratory status for mechanically ventilated patient

II. MATERIALS AND METHOD

Study Design: A quasi experimental research design was used in the current study.

Study setting: This study was carried out in the following ICUs; Casualty care unit (unit I) that contains 8 beds; and the General ICU (unit III) that contains 15 beds,these two units receive patients who have a variety of disorders in acute stage of illness admitted directly from the Emergency room or transferred from the other hospital departments. These units are affiliated to Alexandria Main University Hospital.

Study Duration: January 2017 to June 2017.

Sample size: 60 mechanically ventilated patients.

Sample size calculation: the sample size included in the study based on the power analysis (Epi-Info program7) with the following information (population size =150 over three months, expected frequency =50%, acceptable error =10%, confidence coefficient =95%, minimal sample size =60).

Subjects & selection method: A convenience sample of 60 adult mechanically ventilated patients who were admitted to the above mentioned settings and required continuous invasive mechanical ventilation These patients were divided randomly into two groups 30 patients each, the control group who were subjected to the routine care applied by nursing staff in the study settings and intervention group who had chest percussion and squeezing applied by the researcher.

Inclusion criteria:

1- Patients with continuous invasive mechanical ventilation for more than 48 hours

2- Hemodynamically stable

Exclusion criteria:

1- Patients who had hemodynamic instability.

2- Chest trauma.

3- Patients with Richmond Agitation and Sedation Scale (RASS) score < +1 or >+2.

Procedure methodology

After written informed consent was obtained, two tools were used to collect the data of this study namely. “Respiratory Status Monitoring for Mechanically Ventilated Patients ", and “Chest Percussion and Squeezing Effects Assessment". Tool one **"Respiratory status monitoring for mechanically ventilated patients"** it includes two parts :**Part I**:patients demographics and clinical data such as sex, age and clinical data such as current diagnosis, medical history, prescribed medications, length of ICU stay, RASS and hemodynamic parameters such as central venous pressure, mean arterial pressure, heart rate. **Part II**: respiratory assessment for mechanically ventilated patients. Tool two **“Chest percussion and squeezing effects assessment"** it include secretion volume and oxygenation parameters such as arterial blood gases values and SpO_2 monitoring using pulse oximeter.

The demographic and clinical data of the patients in both control and intervention group was recorded by the researcher using Part I of tool one. Mechanical ventilator data and respiratory status which include breath sounds, arterial blood gases parameters, and SPO_2 were assessed by the researcher using Part II of tool one. After that arterial blood gases were withdrawn as a baseline value before tracheal suctioning for the control group and before the intervention for the intervention group.

Chest percussion was performed for intervention group of patients for 5 minutes in which the researcher used a cupped hand to create an air cushion and energy wave which was transmitted through the chest wall during both the inspiratory and expiratory phases of respiration. Then Chest squeezing technique after that was performed for 5 minutes; in which the researcher used both hands to gradually squeeze the chest wall during the expiratory phase only. Each technique was performed by the researcher twice daily for two consecutive days to the same patient. The respiratory status was reassessed by researcher to evaluate if there is an immediate improvement using part II of tool one. The respiratory status was reassessed by researcher to evaluate if there is an immediate improvement

After that secretions were collected for measurement in a specimen trap (BAL suction catheter) via a suction tube. After completing suctioning, 20mL of sterile saline was flushed through the suction tubing into the specimen trap to clear any secretions left in the catheter. The volume of the aspirated secretion was measured in 0.1mL scale and calculated by subtracting the volume of the 20mL of sterile saline from the total volume of the secretion collected in the specimen trap after tracheal suctioning with both groups. Moreover arterial blood gases were withdrawn from each group to evaluate the oxygenation status. Finally, SpO2 value was recorded at six time points; at the initial baseline rest period, immediately after tracheal suction, at 10, 20, 30, 60 minutes using tool two. Data were collected by the researcher during approximately six months from January 2017 to June 2017,and the collected data were analyzed using the appropriate statistical tests.

Statistical analysis

- **Statistical Analysis of the data**

- Data were fed to the computer and analyzed using IBM SPSS
- Software package version 20.0**. (**Armonk, NY: IBM Corp**).**
- Qualitative data were described using number and percent.
- Significance of the obtained results was judged at the 0.05 level.

The used tests were

1 - Chi-square test

- For categorical variables, to compare between different groups

2 - McNemar and Marginal Homogeneity Test

- Used to analyze the significance between the different stages
- The McNemar and Marginal Homogeneity Test is an extremely simple way to test marginal homogeneity in K×K tables
- The McNemar and Marginal Homogeneity statistic is calculated as

$X^2 = (b - c)^2 / (b + c)$.

III. RESULTS

Table (1) shows the distribution of the studied mechanically ventilated patients according to their demographic data. As regarding to patients' age, 90 %of the control and intervention group with similar percentage were in age range 40-60 years old, while 10% of the control and intervention group with similar percentage were in age 20 -< 40 years old. Regarding patients' sex, 50% and 63.3% of the control and intervention group respectively were male, while 50% and 36.7% of the control and intervention group respectively were female. There is no statistical significant difference found between the two groups regarding patients' age (P= 1.00) and sex (P= 0.297).

In relation to the length of stay in intensive care unit (ICU), 90% and 80% of the control and intervention group respectively their length of ICU stay was ≤4 days, while 10% and 20% of the control and intervention groups respectively their length of ICU stay was >4- ≤ 7 days. There is no statistical significant difference found between two groups according to the length of ICU stay (P=0.472).

Novelty Journals

ISSN 2394-7330

International Journal of Novel Research in Healthcare and Nursing
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Regarding the duration of mechanical ventilation, 73.3% and 80% of control and intervention groups respectively their duration of MV was ≤ 4 days, while 26.7% and 20% of control and intervention groups respectively their duration of MV was >4 - ≤7 days. There is no statistical significant difference found between two groups regarding their duration of mechanical ventilation (P=0.542).

Table (1): Distribution of the studied mechanically ventilated patients according to their demographic data

Studied mechanically ventilated patients characteristics		Control Group N= 30		Intervention Group N=30		Total N= 60		Test of Significance
		No.	%	No.	%	No.	%	
Sex	• Male	15	50.0	19	63.3	34	56.7	X^2= 1.086
	• Female	15	50.0	11	36.7	26	43.3	P= 0.297
Age (years)	20-<40	3	10.0	3	10.0	6	10.0	X^2= 0.0
	40-60	27	90.0	27	90.0	54	90.0	P= 1.00
Length of stay in ICU (days)	≤4	27	90.0	24	80.0	51	85.0	X^2= 1.176
	>4 - ≤7	3	10.0	6	20.0	6	15.0	P= 0.472
Duration of Mechanical Ventilation (days)	≤4	22	73.3	24	80.0	46	76.7	X^2= 0.373
	>4 - ≤7	8	26.7	6	20.0	14	23.3	P= 0.542

χ^2: Chi square test

Table (2) illustrates the distribution of the studied mechanically ventilated patients according to their clinical data. 30% and 33.3% of the control and intervention groups respectively had not respiratory disorders, while 20% and 23.3% of the control and intervention groups respectively had chest infection, 33.3% of the control and intervention groups with equally percentage had pneumonia, and 10% of the control and intervention groups with equally percentage had COPD. There is no statistical significant difference found between the two groups regarding respiratory diagnosis (P= 1.000).

Concerning the cardiovascular system, 93.3% and 96.7% of the control and intervention groups respectively had not cardiovascular disorders. While 3.3% of the control group had hypertension and congestive heart failure with equal percentage, while 3.3% of the intervention group had decompensated heart failure. There is no statistical significant difference found between the two groups regarding cardiovascular diagnosis (P= 0.553).

Regarding the neurological system, 60% and 50% of the control and intervention groups respectively had not neurological disorders, while 26.7% and 33.3% of the control and intervention group respectively had cerebrovascular stroke, 3.3% of the control and intervention groups with equal percentage had septic encephalopathy. There is statistical significant difference found between the two groups regarding neurological diagnosis (P= 0.154).

It can also be noted that 86.7% and 93.3% of the control and intervention groups respectively had not renal problems, while 6.7% of the control and intervention groups with equal percentage had acute kidney injury, and 6.7 % of the control group only had urinary tract infection, and finally 96.7% and 100% of the control and intervention groups respectively had not endocrine problems. There is no statistical significant difference found between the two groups regarding renal diagnosis (P= 0.552) and endocrine diagnosis (P= 0.313).

It can also be noticed that 93.3% and 100% of the control and intervention groups respectively were not on sedation therapy.16.7% and 10% of the control and intervention groups respectively received bronchodilators, while 16.7% of the control group only received mucolytic. There is no statistical significant difference found between the two groups regarding sedative administration (P=0.150) and prescribed medications (P= 0.067).

In relation to chest radiograph finding, 3.3% and 6.7% of the control and intervention groups respectively had normal chest radiograph finding, while 23.3% and 30% of the control and intervention groups respectively had abnormal finding in form of pneumonia, 56.7% and 63.3% of the control and intervention groups respectively had consolidation. Regarding the site of chest radiograph abnormality as shown in radiology, 27.6% and 16.7% of the control and intervention groups respectively had abnormal finding in right side, 44.8% and 40% of the control and intervention groups respectively had abnormal finding in left side, and finally 27.6% and 36.7% of the control and intervention groups respectively had abnormal finding in bilateral chest. There is no statistical significant difference found between the two groups regarding chest radiograph finding (P=0.123).

Novelty Journals

ISSN 2394-7330

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Table (2): Distribution of the studied mechanically ventilated patients according to their Clinical data

Clinical data		Control Group N= 30		Study Group N=30		Total N= 60		Test of Significance
		No.	%	No.	%	No.	%	
Respiratory problems	• No	9	30.0	10	33.3	19	31.7	X^2= 2.155 P= 1.000
	COPD	3	10.0	3	10.0	6	10.0	
	Chest infection	6	20.0	7	23.3	13	21.7	
	Respiratory failure	1	3.3	0	0.0	1	1.7	
	Pneumonia	10	33.3	10	33.3	20	33.3	
	Acute hypoventilation	1	3.3	0	0.0	1	1.7	
Cardiovascular problems	• No	28	93.3	29	96.7	57	95.0	X^2= 0.351 P= 0.553
	Hypertension	1	3.3	0	0.0	1	1.7	
	Congestive heart failure	1	3.3	0	0.0	1	1.7	
	Decompensated Heart failure	0	0.0	1	3.3	1	1.7	
Neurological problems	• No	18	60.0	15	50.0	33	55.0	X^2= 7.022 P= 0.154
	Epilepsy	2	6.7	0	0.0	2	3.3	
	Cerebrovascular stroke	8	26.7	10	33.3	18	30.0	
	Intracerebral hemorrhage	0	0.0	4	13.3	4	6.7	
	Septic encephalopathy	1	3.3	1	3.3	2	3.3	
	Brain tumor	1	3.3	0	0.0	1	1.7	
Renal problems	• No	26	86.7	28	93.3	54	90.0	X^2= 1.825 P= 0.552
	Urinary tract infection	2	6.7	0	0.0	2	3.3	
	Acute kidney injury	2	6.7	2	6.7	4	6.7	
Endocrine problems	• No	29	96.7	30	100.0	59	98.3	X^2= 1.017 P= 0.313
	• Goiter	1	3.3	0	0.0	1	1.7	
Sedative administration	• No	28	93.3	30	100.0	58	96.7	X^2= 2.069 P= 0.150
	• Yes (Level III)	2	6.7	0	0.0	2	3.3	
Prescribed medications	• No	20	66.7	26	86.7	46	76.7	X^2= 3.354 P= 0.067
	-Mucolytic	5	16.7	0	0.0	5	8.3	
	-Neuromuscular block agents	0	0.0	1	3.3	1	1.7	
	-Bronchodilators	5	16.7	3	10.0	8	13.3	
Chest radiograph finding	• Normal finding	1	3.3	2	6.7	3	5.0	X^2= 5.662 P=0.123
	-Atelectasis	5	16.7	0	0.0	5	8.3	
	-Pneumonia	7	23.3	9	30.0	16	26.7	
	-Consolidation	17	56.7	19	63.3	36	60.0	
	• Site of abnormality							X^2= 1.624 P=0.657
	-Right side	8	27.6	5	16.7	13	21.7	
	-Left side	13	44.8	12	40.0	25	41.7	
	-Bilateral chest	8	27.6	11	36.7	19	31.6	

Table (3) shows the distribution of the two groups of patients according to their respiratory assessment .it can be noticed that 60% and 90% of the control and intervention group of patients in post routine care and post intervention respectively had normal respiratory finding by **inspection** in the first time of the first day. There is statistical significant difference between the two groups in post routine care and post intervention in the study (P=0.007*, 0.026*, 0.038*)

This table also shows that 23.3% and 83.3% of the control and intervention group of patients in post routine care and post intervention respectively had normal respiratory finding by **auscultation**.also16.7% and 6.7 of the control and intervention group of patients in post routine care and post intervention respectively had left crepitation in first time of first day. There is statistical significant difference between the two groups in post period (P= 0.001*).

Table (3): Distribution of the two groups of patients according to their respiratory assessment

Respiratory Assessment		Groups															
		First day								Second day							
		1st time				2nd time				1st time				2nd time			
		Post routine care		Post intervention		Post routine care		Post intervention		Post routine care		Post intervention		Post routine care		Post intervention	
		N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Inspection	Normal	18	60.0	27	90.0	23	76.7	26	86.7	22	73.3	29	96.7	22	73.3	28	93.3
	Tachypnea	10	33.3	3	10.0	5	16.7	4	13.3	6	20.0	1	3.3	6	20.0	2	6.7
	Cyanosis	2	6.7	0	0.0	2	6.7	0	0.0	2	6.7	0	0.0	2	6.7	0	0.0

Novelty Journals

ISSN 2394-7330

International Journal of Novel Research in Healthcare and Nursing
Vol. 7, Issue 3, pp: (119-130), Month: September - December 2020, Available at: www.noveltyjournals.com

P		0.007*				0.317				0.026*				0.038*			
Palpation	Normal	30	100	30	100	30	100	30	100	30	100	30	100	30	100	30	100
Percussion	Normal	29	96.7	29	96.7	29	96.7	29	96.7	29	96.7	29	96.7	29	96.7	29	96.7
	Abnormal	1	3.3	1	3.3	1	3.3	1	3.3	1	3.3	1	3.3	1	3.3	1	3.3
P		1.000				1.000				1.000				1.000			
Auscultation	Normal	7	23.3	25	83.3	7	23.3	27	90.0	7	23.3	26	86.7	6	20.0	27	90.0
	Wheezes	1	3.3	0	0.0	1	3.3	0	0.0	1	3.3	0	0.0	1	3.3	1	3.3
	Crepitation bilateral	11	36.7	2	6.7	11	36.7	0	0.0	11	36.7	4	13.3	12	40.0	0	0.0
	Crepitation right	6	20.0	1	3.3	6	20.0	1	3.3	5	16.7	0	0.0	6	20.0	0	0.0
	Crepitation left	5	16.7	2	6.7	5	16.7	2	6.7	6	20.0	0	0.0	5	16.7	2	6.7
P		0.001*				0.001*				0.001*				0.001*			

P: p value for comparing Control and Intervention groups post 1st time and 2nd time using Chi square test

*: Statistically significant at $p \leq 0.05$

Table(4) -(figure 1) describes the distribution of the two groups of patients according to their oxygenation parameters, it can be noticed that 50% and 40% of the control and intervention group of patients in post routine care and post intervention respectively had normal **PH**, also 16.7% and 6.7% of the same groups in post routine care and post intervention respectively had normal **PaCO2**, there is no statistical significant difference between the two groups of patients in the study regarding **PH, PaCO2, HCO3, and SaO_2.**

Concerning PaO_2, it can be observed that 63.3% and 93.3% of the control and intervention group in post routine care and post intervention respectively their PaO_2 finding was >100 mmH_2o in the first time of the first day, also 46.7% and 93.3% of the same group in in post routine care and post intervention respectively their PaO_2 finding was >100 mmH_2o in the second time of the first day, There is statistical significant difference between the two groups in post period in the study(P= 0.007*).

Regarding pulmonary oxygenation capacity index, it can be observed that56.7% and 76.7% of the control and intervention group in post routine care and post intervention respectively their PaO2 / FiO2 ratio was ≥300 mmHg .there is no statistical significant difference between two groups in post period (P= 0.090).

Regarding the SpO_2 reading after suction, it can be noticed that70%, 86.7% and 93% of the control group respectively had SpO_2 reading range 98-100% after 20, 30, and 60 minute of suction respectively, there is statistical significant difference between periods in the second time of the second day only (P = <0.001*).

Within first day of the intervention group, it can be observed that 53.3%and 83.3% of the intervention group at baseline and immediately period after suction respectively had SpO_2 reading range 98-100%, there is highly statistical significant difference between baseline and immediately periods in the first and second time of the first day (P = <0.001*, <0.001* respectively).

Within the second day of the intervention group, it can be noticed that 63.3% and 76.7% of the intervention group at baseline and immediately period after suction respectively had SpO_2 reading range 98-100% in the first time; also 56.7% and 90% of them in the same periods respectively had SpO_2 reading range 98-100% in the second time, there is highly statistical significant difference between baseline and other periods in the second day (P = 0.015*, <0.001* respectively).

Within the control and intervention group, there is no statistical significant difference between two groups regarding SpO_2 (P=0.432).

Table (4): Distribution of the two groups of patients according to their oxygenation parameters

Arterial blood gases finding		Control vs intervention															
		First day								Second day							
		1st time				2nd time				1st time				2nd time			
		Post routine care		Post intervention		Post routine care		Post intervention		Post routine care		Post intervention		Post routine care		Post intervention	
		N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%

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ISSN 2394-7330

International Journal of Novel Research in Healthcare and Nursing
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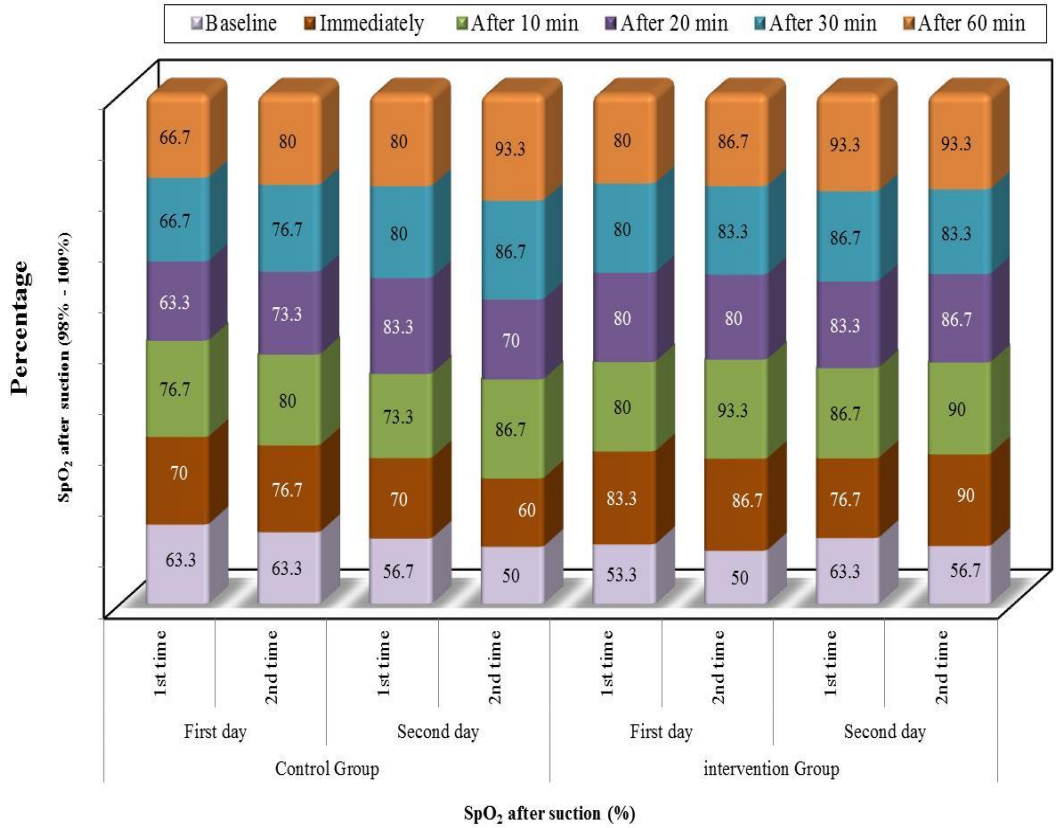
PH	**Normal (7.35-7.45)**	15	50.0	12	40.0	14	46.7	15	50.0	12	40.0	10	33.3	11	36.7	14	46.7
	Alkalemia (>7.45)	1	3.3	3	10.0	2	6.7	2	6.7	0	0.0	4	13.3	0	0.0	1	3.3
	Acedemia (<7.35)	14	46.7	15	50.0	14	46.7	13	43.3	18	60.0	16	53.3	19	63.3	15	50.0
P		0.523				1.000				0.184				0.431			
PaO_2 (mmHg)	**Normal (75 – 100)**	5	16.7	2	6.7	12	40.0	1	3.3	12	40.0	5	16.7	10	33.3	4	13.3
	Hypoxgynation (<75)	6	20.0	0	0.0	4	13.3	1	3.3	3	10.0	0	0.0	4	13.3	1	3.3
	Hyperoxgynation (>100)	19	63.3	28	93.3	14	46.7	28	93.3	15	50.0	25	83.3	16	53.3	25	83.3
P		0.007*				0.001*				0.011*				0.046*			
$PaCO_2$ (mmHg)	Normal **(35 - 45)**	5	16.7	8	26.7	6	20.0	9	30.0	7	23.3	10	33.3	8	26.7	8	26.7
	Respiratory acidosis(>45)	2	6.7	4	13.3	1	3.3	2	6.7	1	3.3	1	3.3	1	3.3	1	3.3
	Respiratory alkalosis(<35)	23	76.7	18	60.0	23	76.7	19	63.3	22	73.3	19	63.3	21	70.0	21	70.0
P		0.420				0.523				0.783				1.000			
HCO_3 (mmHg)	Normal	9	30.0	11	36.7	17	56.7	14	46.7	12	40.0	10	33.3	15	50.0	9	30.0
	Abnormal	21	70.0	19	63.3	13	43.3	16	53.3	18	60.0	20	66.7	15	50.0	21	70.0
P		0.584				0.438				0.592				0.114			
SaO_2 (%)	<90	0	0.0	0	0.0	2	6.7	0	0.0	0	0.0	3	10.0	1	3.3	0	0.0
	≥90	30	100	30	100	28	93.3	30	100	30	100	27	90.0	29	96.7	30	100
P		1.000				0.492				0.237				1.000			
Pulmonary oxygenation capacity index (mmHg)	≥300	17	56.7	23	76.7	14	46.7	22	73.3	16	53.3	23	76.7	11	36.7	21	70.0
	225 – 299	3	10.0	5	16.7	6	20.0	6	20.0	6	20.0	3	10.0	9	30.0	4	13.3
	175-224	4	13.3	2	6.7	4	13.3	1	3.3	4	13.3	2	6.7	4	13.3	3	10.0
	100-174	4	13.3	0	0.0	4	13.3	1	3.3	4	13.3	1	3.3	4	13.3	1	3.3
	<100	2	6.7	0	0.0	2	6.7	0	0.0	0	0.0	1	3.3	2	6.7	1	3.3
P		0.090				0.128				0.195				0.107			



Novelty Journals

ISSN 2394-7330

International Journal of Novel Research in Healthcare and Nursing
Vol. 7, Issue 3, pp: (119-130), Month: September - December 2020, Available at: www.noveltyjournals.com

Table (5) describes the distribution of the two group of patients according to their excreted secretions characteristics, regarding the **amount of excreted secretion**, it can be observed that 13.3% and 76.7% of the control and intervention group of patients in post routine care and post intervention respectively the amount of excreted secretions was >20 ml in the first time of first day. There is statistical significant difference between the two groups in post period of the study (P = 0.001*).

Related to the color of excreted secretions, it can be noticed that 23.3% and 36.7% of the control and intervention groups of patients respectively had clear color of excreted secretions in post period; also 76.7% and 63.3% of the same groups respectively had yellow color of excreted secretions in post period of first time of the first day. There is no statistical significant difference between the two groups in the study (P=0.260)

Regarding the viscosity of excreted secretions, this table shows that 86.7% and 23.3% of the control and intervention group of patients in post routine care and post intervention respectively the viscosity of excreted secretions was thick in the first time of the first day. There is statistical significant difference between the two groups in post period (P= 0.001*).

Table (5): Distribution of the two groups of patients according to their excreted secretion characteristics

Oxygenation parameters		Control vs intervention															
		First day								Second day							
		1st time				2nd time				1st time				2nd time			
		Post routine care		Post intervention		Post routine care		Post intervention		Post routine care		Post intervention		Post routine care		v Post intervention	
		N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Amount of Excreted Secretions (ml)	<5	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
	5 – 10	21	70.0	2	6.7	22	73.3	1	3.3	24	80.0	1	3.3	20	66.7	2	6.7
	>10 – 15	4	13.3	2	6.7	5	16.7	2	6.7	0	0.0	0	0.0	4	13.3	1	3.3
	>15 – 20	1	3.3	3	10.0	0	0.0	1	3.3	2	6.7	2	6.7	1	3.3	3	10.0
	>20	4	13.3	23	76.7	3	10.0	26	86.7	4	13.3	27	90.0	5	16.7	24	80.0
P		0.001*				0.001*				0.001*				0.001*			
Color of secretions	Clear	7	23.3	11	36.7	7	23.3	9	30.0	5	16.7	10	33.3	5	16.7	10	33.3
	Yellow	23	76.7	19	63.3	23	76.7	21	70.0	25	83.3	20	66.7	25	83.3	20	66.7
P		0.260				0.559				0.136				0.136			
Viscosity of secretions	Watery	4	13.3	23	76.7	4	13.3	23	76.7	5	16.7	25	83.3	5	16.7	25	83.3
	Thick	26	86.7	7	23.3	26	86.7	7	23.3	25	83.3	5	16.7	25	83.3	5	16.7
P		0.001*				0.001*				0.001*				0.001*			

P: p value for comparing Control and Intervention groups in post routine care and post intervention using Chisquare test

*: Statistically significant at $p \leq 0.05$

IV. DISCUSSION

Discussion of the finding results in the current study covers two main areas; characteristics of the studied mechanically ventilated patients, and the effectiveness of chest percussion and squeezing on respiratory status.

Most of the studied mechanically ventilated patients were male, aged in range 40-60 years old, with length of ICU stay and duration of mechanical ventilation ≤ 4 days. Additionally, more than half of the studied mechanically ventilated patients admitted to ICU with respiratory and neurological disorders, the majority of them not received sedation therapy and had abnormal chest radiograph finding as shown in radiology, and finally, half of the control group of patients received bronchodilators and mucolytic, while more than half of the intervention group of patients received bronchodilators only. There were no statistical significant differences between the two groups regarding their clinical data.

The current study hypothesized that the mechanically ventilated patients who are subjected to chest percussion and squeezing exhibit improvement in their respiratory status in comparison to those who are not. Regarding the effectiveness of chest percussion and squeezing, concerning the respiratory assessment, The result of the study strongly shows that the majority of the intervention group of patients had normal respiratory finding by inspection and auscultation and also the recurrence of tachypnea and crepitation reduced in post period of the intervention, there is highly statistical significant difference between pre and post intervention, first and second time of the intervention, and between two groups of patients in the study. It may be related to the effect of chest percussion and squeezing which facilitate the removal of

retained secretions, helps in reducing airway resistance, optimizing lung compliance, and decrease the work of breathing, thus improving respiratory rate, which highlights the effect of the intervention. This is in accordance to Kole and Metgud (2014) who conducted a study on the effect of lung squeeze technique and reflex rolling on oxygenation in patients with respiratory problem; they found that there is improvement in chest sound after intervention.

Regarding arterial blood gases, this study displays that there was increase in PaO2 in the majority of the intervention group in post intervention in the study. There is highly statistical significant difference between pre and post intervention, and between two groups of patients. This can be related to that chest percussion and squeezing helps to dislodges and mobilize the trapped secretions in the airway and so decrease airway resistant, improves airway clearance, increase pulmonary volumes, re-inflate atelectasis alveoli, facilitate alveolar recruitment, improve alveolar ventilation, increase tidal volume, and improve gas exchange and oxygenation.

Finding of the present study are in accordance with Meawad et al. (2018) who studied the effect of chest physical therapy modalities on oxygen saturation and partial pressure of arterial oxygen in mechanically ventilated patients, and they found that chest physiotherapy plays an important role in increasing PaO2,also with Zeng, Zhang, Gong and Chen (2017)in a study about chest pulmonary physiotherapy in patients with mechanical ventilation, and concluded that chest physiotherapy increase in PaO2 in their study group who received comprehensive chest physiotherapy.

The finding of the present study reveals that the majority of the intervention group of patients had PaO2 / FiO2 ratio ≥300mmHg in post intervention in the study. There is statistical significant difference between pre and post intervention in the first time of the first and second day, and between the first and second time of the second day of the control group of patients concerning pulmonary oxygenation capacity index in favor to the intervention group of MV patients. Moreover, the present study shows that there was increase in SpO2 reading post routine care in only the second time of the second day at 20, 30, and 60 minute of suction within the control group of patients, and also in post intervention at baseline and immediately period after suction within the intervention group of patients in the study which highlights the immediate effect of the chest percussion and squeezing. This may be related to the effect of the procedure which helps in mobilization and excretion of secretions, maintain mucocilary clearance, resulting improve the external and internal respiration which help the mechanically ventilated patients to less need to oxygen therapy.

Similar to the present study, Kohan et al. (2014) in the study about effects of expiratory ribcage compression before endotracheal suctioning on arterial blood gases in patients receiving mechanical ventilation, they added that ERCC can improve the PaO2/FiO2 readings. Arif, Bashir and Noor (2014) in the study about the effectiveness of chest physiotherapy in the management of bronchiectasis, they found that chest Physiotherapy had significant effect and improvement in SpO2.Contrary and supported to the previous finding in the same time Borges et al. (2017) in the study about expiratory rib cage compression in mechanically ventilated adults; they stated that there was no difference between groups regarding SpO2 However, in the intragroup analysis; SpO2 was significantly increased in the ERCC group, in addition they found that there was no significant changes found in PaO2/FiO2 readings after ERCC with respect to parameters that are used to assess ventilator mechanics.

Additionally, There is highly statistical significant difference between pre and post intervention and between the two groups of patients regarding the amount and viscosity of excreted secretions which highlight the effect of intervention.it may be due to chest percussion helps in mobilization of secretions to central airway, while the thoracic squeezing which is performing during expiration helps in increasing the removal of the airway secretions through increasing the expiratory peak flow in mechanically ventilated patients resulting in the disruption of glycoprotein molecules, reduced mucus viscosity, and increasing the movement and amount of the excreted secretions.

These previous finding in line with Yousefnia-Darzi et al. (2016) who conducted a study on effect of thoracic squeezing on airway secretion removal in mechanically ventilated patients, they reported that the mean weight of the removed secretions with thoracic squeezing was significantly more than that of the secretions removed without squeezing. In agreement with Goncalves et al. (2016) in the study about effects of chest compression on secretion removal, lung mechanics, and gas exchange in mechanically ventilated patients, he stated that in mechanically ventilated patients, chest compression promotes a greater removal of secretions and improvement of static compliance. Contrary to the previous finding Borges et al. (2017) in the study about expiratory rib cage compression in mechanically ventilated adults; they

found that the volume of suctioned secretion was similar to that of the control group in all analyzed situations. There is no difference between groups regarding the variables secretion volume.

V. CONCLUSION

Based on the finding of the current study it can be concluded that the chest percussion and squeezing are applicable and effective maneuvers for mechanically ventilated patients, they improve alveolar ventilation, gas exchange, decrease the force of breathing, and promote airway patency by removing airway secretions. There were highly statistical significant difference between the control and intervention groups regarding tidal volume, amount and viscosity of excretory secretions, respiratory inspection and auscultation in favor to the intervention group. Chest percussion and squeezing can improve the oxygenation parameters as the pulmonary oxygenation capacity index (PaO2/FiO2 readings), SpO2, PaO2 and FiO2.

VI. RECOMMENDATIONS

- Enhance the knowledge of CCNs about chest squeezing technique or expiratory rib cage compression technique through continuous nursing teaching sessions on chest squeezing.
- Conduct periodic workshop and follow up competency assessment.
- Early initiation of these maneuvers for mechanically ventilated patients can prevent several complications and also help the patients to gain independence and return to an active life style
- Periodic audits and feedback on implementation of the maneuvers, to create awareness and motivate CCNs.
- Orientation and in-service training for CCNs regarding implementation of the maneuvers to reduce variation in practice and limited information.
- Assess the effect of chest squeezing and expiratory rib cage compression (ERCC) on longer term outcomes, such as duration of mechanical ventilation and length of hospitalization in intensive care unit.
- Replicate this study on a larger sample for generalization of the result.

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