Effect of Cough Augmentation Techniques on Airway Clearance of Mechanically Ventilated Patients

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Abstract

Background: Mechanical ventilation is a form of life support for 90% of critically ill patients. **Aim:** To evaluate the effect of cough augmentation techniques on the airway clearance of a mechanically ventilated patient. **Subjects and Method: Design:** Quasi- experimental study. **Setting:** This study was conducted at Anesthesia Intensive Care Unit of Tanta Emergency Hospital. **Subjects:** 60 cases divided into two groups 30 in each in the above previously mentioned setting. **Tools:** two tools were utilized in this research. **Tool I**: Mechanically Ventilated Patients Evaluation Sheet**, Tool II:** Patients' Hemodynamic Parameters Sheet. **Results**: patients with a specific medical condition have a significant increase in respiratory rate, heart rate, systolic and diastolic blood pressure, and oxygen saturation after 25 minutes of intervention ($p<0.05$). The study and control groups didn't show significant differences in temperature ($p<0.05$). Mean pulmonary filtration rate (PH) didn't change significantly, but a significant decrease was observed in the third day only among the study group. **Conclusion:** The study found that cough augmentation techniques significantly improved airway clearance in mechanically ventilated patients, leading to increased hemodynamic stability, oxygen saturation, blood gas exchange, and breathing stability. **Recommendation:** The investigation suggests further multi-center studies and the use of cough augmentation techniques in managing secretions complaints in Intensive Care Units.

Keywords: Airway Clearance, Cough Augmentation Techniques, Mechanically Ventilated Patients.

Introduction

Mechanical ventilation is a form of life support for 90% of critically ill patients. Patients who are undergoing mechanical ventilation are more likely to maintain secretion as a result of impaired airway clearance **(Ambrosino & Vitacca, 2018)**. The prolonged accumulation of secretions in the airways of patients with an endotracheal tube results in complete or partial obstruction of the airway. This condition is associated with atelectasis, air trapping,

cyanosis, dysrhythmias, respiratory acidosis, pulmonary hyper distension, and impaired gas exchange. Maintaining patent airway is always the first priority of nursing care, especially in patient on mechanically ventilated patient. It is essential that critically care nurses have sufficient airway management skills **(Sarkar et al., 2017; Ruscic et al., 2017)**.

The risk of lung complications, including ventilator-associated pneumonia (VAP), which is described as a parenchymal lung infection that occurs over 48 hours following the initiation of mechanical ventilation, is increased by the use of invasive ventilator support. It correlates with a general hospital mortality rate of 30% to 70% and happens in around nine to twenty-seven percent of patients undergoing invasive mechanical ventilation. The mortality rates of intubated patients remain greater than those who don't require ventilator support, regardless of the recent advancements in diagnostic modalities and management of these infections. Ventilator Associated Pneumonia remains one of the most prevalent hospital-acquired infections that are encountered in ICU patients **(Papazian et al., 2020)**.

Cough augmentation technique is a procedure that enhances the lung and airway clearance from secretion and prevents pooled secretion in lower airway.it is frequently utilized in patients who are critically ill, intubated, and mechanically ventilated, as well as those who have neurological weakness, spinal cord injury, or neuromuscular diseases. Cough augmentation for proximal secretion clearance may be conducted by manual hyperventilation (MH) and manually-assisted cough (MAC) **(Yousefnia-Darzi et al., 2016; Rose et al., 2017)**.

Manually assisted coughing is also referred to as manual chest compression, expiratory rib cage compression, and squeezing. This method involves the application of aggressive chest compressions during the expiratory phase of mechanical ventilation or the commencement of spontaneous expiration. It aimed to activate one of the most efficient mechanisms of airway clearance by directing secretions toward the trachea, where they may be removed through tracheal aspiration or coughing. Additionally, numerous studies indicate that the frequency of manually assisted coughing may decrease the occurrence of pulmonary complications caused by secretion retention **(Rose et al., 2017; Jeong & Yoo, 2015; Spapen et al., 2017)**.

Thus, the researcher aimed to assess the impact of cough augmentation techniques on the airway clearance of a mechanically ventilated patient.

Significance of study

Patients on mechanical ventilation in the ICU experience considerable accumulation of secretion, thus, airway management is a critical &essential skill that all nurses must have. The core critical care skills include the ability to manage a patient's airway, and nurses must be proficient in providing this service. Depending on the assessment, nurses must also be capable of implementing adequate airway management strategies, like the augmented cough technique which is a safe method for maintaining patent airway and oxygenation **(Heidari & Shahbazi, 2017)**.

Aim

Evaluate the effect of cough augmentation techniques on the airway clearance of a mechanically ventilated patient.

Research Hypothesis:

Mechanically ventilated patients in the study group who are managed by cough augmentation techniques will be expected to have improvement of physiological parameters and arterial blood gases reading compared to the control group.

Subjects and method

Research design:

A quasi- experimental research design was utilized

Subjects:

The sample of the research included a purposive sampling of 60 patients with acute stroke were collected from the previously mentioned setting.Based on Epidemiological Information Program (Epi info) and the total patients admitted per year according to the following parameters: Total patients are 300 per year. The total sample size was (60) patients divided into two equal groups, 30 patients in each as the following:

Control group, consisted of 30 adult patients who received the routine nursing care by hospital nursing staff such as suction.

Study group, consisted of 30 adult patients who receive cough augmentation techniques by the researcher.

Subjects have been chosen regarding to the following criteria:

Inclusion criteria: The subjects that selected according to the following criteria:

-Adult patients (21 to 60 years).

- Both sexes.

-Spent for more than 24 hr. in ICU.

-Hemodynamic stability.

Exclusion criteria:

- Patient with pneumothorax (if chest tube is present).

-Patient with diaphragmatic hernia.

-Patient with cardiac and thoracic surgery.

- Positive end-expiratory pressure (PEEP) > 8 cmH2O.

Tools of data collected:

Two tools were used in the current study. It included the following:

Tool I: Mechanically Ventilated Patients Assessment .This tool was developed by the researcher after reviewing the relevant literature (**Katz, 2018; Rose et al., 2017; Spapen et al., 2017)**. It included two parts as follow **Part (a)**: Patients' Sociodemographic Characteristics and Clinical Data: - This part included patient's age, sex, marital status, diagnosis, past and present medical, level of consciousness and type of medications. **Part (b):** Mechanical Ventilation Parameters Sheet. This part included modes of mechanical ventilation, positive end expiratory pressure (PEEP), peak inspiratory pressure (PIP) in cmH2O, Peripheral oxygen saturation (SpO2), tidal volume, respiratory rate, fraction of inspired oxygen (Fio_2) **(Brooker, 2013; Rimmer et al., 2019)**.

Tool II: Patients' Hemodynamic Parameters. This tool was developed by the researcher after reviewing the relevant literatures **(Brooker, 2013; Rimmer et al., 2019)**. It included two parts as follow:

Part (a): Physiological Parameters Assessment, this part was used to assess vital signs, rhythm, pattern and depth of breathing, amount, consistency and color of secretions, chest movement, breath sound

and oxygen saturation (So_2) which measured by pulse oximetry.

Part (b): Arterial Blood Gases Assessment. It was used to assess PH, PaO_2, $PaCO_2$, HCO_3, O_2 and base excess.

Scoring system:

-Abnormal findings scored (0).

- Normal findings scored (1).

-The scores of the items summed-up and the total divided by the number of the items, giving a mean score; means and standard deviations and computed was measured by pulse.

Method

1. Official Permission to carry out the study obtained from the responsible authorities at the study setting.

2. Ethical and legal consideration:

a. Ethical committee approval was obtained from the faculty of nursing with code No (34/2/2022).

b. Nature of the study not caused any harm or pain to the entire subjects.

c. Informed consent was taken from every patient if he/she is conscious or from one of the family members if patient is unconscious after explanation the aim of the study and including the right to withdrawal at any time.

d. Confidentiality and anonymity maintained by use of code number instead of name and privacy of the patients were taken into consideration regarding data collection.

3. Tools (I and II) were developed by the researcher after review of the relevant literatures.

4. **Tools Validity:**

All tools were tested for content validity for clarity and applicability by 5 experts of Critical Care and Emergency Nursing and Medical Biostatistics and modifications were done accordingly.

5. **A pilot study:**

Conducted on 10% of patients to test the feasibility and applicability of the tools and to determine any obstacles that may encountered during the period of data collection, accordingly, needed modification. Those patients excluded from the study subjects.

5. **Reliability**:

Measured for the study tools using Cronbach's alpha test. Cronbach's Alpha for tool I was 0.881 for 15 items applied on 6 mechanically ventilated patients. Cronbach's Alpha for tool II was 0.826 for 18 items applied on 6 mechanically ventilated patients. Cronbach's Alpha for the sheet in total was 0.897 for 33 items applied on 14 mechanically ventilated patients.

7. Patients who fulfill the inclusion criteria immediately on admission assessed and divided into two equal groups, 30 patients in each group. The researcher started by control group patients first to prevent data contamination.

8. Data were collected over a period of 6 months, started from June 2022 to November 2022. Each session for the patient lasted for about 20-30 minutes to complete the tools and 15-20 minutes for each patient.

9- The present study conducted through four phases as follow:

1-Assessment phase: Assessment was done by the researcher for all mechanically ventilated patients using tool I for both groups. This phase started immediately before applying cough augmented technique to assess the base line data.

2-Planning phase: Based on data of assessment phase and literature review, cough augmentation techniques developed.
Expected outcomes criteria formulated as the following. Expected outcomes:
1. Maintain Stability of hemodynamic parameters.
2. Decrease accumulation of secretion.

3- Implementation phase:

1- Control group patients received their routine hospital nursing care as provided to the patients by intensive care nurses which included suction technique

2- Study group patients received cough augmented technique that implemented by the researcher and agreed by the treating physician in the Anesthesia care unit, it will include the following:

-The procedure of manual hyperinflation. The steps of the implementation of manual hyperinflation are as follows:

Pre procedure preparations:

-The patients' vital signs were assessed to ensure they are stable and in order to detect changes in the patients 'condition.

-The patient was placed in semi fowler's position to optimize ventilation and assists with the drainage of secretions.

-The safety of equipment was ensured to prevent cross-contamination of the bag.

-Pre-oxygenation suction was used facility to disable the alarm.

The procedure:

-The patient was separated from the mechanical ventilator and attached the rebreathing bag or resuscitator ambu Bag to the airway using two hands.

-At the beginning, a tidal volume breath was provided and the patient's chest expansion watched to allow the operator to obtain feeling of patient's lung compliance.

-Manual hyperinflation breaths were performed for at least 2 seconds to make sure it delivered effectively and expand the collapsed alveoli.

-The bag was deflated suddenly on expiration to simulate the mobilization of secretions from the periphery to the central airways.

-The procedure was repeated many times as mentioned to cause more removal of secretion and expansion of the collapsed alveoli.

-If the patient was coughing, the expiratory pressure valve should be released to decrease the pressure developed in the lungs and minimize the risk of barotraumas post procedure.

-Suctioning perform if the patient coughs or secretions were auscultated.

-The above procedure Continued until no more secretions are heard or the chest is clear on auscultation.

The procedure of manual assisted cough (MAC). The manual assisted cough technique consists of manual compression of the rib cage during the expiratory phase and release from the compression at the end of the expiration.

-Patients were placed in the supine position, with the head of the bed at zero degrees of inclination.

-The two hands were placed bilaterally on the lower third of the thorax, or unilaterally with the hands placed on the middle third of the thorax or simultaneously on the chest and abdomen.

- One of the hands ventrally on the chest (above the sternum) and the other on the abdominal region.
- The technique was applied at the beginning of the expiratory phase of the mechanical ventilation, 10 times in each patient, with intervals of three respiratory cycles between each application.
- In the rib cage compression, the researcher performed bilateral squeezing to the lower rib cage gradually during expiration.
- Each rib cage compression was released at the end of expiration to facilitate comfort inspiration.
-Specific care was taken to make sure that compression was executed only during expiration.
-The open suctioning technique was carried out immediately after completion of manual hyperinflation, and manual assisted cough.
-Airway suctioning was performed twice with an interval of 3 hours on the same day for 10 seconds for each patient (as required)
-The secretions were collected in a container connected to the catheter and weighed by a scale.
-Withdrawing the radial arterial sample and assessment of physiological parameters was carried out before and after the above mentioned interventions.
-The duration of session was between 20 and 30 min as guided by patients' fatigue and comfort.
-One session done daily; the patients must be not on feeding or suction at least 2 hours prior to the session.

(**4): Evaluation phase**: Evaluation was done for both control and study groups two times before the procedure and 25 minutes after the procedure for 3 consecutive days using tool (II).

Results

Table (1): Demonstrates percentage distribution of the examined patients regarding to their general characteristics (n=60).

It was observed that about one third (33.33%) of the cases in control group comparing with nearly one-quarter (23.33 %) of the cases in the study group were in the age group among (30-40) years old with the mean age of 40.40±11.3 and 40.1±12.3 years respectively. Regarding gender, it was detected that two-third of the cases (66.67%) in the control and study groups as well were males. Regarding marital status, most patients in the control and study group were married (70% & 56.6% respectively). Also, it was observed that statistically insignificant variance was observed among the two groups regarding general characteristics.

Table (2): Demonstrates percentage distribution of the examined mechanically ventilated patients according to their diagnosis within the examined groups (n=60).

Concerning recent diagnosis, it was reported that more than two third (70.00%) and greater than one-half (60%) of cases in the two control and study groups had Cerebellar Hemorrhage respectively, also statistically insignificant variance was observed among the two groups.

Table (3): Represented distribution of the examined mechanically ventilated patients according to their clinical data.

As regard to past medical history, it was noticed that the most common comorbid

disease (53.33%, 36.67%) among cases in both control and study groups were diabetic, then fifty percent of cases in control group had renal disease comparing with 13.3% of cases in study group. The chief complaint was loss of consciousness in 63.33% and 73.33% in the control and study groups respectively with non- statistically significant variance was detected among the two groups (p value >0.05). As regard to level of consciousness, about two-third of patients in the control group (66.7%) had response to pain compared to 40% of patients in the study group with statistically significant variance among both groups (p value <0.05). Concerning current medication, all cases in the control and study groups (100%) were on analgesic treatment than 86.67% of cases in the control group were on muscle relaxants comparing with two-third of cases in the study group with non-statistically significant variance among the two groups (p value >0.05).

Table (4): Present percentage distribution of the examined mechanically ventilated patents according to modes of mechanical ventilation.

It was detected that most cases in the control group (63.3%) were on SIMV in the 1st day comparing with 80% of cases in the study group then the percentage of patients who were on SIMV increased to 73.3% and 100% in the second day in the control group & study group respectively, then increased again to 76.7% in the third day in the control group and remained constant in the study group, with non-statistically significant variance within 1st day, second day and third day in each group separately (p value >0.05) regarding mode of ventilation.

Table (5): Shows mean scores of physiological parameters of the examined mechanically ventilated patients.

Patients in the study group experienced a significant increase in respiratory rate after 25 minutes of intervention, while the control group did not. Heart rate, systolic and diastolic blood pressure also decreased significantly after 25 minutes of intervention (p value < 0.05), O2 saturation also increased significantly after 25 minutes of intervention, while the control group experienced a decrease. Temperature did not show significant differences between the study group and control group after 25 minutes of intervention P>0.05.

Table (6): Shows mean scores of arterial blood gases of the examined mechanically ventilated patient during the study periods.

There was no significant change in mean pulmonary filtration rate (PH) after 25 minutes of intervention, but a significant decrease was observed in the third day only among the study group. The control group showed no significant decrease in PH throughout the study period. PaO2 increased from 82.80±30.24 to 113.92±32.92 in the first day, while the study group showed a decline in the second and third days. PaCO2 decreased from 30.50±8.24 to 28.85±6.61 in the first day, but a significant decrease was observed in the third day only among the study group. The control group showed no significant decline in PaO2 in the first, second, and third days.

HCO3 decreased from 26.42±5.49 to 26.42±5.49 in the first day, but a decrease was significant in the third day only among the study group. SPO2 increased from

93.95±8.88 to 98.48±0.79 in the first day, but a significant increase in the control group was observed in the third day.

Table (7): Shows association between medical diagnosis of the examined mechanically ventilated patients and their chest assessment post 25 min at 3rd day of admission.

There was significant variance in the amount, consistency, color, depth, and rhythm pattern of cerebellar hemorrhage among patients with different medical diagnoses P<0.05. Among these, 50% had excessive cerebellar hemorrhage, while 13.33% had excessive with Myasthenia Gravis and Gillian barre syndrome, and 6.67% had excessive with respiratory failure. The results were non-statistically significant in the control group P>0.

Table (1): Distribution of the examined mechanically ventilated patients according their general characteristics

Characteristics	The studied patients (n=60)				χ^2 P
	Study group (n=30)		Control group (n=30)		
	No	%	No	%	
Age (in years)					
(21-<30)	8	26.67	6	20.00	
(30-<40)	7	23.33	10	33.33	0.882
(40-<50)	7	23.33	7	23.33	0.830
(50-60)	8	26.67	7	23.33	
Range	**(21-59)**		**(23-59)**		F=0.010
Mean ± SD	**40.10±12.377**		**40.40±11.300**		P=0.922
Gender					
Male	20	66.67	20	66.67	FE
Female	10	33.33	10	33.33	1.00
Marital status					
Single	13	43.33	9	30.00	FE
Married	17	56.67	21	70.00	0.422

FE: Fisher' Exact test

Table (2): Distribution of the examined mechanically ventilated cases regarding their diagnosis

Diagnosis	The studied patients (n=60)				χ^2 P
	Study group (n=30)		Control group (n=30)		
	No	%	No	%	
Cerebellar Hemorrhage	18	60.00	21	70.00	
Myasthenia gravis	4	13.33	0	0.00	**10.154**
Gullian barre Syndrome	4	13.33	0	0.00	**0.117**
Respiratory Failure	4	13.33	9	30.00	

* Significant at level P<0.05

Table (3): Distribution of the examined mechanically ventilated cases regarding their clinical data

Clinical data	The studied patients (n=60)				χ^2 P
	Study group (n=30)		Control group (n=30)		
	No	%	No	%	
# Past medical history					
Respiratory diseases	7	23.33	1	3.33	
Heart diseases	10	33.33	11	36.67	
Renal diseases	4	13.33	15	50.00	**9.392**
Hepatic failure	0	0.00	2	6.67	
Neurological diseases	8	26.67	0	0.00	
Diabetic	11	36.67	16	53.33	
Cancer	0	0.00	2	6.67	
# Chief complaint					
Accident	1	3.33	10	33.33	
Bleeding	5	16.67	6	20.00	
Loss of Consciousness	3	10.00	1	3.33	
Loss of mobility	0	0.00	1	3.33	
Uremic convulsion	0	0.00	2	6.67	
Severe pain	0	0.00	4	13.33	
Deterioration of Consciousness	5	16.67	8	26.67	0.884
Severe Headache	5	16.67	2	6.67	0.347
Confusion	0	0.00	1	3.33	
Bradycardia	0	0.00	1	3.33	
Hypertension	0	0.00	3	10.00	
Edema	1	3.33	2	6.67	
Difficult Breathing	10	33.33	0	0.00	
Head injury	10	33.33	0	0.00	
Disturbed conscious level	3	10.00	0	0.00	
consciousness Level					
Response to voice	15	50.00	3	10.00	**11.601 0.003***
Response to pain	6	20.00	3	10.00	
Unresponsive	3	10.00	7	23.33	
# Type of Medication					
Intropic	0	0.00	1	3.33	
Muscle relaxant	20	66.67	26	86.67	0.890
Analgesic	30	100.00	30	100.00	0.324
Mucolytic	14	46.67	12	40.00	
Bronchodilator	22	73.33	10	33.33	
Others	1	3.33	0	0.00	

More than one answer was chosen * Significant at level P<0.05

Table (4): Distribution of the examined mechanically ventilated patients regarding modes of mechanical ventilation

Mode	The examined cases (n=60)													
	Study group (n=30)						χ^2 P	Control group (n=30)						χ^2 P
	1st day		2nd day		3rd Day			1st day		2nd day		3rd Day		
	No	%	No	%	No	%		No	%	No	%	No	%	
ACV	6	20.0	0	0.0	0	0.0	3.751 0.435	10	33.3	8	26.7	7	23.3	2.966 0.563
SIMV	24	80.0	30	100.0	3	100.		19	63.3	22	73.3	23	76.7	
PCV	0	0.0	0	0.0	0	0		1	3.3	0	0.0	0	0.0	
					0	0.0								

* Significant at level P<0.05

Table (5): Mean scores of physiological parameters of the examined mechanically ventilated patients

Vital signs	The Studied cases (n=60)	Range Mean ± Standard deviation								
		1st day		T P	2nd day		t p	3rd Day		t p
		Pre	Post 25 min		Pre	Post 25 min		Pre	Post 25 min	
1-Respiratory rate (C/m)	Study group	(14-22) 18.53±2.81	(17-28) 24.23±3.36	**7.125 0.000***	(12-28) 19.20±5.33	(18-33) 25.23±4.56	**4.709 0.000***	(13-22) 16.70±2.73	(22-28) 24.47±2.44	**11.604 0.000***
	Control group	(14-26) 18.30±3.46	(14-27) 19.10±2.43	1.077 0.304	(16-25) 21.23±2.61	(16-27) 21.30±2.89	0.009 0.926	(14-34) 23.13±5.12	(16-33) 23.23±4.38	0.007 0.936
2-Heart rate (B/m)	Study group	(90-150) 110.17±17.43	(60-104) 80.70±13.67	**7.284 0.000***	(90-138) 109.63±15.24	(63-110) 84.60±13.17	**6.815 0.000***	(95-130) 110.20±11.62	(58-120) 82.37±12.72	**8.855 0.000***
	Control group	(66-125) 94.13±13.71	(67-110) 86.13±11.07	**6.183 0.016***	(67-140) 102.00±22.16	(55-130) 94.30±16.41	2.341 0.131	(60-140) 109.03±17.24	(67-116) 97.23±14.29	**8.329 0.005***
3-Blood pressure (mmHg) -Systolic pressure	Study group	(90-140) 118.90±16.82	(90-130) 104.00±8.13	**4.367 0.000***	(100-140) 125.33±15.91	(90-130) 109.00±16.68	**3.880 0.000***	(90-150) 135.67±11.94	(70-140) 119.33±17.06	**4.305 0.000***
	Control group	(99-160) 126.30±15.70	(80-178) 128.50±22.74	0.190 0.664	(100-170) 135.00±18.89	(80-160) 122.70±18.25	**6.578 0.013***	(90-160) 133.33±20.40	(90-170) 130.67±18.74	0.278 0.600
-Diastolic pressure	Study group	(90-140) 118.90±16.82	(90-130) 104.00±8.13	**4.367 0.000***	(100-140) 125.33±15.91	(90-130) 109.00±16.68	**3.880 0.000***	(90-150) 135.67±11.94	(70-140) 119.33±17.06	**4.305 0.000***
	Control group	(60-100) 79.53±13.12	(50-100) 76.63±10.75	0.877 0.353	(50-100) 81.00±16.05	(50-100) 76.47±11.10	1.619 0.208	(50-100) 81.00±16.89	(50-100) 78.33±16.63	0.380 0.540

4-Temperature (0c)	**Study group**	(36.6-37.8) 37.16±0.49	(36.5-37.7) 37.08±0.51	0.593 0.555	(37.5-37.9) 37.70±0.15	(37.5-37.8) 37.64±0.13	1.525 0.133	(37.7-38.2) 37.92±0.17	(37.6-38.2) 37.86±0.14	1.813 0.075
	Control group	(36-38) 37.35±0.50	(36.2-38.1) 37.40±0.46	0.163 0.688	(37-38.5) 37.87±0.34	(37-38.6) 37.88±0.34	0.024 0.878	(37.5-39) 38.33±0.39	(37.6-39.2) 38.45±0.38	1.598 0.211
5-Oxygen saturation (O2)	**Study group**	(92-97) 94.87±1.52	(94-98) 95.93±1.37	**2.905 0.005***	(92-98) 95.93±2.19	(94-99) 97.10±1.90	**2.228 0.030***	(94-98) 96.50±1.54	(95-99) 97.33±1.49	**2.122 0.038***
	Control group	(92-100) 96.20±2.38	(90-98) 95.37±1.88	2.256 0.138	(92-100) 96.73±1.86	(93-99) 95.80±1.63	**4.290 0.043***	(92-99) 96.43±2.03	(93-98) 95.50±1.46	**4.190 0.045***

* Significant at level P<0.05

Table (6): Mean scores of arterial blood gases of the examined mechanically ventilated patients during the study periods.

Arterial blood gases	The examined cases (n=60)	Range Mean ± SD								
		1st day		T P	2nd day		t p	3rd day		t p
		Pre	Post 25 min		Pre	Post 25 min		Pre	Post 25 min	
PH	Study Group	(7.39-7.59) 7.52±0.05	(7.40-7.69) 7.52±0.08	0.269 0.789	(7.33-7.74) 7.54±0.11	(7.42-7.58) 7.51±0.03	1.443 0.765	(7.42-7.56) 7.50±0.04	(7.40-7.62) 7.47±0.05	**2.417 0.019***
	Control Group	(7.25-7.63) 7.46±0.09	(7.20-7.65) 7.43±0.11	1.608 0.210	(7.25-7.65) 7.46±0.09	(7.18-7.65) 7.45±0.13	0.237 0.628	(7.18-7.66) 7.45±0.14	(7.32-7.55) 7.43±0.07	0.997 0.322
t , P									**2.79 , 0.007***	
PaO_2	Study Group	(33.2-177) 82.80±30.24	(81.8-198) 113.92±32.92	**3.812 0.00***	(70.5-165) 117.96±21.65	(67.7-197) 115.88±36.98	0.265 0.792	(62-154.7) 101.50±30.74	(77.1-184) 111.44±27.87	1.313 0.194
	Control Group	(51.6-301.5) 142.21±71.58	(43-287) 127.63±60.69	0.724 0.398	(81.2-212.5) 142.38±49.01	(76-206) 126.87±43.20	1.692 0.199	(56.3-273.3) 132.09±46.15	(60-204) 113.30±32.09	3.354 0.072
t , P									0.24 0.812	
$PaCO_2$	Study Group	(20-55.7) 30.50±8.24	(21.2-53.8) 28.85±6.61	0.856 0.396	(19.1-42.1) 31.96±4.24	(26-39.6) 31.55±4.08	0.378 0.707	(26.1-44.8) 35.50±6.60	(26.8-39.7) 32.13±4.66	**2.282 0.026***
	Control Group	(18.2-52.8) 30.87±7.51	(29-49) 30.87±7.51	**24.285 0.000***	(19.1-50.4) 32.68±9.47	(29-49) 39.50±5.96	**11.152 0.001***	(17.7-50) 32.40±9.02	(29-59) 40.17±7.28	**13.470 0.001***

t , P									**5.09 0.000***	
HCO_3	**Study Group**	(18.6-36.9) 26.42±5.49	(3.9-32.7) 26.42±5.49	1.723 0.090	(15.9-29.5) 25.07±3.78	(21.4-27) 24.30±1.98	0.993 0.325	(21.2-32.4) 26.48±3.72	(17.2-39.4) 24.87±4.40	1.535 0.130
	Control Group	(16-29) 21.73±4.08	(17-28) 22.63±3.58	0.837 0.364	(15.2-41.7) 22.52±6.50	(17-32) 24.38±3.65	1.868 0.177	(14.6-32.6) 23.33±4.35	(18.6-39.9) 27.07±5.32	**8.900 0.004***
t , P									1.75 0.086	
SpO_2	**Study Group**	(61.7-99.4) 93.95±8.88	(96.7-99.7) 98.48±0.79	**2.779 0.007***	(93.9-99.3) 97.98±1.60	(94.9-991) 127.99±163.01	1.008 0.318	(93-98.3) 96.77±1.49	(97-99.8) 98.95±0.77	**7.138 0.00***
	Control Group	(91.5-100) 97.59±2.41	(90-98) 95.37±1.88	**15.921 0.000***	(90-99.8) 97.52±2.08	(93-99) 95.80±1.63	**12.744 0.001***	(91.5-99.8) 97.29±2.21	(93-98) 95.50±1.46	**13.634 0.000***
t , P									**11.48 , 0.000***	

Table (7): Relation between medical diagnosis of the examined mechanically ventilated cases & their chest assessment post 25 min at 3rd day of admission.

Chest assessment	Medical diagnosis The studied patients (n=60)																	
	Study group (n=30)								χ^2 P	Control group (n=30)								χ^2 P
	Cerebellar Hemorrhage		Myasthenia Gravis		Gillian barrre syndrome		Respiratory Failure			Cerebellar Hemorrhage	Myasthenia Gravis			Gillian Parrre Syndrome		Respiratory Failure		
	No	%	No	%	No	%	No	%		No	%	No	%	No	%	No	%	
Secretions Amount																		
Small	0	0.00	0	0.00	0	0.00	0	0.00	**16.725 0.001***	13	43.33	0	0.00	0	0.00	5	16.67	FE 1.00
Moderate	3	10.00	0	0.00	0	0.00	2	6.67		8	26.67	0	0.00	0	0.00	4	13.33	
Excessive	15	50.00	4	13.33	4	13.33	2	6.67		0	0.00	0	0.00	0	0.00	0	0.00	
Consistency																		
Mucoid	8	26.67	4	13.33	0	0.00	4	13.33	**12.143 0.007***	4	13.33	0	0.00	0	0.00	1	3.33	1.313 0.519
Thick	10	33.33	0	0.00	4	13.33	0	0.00		7	23.33	0	0.00	0	0.00	5	16.67	
Sticky	0	0.00	0	0.00	0	0.00	0	0.00		10	33.33	0	0.00	0	0.00	3	10.00	
Color																		
Clear	5	16.67	0	0.00	0	0.00	0	0.00	**24.856 0.003***	1	3.33	0	0.00	0	0.00	1	3.33	2.266 0.519
Cloudy	3	10.00	0	0.00	4	13.33	2	6.67		10	33.33	0	0.00	0	0.00	2	6.67	
Yellow	5	16.67	0	0.00	0	0.00	0	0.00		7	23.33	0	0.00	0	0.00	5	16.67	
Green	0	0.00	0	0.00	0	0.00	0	0.00		3	10.00	0	0.00	0	0.00	1	3.33	
Dark brown	5	16.67	4	13.33	0	0.00	2	6.67		0	0.00	0	0.00	0	0.00	0	0.00	

Rhythm pattern	8	26.67	0	0.00	4	13.33	0	0.00	-	6	20.00	0	0.00	0	0.00	2	6.67	FE
Regular	10	33.33	4	13.33	0	0.00	4	13.33		15	50.00	0	0.00	0	0.00	7	23.33	1.00
Irregular																		
Depth																		
Normal	2	6.67	0	0.00	0	0.00	0	0.00		3	10.00	0	0.00	0	0.00	1	3.33	
Shallow	1	3.33	0	0.00	0	0.00	1	3.33	4.568	17	56.67	0	0.00	0	0.00	7	23.33	0.406
Deep	15	50.00	4	13.33	4	13.33	3	10.00	0.600	1	3.33	0	0.00	0	0.00	1	3.33	0.816
Breath sound																		
	18	60.00	4	13.33	4	13.33	4	13.33		0	0.00	0	0.00	0	0.00	0	0.00	
Normal	0	0.00	0	0.00	0	0.00	0	0.00	-	19	63.33	0	0.00	0	0.00	8	26.67	FE
Crackles	0	0.00	0	0.00	0	0.00	0	0.00		2	6.67	0	0.00	0	0.00	1	3.33	1.00
Wheezing																		
Chest movement																		
Symmetrical	18	60.00	4	13.33	4	13.33	4	13.33	-	21	70.00	0	0.00	0	0.00	9	30.00	-

Discussion

Cough is the physiological defense system of airway clearance along with the mucociliary escalator. It is also a troublesome symptom that can be frequent and vigorous and has the potential to serve as a measure of disease **(Lee et al., 2017; Spinou et al., 2017)**. Still, on the opposite side of this spectrum, cough can be absent, weak and inadequate to clear the airways**.** When it does not generate effective airflows to achieve airway clearance, cough augmentation techniques can support one or more of the cough inspiratory, compressive, and expiratory phases **(Spinou, 2018)**.

Distribution of studied Patients' according to sociodemographic characteristics, clinical data and mechanical ventilation parameters.

Regarding demographic characteristics ,it was observed that no statistically significant difference was observed between both groups in relations to demographic characteristics.

Concerning gender, it was observed that two-third of the patients in the control and study groups as well were males. This may be due to males have a more participation in everyday life and dangerous situations than women. Furthermore, the primary workers in most nations exposed them to greater risk that leads to ICU admission (**Duran & Uludağ, 2020)**.

Concerning current diagnosis**,** it was reported that more than two third and more than one-half of patients in both control and study groups had Cerebellar Hemorrhage respectively; also there was no statistically significant difference between both groups. This could attribute to that the setting of data collection were mainly specialized to receive complicated cases as cerebrovascular accidents, traumatized patients and others diagnosis.

However, **(Mitropoulou et al., (2023)** showed that the most common diagnosis among their studied patients on MV was Muscular dystrophy followed by amyotrophic lateral sclerosis and multiple sclerosis. While **(Wibart et al., (2023)** revealed that the most common diagnosis among their studied patients on MV was pulmonary disease followed by Sepsis. Also, **(de Camillis et al., (2018)** showed that acute respiratory failure was the most common reason for starting MV followed by decreased level of consciousness and Hemodynamic instability.

As regard to past medical history, it was noticed that the most common comorbid disease among patients in both control and study groups was diabetes, followed by renal diseases. This may be attributed that large number of studied patient were elderly and had chronic diseases especially cardiovascular and metabolic disorders that increased risk for development of diabetes mellitus.

However, (**Krishnan et al., (2020)** showed that the most common comorbidities among patients on MV, being hypertension, hypercholesterolemia, and diabetes mellitus. While (**de Camillis et al., (2018)** showed that the most common comorbidity among their MV patients was COPD.

Loss of consciousness was a chief complaint in the control and study groups with non- statistically significant difference was observed between both groups (p value >0.05). In relation to Level of consciousness, about two-third of patients in the control group had response to pain compared to more than one third of patients in the study group with statistically significant difference between both groups (p value <0.05). This might because the common studied patients' diagnoses were cerebrovascular accident and polytrauma, theses diagnosis associated with decreased conscious level.

In line with the current study **(de Camillis et al., (2018); Rose et al., (2016)** showed that decreased level of consciousness was a main complain among patients on MV. Literature showed that critically ill patients frequently have an impaired or no cough reflex due to depressed levels of consciousness (**Swingwood et al., 2020).**

Concerning current medication, all patients in the control and study groups were on analgesic treatment followed by muscle relaxants in more than two-third of patients in the study and control groups with non-statistically significant difference between both groups (p value >0.05). Also, this might because the common studied patients' admission etiologies were cerebrovascular accidents and polytrauma, which were associated with severe pain requiring analgesic treatment and muscle relaxants.

Literature, showed that frequent administration of sedatives and analgesics for patient comfort and mechanical ventilation synchrony may difficult the appropriate airway mucus clearance (**de Camillis et al., 2018)**.

Regarding, modes of mechanical ventilation, the current study showed that the two-third of patients in the control group were on synchronized intermittent mandatory ventilation (SIMV) in the first day compared to four-fifth of patients in the study group then the percentage of patients who were on SIMV increased to two-thirds and hundred percent in the second day in the control group and study group respectively, then increased again to three-quarters in the third day in the control group and remained constant in the study group, with non-statistically significant difference between first day, second day and third day in each group separately (p value >0.05) regarding mode of ventilation. This can be attributed that patient on SIMV mod the patients are partial dependent on MV, the ventilator breath is synchronized with patient inspiratory effort and has been described as the most effective and efficient mode of ventilation especially in the ICU.

Also, this will encourage use of patients' respiratory muscles, facilitate spontaneous breathing trials and this in turn enhance early weaning.

However, **de Camillis et al., (2018)** showed that pressure-controlled ventilation was the most commonly used MV mode followed by pressure support ventilation, and there was no significant difference between intervention (cough augmentation)

group and control (standard care) group as regard mode of MV. Moreover, **(de Godoi et al., (2021)** assessed the effect of MV mode on the outcome of MV patients, and the comparative analysis between the modes of ventilation showed no significant differences in length of hospital stay ($p = 0.675$), duration of mechanical ventilation, mortality, failed extubation and the need for tracheostomy.

As regard to mean scores of ventilator parameters, the current study showed that there were statistically significant differences among study group regarding PEEP, PIP, SPO2 and respiratory rate throughout period of study with, while there were statistically significant differences among control group regarding respiratory rate.

The current results suggested that the use of cough augmentation techniques was associated with significant increase in ventilator parameters including PEEP, PIP, SPO2 and respiratory rate. But these parameters not assessed in literature among patients underwent cough augmentation techniques. This result enrolled two well-matched groups in baseline data, as there was no statistically significant difference between the studied groups as regard demographic, clinical data, mode of MV and ventilator parameters.

These results of the current study showed no significant association between modes of mechanical ventilation and the chest assessment post 25 min at 3rd day of admission. To the best of our knowledge this is the first study assessed the association between modes of mechanical ventilation and the chest assessment.

The other hand, it was observed that there was statistically significant difference between age of study group regarding amount, consistency and color of secretion, and respiratory rhythm pattern. While no significant difference was observed regarding depth, breathe sound and chest movement. While Patients in the control group, no significant difference was observed between different age groups regarding secretion, rhythm pattern, depth, breathe sound and chest movement.

Literature, showed that respiratory muscle strength and muscle mass decrease with age, resulting in cough impairment which can decrease in secretion clearance, resulting in disturbance in respiratory rhythm pattern. This can explain the association between age and some chest assessment parameters (**Nagano et al., 2021)**.

The aging process leads to a reduction in respiratory muscle strength. The causes vary but are believed to include muscle weakness and diaphragm atrophy, decreased cross-sectional area of the intercostal muscles, decreased curvature of the diaphragm due to structural changes in the chest wall, and decreased amplitude of the diaphragmatic action potential (**Morisawa et al., 2021)**.

Regarding secretions amount, half of studied patients had excessive cerebellar hemorrhage while thirteen percent had excessive with myasthenia gravis and excessive with Gillian barre

syndrome and six percent had excessive with respiratory failure with statistically significant difference between studied groups.

As regard to consistency, one-third of studied patients had mucoid with Cerebellar Hemorrhage while thirteen percent had mucoid with Myasthenia Gravis and mucoid with Respiratory Failure and thirteen percent had thick Gillian barre syndrome with statistically significant difference between studied groups.

Concerning to color, sixteen percent of studied patients had clear Cerebellar Hemorrhage while thirteen percent had cloudy with Gillian barre syndrome with statistically significant difference between studied groups. It was well-established that patients with cerebellar hemorrhage have impaired or loss of consciousness (**Witsch et al., 2021).**

Also, as previously mentioned, critically ill patients frequently have an impaired or no cough reflex due to depressed levels of consciousness **(Swingwood et al., 2020).** So, patients with cerebellar hemorrhage have impaired or no cough reflex, resulting in accumulation of secretions. This may explain our current findings, but more studies are in need to confirm primary results.

Finally, these results supported that applying the cough augmentation techniques among study group had a good effect on improving patient's' physiological parameters and promote air way clearance among mechanically ventilated patients at the ICU.

Conclusion

The current study showed that cough augmentation techniques have positive impact on airway clearance of mechanically ventilated patients. The intervention resulted in more hemodynamic stability, oxygen saturation, blood gases exchange and breathing stability resulting from airway clearance.

Recommendations

The subsequent suggestions are proposed in accordance with the results of the present investigation:

-Further multi center studies to validate of results.

-Using Cough Augmentation Techniques as a part of the daily care in managing cases complains of secretions in intensive care unit.

-Continuous training sessions and set new policies about recommendations of airway clearance for patients receiving care on a result.

-Additionally, organizing continuous in-service training and refresher sessions for critical care nurses about new modalities and bundles of care for the management airway secretions.

-The same study could be replicated in more hospitals with a larger probability sample for further research.

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