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Effect of active cycle of breathing technique versus autogenic drainage on extubated mechanically ventilated organophosphate compound poisoning patients

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Abstract
Background and Objective: Depression of respiratory center and neural drive and excessive mucus secretion affect respiratory mechanics and leads to difficulty in mucus clearance and oxygen saturation. These are major problems in extubated mechanically ventilated Organophosphate compound Poisoning (OP) patients. It also affects the flow of air and patency of respiratory tract. Therefore the present study aims to compare Active Cycle of Breathing Technique (ACBT) vs Autogenic Drainage (AD) on extubated mechanically ventilated OP patients as assessed by Pulmonary Function and Oxygen Saturation and Sputum Volume.
Materials and Methods: A pre and post study was done and 30 patients mean age group of 20-65 years were included in the study. Group A received ACBT and Group B received AD. Pulmonary Function Test (FVC, FEV1, FEV1/FVC ratio and PEFR), Oxygen Saturation and Sputum volume were taken before and after intervention. The intervention was given twice in a day, 5 days in a week and each session lasts for 15-30 minutes. Data was analyzed by Paired and Unpaired t test.
Results: There was very significant difference (p<0.0001) in Pulmonary Function Test values in ACBT group, Sputum Volume in AD group and there was no significant difference in Oxygen Saturation after 5 days of intervention.
Conclusion: ACBT is more effective in improving pulmonary function and Autogenic Drainage AD is more effective in reducing sputum volume in extubated mechanically ventilated Organophosphate Compound poisoning patients.

Keywords: ACBT, AD, extubated, organophosphate, mechanically ventilated

Introduction
In agriculture pesticides are commonly used to protection against diseases but it also produce pollution in environment and the estimated annual application is more than 4 million [1]. In developing world, occupational, accidental and intentional exposure is a leading public health problem from pesticide poisoning [2]. Millions of people are exposed to danger by hazardous occupational practices and unsafe storage [3]. India the rate of mortality from poisoning is between 15 to 30% but in developed countries, it varies 1% to 2% [4]. In rural India, poisoning is the fourth most common cause of mortality [5].
Organophosphate (OP) insecticides are used extensively in horticulture and agriculture. According to World Health Organization, 3 million people ingest these compounds resulting in 40,000 deaths annually [6]. It produce clinical manifestations by depression of the enzyme cholinesterase resulting in the accumulation of acetylcholine at various receptors which has three types of effects: (1) Muscarinic (2) Nicotinic and (3) Central.
Due to actions on bronchi, salivary, lacrimal, sweat glands, etc.; and also produce pulmonary edema, sweating and bradycardia are includes in muscarinic effects. Nicotinic effects are motor and sympathetic and lead to fasciculation, muscular weakness and tachycardia. Giddiness, anxiety, emotional labiality, ataxia, confusion, and apathy are due to central effects. It have many toxicological effects on respiratory and cardiovascular system, due to this overstimulation of muscarinic acetylcholine receptors in the parasympathetic system causes respiratory disorders such as central failure of breathing. The key findings were rapidly progressive bradypnoea leading to apnea due to loss of respiratory effect and loss of

central inspiratory drive due to poisoning [7]. Myocardial necrosis occurs due to overstimulation of nicotinic acetylcholine receptors in the sympathetic system [8] and other cardiac manifestations are sinus tachycardia, bradycardia, hypertension, impaired heart rate and force of contraction while ECG changes are ST segment elevation, low amplitude T waves, extra systole and prolonged PR interval [9, 10].

The acute cholinergic crisis produces a toxidrome of muscarinic (miosis, hyper-salivation, nausea, emesis, bronchospasm, bronchorrhea, alveolar edema, bradycardia, and hypotension) and nicotinic (sweating, muscle weakness, fasciculation, and paralysis, occasionally with hypertension and tachycardia) [11]. Clinical presentation of OP exposure depends on the specific agents, the quantity and the route of entry. Initial symptoms may range from mild as flu like syndrome, to immediately life threatening respiratory arrest. Toxicity occurs soon after exposure but may be delayed, depending on the agent and route of entry. The most rapid onset of symptoms occurs with consumption, inhalation and the slowest with dermal exposure. Respiratory arrest can occur within 50 minutes of inhalation. OP toxicity generally occurs within 4-12 hrs, full-blown toxicity may not be manifested for 24 hrs. Cholinergic excess produces the signs and symptoms of acute OP exposure. Predominant clinical findings are usually muscarinic followed by CNS and then nicotinic manifestations [12].

Immediate attention to airway and adequate oxygenation is essential for which atropine is administered until secretions dry. Adequate ventilation is needed in these patients, because respiratory distress is common and is the primary cause of mortality in critical cases. Continuous pulse oximetry, antidote administration, mechanical ventilation and admission to an intensive care unit are essential for proper management. Cardiac monitoring during atropine administration is also indicated. Frequent suctioning of the airway along with chest physiotherapy is usually necessary until the patient is adequately atropinized. Endotracheal intubation is often necessary in severe poisoning because of secretions, decreased level of consciousness, or weakness of the respiratory muscles [13].

Mechanical ventilation (MV) is an important life supporting technology in critical care units to provide the support or assistance for the patients who are not able to perform the work of breathing spontaneously and also unloading of respiratory muscles to maintain adequate level of PaO2 and PaCo2 with positive pressure ventilation during surgery and other condition that affects normal breathing [14]. It compares the physiological differences among spontaneous breathing, negative and positive pressure ventilation. It is not a benign therapy and, it can have major beneficial or detrimental effects on body systems depending on how it is initially applied and modified as the patient's condition changes [15]. Patients who are intubated and ventilated may have increased sputum production and significantly impaired bronchial mucociliary transport velocity [16]. This can lead to an increased incidence of pulmonary complications such as secretion retention and pneumonia [17]. Therefore secretion removal is a major aim of physiotherapy treatment in patients who are intubated and ventilated [18]. Anesthesia combined with prolonged supine positioning results in an abnormalities in gas exchange with reductions in the vital capacity and functional residual capacity of the lungs [19, 20, 21]. These factors in combination result in ventilation-perfusion mismatch and abnormal pulmonary shunt fraction [22, 23]. Mucociliary activity, normal breathing cycles, and cough are the primary mechanism of removing secretions from the lung, increased secretion viscosity and volume, dyskinesia of the cilia, and ineffective cough combine to reduce the ability to clear secretions [24]. The implications of the defective mucociliary clearance lead to the accumulation of secretions and the airway obstruction [25]. Decreased expiratory muscle strength also affects expiratory air flow, and this leads to a decrease in cough efficacy and secretion clearance [26]. Patient with variety of breathing techniques have been developed that enhance cephalad airflow bias [27].

As described by Webber and Pryor, Active cycle of breathing technique (ACBT) includes of repeated cycle of three main ventilatory stages; Breathing control, Thoracic expansion exercises and Forced expiratory techniques [28]. It is a flexible method and can be adapted easily to a patient with different states and used independently with or without the inclusion of manual techniques [29]. It is an effective treatment with a slow and relaxed manner reduces the work of breathing and consequently the oxygen requirements with improves pulmonary function, alveolar ventilation and also used to mobilize and clear excess pulmonary secretions from the lung peripheries without increasing airflow obstruction [30] may decrease the frequency of infection thereby preventing further airway damage and deterioration of lung function [31, 32]. The concept of AD (Autogenic Drainage) introduced by Chevaillier [33]. It is breathing at different lung volumes and an active expiration is used to mobilize the mucus. It consist of three phrases: 'unstick', 'collect' and 'evacuate' which maximizes airflow to promote ventilation and secretion clearance [34]. It employs the principles of breathing at different lung volumes (low, middle and high) to loosen and mobilize secretions [35, 36]. The aim is to achieve the highest possible expiratory airflow while avoiding dynamic airway collapse [37]. The speed of the expiratory flow reduces mucus adhesion, shears secretions from bronchial walls, and transports them from the peripheral to proximal airways [38]. Therefore the present study has been taken up to evaluate the combined effect of ACBT and AD for pulmonary function, oxygen saturation and sputum volume on extubated mechanically ventilated Organophosphate Compound Poisoning patients.

Methods

A pre and post study of 30 patients (both male and female) using simple random sampling and allocation with coin method was done. Patients which were extubated (tracheostomy and endotracheal tube) from mechanical ventilated Organophosphate Compound Poisoning aged between 20-65 years included according to inclusion and exclusion criteria. The intervention both ACBT and AD were given 3cycles/ 2-3sets/ 2times in a day/15-30minutes/five days in a week including hold for 3-5 seconds with conventional chest physiotherapy (Percussion/Vibration). The inclusion criteria for this study were both male and female extubated from mechanically ventilated organophosphate compound poisoning patients age between 20 to 65 years, who those willing to participate in this study and exclusion criteria for this study who were hemodynamically unstable, uncooperative, pleuritic chest pain, pneumothorax, with rib fractures, chest trauma and thoracic vertebral fracture.

Outcome Measures

Pulmonary Function Test

Forced Expiratory Volume in One Second (FEV1), Forced Vital Capacity (FVC), FEV1/FVC Ratio and PEFR. This specific measurement computed by the instrument called spirometry (RMS HELIOS 401).

Saturation of Oxygen (SpO2) %

It was measured using Pulse Oximeter. (Model No. Oxy-set 2060, S.N.1107230).

Sputum Volume Measurement

A quantity of sputum were collected and measured in calibrated funnel tube.The study received approval from Institutional Ethical Committee of Pravara Institute of Medical Sciences loni Maharashtra reference no. PIMS/CPT/IEC/2017/187

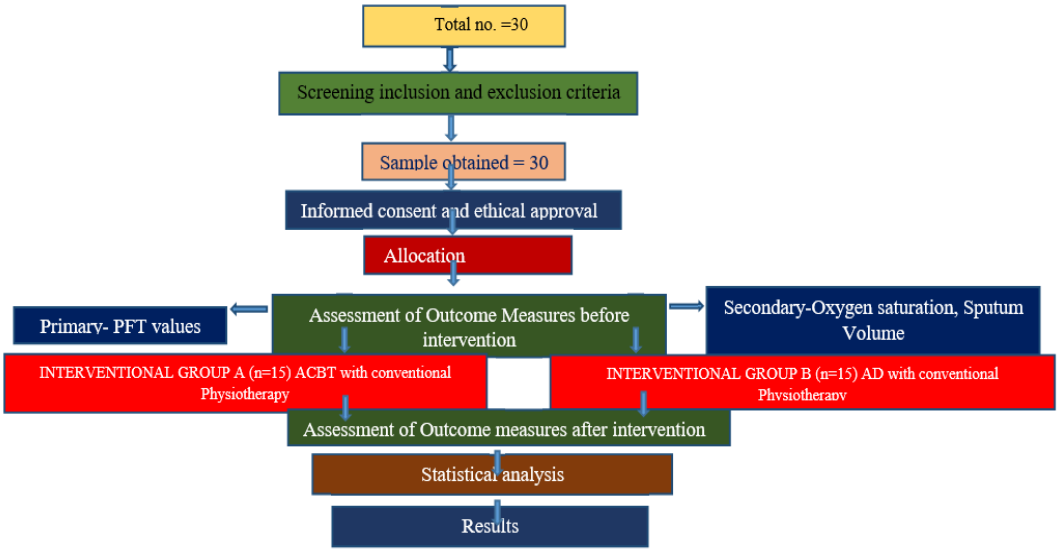


Fig 1.1: Flow chart representing the procedure of selection of patients

Results

Paired t test and Unpairedt test were applied to analyze the data. All statistical analysis was done with utilizing the trial version of Graph Pad Instat software and $p<0.05$ is considered as level of significance.

Forced Vital Capacity (FVC): The mean difference in group A and group B after intervention was 0.20±0.10 and 0.12±0.06 liters respectively.

Forced Expiratory Volume In One Second (FEV1): The mean difference in group A and group B after intervention was 0.21±0.15 and 0.11±0.07 litersrespectively.

FEV1/FVC Ratio: The mean difference in group A and group B after intervention was 10.99±7.82 and 5.69±5.6 liters respectively.

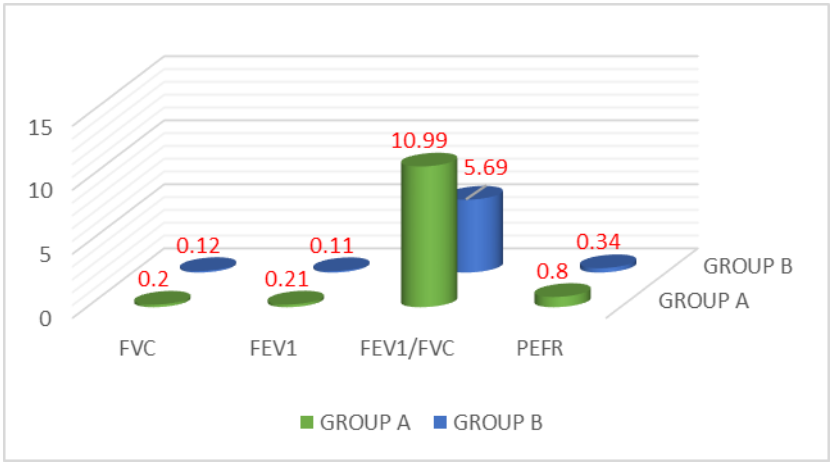
PEFR: The mean difference in group A and group B after intervention was 0.80±0.54 and 0.34±0.48 liters respectively (Table and Graph 1.1).

Oxygen Saturation: It was calculated pre and post after the intervention in both the groups (Table & Graph no.1).The mean difference in group A and group B after intervention was 0.8±0.56 and 1.4±1.59 (Table and Graph 1.2).

Sputum Volume: The mean difference in group A and group B after intervention was 1.6±0.82 and 2.53±1.30 (Table and Graph 1.3).

Table 1.1: Pulmonary Function Test parameters both the group in liters.

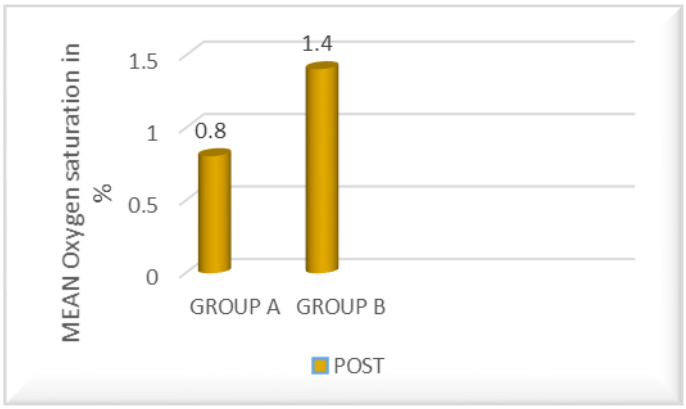
PFT	Groups	Pre	Post	Mean difference	t-value	p-value
FVC	Group A	1.56±0.31	1.76±0.34	0.20±0.10	7.36	<0.0001
	Group B	1.50±0.44	1.62±0.46	0.12±0.06	3.64	0.0013
FEV1	Group A	1.707±0.37	1.28±0.38	0.21±0.15	5.92	<0.0001
	Group B	1.54±0.40	1.65±0.41	0.11±0.07	6.178	<0.0001
FEV1/FVC	Group A	85.70±6.71	96.70±7.19	10.99±7.82	5.443	<0.0001
	Group B	93.17±8.32	98.26±9.06	5.69±5.6	3.509	0.0017
PEFR	Group A	3.42±1.04	4.22±1.28	0.80±0.54	5.697	<0.0001
	Group B	4.78±1.65	5.12±1.67	0.34±0.48	2.709	0.0085



Graph 1.1: Comparison of mean difference between both the groups.

Table 1.2: Mean difference comparison of SpO2 % of both the groups.

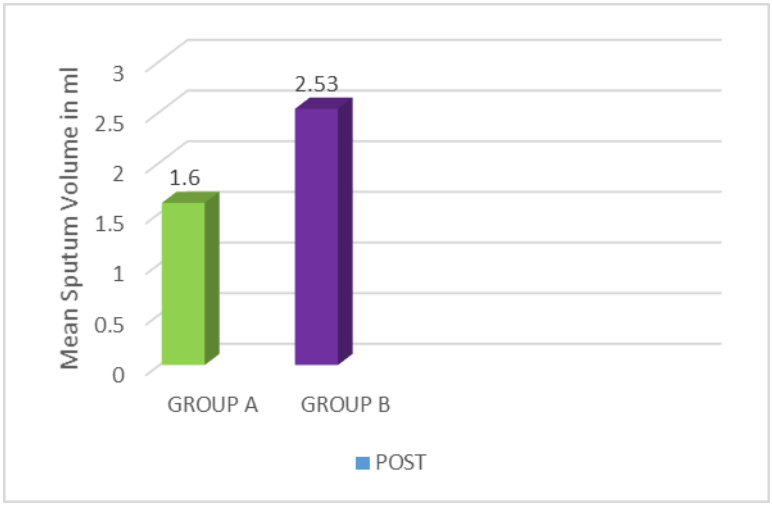
Spo2 %	Group A (Mean Difference)	Group A (Mean Difference)	T value	P value
	0.8±0.56	1.4±1.59	1.375	0.1801



Graph 1.2: Mean difference comparison of SpO2 % of both the groups.

Table 1.3: Mean difference comparison of sputum volume in both the groups.

Sputum Volume	Group A (Mean difference)	GroupB(Mean difference)	t-value	p-value
In ml	1.6±0.82	2.53±1.302	2.343	0.0265



Graph 1.3: Mean difference comparison of sputum volume both the groups in liters.

Discussion

The result obtained in this study indicates that, there was highly significant difference in the PFT values FVC, FEV1, FEV1/FVC ratio, PEFR, significant difference in Sputum Volume and there was no significant difference in Oxygen Saturation after 5 days of intervention.

Force Vital Capacity (FVC): FVC values in group A,

mean difference after 5 days was 0.20±0.10 liters and in group B mean difference after 5 days was 0.12±0.06 liters.

Force Expiratory Volume in one second (FEV1): FEV1 values in group A, mean difference after 5 days was 0.21±0.15 liters and in group B mean difference after 5 days was 0.11±0.07 in liters.

FEV1/FVC Ratio- values in group A, mean difference after 5 days was 10.99±7.82 liters and in group B mean difference after 5 days was 5.69±5.6in liters.

Peak Expiratory Flow Rate (PEFR): values in group A, mean difference after 5 days was 0.80±0.54 liters and in group B mean difference after 5 days was 0.34±0.48 in liters.

Aes *et al*. OP poisoning affect the respiratory system by peripheral muscarinic actions on the airways, nicotinic actions on the respiratory muscles, respiratory center in the brain and direct toxic effect on the alveolar capillary membrane [39]. Brooks *et al.* described after 20 days high dose exposure affects pulmonary functions (FVC, FEV1, FEF25-75%) due to local toxicity to the bronchial epithelium leading to non-immunological asthma and bronchial obstruction [40]. The study was described the comparison of Autogenic Drainage and Active Cycle of Breathing Technique on FEV1, FVC & PEFR in chronic obstructive pulmonary disease patients. Thirty patients who had COPD were allocated randomly into three groups each consist of 10 patients. Group A received AD, Group B was given ACBT and group C received only medication. The treatment was given for 5 days per week for 4 weeks. The outcome measure was used computerized spirometry to evaluate pre and post-test values of FEV1, FVC and PEFR. There was significant improvement in FVC, FEV1 and PEFR values in both groups when compare to group C who received only medication. The results of this study revealed that both AD and ACBT are effective in clearance of secretion, which is one of the causes of the airway obstruction in patients with COPD [41]. In addition, the study suggest Active Cycle of Breathing Technique is effective than Autogenic Drainage for improving pulmonary functions because of stimulation of the respiratory center and respiratory drive and also increases thoracic expansion.

Saturation of Oxygen (SpO2): values in group A, mean difference after 5 days was 0.8±0.56 liters and in group B mean difference after 5 days was1.4±1.59 in liters revealed that was statistically not significant difference between two groups.

The study was showed the effect of long term treatment of AD and ACBT were evaluated in patients with COPD. Thirty clinical stable male COPD patients were randomly assigned to AD or ACBT treatment for a 20 days period. Patient were assessed through pulmonary function tests, arterial blood gases, a six minute walk test, and a modified Borg scale before and immediately after the waking test. AD improved FVC, FEV1, PEFR, FEF 25-75% chronic hypercapnia, arterial oxygenation and exercise performance and dyspnea perception during exercise. The ACBT increased FCV, PEFR, arterial oxygenation and exercise performance. PEFR increased in AD more than ACBT, the increase in oxygen saturation was significantly higher than in ACBT treatment. Chronic hypercapnia improved significantly in AD treatment than in ACBT.No difference found in other lung function parameters. AD is as effective as the ACBT in cleaning secretion and improving lung function [42].

In addition, in present study both techniques was equally effective for improving saturation of oxygen because in both techniques includes inspiratory hold fore 3-5 second. Both techniques works on the principal of collateral ventilation, and (EPP) equal pressure point it may be helpful for to improve oxygen saturation, ventilation perfusion ratio,

Sputum Volume: values in group A, mean difference after 5 days was1.6±0.82 liters and in group B mean difference after 5 days was 2.53±1.302 after 5 days revealed that was statistically significant (in ml) difference between two groups.

Active Cycle of Breathing Technique and Autogenic Drainage both are working on concept of equal pressure point but during FET in people with chronic lung disease and reduced elastic recoil pressure, the driving pressure during a forced expiration is less therefore the EPP will occur earlier in the phase of expiration and in smaller airways than normal. The shift in this EPP (Equal pressure Point) into the smaller airways, which are more compliant, may result in pre mature airway collapse if the force used during the technique is excessive [43, 44].

Freitag *et al* demonstrated an oscillatory movements, hidden vibrations, of the airway walls in addition to the squeezing action produced by the forced expiratory manoeuver [43]. The viscosity of mucus is shear dependent [45] and the shear forces generated during a huff should reduce mucus viscosity [46]. This together with the high flow of a forced expiratory maneuver, would also be expected to aid mucus clearance and the expectoration of sputum [47]. To generate sufficient expiratory pressures during huffing, an upright positioning may need to be adopted to optimize expiratory flow and pressure [47].

In other hand autogenic drainage independent performed breathing technique using controlled breathing to maximize air flow while maximizing airway closure, starting with low lung volume breathing at expiratory reserve volumes. In this techniques the generation of shearing forces induced by airflow at different lung volumes to loosen and mobilize secretion. To achieve highest possible expiratory airflow while avoiding dynamic airway collapse and with the absence of forced expiration or FET may be useful for significant degree of pressure dependent airway collapse. The speed of the expiratory flow reduces the adhesion of mucus, shears secretions from bronchial walls and transports them from the periphery to proximal airway [48].

In addition for more effective secretion clearance in those patients who have greater loss of elastic recoil more control during expiration may be required to avoid airway collapse. In this technique time period during expiration was more because of controlled expiration allow secretion travel further distance with movement of EPP in peripheral airways to mobilize distal secretion while keeping low resistance and avoiding bronchospasm and dynamic collapse. In this study patients using proprioceptive, auditory and vibratory cues and more concentration on expiratory phase clear more secretion compare to ACBT.

The study was done to compare the effect of ACBT and AD with postural drainage on cystic fibrosis patients. Eighteen patients included in this study with two days crossover trial.

There were two session of one method of physiotherapy techniques either ACBT or AD. The study days one week apart one each day the patients were monitored for six hours. Mucus movement was quantified by a radio aerosol technique. Airway clearance was studied qualitatively using xenon-133 scintigraphic studies at the start and end of each day. Expectorated sputum was collected during and for one hour after each session of physiotherapy. Pulmonary functions tests were performed before and after each session. Oxygen saturation (Sao,) and heart rate were measured before, during, and after each session. Autogenic drainage cleared mucus from the lungs faster than ACBT over the whole day. Both methods improved ventilation, as assessed by the xenon-133 ventilation studies. No overall differences were found in the pulmonary function test results, but more patients had an improved forced expiratory flow from 25% to 75% with autogenic drainage, while more showed an improved forced vital capacity with ACBT. No differences were found in sputum weight and heart rate, nor in mean SpO2 over the series, but four patients desaturated during ACBT. Autogenic drainage was found to be as good as ACBT at clearing mucus in patients with cystic fibrosis and is therefore an effective method of home physiotherapy [49].

Limitation of Study

1. At times, it was difficult, as some patients were not able to perform proper techniques with full concentration after extubation due to effect of OP compound poisoning and anesthesia on respiratory drive.
2. At times, it was difficult to voluntarily remove secretion from airway due to suppression of cough reflex.

Suggestion for future research

Future research should be done with Effect of Active Cycle of Breathing Technique and Autogenic Drainage on extubated Organophosphate Poisoning Patients with larger sample size.

Conclusion

The present study shows that ACBT is more effective in improving pulmonary function and Autogenic Drainage is more effective in reducing sputum volume in extubated mechanically ventilated Organophosphate Compound poisoning patients.

Competing Interests: None

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