



High Frequency Chest Wall Oscillation Efficacy on Ventilatory and Quality Of Life Indices In Chronic Obstructive Pulmonary Disease

Mariam E. Mohammed¹, Taghreed S. Farag²

¹Physical Therapy for Cardiopulmonary disorders and geriatrics, Faculty of Physical Therapy, Cairo University, ²Chest Department, Faculty of Medicine for Girls, AL-Azhar University, Egypt

ABSTRACT

Background: Chest physical therapy (CPT) is a widely used intervention for patients with airway diseases. Traditional Physiotherapy and airway clearance are effective in reducing symptom severity and rapid improvements in dyspnea. High frequency chest wall oscillation (HFCWO) creates high velocity, low amplitude oscillatory airflows which enhances mucus clearance. **Objective:** to evaluate efficacy of high frequency chest wall oscillation vest system in the treatment of acute exacerbations of chronic obstructive pulmonary disease patients. **Method:** forty men patients with acute exacerbations of chronic obstructive pulmonary disease were included in the study. Patients were assigned to a single group with pre- and post- treatment protocol application. All patients received high frequency chest wall oscillation with vest system in addition to their prescribed medication. The data concerned with the ventilatory functions included, forced vital capacity (FVC), forced expiratory volume in first second (FEV1), ratio of forced expiratory volume in one second to forced vital capacity (FEV1/FVC), and Forced expiratory flow (FEF25-75 %.) were evaluated at the beginning of the study and after four weeks. Six minute walk test and CAT was also performed. **Results:** showed statistical significant difference for the ventilatory functions (FVC, FEV1, FEV1/FVC, and FEF25-75 %.), also improvement in 6MWT and CAT between pre and post treatment in favor of post treatment condition. **Conclusion:** Vest Clearance HFCWO provided an adequate physiotherapy method to patients with AECOPD, helped sputum expectoration, contributed in stabilization and improvement of respiratory functions, enhanced patients' compliance and independence.

Keywords: chronic obstructive pulmonary disease, high frequency chest wall oscillation, vest airway clearance system

INTRODUCTION

The main goal of chest physical therapy (CPT) is to facilitate mucus elimination by increasing ciliary transport, and improving mucociliary clearance and pulmonary function, in order to reduce the risk of infection and lung damage [1, 2, 3]. In patients with chronic mucous hyper-secretion; techniques of efficient airway clearance may reduce airway occlusion by excess mucus and inflammatory cells, reducing exacerbation frequency, improving lung function, exercise capacity, and quality of life related parameters [4].

Airway clearance techniques involve the application of external forces to enhance the removal of mucus secretions from the airway [5, 6]. There are numerous airway clearance techniques, including conventional chest physiotherapy methods, breathing exercises and autogenic drainage, hand-held positive expiratory pressure (PEP) devices (e.g., mask, mouthpiece or oscillatory PEP devices), active cycle of breathing technique (ACBT), Resistive inspiratory maneuvers (RIM), Flutter and high

frequency chest wall oscillation (HFCWO) [6, 7].

One of the oscillatory devices with High Frequency Chest wall oscillation (HFCWO) systems is the vest airway clearance system. It has been investigated as an alternative or addition to manual chest physiotherapy. HFCWO delivers pressurized air pulses to the external chest wall via the vest, which results in transient cephalad bias airflow spikes in the airways to loosen bronchial mucus so that the patient can more easily expel secretions by coughing [8]. It does not require special positioning or breathing techniques. The technology is technique-independent because user or caregiver factors do not compromise its effectiveness [1].

The objective of this study was to evaluate efficacy of high frequency chest wall oscillation vest system in the treatment of acute exacerbations in COPD patients (AECOPD).

METHODS

This study was conducted at Chest Departments, Al-Zahraa University Hospital. The ethics

committee of University Hospital institute approved the study. An informed written consent was obtained from all participants before their enrollment into the study.

This study was conducted on 40 male patients. All of them had symptoms of chronic airflow limitation and fulfilled criteria set out by GOLD, [2] for diagnosis of COPD, moreover they had clinical symptoms of COPD exacerbation (increased dyspnea, sputum production or purulence). All patients were either smokers or Ex smoker and had post-bronchodilator (FEV1) less than 80% of the predicted value, with an FEV1/FVC not more than 70%. They had an increase in FEV1 less than 200 ml or less than 12% of baseline value, 15–20 min after 4 puffs of inhaled salbutamol via a metered-dose inhaler [2]. All patients have been treated with COPD exacerbation management including all recommended medications, advice on the benefits of regular exercise, and cough clearance of sputum. Medication included bronchodilators, antibiotics, and inhaled corticosteroids (budesonide), oral steroids, if necessary oxygen and patient education, as part of AECOPD protocol.

Exclusion criteria:

Patients with other lung disease except COPD, history of active haemoptysis, any significant musculoskeletal disorders, osteoporosis, recent acute cardiac event (within 6 weeks) or congestive cardiac failure, ICU admission, gastro-esophageal reflux or hiatus hernia.

All Patients assigned as a single group with pre- and post-treatment

A) Assessment procedures

All patients were evaluated for the following:-

1. Spirometry for measuring ventilatory function tests were done before and after interventions using (Spirosift spirometry 5000 FUKUDa NENSHI). Inhaled short-acting or long-acting β -agonists, and sustained-release theophylline, will be withheld for 6, 12, and 24 hours respectively, before the test. The following indices were recorded: forced vital capacity (FVC), forced expiratory volume in first second (FEV1), and FEV1/FVC, forced expiratory flow (FEF25-75 %). Spirometric-indices were calculated using best out of three technically satisfactory trials in accordance to ATS, 1987 [9].

2. COPD assessment test (CAT) is simple questionnaires that are designed for evaluation of COPD impact on health status, and to determine the severity of symptoms. It consists of 8 items, each presented as semantic 6- point different scale, providing a total score range from zero to 40; the higher scores represent worse health. The content of CAT covers daily symptoms (table 1) [10, 11]. After history taking and physical examination, all patient completed CAT questionnaires. The total

CAT score was calculated for each patient by summing the points of each variable.

Table 1: Impact level of COPD on health

CAT score	Impact level
< 10	Low
10 – 20	Medium
21 – 30	High
> 30	Very high

3. Six minute walk distance (6MWD): it is supervised measurement of the distance which patient can walk on the level in 6 minutes. 6MWD were carried out before and after interventions to determine the patient functional capacity (ATS, 2002) [12].

B) Treatment procedures

Vest Airway Clearance System model 104. The system consists of an inflatable soft, flexible vest which is worn over the torso, and flexible plastic hoses attached to it that connect to an air pulse generator which produces and delivers the oscillating air pulses that rapidly inflates and deflates the vest, gently against the thorax, compressing and releasing the chest wall up to 20 times per second. This process, called HFCWO. The optimum oscillating frequency of 13–15 Hz, based on individual patient tolerance during the “tuning procedure” and a pressure setting to achieve a tight but comfortably snug fit. The patients will receive three sessions per week of 20- 30 minutes each for four weeks.

Statistical analysis

Data were analyzed by Microsoft Office 2007 (excel) and Statistical Package for Social Science (SPSS) version 10. Data were expressed as mean \pm SD for quantitative variables. t-test were considered statistically significant when $P < 0.05$.

RESULTS

A total of 40 male patients were included in this study. General characteristics of these patients are shown in (Table 2).

Table 2: Demographic data of AECOPD patients

Items	Range	Mean \pm SD
Age (years)	40 – 68	55.77 \pm 6.16
COPD : duration /y	18-27	20.32 \pm 5.29
SI*	400-850	735.9 \pm 231.2
Height (cm)	160 – 187	168.43 \pm 7.67
Weight (kg)	52 – 103	72.17 \pm 12.83
BMI (kg/m ²)	20.31 - 31.4	25.27 \pm 2.92

SI: Smoking index

DISCUSSION

Respiratory physiotherapy is an important tool in the treatment of COPD. High-frequency airway clearance (HFCWC) assist devices generate either positive or

negative trans-respiratory pressure excursions to produce high-frequency, small-volume oscillations in the airways. HFCWC leads to changes in volume of 15–57 ml and in flow up to 1.6 L/s, which generate minimal coughing to mobilize secretions [4]. Standard CPT is very labor, intensive and time consuming both for hospitalized and non-hospitalized patients with impaired airway clearance [6].

Table 3: Statistical analysis of spirometric- indices, total CAT score, and 6MWT between pre- and post treatment AECOPD patients

Variables	Before ttt	After ttt	P value	% of improvement
	Mean (±SD)			
FVC %	60.71± 11.62	72.30± 5.14	0.003*	15.5
FEV1 %	43.75± 0.75	59.46± 0.27	0.001*	17.9
FEV1 / FVC %	54.45 ± 9.76	57.52 ± 8.45	0.023**	5.6
FEF25-75 %	0.53 ± 0.23	0.54 ± 0.26	0.082	2.5
CAT score	25.67 ± 4.26	17.10 ± 4.87	0.000*	33.3
6 MWT	241.80 ± 49.67	304.27 ± 62.88	0.000*	25.8

* Highly significant,** significant

Table 4: Correlation of post treatment total CAT score and spirometric – indices

Post –treatment	Total CAT score (Post)		
	r	p-value	Significance
FVC	-0.047	0.008	HS
FEV1	-0.664	0.004	HS
FEV1/ FVC %	-0.314	0.091	NS
FEF25-75%	-0.662	0.003	HS

Table 5: Correlation between 6MWT and measured variables

Post -treatment	Total CAT score (Post)		
	r	p-value	Significance
FEV1	0.452	0.012	S
FEV1/FVC (%)	0.488	0.006	HS
FEF25-75%	0.367	0.046	S
CAT score	-0.464	0.01	S

The current work reflected that Vest Airway Clearance System improves ventilatory function parameters. The comparative analysis between the pre and post treatment for AECOPD patients revealed that most of spirometric indices (% predicted) FVC%, FEV1%, FEV1/FVC%, were significantly higher in post treatment AECOPD patients (P-value <0.003, <0.001, <0.023) respectively with a percentage of improvement (15.5%, 17.9%, 5.6%) respectively; In contrast to FEF25-75% which showed no statistically significant difference between pre and the post treated AECOPD patients (P-value <0.082) with only (2.5%) of improvement (table 3).

This result comes in agreement with the study carried out by Nicolini et al., [4] whom founded that respiratory function and laboratory measurements in (CPT and HFCWO) treated patients presented a significant improvement in pulmonary function tests (FVC and FEV1) in comparison with control group. Moreover, the

HFCWO group showed a significant increasing of FVC and FEV1 after treatment ($p \leq 0.006$ and $p \leq 0.001$).

Holland and Button [5] and Mahajan et al., [13] reported that, Vest HFCWO device was well tolerated and that subjects demonstrated an improvement in ventilatory functions. The patients often feel better because they don't have to struggle to breathe and feel less fatigued, so improving quality of life.

In the current study the pre- treatment patients CAT score report showed that the items concerned with breathlessness on stairs /hills ,cough with sputum productions has greatest discriminates for all patients (40 pt.) , whereas the others concerning confidence, sleep disorders , chest tightness were more in severe AECOPD patients (17 pt.). Total CAT score showed also large improvements till discharge; they had significant improvements of dyspnea score, less cough and mucus production than before the treatment; at the same time it was found that the use of supplemental antibiotics and mucolytic drugs were also lowered with the use of vest airway clearance. No subjects dropped out due to intolerance of the device. It was found that the vest HFCWO was well tolerated and that subjects demonstrated significant improvement with reduction in total CAT score i.e. mean± SD (25.67 ± 4.26) VS (17.10 ± 4.87) (P-value <0.0001) with highest percent of improvement in relation to other measured variables 33.3% (table 3).

Several studies [4, 8, 13, 14] come in agreement with our results and concluded that the reduction in CAT score detects early health status improvement and chest wall vibration reduces dyspnea in patients with COPD. Miravittle et al., [14] reported that CAT score can be a useful tool to measure health status during an exacerbation and to evaluate recovery; at the same time CAT score and the number of exacerbations will serve as a marker of disease control.

Our results also coincide with pilot study carried out by Chakravorty et al., [8] As they reported that patients with AECOPD and mucus hyper-secretion at increased risk of declining lung function, tolerated the HFCWO treatment well, leading to improvement in questionnaire symptom score(CAT) and quality of life and reduced symptoms. Also; our result is consistent with Mahajan et al., [13] who stated that HFCWO is well tolerated in adults hospitalized for AECOPD or acute asthma and significantly improves dyspnea also; reported that patient with AECOPD use fewer antibiotics, due to fewer respiratory infections with less hospitalization.

Nicolini et al. [4] reported that HFCWO compared to CPT produced a significant improvement in the dyspnea and improvement in (QoL) scales (BCSS, CAT) (both $p \leq 0.001$). Other researchers compared the use of HFCWO

to standard CPT, oscillatory positive expiratory pressure (OPEP) devices therapy. These studies showed that HFCWO was well tolerated, with better compliance, associated with improved breathing, and decreased fatigue [4, 15, 16, 17, 18].

In the current study the correlation between post treatment total CAT score and results of post treatment spirometric measurement showed that there was statistically significant negative correlation with FVC and FEV1 ($r = -0.47$, $P < 0.008$) and ($r = -0.66$, $P < 0.004$) respectively; on the other hand no correlation founded between FEV1/FVC%, FEF25-75% and total CAT score (table 4).

One of the most important findings of the study carried out by Ghobadi et al., [19] was the inverse correlation between FEV1 and CAT score. As they suggested that a lower FEV1 indicates high CAT score and health impairment due to COPD findings. Ghobadi et al., [19] confirmed that airflow limitation increased with disease severity is better accompanied by increasing CAT.

According to the results of Salma and Yogitha [20] frequent exacerbations had significantly higher CAT scores than infrequent exacerbations ($p < 0.005$). The CAT provides a reliable score of exacerbation severity. Patients with very high CAT score had lower FEV1 values ($P < 0.001$).

In the current study there was a statistical significant increase in 6 MWT i.e. mean \pm SD (241.80 ± 49.67) VS (304.27 ± 62.88) (P -value < 0.000) with 25.8 % of improvement between pre- and post treatment AECOPD patients (table 4).

A recent review of functional walking tests concluded that "the 6MWT is easy to administer, better tolerated, and more reflective of activities of daily living than the other walk tests 21. Our study Consistent with Yohannes and Hardy [22] found that Assessment of severity of COPD and improvement with treatment modalities is best done with dynamic exercise testing such as 6-minute walk tests and incremental shuttle walk tests or with the administration of disease-specific physical disability and quality-of-life questionnaires.

Improvement in performance of the 6-min walk test is important in measuring response to a therapeutic intervention, improves the validity of COPD clinical trials. Hence, it should be strongly considered by clinicians and researchers as an outcome measure for therapeutic interventions in patients with COPD23. Concerning Correlation between post treatment 6 MWT and post treatment spirometric parameters and CAT, There was statistically significant correlation with all measured variables except FVC. Manoj et al., [21] found that there was statistically significant association between

6MWD to all spirometric parameters like FEV1 %, FVC %, FEV1/FVC%, FEF25-75% (table 5).

CONCLUSION

The relationship between CAT score and FEV1% suggests that CAT is linked to severity of airflow limitation.

The HFCWO technique provides an improvement both in pulmonary function and 6MWT in patients with AECOPD and mucus hypersecretion. Since those patients need daily airway clearance, this treatment should be included among the principal options in chest physiotherapy

HFCWO offers the advantage that it can be performed without the assistance from trained health care personnel; moreover, can be performed in acutely ill patients who may be unable to use hand-held devices effectively, such as early in the course of hospitalization.

The vest airway clearance system treatment does not require special positioning or breathing techniques.

Recommendations

Long-term studies are needed, not only to establish the effectiveness of different airways clearance devices or techniques and their cost-effectiveness, but especially to establish their acceptability in order to long-term home use.

REFERENCES

- [1] Hill K., Shane P., and Dina B.: Effect of airway clearance techniques in patients experiencing an acute exacerbation of chronic obstructive pulmonary disease: a systematic review. *Chronic Respiratory Disease*; 7(1):9-17, 2012.
- [2] GOLD: Global Initiative for Chronic Obstructive Lung Disease. Global Strategy for the Diagnosis, Management and Prevention of COPD, Global Initiative for Chronic Obstructive Lung Disease. 2013. p. 1-99. Available from: http://www.goldcopd.org/uploads/users/files/GOLD_Report_2013_Feb20.pdf. [Last accessed on 2014 May 04].
- [3] Ramos F.L., Krahne J.S., and Kim V.: Clinical issues of mucus accumulation in COPD: *International Journal of COPD*; 9:139–150, 2014.
- [4] Nicolini A., Cardini F., Landucci N., Lanata S., Ferrari-Bravo M., and Barlascini C.: Effectiveness of treatment with high-frequency chest wall oscillation in patients with bronchiectasis. *Pulmonary Medicine*; 13(21):2-8, 2013.

- [5] Holland A.E, and Button B.M. : Is there a role for airway clearance techniques in chronic obstructive pulmonary disease. *Chron Respir Dis*; 3(2):83-91, 2006.
- [6] Osadnik C.R., McDonald C.F., Jones A.P., and Holland A.E.: Airway clearance techniques for chronic obstructive pulmonary disease. *Cochrane Database Syst Rev* ;(3), 2012
- [7] Bhowmika A., Chahal K., Austin G. and Chakravorty I: Improving mucociliary clearance in chronic obstructive pulmonary disease: *Respiratory Medicine*; 103(4):496-502, 2008.
- [8] Chakravorty I., Chahal K., and Austin G.: A pilot study of the impact of high-frequency chest wall oscillation in chronic obstructive pulmonary disease patients with mucus hypersecretion: *International Journal of COPD*; 6:693–699, 2011.
- [9] ATS: American Thoracic Society: Standardization of spirometry update. Statement of the American Thoracic Society. *Am Rev Respir Dis*; 136:1285-98, 1987.
- [10] Jones P.W., Brusselle G.G., Dal Negro G., Ferrer M., Kardos P., Levyf M.L., Perez T., Soler J.J., van der Molen C.T.L., and Banik N.: Properties of the COPD assessment test in a cross-sectional European study. *ERJ*; 38:129-35, 2011.
- [11] Jones P.W., Harding G., Berry P.: Development and first validation of the COPD Assessment Test. *Eur Respir J*; 34:648-654, 2009.
- [12] ATS: American Thoracic Society: Guidelines for the Six-Minute Walk Test *Am J Respir Crit Care Med*; 166: 111–117, 2002.
- [13] Mahajan A.K., Diette G.B., Hatipoğlu U., Bilderback A., Ridge A., Harris V.W., Dalapathi V., Badlani S., Lewis S., Charbeneau J.T., Naureckas E.T., and Krishnan J.A.: High frequency chest wall oscillation for asthma and chronic obstructive pulmonary disease exacerbations: a randomized sham-controlled clinical trial. *Respir Res.*; 10 (12):120, 2011.
- [14] Miravittles M., Patricia G.S., Alonso F.N., María J.B., María José Espinosa., and Jesús M.: Course of COPD assessment test (CAT) and clinical COPD questionnaire (CCQ) scores during recovery from exacerbations of chronic obstructive pulmonary disease. *Health and Quality of Life Outcomes*; 11:147, 2013.
- [15] Fainardi V., Longo F., Faverzani S.: Short-term effects of high-frequency chest compression and positive expiratory pressure in patients with cystic fibrosis. *Clin Med Res*; 3(6):279-284, 2011.
- [16] Paul W.J., Gale H., Ingela W., Pamela B., Maggie T., Ren Y., and Nancy K.L.: Tests of the Responsiveness of the COPD Assessment Test Following Acute Exacerbation and Pulmonary Rehabilitation. *CHEST*; 142(1):134–140, 2012.
- [17] Stafler P., Carr S.B. (2010): Non-cystic fibrosis bronchiectasis: its diagnosis and management. *Arch Dis Child Educ Pract Ed.*; 95(3):73-82.
- [18] Yuan N., Kane P., Shelton K., Matel J., Becker B.C., and Moss R.B.: Safety, Tolerability, and Efficacy of High-Frequency Chest Wall Oscillation in Pediatric Patients with Cerebral Palsy and Neuromuscular Diseases: An Exploratory Randomized Controlled Trial; 25(7):815-821, 2010.
- [19] Ghobadi H., Ahari S. S., Kameli A. and Lari S. M.: The Relationship between COPD Assessment Test (CAT) Scores and Severity of Airflow Obstruction in Stable COPD Patients. *Tanaffos* ; 11: 22–26, 2012.
- [20] Salma S., and Yogitha C.: Clinical Correlation of Copd Assessment Test (Cat) Questionnaire with Severity in Acute Exacerbation of Chronic Obstructive Pulmonary Disease. *IOSR Journal of Dental and Medical Sciences: Volume 14, Issue 1 Ver. I; PP. 12-1*, 2015.
- [21] Manoj K.K., Maheshwari V.D., Sumeet G., Kamlesh K., Reshu G., and Shikha K.: “Six minute walk distance: Correlation with spirometric & clinical parameters in chronic obstructive pulmonary disease”. *International J. of Healthcare & Biomedical Research*; (1):217-226, 2013.
- [22] Yohannes A.M. and Hardy C.C.: Treatment of chronic obstructive pulmonary disease in older patients: a practical guide. *Drugs Aging.*; 20(3):209-28, 2003.
- [23] Chandra D., Wise RA., Kulkarni H.S., Benzo RP., Criner G., Make B., Slivka W.A., Ries A.L., Reilly J.J., Martinez F.J., and Sciurba F.C. : Optimizing the 6-min walk test as a measure of exercise capacity in COPD. *Chest*; 142(6):1545-52, 2012.

كفاءة التذبذب عالى التردد عبر جدار الصدر على مؤشرات التهوية الرئوية و الكفاءة الحياتية لمرض الضيق الشعبى الهوائى المزمن

هدف البحث: - تقييم فعالية سترة جهاز التذبذب عالى التردد عبر جدار الصدر في علاج التفاقم الحاد في مرضى السدة الرئوية المزمنة. **تصميم البحث:** - برنامج علاجى باستخدام التذبذب عالى التردد عبر جدار الصدر لمرض الضيق الشعبى الهوائى المزمن. **مقاييس النتائج الرئيسية:** - تقييم وظائف الرئة (القدرة الحيوية القسرية، حجم الزفير القسري في الثانية الأولى، والنسبة بينهما، وكذلك نسبة التدفق القسري للزفير). **طريقة البحث:** - أجرى البحث على أربعين رجل مريض بتفاقم مرض الانسداد الرئوى المزمن. تمت الدراسة على مجموعة واحدة و قد تلقى جميع المرضى العلاج بجهاز التذبذب عالى التردد لجدار الصدر بالإضافة إلى أدويتهم المحددة وتم تقييم جميع المرضى قبل وبعد العلاج لمدة أربعة أسابيع وشمل التقييم وظائف الرئة: القدرة الحيوية القسرية، حجم الزفير القسري في الثانية الأولى، والنسبة بينهما، وكذلك نسبة التدفق القسري للزفير. وكذلك أجرى اختبار الست دقائق مشيا على الأقدام لتحديد القدرات الوظيفية للمريض قبل وبعد تدخل العلاج الطبيعى وأجريت أيضا اختبار تقييم مرض الانسداد الرئوى المزمن. **النتائج:** - أظهرت النتائج فروقات ذات دلالة إحصائية لوظائف الرئة (القدرة الحيوية القسرية، حجم الزفير القسري في الثانية الأولى، والنسبة بينهما، وكذلك نسبة التدفق القسري للزفير). وأظهرت النتائج تحسنا كبيرا بالنسبة لاختبار تقييم مرض الانسداد الرئوى المزمن وكذلك اختبار المشي لمدة 6 دقائق مع زيادة ذات دلالة إحصائية. **الخلاصة:** - سترة جهاز التذبذب عالى التردد لجدار الصدر علاج طبيعى فعال للتفاقم الحاد في مرضى السدة الرئوية المزمنة حيث يؤدي إلى إزالة المخاط الزائد وتحسين وظائف الرئة مما يحسن كفاءة المريض الحياتية.

مفتاح كلمات البحث: - الضيق الشعبى الهوائى المزمن، النوبات الحادة، سترة جهاز التذبذب عالى التردد عبر جدار الصدر، وظائف الرئة.