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Original Research Article

Utility of vest high frequency chest wall oscillation device versus flutter device in acute exacerbation of chronic obstructive pulmonary disease

Taghreed S. Farag[1]*, Mariam EL-Syed[2]

[1]Department of Chest diseases, Faculty of Medicine for Girls, AL-Azhar University, Cairo, Egypt
[2]Physical Therapy for Cardiovascular/Respiratory disorder and geriatrics, Faculty of Physical Therapy, Cairo University, Egypt

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***Correspondence:**
Dr. Taghreed S. Farag,
E-mail: drtaghreedsaied@gmail.com

ABSTRACT

Background: Objectives to assess the effectiveness of high frequency chest wall oscillation (HFCWO) vest system and Flutter devices in the treatment of patients with AECOPD, and to compare the efficacy of HFCWO vest system versus Flutter devices.
Methods: We conducted an interventional study on 108 out of 129 patients presented with AECOPD, recruited from two-university hospitals. They were classified into three groups, HFCWO group (n=37), Flutter group (n=35), and control group (n=36). The HFCWO group and Flutter group were treated with AECOPD medications in addition to either HFCWO or Flutter physiotherapy, three sessions per week, for four weeks, while control group was treated by medications only. All patients were evaluated before and after treatment by spirometry, ABG, CAT score, and the BODE index.
Results: Post treatment assessment for both HFCWO and Flutter groups demonstrated that most of spirometric indices (FEV1%, FVC%, FEV1/FVC %), oxygenations parameters (PaO2, SaO2 %) and CAT score, were significantly improved ($p < 0.05$). The level of perceived dyspnea decreased significantly, walking distance during 6-MWT was extended significantly, the BODE index and MMRC scale decreased significantly. While in control group only oxygenations parameters (PaO2, SaO2 %) was mildly improved. No statistical significant difference was found between vest HFCWO and Flutter device in all measured post treatment parameters ($p > 0.05$).
Conclusions: Both vest HFCWO and Flutter device are highly effective in treatment of patients with AECOPD in terms of improvement in ventilatory function and oxygenation parameters with better exercise tolerance.

Keywords: Acute Exacerbation of chronic obstructive pulmonary disease, high frequency chest wall oscillation, Flutter device, airway clearance devices

INTRODUCTION

Increased cough, sputum volume and/or purulence are key features of acute exacerbation of chronic obstructive disease (AECOPD). Ciliary dysfunction contributes to development of sputum retention with subsequent mucosal injury and airflow obstruction.[1] A process called two-phase gas-liquid flow may regard in this manner as the chief to enhance airway clearance. This process involves transfer of kinetic airflow energy onto sputum surface, resulting in exertion of a shear force that moves sputum in the direction of proximal airway.[2]

Although deep breathing exercises such as pursed lip and diaphragmatic breathing exercise may increase ventilation and improve blood gases, this is accompanied by increased inspiratory muscle effort, reduced mechanical efficiency of breathing and increased

dyspnea.[3] As a result, deep breathing exercises do not have a role in physiotherapy management of AECOPD.[1] Recently, devices of chest physiotherapy (CPT) have emerged as an alternative to conventional CPT. The choice of the suitable device for each patient is a challenge for the physiotherapist in order to achieve better compliance. Numerous benefits were documented to CPT devices, i.e. the independent application and the reduced cost of therapy. In addition, inhalation therapy can be given during the act.[4].

The current devices of CPT are Positive Expiratory Pressure (PEP), High Frequency Chest Wall Oscillation (HFCWO), Oral High Frequency Oscillation, Intrapulmonary Percussive Ventilation, Incentive Spirometry and the Flutter device.[5]

The Flutter device is a controlled vibration system, during expiration Flutter produces PEP and cyclic oscillation of the airways. Expiration against resistance resultant in increasing the alveolar pressure creating PEP which diminish the airways collapsibility and may reducing peripheral airway resistance. The oscillations induce vibrations within the airway wall to decrease the visco-elasticity of tenacious secretions, as well as, to accelerate airflow, enhance movement of secretions from the peripheral to the central airways lumen, improving lung function and oxygenation.[5,6]

One of the oscillatory devices with High Frequency Chest Wall Oscillation (HFCWO) systems is the vest airway clearance system. HFCWO devices generate either positive or negative trans-respiratory pressure excursions to creates high velocity, low amplitude oscillatory airflows when applied through a pneumatic vest worn over the thorax, results in transient cephalad bias airflow spikes in the airways to loosen and moves trapped secretions from the peripheral to proximal airways, which can be removed through coughing or suctioning.[7]

The chronic obstructive pulmonary disease assessment test (CAT) is designed for assessment of COPD impact on health status, it is simple questionnaires that cover daily symptoms; It include three parts (symptoms, activities and affection).[8-12] Identified items of CAT score include dyspnea, cough, expectoration and wheeze, also; systemic symptoms of fatigue and sleep disturbance. Additional indicators included limitations in daily activities, social life, emotional health and feeling in control with the use of rescue medication. CAT score can be a useful tool to measure health status during an exacerbation and evaluate recovery; also, CAT-score and the number of exacerbations will serve as a marker of disease control.[12].

The BODE index was calculated using the score proposed by Celli et al.[13] BODE indicator is considered by experts to be the most reliable tool in assessing the COPD patients in regards of their quality of life and survival rate. The six minutes' walk distance (6MWD) and modified medical research council (MMRC) dyspnea scale, accurately evaluates the tolerance for exertion as an equivalent of physical fitness.[14] Chandra et al., reported that the improvement in performance of the 6-MWD is important in measuring response to a therapeutic intervention.[15]

The aim of this study was to assess the effectiveness of HFCWO vest system and Flutter devices in the treatment of patients with AECOPD and also to compare the efficacy of HFCWO vest system versus Flutter devices.

METHODS

This interventional study was conducted on 108 out of 129 patients presented with AECOPD (Figure 1) in the period from November 2015 to June 2017. They were recruited from two university hospitals (Al-Zahraa University Hospital and Kasr El-Aieny Teaching Hospital), Cairo, Egypt. The ethical committee of the university approved the study. An informed written consent was obtained from all participants before their enrollment into the study, after they informed about the aim of the study, and that their participation in the study is voluntary.

Inclusion criteria

All patients had symptoms of chronic airflow limitation and fulfilled criteria set out by GOLD for diagnosis of COPD, moreover they had clinical symptoms of exacerbation (increased dyspnea, increased cough and sputum production, altered sputum color and/or viscosity, constitutional manifestations).[16,17] All of them had post-bronchodilator forced expiratory volume in first second (FEV1) less than 80% of the predicted value, with an FEV1/FVC not more than 70%. They had an increase in FEV1 <200 ml or <12% of baseline value, 15-20 min after 4 puffs of inhaled salbutamol via a metered-dose inhaler.[18] They were classified into three groups;

- Group I: AECOPD patients treated by medications plus Vest Airway Clearance System device (HFCWO group),
- Group II: AECOPD patients treated by medications plus Flutter device (Flutter group),
- Group III: AECOPD patients treated by medications for AECOPD only (control group).

AECOPD medications including bronchodilators, antibiotics, inhaled and oral steroids, oxygen if indicated as well as advice of regular exercise as part of AECOPD protocol.[16,19]

Exclusion criteria

Patients with pulmonary diseases other than COPD, any significant musculoskeletal disorders, osteoporosis, GERD, hiatus hernia, recent episode of significant hemoptysis or pneumothorax (within 6 months), acute

cardiac event (within 6 weeks) and ICU admission were excluded from the study.

The drop-out criteria were refusing of participations into the study, occurrence of any of the exclusion criteria during the study period, shift to intensive care unit (ICU). Only one patient Flutter group was unable to perform forced expiratory maneuvers, therefore he shifted to vest HFCWO group and dropped out from Flutter group at the beginning of the study.

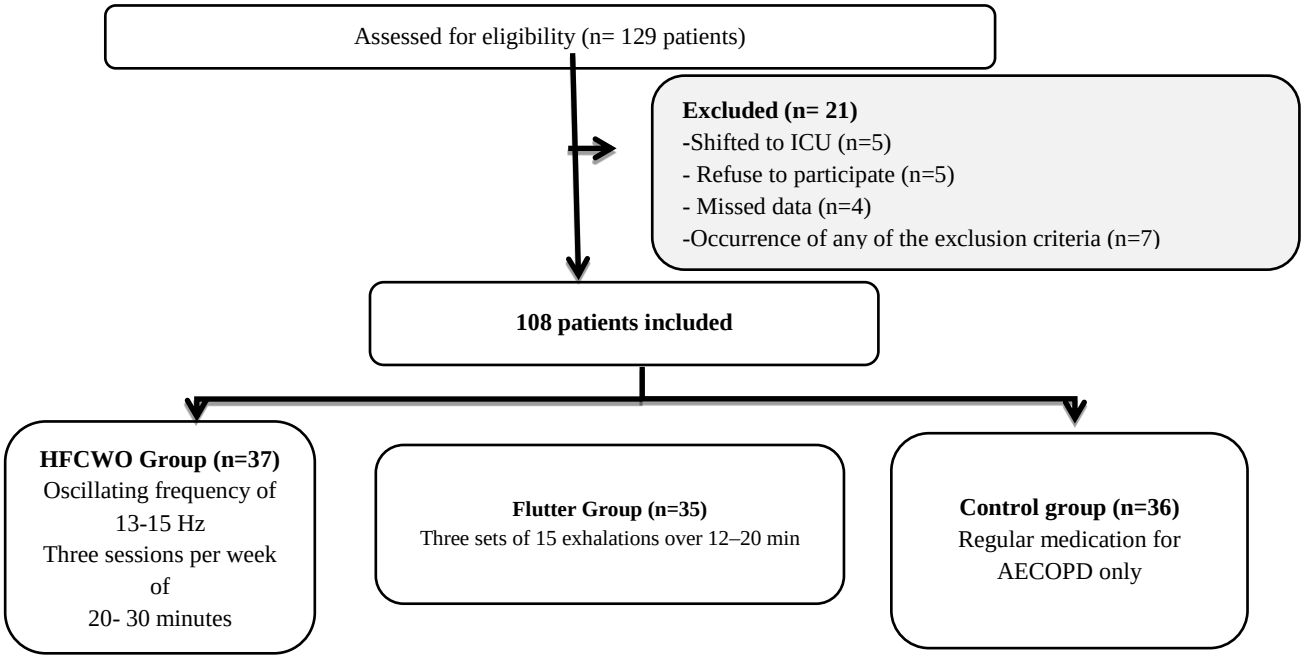

Figure 1: Flowchart for patient's selection criteria.

Study design

The following assessments were carried out before and after treatment protocol for all participants

- *Spirometry*

Using (Spirosift spirometry 5000 FUKUDa NENSHI), the following indices were recorded FEV1, FVC, and FEV1/FVC, forced expiratory flow rate (FEF25-75 %). Spirometric-indices were calculated using best out of three technically satisfactory trials in accordance to ATS/ERS.[18]

- *Arterial Blood gases (ABGs)*

Using "rapid lap analyzer 248", the following values were recorded; oxygen saturation (SaO2 %), power of hydrogen (pH), arterial partial oxygen pressure (PaO2mmHg), arterial partial carbon dioxide pressure (PaCO2mmHg) and bicarbonate (HCO3 mEq/L).

- *COPD assessment test (CAT)*

CAT score consists of 8 items, each presented as 6- point different scale, providing a total score range from zero to 40. The total CAT score was calculated by summing the points of each variable, the higher scores represent worse health.[8-12] It was classified into four categorizes; low (< 10), medium (10-20), high (21-30) and very high (> 30).[11,12]

Table 1: Parameters of the BODE index.

	0	1	2	3
FEV_1% pred	≥65	50-64	36-49	≤35
6MWD (m)	≥350	250-349	150-249	≤149
MMRC	0-1	2	3	4
BMI (kg/m^2)	>21	≤21		

(FEV_1% pred = predicted amount as a percentage of the forced expiratory lung volume in one second; 6MWD = six minute walking distance; MMRC = modified medical research council dyspnea scale; BMI = body mass index.

- *Assessment of the BODE index*

It was calculated using the score proposed by Celli et al; body mass index (B) was used to assess nutritional status [BMI=Wt (kg)/Ht (m^2)] (kg/m^2), FEV1% (O) was used to assess degree of airway obstruction, MMRC (D) was used to assess patient's level of dyspnea and 6-minute walking test (6MWD) (E) was carried out to determine

patient functional capacity.[13,14,20,21] The patients were received points ranging from zero (lowest value) to 3 (maximal value). For BMI, the values were 0 or 1. The points for each variable were added, so that the BODE index ranged from zero- 10 points (Table 1).[13,14]

-Modified Medical Research Council (MMRC)

It was used to assess the patient's level of dyspnea. It does not define the subjective dyspnea per se, but rather the degree of disability that such breathlessness poses on day-to-day activities. The MMRC dyspnea range from grade 0- 4.[14]

- Six minute walk distance (6MWD)

It was used to assess the exercise capacity, which was done according to ATS.[20] Subjects were asked to cover as much ground as possible in a period of 6 minutes but allowed to stop if there were symptoms of dyspnea; however, they were instructed to resume walking as soon as they felt able to do so. Testing was performed in a location where a rapid, appropriate response to an emergency service is available.[20]

- *High-frequency chest wall oscillation (HFCWO)*

It was provided with the (Hill-Rom-Vest Airway Clearance System Model 104-ABI). The Vest system is a small medical device, employing HFCWO technology. 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 5-20 times /second to create airflow within the lungs. The vest air pulse generator was set at low pressures and frequency and then increased to the recommended pressure/frequency (optimum oscillating frequency of 13-15Hz) based on individual patient tolerance during the "tuning procedure," and a pressure setting to achieve a tight but comfortably snug fit. These air pulses oscillate the chest and the vibrations reportedly cause transient flow increases in the airways, loosening mucus and producing cough like sheer forces.

The patients received three sessions / week of 20- 30 minutes, starting from the first day of hospital admission and continued after discharge giving a total study period of 4 weeks.[5,22,23]

The patient was positioned in a relaxed and comfortable position either sitting upright or lying down, as no special position is recommended. No sessions immediately after a meal. For comfort, a single layer of clothing was worn and the circumferential inflatable vest applied to the patient's chest wall. The patients breathing wasn't restricted during vest deflation. After completing the session, the patient was instructed to take deep breathing and cough to clear the loosened secretions. The patients were monitored throughout the sessions for vital signs, changes in the respiratory pattern, work of breathing, and skin color. Finally, the patients were asked how tolerable the device was.

- *The Flutter mucus clearance device*

It is a portable pipe-shaped device with a hardened plastic mouthpiece at one end, a plastic protective, perforated cover at the other end, and a high-density stainless steel ball resting in a plastic circular cone inside the bowl of the ''pipe''. During expiration through the Flutter, the expiratory flow move the steel ball up and down, creating PEP and oscillations with a back transmission to the patient, to facilitate mucus expectoration.[24,25] The patients placed in erect positions; in a well-supported chair with a neutral lumbar spine to enhances the function of the diaphragm and the pelvic floor, minimizes musculoskeletal stress and to ensure the best transmission of vibration to chest wall.[26] They were instructed to inhale deeply and hold his/her breathe for 2-3 second, then expire slowly through the Flutter valve, which cause oscillations of the steel ball inside the cone of the Flutter.[5] Routinely, three sets of 15 exhalations are performed over 12–20 minutes. After each series of exhalations, patients were instructed to "huff" and cough, thereby aiding expectoration.[3] As the generation of oscillation and pressure are dependent on the expiratory flow and gravity forces, the frequency of the oscillations was modulated by changing the inclination of the Flutter device slightly up or down from its horizontal position. The neutral position (or zero degrees) is considered the one which the device has an angle of 90 degrees with the head position, i.e., parallel to the ground. In general, with the device turned upward (positive degrees) the pressure and oscillation were increased, while turned the device downward (negative degrees), the pressure and oscillation were decreased.[24]

The volume of expectorated sputum was difficult to evaluated as some patients swallow it which decreasing its amount, others expectorate sputum mixed with saliva which increasing its amount. Additionally, patients were not admitted during the whole study period (4 weeks). Therefore, the volume of the expectorated sputum was not assessed in the current study.

Statistical analysis

Data were analyzed by Statistical Package for Social Science (SPSS) version 17. Data were expressed as mean ±SD for quantitative variables. ANOVA and t-test were considered statistically significant when $p<0.05$.

RESULTS

A total of 129 patients were assessed for eligibility, 108 AECOPD patients met the inclusion criteria and classified into three groups; HFCWO group (n=37, 24

men and 13 women), Flutter group (n=35, 25 men and 10 women) and control group (n=36, 27 men and 9 women). The three groups are age matched (p = 0.28), with no significant difference between them regarding disease duration, smoking (pack/years) and BMI (p=0.73, 0.32 and 0.10 respectively) (Table 2).

Table 2: Baseline characteristics for AECOPD patients studied groups.

Variables		HFCWO Group (n=37)	Flutter Group (n=35)	Control group (n=36)	p-value
Age/yrs) (Mean ± SD)		64.0 ± 2.4	60.9 ± 1.6	63.7 ± 2.1	0.28
Sex	Male n (%)	24 (64.9%)	25 (71.4%)	27 (75.0%)	0.821
	Female n (%)	13 (35.1%)	10 (28.6%)	9 (25.0%)	
COPD duration /yrs (Mean ± SD)		28.4 ± 5.6	27.8± 4.8	28.0± 2.5	0.738
Pack yrs smoking (Mean ± SD)		50.8 ± 3.5	58.3 ± 6.6	49.9 ± 7.1	0.32
Smoking Status	Current smoker n (%)	22 (59.4%)	19 (54.2%)	20 (55.6%)	
	EX-smoker n (%)	15 (40.5%)	16 (45.7%)	16 (44.4%)	
BMI (kg/m²) (Mean ± SD)		27.99±6.25	28.46 ±3.61	27.8 ±2.7	0.104

Table 3: Spirometric-indices, arterial blood gases, CAT-score, BODE index before and after intervention among the three studied groups.

Variables	HFCWO Group (n=37)			Flutter group (n=356)			Control group (n=36)		
	Pre - treatment	Post - treatment	P value	Pre - treatment	Post - treatment	P value	Pre - treatment	Post- treatment	P value
FEV_1 %	44.8± 0.8	53.4± 5.3	0.002*	43.8± 0.8	52.2± 4.9	0.003*	45.8± 1.6	52.6± 2.1	0.055
FVC %	60.7± 11.6	72.3± 5.1	0.003*	70.9±7.5	76.6±9.0	0.019**	69.4±6.9	71.7±8.0	0.07
FEV_1 / FVC %	53.5 ± 9.8	56.6± 7.5	0.023**	54.36 ± 8.8	57.5 ± 8.3	0.023**	55.5 ± 6.7	57. 2 ± 5.9	0.056
FEF $_{25-75\ \%}$	53. 4 ± 0.2	54.12 ± 0.26	0.082	58.5±10.06	4.6 ±12.5	0.27	58.4±8.1	9.0 ±10.2	0.3
pH	7.36±0.01	7.35±0.1	0.37	7.4±0.03	7.45±0.2	0.063	7.35±0.04	7.44±0.1	0.07
$PaCO_2$,mm Hg	46.2 ± 3.7	47.9 ± 4.8	0.56	46.8 ± 4.4	48.6 ± 4.2	0.48	45.9 ± 5.4	45.0 ± 3.5	0.51
PaO_2 ,mm Hg	70.5± 5.5	78.0± 6.8	0.001*	62.0 ±9.9	65.3± 10.1	0.001*	63.0 ±10.6	57.1± 8.2	0.02*
SaO_2 %	89.1±3.0	94.3±1.0	0.002*	85.7±3.8	97.6 ± 0.4	0.001*	83.4±2.2	90.7 ± 0.6	0.04*
CAT score	19.9± 7.1	15.5± 6.3	0.003*	20.2±7.2	16.0±6.2	0.005*	21.2±6.4	19.8±3.3	0.055
BODE index	4.0± 5.5	3.2 ± 0.3	0.002*	4.5 ± 1.6	3.0± 4.5	0.001*	4.9 ± 1.9	4.0± 4.48	0.06
MMRC scale	3.4±0.9	2.1±0.7	0.001*	3.3±0.9	2.0±0.9	0.002*	4.0±0.9	3.8±0.9	0.07
6 MWD(m)	208 ± 0.8	269.3 ± 62.9	0.000*	204 ± 0.3	258.7±43.4	0.008**	210 ± 0.1	221.5±418.3	0.08
BMI (kg/m²)	278.0±6.3	27.92±6.5	0.9	28.5 ±3.6	28.5 ±3.6	0.99	27.8 ±2.7	27.7±2.5	0.06

* Highly significant ** significant

Post-treatment assessment for the three studied groups demonstrated that most of the spirometric indices (FEV1%, FVC%, FEV1/FVC %) were significantly improved in HFCWO and Flutter groups only, while oxygenation parameters (PaO2, SaO2 %) were significantly improved ($p < 0.05$) in the three studied groups. The level of perceived dyspnea decreased significantly, walking distance during 6-MWT was extended significantly, while BODE index, MMRC scale and total CAT score were reduced significantly in HFCWO and Flutter groups only. No statistical significant differences were observed in BMI, FEF 25-75%, pH, PaCO2 and HCO3 in the three groups (Table 3). On evaluation of pre- treatment CAT score report for the three studied groups, the items concerned with breathlessness on stairs /hills, cough with sputum productions were described by every patient (n= 108), whereas the others concerning confidence, sleep disorders, chest tightness were more common among patients with severe exacerbations (45.9% in HFCWO group, 62.9% in Flutter group, and 55.6% in control group).

The comparative analysis between pre and post-treatment CAT-score revealed improvement with significant reduction in total CAT-score in post-treatment for both

HFCWO and Flutter groups ($p < 0.05$) with no improvement in control group ($p < 0.055$) (Table 3). HFCWO and Flutter groups had significantly improvement of dyspnea score, less cough and mucus production.

Aiming to evaluate the efficacy of HFCWO as a non-invasive method of airway clearance system, we compare the post-treatment parameters of HFCWO group with that of Flutter group and we found that all post treatment measured parameters were comparable between both groups (Table 4).

Table 4: Comparison of effectiveness of HFCWO vest system versus Flutter device in AECOPD.

Variables	HFCWO Group (n=37) Mean ± SD	Flutter Group(n=35) Mean ± SD	P value
FEV_1 %	53.4± 5.3	52.2± 4.9	0.24
FVC %	75.2 ± 5.1	83.4 ± 4.5	0.16
FEV_1 / FVC %	67.8 ± 4.9	73.8 ± 3.0	0.09
$FEF_{25-75\%}$	47.2 ± 4.1	51.9 ± 3.1	0.08
pH	7.35±0.1	7.5±0.22	0.07
$PaCO_2$, mm Hg	47.9 ± 4.8	48.6 ± 4.16	0.34
PaO_2, mm Hg	78.1± 6.8	65.3± 10.1	0.01
SaO_2 %	94.3±1.0	97.6 ± 0.4	0.01
CAT score	15.5± 6.3	16.0±6.24	0.38
BODE index	3.3±0.9	3.2 ± 0.2	0.13
BMI (kg/m²)	28.0±6.3	28.5 ±3.6	0.10
MMRC scale	3.4±0.9	3.1±0.9	0.63
6MWD(m)	269.3 ± 62.9	258. 7±43.4	0.01

Table 5: Adverse events during the course of the study in both HFCWO groups and Flutter group.

Adverse Event	HFCWO Group (n=37) n. (%)	Flutter Group (n=35) n. (%)
Inability to perform forced expiratory maneuvers	0 (0.0%)	1 (0.03%)
Throat discomfort	1 (2.7 %)	3 (8.57%)
Musculoskeletal Chest discomfort	1 (2.7 %)	2 (5.7 %)
Generalized weakness	0 (0.0%)	0 (0.0%)
Episode of significant hemoptysis	2 (5.4 %)	1 (2.8%)
Syncope	0 (0.0%)	1 (2.8 %)
Paroxysm of cough	0 (0.0%)	1 (2.8 %)

Regarding the adverse events during the course of the study, the vest HCWO and Flutter device, both were well tolerated. As the Flutter required vigorous exhalations to achieve oscillation, throat discomfort was recorded in (8.57 %) and musculoskeletal discomfort in (5.7 %) of patients in the first week; no patients discontinued use of the device because of this adverse event. Episode of significant hemoptysis was recorded in (5.4%) among the HCWO group. Other adverse events were minor i.e. transient paroxysm of cough, syncope, which was the most common adverse effect with single use of the Flutter, was not seen with chronic use (Table 5).

DISCUSSION

In the current study, the three studied groups are age matched with male predominance, with no significant differences between them regarding disease duration, smoking pack/years and BMI which indicate that there is proper selection of participants to ensure strict control of confounders that affect mucociliary clearance, as Bhowmik et al postulated that mucociliary clearance (MCC) is influenced by physiological factors such as age, gender, posture, sleep and exercise.[25] Moreover, environmental pollution and tobacco smoking have negative effect on MCC probably due to altered cilia, mucus or the periciliary layer, or a mixture of these.

The main finding of the current study is that both vest HFCWO system and Flutter device significantly improve oxygenation parameters and spirometric indices, while in control group only oxygenation parameters (SaO2 and PaO2) were mildly improved. These findings indicate that chest physiotherapy (HFCWO and Flutter) had positive impacts in treatment of patients with AECOPD possibly through improving airway clearance, that subsequently improve pulmonary function tests and oxygenation. Braveman et al., reported that in COPD patients HFCWO produces improvements in gas mixing and homogenization of alveolar ventilation for previously closed or under ventilated lung units.[27] Other two authors reported that the Flutter as an oscillating PEP device enhances movement of secretions from the peripheral to the central airways lumen, improving lung function and

oxygenation.[5,6] Additionally, Zakerimoghadam et al., mentioned that chest physiotherapy whatever its types enhance MCC, increase ventilation and improve blood gases.[3]

The improved spirometric-indices reported among our patients in HFCWO or Flutter with no improvement in control group (Table 3), was similar to the results reported by Nicolini et al., who concluded that, there was significant improvement in pulmonary function tests (FEV1 or FVC) in CPT and HFCWO treated patients in comparison to control group.[4] Conversely, Chakravorty et al., found no significant change in baseline spirometric-indices (FEV1 or FVC) with HFCWO versus post-intervention ones.[7] Mahajan et al., and Holland et al., reported that the vest HFCWO device was well tolerated with improvement in ventilatory functions.[23,28] The patients often feel better because they don't have to struggle to breathe and feel less fatigued, so improving quality of life.

The effects of Flutter on PFT have been researched in a lot of clinical studies, and their results are controversial. A number of studies have obtained positive impact of Flutter, with an increase in the VC and FVC and a decrease in the RV, FRC and TLC, in patients with cystic fibrosis, COPD and others.[29-35] However, other studies with similar propose; demonstrate non-significant effect on PFT.[36-39] The controversial effects of Flutter device among the studies may be related to multifactor; firstly, the generation of oscillation and pressure are dependent on the expiratory flow and gravity forces. Secondly: the device has a flow dependent resistance. So; flows and/or positions may be different and not controlled among the studies which mean a resistance decreases as the flow decreases.[38] Thirdly: if secretion was expectorated, the PFT would improve, but if the secretions move inside the airways with a late expectoration, patient can experience a transitory decrease in the pulmonary function.[26]

In the current study, the pre-treatment CAT score evaluation for three groups showed that the items of exertion dyspnea, productive cough were reported by every patient (n=108), whereas the other item concerning self-assurance, sleep disturbances, chest tightness were reported by patients with more severe AECOPD. Additionally, there was significant reduction in total CAT score in post-treatment for both HFCWO and Flutter groups with no improvement in control group [$P<0.003$ and $P<0.005$, $p=0.055$)] respectively. The HFCWO group and Flutter group had significantly improvement of dyspnea score, less cough and mucus production than before. These findings point out that cough, expectoration and dyspnea were the most common troubling symptoms among patients with AECOPD and adjunctive treatment with either HFCWO or Flutter devices help expectoration and airway clearance with subsequent reduction in CAT-score items given for each one of these variable and hence reduction of total CAT-score. Numerous studies 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 COPD patients.[4,6,12,23] Our results also coincide with pilot study carried out by Chakravorty et al. whom reported that patients with AECOPD and mucus hypersecretion are at increased risk of declining lung function, tolerated the HFCWO treatment well, leading to improvement in CAT-score and quality of life and reduced symptoms.[7] Moreover; our result is consistent with Mahajan et al., 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.[23]

In order to evaluates the tolerance to exertion as an equivalent to physical fitness, we used therapeutic effects of vest HFCWO and Flutter groups on the BODE index and its components, there was significant improvement of BODE index, 6-MWD, MMRC scale in HFCWO and Flutter groups, while BMI did not show any significant difference in both groups. On the other hand, all these variables did not differ in control group (Table 3). These findings indicate that as HFCWO and Flutter improve oxygenation parameters, with resultant increase in oxygen delivery to the tissue which enhance metabolic activity with subsequent improvement in physical activity, walking distance and reduced dyspnea scale. Our results also coincide with that reported by Kurzaj et al., as they concluded that after a week of physiotherapy, the BODE index improved in AECOPD group and control group, but the significant difference was higher in the AECOPD group.[39] In addition, in AECOPD all BODE components highly significantly improved except BMI, whereas in the control group only exercise capacity was significantly improved.

Our study revealed that there was no significant difference in all post-treatment measured parameters between HFCWO vest system and Flutter device ($p > 0.05$) (Table 4), which indicating that both of them provides an adequate physiotherapy method to AECOPD patients. However, the Flutter device had some adverse events than HFCWO in terms of throat and musculoskeletal chest discomfort, syncope and paroxysm of cough, while hemoptysis was common in HFCWO. These adverse effects may be due to that Flutter is a semi-invasive device used by mouth and require forced expiratory maneuver which increase intrathoracic pressure with subsequent cough, syncope, and musculoskeletal discomfort. In addition, the effective use of the Flutter device requires patient's cooperation, compliance, training, concentration, appropriate positioning of the mouthpiece, proper sterilization and no mass use, however, it is reasonably priced. On the other hand, the HFCWO vest airway clearance is relatively expensive, but has a lot of advantage i.e. high rates of compliance because of the simplicity of the usage it does not require special positioning or breathing techniques. It is technique-independent; performed without assistance

from trained health care personnel, so, caregiver factors do not compromise its effectiveness. Moreover; it can be performed in acutely ill patients (i.e. ICU patients and children) who may be unable to use Flutter devices effectively.

CONCLUSION

Airway clearance technique provides an improvement in pulmonary function, blood gases, CAT-score and BODE in patients with AECOPD. Therefore, we recommend its use in management of these patients. Although both vest HFCWO device and Flutter device were well tolerated by most patients, the adverse effects were more common in Flutter group. However, long-term studies are required to establish the efficacy and safety of both devices, their cost-effectiveness and to establish their acceptability for long-term home use.

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