Original Article

doi:10.31674/mjn.2026.v18i01.011

MJN

Conventional versus High-Frequency Chest Wall Oscillation Care among Critically Ill Patients: A Comparative Nursing Evaluation of Respiratory Outcomes

Shimaa Abdelnaby Kamel[1*], Mogedda Mohamed Mehany[1], Marwan Nasreldin Mohammed[2], Naglaa Ahmed Ahmed[1]

[1]Department of Critical Care and Emergency Nursing, Faculty of Nursing, Assiut University, 2072350 Assiut Governorate, Egypt

[2]Department of Chest Diseases and Tuberculosis, Faculty of Medicine, Assiut University, 2072350 Assiut Governorate, Egypt

**Corresponding Author's Email: shimaa1993@aun.edu.eg*

ABSTRACT

Background: The critical care nurse plays a significant role in applying airway clearance methods, including conventional chest wall physiotherapy as well as High-Frequency Chest Wall Oscillation (HFCWO), which became a therapeutic modality to mobilize mucus in different respiratory pathologies. **Objectives:** To evaluate respiratory outcomes following application of conventional versus high-frequency chest wall oscillation care among critically ill patients. **Methods**: A quasi-experimental research design was conducted at the respiratory Intensive Care Unit (ICU), Assiut University Hospital, Egypt, on a purposive sample of 60 adult critically ill patients. Patients were selected and assigned to two groups: 30 in the conventional group and 30 in the HFCWO group. Tools: Three tools were utilized in this study I. Clinical and Demographic Profile II. Respiratory system assessment III. Patients Outcomes. **Results**: As regards arterial blood gases, there were significant time effects for Partial Pressure of Oxygen in Arterial Blood (PaO_2) and Arterial Oxygen Saturation (SaO_2). Significant time × group interactions were observed for both variables, indicating greater improvement in the HFCWO group. There were significant differences in volume of secretion on the fourth ($p = 0.042$*) and seventh ($p = 0.017$*) days. Additionally, the HFCWO group's ICU stay was shorter than that of the conventional group, with a statistically significant difference ($p = 0.042$*). **Conclusion:** HFCWO therapy was more effective in improving respiratory outcomes and decreasing the length of ICU stay than conventional chest physiotherapy. These results support replication of this study using a larger probability sample in several hospitals in Upper Egypt.

Keywords: Critically Ill Patients; High-Frequency Chest Wall Oscillation; Nursing Evaluation; Respiratory Outcomes

INTRODUCTION

Many critically ill patients often have an increased risk for respiratory infection, sputum retention and a greater number of them may require intubation and mechanical ventilation. Since the inflammatory response increases the production and accumulation of mucus in the airways, conventional and unconventional techniques of secretion removal are used (Costa *et al.,* 2026). Chronic Obstructive Pulmonary Disease (COPD) is a clinical disease that is characterized by persistent coughing, excessive secretions, and shortness of breath. The key characteristics are abnormal overproduction of mucus, which often contributes to a decrease in symptom stability and patients becoming vulnerable to repeated disease exacerbations despite optimal drug treatment (Mari *et al.,* 2025). Exacerbations also worsen quality of life and increase the likelihood of future episodes (Huang *et al.,* 2025).

COPD is a progressive respiratory disorder and predominantly affects smokers and individuals older than 40 years, with prevalence increasing with advancing age. It remains a major global cause of morbidity and mortality (Singh *et al.,* 2023). According to the Global Initiative for Chronic Obstructive Lung Disease (GOLD), quitting

Received: January 15, 2026 Received in revised form: June 11, 2026 Accepted: June 25, 2026

smoking is one of the most effective methods to prevent and manage COPD. It lowers exposure and treatment-related expenses (Ilyas & Iram, 2017). Overall, despite advances in management, further improvement is still needed to enhance treatment effectiveness and prognosis, particularly during exacerbations (Khan *et al.,* 2023).

Management of airway clearance has been a key component of treatment to facilitate mobilization and removal of pulmonary secretions, which is essential for managing acute respiratory diseases as well as maintaining respiratory health. Effective airway clearance starts with identifying secretions in the airway and ends with expectoration (Gipsman *et al.,* 2023). Conventional chest physiotherapy, positive expiratory pressure-based systems, modified postural drainage, or therapeutic positioning are airway clearance techniques. Furthermore, mechanically assisted modalities like high-frequency chest wall oscillation and high-frequency chest wall compression have become more clinically useful in mucus mobilization and expectoration by applying rapid oscillatory or percussion forces to the thoracic wall (Marin *et al.,* 2024).

HFCWO delivers external chest compression through an inflatable vest connected to an air-pulse generator. By applying oscillations at varying frequencies, the technique enhances mucus mobilization from both central and peripheral airways (Rai & Sharma, 2026). HFCWO has been effectively used in patients with COPD (Costa *et al.,* 2026). HFCWO appears to be more effective in improving pulmonary function and exercise tolerance, particularly in advanced stages of obstructive disease (Tahir *et al.,* 2026).

The critical care nurse has a vital role in the patient's care who is receiving HFCWO care through continuous assessment of the hemodynamic status and monitoring oxygenation, breath rate, sounds, cough effectiveness, degree of dyspnea, and characteristics of respiratory secretions before, during, and after care as well as delivering tailored education on disease management and self-care strategies to reduce the risk of exacerbations (Wang *et al.,* 2025). In addition, nurses are responsible for ensuring correct device application; adjusting parameters; and monitoring patient tolerance and comfort, as well as potential adverse effects such as desaturation, fatigue, or hemodynamic instability. Nurses' conceptualization and integration of impaired airway clearance within the nursing process are very heterogeneous (Gaspar *et al.,* 2024).

Despite these reported benefits, limited evidence is available regarding the effectiveness of HFCWO in patients with COPD, particularly from a nursing perspective. Therefore, this study aimed to evaluate the use of HFCWO in patients with COPD admitted to the respiratory intensive care unit.

Significance of the Study

In the respiratory ICU at Assiut University Hospital, patients commonly suffer from dyspnea and ineffective airway clearance. Accordingly, some patients receive conventional chest physiotherapy, and others receive HFCWO care, who show more respiratory improvement, as evidenced by the medical records of patients from May 2023 to May 2024 of Assiut University Hospital Record. Initiation of HFCWO therapy showed a substantial reduction in the number of hospitalizations and improved quality of life and lung function (Quissesa *et al.,* 2021). Focused pulse HFCWO therapy improved respiratory function and quality of life in patients with moderate to severe COPD, enhanced daily activity performance, and reduced exacerbation rates (Pestelli *et al.,* 2024).

Aim of the Study

To evaluate respiratory outcomes following application of conventional versus high-frequency chest wall oscillation care among critically ill patients.

Research Hypothesis

H_0: Patients who are using a high-frequency chest wall oscillation device will not exhibit any change in respiratory function or ICU stay compared to those who are receiving conventional chest physiotherapy.

H_1: Patients who are using a high-frequency chest wall oscillation device will exhibit more improvement in respiratory function compared to those who are receiving conventional chest physiotherapy.

H_2: Patients who are using a high-frequency chest wall oscillation device will exhibit a shorter ICU stay than those who are receiving conventional chest physiotherapy.

METHODOLOGY

Study Design

The study was conducted by using a quasi-experimental research design.

Setting

The study was conducted at the respiratory intensive care unit at Assiut University Hospital, Egypt.

Sample

A purposive sample of sixty adult patients who met the eligibility criteria was assigned sequentially to the conventional group first, followed by the HFCWO group, with thirty patients in each group from August 2024 to March 2025.

Inclusion Criteria

All oriented non-mechanically ventilated critically ill patients who were newly admitted with age (18 to ≤ 65 yrs), diagnosed with exacerbation of COPD, and suffered from dyspnoea or difficult airway clearance (Saad *et al*., 2023).

Exclusion Criteria

Patients with brain death, pulmonary oedema, pulmonary embolism, terminal stage of cancer, or subcutaneous emphysema.

The sample size was calculated according to the study's findings by Farag and Mariam (2018). By comparing two means of SaO_2 pre and post intervention with a power of 80% and an alpha 5%. The mean difference was 2.3, with a standard deviation of 3.8 in the conventional group and 2.2 in the HFCWO group. It was calculated that the minimum sample size required is 30 for each group.

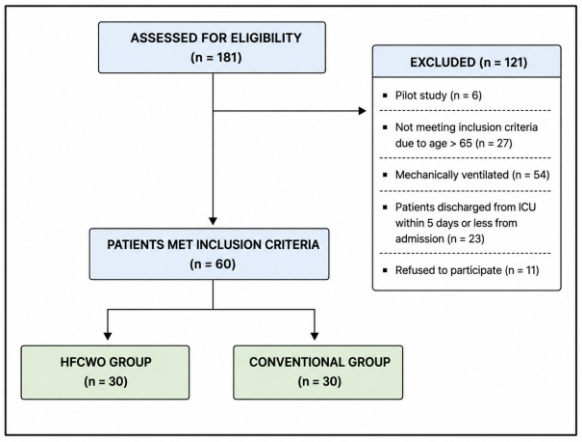


Figure 1: Flowchart of Patient's Selection Criteria

Study Tools

Three tools were utilized by the researcher after reviewing the related literature.

Tool I

Clinical and Demographic Profile Ge *et al.* (2023); it was developed by the researcher and included.

Part I

Patient characteristics and clinical data, such as age, gender, and clinical presentation. It also included the Smoking Index formula, which is determined by multiplying the number of years of smoking by the number of cigarettes smoked daily (Philippe *et al.,* 2025).

Part II

Laboratory measurements, which included results of Arterial Blood Gases (ABGs), pH, PaO_2, Partial

Pressure of Arterial Carbon Dioxide ($PaCO_2$), Bicarbonate Ion (Arterial Bicarbonate) (HCO_3^-), and SaO_2.

Tool II

Respiratory system assessment by Huang *et al.* (2022); it was developed by the researcher and included three parts.

Part I

Respiratory system assessment sheet, which was designed by a researcher to monitor respiratory rate, Fraction of Inspired Oxygen (FiO_2), and Oxygen Saturation by Pulse Oximetry (SpO_2). Moreover, the number of secretions was classified according to Karinja *et al.* (2015) into the following categories: 0 (absent), 1 (<6 ml), 2 (6-10 ml), or 3 (>10 ml) if present.

Part II

The 5-point Likert scale for dyspnea (5PLS); it was adopted from Weber *et al.* (2014). This psychometric tool measures breathlessness on a relative ordinal scoring system as (1) absence of dyspnea, (2) mild shortness of breath, (3) moderate shortness of breath, (4) severe shortness of breath and (5) the worst possible shortness of breath.

Part III

Cough Symptom Score (CSS) is the measure, which was adopted from Hsu *et al.* (1994) and used by Jakusova and Brozmanova (2023). The CSS was a two-part questionnaire considering the frequency and severity of coughing during the day and at night. Results were scored from 0 to 5, with 0 indicating no cough; 1 indicating cough for one short period; 2 indicating cough for more than two short periods; 3 indicating frequent coughing which did not interfere with usual daytime activities; 4 indicating frequent coughing that did not interfere with usual daytime activities; and 5 indicating distressing coughs most of the day.

Tool III

Patients' outcomes tool, which included expected patients' outcomes in terms of duration of ICU stay.

Procedure

The study included preparatory, implementation, and evaluation phases.

Preparatory Phase

In this phase official permissions were documented by hospital authorities at the respiratory intensive care unit and the faculty of nursing.

A panel of five critical care and emergency specialists assessed the content validity of tool I and tool II, part one, for appropriateness and clarity. 0.92 was the Content Validity Index (CVI).

The reliability of the study tools was assessed using Cronbach's alpha. Tool I ($\alpha = 0.735$) and Tool II (part one) ($\alpha = 0.761$). The 5-point dyspnea scale (Tool II, part two) is a validated clinical tool, although Cronbach's alpha was not reported in its original validation. Tool II (part three) ($\alpha = 0.928$). Tool III included objective clinical outcomes, such as ICU stay, and did not require internal consistency testing.

The pilot study was implemented with six patients (10%) before implementation to evaluate objectivity and clarity of tools, required no modifications and excluded to prevent any potential bias.

Implementation Phase

Data Collection

The studied sample fulfilled the research criteria and was allocated into the conventional group and HFCWO group.

The conventional group received the conventional chest physiotherapy (vibration or percussion) twice

daily for 7 consecutive days.

The HFCWO group received care with an available HFCWO device (Seoil Pacific Corp. company). Patients were seated comfortably, and parameters were adjusted on percussor mode, inhale pressure (40 cm H_2O), oscillatory frequency (450 CPM), I:E ratio (1:2), and time set (30 minutes). Then patients performed deep breathing and coughing to expectorate secretions twice daily for 7 consecutive days and were assessed until discharge.

The HFCWO device is easy to use and time-efficient, offering a practical alternative to conventional chest physiotherapy. It consists of an air pulse generator and an inflatable vest that receives air pulses, which compress the chest wall and help in mobilizing tracheal mucus. Assessment of patient files pre-intervention for the following data: age, gender, clinical presentation, and smoking history; smokers are classified as follows: mild smoker is SI $\leq$ 200, moderate smoker is 200 < SI < 400 and heavy smoker is SI $\geq$ 400. During the implementation period, in collaboration with the nursing staff, the researcher evaluated and recorded results of ABGs, respiratory rate, SpO_2, FiO_2, presence and number of secretions, if present**.** Also, presence or absence of dyspnoea by using the 5-point Likert scale for dyspnoea, daytime and nighttime cough symptoms by using CSS pre-intervention, 4th, and 7th day.

Evaluation Phase

Each included patient in this study was evaluated for all assessed tools for improvement of overall respiratory outcomes pre-intervention, on the 4th, and on the 7th day and evaluated for length of ICU stay.

Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics version 26. Categorical variables were presented as frequencies and percentages and compared using the chi-square test or Fisher's exact test, as appropriate. Continuous variables were expressed as mean ± standard deviation for normally distributed data or median (interquartile range) for non-normally distributed data, and an independent samples t-test or Mann–Whitney U test was used for analysis. Repeated measures ANOVA was used for repeated measurements. A p-value < 0.05 was considered statistically significant.

Ethical Considerations

The researchers obtained ethical clearance from the Ethical Research Committee of the Faculty of Nursing, Assiut University, Egypt, with ethical code 1120240830 on 1st July 2024.

RESULTS

Table 1: Baseline Demographics and Clinical Characteristics of Patients in HFCWO and Conventional Groups

Item		HFCWO group (n=30)	Conventional group (n=30)	*p*-value	Test	Effect Size	CI 95%	Interpretation
Age Groups	**18 to < 30 yrs.**	2(6.7%)	2(6.7%)	0.437	Chi-square test $\chi^2(3) = 2.72$	Cramér's V = 0.21	0.00 to 0.44	Small effect
	30 to < 40 yrs.	2(6.7%)	6(20%)					
	40 to < 50 yrs.	8(26.7%)	5(16.7%)					
	50 to ≤ 65 yrs.	18(60%)	17(56.7%)					
Gender	**Male**	18(60%)	21(70%)	0.589	Fisher's exact	Phi = 0.105	- 0.15 to 0.35	Small effect
	Female	12(40%)	9(30%)					
Smoking Status	**Non-smokers**	12(40%)	18(60%)	0.033*	Chi-square test $\chi^2(3) = 8.71$	Cramér's V = 0.38	0.14 to 0.58	Moderate effect
	Mild	6(20%)	0(0%)					
	Moderate	4(13.3%)	7(23.3%)					
	Heavy	8(26.7%)	5(16.7%)					
Length of ICU Stays (days)		8 (IQR 3)	9 (IQR 5)	0.032*	Mann-Whitney U	r = 0.28	0.02 to 0.49	Small–moderate effect

**Statistically significant difference, p<0.05, Values are presented as n (%) for categorical variables and median Interquartile Range (IQR) for continuous variables, Between-group comparisons used Chi-square test, Fisher's exact test, or Mann–Whitney U test as appropriate, Effect sizes with 95% confidence intervals are reported*

Table 1 clarifies that baseline demographic characteristics were largely similar between the HFCWO and conventional groups. However, there is a statistically significant difference between both groups regarding

Smoking history (p = 0.033*). The HFCWO group experienced a shorter ICU stay than those in the conventional group (p = 0.032*).

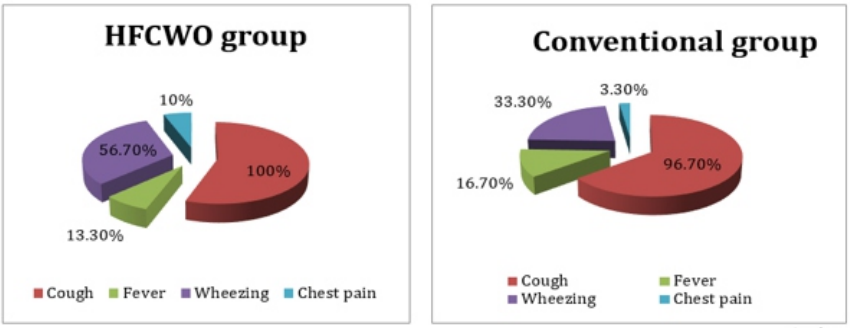


Figure 2: Comparison of Clinical Presentation between the High-Frequency Chest Wall Oscillation (HFCWO) Group and Conventional Group at Admission

Figure 2 compares the percentages of patients presenting with cough, fever, wheezing, and chest pain at admission in the HFCWO and conventional groups. Patients could present with more than one symptom; therefore, percentages are not mutually exclusive. No statistically significant differences between the two groups (p > 0.05). Cough was the most common symptom in both groups.

Table 2: Comparison of Arterial Blood Gas Parameters between the HFCWO and Conventional Groups over Time

(ABGs)	Group (n=30)	Pre intervention	4th day	7th day	p (Time)	p (Interaction)	p (group)	Effect Size (η^2)	Interpretation
pH	HFCWO Group	7.34 ± 0.10	7.38 ± 0.07	7.39 ± 0.06	0.002	0.859	0.019	0.113	Significant effect (time + group)
	Conventional Group	7.38 ± 0.12	7.42 ± 0.07	7.42 ± 0.04					
	CI 95%	-0.87 to 0.15	-0.85 to 0.20	-0.82 to 0.17					
PaO_2 (mmHg)	HFCWO Group	72.53 ±21.03	83.23 ± 16.40	85.90 ± 14.92	0.020	0.033	0.013	0.078	Significant improvement
	Conventional Group	72.53 ± 12.96	73.57 ± 15.33	72.77 ± 11.04					
	CI 95%	-8.86 to 8.86	3.91 to 15.40	7.55 to 18.70					
$PaCO_2$ (mmHg)	HFCWO Group	60.13 ± 19.05	58.32 ± 16.48	60.67 ± 18.41	0.453	0.658	0.200	0.014	Non-Significant
	Conventional Group	57.40 ± 23.68	53.29 ± 17.71	53.64 ± 10.81					
	CI 95%	-8.82 to14.28	-0.53 to10.58	0.40 to 14.46					
HCO_3^- (mEq/L)	HFCWO Group	33.63 ± 8.80	35.98 ± 14.51	36.38 ± 8.63	0.303	0.603	0.401	0.020	Non-Significant
	Conventional Group	33.05 ± 10.27	33.97 ± 8.64	33.52 ± 6.89					
	CI 95%	-4.68 to 5.84	-3.24 to 7.26	-2.62 to 8.33					
SaO_2 (%)	HFCWO Group	90.13 ± 6.66	94.30 ± 3.54	93.23 ± 5.67	< 0.001	0.022	0.331	0.145	Significant time × group interaction
	Conventional Group	91.57 ± 3.13	92.30 ± 3.87	95.70 ± 2.67					
	CI 95%	-3.25 to 0.37	-0.40 to 3.60	-4.92 to 0.01					

**Statistically significant difference, p<0.05*

Table 2 presents significant time effects for PaO_2 and SaO_2. Significant time × group interactions were observed for both variables, indicating greater improvement in the HFCWO group. However, pH showed a significant group effect without interaction, while $PaCO_2$ and HCO_3^- showed no significant differences. Effect sizes ranged from small to large, with the greatest effect observed for SaO_2.

Table 3: Respiratory Assessment Parameters in HFCWO and Conventional Groups

Group		HFCWO group (n=30)	Conventional group (n=30)	*P*-value	Median Difference	Effect size (r)	CI 95%	Interpretation
Pre intervention	Respiratory Rate (breaths/min)	25 (3.3)	26.5 (6)	0.152	-1.50	0.18	-0.07 to 0.41	Small effect
	SpO_2 (%)	90.5 (4)	91 (5.5)	0.727	- 0.50	0.04	-0.21 to 0.29	Trivial effect
	FiO_2 (%)	40 (15)	40 (10)	0.041*	0.00	0.26	0.01 to 0.49	Small effect
4th day	Respiratory Rate (breaths/min)	21 (2.5)	21 (4.3)	0.715	0.00	0.05	-0.20 to 0.30	Trivial effect
	SpO_2 (%)	94 (3.3)	93 (4.3)	0.352	1.00	0.12	-0.14 to 0.37	Small effect
	FiO_2 (%)	31 (9)	35 (9)	0.529	- 4.00	-0.08	-0.17 to 0.33	Trivial effect
7th day	Respiratory Rate (breaths/min)	23 (4.3)	24 (5.5)	0.004*	- 1.00	-0.37	0.12 to 0.58	Moderate effect
	SpO_2 (%)	93 (1.3)	92 (4.3)	0.055	1.00	0.25	-0.01 to 0.49	Small effect
	FiO_2 (%)	28 (7)	28 (4)	0.969	0.00	0.01	-0.24 to 0.26	No effect

**Statistically significant difference, p<0.05, Data are presented as median Interquartile Range (IQR), Mann–Whitney U test*

Table 3 indicates that respiratory assessment parameters were generally comparable between the two groups. However, the HFCWO group demonstrated a significantly lower respiratory rate than the conventional group ($p = 0.004$*) on 7th day, while no significant between-group differences were observed for SpO_2 or FiO_2.

Table 4: Comparison between the Two Groups Regarding the Number of Secretions across the Assessment Days

Number of Secretions		HFCWO group (n=30)	Conventional group (n=30)	*p*-value	*df*
Pre-intervention	< 6 ml	7 (23.3%)	11(36.7%)	0.104	2
	6 – 10 ml	19 (63.30%)	19 (63.30%)		
	> 10 ml	4 (13.3%)	0 (0.0%)		
At 4th day	No Secretion	1 (3.3%)	4 (13.3%)	0.042*	3
	< 6 ml	18 (60.0%)	12 (40.00%)		
	6 – 10 ml	6 (20.0%)	13 (43.3%)		
	> 10 ml	5 (16.7%)	1 (3.3%)		
At 7th day	No Secretion	18 (60%)	11 (36.67%)	0.017*	3
	< 6 ml	5 (16.7%)	15 (50%)		
	6 – 10 ml	7 (23.3%)	3 (10%)		
	> 10 ml	0 (0.0%)	1 (3.33%)		

**Statistically significant difference, p<0.05, Fisher's exact test*

Table 4 demonstrates that there were significant differences in the volume of secretions observed on the fourth and seventh days ($p = 0.042$* and 0.017*, respectively), indicating greater improvement in secretion clearance among patients in the HFCWO group compared with the conventional group.

Table 5: Comparison between the Two Groups Regarding the 5-point Likert Scale for Dyspnoea

The 5-point Likert scale for dyspnoea		HFCWO group (n=30)	Conventional group (n=30)	*p*-value	*df*
Pre-intervention	Moderate Shortness of Breath	11(36.7%)	6 (20%)		
	Severe Shortness of Breath	16 (53.3%)	23 (76.7%)	0.217	2
	The Worst Possible Shortness of Breath	3(10.0%)	1(3.3%)		
At 4th Day	Absence of Dyspnoea	4 (13.3%)	0 (0.0%)		
	Mild Shortness of Breath	21(70.0%)	17 (56.7%)		
	Moderate Shortness of Breath	5 (16.7%)	13 (43.33%)	0.018*	2
At 7th Day	Absence of Dyspnoea	24 (80.0%)	15 (50.0%)		
	Mild Shortness of Breath	1(3.3%)	10 (33.33%)		
	Moderate Shortness of Breath	2 (6.7%)	3(10.0%)		
	Severe Shortness of Breath	2 (6.7%)	2(6.7%)		
	The Worst Possible Shortness of Breath	1(3.3%)	0 (0.0%)	0.011*	4

**Statistically significant difference, p<0.05, Fisher's exact test*

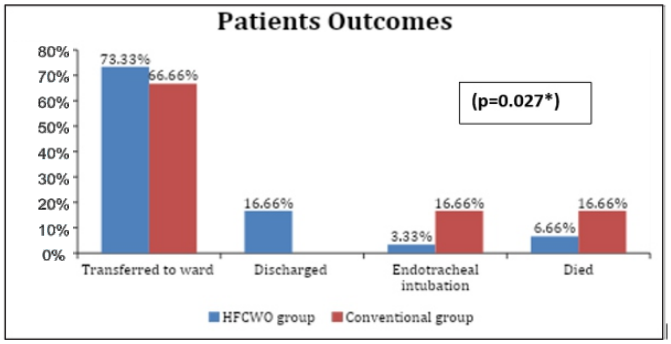
Table 5 demonstrates that baseline dyspnoea scores were comparable between the two groups. Significant improvements in dyspnoea were observed in the HFCWO group compared with the conventional group on 4th day ($p = 0.018$*) and 7th day ($p = 0.011$*).

Table 6: Comparison between the Two Groups in Relation to Cough Symptom Score (daytime)

Cough Symptom Score (daytime)		HFCWO Group (n=30)	Conventional Group (n=30)	*p*-value	*df*
Pre-intervention	Cough for More Than 2 Short Periods	1(3.3%)	0 (0.0%)	1.000	3
	Frequent Coughing Which Did Not Interfere with Usual Daytime Activities	19 (63.30%)	20 (66.70%)		
	Frequent Coughing Which Did Interfere with Usual Daytime Activities	7 (23.3%)	6 (20.0%)		
	Distressing Coughs Most of the Day	3 (10.0%)	4 (13.3%)		
At 4th day	No Cough During the Day	1(3.3%)	0 (0.0%)	0.012*	4
	Cough for One Short Period	7 (23.3%)	0 (0.0%)		
	Cough for More Than Two Short Periods	17 (56.7%)	21(70.0%)		
	Frequent Coughing, Which Did Not Interfere with Usual Daytime Activities	5 (16.7%)	9 (30.0%)		
At 7th day	No Cough During the Day	15(50.0%)	9 (30.0%)	0.006*	4
	Cough for One Short Period	14 (46.7%)	12 (40.00%)		
	Cough for More Than Two Short Periods	0 (0.0%)	8 (26.7%)		
	The Frequent Coughing did not Interfere with Regular Daytime Activities.	0 (0.0%)	1 (3.3%)		
	Distressing Coughs Most of the Day	1(3.3%)	0 (0.0%)		

**Statistically significant difference; p<0.05; Fisher's exact test*

Table 6 indicates that patients in the HFCWO group showed significantly greater improvement in daytime cough symptoms than those in the conventional group on the fourth and seventh assessment days ($p<0.05$). Regarding night-time cough symptoms, no significant differences were observed between both groups throughout the intervention period ($p > 0.05$), although both groups demonstrated gradual improvement over time.



**Statistically significant difference; p<0.05*

Figure 3: Comparison of Patients' Outcomes between the HFCWO and Conventional Groups

Figure 3 demonstrates a statistically significant difference in patients' outcomes between the HFCWO and conventional groups ($p = 0.027$*). Most patients were transferred to the chest ward, with a higher proportion in the HFCWO group (73.33%) than in the conventional group (66.66%).

DISCUSSION

This study emphasized the critical role of nursing assessment and intervention in optimizing the effectiveness of HFCWO therapy, which has been used as adjunctive treatment to improve lung function since it has demonstrated safety, tolerability, and improved compliance among patients with excessive secretions (Marin *et al.,* 2024). Therefore, this study was to evaluate respiratory outcomes following application of conventional versus high-frequency chest wall oscillation care among critically ill patients.

Considering the statistical analysis, no statistically significant difference was observed between the groups regarding gender distribution ($p > 0.05$). Most patients were in age group (50 to ≤ 65 yrs.). Moreover, most of both groups were men (60% in the HFCWO group and 70% in the conventional group). These findings were in line with Samir *et al.* (2024), who found that the approximately 51 to 60 years age range was observed

in nearly half of the study group (48.9%) and (62.2%) of the control group, and the majority of them were males. From the researcher's opinion, COPD seems to be more common in males, patients with a history of smoking, or advanced age. Smoking history analysis showed that the smoking status in the HFCWO and conventional groups was statistically significant ($p = 0.033$*) as non-smokers were represented in a higher percentage in the conventional group (60% compared to 40%). This observation was contrary to Farag and Mariam (2018), who found no statistically significant variation in the smoking status among the groups under study in terms of pack-years ($p = 0.32$).

Through continuous nursing monitoring of respiratory parameters, there were significant time effects for PaO_2 and SaO_2. Significant time × group interactions were observed for both variables, indicating greater improvement in the HFCWO group. These results agreed with Cheng *et al.* (2022), who reported the improvement of post-intervention PaO_2 and a decrease in $PaCO_2$ ($p < 0.05$). Also, these findings were agreed with by Farag and Mariam (2018), who mentioned that post-treatment assessment for both HFCWO and Flutter groups demonstrated that oxygenation parameters (PaO_2, SaO_2%) were significantly improved. Nevertheless, this was contrary to Longhini *et al.* (2020), who did not find any differences in ABGs among studied groups. These findings highlight that the success of HFCWO therapy is strongly influenced by skilled nursing care. After seven days of intervention, the HFCWO group showed a lower respiratory rate with a statistically significant difference ($p = 0.004$*) compared with another group. This is similar to Reda *et al.* (2024), who mentioned that "Additionally, a significant difference in RR was found in this study between the conventional group and the intervention group (who got both manual chest physical therapy and a cough assist device) ($p = 0.004$*)."

Nursing assessment before, during, and after treatment includes evaluation of cough effectiveness and secretion characteristics. It was observed that the management of secretions became better by 4th and 7th day ($p = 0.042$* and 0.017*), respectively. 60% Of the HFCWO group displayed no distinguishable secretions versus (36.67%) in the conventional group at 7th day. This is inconsistent with Quissesa *et al.* (2021), who associated high-frequency oscillation with the best airway clearance, and also supported by Wang and Leng (2026), who stated that the sputum volume of patients on postoperative days 2, 3, 4, and 5 in the study group was significantly lower than that in the control group ($p < 0.05$). However, these results contradicted those of Lin *et al.* (2017), who reported that "no statistically significant difference in sputum volume was observed between the two groups ($p = 0.085$)".

On the topic of dyspnea, these results revealed that the HFCWO group showed improvement of dyspnea severity over the conventional group on 4th and 7th days with statistically significant differences ($p = 0.018$* and 0.011*), respectively. These findings agreed with Ahmed *et al.* (2024), who stated that compared to the Lung Flute, HFCWO provides more significant improvements in pulmonary function and exertional dyspnea in post-COVID men with COPD. But these results were contrary to Huang *et al.* (2022), who found that the severity of dyspnoea did not significantly improve in COPD patients following the HFCWO.

In addition, the HFCWO group experienced greater improvement in daytime cough symptoms compared to the conventional group on the 4th and 7th days, with statistically significant differences ($p = 0.012$* and 0.006*), respectively. These findings were supported by Farag & Mariam (2018)**,** who stated that the dyspnea score, coughing, and mucus production were considerably enhanced in the HFCWO and Flutter groups. Expectoration and airway clearance are facilitated by adjunctive treatment with either HFCWO or Flutter devices.

But night-time cough symptoms were statistically unchanged between two groups. From a researcher's point of view, this may be due to physiological changes that occur during sleep, including congestion, immobility, or changes in respiratory mechanics. Patients who received HFCWO care had a shorter ICU stay than those in the conventional group, with statistical significance *(p* = 0.032*). Cheng *et al.* (2022) observed similar results, showing that "Group A (Intervention Group)" patients exhibited a significantly shorter length of stay than "Group B (Control Group)" with *p* values < 0.05. However, Lee *et al.* (2011) observed no statistically meaningful group differences in length of stay.

Limitations

A major limitation of this study was the small sample size, which may have reduced the statistical power and limited the generalizability of the findings. The number of eligible patients was restricted by the inclusion

criteria, as most patients admitted to the respiratory ICU required mechanical ventilation and prolonged ICU stays, while many others were discharged within five days of ICU admission. In addition, some eligible patients declined to participate. Therefore, the findings should be interpreted with caution.

Future Scope

Further research should involve larger and more representative samples to confirm these findings, clarify the effectiveness of HFCWO in critically ill patients with different respiratory conditions, and improve the generalizability of the results. Future studies should also focus on establishing evidence-based treatment protocols and evaluating the long-term effects of HFCWO on respiratory function.

CONCLUSION

This study demonstrated that HFCWO was more effective than conventional chest physiotherapy in improving respiratory and clinical outcomes among patients with COPD admitted to the respiratory intensive care unit. Patients in the HFCWO group showed significant improvements in dyspnea scores, respiratory rate, daytime cough symptoms, and secretion clearance. They were also more likely to be transferred to the respiratory unit and had a shorter ICU length of stay. These findings contribute to nursing knowledge by supporting the use of HFCWO as an evidence-based airway clearance for critically ill patients with COPD. Integrating HFCWO into routine nursing care may improve patient outcomes.

CRediT Authorship Contribution Statement

Sh.A.K.: Conceptualization, methodology, data curation, formal analysis, writing – original draft. M.M.M: Supervision, data curation, revision and editing. M.N.M.: Supervision, revision and editing. N.A.A.: Clinical supervision, data curation and editing.

AI Assistance Declaration

The authors declare that generative AI tools (such as ChatGPT) were used only for language enhancement and grammar correction during the preparation of this manuscript. The authors carefully revised the content and will take full responsibility for the final version of the manuscript.

Conflict of Interest

There were no competing interests among the authors.

ACKNOWLEDGEMENT

The authors truly appreciated all patients, doctors, and nurses who participated in this study at the respiratory ICU.

REFERENCES

Ahmed, O. S. M., Abd El-Rahim Abd El-Aty, S., Ahmed El-Hadidy, H., Mohamed Abdelhakiem, N., & Mohamed El-Moatasem, A. (2024). Efficacy of high-frequency chest wall oscillations vs. lung flute in chronic obstructive pulmonary disease patients with post-COVID. *European Review for Medical & Pharmacological Sciences, 28*(3), 1227-1233. https://doi.org/10.26355/eurrev_202402_35361.

Cheng, G., Wu, J., Hu, Z., Xiao, Y., Zeng, B., & Zhou, Y. (2022). Effects of high-frequency Chest Wall Oscillation Expectoration System on pulmonary rehabilitation and cortisol function in patients with severe AECOPD. *Disease Markers, 2022*(1), 3380048. https://doi.org/10.1155/2022/3380048.

Costa, M. F. P., de Macedo, G. K. B., Figueiredo, A. T. D. N. S., da Fonseca Filho, G. G., & Monteiro, K. S. (2026). Use of high-frequency chest wall oscillation therapy in infants: protocol for a feasibility randomised controlled clinical trial. *BMJ Open Respiratory Research, 13*(1), e003505. https://doi.org/10.1136/bmjresp-2025-003505

Farag, T. S., & Mariam, E. S. (2018). Utility of vest high-frequency chest wall oscillation device versus flutter device in acute exacerbation of chronic obstructive pulmonary disease. *International Journal of Research in*

Medical Sciences, 6(1), 1-9, https://doi.org/10.18203/2320-6012.ijrms20175703.

Gaspar, L., Reis, N., Sousa, P., Silva, A. P. E., Cardoso, A., Brito, A., ... & Machado, N. (2024). Nursing process related to the nursing focus "airway clearance": a scoping review. *Nursing Reports, 14*(3), 1871-1896. https://doi.org/10.3390/nursrep14030140

Ge, J., Ye, Y., Tan, Y., Liu, F., Jiang, Y., & Lu, J. (2023). High-frequency chest wall oscillation multiple times daily can better reduce the loss of pulmonary surfactant and improve lung compliance in mechanically ventilated patients. *Heart & Lung, 61*, 114-119, https://doi.org/10.1016/j.hrtlng.2023.05.007.

Gipsman, A. I., Lapinel, N. C., & Mayer, O. H. (2023). Airway clearance in patients with neuromuscular disease. *Paediatric Respiratory Reviews, 47*, 33-40, https://doi.org/10.1016/j.prrv.2023.02.002.

Hsu, J. Y., Stone, R. A., Logan-Sinclair, R. B., Worsdell, M., Busst, C. M., & Chung, K. F. (1994). Coughing frequency in patients with persistent cough: assessment using a 24 hour ambulatory recorder. *European Respiratory Journal, 7*(7), 1246-1253, https://doi.org/10.1183/09031936.94.07071246.

Huang, H. P., Chen, K. H., Tsai, C. L., Chang, W. P., Chiu, S. Y. H., Lin, S. R., & Lin, Y. H. (2022). Effects of high-frequency chest wall oscillation on acute exacerbation of chronic obstructive pulmonary disease: A systematic review and meta-analysis of randomized conventionalled trials. *International Journal of Chronic Obstructive Pulmonary Disease*, 2857-2869, https://doi.org/10.2147/COPD.S378642.

Huang, Y. J., Wang, K. Y., Chien, W. C., Chung, C. H., Kao, L. T., Kao, S., & Chian, C. F. (2025). Paradigm shift in the treatment of chronic obstructive pulmonary disease improves patient outcomes. *International Journal of Chronic Obstructive Pulmonary Disease, 2025*(20), 1965-1972 https://doi.org/10.2147/COPD.S511593.

Ilyas, N., & Iram, M. (2017). Living with chronic obstructive pulmonary disease: A case study. *The Malaysian Journal of Nursing, 8*(4), 36-41. https://ejournal.lucp.net/index.php/mjn/article/view/463

Jakusova, J., & Brozmanova, M. (2023). Methods of cough assessment and objectivization. *Physiological Research, 72*(6), 687-700, https://doi.org/10.33549/physiolres.935062.

Karinja, M. N., Esterhuizen, T. M., Friedrich, S. O., & Diacon, A. H. (2015). Sputum volume predicts sputum mycobacterial load during the first 2 weeks of antituberculosis treatment. *Journal of Clinical Microbiology, 53*(4), 1087-1091. https://doi.org/10.1128/jcm.02379-14

Khan, K. S., Jawaid, S., Memon, U. A., Perera, T., Khan, U., Farwa, U. E., ... & Chaudhry, W. R. (2023). Management of chronic obstructive pulmonary disease (COPD) exacerbations in hospitalized patients from admission to discharge: A comprehensive review of therapeutic interventions. *Cureus, 15*(8), e43694. https://doi.org/10.7759/cureus.43694

Lee, D. S., Park, S. W., Yeom, S. R., Han, S. K., Lee, S. H., & Ryu, J. H. (2011). High-frequency chest wall oscillation therapy: Clinical effectiveness in the patients with pulmonary contusion. *Acute and Critical Care, 26*(4), 256-260, https://doi.org/10.4266/kjccm.2011.26.4.256.

Longhini, F., Bruni, A., Garofalo, E., Ronco, C., Gusmano, A., Cammarota, G., Pasin, L., Frigerio, P., Chiumello, D., & Navalesi, P. (2020). Chest physiotherapy improves lung aeration in hypersecretive critically ill patients: a pilot randomized physiological study. *Critical Care, 24*(1), 479. https://doi.org/10.1186/s13054-020-03198-6.

Mari, P. V., Coppola, A., Lorenzo, C., & Francesco, M. (2025). Focused pulse high-frequency chest wall oscillation (FP-HFCWO) for mucus management in COPD (chronic obstructive pulmonary disease) and asthma: A single-center cohort study. *The Open Respiratory Medicine Journal, 19*, e18743064391693. https://doi.org/10.2174/0118743064391693250627115047.

Marin, A., Chiaradia, V. C., Dobre, M., Brateanu, A., Baltatu, O. C., & Campos, L. A. (2024). High-frequency chest wall oscillation devices: An umbrella review and bibliometric analysis. *Computers in Biology and Medicine,*

182, 109135. https://doi.org/10.1016/j.compbiomed.2024.109135.

Pestelli, M. T., Grecchi, B., Vottero, E., Galli, A., Nicolini, A., Compalati, E., Banfi, P., Diaz de Teran, T., Gonzales, M., D'Abrosca, F., Lippi, L., Ferrario, S., Sheridan, S., Dimabayu-Francisco, M., Soldaro, P., & Nicod, L.. (2024). Effectiveness of a new" focused pulse" high-frequency chest wall oscillation in patients with moderate to severe COPD. *Minerva Medica, 115*(1), 4-13. https://doi.org/10.23736/S0026-4806.23.08874-2

Philippe, N., El Kholy, D. O. A. Â., Lotfy, M., & Sadaka, M. (2025). Relation between smoking as a single cardiovascular risk factor and angiographic data in young patients with acute Coronary Syndrome: A retrospective single-center study. *The Medical Journal of Cairo University, 93*(03), 445-458. https://doi.org/10.21608/mjcu.2025.423605.

Quissesa, A., Juhdeliena, J., & Gultom, E. C. V. (2021). High-frequency chest wall oscillation: Airway clearance management for obstructive pulmonary disease patients. *Nursing Current: Jurnal Keperawatan, 9*(2), 116-127. https://doi.org/10.19166/nc.v9i2.4916.

Rai, N., & Sharma, S. (2026). Exploring the impact of physiotherapy in reducing the incidences of ventilator-associated pneumonia: A narrative review. *Indian Journal of Physiotherapy and Rehabilitation Science, 4*(2), 1–9. https://www.ijptrs.com/view-issue-pdf/397

Reda, N., Seery, Z., Meligy, B., & Abd Elgaffar, H. (2024). Effect of cough assist device on hemodynamic status and oxygen saturation for ventilated children. *The Egyptian Journal of Hospital Medicine, 95*, 1853-1856. https://doi.org/10.21608/ejhm.2024.354956.

Saad, E., Maamoun, B., & Nimer, A. (2023). Increased red blood cell distribution predicts severity of chronic obstructive pulmonary disease exacerbation. *Journal of Personalized Medicine, 13*(5), 843. https://doi.org/10.3390/jpm13050843.

Samir, N., Mohamed, M., Emara, M., & Othman, W. (2024). Effect of high-frequency chest wall oscillation vest device versus chest physiotherapy on chronic obstructive pulmonary disease patients outcome. *Mansoura Nursing Journal, 11*(2), 215-224. https://doi.org/10.21608/mnj.2024.250645.1362.

Singh, M. P., Kumar, R., Sharma, G., & Singh, A. (2023). Assessment of spectrum of clinical profile in COPD patients. *International Journal of Life Sciences, Biotechnology and Pharma Research, 12*(4), 641–644. https://ijlbpr.com/uploadfiles/121vol12issue4pp641-644.20231117072259.pdf

Tahir, K., Qaisrani, A., Ahmed, H. I., & Baloch, M. (2026). Active cycle of breathing technique versus high-frequency chest wall oscillation in pulmonary function in adult chronic obstructive pulmonary disease patients: A randomized clinical trial. *Journal of Health and Rehabilitation Research, 6*(1), 1-11. https://doi.org/10.61919/jhrr.v6i1.1936.

Wang, Q., Tang, H., & Zhang, M. (2025). The clinical nursing effect of empowerment-based continuing nursing combined with pulmonary rehabilitation for chronic obstructive pulmonary disease. *BMC Pulmonary Medicine, 25*, 315. https://doi.org/10.1186/s12890-025-03683-0

Wang, Y., & Leng, H. (2026). Efficacy of levosalbutamol for lung cancer patients receiving postoperative sputum expectoration by high-frequency chest wall oscillation. *Pakistan Journal of Pharmaceutical Sciences, 39(*2), 481–486. https://doi.org/10.36721/PJPS.2026.39.2.REG.15176.1

Weber, C. K., Miglioranza, M. H., de Moraes, M. A., Sant'anna, R. T., Rover, M. M., Kalil, R. A., & Leiria, T. L. L. (2014). The five-point Likert scale for dyspnoea can properly assess the degree of pulmonary congestion and predict adverse events in heart failure outpatients. *Clinics, 69,* 341-346. https://doi.org/10.6061/clinics/2014(05)08.