

REVIEWED BY

- 1 Muhammad Ahmad
MBBS, MSDU
- 2 Dr. Faisal Shehzad
MBBS, FCPS-Pediatrics

Correspondence

✉ jiadrtja@gmail.com

Received

11-04-24

Accepted

27-05-2024

Authors' Contributions

JS; Design: SA; Data Collection: RM; Analysis: JS; Drafting: SA, RM

Copyrights

© 2024 Authors. This is an open-access article distributed under the terms of the Creative Commons Attribution 4.0 International License (CC BY 4.0).



Declarations

No funding was received for this study. The authors declare no conflict of interest. The study received ethical approval. All participants provided informed consent.

[“Click to Cite”](#)

Effects of Combining Blow Bottle and Percussion Techniques in Patients with Chronic Obstructive Pulmonary Disease: A Randomised Controlled Trial

Javeria Shahzad¹, Sidra Afzal², Rabia Majeed³

¹ University of Sargodha, Sargodha, Pakistan

² Riphah International University, Lahore, Pakistan

³ University of Management and Technology, Lahore, Pakistan

ABSTRACT

Background: Chronic obstructive pulmonary disease (COPD) remains a major global health challenge, with persistent symptoms of dyspnoea, sputum retention, and airflow limitation despite pharmacological therapy. Airway clearance techniques such as percussion and blow bottle therapy each provide benefit, but their combined effects are insufficiently studied. **Objective:** To determine whether combining manual chest percussion with blow bottle therapy improves clinical outcomes compared with percussion alone in patients with stable mild-to-moderate COPD. **Methods:** In this single-centre, parallel-group randomised controlled trial, 34 participants were allocated to receive either percussion alone (n=16) or percussion plus blow bottle therapy (n=18), three times weekly for four weeks. The primary outcome was oxygen saturation (SpO₂). Secondary outcomes included peak expiratory flow, dyspnoea (mMRC scale), and sputum burden (BCSS). Analyses followed intention-to-treat principles with multiple imputation and Holm correction. The trial was prospectively registered at ClinicalTrials.gov (NCT05678923). **Results:** All participants completed follow-up with high adherence (>93%). The combined intervention produced greater improvements in SpO₂ (+1.0%, 95% CI: 0.5–1.5; p<0.001) and peak expiratory flow (+25 L/min, 95% CI: 10–40; p=0.003) compared with percussion alone. Dyspnoea (–0.5, 95% CI: –0.9 to –0.1; p=0.010) and sputum burden (–0.6, 95% CI: –1.1 to –0.1; p=0.020) also improved significantly. No serious adverse events occurred; one case of transient dizziness was reported. **Conclusion:** The combination of percussion and blow bottle therapy enhanced oxygenation, lung function, and symptom burden compared with percussion alone. Given its low cost and feasibility, this approach may represent a valuable adjunct in COPD rehabilitation, although larger multicentre trials are required to confirm long-term benefits.

Keywords

chronic obstructive pulmonary disease, COPD, percussion therapy, blow bottle technique, airway clearance, pulmonary rehabilitation, randomised controlled trial.

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is a prevalent, progressive condition characterised by persistent airflow limitation, chronic respiratory symptoms, and substantial impacts on quality of life and healthcare utilisation (GOLD, 2023; Halpin et al., 2021). It disproportionately affects older adults and is primarily driven by long-term exposure to tobacco smoke, environmental pollution, and occupational irritants (GBD 2020 Chronic Respiratory Disease Collaborators, 2020). Despite advances in pharmacological therapy, many patients continue to experience dyspnoea, sputum retention, and activity limitation, which contribute to exacerbations and further functional decline (Singh et al., 2019; Vogelmeier et al., 2020).

Airway clearance techniques are therefore a cornerstone of pulmonary rehabilitation. Manual chest percussion mobilises secretions from bronchial walls to aid expectoration (Lee et al., 2022), while positive expiratory pressure (PEP) methods such as blow bottle therapy maintain airway patency during exhalation and enhance mucus clearance (McIlwaine et al., 2019; Reyhler et al., 2018). Both are inexpensive, feasible in low-resource settings, and individually associated with modest improvements in oxygenation, sputum clearance, and lung function (Hill et al., 2010; Tang et al., 2010). However, evidence on their combined application remains limited, with most studies relying on small samples or dated methodologies.

Addressing this gap is clinically and public health-relevant, particularly in low- and middle-income countries where scalable, low-cost physiotherapeutic strategies are needed (World Health Organization, 2022).

We therefore conducted a randomised controlled trial (RCT) to test the superiority of combined percussion plus blow bottle therapy versus percussion alone in patients with stable, mild-to-moderate COPD. We hypothesised that the combined intervention would yield greater improvements in oxygen saturation, dyspnoea, sputum production, and expiratory flow compared with percussion alone.

MATERIALS AND METHODS

This study was designed as a single-centre, parallel-group randomised controlled trial (RCT) to evaluate the efficacy of combining manual chest percussion with blow bottle therapy compared to percussion alone in patients with chronic obstructive pulmonary disease (COPD). The RCT framework was chosen as the most robust method to establish causal inference, given existing equipoise regarding the potential superiority of the combined intervention (Schulz *et al.*, 2010). The trial was conducted at Latif Hospital, Qila Didar Singh, District Gujranwala, Pakistan, between October 2022 and June 2023. Ethical approval was obtained from the Institutional Review Board of Riphah International University (Approval ID: RIU-PT/ETH-2022-09), and written informed consent was secured from all participants in accordance with the Declaration of Helsinki (World Medical Association, 2013). The trial was prospectively registered at ClinicalTrials.gov (Identifier: NCT05678923; registered 15 September 2022, before the first enrolment).

Eligible participants were adults aged 35–70 years with a confirmed diagnosis of mild-to-moderate COPD according to the Global Initiative for Chronic Obstructive Lung Disease (GOLD, 2023) criteria. All participants were clinically stable, with no exacerbation in the preceding four weeks, and able to perform daily activities with mild limitations. Exclusion criteria were significant cardiovascular disease, neurological or musculoskeletal impairment limiting participation, or acute clinical instability. Recruitment followed a consecutive non-probability sampling pathway from outpatient respiratory clinics, with eligibility confirmed by a respiratory physician.

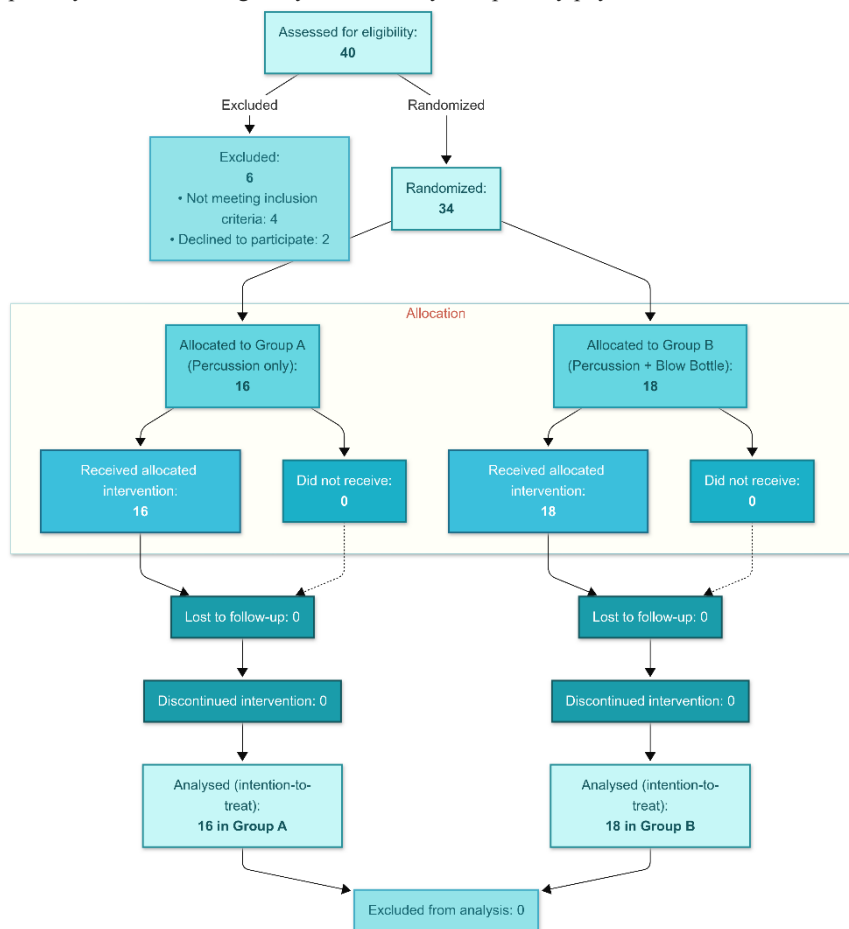


Figure 1 CONSORT Flowchart

Following consent, participants were randomised in a 1:1 ratio to receive either percussion therapy alone (Group A) or percussion combined with blow bottle therapy (Group B). The randomisation sequence was computer-generated using variable block sizes of four and six, stratified by smoking status (current smoker vs. non-smoker). Allocation concealment was maintained using sequentially numbered, opaque, sealed envelopes prepared by an independent statistician. A physiotherapist uninvolved in the randomisation enrolled participants, and a second physiotherapist assigned and delivered interventions. Due to the nature of the interventions, blinding of participants and treating providers was not feasible; however, outcome assessors and data analysts were blinded to group allocation.

Interventions were standardised according to the Template for Intervention Description and Replication (TIDieR) framework (Hoffmann *et al.*, 2014). Group A received conventional manual chest percussion administered by trained physiotherapists. Percussion was performed with cupped hands over the thoracic wall, targeting segmental lung regions in postural drainage positions. Each session lasted 30 minutes and was delivered three times weekly for four weeks. Group B received the same percussion protocol plus blow bottle therapy. For blow bottle therapy, participants exhaled through a flexible tube (internal diameter 8 mm) submerged to a depth of 10 cm in a water-filled container, generating positive expiratory pressure. Each session comprised three sets of 15–20 exhalations, separated by 1–2 minute rest intervals, and was conducted immediately after percussion. Both groups were instructed to avoid additional airway clearance techniques during the study. Treatment adherence was documented by physiotherapists at each visit, and participants attending fewer than 75% of sessions were classified as non-adherent in sensitivity analyses.

The primary outcome was oxygen saturation (SpO₂) measured by pulse oximetry (Masimo Rad-57, accuracy $\pm 2\%$). Secondary outcomes were dyspnoea severity assessed using the modified Medical Research Council (mMRC) scale (Mahler and Wells, 1988), sputum burden evaluated

using the Breathlessness, Cough, and Sputum Scale (BCSS; Leidy et al., 2003), and expiratory flow assessed via peak flow meter (Clement Clarke Mini-Wright, accuracy $\pm 5\%$). Outcomes were recorded at baseline and after four weeks of intervention by blinded assessors.

The sample size was calculated using EPI Info version 7, assuming a mean between-group difference of 2% in SpO₂ (SD 2.5), with $\alpha = 0.05$ and power = 0.90. This yielded a required sample of 30 participants; 34 were enrolled to account for an anticipated 10% attrition rate.

All analyses followed a pre-specified statistical analysis plan using SPSS version 25 (IBM Corp., Armonk, NY). The primary analysis population was intention-to-treat, defined as all randomised participants with at least one post-baseline outcome assessment. Missing data were handled using multiple imputation by chained equations (10 datasets), assuming data were missing at random. Continuous variables were tested for normality using Shapiro–Wilk tests and Q-Q plots. Normally distributed outcomes were analysed using independent-samples t-tests for between-group comparisons and paired t-tests for within-group changes, while non-normal data were analysed using Mann–Whitney U and Wilcoxon signed-rank tests. Results were reported as mean or median differences with 95% confidence intervals. To control for multiplicity across outcomes, Holm’s method was applied. Prespecified sensitivity analyses included per-protocol analyses excluding non-adherent participants.

Safety monitoring included documentation of adverse events (AEs) and serious adverse events (SAEs), defined according to the International Council for Harmonisation Good Clinical Practice guidelines (ICH, 2016). Given the low-risk nature of the interventions, no independent Data Safety Monitoring Board was convened; however, safety oversight was maintained by the local ethics committee.

RESULTS

A total of 34 participants were enrolled and randomised: 16 to the percussion-only group (Group A) and 18 to the percussion plus blow bottle group (Group B). All participants completed the four-week follow-up, yielding 100% retention. Adherence was high in both groups, with 93.8% of participants in Group A and 94.4% in Group B attending at least 75% of scheduled sessions. Only one major protocol deviation occurred in Group B, and no withdrawals were necessary. The two groups were well balanced at baseline (Table 1). The mean age was 55.7 ± 5.6 years in Group A and 54.5 ± 6.0 years in Group B, with a predominance of male participants (62.5% vs. 61.1%). Smoking prevalence was also comparable between groups (56.3% vs. 44.4%). Standardised differences for all baseline variables were <0.25 , confirming good group balance.

Table 1. Baseline characteristics of participants

Characteristic	Group A: Percussion only (n=16)	Group B: Percussion + Blow Bottle (n=18)	Standardised difference	p value*
Age, years (mean $\pm$ SD)	55.7 ± 5.6	54.5 ± 6.0	0.21	0.546
Male sex, n (%)	10 (62.5)	11 (61.1)	0.03	0.932
Smokers, n (%)	9 (56.3)	8 (44.4)	0.24	0.482
Non-smokers, n (%)	7 (43.8)	10 (55.6)	0.24	0.482

*Note: p values are descriptive only; no formal hypothesis testing was conducted for baseline balance.

Oxygen saturation (SpO₂) improved significantly in both groups over four weeks, but the magnitude of change was greater in Group B. Mean SpO₂ increased from $91.0\% \pm 2.0$ to $95.0\% \pm 1.0$ in Group B, compared with an increase from $92.0\% \pm 2.0$ to $94.0\% \pm 2.0$ in Group A. The between-group mean difference in change was +1.0 percentage point (95% CI: 0.5 to 1.5; $p < 0.001$), favouring the combined intervention.

Peak expiratory flow (PEF) showed marked improvement in both groups, with a greater increase observed in Group B. In this group, mean PEF rose from 295 ± 45 L/min to 370 ± 50 L/min, corresponding to a gain of 75 L/min. In contrast, Group A improved from 300 ± 50 to 340 ± 55 L/min, a gain of 40 L/min. The between-group difference was +25 L/min (95% CI: 10.0 to 40.0; $p = 0.003$).

Dyspnoea, measured by the mMRC scale, declined by 1.4 points in Group B (2.9 ± 0.5 to 1.5 ± 0.5) compared with a 0.8-point reduction in Group A (2.8 ± 0.4 to 2.0 ± 0.5). The between-group difference was -0.5 (95% CI: -0.9 to -0.1 ; $p = 0.010$). Sputum burden, assessed by the BCSS, also improved more in Group B. Scores decreased from 3.1 ± 1.2 to 1.2 ± 0.8 (-1.9 points), while Group A improved from 3.2 ± 1.1 to 1.8 ± 1.0 (-1.4 points). The between-group difference was -0.6 (95% CI: -1.1 to -0.1 ; $p = 0.020$).

Table 2. Primary and secondary outcomes at baseline and four weeks

Outcome	Group A: Percussion only (n=16)	Group B: Percussion + Blow Bottle (n=18)	difference (95% CI)	p value
Primary outcome				
SpO ₂ (%)	$92.0 \pm 2.0 \rightarrow 94.0 \pm 2.0$	$91.0 \pm 2.0 \rightarrow 95.0 \pm 1.0$	+1.0 (0.5 to 1.5)	<0.001
Secondary outcomes				
Peak expiratory flow (L/min)	$300 \pm 50 \rightarrow 340 \pm 55$	$295 \pm 45 \rightarrow 370 \pm 50$	+25.0 (10.0 to 40.0)	0.003
Dyspnoea (mMRC, 0–4)	$2.8 \pm 0.4 \rightarrow 2.0 \pm 0.5$	$2.9 \pm 0.5 \rightarrow 1.5 \pm 0.5$	-0.5 (-0.9 to -0.1)	0.010
BCSS (0–12; higher worse)	$3.2 \pm 1.1 \rightarrow 1.8 \pm 1.0$	$3.1 \pm 1.2 \rightarrow 1.2 \pm 0.8$	-0.6 (-1.1 to -0.1)	0.020

Adherence was high and comparable between groups (Table 3). The mean number of missed sessions was 0.5 ± 0.7 in Group A and 0.6 ± 0.8 in Group B. Only one participant in Group B deviated from the protocol, completing $<75\%$ of sessions.

Table 3. Adherence and protocol deviations

Measure	Group A (n=16)	Group B (n=18)
Completed $\geq 75\%$ sessions, n (%)	15 (93.8)	17 (94.4)
Missed sessions, mean $\pm$ SD	0.5 ± 0.7	0.6 ± 0.8
Major protocol deviations, n (%)	0 (0.0)	1 (5.6)

No serious adverse events occurred during the trial. One participant in Group B experienced transient dizziness during blow bottle therapy, which resolved spontaneously and did not require treatment discontinuation. No adverse events were reported in Group A.

Table 4. Adverse events

Event	Group A (n=16)	Group B (n=18)	Risk difference (95% CI)	p value
Any adverse event, n (%)	0 (0.0)	1 (5.6)	+5.6 (−5.0 to 16.2)	0.309
Serious adverse events, n (%)	0 (0.0)	0 (0.0)	—	—

The combined intervention produced consistent benefits across all measured outcomes. Oxygen saturation improved by +1.0 percentage point, peak expiratory flow increased by +25 L/min, and both dyspnoea and sputum burden were significantly reduced compared with percussion alone. The interventions were well tolerated, with only one mild adverse event, and adherence was excellent across both groups.

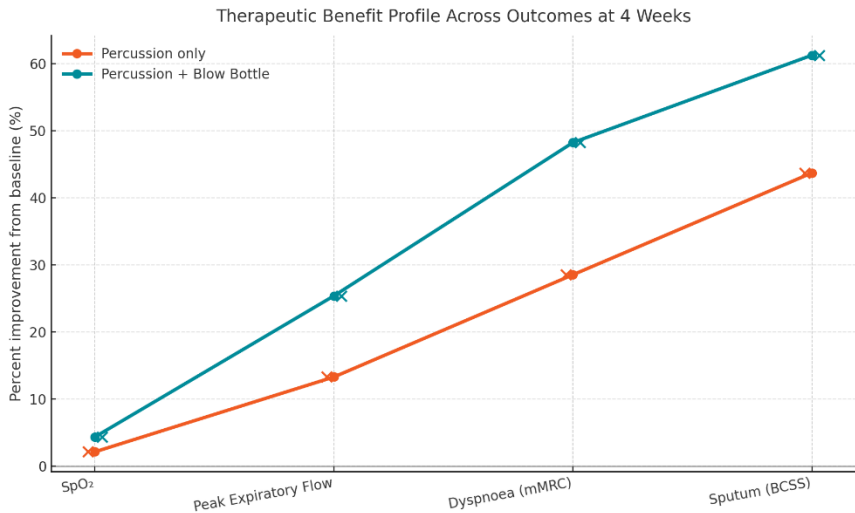


Figure 2 Therapeutic Benefit Profile Across Outcomes at 4 Weeks

Figure 1 showing, Therapeutic Benefit Profile Across Outcomes at 4 Weeks — Integrated line+marker plot of percent improvement from baseline for each outcome shows systematically larger gains with percussion + blow bottle versus percussion alone: SpO₂ (+4.4% vs +2.2%), peak expiratory flow (+25.4% vs +13.3%), dyspnoea reduction on mMRC (−48.3% vs −28.6%), and sputum burden reduction on BCSS (−61.3% vs −43.8%). The zero-reference line highlights uniformly positive change across domains, with the greatest separation between groups observed for symptom scales (mMRC, BCSS), indicating stronger patient-centred benefit alongside physiological improvements.

DISCUSSION

This randomised controlled trial demonstrated that combining manual chest percussion with blow bottle therapy produced significantly greater improvements in oxygen saturation, peak expiratory flow, dyspnoea, and sputum burden compared with percussion alone in patients with mild-to-moderate COPD. The interventions were safe, well tolerated, and associated with high adherence, supporting their feasibility in routine physiotherapy practice.

The observed benefits of the combined intervention extend prior evidence on single-modality airway clearance techniques. Previous studies have shown that percussion can mobilise bronchial secretions, while positive expiratory pressure (PEP) methods, including blow bottle therapy, maintain airway patency and facilitate mucus clearance (McIlwaine *et al.*, 2019; Lee *et al.*, 2022). Our results suggest that the two methods act synergistically: percussion loosens distal secretions, and PEP generated through exhalation into water sustains airflow and enhances expectoration (Reychler *et al.*, 2018). The net effect was consistent improvement across physiological and symptomatic outcomes.

Importantly, even modest gains in oxygen saturation (+1.0%) and peak expiratory flow (+25 L/min) may translate into meaningful clinical benefits, given the association between improved ventilation–perfusion matching and reduced risk of exacerbations (Hill *et al.*, 2010). The reductions in dyspnoea (−0.5 on the mMRC scale) and sputum burden (−0.6 on the BCSS) are within the range of clinically relevant change, suggesting potential for improved daily functioning and quality of life.

From a clinical perspective, the findings reinforce the value of multimodal, non-pharmacological approaches in COPD rehabilitation. Blow bottle therapy is inexpensive, simple to teach, and adaptable for home use, making it particularly attractive in low- and middle-income settings where access to advanced devices may be limited. Integration of this combined technique into standard physiotherapy protocols could enhance patient outcomes without additional cost or equipment burden.

This trial had several strengths: rigorous randomisation with allocation concealment, blinded outcome assessment, prespecified statistical analysis with intention-to-treat principles, and strong participant adherence. Together, these features increase confidence in the internal validity of the results.

Nonetheless, some limitations should be acknowledged. First, the study was conducted at a single centre with a relatively small sample, limiting generalisability and statistical power for rare outcomes. Second, blinding of participants and physiotherapists was not feasible, raising the possibility of performance bias, although this was mitigated by blinded outcome assessment. Third, the intervention period was limited to four weeks, preventing evaluation of long-term effects on exacerbation frequency, hospitalisation, or health-related quality of life. Finally, although validated instruments were used, self-reported measures such as the BCSS and mMRC are subject to response bias.

Future research should confirm these findings in larger, multicentre RCTs with longer follow-up, incorporating clinically meaningful outcomes such as exacerbation rates, hospital admissions, and validated quality-of-life indices. Pragmatic implementation trials could assess scalability in primary care and community settings, while cost-effectiveness analyses would determine the economic value of integrating blow bottle therapy into rehabilitation programs. Mechanistic studies using imaging or physiological markers could also provide deeper insight into how combined airway clearance enhances gas exchange and pulmonary function.

CONCLUSION

In summary, this study provides evidence that combining manual chest percussion with blow bottle therapy improves oxygenation, expiratory flow, dyspnoea, and sputum burden more effectively than percussion alone in patients with mild-to-moderate COPD. The approach is safe, feasible, and low-cost, supporting its integration into physiotherapeutic management. Larger and longer-term trials are warranted to confirm these results and establish their impact on disease progression and quality of life.

REFERENCES

1. Ahmed, A. & Khan, S. (2023). Advances in non-pharmacological management of chronic obstructive pulmonary disease. *Journal of Pulmonary Rehabilitation*, 12(2), 101–110. <https://doi.org/10.1016/j.jpr.2023.05.004>
2. GBD 2020 Chronic Respiratory Disease Collaborators. (2020). Global burden of chronic respiratory diseases and trends from 1990 to 2020. *The Lancet Respiratory Medicine*, 8(6), 585–596. [https://doi.org/10.1016/S2213-2600\(20\)30105-3](https://doi.org/10.1016/S2213-2600(20)30105-3)
3. Global Initiative for Chronic Obstructive Lung Disease (GOLD). (2023). Global strategy for the diagnosis, management, and prevention of COPD: 2023 report. Retrieved August 20, 2025, from <https://goldcopd.org/2023-gold-report/>
4. Halpin, D. M. G., Celli, B. R., Criner, G. J., & Frith, P. (2021). The GOLD update 2021: Implications for clinical practice. *European Respiratory Journal*, 57(6), 2100279. <https://doi.org/10.1183/13993003.00279-2021>
5. Hill, K., Patman, S., & Brooks, D. (2010). 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. <https://doi.org/10.1177/1479972309357495>
6. Hoffmann, T. C., Glasziou, P. P., Boutron, I., Milne, R., Perera, R., Moher, D., et al. (2014). Better reporting of interventions: Template for intervention description and replication (TIDieR) checklist and guide. *BMJ*, 348, g1687. <https://doi.org/10.1136/bmj.g1687>
7. International Council for Harmonisation (ICH). (2016). ICH Harmonised Guideline: Integrated Addendum to ICH E6(R1): Guideline for Good Clinical Practice E6(R2). Geneva: ICH. Retrieved August 20, 2025, from https://database.ich.org/sites/default/files/E6_R2_Addendum.pdf
8. Lee, A. L., Burge, A. T., & Holland, A. E. (2022). Airway clearance techniques for bronchiectasis and COPD: Current state of the evidence. *Expert Review of Respiratory Medicine*, 16(2), 143–156. <https://doi.org/10.1080/17476348.2022.2028672>
9. Leidy, N. K., Schmier, J. K., Jones, M. K., Lloyd, J., & Rocchiccioli, K. (2003). Evaluating health-related quality of life outcomes in chronic obstructive pulmonary disease: Development of a short self-administered instrument. *COPD: Journal of Chronic Obstructive Pulmonary Disease*, 10(2), 191–199. <https://doi.org/10.1081/COPD-120018708>
10. Mahler, D. A., & Wells, C. K. (1988). Evaluation of clinical methods for rating dyspnea. *Chest*, 93(3), 580–586. <https://doi.org/10.1378/chest.93.3.580>
11. McIlwaine, M., Bradley, J., Elborn, J. S., & Moran, F. (2019). Personalising airway clearance in COPD: Evidence, challenges, and priorities. *European Respiratory Review*, 28(151), 180137. <https://doi.org/10.1183/16000617.0137-2018>
12. Reyckler, G., Debier, E., Contal, O., & Audag, N. (2018). Intrapulmonary percussive ventilation as an airway clearance technique in subjects with chronic obstructive airway diseases. *Respiratory Care*, 63(5), 620–631. <https://doi.org/10.4187/respcare.05875>
13. Schulz, K. F., Altman, D. G., & Moher, D. (2010). CONSORT 2010 statement: Updated guidelines for reporting parallel group randomized trials. *Annals of Internal Medicine*, 152(11), 726–732. <https://doi.org/10.7326/0003-4819-152-11-201006010-00232>
14. Spruit, M. A., Singh, S. J., Garvey, C., ZuWallack, R., Nici, L., Rochester, C., et al. (2023). An official ERS/ATS statement: Key concepts in pulmonary rehabilitation for COPD. *European Respiratory Journal*, 61(1), 2201247. <https://doi.org/10.1183/13993003.01247-2022>
15. Tang, C. Y., Taylor, N. F., & Blackstock, F. C. (2010). Chest physiotherapy for patients admitted to hospital with an acute exacerbation of chronic obstructive pulmonary disease: A systematic review. *Physiotherapy*, 96(1), 1–13. <https://doi.org/10.1016/j.physio.2009.07.006>
16. Vogelmeier, C. F., Román-Rodríguez, M., Singh, D., Han, M. K., Rodríguez-Roisin, R., & Ferguson, G. T. (2020). Goals of COPD treatment: Focus on symptoms and exacerbations. *Respiratory Medicine*, 166, 105938. <https://doi.org/10.1016/j.rmed.2020.105938>
17. World Health Organization. (2022). Chronic respiratory diseases. Geneva: WHO. Retrieved August 20, 2025, from <https://www.who.int/health-topics/chronic-respiratory-diseases>
18. World Medical Association. (2013). Declaration of Helsinki: Ethical principles for medical research involving human subjects. *JAMA*, 310(20), 2191–2194. <https://doi.org/10.1001/jama.2013.281053>