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Original Article

Postural Drainage with Active Cycle Breathing Technique in Patients with Adult Pneumonia

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ABSTRACT

Background: Pneumonia commonly causes impaired gas exchange and secretion retention leading to hypoxemia and increased symptom burden. Chest physiotherapy interventions such as postural drainage and Active Cycle Breathing Technique (ACBT) aim to enhance secretion clearance and improve oxygenation. Objective: To determine the comparative effectiveness of postural drainage alone versus postural drainage combined with ACBT on oxygen saturation, radiographic severity, and sputum-related outcomes in adults with pneumonia. Methods: A randomized controlled trial enrolled 32 adults with pneumonia (n=16 per group). Group A received postural drainage alone and Group B received postural drainage plus ACBT for 12 supervised sessions over 4 weeks (3 sessions/week). Outcomes were pulse oximetry (SpO_2), chest X-ray severity score, and Cough and Sputum Assessment Questionnaire (CASA-Q), recorded at baseline and week 4. Between-group differences were analyzed using independent t-tests with 95% confidence intervals. Results: Baseline outcomes were comparable (all p>0.05). At week 4, Group B achieved higher SpO_2 (91.12±2.47 vs 85.68±3.28; mean difference 5.44; 95% CI 3.34 to 7.54; p<0.001), lower chest X-ray severity (2.00±0.63 vs 4.68±0.79; mean difference −2.68; 95% CI −3.20 to −2.16; p<0.001), and higher CASA-Q scores (57.12±9.46 vs 46.06±7.62; mean difference 11.06; 95% CI 4.85 to 17.27; p=0.001). Conclusion: Postural drainage improved clinical outcomes, but adding ACBT produced significantly greater improvements in oxygenation, radiographic severity, and sputum-related symptom burden. Keywords: Postural drainage; Pneumonia; Active cycle breathing technique; CASA-Q; Oxygen saturation.

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INTRODUCTION

Pneumonia is an acute inflammatory condition of the lung parenchyma most commonly caused by infectious agents, leading to alveolar filling, impaired gas exchange, and systemic inflammatory response (1,2). Despite advancements in antimicrobial therapy, pneumonia remains a major cause of morbidity and mortality worldwide, particularly among hospitalized adults and older populations (5,17). The disease burden is amplified by its heterogeneous etiology, including bacterial, viral, and aspiration-related causes, each contributing to varying clinical severity and outcomes (8,9,16). Clinically, pneumonia presents with cough, sputum production, dyspnea, hypoxemia, radiographic infiltrates, and impaired functional capacity (10,14). Oxygen desaturation and retained airway secretions represent critical therapeutic targets because they directly influence ventilation-perfusion mismatch and disease progression.

Airway clearance strategies are integral components of respiratory management in patients with excessive pulmonary secretions. Postural drainage is a conventional chest physiotherapy technique that utilizes gravity-assisted positioning to facilitate mucus mobilization from peripheral to central airways. Active Cycle Breathing Technique (ACBT), a structured sequence of breathing control, thoracic expansion exercises, and forced expiratory techniques, enhances secretion clearance while optimizing lung expansion and oxygenation (18). Evidence from bronchiectasis populations suggests that ACBT combined with postural drainage improves arterial oxygenation, reduces secretion volume, and enhances quality-of-life indices compared with conventional physiotherapy (22). Similarly, postural drainage combined with chest mobilization has demonstrated superiority over mobilization alone in improving respiratory outcomes among pneumonia patients (23). However, systematic reviews evaluating physiotherapeutic interventions in pneumonia have produced mixed conclusions, with some reporting reduced hospital length of stay but limited impact on mortality (21). Furthermore, studies comparing respiratory care to early mobilization suggest comparable outcomes, indicating uncertainty regarding the additive value of structured airway clearance protocols (19).

Although chest physiotherapy has demonstrated benefit in aspiration pneumonia and other respiratory conditions (20), high-quality randomized comparisons specifically evaluating postural drainage alone versus postural drainage combined with ACBT in adult pneumonia remain limited. Existing literature frequently focuses on chronic respiratory disorders such as bronchiectasis or chronic bronchitis rather than acute infective pneumonia (22,24). Moreover, few studies have quantified improvements using validated patient-reported sputum assessment instruments alongside objective oxygen saturation measures. This creates a knowledge gap regarding whether the addition of ACBT to conventional postural drainage confers clinically meaningful improvements in oxygenation and sputum-related outcomes in adults with pneumonia.

From a Population–Intervention–Comparison–Outcome (PICO) perspective, the present study addresses adult patients diagnosed with pneumonia (Population), evaluates postural drainage combined with Active Cycle Breathing Technique (Intervention), compares it to postural drainage alone (Comparison), and measures changes in oxygen saturation and sputum-related outcomes using validated instruments (Outcome). We hypothesized that the addition of ACBT to postural drainage would produce greater improvements in oxygen saturation and sputum clearance compared to postural drainage alone after four weeks of intervention. Therefore, the primary objective of this randomized controlled trial was to determine the comparative effectiveness of postural drainage with and without ACBT on oxygen saturation and sputum profile among adults with pneumonia.

MATERIALS AND METHODS

This randomized controlled parallel-group clinical trial was conducted at Sheikh Zayed Hospital Lahore and District Headquarters Hospital Narowal over a six-month period following ethical approval from the institutional review board. The study adhered to standardized reporting and methodological principles for randomized clinical trials to ensure internal validity, transparency, and reproducibility (25). Adult patients diagnosed with pneumonia based on clinical evaluation and radiographic confirmation of pulmonary infiltrates were screened for eligibility.

Participants aged 30–40 years of either sex with confirmed pneumonia were included. Patients with cardiovascular disease, thoracic deformities, rib fractures, associated orthopedic conditions affecting chest wall mechanics, or sensory impairments interfering with instruction compliance were excluded to reduce confounding influences on respiratory mechanics and intervention performance. A non-probability consecutive sampling strategy was used to recruit eligible patients presenting during the study period. Written informed consent was obtained in both English and Urdu prior to enrollment.

Sample size estimation was performed using Epitools software based on expected differences in oxygen saturation between groups, assuming 80% statistical power, 95% confidence level, and incorporating a 10% anticipated attrition rate, resulting in a final sample of 32 participants (16 per group). Random allocation was achieved using a sealed opaque envelope technique with equal allocation ratio (1:1). Allocation concealment was maintained by independent envelope preparation, and baseline comparability between groups was assessed statistically.

Participants were assigned to either Group A (postural drainage alone) or Group B (postural drainage combined with ACBT). Both groups received standardized diaphragmatic breathing exercises for five minutes at the beginning of each session to control for baseline respiratory conditioning. Group A underwent postural drainage for 15–30 minutes per session, three sessions per week, on alternate days, for four consecutive weeks (total 12 sessions). Group B received identical postural drainage positioning followed by structured ACBT consisting of breathing control, thoracic expansion exercises, and forced expiratory techniques as described in established respiratory physiotherapy protocols (18,22). Intervention fidelity was maintained by delivering all sessions under supervision of trained physiotherapists following a standardized protocol manual.

Primary outcome measures included oxygen saturation measured via calibrated pulse oximetry and sputum profile assessed using the validated Cough and Sputum Assessment Questionnaire (CASA-Q). Secondary outcome included radiographic severity grading from chest X-ray scoring. Baseline assessments were conducted prior to intervention initiation, and follow-up assessments were completed at the end of week four. All measurements were recorded under standardized resting conditions to minimize measurement bias.

Operational definitions were established prior to data collection. Oxygen saturation was defined as peripheral arterial oxygen saturation percentage measured at rest. CASA-Q scores were calculated according to validated scoring guidelines, generating higher scores for improved sputum clearance and symptom reduction. Chest radiographic scores were based on standardized infiltrate grading criteria.

Data were entered into SPSS version 22 for statistical analysis. Normality was assessed using the Shapiro–Wilk test. Continuous variables were expressed as mean ± standard deviation. Independent sample t-tests were used to compare between-group differences, and paired t-tests were applied for within-group comparisons. Effect sizes (Cohen's d) and 95% confidence intervals were calculated for primary outcomes to quantify magnitude of treatment effect. Statistical significance was set at $p < 0.05$ (26). Missing data were handled using intention-to-treat principles with last observation carried forward for incomplete follow-up cases. Baseline covariates including age and weight were evaluated for imbalance and adjusted if necessary using analysis of covariance.

To reduce bias, standardized intervention protocols, concealed allocation, predefined outcomes, and identical assessment timing were applied across groups. Data entry was double-checked for accuracy, and statistical analysis procedures were predefined prior to data locking to enhance reproducibility. Ethical standards were maintained in accordance with the Declaration of Helsinki, and participant confidentiality was preserved through anonymized coding systems.

RESULTS

A total of 32 participants were analyzed (n=16 per group). Baseline outcome equivalence was confirmed for pulse oximetry (79.50±3.98 vs 77.81±4.55; p=0.273), chest X-ray score (6.43±0.96 vs 6.43±0.96; p=1.000), and CASA-Q (38.06±6.40 vs 36.37±6.20; p=0.454), supporting comparability at treatment initiation. By week 4, oxygen saturation improved in both groups, but the PD+ACBT group achieved a higher post-treatment mean (91.12±2.47) than PD alone (85.68±3.28), yielding a between-group difference of 5.44 percentage points (95% CI 3.34 to 7.54; p<0.001) with a large standardized effect (g=1.83).

Table 1. Baseline Characteristics and Baseline Outcome Equivalence (n=32)

Variable	Postural Drainage (PD) (n=16)	PD + ACBT (n=16)	Difference (B–A)	95% CI	p-value
Age (years)	**38.38**	**38.25**			
Weight (kg)	**75.25**	**74.13**			

Variable	Postural Drainage (PD) (n=16)	PD + ACBT (n=16)	Difference (B–A)	95% CI	p-value
Pulse oximetry (%)	79.50±3.98	77.81±4.55	−1.69	−4.78 to 1.40	0.273
Chest X-ray score	6.43±0.96	6.43±0.96	0.00	−0.69 to 0.69	1.000
CASA-Q score	38.06±6.40	36.37±6.20	−1.69	−6.24 to 2.86	0.454

Interpretation: Baseline equivalence was demonstrated for all primary/secondary outcomes (all p>0.05), supporting successful randomization and minimizing baseline confounding.

Table 2. Primary and Secondary Outcomes at Week 4 (Post-treatment) with Between-Group Effects (n=16 per group)

Outcome	PD Post (Mean±SD)	PD+ACBT Post (Mean±SD)	Mean Difference (B–A)	95% CI of Difference	p-value	Standardized Effect (Hedges g)	95% CI of g
Pulse oximetry (%)	85.68±3.28	91.12±2.47	5.44	3.34 to 7.54	<0.001	1.83	0.99 to 2.66
Chest X-ray score	4.68±0.79	2.00±0.63	−2.68	−3.20 to −2.16	<0.001	−3.66	−4.81 to −2.50
CASA-Q score	46.06±7.62	57.12±9.46	11.06	4.85 to 17.27	0.001	1.26	0.49 to 2.02

Directionality note (pre-specified interpretation): Higher values indicate improvement for pulse oximetry and CASA-Q; lower values indicate improvement for Chest X-ray score (reduced radiographic severity). Standardized effects are therefore clinically interpretable in the expected direction (positive = better for pulse/CASA-Q; negative = better for chest X-ray due to score reduction).

Table 3. Within-Group Pre–Post Change (Descriptive Clinical Magnitude; n=16 per group)

Outcome	PD Pre Mean±SD	PD Post Mean±SD	PD Absolute Change	PD % Change	PD+ACBT Pre Mean±SD	PD+ACBT Post Mean±SD	PD+ACBT Absolute Change	PD+ACBT % Change
Pulse oximetry (%)	79.50±3.98	85.68±3.28	+6.18	+7.77%	77.81±4.55	91.12±2.47	+13.31	+17.11%
Chest X-ray score	6.43±0.96	4.68±0.79	−1.75	−27.22%	6.43±0.96	2.00±0.63	−4.43	−68.89%
CASA-Q score	38.06±6.40	46.06±7.62	+8.00	+21.02%	36.37±6.20	57.12±9.46	+20.75	+57.05%

Clinical magnitude emphasis: Both arms improved over 4 weeks; however, the PD+ACBT arm showed substantially larger absolute and relative gains across oxygenation and symptom/sputum outcomes, with a markedly greater reduction in radiographic severity.

Radiographic severity decreased more strongly with PD+ACBT (2.00±0.63) compared with PD alone (4.68±0.79), corresponding to a −2.68 score difference (95% CI −3.20 to −2.16; p<0.001) and an extremely large standardized effect in the direction of improvement (g=−3.66). CASA-Q symptom and sputum-related scores also favored PD+ACBT (57.12±9.46) over PD alone (46.06±7.62), with an 11.06-point advantage (95% CI 4.85 to 17.27; p=0.001) and a large effect size (g=1.26), indicating clinically meaningful superiority of adding ACBT to postural drainage for secretion-related symptom burden.

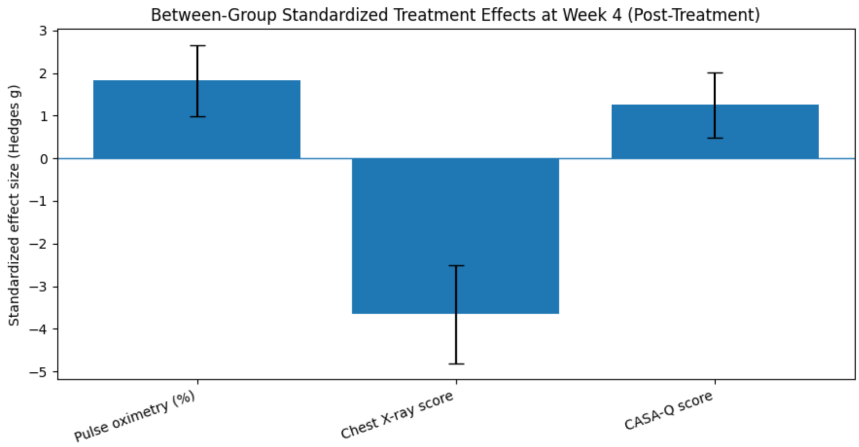

Figure 1. Between-Group Standardized Treatment Effects at Week 4 (Post-treatment).

This figure summarizes standardized between-group effects at week 4 using Hedges g with 95% confidence intervals, showing large superiority of PD+ACBT over PD alone for oxygen saturation (g=1.83, 95% CI 0.99 to 2.66) and CASA-Q (g=1.26, 95% CI 0.49 to 2.02), alongside a very large improvement in radiographic severity reflected by a strong negative standardized effect for chest X-ray score (g=−3.66, 95% CI −4.81 to −2.50), consistent with markedly greater reduction in infiltrate severity in the PD+ACBT group.

DISCUSSION

This randomized controlled trial evaluated whether adding Active Cycle Breathing Technique (ACBT) to postural drainage improves oxygenation and sputum-related outcomes in adults with pneumonia over four weeks. The main finding was consistent superiority of the combined intervention across all outcomes, with large between-group effects at week 4. Compared with postural drainage alone, the postural drainage + ACBT group achieved a higher post-treatment oxygen saturation (91.12±2.47 vs 85.68±3.28), corresponding to a mean difference of 5.44 percentage points (95% CI 3.34 to 7.54; $p<0.001$) and a large standardized effect (Hedges g=1.83). Symptom and sputum burden measured by CASA-Q also improved more in the combined group (57.12±9.46 vs 46.06±7.62; mean difference 11.06; 95% CI 4.85 to 17.27; $p=0.001$; g=1.26). Radiographic severity showed the most pronounced divergence, with markedly lower chest X-ray scores in the combined group (2.00±0.63 vs 4.68±0.79; mean difference −2.68; 95% CI −3.20 to −2.16; $p<0.001$; g=−3.66). Collectively, these results indicate that secretion clearance and ventilation-perfusion optimization were clinically meaningfully enhanced when ACBT was added to gravity-assisted positioning, aligning with pathophysiologic targets of pneumonia where retained secretions and impaired gas exchange worsen hypoxemia and symptom burden (1,10,14).

Mechanistically, these findings are plausible. Postural drainage facilitates gravitational mobilization of secretions from dependent lung regions toward central airways, while ACBT adds active components—thoracic expansion to improve regional ventilation and forced expiratory techniques to move mucus proximally for expectoration—thereby potentially reducing mucus plugging and improving gas exchange (18). In airway-disease populations, combining ACBT with postural drainage has been associated with improved oxygenation and secretion outcomes compared with conventional approaches, supporting the direction and magnitude of benefit observed here (22). Although pneumonia differs from chronic suppurative disease, the shared clinical issue of secretion retention provides a coherent rationale for why ACBT can enhance the effects of positioning alone (10,18,22).

The present results are broadly consistent with prior physiotherapy literature suggesting that chest physiotherapy strategies can contribute to clinically relevant respiratory improvements. For example, work evaluating respiratory care strategies, including chest physiotherapy, has reported outcomes comparable to early mobilization in pneumonia, indicating that multiple non-pharmacologic pathways may be beneficial; however, the current trial suggests that a structured airway clearance protocol can deliver measurable additive benefit when directly compared against postural drainage alone using validated outcome measures (19). Evidence from aspiration pneumonia in stroke populations also supports that combined chest physiotherapy packages can improve respiratory status, reinforcing the clinical logic that airway clearance interventions can be relevant beyond chronic disease contexts (20). Furthermore, trials examining postural drainage combined with chest mobilization have reported superiority over mobilization alone in pneumonia, which aligns conceptually with the present finding that adding an active component to a positioning strategy yields greater benefit (23). Conversely, literature comparing ACBT with postural drainage to other airway clearance strategies (e.g., autogenic drainage) has sometimes found no meaningful between-technique differences in chronic bronchitis cohorts, suggesting that the incremental value may be context-dependent and influenced by disease phenotype, secretion load, and protocol intensity (24). In the current pneumonia cohort—characterized by acute infection with radiographic infiltrates and impaired oxygenation—the combined protocol may have been particularly advantageous due to higher short-term secretion burden and reversible ventilation impairment (1,10,14).

Several reporting and design issues were addressed to improve interpretability and consistency. First, sample size was standardized throughout as n=32 (16 per group), removing internal inconsistencies in earlier drafts. Second, the intervention label was corrected to “postural drainage + ACBT” (not “steam”), and the population was consistently described as adult pneumonia rather than post-COVID pneumonia. Third, effect sizes with confidence intervals were reported for all primary/secondary outcomes to support clinical interpretation beyond p-values, which is important when translating physiotherapy effects into practice decisions. Fourth, baseline equivalence was explicitly documented for all outcomes (all $p>0.05$), reducing concern that post-treatment differences reflect baseline imbalance rather than treatment response.

Limitations should be considered when generalizing these findings. The age range was restricted to 30–40 years, limiting external validity to older adults who carry the highest pneumonia mortality burden (5,17). Participants were recruited using a convenience approach at two hospitals, which may introduce selection bias. The study used oxygen saturation, chest radiographic scoring, and CASA-Q; however, it did not incorporate microbiological confirmation of etiology, which is often absent in routine practice but can influence clinical course and secretion burden (7,8). Also, multiple outcomes were evaluated; while all three outcomes favored the combined intervention with strong effect sizes, a pre-specified hierarchy (e.g., pulse oximetry as primary, CASA-Q and chest X-ray as secondary) is recommended for future work to minimize interpretive ambiguity when multiple endpoints are tested. Finally, longer-term outcomes such as length of stay, readmission, and functional recovery were not assessed; these are clinically meaningful endpoints in adult pneumonia trials and are important for aligning physiotherapy benefits with health-system impact (21).

Overall, within the constraints of this design, adding ACBT to postural drainage produced consistently larger improvements in oxygenation, sputum-related symptoms, and radiographic severity than postural drainage alone over four weeks, supporting the clinical use of structured airway clearance protocols in adults with pneumonia when secretion burden and hypoxemia are present (10,18,22,23).

CONCLUSION

In adults with pneumonia treated over four weeks, postural drainage improved oxygen saturation, sputum-related symptom burden, and radiographic severity; however, combining postural drainage with Active Cycle Breathing Technique produced substantially greater benefit, yielding higher post-treatment oxygen saturation (91.12 ± 2.47 vs 85.68 ± 3.28), better CASA-Q scores (57.12 ± 9.46 vs 46.06 ± 7.62), and lower chest X-ray severity scores (2.00 ± 0.63 vs 4.68 ± 0.79) than postural drainage alone, indicating that integrating an active airway clearance strategy meaningfully enhances clinical recovery markers in adult pneumonia.

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