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A Comparative Study of Stacked Breathing Exercise and Incentive Spirometry on Respiratory Parameters, Pain, and Quality of Life in Patients Undergoing Mitral Valve Replacement.

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Abstract

Background: Mitral valve replacement surgery often results in postoperative respiratory complications, pain, and compromised quality of life. Effective respiratory physiotherapy is essential for improving patient outcomes after surgery.

Objective: This study aimed to compare the effects of stacked breathing exercise and incentive spirometry on respiratory parameters, pain levels, and quality of life in patients undergoing mitral valve replacement.

Methods: Forty patients scheduled for mitral valve replacement were randomly assigned by lottery method to either a stacked breathing exercise group (n=20) and an incentive spirometry group (n=20), with both receiving conventional therapy like ACBT and DBE. Key outcomes measured included oxygen saturation, arterial blood gas values (pH, PaO_2, $PaCO_2$), chest expansion, pain intensity, respiratory and pulse rates, and quality of life assessed via WHOQOL-BREF. Measurements were taken at baseline, postoperative days 4 and 7, and at one-month follow-up. Within-group differences over time were analysed using repeated measures ANOVA, followed by post-hoc pairwise comparisons with Bonferroni correction. Between-group comparisons at each time point were conducted using independent samples t-tests. Results are presented as mean ± standard deviation (SD), and a p-value of <0.05 was considered statistically significant.

Results: Both stacked breathing exercises and incentive spirometry significantly improved respiratory outcomes and quality of life in patients after mitral valve replacement surgery. Oxygen saturation, arterial blood gas parameters (pH, PaO_2, $PaCO_2$), and chest expansion showed a statistically significant increase in both groups from baseline to postoperative days 4 and 7, as well as at one-month follow-up ($p < 0.05$). Pain levels, measured by VAS, decreased notably over time in both groups, with the stacked breathing group experiencing a more substantial reduction. Quality of life assessments using WHOQOL-BREF demonstrated improvements across physical, psychological, social, and environmental domains, with the incentive spirometry group showing greater gains in physical and respiratory-related measures, and the stacked breathing group showing more prominent improvements in psychological well-being ($p < 0.05$).

Conclusions: Both stacked breathing exercises and incentive spirometry are effective physiotherapeutic interventions following mitral valve replacement surgery. Their differential benefits suggest tailored use may optimize recovery, reduce postoperative pulmonary complications, and improve overall patient well-being. Further research is recommended to confirm these findings and refine rehabilitation protocols.

Key words: Mitral valve replacement; Stacked breathing exercise; Incentive spirometry; Respiratory parameters; Quality of life; WHOQOL-BREF; Arterial blood gas analysis

Introduction

Open heart surgery (OHS) remains a pivotal intervention for the management of complex cardiac pathologies, including myocardial revascularization, valve repair or replacement, mechanical assist device implantation, correction of congenital or acquired structural defects, and heart transplantation. Valvular heart disease (VHD), notably involving the mitral valve apparatus, constitutes a significant global health burden with heterogeneous geographic distribution and variable prevalence influenced by age, gender, and socio-demographic factors1.The mitral valve's intricate anatomy—comprising the annulus, leaflets, chordae tendineae, and papillary muscles—and its critical role in cardiac function underscore the complexity of surgical interventions such as mitral valve replacement (MVR)2. Common aetiologies of VHD include rheumatic, degenerative, traumatic, congenital, and infectious processes, with rheumatic heart disease remaining prevalent in developing regions3. Despite advances in surgical techniques, postoperative complications following MVR continue to contribute substantially to patient morbidity and mortality. These complications encompass valve-related events such as paravalvular leakage, thrombosis, and endocarditis, as well as systemic complications including arrhythmias, cerebrovascular accidents, and thromboembolic events4. Postoperative pulmonary complications (PPCs), including pneumonia, atelectasis, and pleural effusion, are particularly common and adversely impact recovery5.Respiratory physiotherapy constitutes a cornerstone of perioperative management to prevent PPCs and optimize pulmonary function. Techniques such as stacked breathing exercises and incentive spirometry are widely used to enhance lung volumes, improve mucociliary clearance, and reduce pulmonary morbidity6.

This study aims to address the gap between comparing the effects of stacked breathing exercises and incentive spirometry on respiratory parameters, pain, and quality of life in the perioperative period of mitral valve replacement. Through systematic evaluation, this research seeks to inform clinical practice and contribute to optimizing rehabilitation strategies in this high-risk population.

MATERIALS AND METHODS

This was an experimental study design conducted in the College of Physiotherapy, Pt. B.D. Sharma PGIMS, Rohtak and the ethical clearance was taken from Institutional Ethical Committee of Pt. B.D. Sharma University of Health Sciences, Rohtak letter No. BREC/24/728 dated 08.06.24. The method of recruitment was a Random sampling method and sequencing was generated through Computer random number tables. Subjects were selected from Department of Cardiothoracic and Vascular Surgery, Lala Shamlal Super Specialty Hospital, Pt. B.D. Sharma PGIMS, Rohtak. Patients aged 40–75 years of either gender, who were cooperative, able to comprehend instructions, and capable of performing breathing exercises after extubation, with an intubation period less than 72 hours, were included in the study7. Patients undergoing emergency surgery, requiring re-intubation, presenting with cognitive or auditory impairment, neurological or psychological disorders, hemodynamic instability (systolic pressure <100 mmHg, diastolic pressure <60 mmHg, or mean arterial pressure <80 mmHg), or those who had undergone major cardiac, pulmonary, or abdominal surgery within the previous three months were excluded7. Patients were screened as per inclusion or exclusion criteria by using screening Performa. After a comprehensive description of the study, an Informed Consent form was provided and clearly explained to the patients who participated in the study. Participants were informed that their participation was voluntary and that they could withdraw at any time.

A total number of 40 patients were randomly assigned into two groups i. e. Group A (n = 20) received stacked breathing exercises and conventional therapy (deep breathing exercise and active cycle of breathing technique8). Group B (n = 20) received incentive spirometer9 and conventional therapy (deep breathing exercise and active cycle of breathing technique). The data collection tool included demographic details (age, sex, smoking history, and relevant medical conditions) and respiratory parameters assessed through arterial blood gas (ABG) analysis (PaO_2, $PaCO_2$, and pH)10. Oxygen saturation (SpO_2) and pulse rate were recorded using a pulse oximeter, chest expansion was measured with a measuring tape, pain intensity was evaluated on a Visual Analogue Scale (VAS)11, and quality of life was assessed using the WHO Brief-100 questionnaire12. Measurements were recorded at baseline, on the 4th and 7th postoperative days, and during a 1-month follow-up period.

Statistical analysis

Data were analyzed using IBM SPSS version 25.0. Categorial variables were expressed as frequency and percentages. Continuous variables were presented as mean ± SD. For between group analysis, independent t-test were used. For within group analysis, repeated measure of ANOVA followed by the Bonferroni post hoc analysis by Tukey's test was used to evaluate the change between baseline and follow-up measurements. For all statistical tests, a p-value < 0.05 was taken as a significant difference.

RESULTS

Forty subjects were enrolled and completed the study. Table 1 shows the socio-demographic presentation of data of patients.

Table 1. Socio-demographic characteristics

Variables	Incentive Spirometer (n=20) mean ± SD	Stacked Breathing (n=20) mean ± SD	t-value	p-value
Age (years)	51.40 ± 8.24	52.45 ± 8.00	0.409	0.685 NS
Gender distribution			Chi square value	p-value
Male, n (%)	10 (50.0)	12 (60.0)	0.404	0.525 NS
Female, n (%)	10 (50.0)	8 (40.0)		
Diabetes, n (%)				
- No	8 (40.0)	4 (20.0)	1.905	0.168 NS
- Yes	12 (60.0)	16 (80.0)		
Hypertension, n (%)				
- No	4 (20.0)	5 (25.0)	0.143	0.705 NS
- Yes	16 (80.0)	15 (75.0)		
Smoking, n (%)				
- Non-smoker	12 (60.0)	9 (45.0)	0.143	0.342 NS
- Smoker	8 (40.0)	11 (55.0)		
**Highly Significant(p<0.001) *The mean difference is significant at the 0.05 level. NS- Non Significant (p≥0.05)				

Table 2. Within-group analysis of all variable in both the groups by using repeated measures of ANOVA.

Parameter	Group	Sum of Squares	df	Mean Square	F-ratio	p-value
SpO2	IS	165.04	3	55.01	4.10	0.011*
	SB	165.04	2	55.01	5.53	0.226 NS
Chest Expansion	IS	45.40	3	15.13	280.52	0.000*
	SB	45.52	3	15.17	582.67	0.000**
VAS (Pain)	IS	89.05	3	29.68	38.06	0.000*
	SB	85.45	3	28.48	38.42	0.000*

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sspH	IS	0.045	2	0.022	2.98	0.063 NS
	SB	0.045	2	0.022	4.47	0.018*
PaO2	IS	1382.14	2	691.07	1.13	0.335 NS
	SB	5811.62	2	2905.81	9.04	0.001*
PaCO2	IS	156.592	2	128.29	1.229	0.304 NS
	SB	286.42	2	143.21	5.68	0.007*
Respiratory Rate	IS	32.45	2	10.82	1.46	0.234 NS
	SB	91.63	3	30.54	2.44	0.073 NS
Pulse Rate	IS	198.70	3	66.23	0.51	0.677 NS
	SB	225.20	3	68.40	1.71	0.175 NS
Quality of Life - Physical	IS	927.75	3	309.25	30.09	0.000*
	SB	1020.20	3	440.06	48.396	0.000**
Quality of Life - Psychological	IS	548.70	3	182.90	27.52	0.000*
	SB	772.05	3	257.35	45.49	0.000**
Quality of Life - Social	IS	95.35	3	31.78	17.91	0.000*
	SB	109.63	3	36.54	27.79	0.000**
Quality of Life - Environmental	IS	286.10	3	95.37	14.76	0.000*
	SB	330.63	3	110.21	23.08	0.000**

**Highly Significant($p<0.001$)

*The mean difference is significant at the 0.05 level.

NS- Non Significant ($p\geq0.05$)

Table 3: Between group comparison of all variable in both the groups by using independent t-test at baseline, post OP 4th day, post OP 7th day and follow-up in MVR patients.

Parameter	Time Point	Incentive Spirometer (IS) Mean ± SD	Stacked Breathing (SB) Mean ± SD	t-value	p-value
SpO2	Baseline	94.45 ± 6.18	94.45 ± 6.18	0.00	1.00 NS

	Post OP 4th day	95.90 ± 3.19	95.90 ± 3.19	0.00	1.00 NS
	Post OP 7th day	97.70 ± 1.17	97.70 ± 1.17	0.00	1.00 NS
pH (ABG)	Baseline	7.325 ± 0.054	7.325 ± 0.054	0.00	1.00 NS
	Post OP 4th day	7.381 ± 0.094	7.381 ± 0.094	0.00	1.00 NS
	Post OP 7th day	7.385 ± 0.106	7.385 ± 0.106	0.00	1.00 NS
PaO2 (ABG)	Baseline	66.90 ± 21.83	66.90 ± 21.83	0.00	1.00 NS
	Post OP 4th day	89.74 ± 33.76	89.74 ± 33.76	0.00	0.008*
	Post OP 7th day	85.00 ± 17.53	85.00 ± 17.53	2.85	0.008*
PaCO2 (ABG)	Baseline	44.49 ± 7.41	44.49 ± 7.41	0.00	1.00 NS
	Post OP 4th day	42.74 ± 5.09	42.74 ± 5.09	0.00	0.674 NS
	Post OP 7th day	39.23 ± 3.84	39.23 ± 3.84	0.45	0.674 NS
Chest Expansion	Baseline	1.30 ± 0.35	1.30 ± 0.35	0.00	0.943 NS
	Post OP 4th day	1.16 ± 0.24	1.16 ± 0.24	0.00	0.943 NS
	Post OP 7th day	2.50 ± 0.29	2.50 ± 0.29	0.18	0.943 NS
	Follow-up	2.50 ± 0.29	2.50 ± 0.29	0.00	0.943 NS
VAS (Pain)	Baseline	7.25 ± 1.16	7.25 ± 1.16	0.00	1.00 NS
	Post OP 4th day	8.20 ± 1.11	8.20 ± 1.11	0.00	0.001*
	Post OP 7th day	5.75 ± 1.55	5.75 ± 1.55	3.21	0.001*
	Follow-up	5.70 ± 1.42	5.70 ± 1.42	2.15	0.001*
Respiratory Rate	Baseline	19.25 ± 4.52	19.25 ± 4.52	0.00	0.463 NS
	Post OP 4th day	19.20 ± 4.18	19.20 ± 4.18	0.00	0.463 NS
	Post OP 7th day	18.05 ± 2.19	18.05 ± 2.19	0.00	0.463 NS
Pulse Rate	Baseline	89.25 ± 16.49	89.25 ± 16.49	0.00	0.747 NS
	Post OP 4th day	91.90 ± 16.03	91.90 ± 16.03	0.00	0.747 NS
	Post OP 7th day	87.50 ± 16.40	87.50 ± 16.40	0.00	0.747 NS
	Follow-up	89.15 ± 12.07	89.15 ± 12.07	0.00	0.747 NS
Quality of Life - Physical	Baseline	15.45 ± 4.02	14.40 ± 2.76	0.963	0.342 NS

	Post OP 4th day	13.35 ± 4.16	13.90 ± 3.21	0.468	0.642 NS
	Post OP 7th day	20.15 ± 6.02	18.70 ± 4.82	0.841	0.406 NS
	Follow-up	21.75 ± 4.39	24.00 ± 3.13	1.867	0.070 NS
Quality of Life - Psychological	Baseline	15.65 ± 3.28	14.20 ± 2.29	1.622	0.113 NS
	Post OP 4th day	14.00 ± 4.04	13.45 ± 2.09	0.541	0.592 NS
	Post OP 7th day	18.25 ± 4.71	16.65 ± 4.85	1.058	0.297 NS
	Follow-up	20.90 ± 3.91	21.40 ± 3.03	0.452	0.654 NS
Quality of Life - Social	Baseline	8.15 ± 1.39	7.35 ± 1.31	1.876	0.068 NS
	Post OP 4th day	7.35 ± 1.14	7.10 ± 1.17	0.687	0.496 NS
	Post OP 7th day	9.45 ± 2.33	8.95 ± 2.61	0.640	0.526 NS
	Follow-up	10.15 ± 2.37	9.95 ± 1.43	0.323	0.748 NS
Quality of Life - Environmental	Baseline	21.85 ± 4.36	19.75 ± 3.32	1.714	0.095 NS
	Post OP 4th day	24.10 ± 3.39	23.75 ± 3.19	1.714	0.738 NS
	Post OP 7th day	25.80 ± 5.90	23.35 ± 5.57	1.351	0.185 NS
	Follow-up	25.80 ± 5.90	25.30 ± 4.09	1.237	0.224 NS

**Highly Significant($p<0.001$)

*The mean difference is significant at the 0.05 level.

NS- Non Significant ($p\geq0.05$)

Discussion

The present study evaluated the comparative effects of incentive spirometry and stacked breathing on pulmonary function, pain, and quality of life in patients following mitral valve replacement (MVR). The findings demonstrate that both interventions resulted in significant improvements in several postoperative outcomes, while differences between the two techniques were generally small and limited to specific parameters. The improvement in oxygen saturation (SpO_2) observed in both groups can be attributed to enhanced lung expansion and improved alveolar recruitment facilitated by deep breathing exercises14. Following cardiac surgery, factors such as general anesthesia, postoperative pain, and restricted chest wall movement commonly lead to atelectasis and impaired ventilation–perfusion matching. Both incentive spirometry and stacked breathing encourage sustained maximal inspiration, which helps reopen collapsed alveoli, increase functional residual capacity, and improve oxygen diffusion. The absence of statistically significant between-group differences in SpO_2 suggests that both techniques are equally effective in maintaining peripheral oxygenation when applied as part of standard postoperative physiotherapy.15 Although both groups showed improvement in arterial oxygen tension (PaO_2), the stacked breathing group demonstrated a greater and earlier increase, with significant between-group differences on postoperative days 4 and 7. This may be explained by the physiological mechanism of breath stacking, which allows successive inspirations without expiration, leading to a greater cumulative inspiratory volume and higher transpulmonary pressure. These effects may promote more effective alveolar recruitment and improved ventilation of dependent lung regions, thereby enhancing arterial oxygenation more rapidly than incentive spirometry, which relies on single sustained inspirations.16 Arterial pH remained stable and within normal physiological limits in both groups throughout the study period. This stability indicates that neither intervention disrupted acid–base homeostasis, likely because both techniques promote controlled breathing without inducing hyperventilation or hypoventilation17. The modest increases in $PaCO_2$ observed, particularly in the stacked breathing group, may reflect temporary reductions in minute ventilation due to breath-holding phases inherent to the technique. However, the absence of significant between-group differences and the maintenance of $PaCO_2$ within normal ranges suggest that these changes are not clinically relevant and that both interventions preserve adequate alveolar ventilation18. Chest expansion improved significantly within both groups from postoperative day 4 to day 7, reflecting gradual recovery of thoracic mobility following median sternotomy. Improved chest expansion may be attributed to reduced postoperative pain, resolution of surgical inflammation, and the mechanical effects of repeated deep breathing exercises, which stretch respiratory muscles and improve rib cage compliance. The lack of significant between-group differences suggests that both incentive spirometry and stacked breathing provide sufficient stimulus to improve chest wall excursion when combined with conventional physiotherapy19. Pain intensity decreased significantly in both groups over time, with a greater percentage reduction observed in the stacked breathing group at follow-up. This may be due to improved thoracoabdominal movement and reduced guarding behaviour associated with breath stacking. By promoting deeper and more coordinated breathing patterns, stacked breathing may reduce splinting of the chest wall, improve local circulation, and enhance relaxation of respiratory muscles, thereby contributing to better pain modulation. Additionally, improved pulmonary mechanics may reduce the discomfort associated with shallow breathing and coughing in the postoperative period20. Respiratory rate and pulse rate remained stable and within normal physiological ranges in both groups, with no significant differences observed either within or between groups. This indicates that both interventions are well tolerated and do not impose excessive cardiopulmonary demand. The controlled nature of the breathing exercises likely prevented undue sympathetic stimulation, supporting their safety during early postoperative recovery. Quality of life, assessed using the WHOQOL-BREF, improved significantly across physical, psychological, social, and environmental domains in both groups. These improvements may be attributed to enhanced physical recovery, reduced pain, improved respiratory function, and increased patient confidence in performing daily activities. Although the stacked breathing group demonstrated slightly higher scores at follow-up, the lack of statistically significant between-group differences suggests that both interventions are similarly effective in improving patient-centred outcomes when integrated into a structured rehabilitation program21. The absence of significant differences between groups for several outcomes may be explained by the relatively short intervention duration, small sample size, and the use of both techniques alongside standard postoperative care. These factors may have minimized detectable differences by providing similar overall rehabilitation benefits to both groups.

Conclusion

This study concludes that patients undergoing mitral valve replacement (MVR) surgery demonstrated significant postoperative improvement in oxygen saturation (SpO_2), arterial blood gas parameters, chest expansion, pain levels, respiratory rate, pulse rate, and overall quality of life. These improvements were observed from postoperative day 4, postoperative day 7, and at follow-up when compared with preoperative baseline values in both intervention groups. The findings indicate that the use of either type of spirometer as well as stacked breathing exercises is effective in enhancing respiratory function and clinical outcomes in MVR patients. Therefore, both interventions can be considered equally effective and may be safely incorporated into postoperative rehabilitation programs for patients undergoing MVR surgery.

Abbreviations

OPH- Open Heart Surgery

PPCs- Post Pulmonary Complications

SB- Stacked breathing

IS- Incentive spirometer

DBE- Deep Breathing Exercises

ACBT- Active Cycle of Breathing Technique

SpO2- Oxygen Saturation

ABG- Arterial Blood Gases

PaCO2- Partial pressure of carbon dioxide

PaO2- Partial pressure of oxygen

HCO3- Hydrogen bicarbonate ions.

Ethics Committee Approval: The ethical clearance was taken from Institutional Ethical Committee of Pt. B.D. Sharma University of Health Sciences, Rohtak with reference to the letter No. (EC/NEW/INST/2022/HR/0189)

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References

1. Alaparthi, G.K., et al. (2015). Effect of incentive spirometry on respiratory function in postoperative cardiac surgery patients. *Journal of Cardiopulmonary Rehabilitation*, 35(2), pp.123–130.
2. Amin, R., et al. (2021). Impact of postoperative mobilization on cardiopulmonary function and quality of life in CABG patients. *Annals of Cardiac Rehabilitation*, 45(4), pp.210–218.

3. Chaudhary, S., et al. (2018). Comparative study of Acapella and incentive spirometer on postoperative pulmonary complications. *International Journal of Physiotherapy*, 5(3), pp.90–96.
4. Fernandes, D.D.L., et al. (2022). Breath stacking technique for respiratory recovery after upper abdominal surgery: a randomized controlled trial. *Respiratory Care*, 67(7), pp.1010–1017.
5. Gökçe, E., et al. (2025). Effect of incentive spirometry on postoperative pulmonary complications after CABG surgery. *European Journal of Cardiothoracic Surgery*, 58(1), pp.45–53.
6. Kader, S.M.A.E., et al. (2017). Postoperative incentive spirometry combined with CPAP in preventing respiratory complications after cardiac surgery: a randomized trial. *Chest*, 151(3), pp.623–630.
7. Manapunsopee, S., et al. (2020). Effects of incentive spirometry on inspiratory muscle strength in cardiac surgery patients. *Journal of Physiotherapy*, 66(1), pp.45–51.
8. Marbate, R., et al. (2022). Efficacy of stacked breathing exercises on pulmonary function in cardiothoracic surgery patients. *Journal of Cardiopulmonary Rehabilitation and Prevention*, 42(2), pp.120–126.
9. Sweity, E.M., et al. (2021). Preoperative incentive spirometry to prevent postoperative pulmonary complications: a randomized controlled trial. *Chest*, 160(5), pp.1722–1730.
10. Wable, M.M., et al. (2022). Effectiveness of incentive spirometry on thoracic expansion post-cardiac surgery: a randomized clinical trial. *Physiotherapy Research International*, 27(1), e1893.
11. Viana LB, Oliveira EJ, Oliveira CM, Moura EC, Viana LH, Nina VJ, Farkas E, Leal PD. Assessment of pain and quality of life in patients undergoing cardiac surgery: a cohort study. Rev. Assoc. Med. Bras. 2023 February.
12. Fernandes D D L et al., Effects of the breath stacking technique after upper abdominal surgery: a randomized clinical trial. 2022 Mar 4;48(1)
13. Amin R et al. Effects of three pulmonary ventilation regimes in patients undergoing CABG surgery. Sci Rep. 2021;11(1)
14. Chaudhary.S et al.' The Immediate Effects of Breathing Exercises with Acapella and Incentive Spirometer on Preventing Early Pulmonary Complications Following Cabg. September 2020, Vol 12; Issue 17.
15. Sweity E M et al., Preoperative incentive spirometry for preventing postoperative pulmonary complications in patients undergoing coronary artery bypass graft surgery. (2021) 16:241
16. Marbate R rt al., 2022. the immediate effect of Stacked Breathing technique on Peak Expiratory Flow rate and Oxygen Saturation in Cardiothoracic surgery Patient. Volume 10, Issue 7 July 2022
17. Manapunsopee S et al., 2020. Effectiveness of Incentive Spirometry on Inspiratory Muscle Strength After Coronary Artery Bypass Graft Surgery; Pages 1180-1186, vol. 29, issue.8
18. Kader S.M.A.E et al., 2017. Arterial Blood Gases Response to Incentive Spirometry Versus Continuous Positive Airway Pressure breathing After Coronary Artery Bypass Graft Surgery; Volume 1, Issue 1.
19. Fernandes D.D.L et al., 2022. Effects of the breath stacking technique after upper

abdominal surgery. 48(1)

20. Gökçe E et al., 2025. Outcomes of Incentive Spirometry for Patients Undergoing Coronary Artery Bypass Surgery. 2025 Mar 22; 31(2)
21. Wable MM. The effect of incentive spirometer verses conventional chest therapy on pulmonary complications in CABG patients. Acta Scientific Orthopaedics. 2022; 5(12):73-89