ORIGINAL ARTICLE

Effect of Buteyko Breathing Technique as an Adjunct to Routine Physiotherapy on Pulmonary Functions in Patients Undergoing Off-pump Coronary Artery Bypass Surgery: A Randomized Controlled Trial

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Abstract

Background: Coronary artery disease (CAD) poses a substantial and increasing public health concern in India, particularly among individuals aged 20 and above. The postoperative phase following coronary artery bypass graft (CABG) surgery presents potential complications, notably impacting the pulmonary system. Emerging evidence suggests that the Buteyko breathing technique not only improves lung function but also positively influences the psychological well-being of CABG patients. This study seeks to assess the impact of the Buteyko breathing technique on pulmonary functions in individuals who have undergone off-pump CABG.

Materials and methods: In this randomized controlled trial, patients undergoing off-pump CABG were allocated to either the Buteyko breathing technique group ($n = 35$) or the control group ($n = 35$). The intervention group received supervised Buteyko breathing technique sessions twice daily for 15 minutes, concurrently with cardiac rehabilitation from postoperative day (POD-2 to POD-7). The control group underwent phase I cardiac rehabilitation. Outcome measures, including pulmonary function test (PFT), chest expansion, and breath-holding tests were evaluated at baseline (POD-2) and conclusion (POD-7).

Results: Statistical analyses were conducted with a significance level set at $p < 0.05$. Both the control and intervention groups exhibited statistically significant improvements in pulmonary function, chest expansion at three levels, and breath-holding time ($p = 0.0001$). However, the Buteyko breathing group demonstrated a more significant improvement compared with the control group.

Conclusion: The integration of the Buteyko breathing technique into conventional physiotherapy proves to be a beneficial strategy, leading to improvements in pulmonary function, breath-holding duration, and chest expansion for individuals who underwent off-pump CABG surgery.

Keywords: Buteyko breathing technique, Cardiac rehabilitation, Coronary artery bypass graft, Off-pump CABG, Pulmonary functions.

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Highlights

The incorporation of Buteyko breathing into post-CABG rehabilitation yields significant advancements in pulmonary function, breath-holding duration, and chest expansion. Its demonstrated efficacy, particularly in reversing carbon dioxide exchange, suggests a promising role as a supplementary approach to enhance respiratory outcomes and overall patient wellness post-cardiac surgery.

Introduction

Coronary artery disease (CAD) stands as a formidable global health challenge, exerting a substantial toll on disability and mortality worldwide. Within the Indian population,[1] coronary artery disease holds a prominent position among the leading causes of death, emphasizing its critical impact on public health. The key risk factors associated with CAD, including smoking, dyslipidemia, hypertension, diabetes, abdominal adiposity, sedentary lifestyle, psychological stress, and inadequate fruit and vegetable intake, collectively contribute to more than 90% of cases within the population.[2] Importantly, India witnesses an annual occurrence of approximately 140,000 coronary artery bypass graft (CABG) surgeries, underlining the significance of cardiac interventions in addressing CAD.[3]

The intricate nature of bypass surgeries on the coronary arteries, regardless of the use of extracorporeal circulation, gives

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rise to notable disruptions in respiratory system function. While some studies suggest that off-pump CABG may not confer superior protection against postoperative pulmonary dysfunction compared with CABG with cardiopulmonary bypass (CPB), the impact of these surgical interventions on respiratory outcomes remains a critical area of investigation.[4,5]

Complications arising during the postoperative period following CABG can substantially contribute to morbidity and mortality, often leading to extended hospital stays.[6] Postoperative pulmonary dysfunction manifests with diverse clinical indications, ranging from widespread arterial hypoxemia to the less common but severe acute respiratory distress syndrome (ARDS). Evidence suggests that altering breathing patterns, including specific techniques like breath-holding, holds therapeutic promise for individuals undergoing various respiratory treatments.[7,8]

The Buteyko breathing technique, grounded in breath control and breath-holding methods, emerges as a therapeutic approach aimed at restoring natural diaphragmatic breathing. Offering benefits such as symptom relief, improved breath control, and enhanced oxygen delivery to cells and tissues; the technique utilizes measures like control pause (CP).[9] Previous studies have highlighted its positive effects on bronchial asthma symptoms and peak expiratory flow rate (PEFR) in asthma patients.[10]

Despite the existing body of literature exploring the beneficial impact of the Buteyko breathing technique on anxiety, symptoms, and hospital stays, a research gap persists regarding its influence on pulmonary function and chest expansion following coronary artery bypass surgery. This study endeavors to address this gap by investigating the potential effects of the Buteyko breathing technique in patients who have undergone off-pump CABG.

Materials and Methods

Study Design

A parallel-arm superiority randomized controlled trial was conducted to evaluate the efficacy of the Buteyko breathing technique in conjunction with routine physiotherapy on pulmonary functions in patients who had undergone off-pump CABG.

Setting and Participant Recruitment

The study took place at tertiary care Hospital in Maharashtra, India, spanning the recruitment period from December 2022 to August 2023. Inclusion criteria involved subjects aged 48–71, regardless of gender, with triple vessel disease and who had undergone off-pump coronary artery bypass surgery.[11] Exclusion criteria encompassed patients on mechanical ventilation or NIV support for more than 24 hours, those with renal failure, hemodynamic instability, a history of prior cardiac surgery, or any pulmonary disease.

Sample Size Calculation

The sample size of 70 participants was determined using G Power software, adopting an alpha value of 0.05 and a power of 0.95, while considering a substantial effect size of 0.8.

Ethical Consideration

The study received approval from the Institutional ethics committee (MGM/IOP/IEC/PG/2022/05) and was registered on the ClinicalTrials.gov website (registration number: CTRI/2022/12/048295).

The primary investigator has over 4 years of experience in cardiovascular and thoracic surgery units (CVTS) with professional certification. The research team, led by experienced academics with 12+ years of expertise with postgraduate degrees in cardiovascular and respiratory physiotherapy, specializes in ICU patient treatment. A single physiotherapy staff consistently delivered the intervention, closely monitored for protocol adherence by a dedicated supervisor who ensured intervention fidelity and quality through feedback.

Randomization

The study employed a block randomization method, and the randomization process was conducted by a blinded external investigator using (www.sealedenvelope.com) prior to the study's commencement. The randomization list was generated without stratification, with predefined block sizes and list length. Through this process, participants were randomly assigned in a 1:1 ratio to two groups: the Intervention group (Group A)—Buteyko breathing technique with cardiac rehabilitation phase I, and the control group (Group B)—received only cardiac rehabilitation phase I.

Every eligible participant was subsequently provided with the informed consent form. Participants who fulfilled the eligibility criteria were sampled, informed about the research study, and asked to provide their consent to participate.

Outcome Measures

The study's primary outcome variables are:

Pulmonary Function Test (PFT)[12–14]

The inpatient PFT utilized the Winspiro USB spirometer, assessing forced expiratory volume in the first second (FEV1), forced vital capacity (FVC), and the FEV1/FVC ratio. Subjects assumed a comfortable seated position on the bed, wearing loose clothing to ensure no constraints during the test. Subjects were guided to relax completely by performing 2–3 deep breaths. The spirometer's mouthpiece was inserted into the mouth, and a nose clip secured in place. Subjects executed forceful inhalation through the mouth, followed by a vigorous, prolonged exhalation for 6 seconds. Subsequently, a deep inhalation through the mouth was performed with a chest binder on. The spirometry demonstrated a high level of specificity (97.75%) and sensitivity (73.04%).

Chest Expansion[15,16]

Patients were seated upright, with slightly bent elbows, allowing hands to rest on their hips. The chest, uncovered, underwent measurements of expansion at three specific levels: axillary, nipple, and xiphoid process levels, utilizing a non-stretchable inch tape. Patients were instructed to exhale fully, followed by maximal inhalation for measurement. This process was repeated three times at each level, and the average of the readings was calculated and documented. The procedure, known for its good intra- and inter-rater reliability and reproducibility, adds precision to the assessment of chest expansion.

The study's secondary outcome variables are:

Breath-holding Test[17,18]

The participant is instructed to take a deep inhalation, followed by a controlled exhalation while sequentially counting, starting from 1 and continuing until they are no longer able to hold their breath. The ability to achieve a count ranging between 30 and 40 repetitions is considered indicative of a robust vital capacity, reflecting a healthy respiratory function. This count not only serves as a measure of current pulmonary capacity but also offers insights into the trend

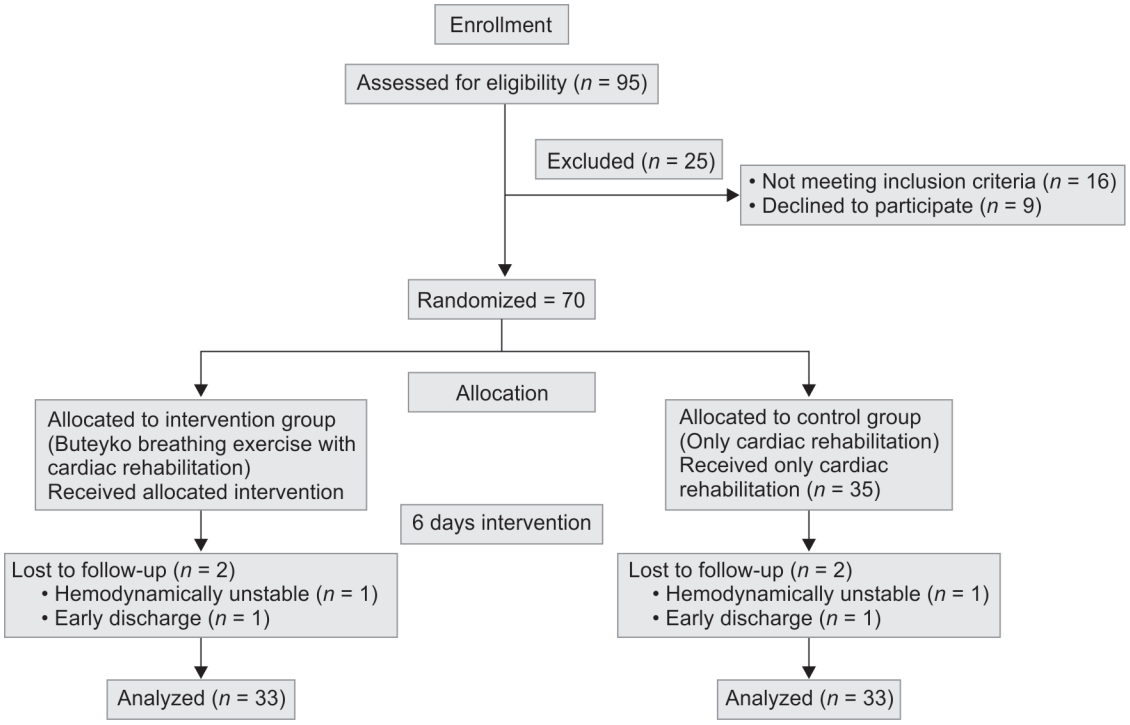

Fig. 1: Patient flowchart

of pulmonary function, indicating whether it is experiencing improvement or decline. This test is applicable to both preoperative and postoperative patients, providing valuable information about the trajectory of their respiratory health.

Procedure

The baseline demographic data encompassing age, sex, height, weight, comorbidities, addiction history, PFT results, chest expansion using an inch tape, and breath-holding time on POD-2 were collected.

Participants in group A underwent a comprehensive intervention, receiving cardiac rehabilitation phase I along with the Buteyko breathing technique.

Buteyko Breathing Technique Protocol[19,20]

The participant took an upright position in a chair, ensuring that their shoulders were relaxed and their lower back was supported against the chair's backrest. They were instructed to execute a gentle inhalation followed by a soft exhalation. Subsequently, the participant was guided to hold their nose during the exhalation phase, maintaining a state of partial lung emptiness without excessive depletion. The duration, measured in seconds, during which the participant comfortably sustained this breath-holding until the initial urge to breathe was noted. Following the breath-holding phase, the participant was instructed to release their nose and inhale through it. This sequence was repeated multiple times.

Dosages

Total protocol duration: 6 days.

Total time for each exercise session: 10–15 minutes, performed twice per day.

Frequency: 2 times per day.

Conversely, participants allocated to the control group (group B) underwent cardiac rehabilitation phase I[21] without the supplementary Buteyko breathing technique. Following the culmination of the 6-day intervention period, all patients underwent a reevaluation, during which outcome measures, including PFTs, chest expansion measurements, and breath-holding time were reassessed.

Statistical Analysis

The data were subjected to analysis using SPSS version 27.0 software. Descriptive variables were employed to assess the normality of the data. Descriptive statistics, including percentages, means, and standard deviations were computed to provide a summary of the demographic and clinical characteristics of the study participants. To compare variables between POD-2 and POD-7, paired *t*-tests were performed, and between-group analyses were conducted using unpaired *t*-tests. These statistical tests were applied to examine differences in PFT results, chest expansion measurements, and breath-holding time. The significance level for statistical analysis was set at $p < 0.05$, indicating that *p*-values below this threshold were deemed statistically significant.

Results

A total of 95 patients were initially screened for eligibility. Following the exclusion of 16 patients who did not meet the inclusion criteria and 9 patients who declined participation, a final 70 patients completed the study. Of these, 66 patients successfully completed the study, while 4 were lost to follow-up until POD-7. The reasons for loss to follow-up included early discharge in two cases and the development of hemodynamic instability in two other cases (Fig. 1).

Table 1 summarizes the characteristics of study participants, comparing the intervention group ($n = 33$) and the control group ($n = 33$). Both groups, with similar age (60.30 ± 7.49 vs 60.57 ± 7.62, $p = 0.88$), gender distribution, height, and weight, exhibited no significant differences. Comorbidity profiles, including diabetes, hypertension, and thyroid conditions, were comparable between

Table 1: Demographic and clinical characteristics of study participants in the intervention and control groups

Characteristics	*Intervention group (n = 33)*	*Control group (n = 33)*	*p-value*
Age in years	60.30 ± 7.49	60.57 ± 7.62	0.88
Gender (male/female)	23/10	26/7	0.39
Height in inches	62.59 ± 3.02	62.76 ± 3.93	0.84
Weight in pounds	139.54 ± 16.11	135.95 ± 15.58	0.36
Comorbidities			
No comorbidities	8 (24.24%)	8 (24.24%)	0.64
DM	4 (12.12%)	7 (21.21%)	
DM, HT	7 (21.21%)	7 (21.21%)	
HT	14 (42.42%)	10 (30.30%)	
Thyroid	0 (0%)	1 (3.03%)	
Addiction			
No addiction	19 (57.58%)	15 (45.45%)	0.19
Alcohol	0 (0%)	2 (6.06%)	
Beedi	0 (0%)	3 (9.09%)	
Ex-smoker	5 (15.15%)	8 (24.24%)	
Smoker	4 (12.12%)	2 (6.06%)	
Tobacco	5 (15.15%)	3 (9.09%)	

DM, diabetes mellitus; HT, hypertension

Table 2: Pulmonary function test parameters and changes at postoperative days 2 and 7 in control and intervention groups

Parameters	*Group*	*POD-2*	*POD-7*	*Mean difference*	*p-value*
FEV1	CG	0.74 ± 0.25	1.07 ± 0.29	0.33 ± 0.15	0.0001
	IG	0.73 ± 0.20	1.50 ± 0.28	0.76 ± 0.24	
FVC	CG	0.94 ± 0.29	1.25 ± 0.32	0.31 ± 0.19	0.0001
	IG	0.95 ± 0.26	1.78 ± 0.31	0.82 ± 0.32	
FEV1/FVC	CG	50.24 ± 4.78	56.06 ± 4.80	5.81 ± 2.14	0.0001
	IG	51.55 ± 4.13	63.28 ± 3.69	11.72 ± 3.53	

CG, control group; FVC, forced vital capacity; FEV1, forced expiratory volume in 1 second; IG, intervention group; POD, postoperative day

the groups. Notably, no significant variations were observed in addiction patterns. The majority had no addiction (57.58% in intervention, 45.45% in control), and the prevalence of specific addictions like alcohol, beedi, and tobacco varied insignificantly.

Table 2 displays the PFT parameters for the control group (CG) and intervention group (IG) at POD-2 and POD-7. Significant improvements from POD-2 to POD-7 are evident in forced expiratory volume in 1 second (FEV1), FVC, and FEV1/FVC ratio for both groups ($p < 0.0001$). The mean differences emphasize positive changes, underscoring the efficacy of the Buteyko breathing technique. These findings highlight substantial enhancements in pulmonary function, affirming the potential benefits of the intervention in patients following off-pump CABG.

Table 3 illustrates chest expansion measurements at axillary, nipple, and Xiphisternum levels for the control group (CG) and intervention group (IG) on POD-2 and POD-7. Notable enhancements are evident in all measurements for both groups from POD-2 to POD-7 ($p < 0.0001$), indicating positive changes in chest expansion. The mean differences emphasize substantial improvements, affirming the effectiveness of the Buteyko breathing technique in enhancing respiratory outcomes. These findings underscore the technique's impact on chest mobility, supporting its role as a beneficial adjunct to standard physiotherapy in patients undergoing off-pump CABG.

Table 3: Chest expansion measurements and changes at different levels on postoperative days 2 and 7 in control and intervention groups

Level of measurements	*Group*	*POD-2*	*POD-7*	*Mean difference*	*p-value*
Axillary (Inches)	CG	0.39 ± 0.12	0.61 ± 0.17	0.22 ± 0.10	0.0001
	IG	0.46 ± 0.14	0.77 ± 0.14	0.31 ± 0.06	
Nipple (Inches)	CG	0.52 ± 0.16	0.77 ± 0.21	0.25 ± 0.14	0.0001
	IG	0.64 ± 0.20	1.06 ± 0.21	0.42 ± 0.11	
Xiphisternum (Inches)	CG	0.62 ± 0.18	0.92 ± 0.28	0.30 ± 0.17	0.0001
	IG	0.82 ± 0.24	1.37 ± 0.27	0.54 ± 0.17	

CG, control group; IG, intervention group; POD, postoperative day

Table 4: Breath-holding test parameters and changes at postoperative days 2 and 7 in control and intervention groups

Parameter	*Group*	*POD-2*	*POD-7*	*Mean difference*	*p-value*
Breath-holding time (seconds)	CG	4.36 ± 1.34	8.90 ± 2.05	4.54 ± 1.32	0.0001
	IG	5.18 ± 1.35	12.33 ± 1.99	7.15 ± 1.27	

CG, control group; IG, intervention group; POD, postoperative day

Table 4 presents breath holding test results for the control group (CG) and intervention group (IG) on POD-2 and POD-7. Both groups exhibit significant improvements in breath-holding time from POD-2 to POD-7 ($p < 0.0001$), indicating the positive influence of the Buteyko breathing technique. The mean differences emphasize substantial enhancements, underscoring the technique's efficacy in increasing breath-holding capacity. These findings suggest that incorporating the Buteyko breathing technique into standard physiotherapy positively contributes to respiratory outcomes, specifically in breath-holding capacity, for patients undergoing off-pump CABG.

Discussion

The current study was conducted to assess the effects of integrating the Buteyko breathing technique into phase I cardiac rehabilitation for individuals who underwent off-pump CABG surgery. The results demonstrate significant enhancements in pulmonary functions, breath-holding capacity, and chest expansion in these post-CABG patients. The study included a total of 66 participants who had undergone CABG surgery. Importantly, the findings highlight substantial improvements in respiratory outcomes, emphasizing the potential benefits of incorporating the Buteyko breathing technique into the early phases of cardiac rehabilitation for individuals following off-pump CABG procedures.

Following CABG surgery, a substantial decline in various pulmonary functional parameters is well-acknowledged, impacting even those with normal pre-surgery lung functions. Westerdahl et al.'s study highlighted decreased lung volumes, including functional residual capacity (FRC), forced expiratory volume in 1 second (FEV1), vital capacity (VC), and inspiratory capacity (IC), persisting up to 4 months post-surgery. Significant reductions, such as a 25% average decrease in FVC, FEV1, and PEFR were observed, suggesting complex changes in mechanics and chest

wall movement following thoracic intervention.[22,23] The present study echoes these observations, demonstrating significant mean differences in FEV1, FVC, and FEVI/FVC, with the intervention group showing greater significance, aligning with findings in a study by Afle GM and Grover SK.[24] This underscores the potential of the Buteyko breathing technique to readjust respiratory functioning and decrease the effort required for breathing, emphasizing its positive impact on pulmonary parameters.

The Buteyko breathing technique's primary goal, as outlined in studies, is to systematically restore the breathing center's functioning to adapt to elevated carbon dioxide (CO_2) levels, subsequently reducing minute ventilation rates. Achieved through relaxation of auxiliary breathing muscles and increased abdominal muscle engagement, this method teaches individuals to reduce their breathing volume. These mechanisms collectively reduce respiratory effort, promote muscle relaxation, and enhance diaphragmatic function. The study aligns with these principles, illustrating the technique's efficacy in improving respiratory outcomes, specifically in FEV1, FVC, and FEVI/FVC, emphasizing its potential as a therapeutic adjunct in post-CABG patients.[20]

In our study, chest expansion, another primary outcome, was assessed using an inch tape. The statistical analysis revealed significant *p*-values for both the control and intervention groups across all three measurement levels—axillary, nipple, and Xiphisternum. Significantly, the mean differences consistently favored the intervention group, indicating larger improvements in chest expansion compared with the control group. This discrepancy in mean differences may be attributed to the Buteyko breathing technique's ability to enhance diaphragmatic function and reduce the dependence on auxiliary muscles during breathing, ultimately contributing to superior chest expansion outcomes.[20,25]

Furthermore, our findings highlight substantial improvements in breath-holding time for both intervention and control groups, with the intervention group displaying a more pronounced enhancement in the average value. This aligns with findings from various studies, emphasizing the capability of extended breath-holding in the Buteyko Breathing Technique to initiate a reversal in carbon dioxide gas exchange.[25,26] This, in turn, triggers the body's inherent production of antioxidants with repetitive utilization of the technique. These observations collectively emphasize the positive impact of the Buteyko breathing technique on both chest expansion and breath-holding capacity, suggesting its efficacy as an adjunctive therapeutic approach.[25,27]

The research has notable constraints, such as the absence of an essential long-term follow-up component. Moreover, challenges arose during the POD-2 PFT due to discomfort at the drain site, and concerns about movement were stemming from the midline incision.

Future investigations could involve interventions implemented during phases II and III of cardiac rehabilitation, potentially addressing any limitations encountered in the current study. Additionally, conducting preoperative and postoperative PFTs could offer a straightforward means of comparing values, enhancing the comprehensiveness of the research outcomes.

Conclusion

The integration of the Buteyko breathing technique into conventional physiotherapy proves to be a beneficial strategy, leading to improvements in pulmonary function, breath-holding duration, and chest expansion for individuals who underwent off-pump CABG surgery.

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