Research Article

Effect of Preoperative Respiratory Rehabilitation on Post operative Outcomes in Coronary Artery Bypass Graft Patients: A randomized clinical trail

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ABSTRACT

Background: Coronary artery bypass graft, a surgical way to bypass blocked portions of coronary arteries, comes with many postoperative complications including a decline in pulmonary function. Some preoperative exercises help reduce such pulmonary complications and improve postoperative pulmonary function.

Objectives: to determine the effects of preoperative respiratory rehabilitation on post-operative pulmonary functioning in CABG patients.

Methods: a randomized clinical trial with two groups was conducted in the Armed Forces Institute of Cardiology & NIHD Rawalpindi from June 2022- July 2023. The n=86 participants included ages between 40-65 years, those undergoing elective CABG surgery for any cardiac disease, patients who covered at least 400 steps on a 6-minute walk test, patients with ejection fraction 45% or more, and those who reserved at 4th postoperative day of CABG. Group A received Pre and Postoperative Respiratory Rehabilitation. Both groups received postoperative care for 4 days. All the patients were assessed for FEV1, FVC, and their ratio (FEV1/FVC) at baseline, on the 7th day, and on the 4th postoperative day of CABG surgery

Results: the experimental group significantly improved FVC compared to the control group, with moderate improvements observed (p=0.03*) by Day 7 and substantial improvements (p<0.001) by Post Day 4. When compared, at day 7 before surgery no significant difference (p=0.07) observed but The experimental group showed more significant improvement (p=0.006**) post operative day 4. Overall, no significant difference (p<0.05) between the experimental group and the control group consistently in all assessment level of FEV_1/FVC ratio.

Conclusion: The experimental intervention demonstrated positive effects on FVC and FEV1, reflecting improved lung function, while no significant impact was observed on the FEV1/FVC ratio, suggesting that the intervention did not affect the airflow dynamics in relation to lung volume.

Keywords: Forced expiratory volume; Forced vital capacity; FEV1/FVC ratio; preoperative respiratory rehabilitation, coronary artery bypass graft surgery

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INTRODUCTION

Coronary artery disease (CAD) although most common in developing countries, is still one of major causes of deaths in developed countries[1]. Coronary artery bypass graft surgery (CABG) is performed to restore the blood supply of heart by bypassing the blocked vessels, after the diagnosis of disease through the angiography[2].

Preoperative respiratory rehabilitation has gained significant attention for the improved postoperative outcomes in coronary artery bypass graft (CABG) patients[3]. Studies have demonstrated that preoperative interventions, including inspiratory muscle training (IMT), deep breathing exercises, and incentive spirometry, can reduce the incidence of postoperative pulmonary complications (PPCs) and enhance recovery[4, 5].

Additionally, the use of preoperative respiratory rehabilitation programs that include expiratory positive airway pressure (EPAP), breathing exercises, and ambulation has been linked to improved pulmonary function, increased mobility, and better physical endurance in CABG patients[4-7]. Randomized control trials have supported the effectiveness of preoperative IMT in reducing atelectasis, enhancing oxygen saturation, and shortening ICU and hospital stays[8, 9]. However, the duration and intensity of these preoperative programs influence their efficacy, with prolonged training yielding better outcomes[10].

Despite the established benefits of preoperative respiratory rehabilitation in coronary artery bypass grafting (CABG) patients, there is limited evidence from Pakistan. In healthcare resources, patient education, and access to structured rehabilitation programs may differ significantly within the country as well as from developed nations. Most available studies are conducted in high-income countries with advanced healthcare systems, where patients are more likely to receive standardized care and preoperative counseling. Addressing this research gap is crucial for reducing morbidity, mortality, and healthcare costs. Evaluating the effect of preoperative respiratory rehabilitation in a local context, this study can provide evidence to inform clinical guidelines and policies tailored to the needs and limitations of the Pakistani healthcare system.

METHODS

Study Design and Setting: A single-blinded randomized clinical trial was conducted in the Armed Forces Institute of Cardiology & NIHD Rawalpindi (Approval # 9/2/R&D/2022/230). The study was completed within 1 year from June 2022- to July 2023 and approval was taken from the research and ethical committee (REC) of the Faculty of Rehabilitation and Allied Health Sciences (Ref # Riphah/RCRS/REC/ 01378) Riphah International University. Informed consent was obtained from potential trial participants or authorized surrogates by getting a signature form from them.

Participants: The participants included ages between 40-65 years, those undergoing elective CABG surgery for any cardiac disease, patients who covered at least 400 steps on a 6-minute walk test, patients with ejection fraction 45% or more, and those who reserved at 4th postoperative day of CABG. Any patients with acute ailments e.g. deteriorating cardiac condition, patients with a cardiac emergency (shock, acute MI), neurological disorders e.g. altered state of consciousness, paralysis, and those having redo surgeries were excluded from the study. Moreover, patients with any musculoskeletal disorder e.g. amputation of a limb, problems of balance and risks of falls, muscle weakness grade 3 or less, osteoporosis; leading to limitation in exercise were also excluded.

Sample Size: A nonprobability consecutive sampling technique was used to achieve the measured sample size. A total of n=86 sample size was calculated through G power, keeping the effect size small (0.1), α error margin at 0.05. To avoid β error probability, the power (1- β) was set at 0.80%. A total of n=120 patients were assessed for eligibility and n=86 participants fulfilled the inclusion criteria and were randomly allocated to group A (n=43) and group B (n=43). A total of n=73 participants were analyzed at the end of the study due to the loss of follow-up of n=5 patients from the experimental Group (n=38) and n=8 from the control group (n=35). (Figure 1)

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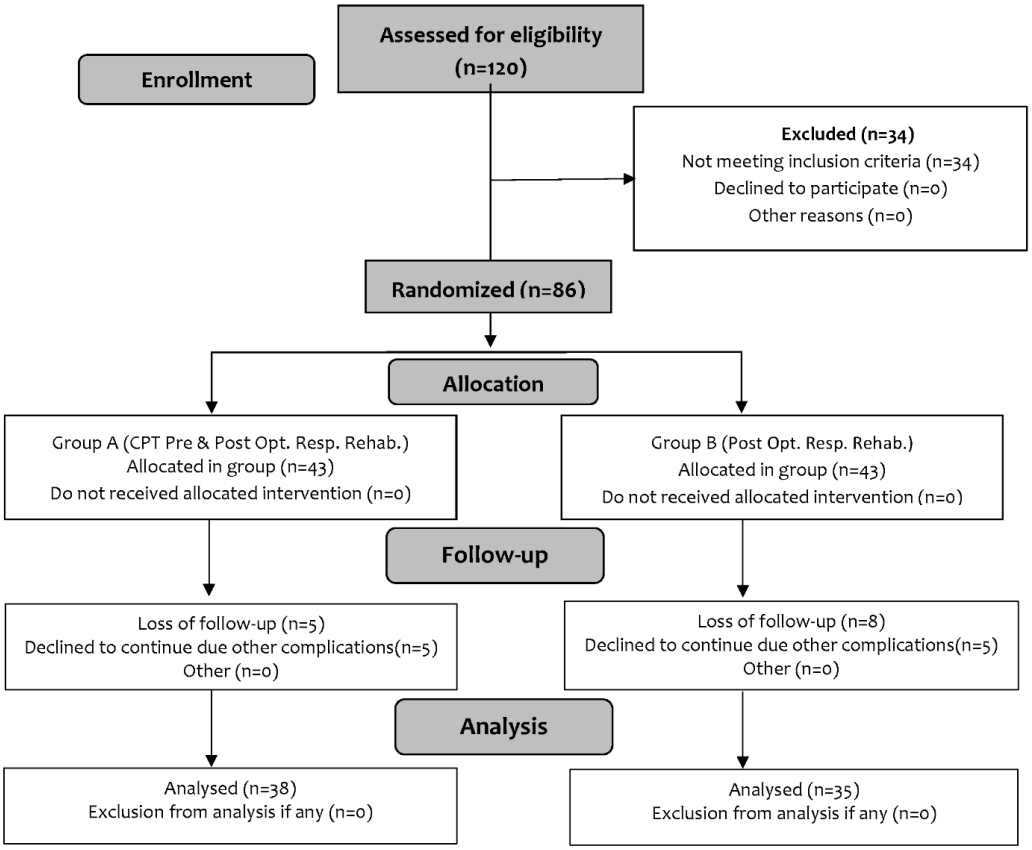

Figure 1: CONSORT diagram

Randomization and blinding: The participants were enrolled by nonprobability convenience sampling technique. There was no sequence generation by any means, participants were allocated randomly to interventions after screening according to selection criteria. The researcher blinded participants after assigning them to intervention by single blinding technique.

Intervention/Protocol: After the selection of patients who fulfilled the inclusion criteria and by obtaining consent from patients, Group A received Pre and Postoperative Respiratory Rehabilitation i.e. The Preoperative respiratory rehabilitation included the out of bed mobilization, forced expiratory techniques, active cycle of breathing techniques (ACBT) and incentive spirometry for 7 days. When both groups received postoperative incentive spirometry and chest percussion for 4 days. The patients were guided properly to perform each exercise or activity and to use the spirometer. All the interventions were performed under the monitoring of the researcher. For detailed intervention please see Table 1.

Table 1: Intervention Protocol in Both Groups

Group	Intervention	Details	Frequency/Duration
Group A: Pre and Post operative Respiratory Rehabilitation	Out of Bed Activity	Ankle pumps and lower extremity ROM in bed, 4-5 repetitions each. Sitting in bed/chair for 1 minute while monitoring vitals. 6-minute walk with rest on fatigue.	1 set, 3 times/day, for 7 days.
	Active Cycle of Breathing Techniques (ACBT)	Phase 1: 3-4 cycles of normal breathing (inspiration through nose, expiration through mouth). Phase 2: Slow inspiration through nose, 2-3 sec hold, and normal expiration. Phase 3: 2-3 huffs to expel secretions.	3 sets/day, for 7 days.
	Forced Expiratory Technique	Normal inhalation, prolonged exhalation into a bottle half filled with water to form bubbles. 2 sets of 4 repetitions.	4 times/day, for 7 days.
	Incentive Spirometry	Flow-based spirometer, 5 sets of 5 repetitions.	3 times/day, for 7 days.
Group B: Post operative Respiratory Rehabilitation	Incentive Spirometry	Flow-based spirometer, 5 sets of 5 repetitions.	3 times/day, for 4 days.
	Chest Percussion	Percussion of each lung lobe, performed if secretions were retained.	As needed, based on patient condition.

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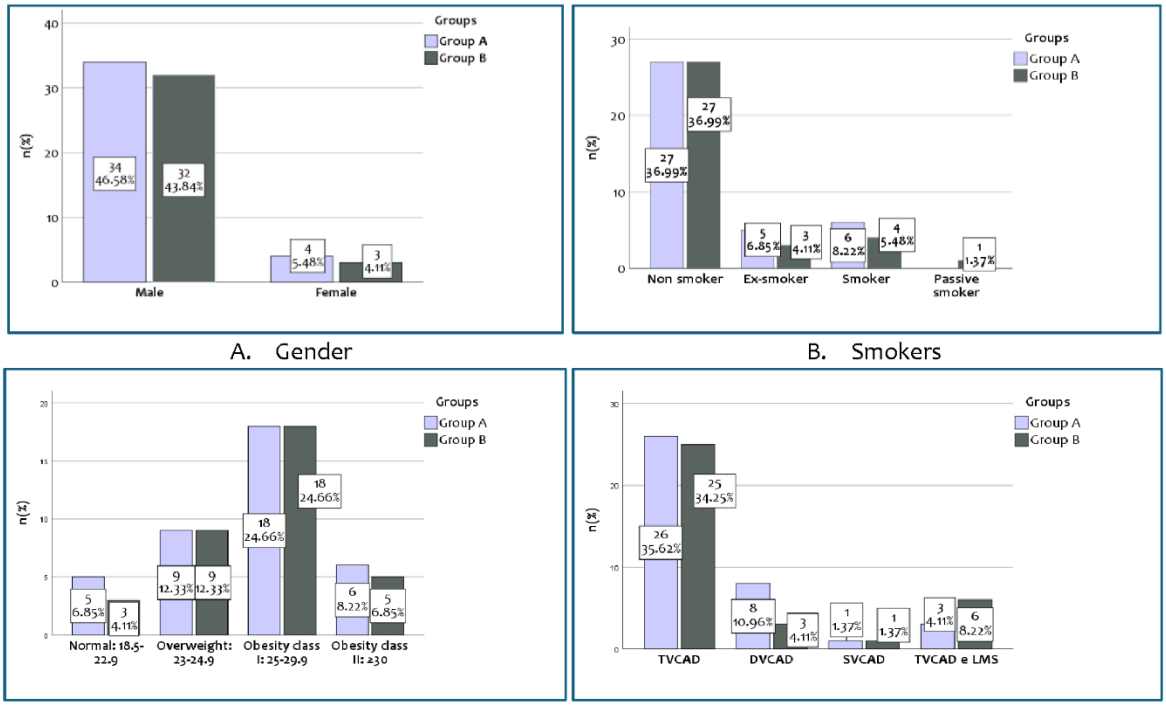
Assessment: After receiving the interventions of relative experimental and control groups, all the patients were assessed through pulmonary function testing by digital portable spirometer, and their FEV1, FVC, and ratio were assessed at baseline, on the 7th day, and on the 4th postoperative day of CABG surgery

Statistical Methods: For the analysis of data SPSS version 25 was used. The patient's demographics data including BMI, smoking history, age, and Ejection fraction were presented as mean, standard deviation, frequency, and percentages. As the data fulfilled the assumption of the parametric test, a Repeated measure ANOVA test with pairwise comparison was used for determination of change within a group determining the results at baseline, 7th day, and post-operative 4th day, as parametric tests were found relevant according to the data. Whereas an independent T-test was used between the group results were applied to compare the means between two unrelated groups.

RESULTS

The Mean age of the patients was 55.68±7.29 years, BMI 26.33±3.51 kg/m², and ejection fraction was 51.71±7.4 percent, respectively.



A. Gender B. Smokers

C. BMI Category D. Type of disease

Figure 2: Distribution of Demographic Variables

this study included n=66 males and n=07 females. (Figure 2A) A majority (n=64) of the participants were nonsmoker; whereas n=8 were ex-smokers who quitted smoking 1 year ago, while n=12 participants in the study were smoker, and n=1 was passive smoker. (Figure 2B) The Body mass index (BMI) was calculated in accordance with the Asia-Pacific classification, which showed that n=36 participants were categorized into Obese class I, n=18 into Overweight category, n=11 was into Obese class II category and only n=8 were categorized inti normal weight category. (Figure 2C) While triple vessel coronary artery disease (TVCAD) being more prevalent (n=58), 14 patients presented with double vessel CAD (DVCAD), 10 Patients had TVCAD through left main stem disease and 3 patients had single vessel coronary artery disease (SVCAD). (Figure 2D)

The results of the RMANOVA showed Forced Vital Capacity (FVC %), in the experimental group, a significant increase from baseline to Day 7 (p=0.02) and an even more significant improvement by Post Day 4 (p<0.001), indicating a large effect size and substantial impact of the intervention. In contrast, the control group exhibited no significant change from baseline to Day 7 (p=1), but a notable improvement by Post Day 4 (p<0.001), suggesting effect of Intervention. For Forced Expiratory Volume (FEV_1 %), the experimental group showed significant improvements from baseline to Day 7 (p=0.009) and a significant increase by Post Day 4 (p<0.001), augmenting the substantial benefit of the intervention over time. Similarly, the control group demonstrated a smaller but significant improvement from baseline to Day 7 (p=0.03) and a continued increase by Post Day 4 (p<0.01), indicating some recovery. For the FEV_1/FVC ratio, the experimental group experienced moderate improvements, with significant changes observed from baseline to Day 7 (p=0.02) and Post Day 4 (p=0.004). In contrast, the control group exhibited no significant changes across time points (p>0.5),

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suggesting that this parameter was less responsive to incentive spirometry. (Table 2)

Table 2: Within group changes (Group A & B)

Group		Mean	SD	MD/F(df)	p-value	ηp^2
		FVC (%)				
Group A (n=38)	Baseline	89.03	24.232	-7.82	0.02*	-
	Day 7	96.85	22.848	60.23	.000***	-
	Post Day 4	36.62	5.997	209.98(1.81,67.22)	.000***	.850
Group B (n=34)	Baseline	83.67	23.664	-1.11	1	-
	Day 7	84.78	23.408	54.92	.000***	-
	Post Day 4	29.86	6.850	184.60(1.48,44.64)	.000***	.848
		FEV_1 (%)				
Group A (n=38)	Baseline	93.44	26.306	-4.51	0.009**	-
	Day 7	97.95	26.064	58.42	.000***	-
	Post Day 4	39.52	10.912	147.430	.000***	.799
Group B (n=34)	Baseline	82.91	21.853	-4.36	0.03*	-
	Day 7	87.27	23.664	55.14	.000***	-
	Post Day 4	32.13	11.518	147.797	.000***	.813
		FEV_1/FVC Ratio				
Group A (n=38)	Baseline	84.4474	15.30712	-.90	1	-
	Day 7	85.3555	14.47026	-7.22	0.02*	-
	Post Day 4	92.5789	8.45858	5.923	.004**	.138
Group B (n=34)	Baseline	87.7589	19.90660	0.2	1	-
	Day 7	87.5597	18.49021	-7.64	0.33	-
	Post Day 4	95.2000	15.99412	2.443	.125	.067

*Level of significance- p<0.001***, p<0.01**, p<0.05*; SD-standard deviation; df-degree of freedom; ηp^2-partialeta-squared; FVC-forced vital capacity; FEV_1-forced expiratory volume; MD-mean difference; Group A- pre and post operative respiratory rehabilitation; Group B- post operative respiratory rehabilitation*

The independent t-test results demonstrate that the experimental group significantly improved FVC compared to the control group, with moderate improvements observed (p=0.03*) by Day 7 and substantial improvements (p<0.001) by Post Day 4. When compared, at day 7 before surgery no significant difference (p=0.07) was observed but The experimental group showed more significant improvement (p=0.006**) post operative day 4. Overall, no significant difference (p<0.05) between the experimental group and the control group consistently in all assessment levels of FEV_1/FVC ratio. (Table 3)

Table 3: Comparison between group A & B

		Group A (n=38)		Group B (n=34)		MD	p-value	Cohen's d
		Mean	SD	Mean	SD			
FCV (%)	Baseline	89.03	24.23	83.67	23.66	5.72	.309	-
	Day 7	96.85	22.84	84.78	23.40	12.07	.030*	0.52
	Post Day 4	36.62	5.99	29.86	6.85	6.71	.000***	1.05
FEV (%)	Baseline	93.44	26.30	82.91	21.85	10.52	.068	-
	Day 7	97.95	26.06	87.27	23.66	10.67	.072	-
	Post Day 4	39.52	10.91	32.13	11.518	7.39	.006**	0.65
FEV_1/FVC Ratio	Baseline	84.44	15.30	87.75	19.90	-.6761	.877	-
	Day 7	85.35	14.47	87.55	18.49	-2.20	.571	-
	Post Day 4	92.57	8.45	95.20	15.99	-2.62	.379	-

*Level of significance- p<0.001***, p<0.01**, p<0.05*; SD-standard deviation; df-degree of freedom; ηp2-partialeta-squared; FVC-forced vital capacity; FEV1-forced expiratory volume; MD-mean difference; Group A- pre and post operative respiratory rehabilitation; Group B- post operative respiratory rehabilitation*

DISCUSSION

The findings of the study underscore the efficacy of preoperative respiratory rehabilitation, particularly through active interventions like out-of-bed mobilization and respiratory exercises, in enhancing Forced Vital Capacity (FVC) and Forced Expiratory Volume (FEV %) compared to traditional methods such as incentive spirometry. Evidence from various studies indicates that these dynamic rehabilitation techniques significantly improve pulmonary function, reduce the incidence of postoperative complications like pneumonia, and facilitate quicker recovery post-CABG surgery[11, 12].

The experimental group in the study exhibited marked improvements in FVC and FEV, aligning with literature that highlights the benefits of early mobilization and comprehensive preoperative care[13, 14]. Conversely, the control group, while showing some improvement, did not achieve the same level of benefits, emphasizing the necessity for more robust preoperative strategies to optimize

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patient outcomes following cardiac surgery[12, 15]. The observed differences in postoperative outcomes can be attributed to the comprehensive multifaceted approach, including ankle pumps, lower extremity range of motion exercises, and Active Cycle of Breathing Techniques (ACBT), which enhanced respiratory function more effectively than incentive spirometry alone[16, 17].

Previous studies have shown that while incentive spirometry can reduce postoperative pulmonary complications, its efficacy is often limited compared to more integrated rehabilitation strategies[18, 19]. For instance, a systematic review indicated that preoperative breathing exercises significantly improve respiratory performance and reduce complications, suggesting that the combination of techniques used in the experimental group may provide synergistic benefits[17]. The significant improvements in FVC observed in the experimental group highlight the importance of a holistic approach to preoperative care in enhancing postoperative recovery[19, 20].

In contrast, the control group, while showing some improvement in FEV, did not achieve the same level of significance, indicating that the structured preoperative approach may be more effective in mitigating pulmonary complications[17, 18]. Previous literature supports that preoperative respiratory exercises can lead to better postoperative outcomes, including reduced atelectasis and improved oxygenation, thus highlighting the importance of tailored preoperative interventions[21].

The observed differences in the FEV_1/FVC ratio improvements between the experimental and control groups in the study on preoperative respiratory rehabilitation for CABG patients can be contextualized within the existing literature. While the experimental group showed significant enhancements in respiratory function (FEV_1/FVC ratio), particularly from baseline to Day 7 and Post Day 4, respectively, the control group did not exhibit notable changes[16, 18]. This aligns with findings from other studies that emphasize the efficacy of preoperative interventions, such as incentive spirometry and breathing exercises, in reducing postoperative pulmonary complications and improving oxygenation[21-23]. However, some literature suggests that the benefits of such interventions can be inconsistent, with certain studies reporting no significant differences in outcomes like atelectasis and hypoxemia[24].

The variability in results may stem from differences in study design, patient populations, and the specific rehabilitation protocols employed, highlighting the need for standardized approaches to maximize postoperative respiratory outcomes.

CONCLUSION

The experimental intervention demonstrated positive effects on FVC and FEV1, reflecting improved lung function. While the FEV_1/FVC ratio exhibited moderate improvements in the experimental group, it remained less responsive in the control group, underscoring the need for tailored, multifaceted approaches to optimize respiratory recovery post-surgery. Overall, this study demonstrates that a structured and integrative preoperative rehabilitation program can significantly enhance recovery and pulmonary outcomes in CABG patients, advocating for its routine incorporation into pre-surgical care protocols.

DECLARATIONS & STATEMENTS

Author's Contribution

AI and MAAM, and IT: substantial contributions to the conception and design of the study.
AI and AK: acquisition of data for the study.
AI, KM and SSAI, : analysis of the data for the study. AA and AI, QU, MM and KM : interpretation of data for the study.
AA: drafted the work.
AI, SS, QU, MM, KM, MAAM, and IT: revised it critically for important intellectual content.
AI, SS, QU, MM, KM, MAAM, and IT: final approval of the version to be published and agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All authors contributed to the article and approved the submitted version.

Ethical Statement

The study was conducted in the Armed Forces Institute of Cardiology & NIHD Rawalpindi (Ref No. 9/2/R&D/2022/230) and approval was taken from the research and ethical committee (REC) of the Faculty of Rehabilitation and Allied Health Sciences (Ref. No. Riphah/RCRS/REC/ 01378) Riphah International University.

Consent Statement

Informed consent was obtained from all subjects involved in the study.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Acknowledgments

None to declare.

Conflicts of Interest

The authors declare no conflict of interest.

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