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Original Article

Effects of Respiratory Physiotherapy in Pulmonary Dysfunction after Cardiac Surgery

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ABSTRACT

Background: Cardiovascular system diseases are a leading cause of death globally. Heart surgeries, performed worldwide to treat these conditions, are often followed by high rates of postoperative complications.

Objective: The study aimed to compare the effects of pulmonary physiotherapy on respiratory dysfunction following cardiac surgery.

Methods: Forty patients with pulmonary dysfunction post-coronary artery bypass grafting (CABG) participated in the study. They were randomly assigned to receive either postoperative pulmonary physical therapy, including breathing exercises and respiratory muscle training, or conventional physical therapy exercises. Vital capacity (VC), forced vital capacity (FVC), forced expiratory volume in one second (FEV1), and inspiratory capacity (IC) were measured using spirometry. Data analysis was conducted using the Statistical Package for the Social Sciences (SPSS), with paired t-tests comparing all variables. Results were considered significant at a p-value < 0.05.

Results: The study included 21 participants in each group, with a mean age of 55.37 ± 8.72 years. Mean vital capacity in Group A was 2.40 ± 0.46 pre-treatment, increasing to 2.97 ± 0.43, while in Group B it was 2.34 ± 0.41 at baseline, increasing to 2.98 ± 0.36, with a p-value > 0.05 indicating no significant pre- and post-test effects in Group A. Significant pre-post differences in spirometry values were observed within both groups, but no significant differences were noted when compared across the groups following CABG.

Conclusion: The study concluded that pulmonary rehabilitation post-cardiac surgery is highly recommended to minimize postoperative complications of heart surgery. It contributes significantly to the prognosis of these patients, emphasizing the importance of preoperative procedures focused on preventing pulmonary system complications and facilitating recovery in the postoperative period after major cardiac surgeries.

Keywords: coronary artery bypass, physical therapy, respiratory function tests, thoracic surgery, positive pressure respiration.

INTRODUCTION

Cardiovascular diseases are the leading cause of death in both developed and developing countries, with an increasing prevalence noted in the latter. A study encompassing 115,022 heart surgeries revealed an overall mortality rate of 8%, predominantly occurring postoperatively, with respiratory complications being a frequent cause (1). The pulmonary complications following heart surgery are often secondary to the use of cardiopulmonary bypass (CPB), surgical trauma, anesthesia, as well as preoperative factors such as age and smoking habits (2). Compared to preoperative lung volumes, a mean reduction of 40–50% in forced vital capacity and expiratory volume in the first second is reported on the first and third postoperative days (3). On the second postoperative day, a significant reduction of 62% in vital capacity (VC) is noted, with lung volumes potentially remaining reduced for up to four months after the procedure (4). A majority of patients undergoing open-heart surgery develop postoperative atelectasis, contributing to impaired gas exchange at the alveolar level (5). Risk factors associated with decreased lung volumes post-surgery include chronic obstructive pulmonary disease (COPD), general health conditions, a history of smoking, and advanced age (6). Pulmonary complications, encompassing adverse changes in the respiratory system postoperatively, commonly present as altered respiratory

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muscle function, reduced lung volume, atelectasis, and respiratory failure, which significantly contribute to morbidity and mortality (7). The incidence of postoperative complications varies from 5 to 80%, depending on patient demographics and the criteria used to define complications, with variation also observed across hospitals (8). Interventions commonly employed by physiotherapists, such as postoperative breathing exercises, effective coughing techniques, inspiratory muscle training, and early patient mobilization, aim to limit the reduction in lung volumes and the development of atelectasis, while improving blood oxygenation following open-heart surgery (9). Cardiac bypass is also implicated in ischemia-reperfusion syndrome, characterized by the release of free radicals and proteolytic enzymes, leading to tissue injury. Major factors contributing to morbidity and mortality include pulmonary dysfunction, pneumonia, atelectasis, and secretion retention due to reduced physical activity post-surgery (10). Conventional definitions of postoperative pulmonary complications include atelectasis, disease exacerbation, bronchospasm, and pneumonia, but may extend to upper airway obstruction and complications from obstructive apnea (11). Given these presentations and potential repercussions, cardiorespiratory physiotherapy has been recognized as a critical intervention to reverse, limit, or prevent these complications through a variety of techniques (12). Chest physiotherapy is routinely used to prevent or mitigate pulmonary complications post-surgery, with treatment comprising early mobilization, frequent patient repositioning, breathing exercises, and effective coughing and huffing techniques (13). Various mechanical devices, such as continuous positive airway pressure (CPAP), spirometry, and intermittent positive pressure (IPP) breathing, are also employed to enhance postoperative pulmonary function (14). Additionally, resistive breathing techniques like positive expiratory pressure (PEP) and inspiratory resistance positive expiratory pressure (IR-PEP) have been introduced to improve diaphragm function post-open heart surgery (15). Forced vital capacity (FVC) measures the maximum amount of air exhaled forcefully after maximal inhalation (16), while the first-second volume indicates the amount exhaled in the first second of this maneuver (17). Hussain et al. conducted a study using spirometry, training patients in its use, as is common in clinical settings, concluding both are effective in reducing atelectasis and improving lung function post-coronary artery bypass grafting (CABG) (18). The literature review indicates that respiratory physiotherapy has not been extensively utilized as a primary treatment modality, with most trials suggesting it as a home-based care component post-surgery (19). Variations in chest physiotherapy techniques exist globally, with no consensus on the optimal approach post-open heart surgery (20). Therefore, this study aims to evaluate the efficacy of pulmonary physiotherapy techniques, such as spirometry and deep breathing exercises, in conjunction with chest muscle training post-procedures like CABG, compared to conventional physiotherapy methods. The objective is to assess the impact of pulmonary physiotherapy on respiratory dysfunction following cardiac surgery, with a focus on respiratory physiotherapy as the primary intervention, contributing to the evidence base on its effects on postoperative outcomes in patients with pulmonary dysfunction.

MATERIAL AND METHODS

This non-randomized trial was conducted at Sheikh Zayed Hospital, Lahore. The study received approval from Riphah College of Rehabilitation and Allied Health Sciences (REC/RCR& AHS/21/0308) and was carried out from 15 June 2021 to January 2022. Data collection utilized purposive convenience sampling. The sample size was calculated based on the means of Group 1 (66.07) and Group 2 (69.25), with variances of 13.85 and 11.65, respectively. Considering a confidence level of 0.95, a study power of 0.80, a ratio of sample sizes (n2/n1) of 1, two-tailed tests, and an anticipated 20% drop rate, the sample size for each group was determined to be 24 (21).

The study included subjects of both genders, aged between 40 to 80 years, who had undergone coronary artery bypass grafting (CABG) and exhibited a symptom cascade indicative of pulmonary dysfunction. Exclusion criteria encompassed patients with active or unstable angina, multiple cardiac or other surgeries, primary pulmonary diseases such as COPD or Tuberculosis, hemodynamic complications like myocardial infarction and marked hypotension, oxygen saturation less than 94 millimeters of mercury, mechanical ventilation exceeding 24 hours, past open-heart surgery, or renal insufficiency, including those on dialysis. Demographic screening and a set of outcome measures were used. Eligible patients were invited to participate in the study following a set protocol that included obtaining permission and consent forms (assent from guardians when necessary).

Spirometry, the primary tool for lung function testing, measures inhaled and exhaled air volumes, flows, and times. It is noninvasive, objective, and sensitive to early changes, used to detect lung diseases, assess lung impairment, and evaluate medication effects (22). Group A (Experimental Group) received pulmonary physiotherapy, while Group B received routine care without pulmonary physiotherapy. Spirometry measurements included vital capacity (VC), inspiratory capacity (IC), forced vital capacity (FVC), and forced expiratory volume in one second (FEV1).

Patients in Group A underwent respiratory physiotherapy, primarily focusing on respiratory muscle training. This included using a spirometer and balloon blowing for 30 minutes daily. The correct posture was ensured for spirometer measurements, with patients sitting upright, feet flat on the floor, wearing loose clothing, and relaxing their abdominal muscles. The spirometer was used for 5

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minutes, five times a day. For FVC and FEV1 measurements, patients inhaled deeply and then exhaled forcefully and completely. VC measurements involved a steady, complete exhalation. A nose clip was particularly used for VC measurements to prevent air leakage due to low flow. The inspiratory vital capacity (IVC) maneuver was performed at the end of FVC/VC by inhaling deeply after complete exhalation. Respiratory muscle training guidelines included various breathing exercises, such as inhaling through the nose and exhaling through the mouth, using abdominal or chest muscles, and incorporating arm movements and trunk pivoting. All patients performed 30 full breaths with a rubber balloon hourly during daytime and began these activities one hour after extubation, continuing until the fourth postoperative day.

Group B patients received standard postoperative physiotherapy twice daily, including active mobilization and exercises for the upper limbs and chest. They were encouraged to stand and sit out of bed on the first postoperative day, walk a short distance on the second day, and walk freely in the hallway by the third day.

Spirometry was used preoperatively and on the fourth postoperative day to measure lung volumes, including VC, FVC, FEV1, and IC. The highest value of three acceptable maneuvers was recorded for VC, FVC, and FEV1, and a mean value was calculated for IC.

Data analysis was conducted using the Statistical Package for the Social Sciences (SPSS) for Windows, version 21. The data was expressed as mean ± SD. The Shapiro-Wilk Test was used to assess the normality of the data. Parametric paired and independent t-tests were applied to compare within and between groups, respectively, with a significance level set at 95% ($p<0.05$). The ethical clearance was taken from Riphah International University, Lahore, with Reference REC/RCR& AHS/21/0308.

RESULTS

In the experimental Group A, 65.00% of the participants were females and 35.00% were males. In Group B (Routine Care), the composition was 60.00% females and 40.00% males. The average age of the participants was 55.37 ± 8.72 years. In terms of vital capacity, the mean value in Group A was 2.40 ± 0.46 pre-treatment, which increased to 2.97 ± 0.43 post-treatment. For Group B, the baseline mean was 2.34 ± 0.41, rising to 2.98 ± 0.36 post-treatment. However, the P-value was >0.05, indicating no significant difference in pre- and post-test effects in both Group A and Group B. This finding is illustrated in Table 1.

A significant difference in spirometry values was observed within each group pre- and post-treatment. However, when comparing the results between the two groups post-coronary artery bypass grafting (CABG), no significant difference was noted, leading to the acceptance of the null hypothesis. This is detailed in Table 2.

Table No. 1 Within Group comparison of outcomes (n=20)

Outcomes	Evaluation	Group A		Group B		P-value
		Mean	SD	Mean	SD	
Vital Capacity	Pre-Treatment	2.40	0.46	2.43	0.41	0.94
	Post-Treatment	2.97	0.43	2.98	0.35	0.68
Forced Vital Capacity in liter	Pre-Treatment	90.6	14.34	91.45	0.39	0.68
	Post-Treatment	94.0	13.4	95.05	13.73	0.69
Forced Expired Volume 1 liter	Pre-Treatment	94.6	14.93	94.35	12.70	0.21
	Post-Treatment	97.85	12.0	94.15	14.39	0.19
Inspiratory Capacity	Pre-Treatment	2.05	0.51	2.130	0.46	0.45
	Post-Treatment	2.47	0.66	2.66	0.46	0.56

Table No. 2 Between Group differences of outcomes (n=20)

Evaluation	Mean	SD	SD Error Mean	95% Confidence Interval differences		t	df	P-value
				Lower	Upper			
Pre-Post Vital Capacity	0.97	0.12	0.19	0.93	1.01	50.71	40	0.00
Pre-Post forced vital Capacity	0.99	0.26	0.00	0.98	1.00	238.45	40	0.00
Pre-Post Forced Expiratory volume ta the end of 1st second	0.98	0.09	0.15	0.95	1.01	62.87	40	0.00
Pre-Post Inspiratory Capacity	0.92	0.17	0.02	0.87	0.98	33.49	40	0.00

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DISCUSSION

Exercise-based therapy is routinely employed in the postoperative management of cardiac surgeries to address pulmonary complications such as pneumonia, atelectasis, and pleuritic effusions, aiming to accelerate recovery and improve lung function typically within approximately 15 days post-surgery (24). Coronary artery bypass grafting (CABG) is frequently associated with post-operative complications like pneumonia and atelectasis (25). This study primarily aimed to evaluate the efficacy of pulmonary physiotherapy techniques, including spirometry and deep breathing exercises, coupled with chest muscle training post-CABG, and compared these with conventional physiotherapy techniques.

Renault et al. (2009) conducted a review on the various methods used in chest physiotherapy post-cardiovascular surgery, selecting eleven randomized controlled trials. Among these studies, spirometry was used in three, deep breathing exercises in six, and deep breathing with positive expiratory pressure (PEP) in four. Positive expiratory pressure with increased inspiratory resistance was employed in two studies. Three studies utilized intermittent positive pressure breathing. Continuous PEP and bi-level positive airway pressure were used in three and two studies, respectively. The protocols varied, and co-interventions were common (26). This study's groups were homogeneous regarding surgical procedures and other demographics. A significant pre-post difference in spirometry values was observed within both groups, but no significant difference was noted across the groups post-CABG. This aligns with the findings of Collins J-A et al. (2015), who reported a decline in maximum expiratory pressure (MEP) initially, with partial recovery by the seventh postoperative day. Oxygen saturation was the only variable fully recovered by the seventh day. Their study also noted insignificant differences between groups undergoing spirometry and those performing deep breathing exercises in terms of MEP, spirometry values, and oxygen saturation in CABG patients (27).

Cordeiro et al. (2016) conducted a study on preoperative inspiratory muscle training at home to improve lung function and reduce morbidity and mortality in CABG patients. They found no significant differences in pre and post values of arterial blood gas (ABG), maximal inspiratory pressure (MIP), and MEP. However, forced vital capacity (FVC) and maximal voluntary ventilation (MMV) showed improvement postoperatively, though the clinical benefits of the program were not conclusively determined (28).

The current study also demonstrated significant differences within groups in terms of vital capacity, forced vital capacity, forced expiratory volume, and inspiratory capacity, but not between groups post-CABG. These results are supported by another study suggesting that spirometry combined with physiotherapy is more effective than physiotherapy alone in reducing postoperative complications in high-risk patients after CABG (34).

Johnson et al. (2020) identified height and weight as significant variables affecting respiratory parameters on spirometry (29), but the current study did not focus on these factors and their correlations. In conclusion, respiratory therapy is a crucial component of pre- and postoperative care in cardiac surgery. The reliability of the results could have been enhanced by more effective patient documentation. The effects of respiratory physiotherapy could be further analyzed using more sensitive diagnostic tests. Due to time constraints, more intensive patient supervision was not feasible. This study concludes that pulmonary rehabilitation post-cardiac surgery is strongly recommended to minimize post-operative complications. Future research should involve larger sample sizes for broader generalization. The role of respiratory therapy in the pre- and postoperative periods of CABG is of paramount importance, yet further studies are necessary to explore these aspects using specific methodological approaches aimed at standardizing procedures. Homogeneous criteria should be employed to evaluate the variables.

CONCLUSION

This study determined that cardiopulmonary physical therapy interventions are effective as postoperative treatments for patients with pulmonary dysfunction following cardiac surgeries. Significant differences in spirometry values were observed pre- and post-intervention within both groups. However, when comparing these outcomes across the groups post-coronary artery bypass grafting (CABG), no significant differences were found, thereby supporting the acceptance of the null hypothesis.

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