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Impact of a supervised pulmonary rehabilitation program on postoperative dyspnea in patients undergoing cardiac surgery

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Abstract
Aim: This prospective study aimed to analyze the impact of postoperative in-hospital pulmonary rehabilitation on pulmonary outcomes in patients who underwent cardiovascular surgery.
Material and Methods: This study was carried out on subjects who underwent cardiovascular surgery and were scheduled for a supervised pulmonary rehabilitation program following the cardiac surgery in our institute. The BORG scale of perceived exertion, a 100 points VAS scale for the severity of perceived dyspnea, and Respiratory Distress Assessment Instrument (RDAI) score were applied before and after completion of pulmonary rehabilitation program. Dyspnea, orthopnea, tachypnea, anxiety, cough and presence of sputum were also recorded prior to and subsequent to pulmonary rehabilitation. Blood gas analysis was also carried out before and after pulmonary rehabilitation.
Results: BORG scale score (1.89±0.07 vs. 1.21±0.05, p=0.001), VAS scale scores for dyspnea (5.7±0.4 vs. 8.5±0.8, p<0.001), and RDAI scores (4.2±0.5 vs. 7.8±1.2, p<0.001) improved significantly following pulmonary rehabilitation. The prevalence of dyspnea and tachypnea also reduced following pulmonary rehabilitation. No significant change was observed in blood gas analysis results.
Discussion: Application of a supervised pulmonary rehabilitation program including removal of bronchial secretions, postural drainage, percussion, vibration and aspiration and patients positioning improves self-reported dyspnea in patients who underwent cardiac surgery.

Keywords
Pulmonary Rehabilitation, Dyspnea, Cardiac Surgery

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Introduction

Surgical stress and anesthesia deteriorate the ventilation/perfusion balance through the reduction of functional residual capacity as a consequence of the inhibition of the hypoxic pulmonary vasoconstrictive response, elevation of the diaphragm, and reduction in mucociliary clearance [1]. Moreover, the absence of a cough reflex and the presence of artificial airway and related mucosal damage may result in pulmonary infections, particularly ventilator-associated pneumonia. Cardiovascular surgery is a major surgery that may further deteriorate pulmonary function due to the devastating nature of the surgical procedure and postoperative pain associated with mid-line thoracotomy [2,3].

Pulmonary rehabilitation is a multidisciplinary intervention developed to improve exercise capacity, functional status, and health-related quality of life, and to reduce dyspnea and fatigue among patients with chronic respiratory conditions. The role of pulmonary rehabilitation in postoperative outcomes in patients with chronic obstructive pulmonary disease is well established [4]. Pulmonary rehabilitation also led to promising improvements in exercise capacity, dyspnea, and health-related quality of life in patients undergoing lung transplantation and lung volume reduction surgery [5,6]. Studies on patients with lung cancer have also revealed that pulmonary rehabilitation lowers the risk of postoperative complications and reduces the length of hospital stay. Despite satisfactory evidence regarding the role of pulmonary rehabilitation on postoperative outcomes and health-related quality of life in patients undergoing lung surgery, there is no evidence of its role in pulmonary outcomes in subjects undergoing cardiovascular surgery.

This prospective study aimed to analyze the impact of postoperative in-hospital pulmonary rehabilitation on pulmonary outcomes in patients who underwent cardiovascular surgery.

Material and Methods

This study was carried out on subjects who underwent cardiovascular surgery at Mehmet Akif Ersoy Training and Research Hospital, Department of Thoracic and Cardiovascular Surgery, between May 2016 and November 2016. Written informed consent was obtained from all subjects. The study was approved by the local ethics committee and conducted in accordance with the Declaration of Helsinki. All subjects received supervised pulmonary rehabilitation coordinated by a physical medicine and rehabilitation specialist for a minimum duration of 20 minutes, twice daily until discharge. Pulmonary rehabilitation programs, including improvement of bronchial hygiene and removal of bronchial secretions, postural drainage, percussion, vibration, and aspiration, were applied to all subjects following cardiac surgery. Subjects with postoperative pulmonary atelectasis were positioned according to the localization of the atelectatic lung area to improve the ventilation/perfusion ratio.

The demographic and clinical features of the study participants were recorded prior to enrollment. The BORG scale of perceived exertion (6 points indicating no feeling of exertion and 20 points indicating very, very hard), VAS scale of 100 points for the severity of perceived dyspnea (0 points indicating no dyspnea and 100 points indicating severe dyspnea perceived ever), and respiratory distress assessment instrument (RDAI) score (0 points indicating no respiratory distress and 17 points indicating severe respiratory distress) were applied before and after completion of the pulmonary rehabilitation program.

The Borg CR10 scale is a tool for measuring an individual's effort and exertion, breathlessness, and fatigue during physical work [7]. The individuals were asked to circle or tick the number that best describes breathlessness from 0 to 10; 0 indicates no exertion at all and 10 indicates maximal) on average over the last 24 h.

The RDAI score was originally developed to assess the response to treatment of bronchiolitis [8]. However, recent data indicate that the RDAI score can also be used to predict short-term outcomes of acute lower respiratory tract infections [9]. The RDAI score is the sum of the row scores, including wheezing in expiration, inspiration, and lung fields, and supraclavicular, intercostal, and subcostal retractions, with a total range of 0 to 17; higher scores indicate more severe disease.

Dyspnea, orthopnea, tachypnea, anxiety, cough, and sputum were also recorded before and after pulmonary rehabilitation. The mean systolic and diastolic blood pressure, heart rate, and respiration rate were recorded. Blood gas analysis was performed before and after pulmonary rehabilitation (ABL800 FLEX blood gas analyzer, Radiometer, Brønshøj, Denmark).

Differences in BORG scale scores, VAS scale scores, and RDAI scores and in the prevalence of dyspnea, orthopnea, and tachypnea between the pre-and post-rehabilitation periods were the primary outcome measures of this study. Changes in blood gas analysis parameters, including pH, SaO2, pO2, pCO2, and HCO3, was the secondary outcome measure.

Statistical analysis

All analyzes were performed using SPSS v21 (SPSS Inc., Chicago, IL, USA). The Shapiro-Wilk test was used to determine whether the variables were normally distributed. Data are presented as mean ± standard deviation or median (minimum–maximum) for continuous variables according to the normality of distribution and frequency (percentage) for categorical variables. The paired samples t-test was used to analyze normally distributed continuous variables. The McNemar test was used to compare pre-and post-rehabilitation prevalence of dyspnea, orthopnea, tachypnea, anxiety, cough, and presence of sputum. Two-tailed p-values of less than 0.05, were considered statistically significant.

Results

A total of 50 patients (mean age 57.5±8.2 years, 70% males) who underwent cardiac surgery in our institute and underwent pulmonary rehabilitation subsequent to the surgery were included in this study. Baseline demographic and clinical features of the study group are shown in Table 1. Thirty-seven subjects underwent cardiac surgery for multivessel coronary artery disease, 12 subjects with valvular disease, and 1 subject with congenital heart disease. Comparison of pre-and post-rehabilitation BORG scale scores, VAS scale scores for dyspnea, and RDAI scores and blood glucose results are presented in Table 2. BORG scale score (1.89±0.07 vs. 1.21±0.05, p=0.001), VAS scale scores for dyspnea (5.7±0.4 vs. 8.5±0.8, p<0.001),

Table 1. Baseline demographic features of the study group

	n=50
Age, years	57.5±8.2
Gender, male	35 (70%)
BMI, kg/m2	27.5±4.2
Hypertension, n	23 (46%)
Diabetes, n	15 (30%)
COPD, n	2 (4%)
Smoking, n	34 (78%)
Preoperative diagnosis	
CAD, n	37 (74%)
Valvular heart disease, n	12 (24%)
Congenital heart disease, n	1 (2%)
Ejection fraction, %	49.1±7.6

Table 2. Clinical parameters and blood gas analysis results prior to and subsequent to pulmonary rehabilitation

	Pre-PR	Post-PR	P-value
BORG	0.89±0.07	0.61±0.05	0.001
VAS	8.5±0.8	5.7±0.4	<0.001
RDAI	7.8±1.2	4.2±0.5	<0.001
Dyspnea, n	27 (54%)	19 (38%)	0.021
Ortopnea, n	12 (24%)	6 (12%)	0.250
Tachypnea, n	20 (40%)	10 (20%)	0.002
Anxiety, n	8 (16%)	4 (8%)	0.289
Cough, n	8 (16%)	7 (14%)	0.921
Sputum, n	14 (28%)	10 (20%)	0.219
Systolic BP, mmHg	137±19	131±19	0.001
Diastolic BP, mmHg	65±10	63±11	0.096
Heart rate, min	92±10	91±9	0.283
Respiratory rate, min	19.2±2.5	18.6±2.6	0.078
pH	7.434±0.036	7.428±0.036	0.128
SaO2, %	95.9±4.7	97.0±3.9	0.439
pO2	99.4±8.6	93.8±5.2	0.174
pCO2	35.1±4.3	35.7±3.6	0.329
HCO3	24.1±2.9	23.9±2.7	0.293

Data are presented as mean ± standard deviation for continuous variables and as frequency (percentage) for categorical variables. PR= Pulmonary rehabilitation, RDAI= Respiratory Distress Assessment Instrument, VAS= Visual analogue scale

and RDAI scores (4.2±0.5 vs. 7.8±1.2, p<0.001) improved significantly following pulmonary rehabilitation. The prevalence of dyspnea and tachypnea was also reduced following pulmonary rehabilitation. Moreover, systolic blood pressure decreased from 137±19 mmHg to 131±19 mmHg after pulmonary rehabilitation; however, no significant changes were observed in diastolic blood pressure, heart rate, and respiratory rate with pulmonary rehabilitation. The pre-and post-rehabilitation pH, SaO2, pO2, pCO2, and HCO3 were similar.

Discussion

These findings reveal that pulmonary rehabilitation leads to significant improvement in pulmonary function, as indicated by improved BORG, VAS, and RDAI scores and reduced frequency of dyspnea and tachypnea following the adoption of pulmonary rehabilitation measures.

Standardized rehabilitation of patients admitted to the intensive care unit usually includes respiration exercises, manual hyperinflation, and percussive techniques, active and passive joint exercises, patient positioning, and ambulation and muscle exercises [10,11]. Special measures used to facilitate weaning are used in mechanically ventilated patients. However, despite standardized rehabilitation programs, postoperative patients are at high risk for pulmonary complications as a consequence of depressed mucociliary clearance, suppressed cough, and resultant reduction in lung volumes and retention of secretions. All these factors contribute to the development of atelectasis and impaired respiratory function, which further precipitate pulmonary infections. The development of pulmonary complications is associated with significant morbidity and mortality and may prolong hospital stay [12-14]. Patients undergoing cardiovascular surgery are at high risk for postoperative pulmonary complications resulting from pulmonary injury related to cardiopulmonary bypass, mechanical ventilation, and surgical manipulation of the thoracic cavity [15]. Several reports indicate that approximately 10% to 25% of patients undergoing cardiac surgery experience pulmonary complications. Development of pulmonary complications following cardiac surgery has been reported to be associated with a four-fold increase in mortality and prolonged intensive care unit stay. Long-term mortality has been shown to increase in patients with pneumonia following cardiac surgery. Intraoperative lung-protective ventilation techniques, including lower tidal volumes, lower driving pressures, and positive end-expiratory pressure, have been shown to reduce pulmonary complications after cardiac surgery [16-18].

Despite the detrimental impact of cardiovascular surgery on pulmonary function, the role of pulmonary rehabilitation in the ICU and the ward following cardiac revascularization surgery and valvular surgery is questionable. This study is the first to demonstrate that supervised pulmonary rehabilitation significantly reduces dyspnea and tachypnea in patients who undergo cardiac surgery. The pulmonary rehabilitation program performed in our institute includes removal of bronchial secretions, postural drainage, percussion, vibration and aspiration, and body positioning performed to overcome atelectasis. We speculate that a supervised pulmonary rehabilitation program leads to an improvement in dyspnea by cleansing the airway, promoting effective ventilation, and reducing the atelectatic lung areas, thus improving vital capacity. However, further randomized, prospective studies with larger sample sizes are required to address the role of pulmonary rehabilitation programs in pulmonary function.

The present study has some limitations that need to be mentioned. First, pulmonary rehabilitation was applied only during the postoperative period. Therefore, we could not provide data concerning the role of a preoperative pulmonary rehabilitation program in patients scheduled for cardiac surgery. Second, we did not perform a mortality analysis and did not investigate the role of pulmonary rehabilitation in cardiovascular outcomes. Thus, further studies investigating the role of pulmonary rehabilitation in cardiovascular outcomes are required.

Conclusion

Application of a supervised pulmonary rehabilitation program

including removal of bronchial secretions, postural drainage, percussion, vibration, and aspiration, and patient positioning improves self-reported dyspnea in patients who undergo cardiac surgery. Further prospective, randomized, and controlled trials are required to address the role of pulmonary rehabilitation in other cardiovascular outcomes.

Scientific Responsibility Statement
The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement
All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

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Conflict of interest
None of the authors received any type of financial support that could be considered potential conflict of interest regarding the manuscript or its submission.

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