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Original Article / Özgün Makale

Is physiotherapy effective on the occurrence of postoperative pulmonary complications in patients undergoing coronary artery bypass graft surgery? A randomized controlled trial

Koroner arter baypas greft cerrahisi yapılan hastalarda ameliyat sonrası pulmoner komplikasyon gelişiminde fizyoterapi etkili midir? Randomize kontrollü çalışma

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ABSTRACT

Background: This study aims to investigate the efficacy of a specific physiotherapy protocol on the occurrence of postoperative pulmonary complications, length of intensive care unit (ICU) and hospital stay, and duration of intibutation in patients undergoing coronary artery bypass graft (CABG) surgery with variable postoperative pulmonary complication risk profiles.

Methods: Between June 2012 and October 2014, a total of 170 patients (116 males, 54 females; mean age 57.0±10.0 years; range 30 to 79 years) who underwent CABG surgery in our clinic were divided into two risk groups on the basis of their risk scores (low-risk ≤1 point or high-risk ≥2 point). A physiotherapy protocol consisted of four phases was performed from baseline until discharge. The incidence of postoperative pulmonary complications was scored by a blinded investigator on an ordinal scale of 1 to 4. Functional capacity was evaluated using a six-minute walk test (6MWT). Hospital Anxiety and Depression Scale (HADS) for anxiety and depression and Short Form-36 for quality of life were applied.

Results: The incidence of postoperative pulmonary complications, length of stay in the hospital and ICU and duration of intubation were not statistically significant in high-risk group, compared to the low-risk group ($p>0.05$). There was a significant decrease in 6MWA distance from baseline to discharge for all patients; however, the decline was lower in high-risk group. There was no statistically significant differences in the quality of life and depression scores between the groups after treatment ($p>0.05$). We observed statistically significant differences in anxiety scores between the groups after treatment ($p<0.05$).

Conclusion: This randomized, controlled trial demonstrated that physiotherapy might help patients in high-risk group for faster recovery after CABG. Physiotherapy is more critical in high-risk patients to obtain similar results as in low-risk group.

Keywords: Coronary artery bypass graft surgery; physiotherapy; postoperative pulmonary complication.

ÖZ

Amaç: Bu çalışmada koroner arter baypas greft (KABG) cerrahisi yapılan ameliyat sonrası farklı pulmoner komplikasyon risk profiline sahip hastalarda, spesifik bir fizyoterapi protokolünün ameliyat sonrası pulmoner komplikasyon gelişimi, yoğun bakım ünitesinde (YBÜ) ve hastanede kalış süresi ve entübasyon süresi üzerine etkileri araştırıldı.

Çalışma planı: Haziran 2012 - Ekim 2014 tarihleri arasında kliniğimizde KABG ameliyatı yapılan 170 hasta (116 erkek, 54 kadın; ort. yaş 57.0±10.0 yıl; dağılım 30-79 yıl) risk skorlarına göre (düşük ≤1 puan veya yüksek ≥2 puan) iki risk grubuna ayrıldı. Dört fazdan oluşan bir fizyoterapi protokolü başlangıçtan taburculuğa kadar uygulandı. Ameliyat sonrası pulmoner komplikasyon insidansı, kör bir araştırmacı tarafından 1-4'lük bir ölçek ile derecelendirildi. Fonksiyonel kapasite altı dakikalık yürüme testi (6DYT) ile değerlendirildi. Anksiyete ve depresyon için Hastane Anksiyete ve Depresyon Skalası (HADS) ve yaşam kalitesi için Kısa Form-36 uygulandı.

Bulgular: Düşük risk grubuna kıyasla, yüksek risk grubunda ameliyat sonrası pulmoner komplikasyon insidansı, hastanede ve YBÜ'de kalış süresi ve entübasyon süresi istatistiksel olarak anlamlı değildi ($p>0.05$). Tüm hastaların 6DYT mesafesinde başlangıca kıyasla taburculuğa kadar anlamlı bir düşüş görüldü; ancak düşüş yüksek risk grubunda daha azdı. Tedavi sonrası gruplar arasında yaşam kalitesi ve depresyon skorları açısından istatistiksel olarak anlamlı bir fark yoktu ($p>0.05$). Tedavi sonrası gruplar arasında anksiyete skorları açısından istatistiksel olarak anlamlı bir fark gözlendi ($p<0.05$).

Sonuç: Randomize kontrollü bu çalışma, fizyoterapinin, yüksek risk grubundaki hastaların KABG sonrası daha hızlı iyileşmesine yardım edebileceğini gösterdi. Fizyoterapi, yüksek riskli hastalarda düşük risk grubu ile benzer sonuçları elde edebilmek için çok daha önemlidir.

Anahtar sözcükler: Koroner arter baypas greft cerrahisi; fizyoterapi; ameliyat sonrası pulmoner komplikasyon.

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Despite technical and technological developments in recent years, the incidence of postoperative pulmonary complications (PPC) is over 30%.[1] Cardiopulmonary bypass usually causes lung injury, atelectasis, gas exchange abnormalities, pulmonary edema, and a reduction in respiratory function.[2] The PPC increases the morbidity, mortality, and duration of hospitalization, as well as care cost.[3]

Physiotherapy is used prophylactically to prevent and control the PPC after coronary artery bypass graft (CABG); however, there is no consensus on the optimal physiotherapy protocol in patients undergoing cardiac surgery. Also, the effects of these physiotherapy interventions on the occurrence of PPC and identifying patients who may benefit from such interventions are still controversial. Although the physiotherapy after heart surgery is recommended by guidelines, the routine physiotherapy is questioned in non-complicated patients.[4] The identification of optimal physiotherapy protocol and showing its efficiency in patients with different PPC risk scores can help to direct these interventions toward people who may benefit from such interventions and may reduce the incidence of PPC.

To the best of our knowledge, there is no study investigating the effects of a specific physiotherapy protocol after CABG in patients with variable PPC risk profiles. Several studies, to date, likely included patients without any comorbidities. Therefore, we aimed to investigate the efficacy of a specific physiotherapy protocol on the occurrence of PPC, length of intensive care unit (ICU) and hospital stay, and duration of intibutation in patients undergoing CABG surgery with variable PPC risk profiles.

PATIENTS AND METHODS

We conducted a single-blinded randomized controlled trial. A total of 492 patients undergoing CABG surgery at the cardiovascular surgery unit of Gülhane Military Medicine Academy between June 2012 and October 2014 were enrolled. Inclusion criteria were age between 18 and 90 years and willing to participate by signing the written consent form. Exclusion criteria were as follows: other surgical procedures without associated CABG, history of a cerebrovascular accident, use of immunosuppressive medication within 30 days before surgery, and the presence of a neuromuscular disorder, cardiovascular instability, or an aneurysm. After screening, 170 patients (116 males, 54 females; mean age 57.0±10.0 years; range 30 to 79 years) were included in the study. The study protocol was approved by the Ethics Committee of the Gülhane Military Medicine Academy and was conducted in accordance with the principles of the Declaration of Helsinki.

Table 1. Pulmonary risk score scale

Parameters	Score
Age >70 years	1
Cough and expectoration	1
Diabetes mellitus	1
Smoker	1
Chronic obstructive pulmonary disease:	
FEV_1 <75%$_{predicted}$ or pulmonary medication used	1
Body mass index >27.0	1
Spirometry:	
FEV_1 <80%$_{predicted}$ and FEV_1/FVC <70%$_{predicted}$	2

Preoperative evaluation and risk stratification

Demographic characteristics, preoperative risk factors, and operative data were recorded. According to the definitions of the Society of Thoracic Surgeons[5,6] for the risk factors and the according to study of Hulzebos et al.,[7] the variables were scored to identify the risk of developing PPC (Table 1). The patients were divided into two risk groups on the basis of their scores (low-risk, ≤1 point; n=85 or high-risk ≥2 point; n=85). Then, these patients were either randomized to high-risk group or low-risk group by a computer-generated randomization table (Figure 1).

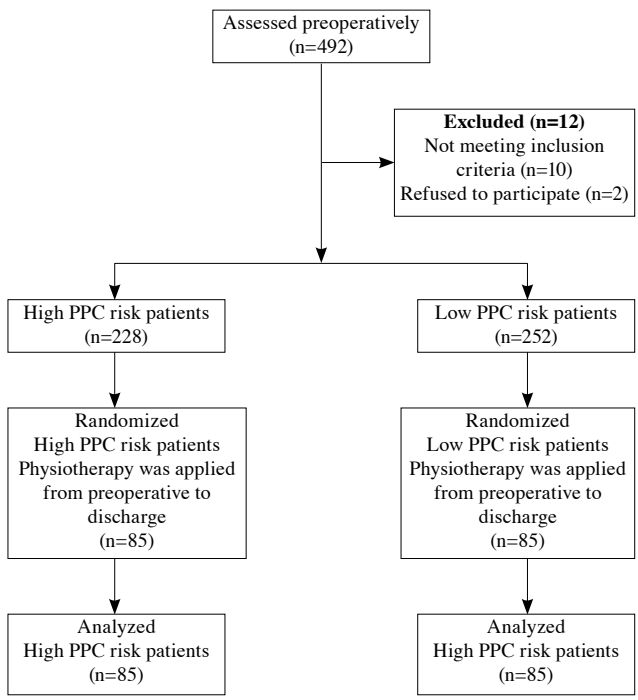

Figure 1. Flow diagram of the study. PPC: Postoperative pulmonary complications.

Appendix 1. BURANCAN-Cardiorespiratory Physiotherapy Protocol (BURANCAN-CrPT)

Phase 1. Preoperative training and exercise programme

- Preoperative assessment
- To give information about the surgery, process in the intensive care unit and the importance and benefits of exercises. To inform about post-surgical pain and to encourage about how to cope with it.
- Teaching the exercises to be used immediately after surgery.
- Education regarding the use of the Borg scale in relation to postoperative exercises.
- To practice different breathing techniques (The physiotherapist showed the active cycle of breathing techniques (ACBT), deep breathing exercises (slow maximal inspiratory manoeuvres up to total lung capacity, followed by passive expiration to functional residual capacity), diaphragmatic breathing exercises, thoracic expansion exercises at various levels (lower, mid and upper) with tactile stimulation, breathing exercises with flow-based incentive spirometer, pursed-lip breathing, secretion-removal manoeuvres and supported/assisted coughing and huffing (forced expiratory with the glottis open) techniques. And the patients learned active exercises of thorax, upper and lower extremities (with restriction of the flexion and abduction to an angle of 90º) with combination of breathe. Preoperative training and exercise programme familiarized with them earlier and this process make it easier for the patients to cooperate after surgery.
- Teaching to properly move and change positions, teaching how to sit up from the supine position and to lie down from the sitting position.

Phase 2. The first postoperative day and the process in the intensive care unit

- Physiotherapy was started immediately after extubation. ACBT, thoracic expansion exercises, breathing exercises with flow-based incentive spirometer, pursed-lip breathing, diaphragmatic breathing, lower and upper rib cage breathing exercises, assisted cough and huffing techniques were used after extubation. The breathing facilitating manoeuvres with the sensory and verbal stimulation were used to facilitate deep breathing in sleepy patients. Breathing exercises were applied by a physiotherapist every hour in intensive care unit. While making exercises, the patients were closely monitored. The patients were mobilized in the morning of the first postoperative day by the physiotherapists and they walked 30 meters in the intensive care unit and 80 m on the ward in the afternoon on the first postoperative day. Also active exercises of upper and lower extremities (with restriction of the flexion and abduction to an angle of 90º) with combination of breathe were done.

Phase 3. The process in service

- The exercise protocol consisted of progressive exercises, as done in standardized phase I cardiac rehabilitation interventions which elicited energy expenditures of 2 METS and progressed to 4 METS for half an hour twice a day were applied by physiotherapists. Patients were familiarized with the Borg Scale prior to each physiotherapy session, and were instructed to exercise at an RPE of 3-4 (‘moderate’ to ‘somewhat strong’). Also ACBT, thoracic expansion exercises, breathing exercises with flow-based incentive spirometer, pursed-lip breathing, diaphragmatic breathing, lower and upper rib cage breathing exercises, assisted cough and huffing techniques were done. Positioning and manual techniques such as percussion, vibration and shaking were used for airway clearance. The patients walked in the corridor freely every hour at daytime. The distance of walking was increased gradually at an RPE of 3-4 (‘moderate’ to ‘somewhat strong’). Gradually increasing mobilization program continued until discharge. Also they were instructed to perform five breathing exercise sets which consisted of three deep breaths without the mechanical device, three deep breaths with flow-based incentive spirometer and one or two assisted cough or huffing every hour at daytime. But the intensity and the duration of exercise were depend on patient’s fatigue which must not exceed 6 in a 10-point Borg scale and the maximum allowed heart rate increase is an increase by 20% of the baseline heart rate.

Phase 4. Discharge

- To climbing two flights of stairs on the discharge day for prescribing home exercise program. According to the changes in the patient's heart rate and fatigue while climbing two flights of stairs, the intensity and duration of home exercise program were determined.
- To give information about sternum protection, daily activities, energy conservation techniques, relaxation and stress management techniques and home exercises. Home exercise program was consisted of walking, breathing exercise, climbing stairs, posture exercises and active exercises of upper and lower extremities.
- Education regarding the progression of exercise following hospital discharge.

Table 2. Definitions of postoperative pulmonary complications

Grade	Definition
1	• Cough, dry • Microatelectasis: abnormal lung findings and temperature >37.5 °C without other documented cause; results of chest radiograph either normal or unavailable • Dyspnea, not due to other documented cause
2	• Cough, productive, not due to other documented cause • Bronchospasm: new wheezing or pre-existent wheezing resulting in change therapy • Hypoxemia: alveolar-arterial gradient >29 and symptoms of dyspnea or wheezing • Atelectasis: radiological confirmation plus either temperature >37.5 °C or abnormal lung findings • Hypercarbia, transient, requiring treatment, such as naloxone or increased manual or mechanical ventilation • Adverse reaction to pulmonary medication
3	• Pleural effusion, resulting in thoracentesis • Pneumonia, suspected: radiological evidence without bacteriologic confirmation • Pneumonia, proved: radiological evidence and documentation of pathological organism by Gram's stain or culture • Pneumothorax • Re-intubation postoperative or intubation, period of ventilator dependence does not exceed 48 hours
4	• Ventilatory failure: postoperative ventilator dependence exceeding 48 hours, or re-intubation with subsequent period of ventilator dependence exceeding 48 hours.

Physiotherapy protocol

The interventions were performed by a team of physiotherapists who had no influence on the decisions related to the patient care, including extubation, ICU stay and hospital discharge. This program was only paused for surgery through to the day of extubation and it was re-started until the day of hospital discharge. The protocol was consisted of four phases (Appendix 1).

Table 3. Baseline characteristics of patients in high-risk and low-risk group

	High-risk group (n=85)			Low-risk group (n=85)		
	n	%	Mean±SD	n	%	Mean±SD
Demographic data						
Gender						
Male	59	69.41		57	67.06	
Female	26	30.59		28	32.4	
Body mass index (kg/m^2)			27.9±3.6			25.7±2.9
Age (years)			58.6±9.6			55.4±10.2
History of cigarette smoking	60	70.59		40	46.5	
Ejection fraction			52.6±8.1			59.4±7.6
Myocardial infarction history	21	24.71		8	9.41	
Hypertension	27	31.76		38	44.71	
Hypercholesterolemia	22	25.88		23	27.06	
History of COPD, on medication	10	11.76		1	1.18	
Diabetes mellitus, on medication	40	47.06		7	8.24	
Surgical data						
Cardiopulmonary bypass time in minutes			71.7±39.3			70.8±31.9
Aortic clamping time in minutes			40.1±23.5			38.4±20.1
Duration mechanical ventilation in hours			12.2±3.3			11.7±3.8
Duration of drains (day)			1.3±0.7			1±0.0
Affected vessels			2.7±0.9			2.4±0.9

SD: Standard deviation; COPD: Chronic obstructive pulmonary disease.

Primary outcomes

The incidence of PPC was scored by a blinded independent investigator on an ordinal scale of 1 to 4 (Table 2).[7] Anteroposterior chest X-ray was performed in the standing position preoperatively and on the discharge day. The presence or absence of atelectasis, infiltration, pneumothorax, pleural effusion, and pulmonary edema were recorded. An arbitrary scale was used to score atelectasis: 0, no abnormality; 1, minimal abnormality (plate atelectasis); 2, moderate abnormality (segmental atelectasis); 3, major abnormality (lobar atelectasis).[8] The postoperative length of ICU and postoperative hospital stay and duration of intibutation were obtained from the patients' records.

Secondary outcomes

Functional exercise capacity was evaluated using a six-minute walk test (6MWT).[9] The 6MWT was performed preoperatively and was repeated on the fifth postoperative day. The patients were instructed to walk as far as possible within six minutes in an enclosed 30 m long hospital corridor. The maximum distance covered at the end of the test was recorded. The Turkish version of the Hospital Anxiety and Depression Scale (HADS) was applied for the evaluation of anxiety and depression. The HADS is a screening tool for anxiety and depression used in non-psychiatric clinical populations. It is divided into an Anxiety subscale (HADS-A) and a Depression subscale (HADS-D).[10] The health-related quality of life (HRQoL) was also assessed using the Turkish version of the 36-Item Short Form Health Survey (SF-36; first version), a self-administered questionnaire, including 36 questions with eight different aspects: physical functioning, physical role functioning, bodily pain, general health, vitality, social functioning, emotional role functioning, and mental health.[11]

Statistical analysis

All statistical analyses were performed using SPSS version 16.0 statistical package (SPSS Inc., Chicago, IL, USA). Using the formula for sample size determination with a desired statistical power of 0.9, a medium effect size (d=0.50) and an alpha of 0.05, minimum sample size of 85 subjects for each group were calculated to reach statistical significance.[12] The Kolmogorov-Simirnov/Shapiro-Wilk test was used to analyze normally distributed continuous variables. The descriptive statistics were expressed in the mean ± standard deviation for the continuous variables and in number of patients and percent (%) for the categorical variables. Differences in nominal variables between the high-risk group and the low-risk group were tested with the chi-square test. The Student t test was performed to compare the groups Paired t test was used to perform intragroup comparisons. A p value of <0.05 was considered statistically significant.

RESULTS

Demographic characteristics, clinical characteristics, and perioperative data are shown in Table 3. Physiotherapy sessions were well tolerated without any complaints in all patients and no adverse effects occurred during the evaluation and treatment.

The results of primary outcomes were shown in Table 4. The incidence of PPC grades were not statistically significant in high-risk group, compared to the low-risk group (p>0.05). The length of stay in the hospital and ICU was not statistically significant between the high-risk and low-risk groups (p>0.05).

Preoperatively, the distance covered during 6MWT was significantly low in high-risk group, compared to the low-risk group (p<0.05) (Table 5). There was a significant decrease in 6MWA distance from

Table 4. Duration of postoperative hospitalization, intensive care unit and grade of postoperative pulmonary complications between the high-risk and low-risk groups

	High-risk group (n=85)			Low-risk group (n=85)			
	n	%	Mean±SD	n	%	Mean±SD	*p*
Duration of hospitalization (day)			7.6±1.4			7.6±1.4	0.879
Intensive care unit stay (day)			1.2±0.5			1.2±0.2	0.349
Level of PPC							
Grade 1	43	50.59		40	47.06		0.645
Grade 2	9	10.59		8	9.42		0.798
Grade 3	5	5.88		4	4.71		0.732
Grade 4	2	2.35		1	1.17		0.745
PPC grade ≥2	16	18.82		13	15.29		0.541

SD: Standard deviation; PPC: Postoperative pulmonary complications.

Table 5. Comparison of preoperative functional capacity, anxiety, depression and quality of life scores

	Preoperative		
	High-risk group (n=85)	Low-risk group (n=85)	Group difference
	Mean±SD	Mean±SD	*p*
6MWT			
6MWT (m)	458.8±63.2	500.0±59.3	0.00*
Δ Heart rate (bpm)	18.2±9.4	16.8±11.5	0.02*
Δ Borg dyspnea	3.3±1.4	2.6±1.4	0.02*
SF-36 (0-100)			
Physical functioning	76.1±11.6	78.9±19.7	0.58
Social functioning	66.3±24.8	67.2±26.8	0.64
Role-physical	48.1±37.4	63.2±38.6	0.00*
Role-emotional	46.1±32.0	56.9±38.7	0.02*
Bodily pain	52.2±18.6	65.0±28.5	0.00*
Vitality	54.1±17.4	62.3±16.6	0.00*
General health	62.5±16.1	69.5±19.6	0.00*
Mental health	66.6±16.8	73.5±18.5	0.00*
Hospital Anxiety and Depression Scale			
Anxiety subscale score	6.4±2.5	6.3±2.8	0.66
Depression subscale score	6.3±3.7	6.2±3.2	0.62

SD: Standard deviation; 6MWT: Six minute walk test; SF-36: Short Form 36; * p<0.05.

preoperative to discharge for all patients; however, this decline was lower in high-risk group (Table 6). Therefore, there was no significant differences in the distance covered during 6MWT on the discharge day between the high-risk and low-risk groups after treatment (p>0.05).

Preoperatively and postoperatively, there was no significant differences in the HRQoL scores between the groups (p>0.05). Preoperatively, the depression and anxiety scores were similar between the groups. There was a significant decrease in anxiety scores from preoperative to discharge for all patients; however, this

Table 6. Comparison of postoperative functional capacity, anxiety, depression and quality of life scores

	Postoperative		
	High-risk group (n=85)	Low-risk group (n=85)	Group difference
	Mean±SD	Mean±SD	*p*
6MWT			
Distance (m)	435.4±54.0	437.8±63.2	0.68
Δ Heart rate (bpm)	22.6±10.5	20.4±8.8	0.02*
Δ Borg dyspnea	3.4±0.4	2.7±0.6	0.01*
SF-36 (0-100)			
Physical functioning	77.8±19.6	79.7±14.6	0.58
Social functioning	68.1±21.8	67.5±20.1	0.64
Role-physical	49.2±27.8	65.2±27.2	0.00*
Role-emotional	47.5±30.6	57.9±28.4	0.00*
Bodily pain	51.4±17.1	62.2±23.2	0.00*
Vitality	52.3±18.3	63.3±18.9	0.00*
General health	63.6±16.3	70.7±18.3	0.00*
Mental health	66.1±20.7	72.1±14.8	0.00*
Hospital Anxiety and Depression Scale			
Anxiety subscale score	4.4±2.1	5.6±3.0	0.64
Depression subscale score	6.2±3.0	6.1±2.8	0.61

SD: Standard deviation; 6MWT: Six minute walk test; SF-36: Short Form 36; * p<0.05.

Table 7. Effects of physiotherapy on functional capacity, anxiety, depression and quality of life scores

	High-risk group (n=85)			Low-risk group (n=85)		
	Before physiotherapy	After physiotherapy		Before physiotherapy	After physiotherapy	
	Mean±SD	Mean±SD	*p*	Mean±SD	Mean±SD	*p*
6MWT						
Distance (m)	458.8±63.2	435.4±54.0	0.01*	500.0±59.3	437.8±63.2	0.00*
Δ Heart rate (bpm)	18.2±9.4	22.6±10.5	0.00*	16.8±11.5	20.4±8.8	0.00*
Δ Borg dyspnea	3.3±1.4	3.4±0.4	0.81	2.6±1.4	2.7±0.6	0.88
SF-36 (0-100)						
Physical functioning	76.1±11.6	77.8±19.6	0.89	78.9±19.7	79.7±14.6	0.83
Social functioning	66.3±24.8	68.1±21.8	0.88	67.2±26.8	67.5±20.1	0.88
Role-physical	48.1±37.4	49.2±27.8	0.83	63.2±38.6	65.2±27.2	0.79
Role-emotional	46.1±32.0	47.5±30.6	0.69	56.9±38.7	57.9±28.4	0.81
Bodily pain	52.2±18.6	51.4±17.1	0.81	65.0±28.5	62.2±23.2	0.83
Vitality	54.1±17.4	52.3±18.3	0.77	62.3±16.6	63.3±18.9	0.78
General health	62.5±16.1	63.6±16.3	0.80	69.5±19.6	70.7±18.3	0.84
Mental health	66.6±16.8	66.1±20.7	0.78	73.5±18.5	72.1±14.8	0.88
HADS						
Anxiety subscale score	6.4±2.5	4.4±2.1	0.00*	6.3±2.8	5.6±3.0	0.02*
Depression subscale score	6.3±3.7	6.2±3.0	0.81	6.2±3.2	6.1±2.8	0.78

SD: Standard deviation; 6MWT: Six minute walk test; SF-36: Short Form 36; HADS: Hospital Anxiety and Depression Scale; * p<0.05.

decline was much more in high-risk group (Table 5). There was no significant difference in depression scores between the groups after treatment (p>0.05) (Table 7).

DISCUSSION

In this study, we showed that our specific physiotherapy protocol had similar effects on the occurrence of PPC, postoperative length of ICU stay, duration of hospitalization, and intibutation and HRQoL in high-risk and low-risk groups after CABG surgery. Also, physiotherapy protocol is much more effective on the functional capacity and anxiety in high-risk group.

The effects of physiotherapy techniques in uncomplicated patients following CABG have been well-documented. In clinical practice, recommendations for exercise prescriptions and content of physiotherapy protocol may vary between medical centres and countries.

Renault et al.[13] concluded that physiotherapy techniques is too wide and there is no evidence about the superiority of one technique over the other. Therefore, using a specific protocol which consisted of some of these physiotherapeutic interventions is more suitable after heart surgery.

In our study, the incidence of PPC at least grade 2 is 20% in high-risk group and 18% in low-risk-group. Also, Johnson et al.[14] showed an incidence rate of 20%, similar to our results. Other studies reported lower incidence rates, such as those carried out by Stiller et al.[15] with an incidence rate of 7.1%, or Jenkins et al.[16] with an incidence rate of 10%. However, Dull and Dull[17] reported higher incidence rates, the incidence of PPC is 77% after heart surgery. These differences may be ascribable to various factors. The definition of PPC seems to be uncertain, though. In some studies, the definition of PPC is based only on chest radiographic changes, while others use a combination of variables for the definition. In our study, we used a scale which consisted of a combination of all variables and rated PPC.

In the literature data, physiotherapy interventions used to prevent PPC after CABG surgery have been questioned. Crowe and Bradley[18] reported that there was no addition of incentive spirometer to the physiotherapy protocol (deep breathing exercises, early mobilization and bronchial hygiene techniques). Jenkins et al.[16] compared the intervention group (incentive spirometer, deep breathing exercises coughing/huffing) with a control group (only early mobilization) and reported that there was no difference between the groups in recovery of pulmonary function or incidence of PPC. Herdy et al.[19] showed the effects of preoperative physiotherapy in minimizing possible adverse effects of cardiac surgery. Also, Yánez-Brage et al.[20] reported a lower number of pulmonary atelectasis

in patients who had physiotherapy in the preoperative phase of CABG surgery. In a systematic review, Valkenet et al.[21] suggested a benefit of preoperative physiotherapy on PPC and length of hospitalization.

Furthermore, our results showed that physiotherapy make the patients with a high probability of PPC more resistant to the adverse effects of surgery and, consistent with the literature data, physiotherapy supported postoperative recovery after surgery. The patients with a high-risk for PPC had similar results such as patients with low-risk. As the length of stay in the hospital and ICU, the duration of intubation and days requiring a chest tube were similar in high-risk group, compared to the low-risk group.

In our physiotherapy protocol, we used deep breathing exercises, breathing exercises with incentive spirometer, thoracic expansion exercises at various levels and active cycle of breathing techniques. They produced an increase in the lung volume during the inspiration and collateral ventilation might result in increased alveolar ventilation, and thereby, reduced incidence of atelectasis. Also, using these exercises yielded a lower incidence of chest X-ray alterations, reduced atelectasis rates, pleural effusion, and pulmonary consolidation in both risk groups, which is also consistent with other study findings. In addition, it may be secondary to a lower incidence of pulmonary infections. Damaging and adverse effects of surgery on cough and bronchial hygiene are predisposing factors to the occurrence of lung infections. We used positioning and manual techniques such as percussion, vibration, and shaking for airway clearance, supported/assisted coughing and huffing in our physiotherapy protocol. Thus, no occurrence of lung infection was observed in high-risk group and in low-risk group in our study.

The 6MWT scores at the hospital discharge for both risk groups (444 m and 431 m, respectively) are consistent with the scores reported by Verrill et al.[22] (mean 462 m), (481 m men, 440 m women, respectively). Hirschhorn et al.[23] reported 12.5% and 23.5% decline in the 6MWT distance one week after CABG surgery in the intervention and control groups, respectively. Similar to our results, the distance walked during 6MWT significantly decreased at discharge in all patients, although this decline was lower in high-risk group.

Baptista et al.[24] reported that CABG surgery improved the HRQoL scores in all patients; however, the improvement was greater in patients who walked less than 350 meters preoperatively. In our study, we did not find any difference in the HRQoL scores between the groups. It can be attributed to the fact that the 6MWT scores were higher than 350 meters in both groups.

Moreover, preoperative anxiety and depression symptoms are significantly associated with increased surgical mortality and morbidity rates in CABG patients.[25] Additionally, preoperative anxiety and postoperative depression increases postoperative re-admission rates more than two fold.[25] Garbossa et al.[25] reported the effects of preoperative and postoperative physiotherapy instructions on the anxiety of patients after CABG surgery. The lower levels of anxiety were observed in patients who were instructed and educated on physiotherapy and exercise in the preoperative period, compared to the control group. In our study, patients received information, were instructed, and educated on physiotherapy and breathing exercises preoperatively and both groups had reduced anxiety scores with a more prominent reduction in high-risk group. Several authors reported that prolonged duration of hospitalization increases stress and anxiety.[25] In our study, the length of hospital stay was relatively short; however, there was a decline in the anxiety scores in both risk groups.

In conclusion, this randomized, controlled trial demonstrated that physiotherapy helps patients in high-risk group for faster recovery after CABG. Physiotherapy is more critical in high-risk patients to obtain similar results, as in low-risk group. Therefore, screening patients to detect the presence of clinically significant risk factors may help to tailor a more effective physiotherapy program. In addition, our specific physiotherapy protocol is effective in both groups and better and applicable interventions are needed to treat and care for patients undergoing CABG surgery. Further investigations should be directed toward confirming our findings and expanding this area of research.

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