EFFECT OF PREOPERATIVE RESPIRATORY REHABILITATION IN PATIENTS UNDERGOING CARDIAC SURGERY

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SUMMARY – The aim of the study was to evaluate the effects of preoperative respiratory rehabilitation on functional capacity, length of stay in intensive care unit (ICU), duration of mechanical ventilation (MV) and total hospitalization, as well as to estimate arterial blood gas (ABG) values in patients undergoing cardiac surgery. Nineteen patients were included in the randomized observational study, divided into two groups: group A (intervention) and B (control). Preoperative and postoperative rehabilitation was performed in group A, and only postoperative rehabilitation in group B. Rehabilitation was carried out according to a predefined protocol. We used ABG to evaluate respiratory function, two-minute walk test (2MWT) and sit-to-stand test to assess functional capacity. The following data were obtained from medical documentation: duration of MV, length of stay at ICU, occurrence of postoperative pulmonary complications, and length of total hospitalization in both groups. Significant between-group difference was found for the length of total hospitalization and duration of MV (p<0.05 both). Analysis of the mean values of 2MWT on the last day of hospitalization (p=0.005), sit-to-stand test before surgery (p=0.022) and on the last day of hospitalization (p=0.008) showed statistically significant differences. The length of hospital stay significantly correlated with preoperative rehabilitation in group A (r=0.885; p<0.0001). There was no difference in ABG parameters between the groups. The study showed that preoperative respiratory rehabilitation had an effect on reducing duration of MV and length of total hospitalization, and improved functional capacity.

Key words: *Respiratory rehabilitation; Aorto-coronary bypass; Mechanical ventilation; Arterial blood gas analysis*

Introduction

Cardiovascular diseases (CVD) were the most common underlying cause of death in the world and 17.9 million people died from CVD in 2016, accounting for 31% of all global deaths[1]. Coronary artery bypass graft (CABG) surgery is a safe procedure for treatment of CVD with low rates of morbidity and

mortality in general[2], and is still an excellent option for treatment of obstructive coronary artery disease[3], in patients with diabetes[4], elderly patients[5], and patients with low left ventricular ejection fraction (LVEF)[6]. Although CABG surgery is successful, patients undergoing cardiac surgery are at a risk of postoperative pulmonary complications (PPC), which lead to increased postoperative morbidity and mortality[7]. The incidence of PPC varies from 20% to 95% depending on the type of surgery, and the most common complications are atelectasis (27%-95%) and pleural effusion (16.6%-88%)[8]. PPC after cardiac surgery leads to prolonged hospitalization, large hospitalization costs, loss of

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working days, and even death. The most commonly recorded preoperative risk factors for PPC are age over 70 years, diabetes mellitus, body mass index (BMI) >28, preoperative arrhythmias or unstable angina pectoris, chronic obstructive pulmonary disease, smoking, and hepatic insufficiency.

In patients scheduled for cardiac surgery, cardiac rehabilitation (CR) significantly contributes to better prognosis, where the goal in the preoperative period is to prevent and minimize pulmonary complications, whereas in the postoperative period the goal is continuation of pulmonary expansion, rapid verticalization, and reduction in hospitalization length. The main goal of CR is to increase physical and psychosocial recovery after cardiac surgery and reduce the risk of future cardiac events by improving lifestyle[9]. In order to reduce the risk of PPC, it is best to start with physical therapy in the preoperative period. A few studies demonstrated that preoperative physical therapy (respiratory rehabilitation) had advantages over postoperative care alone in cardiac surgery patients[7,8]. There is a lack of evidence in the literature to standardize the measurement of postoperative complications and an objective measure of functional capacity in cardiac surgery patients. Walk tests are measures that could potentially be administered as part of the assessment to determine functional performance. Walk tests are widely used as a means of quantifying functional exercise capacity. The duration of the tests varies, but six-minute duration has been recommended by the American Thoracic Society[10]. Shorter walk tests, two-minute walk test (2MWT) in particular, are being used increasingly. In cardiac rehabilitation, 2MWT is a valid and reliable measure of functional capacity, and it is commonly used. This is an inexpensive and safe test of cardiovascular endurance in cardiac surgery population[11].

The aim of the study was to evaluate the effects of preoperative respiratory rehabilitation on functional capacity, length of stay at the intensive care unit (ICU), duration of mechanical ventilation (MV), length of total hospitalization, and values of arterial blood gas (ABG) parameters in patients undergoing cardiac surgery.

Patients and Methods

A simple randomized observational study was carried out over a six-month period at the Department of Cardiac Surgery, Clinical Center of Montenegro. The study was approved by the Ethics Committee of the Clinical Center of Montenegro.

Patients

The study included 19 patients using percutaneous coronary intervention and diagnosed with three-vessel coronary disease (left anterior descending artery, circumflex artery or right coronary), severe luminal stenosis >75%, aortic valve stenosis and mitral valve stenosis.

Exclusion criteria

Patients with chronic respiratory disease, recent acute myocardial infarction (within 2 months), unstable cardiac disorders, patients scheduled for transcatheter aortic valve implantation, cognitive disorders, neurological disorders, musculoskeletal disorders, chronic renal insufficiency, emergency surgery, patients with LVEF <40 were excluded from the study. Prior to starting rehabilitation, cardiologic evaluation was performed in all patients. Patients received thorough explanation of the study protocol, were asked to participate in the study and provided verbal approval for it.

Randomization

There were 27 patients hospitalized at the Department of Cardiac Surgery, Clinical Center of Montenegro, scheduled for cardiac surgery (CABG surgery, aortic valve surgery, mitral valve surgery, or combined). After applying the inclusion and exclusion criteria, 19 patients were included in the study. Patients were randomized into two groups as follows: group A (intervention) received both preoperative and postoperative rehabilitation, whereas group B (control) received only postoperative rehabilitation.

Demographic data and preoperative risk factors were obtained by interview (age, sex, body weight, body height, BMI, current diagnoses, smoking history, myocardial infarction history, and comorbidities).

Rehabilitation therapy

Preoperative CR included the following: 1) diaphragmatic breathing and relaxation of the chest (10 deep breathing attempts, deep nasal inhaling and exhaling through the mouth); 2) postural education (training on protective positions and cough move-

ments and initiation of the whole trunk and extremities); and 3) patient education about self-care and modification of risk factors. In group A, preoperative CR was performed twice a day.

Postoperative CR included the following: 1) diaphragmatic breathing (techniques to cleanse the lungs including mobilization, manual techniques, use of the active cycle of breathing); 2) postural education (on the position of the whole trunk, shoulder and pelvis in the lying and sitting positions in bed); 3) active exercises in bed for mobilizing distal and middle segments of lower extremities (prevention of deep vein thrombosis and pulmonary embolism; 4) transferring from supination to sitting over the edge of the bed; 5) diaphragmatic breathing in sitting position in bed; 6) transferring from sitting to standing position next to the edge of the bed (verticalization of the patient with the bed), stepping near the edge of the bed with assistance of a physiotherapist; and 7) walking with the assistance of a physiotherapist to stand-alone walk of 50-200 m. Postoperative CR was initiated two hours after patient extubation in ICU and was implemented until the end of hospitalization. Postoperative CR was performed three times a day in both groups A and B.

Termination criteria for rehabilitation therapy were as follows: arterial blood pressure <65 mm Hg or >160 mm Hg, heart rate <50 beats/min or >130 beats/min, respiratory rate <12 breaths/min or >40 breaths/min, pulse oximetry <80%, heart rhythm disorders, acute bleeding, acute myocardial infarction, dehiscence of the wound, disturbance of consciousness, and acute psychiatric conditions.

We used the following ABG parameters to evaluate respiratory function in both groups: partial pressure of carbon dioxide (PCO_2), partial oxygen pressure (PO_2), bicarbonate (HCO_3), and oxygen saturation (O_2sat). The parameters were measured two hours after extubation in ICU and then just before leaving the ICU.

To evaluate functional capacity, we used 2MWT and sit-to-stand test. Patients performed 2MWT and sit-to-stand test on the first day of hospitalization, before surgery, and on the last day of hospitalization in both groups.

Data obtained from medical documentation were duration of MV, length of stay at ICU, occurrence of PPC, and length of total hospitalization in both groups.

Clinical assessment

We used the following ABG parameters to evaluate respiratory function in both groups: PCO_2, PO_2, HCO_3 and O_2sat. The parameters were measured two hours after extubation in ICU and then just before leaving the ICU.

To evaluate functional capacity, we used 2MWT and sit-to-stand test. Patients performed 2MWT and sit-to-stand test on the first day of hospitalization, before surgery, and on the last day of hospitalization in both groups.

Data obtained from medical documentation included duration of MV, length of stay in ICU, occurrence of PPC, and length of total hospitalization in both groups.

Statistical analysis

Descriptive statistical analysis revealed the following statistical parameters: arithmetic mean, standard deviation, minimum (min) and maximum value (max), absolute frequency (N) and structure index (%).

Analytical statistical methodology was employed to assess statistical significance of differences in the mean values of particular parameters between the two study groups. We used parametric tests and nonparametric tests in case of the coefficient of variation >30%. Comparison of the frequency of reporting individual modalities of attributive features between the groups was performed by Pearson χ^2-test/Fisher exact test. We used Student's t-test or Mann-Whitney U-test for comparison of the mean values between the two groups. Pearson correlation analysis was used to measure the association of particular parameters.

Statistical analysis was performed using the Excel program, Microsoft Office software, and PASW version 18.0. As the statistical significance threshold, the estimation error was less than 5% ($p<0.05$).

Results

Nineteen patients were randomly assigned into two groups, A (n=11) and B (n=8). All patients completed the scheduled rehabilitation. There were no significant differences in demographic characteristics between the groups (sex, age, BMI, or smoking status) (Table 1).

Table 1. Demographic characteristics of two patient groups

			Group Control	Group Intervention	Total	
Sex	Male	n	5	8	13	Fisher exact test
		% group	62.5%	72.7%	68.4%	
		% of total	26.3%	42.1%	68.4%	
	Female	n	3	3	6	p=0.506
		% group	37.5%	27.3%	31.6%	
		% of total	15.8%	15.8%	31.6%	
Age (yrs)			64.75±4.268	61.18±9.673	62.68±7.89	t=0.971
			55-68	44-73	44-73	p=0.345
Body mass index (kg/m^2)			26.137±3.01	27.082±3.60	26.68±3.31	t=0.604
			22.1-30.1	21.8-32.4	21.8-32.4	p=0.554
Smoking history	Non-smokers	n	4	3	7	
		% group	50.0%	27.3%	36.8%	
		% of total	21.1%	15.8%	36.8%	
	Ex-smokers		2	4	6	
			25.0%	36.4%	31.6%	
			10.5%	21.1%	31.6%	χ^2=1.028
	Smokers	n	2	4	6	p=0.598
		% group	25.0%	36.4%	31.6%	
		% of total	10.5%	21.1%	31.6%	
Total		N	8	11	19	
		% group	100.0%	100.0%	100.0%	
		% of total	42.1%	57.9%	100.0%	

The mean duration of preoperative rehabilitation was 6.73±2.76 days. Comparing the mean values of the length of stay at ICU (A: 2.73±0.95 and B: 3.50±1.069), there were no significant differences between the groups. Comparison of the mean length of total hospitalization in group A (11.27±1.794) and group B (16.88±3.357) revealed significant between-group differences (p=0.002). The mean duration of MV was 24.63±10.460 and 15.64±7.778 in group A and B, respectively, yielding significant differences between the two groups (p=0.038) (Table 2). Evaluation of the mean values of ABG parameters showed no significant difference between the two groups (Table 3). Considering functional capacity parameters, only the mean values of 2MWT before surgery showed no statistically significant differences between the two groups. Analysis of the mean values of 2MWT on the last day of hospitalization (p=0.005), and of the sit-to-stand test before surgery (p=0.022) and on the last day

of hospitalization in both groups (p=0.008) showed significant differences between the two groups (Table 4). Analysis of the occurrence of complications (complications reported with yes/no in both groups) showed no significant differences between the groups (Fisher exact test, p=0.067) (Table 5). In group A, significant correlation was recorded between the length of hospitalization and duration of preoperative rehabilitation (r=0.885; p<0.0001) (Fig. 1).

Discussion

Nowadays, the profile of patients undergoing CABG is changing to a higher-risk profile, i.e. elderly patients with comorbid medical problems. Our study was so designed to examine whether preoperative rehabilitation in patients undergoing cardiac surgery had an effect of reducing the length of stay at ICU, duration of MV, occurrence of PPC, and length of total

Table 2. Length of ICU stay, total hospitalization and mechanical ventilation in two patient groups

		n	Mean	SD	t-test
Length of hospital stay (days)	Control	8	16.88	3.357	t=4.717
	Intervention	11	11.27	1.794	*p=0.002
Length of ICU stay (days)	Control	8	3.50	1.069	t=1.705
	Intervention	11	2.73	0.905	p=0.106
MV (h)	Control	8	24.63	10.460	Z=2.071
	Intervention	11	15.64	7.788	*p=0.038

ICU = intensive care unit; MV = mechanical ventilation; Intervention (group A); Control (group B); SD = standard deviation; *p<0.05

Table 3. Arterial blood gas parameters (ABG)

	Group	n	Mean	SD	t-test
$PCO2\_I$	Control	8	46.50	6.568	t=1.185
	Intervention	11	41.78	9.726	p=0.252
$PO2\_I$	Control	8	117.63	33.979	t=0.449
	Intervention	11	124.45	31.851	p=0.659
$HCO3\_I$	Control	8	28.138	5.1887	t=1.101
	Intervention	11	25.982	3.3695	p=0.286
SO_2_I	Control	8	91.775	15.1219	t=1.701
	Intervention	11	99.464	0.9080	p=0.107
$PCO2\_Z$	Control	8	41.75	5.285	t=0.099
	Intervention	11	42.09	8.642	p=0.923
$PO2\_Z$	Control	8	121.45	19.430	t=1.612
	Intervention	11	137.27	22.222	p=0.125
$HCO3\_Z$	Control	8	28.01	3.060	t=0.371
	Intervention	11	28.59	3.540	p=0.715
SO_2_Z	Control	8	97.837	1.5982	t=1.373
	Intervention	11	92.691	10.4308	p=0.188

SD = standard deviation; PCO2_I = partial pressure of carbon dioxide two hours after patient extubation; PO2_I = partial oxygen pressure two hours after patient extubation; HCO3_I = bicarbonate two hours after patient extubation; SO2_I = oxygen saturation two hours after patient extubation; PCO2_Z = partial pressure of carbon dioxide immediately before patient transfer from the intensive care unit (ICU); PO2_Z = partial oxygen pressure just before patient transfer from the ICU; HCO3_Z = bicarbonate just before patient transfer from the ICU; SO2_Z = oxygen saturation just before patient transfer from the ICU

hospitalization. It was also examined whether there was a difference in the values of ABG parameters between the groups. We also examined functional capacity using the 2MWT and sit-to-stand test.

A limited number of studies evaluated the effect of preoperative respiratory rehabilitation in patients undergoing cardiac surgery[12,13]. In our study, preoperative respiratory rehabilitation significantly influenced the length of total hospitalization, which is one of the

benefits of preoperative respiratory rehabilitation, similar to the results of several studies[8,14]. Arthur *et al.* demonstrated that preoperative physical training reduced the length of hospitalization[14]. We did not find an effect of preoperative rehabilitation on ICU length of stay, although Snowdon *et al.*[15] have reported such a connection. The mean ICU length of stay was 2.73±0.90 days in group A, which did not differ significantly from group B (3.50±1.07 days). Mansueto *et*

Table 4. Functional capacity parameters

	Groups	n	Mean	SD	t-test
2MWT-before (meters)	Control	8	110.75	14.140	t=0.778
	Intervention	11	116.73	18.023	p=0.447
Sit-stand- before	Control	8	7.63	3.204	Z=2.297
	Intervention	11	9.36	1.433	p=0.022
2MWT-last-day (meters)	Control	8	96.25	8.102	t=3.257
	Intervention	11	110.27	10.001	p=0.005
sit-stand-last day	Control	8	4.50	0.926	t=2.996
	Intervention	11	6.91	2.119	p=0.008

SD = standard deviation; 2MWT-before = two-minute walk test before cardiac rehabilitation; sit-stand-before = sit-to-stand test before cardiac rehabilitation; 2MWT-last-day = two-minute walk test after cardiac rehabilitation; sit-stand-last day = sit-to stand test after cardiac rehabilitation

Table 5. Occurrence of complications

			Group		
			Control	Intervention	Total
Complications	No	n	3	9	12
		% within group	37.50%	81.82%	63.16%
		% of total	15.79%	47.37%	63.13%
	Yes	n	5	2	7
		% within group	62.50%	18.18%	36.84%
		% of total	26.32%	10.53%	36.84%
Total		N	8	11	19
		% within group	100.0%	100.0%	100.0%
		% of total	42.11%	57.89%	100.0%

al.[16] also report that preoperative inspiratory muscle training resulted in reduction of the length of postoperative hospital stay.

The results of our study revealed preoperative rehabilitation to have reduced the duration of MV, as also indicated in the study by Hulzebos *et al.*[13]. Zanini *et al.*[17] report that preoperative respiratory rehabilitation was associated with the duration of MV in patients undergoing cardiac surgery. Also, rehabilitation minimized the possibility of MV complication and accelerated the speed of patient recovery[8]. Hulzebos *et al.*[7] showed that preoperative physical therapy could reduce the length of MV, incidence of PPC (atelectasis and pneumonia), and length of total hospitalization in patients undergoing cardiovascular surgery. Moreover, in patients in whom preoperative respiratory rehabilitation was performed, the incidence of PPC was decreased by 50% in comparison to patients who had conventional care[13]. Preoperative respiratory rehabilitation was associated with reduction in the occurrence of postoperative atelectasis and pneumonia, compared to patients who received conventional care or non-exercise intervention[18].

In our study, the results on the incidence of complications (complications reported by yes/no in both groups) did not differ significantly between the groups, but there was difference in the rate of complications between group A (2 complications) and group B (5 complications).

Evaluation of the ABG parameters did not show differences between the two groups.

Moradian *et al.*[19] suggest that early mobilization in the postoperative period in patients after CABG increased partial oxygen pressure in arterial blood. There are a small number of studies that examined the effects of preoperative respiratory rehabilitation on respirato-
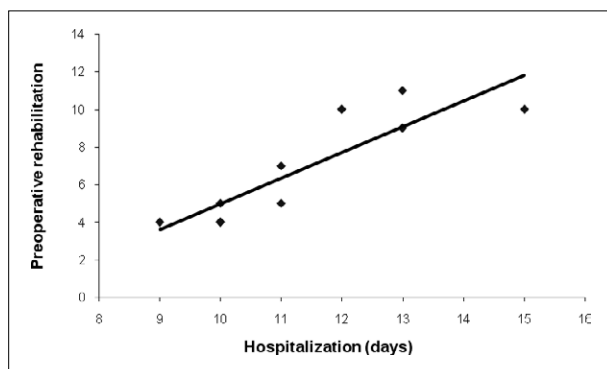
Fig. 1. Correlation between length of hospital stay and preoperative rehabilitation in the intervention group.

ry function based on ABG parameters, so additional studies on the topic are considered necessary.

The results of our study demonstrated significant differences between the groups in the mean values of 2MWT on the last day of hospitalization, sit-to-stand test before and after surgery (last day of hospitalization) in both groups. We chose to investigate 2MWT because it is a practical and feasible test to apply before and after cardiac surgery.

Our study showed strong correlation between the length of hospitalization and preoperative rehabilitation in group A, suggesting that the implementation of preoperative rehabilitation is necessary in patients undergoing cardiac surgery.

A limitation of the study was a small sample because cardiac surgery was postponed after repeated angiography in a great number of patients.

Conclusion

The study showed that preoperative respiratory rehabilitation reduced the duration of MV and total length of hospitalization in cardiac surgery patients. The results also showed that preoperative respiratory rehabilitation could have favorable effects on patient functional capacity. Study results suggest the implementation of preoperative rehabilitation to be necessary in patients undergoing cardiac surgery.

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Sažetak

UTJECAJ PRIJEOPERACIJSKE RESPIRACIJSKE REHABILITACIJE
KOD KARDIOKIRURŠKIH BOLESNIKA

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Cilj rada je bio procijeniti učinak prijeoperacijske respiracijske rehabilitacije na funkcionalni kapacitet, dužinu boravka u jedinici intenzivnog liječenja (JIL), trajanje mehaničke ventilacije (MV) i ukupnu hospitalizaciju te procijeniti vrijednosti plinske analize arterijske krvi (ABG) kod bolesnika podvrgnutih kardiokirurškim operacijama. U radomiziranu opservacijsku studiju bilo je uključeno 19 bolesnika podijeljenih u dvije skupine: skupina A (ispitivana) i B (kontrolna). Prijeoperacijska i poslijeoperacijska rehabilitacija provedena je u skupini A, a samo poslijeoperacijska rehabilitacija u skupini B. Rehabilitacija je provođena prema unaprijed utvrđenom protokolu. Rabili smo parametre ABG za procjenu respiracijske funkcije, a za procjenu funkcionalnog kapaciteta 2-minutni test hoda (2MWT) i *sit-to-stand* test. Sljedeći podaci prikupljeni su iz medicinske dokumentacije: dužina MV, dužina boravka u JIL, pojava komplikacija i dužina ukupne hospitalizacije. Nađena je značajna razlika između skupina za dužinu ukupne hospitalizacije (p<0,05) i dužinu MV (p<0,05). Analiza srednjih vrijednosti 2MWT posljednjeg dana hopitalizacije (p=0,005), *sit-to-stand* testa prije operacije (p=0,022) i posljednjeg dana hospitalizacije (p=0,008) između skupina pokazala je statistički značajnu razliku. Dužina hospitalizacije je značajno korelirala s prijeoperacijskom rehabilitacijom u skupini A (r=0,885; p<0,0001). Nije bilo razlike u parametrima ABG između skupina. Studija je pokazala da je prijeoperacijska respiracijska rehabilitacija utjecala na smanjenje dužine MV, dužinu trajanja ukupne hospitalizacije te na poboljšanje funkcionalnog kapaciteta.

Ključne riječi: *Respiracijska rehabilitacija; Aortokoronarna premosnica; Mehanička ventilacija; Plinska analiza arterijske krvi*