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Original Article

Effects of Early Mobilization on Hemodynamics and Pain after Coronary Artery Bypass Graft Surgery: A Randomized Controlled Trial

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Abstract

Introduction: Patients with coronary artery disease (CAD) can improve quality of life by undergoing coronary artery bypass graft (CABG), but they may face various complications. Early mobilization can help prevent these complications. This study aimed to evaluate the effects of two early mobilization protocols on pain and hemodynamic outcomes in patients who had CABG surgery.

Methods: This was a randomized, blinded clinical trial with a three-arm parallel design, conducted on 105 patients who underwent CABG at Shahid Madani hospital in Tabriz. The patients were randomly assigned to three groups: control, first intervention, and second intervention. The control group received standard care, while two intervention groups received early mobilization based on passive and active range of motion (ROM) activities and early mobilization based on deep breathing exercises respectively. Data were collected using a questionnaire that measured pain intensity using a facial pain scale and hemodynamic indicators using a monitor device. Data analysis was performed using SPSS version 24 software and descriptive and inferential statistics methods.

Results: According to the study, the second intervention group is more effective than the first intervention group. The results indicated that in both morning and evening shifts, the mean of systolic blood pressure (SBP) increased significantly in three groups. Also, the mean of diastolic blood pressure (DBP) increased significantly in both shifts in intervention group 1 and control. The mean of DBP decreased (MD=-26.0, 95% CI: -5.6 to -1.2; $P=0.003$) significantly among intervention group 2 compared to control group in the evening. The results also indicated that the mean of heart rate (HR) raised significantly in both shifts in all three groups. In the morning, there was a significant difference between intervention group 2 and 1 compared to control. The mean of arterial oxygen saturation was a significant difference between intervention group 2 and intervention group 1 and control group in the both shifts. The mean of pain decreased significantly in the morning in two intervention groups. Similarly, in the evening, the mean of pain decreased significantly in intervention group 1, and intervention group 2. Both in the morning and evening, there was a significant difference between intervention group 2 and intervention group 1 ($P<0.001$).

Conclusion: This study provides valuable insights into the effects of early mobilization interventions on patients after CABG, but more research is needed to determine the optimal timing and intensity of mobilization protocols for patients after CABG and to explore the long-term effects and cost-effectiveness of these interventions.

Introduction

According to the World Health Organization (WHO), cardiovascular diseases (CVDs) constitute the leading cause of death worldwide. CVDs constituted approximately 33.3% of worldwide mortality in 2021.[1] Coronary artery disease (CAD) is one of the leading causes of mortality and morbidity worldwide.[2] It is a major public health challenge that affects millions of people and their quality of life.[3] In Iran, CAD accounts for 50% of annual deaths and imposes a burden on the health care system and the society.[4]

The goal of treating CAD is to restore adequate blood supply to the myocardial regions that suffer from severe stenosis or occlusion of the coronary arteries. Percutaneous transluminal coronary angioplasty (PTCA) and coronary artery bypass grafting (CABG) surgery

are the available treatment options.[5] CABG surgery has significant effects on reducing mortality and improving the prognosis of patients with CAD.[6] However, CABG surgery also poses some common problems, such as the extensive hemodynamic changes.[7]

Incomplete drainage of blood and fluid from the pericardial and pleural cavities in a short time after surgery can cause problems for patients directly or indirectly, such as reduced cardiac output, blood pressure changes, pulse changes, arrhythmia and respiratory problems. These problems lead to extensive hemodynamic changes after surgery and consequently sternotomy and reoperation the definition of hemodynamic changes.[8,9] Moreover, after CABG surgery, the person usually becomes immobile for a few hours and needs mechanical ventilation, which causes the progression of neuromuscular weakness in 25% to 60% of patients.[10] Patients after CABG surgery are transferred to the cardiac surgery intensive care unit (ICU) and usually stay there for three days, which is another cause of immobility after CABG surgery.[11] The International Association for the Study of Pain defines pain as "an unpleasant sensory and emotional experience associated, or similar to that associated, with actual or potential tissue damage."[12] Post-operative pain is the most prevalent type of acute pain. It is reported that 80% of surgical patients experience post-operative pain, and the frequency and intensity are greatest from the first to the fourth post-operative day. In this sense, post-operative pain management should be a priority in the care of these patients. When pain is not properly controlled, the patient becomes predisposed to chronic post-operative pain, which can have a significant impact on quality of life.[13]

Patients who have undergone CABG surgery and have improved blood supply to the heart after surgery are good candidates for cardiac rehabilitation.[14] The WHO defines cardiac rehabilitation as "a set of activities that guide a cardiac patient to achieve the best physical, psychological and social status possible and enable them to resume their normal social life and active life".[15] Cardiac rehabilitation after CABG surgery is performed in three phases: early mobilization after surgery, daily progressive exercise and discharge and continuation of exercise.[16]

Early mobilization includes activities that start with hemodynamic and respiratory stabilization and usually in the first hour of admission to the ICU. Early mobilization is an effective nursing intervention that improves patient care outcomes and prevents complications related to immobility.[17,18] The benefits of early mobilization include reduced duration of mechanical ventilation, reduced hospital stay, improved functional status and reduced pain intensity.[10,19,20] However, there is a lack of valid evidence on how, when, and type of early mobilization exercises and diversity of early mobilization protocols.[21-23] Considering the importance of the subject and that there was no specific protocol for standard implementation of early mobilization in cardiac surgery ICUs so far and nurses in these centers act routinely, this study aimed to compare the effects of early mobilization based on passive and active range of motion (ROM) activities with early mobilization based on deep breathing exercises on pain intensity and hemodynamic changes in patients admitted to cardiac surgery ICU after CABG at Shahid Madani Hospital in Tabriz.

Materials and Methods

The present study is a randomized single-blind clinical trial with a parallel three-arm design. The study compares the effects of two intervention groups and one control group on the outcomes of patients post CABG. The first intervention group received the progressive early mobilization protocol based on the Morris protocol and modified by Azarfarin et al[24] the second intervention group received the early mobilization protocol with respiratory muscle strengthening exercises designed by Yayla and Özer,[25] the control group received the usual and routine care of the ward.

Participants

Ethical approval was obtained from Tabriz University of Medical Services' research ethics committee (IR.TBZMED.REC.1401.163) before conducting the research, and this study was registered in the Iranian Clinical Trial Registration Center (IRCT20160110025937N7).

The research population consisted of all patients over 18 years old, who referred to Shahid Madani Cardiovascular Center in Tabriz from October 2022 to February 2023 and were diagnosed with CAD and underwent CABG. The potential participants who met the study inclusion criteria received a detailed explanation of the research objectives from the researchers. They were then requested to give their informed consent and participate in the study.

The sample size for each group was determined to be 32 participants, based on an alpha level (type I error rate) of 0.05, a beta level (type II error rate) of 0.01, and a power (probability of detecting a true effect) of 95%. To account for a 10% dropout rate, each group was increased to 35 participants, resulting in a total of 105 participants. All participants completed the study, meaning that the data analysis was performed on 105 participants. The eligible samples (n = 105) were randomly assigned to three groups: first intervention group (n = 34), second intervention group (n = 35), and control group (n = 36), with a 1:1:1 allocation ratio. A pilot study with 30 participants (10 participants in each group) was conducted to help with sample size calculation. The sample size was calculated using G*Power software. The random allocation sequence was generated by a person who was not involved in the research, using RAS (Random Allocation Software) and random block sizes of 3 and 6 for the three groups. The allocation concealment was done based on the generated sequence, using opaque, sealed, and uniform envelopes that were numbered from 1 to 105. The first person who

entered the study was given envelope number 1 and this process continued until the end. Therefore, the researcher and the research subject were blinded (unaware of the treatment received) until after the envelopes were opened. In this study, the statistical analyst and outcome examiner were also blinded.

We included participants who had no history of neuromuscular degenerative diseases (e.g., amyotrophic lateral sclerosis, muscular dystrophy, Parkinson's disease), no unstable fractures that impaired their movement, no lower limb amputation, no history of cerebrovascular events, traumatic brain injury, radiotherapy or chemotherapy in the last 6 months, systolic blood pressure (SBP) above 90 mm Hg and heart rate (HR) between 60 and 100 beats per minute, measured by a standard sphygmomanometer and a pulse oximeter, and communication skills. We excluded participants who had cardiac or respiratory arrest during or after admission to the ICU, mechanical ventilation for more than 24 hours, HR above 120 or uncontrolled arrhythmias, unstable angina, open sternum, SpO2 below 90, or unwillingness to continue cooperation and inability to perform interventions.

Interventions

Early Mobilization Protocol of the First Intervention Group

The participants in the first intervention group 24 hours after CABG, received a progressive early mobilization protocol based on Morris protocol and modified by Azarfarin et al.[24] The protocol consisted of the following phases: Phase 1: Position change in the bed and then raised the head of the bed to 45 degrees. Phase 2: ROM exercises for upper and lower limbs for 5 minutes. Phase 3: Sitting on the bed for 5 minutes with the help and support of the researcher. Phase 4: Sitting on the edge of the bed for 5 minutes. Phase 5: Standing next to the bed for 5 minutes according to their tolerance level and then was transferred to a chair next to the bed and stayed in this position for another 5 minutes. Phase 6: Walking with assistance a distance with the help of a nurse and accompanied by a pulse oximeter and with monitoring of HR and SPO2 levels and patient's tolerance level and with assurance of connections and drainage tube for 6 minutes. The total duration of the protocol was 25-30 minutes depending on the patient's tolerance level and if the patients showed intolerance, they were returned to their bed. We did this intervention for 5 days. After completing the final phase and also 15 minutes after the intervention, we measured hemodynamic variables and pain intensity using the mentioned tools.

The Early Mobilization and Breathing Exercises Protocol for the Second Intervention Group

The second intervention group followed an early mobilization protocol by Yayla and Özer.[25] The early mobilization team performed the protocol in the first 5 days after surgery and gradually completed in the following days. The protocol had 4 phases on the day of surgery and 5 phases on the other days. If participants were fully conscious, i.e., Glasgow Coma Scale criterion (GCS) = 15, we performed the intervention 6-8 hours after removing the tracheal tube that was inserted for mechanical ventilation. The intervention was as follows: Phase 1: Position change and then raised the head of the bed to 30 to 45 degrees. Phase 2: Respiratory exercises; We performed incentive spirometry, deep breathing exercises, and coughing eight times a day (twice a day, each time 4 sets). To perform incentive spirometry, we placed the patients in a sitting or semi-sitting position and by placing the incentive spirometer tube in their mouth, they performed inhalation inside the device and after inhalation they held their breath for three seconds and then exhaled slowly through their mouth. We told them to gradually perform deeper breathing by increasing the amount of raising balls. Then after completing incentive spirometry, we taught them to cough more effectively out of chest secretions by mouth by supporting wound areas with pillows and hands while coughing. We also performed deep breathing exercises as follows: The patient breathed deeply through their nose and while doing so placed their hands on their chest to reduce pain and perform comfortable breathing and after inhalation held their breath for three seconds and then exhaled while puckering their lips and tightening their abdominal muscles. Phase 3: Passive exercises; we performed passive exercises of limbs twice a day and each time 5 sets for 10 minutes according to patient's tolerance level. Phase 4: Sitting on chair; we transferred the patients to a chair next to the bed and made them sit twice a day for different durations depending on the day: 15 minutes on day zero, 20 minutes on day one, 30 minutes on day two, and 45 minutes on day three and four. Phase 5: Walking with assistance; we made the patients walk with the help of a nurse twice a day for different distances depending on the day: 150 steps on day one, 250 steps on day two, and 400 steps on day three and four. We controlled hemodynamic indices and pain intensity immediately and 15 minutes after performing the intervention using standard tools such as blood pressure monitor, pulse oximeter, electrocardiogram, and visual analogue scale.

The control group received the routine hospital intervention for early mobilization after cardiac surgery, which consisted of dangling their legs from the bed and walking a distance according to their tolerance level twice a day until discharge from ICU. The patients' privacy was maintained by drawing the curtains around their bed in three groups to prevent data contamination. Figure 1 shows the flowchart of the study.

Instruments

To gather data about the participants' individual and social characteristics, a questionnaire developed by the researcher was employed. The questionnaire asked about

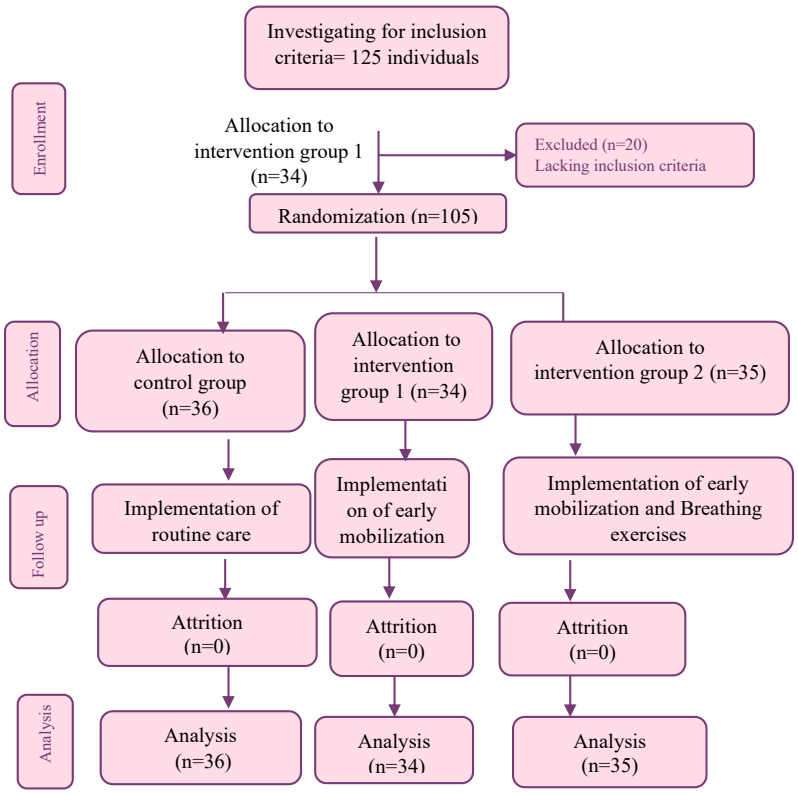

Figure 1. Flow diagram of participants

their age, gender, weight, education, marital status, family history of heart disease, and coexisting conditions of hypertension, hyperlipidemia, diabetes, smoking, and history of hospitalizations due to CAD, previous surgeries, and medication use. The visual pain scale was chosen as the pain assessment tool because it is simple, valid, and reliable for measuring pain intensity in conscious patients.[26] In this study was used the Persian version of the visual pain scale which was used by Hassanpour-Dehkordi et al.[27] The patients were asked to mark their pain level on a 10-cm line, where the left side (number zero) indicated no pain and the right side (number 10) indicated the most severe pain. This tool is a 10-cm criterion, where the left side (number zero) indicates no pain and the right side (number 10) indicates the most severe pain. Obtaining a score of 1-3 indicates mild pain, 4-7 moderate pain and 8-10 indicates severe pain. To assess the reliability of the visual pain scale using parallel tools method, two tools VAS and Face analogue scale (FAS) were used simultaneously and the correlation between the results of two tools was determined. The results of two tests indicated a high correlation of 0.8 which show acceptable reliability. We measured hemodynamic indices using the monitoring device, which controls SPO2, Non-Invasive Blood Pressure (NIBP), HR. Hemodynamic indices included: SBP, diastolic blood pressure (DBP), HR and oxygen saturation (SPO2). The device was calibrated when were used for intervention by medical engineers. We measured the indices before and immediately and 15 minutes after the interventions in all three groups. One of the team members (SJ) herself performed the measurements. We used two different devices to examine the reliability of the instrument in determining hemodynamic indices. We selected a monitoring device and a sphygmomanometer and handheld pulse oximeter that were calibrated by the medical engineer of the center. We measured hemodynamic indices using both devices and compared the results. We observed that the result obtained from both devices was identical, which indicates the reliability of the measurement method.

Data Analysis

The collected data from all three groups were analyzed using SPSS software version 24 (IBM Corp., Armonk, NY, USA). The normality of data distribution was checked and confirmed ($P>0.05$) by Kolmogorov-Smirnov test, and therefore parametric tests were used. We reported the quantitative and qualitative data based on the mean (SD) and number (%). The intergroup comparison of demographic information was done using the chi-square, chi-square test for trend and one-way ANOVA. Independent samples *t* test was used for comparison between groups before the intervention. Paired *t* test was used to compare variables within the group. Repeated measures ANOVA was used to compare quantitative variables between groups after intervention adjusted for adjusted for baseline measure and body mass index (BMI). We considered a *P* value of less than 0.05 to be

statistically significant.

Results

Participant

The majority of participants (38.5%) were in the age group of 50–59. Almost all of them were men (94.3%). The demographic and clinical characteristics of the participants were similar and there was no significant difference among three groups. Participants were significantly different in terms of BMI and level of consciousness ($P > 0.05$). The three study groups were similar in terms of other characteristics (Table 1).

Systolic Blood Pressure

After adjusting for baseline measure of BMI, the results of analysis of covariance (ANCOVA) test showed that there was no significant difference in the mean SBP between the groups after the intervention in both morning and evening shifts ($P > 0.05$) (Table 2).

Diastolic Blood Pressure

In the intervention group 2, there was no significant change in DBP in both morning and evening ($P > 0.05$). After adjusting for baseline measure of BMI, the results of ANCOVA test indicated that in the morning, there was no significant difference between intervention group 2 and 1 compared to control group or to each other. Only the mean of DBP decreased significantly among intervention group 2 compared to control group in the evening (Table 2).

Heart Rate

According to the repeated measures ANOVA (within group) showed that the mean (SD) of HR raised significantly in the morning in intervention group 1, and intervention group 2, in the evening, the mean of HR increased significantly in intervention group 1, intervention group 2, and control group. In the morning, there was a significant difference between intervention group 2 and 1 compared to control group ($P < 0.001$). In the evening, there was no significant difference between intervention group 2 and 1 compared to control group or to each other with reporting mean (SD) and *P* value (Table 3).

Arterial Oxygen Saturation

The results of repeated measures ANOVA (within group) indicated that the mean (SD) of SaO2 increased significantly in the morning in intervention group. There was also a significant difference between intervention group 2 and intervention group 1 and control group ($P < 0.001$). Similarly, in the evening, the mean of SaO2 increased significantly in intervention group 2. There was a significant decrease in the mean of SaO2 in the control group. There was a significant difference between intervention group 1 and control group in the evening ($P < 0.001$). As well as there was a significant difference between intervention group 2 and intervention group 1 and control group both in the morning and in the evening ($P < 0.001$) (Table 4).

Pain

The results of repeated measures ANOVA (within group) indicated that the mean (SD) of pain decreased significantly in the morning in intervention group 1, intervention group 2, and control group. Similarly, in the evening, the mean of pain decreased significantly in intervention group 1, and intervention group 2. Both in the morning and evening, there was a significant difference between intervention group 2 and intervention group 1 ($P < 0.001$) (Table 5).

Discussion

This study aimed to assess the impact of two types of early mobilization protocols on the post-operative outcomes of patients who underwent cardiac surgery.

The results show that the SBP of the patients in all three groups raised after the intervention compared to before the intervention. However, the changes in SBP and DBP among the three groups were not statistically significant, either before or after the mobilization protocols for patients who underwent open heart surgery. The results of different studies on the effect of mobility and exercise on SBP and DBP of patients after heart surgery are different. A study showed that HR, SBP and DBP increased from baseline at post-exercise and then decreased at 15- and 30-min post-exercise in CABG patients.[28] The results of Cassina and colleagues' study showed that arterial pressure and blood pressure decreased, while the heart rate did not change. The mean arterial pressure also decreased, and these changes were reversed by positioning the patient in a horizontal position.[29] In another study, the changes in SBP and DBP before and after the intervention were not statistically significant in both groups, according to a study by Mohamadi titled "clinical trial of progressive muscle relaxation on vital signs of patient with heart attack".[30] The results of a similar study in Iran showed that early mobilization after surgery is safe and does not affect the hemodynamic status of patients,[31] which is consistent with the results of our study. However, it is important to monitor the vital signs of the patients during and after the mobilization protocols and to individualize the interventions based on the patient's condition and tolerance. More research is needed to determine the optimal timing and intensity of mobilization protocols for patients after open heart surgery. According to the finding, HR increased significantly after two types of interventions. The results of some studies were in contrary with the findings of our study. Some of them have investigated the effect of early mobilization on coronary artery patients, the researchers have reported a decrease in heart rate.[32,33] This decrease in

Table 1. Demographic characteristics of participants in the control and intervention groups

Variables	Intervention group 2	Intervention group 1	Control group	*P* value
Age, No. (%)				
40-49	4 (11.4)	3 (8.8)	4 (11.1)	
50-59	15 (42.9)	12 (53.3)	7 (19.4)	0.28*
60 and above	16 (45.7)	19 (55.9)	25 (69.4)	
Sex, No. (%)				
Woman	1 (2.9)	2 (5.9)	3 (8.3)	0.60*
Man	34 (97.1)	32 (94.1)	33 (91.7)	
Job, No. (%)				
Worker	2 (5.7)	11 (34.4)	6 (18.2)	
Self-employment	19 (55.9)	14 (43.8)	17 (51.5)	0.45*
Employee	12 (34.2)	5 (15.6)	7 (21.2)	
Homemaker	1 (2.9)	2 (6.3)	3 (9.1)	
Education, No. (%)				
Illiterate	6 (17.1)	8 (23.5)	6 (16.7)	
Elementary	13 (37.1)	12 (35.3)	13 (36.1)	0.73**
Diploma and sub-diploma	11 (31.4)	14 (41.2)	10 (27.8)	
Tertiary	5 (14.3)	0 (0.0)	7 (19.4)	
Previous hospitalization history, No. (%)				
No hospitalization	2 (6.7)	11 (34.4)	7 (19.4)	
One day	20 (66.7)	15 (46.9)	21 (58.3)	0.118*
Two days	5 (16.7)	6 (18.8)	5 (13.9)	
Three days	2 (6.7)	11 (34.4)	7 (19.4)	
Medication				
Beta blocker	14 (40.0)	16 (51.6)	17 (47.2)	
ACEIs	12 (34.2)	13 (38.2)	12 (33.3)	0.457*
Nitrates	2 (5.7)	2 (5.8)	7 (19.4)	
BMI (kg/m^2), Mean (SD)	22.94 (8.242)	6.17 (3.96)	25.78 (3.18)	F=3.36, df=2 P=0.04***
SBP (mm Hg), Mean (SD)	115.13 (25.94)	120.27 (19.74)	120.61 (11.89)	F=0.66, df=2 P=0.52***
DBP (mm Hg), Mean (SD)	75.86 (9.96)	78.13 (15.63)	73.50 (10.93)	F=1.08, df=2 P=0.36***
Blood sugar (mg/dL)	142.94 (68.05)	132.05 (47.85)	146.83 (53.76)	F=0.06, df=2 P=0.54***
Ejection fraction (%)/	48.14 (7.48)	47.94 (8.53)	47.91 (8.22)	F=0.01, df=2 P=0.99***
Recovering alertness after CABG	14.85 (1.87)	24 (0)	24 (0)	F=382.89, df=2 P<0.05***

SBP, Systolic blood pressure; DBP, Diastolic blood pressure; ACEIs, Angiotensin-converting enzyme inhibitors; CABG, coronary artery bypass graft.
*Chi-square; **Chi-square test for trend; ***One-way ANOVA.

heart rate probably occurred in a longer follow-up than in our study. We measured the heart rate immediately after the interventions, which certainly increases following the activity of the heart rate.[34] Regular exercises (endurance, strength and motor) can lower the heart rate and make the heart more efficient. This may be because the heart pumps more blood with each contraction and receives more blood volume due to exercise, as shown by various studies.[35]

This study demonstrated that early mobilization based on deep breathing exercises was effective in improving the oxygen saturation (SaO2) of patients who underwent CABG. The intervention group 2, who received this protocol, showed a significant increase in SaO2 compared to the control group and the intervention group 1, who received the usual care and the early mobilization based on passive and active ROM activities, respectively. The mechanism behind this effect may be related to the increased lung volume, alveolar ventilation, and respiratory muscle strength that result from deep breathing exercises.[36] Several studies have demonstrated that breathing exercises, incentive spirometry, bed exercises,

Table 2. Systolic and diastolic blood pressure at baseline, immediately, and 15 min after intervention

Follow up	Mean (SD)			Adjusted MD (95%CI) $_{Int. 1/C}$	$P_{Int. 1/C}$	Adjusted MD (95%CI) $_{Int. 2/C}$	$P_{Int. 2/C}$	Adjusted MD (95%CI) $_{Int. 2/Int. 1}$	$P_{Int. 2/Int. 1}$
	Int. 1	Int. 2	Control group						
SBP									
Baseline, AM	117.3 (12.6)	121.4 (11.8)	115.2 (14.0)	-	0.77*	-	0.10*	-	0.37*
Immediately after, AM	120.8 (11.8)	125.2 (10.4)	119.3 (13.5)	-0.7 (-2.1,0.7)	0.32**	-0.2 (-1.7,1.3)	0.76**	0.5 (-1.0,2.0)	0.51**
15 min after, AM	120.5 (11.3)	125.9 (9.9)	118.7 (13.7)						
MD (95% CI), P***	3.2 (1.8, 4.5) <0.001	3.8 (2.7, 5.0) <0.001	4.1 (2.5, 5.7) <0.001	-	-	-	-	-	-
Baseline, PM	117.6 (11.9)	120.9 (11.9)	116.9 (11.5)	-	0.96*	-	0.32*	-	0.49*
Immediately after, PM	121.9 (11.7)	124.7 (10.0)	120.3 (10.8)	1.0 (-4.1, 6.3)	0.68**	5.2 (-0.1, 10.6)	0.05**	4.1 (-1.2,9.5)	0.12
15 min after, PM	120.8 (11.9)	125.7 (9.9)	120.3 (10.5)						
MD (95% CI), P***	3.1 (2.1, 4.1) <0.001	4.1 (2.9, 5.2) <0.001	3.9 (2.5, 5.2) <0.001	-	-	-	-	-	-
DBP									
Baseline, AM	69.6 (9.9)	73.1 (10.8)	67.5 (11.6)	-	0.69*	-	0.08*	-	0.38*
Immediately after, AM	72.04 (9.9)	76.32 (10.0)	69.61 (11.1)	2.4 (-2.4, 7.4)	0.31**	5.6 (0.5, 10)	0.05**	3.1 (-1.9,8.1)	0.22**
15 min after, AM	71.61 (9.3)	73.96 (8.7)	69.19 (12.1)						
MD (95% CI), P***	1.9 (0.09, 3.8) 0.041	-0.1 (-1.9, 1.7) 0.888	2.4 (1.3, 3.6) <0.001	-	-	-	-	-	-
Baseline, PM	69.0 (8.7)	72.3 (8.5)	68.3 (10.9)	-	0.95*	-	0.19*	-	0.33*
Immediately after, PM	71.11 (8.6)	73.13 (9.6)	70.62 (12.2)	-1.6 (-3.7, 0.4)	0.12**	-3.4 (-5.6, -1.2)	0.003**	-1.7 (-3.9, 0.3)	0.10**
15 min after, PM	70.52 (7.5)	72.46 (7.7)	70.89 (10.9)						
MD (95% CI), P***	1.4 (0.2, 2.7) 0.020	-0.1 (-2.2, 1.9) 0.868	3.6 (1.7, 5.5) <0.001	-	-	-	-	-	-

SBP: Systolic blood pressure; DBP: Diastolic blood pressure; Int. 1: Intervention group1, early mobilization protocol; Int. 2: Intervention group2: early mobilization protocol and breathing exercises; AM: morning shift; PM: afternoon shit.
*Independent samples t test, **Repeated measures ANOVA adjusted for baseline measure and BMI, ***Repeated measures ANOVA (within group).

Table 3. Heart rate at baseline, immediately after intervention

Follow up	Mean (SD)			Adjusted MD (95%CI) $_{Int. 1/C}$	$P_{Int. 1/C}$	Adjusted MD (95% CI) $_{Int. 2/C}$	$P_{Int. 2/C}$	Adjusted MD (95% CI) $_{Int. 2/Int. 1}$	$P_{Int. 2/Int. 1}$
	Int. 1	Int. 2	Control group						
HR									
Baseline, AM	80.7 (11.9)	83.5 (6.8)	78.9 (8.9)	-	0.71*	-	0.10*	-	0.42*
Immediately after, AM	82.8 (11.1)	86.7 (6.9)	75.8 (10.3)	4.35 (2.0,6.7)	<0.001**	5.5 (3.1, 8.0)	<0.001**	1.2 (-1.1, 3.6)	0.31**
MD (95% CI), P***	2.1 (1.0,3.3) <0.001	3.0 (1.3,4.6) <0.001	-1.4 (-3.4,0.6) 0.170	-	-	-	-	-	-
Baseline, PM	79.7 (12.0)	83.2 (6.7)	79.0 (9.5)	-	0.94*	-	0.16*	-	0.30*
Immediately after, PM	82.7 (11.8)	87.2 (7.8)	79.42 (8.5)	1.4 (-0.1, 3.0)	0.07**	2.4 (0.7, 4.1)	0.005**	0.9 (-6.9, 2.6)	0.25**
MD (95% CI), P***	2.9 (1.7, 4.1) <0.001	3.7 (2.7, 4.7) <0.001	1.8 (0.7, 3.0) 0.002	-	-	-	-	-	-

HR: Heart rate; Int. 1: Intervention group1, early mobilization protocol; Int. 2: Intervention group2: early mobilization protocol and breathing exercises; AM: morning shift; PM: afternoon shit; MD (95% CI): mean difference (95% confidence interval).
*Independent samples t test, ** ANCOVA test adjusted for baseline measure of BMI, ***Paired sample *t* test.

and early mobilization can improve the outcomes of CABG patients by enhancing gas exchange, oxygen saturation, and preventing pulmonary complications such as atelectasis, pneumonia, and pleural effusion.[29,37,38] A randomized controlled study by Girgin et al showed that pulmonary rehabilitation, which included deep breathing exercises, improved the respiratory functions and quality of life of patients after CABG.[39] Another study showed that preoperative incentive spirometry for two days and postoperative exercises of deep breathing, coughing, and early walking following CABG prevented and reduced the occurrence of atelectasis, shortened the hospital stay and the duration of mechanical ventilation, and enhanced the postoperative oxygenation and pain management.[40] These studies and our study suggest that deep breathing exercises can enhance the pulmonary function and gas exchange of patients after CABG, which may reduce the risk of post-operative complications and improve the recovery process. However, some studies have reported different findings from this study which showed that there was no significant difference in arterial blood oxygen saturation, pulmonary function or complications

Table 4. SaO2 at baseline, immediately, and 15 minutes after intervention after surgery

Follow up	Mean (SD)			Adjusted MD (95% CI) $_{Int. 1/C}$	$P_{Int. 1/C}$	Adjusted MD (95% CI) $_{Int. 2/C}$	$P_{Int. 2/C}$	Adjusted MD (95% CI) $_{Int. 2/Int. 1}$	$P_{Int. 2/Int. 1}$
	Int. 1	Int. 2	Control group						
SaO2									
Baseline, AM	93.4 (1.7)	93.8 (0.8)	93.8 (0.7)	-	0.33*	-	0.99*	-	0.31*
Immediately after, AM	93.6 (1.8)	94.7 (0.8)	94.3 (0.7)	0.3 (-0.2, 0.3)	0.78**	0.79 (0.5, 1.0)	<0.001**	0.75 (0.4, 1.0)	<0.001**
MD (95% CI), P***	0.1 (-0.08 ,0.4) 0.172	0.8 (0.7,1.0) <0.001	0.06 (-1.0,0.2) 0.419	-	-	-	-	-	-
Baseline, PM	93.4 (1.7)	93.8(0.8)	93.9(0.6)	-	0.18*	-	0.94*	-	0.10*
Immediately after, PM	93.6 (1.6)	95.0 (0.9)	93.6(1.1)	0.4 (0.1, 0.7)	0.003**	1.3 (1.0, 1.7)	<0.001**	0.9 (0.5, 1.2)	<0.001**
MD (95% CI), P***	0.1 (-0.1, 0.4) 0.245	0.9 (0.8, 1.0) <0.001	-0.3 (-0.5, -0.1) 0.001	-	-	-	-	-	-

SaO2: arterial oxygen saturation; Int. 1: Intervention group1, early mobilization protocol; Int. 2: Intervention group2: early mobilization protocol and breathing exercises; AM: morning shift; PM: afternoon shit; MD (95% CI): mean difference (95% confidence interval).
*Independent samples t test, ** ANCOVA test adjusted for baseline measure of BMI, ***Paired sample *t* test.

Table 5. Pain at baseline, immediately, and 15 minutes after intervention after surgery

Follow up	Mean (SD)			Adjusted MD (95%I) $_{Int. 1/C}$	$P_{Int. 1/C}$	Adjusted MD (95%I) $_{Int. 2/C}$	$P_{Int. 2/C}$	Adjusted MD (95%I) $_{Int. 2/Int. 1}$	$P_{Int. 2/Int. 1}$
	Int. 1	Int. 2	Control group						
Pain									
Baseline, AM	2.1 (0.7)	2.0(0.8)	1.9 (0.6)	-	0.64*	-	0.91*	-	0.87*
Immediately after, AM	1.9 (0.6)	1.5(0.7)	1.6 (0.6)	0.2 (-0.0, 0.4)	0.57**	-0.2 (-0.4, 0.02)	0.79**	-0.4 (-0.6, -0.1)	<0.001**
15 min after, AM	1.6 (0.7)	1.2(0.6)	1.3 (0.5)						
MD (95% CI), P	-0.4 (-0.6, -0.1) 0.003	-0.7 (-0.9, -0.5) <0.001	-0.5 (-0.7, -0.2) <0.001	-	-	-	-	-	-
Baseline, PM	1.8 (0.6)	1.6 (0.8)	1.5 (0.7)	-	0.09*	-	0.70*	-	0.38*
Immediately after, PM	1.5 (0.7)	1.2 (0.5)	1.1 (0.6)	0.08 (-0.1, 0.3)	0.48**	-0.1 (-0.4, 0.07)	0.16**	-0.2 (-0.5, -0.01)	<0.001**
15 min after, PM	1.3 (0.7)	1.1 (0.6)	0.9 (0.5)						
MD (95% CI), P***	-0.5 (-0.8, -0.3) <0.001	-0.7 (-0.9, -0.4) <0.001	-0.2 (-0.4,0.05) 0.107	-	-	-	-	-	-

SaO2: arterial oxygen saturation; Int. 1: Intervention group1, early mobilization protocol; Int. 2: Intervention group2: early mobilization protocol and breathing exercises; AM: morning shift; PM: afternoon shit; MD (95% CI): mean difference (95% confidence interval).
*Independent samples t test, ** Repeated measures ANOVA test adjusted for baseline measure of BMI, *** Repeated measures ANOVA (within group).

among the intervention group, who did not receive deep breathing exercises as part of their physiotherapy program after surgery.[41-44] There may be differences in the study design, population, duration and the exercise load and outcome measures that could explain the contradictory results.[45]

The pain of the patients in all three groups got better after they followed the hospital's usual treatment and early mobilization protocols. But the early mobilization with deep breathing exercises group had more pain relief than the early mobilization with passive and active ROM activities group. These findings are consistent with other studies that have reported similar outcomes.[25,46,47] Other studies have reported that similar interventions such as incentive spirometry,[48] and oxygen therapy,[49] and nurse-based pain management programs,[50] may have beneficial effects on postoperative outcomes in patients undergoing surgery. There are several possible reasons why pain decreases after early mobilization protocol. One reason is that early mobilization can improve blood circulation and oxygen delivery to the tissues, which can reduce inflammation and promote healing.[51] Another reason is that early mobilization can stimulate the release of endorphins, which are natural painkillers that can block pain signals in the brain.[52] Early mobilization can also prevent muscle stiffness and joint contractures, which can cause pain and limit mobility.[53]

This study has several strengths and limitations that should be considered when interpreting the results. One of the strengths of this study is that it used a randomized controlled trial design, which is the gold standard for evaluating the effectiveness of interventions. Another strength is that it used three different mobilization protocols, which allowed for a comparison of the effects of different types and intensities of exercises on the outcomes of interest. Moreover, the study measured the vital signs and pain of the patients before and after the intervention, which provided objective and quantitative data on the changes in the hemodynamic status and pain of the patients. Furthermore, the study used a standardized protocol for measuring the vital signs and pain of the patients, which ensured consistency and accuracy in the data collection process. However, this study also has some limitations that should be acknowledged. One of the

limitations is that the study did not measure the baseline vital signs and pain of the patients before the surgery, which could affect the comparison of the outcomes after the intervention. Another limitation is that the study did not control for other factors that could influence the vital signs and pain of the patients, such as medication use, comorbidities, psychological status, or environmental conditions. A third limitation is that the study did not follow up with the patients after discharge, which could limit the generalizability and applicability of the results to the long-term recovery of the patients.

Conclusion

The aim of this study was to compare the effects of two different mobilization protocols on the vital signs and pain of patients who underwent CABG surgery. The results showed that early mobilization interventions did not have adverse effects on blood pressure and heart rate, but improved arterial oxygen saturation and reduced pain in patients after CABG surgery. In addition, patients who received a combination of passive exercises and deep breathing, had better outcomes than patients who, which received only ROM exercises, and control group, which received only routine care. Therefore, this study supports the use of early mobilization based on a variety of exercises as a simple and effective intervention for faster recovery of patients after CABG surgery. This study contributes to the existing knowledge and practice in the field by providing evidence for the safety and efficacy of early mobilization interventions for patients after CABG surgery. However, this study has some limitations, such as the small sample size and the short duration of the intervention. Future research is needed to determine the optimal timing and intensity of mobilization protocols for patients after CABG surgery, as well as to explore their long-term effects on other outcomes such as quality of life or functional status.

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Research Highlights

What is the current knowledge?

This study contributes to the existing knowledge and practice in the field by providing evidence for the safety and efficacy of early mobilization interventions for patients after CABG surgery.

What is new here?

- The results showed that early mobilization interventions did not have adverse effects on blood pressure and heart rate, but improved arterial oxygen saturation and reduced pain in patients after CABG surgery.
- In addition, intervention group 2, which received a combination of passive exercises and deep breathing, had better outcomes than intervention group 1, which received only ROM exercises, or control group, which received only routine care.
- This study supports the use of early mobilization based on a variety of exercises as a simple and effective intervention for faster recovery of patients after CABG surgery.

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Competing Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and publication of this article.

Data Availability Statement

The data available for all

Ethical Approval

This study was approved by the ethics committee in the research of Tabriz University of Medical Sciences ad approved by the code of ethics by No: IR.TBZMED.REC.1401.163. Informed consent assured patients of anonymity, freedom to withdraw from the study at any time and data security.

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