JRSR 9 (2022) 42-46

Journal of Rehabilitation Sciences and Research

Journal Home Page: jrsr.sums.ac.ir

Original Article

The Effects of Coronary Artery Bypass Grafting on Postural Balance

Sara Abolahrari-Shirazi[1,2]*, PhD; Farahnaz Emami[1,2], PhD; Zahra Rojhani-Shirazi[1,2], PhD; Mansour Janati[3], MD; Mersa Razeghi[1], BSc

[1]Department of Physical Therapy, School of Rehabilitation Sciences, Shiraz University of Medical Sciences, Shiraz, Iran
[2]Rehabilitation Sciences Research Center, Shiraz University of Medical Sciences, Shiraz, Iran
[3]Department of Cardiovascular Surgery, Faghihi Hospital, Shiraz University of Medical Sciences, Shiraz, Iran

ARTICLE INFO

Article History:
Received: 15/09/2021
Revised: 27/12/2021
Accepted: 30/01/2022

Keywords:
Cardiac rehabilitation
Coronary artery bypass grafting
Equilibrium
Postural balance
Quality of life

Please cite this article as:
Abolahrari-Shirazi S, Emami F, Rojhani-Shirazi Z, Janati M, Razeghi M. The Effects of Coronary Artery Bypass Grafting on Postural Balance. JRSR. 2022;9(1):42-46.

ABSTRACT

Background: Coronary Artery Bypass Graft (CABG) surgery is associated with several complications. Balance disorders have been reported in patients. The impairments were associated with fall-related injuries and increase the possibility of morbidity, mortality, and healthcare costs. The present study aimed to compare postural balance before and after CABG surgery in patients with established coronary artery disease.

Methods: This cross-sectional study was conducted on 87 patients aged 45-65 years who had undergone CABG surgery through the great saphenous vein. Participants were enrolled into the study by convenience sampling. To assess static balance, individuals were asked to perform the Single Leg Stance Test (SLST). In addition, dynamic balance was measured by the Y-balance test, and the Functional Reach Test (FRT) was conducted before and after CABG surgery. These clinical tests were performed during the week before surgery and repeated one month after that. Paired t-test was used to compare the Y-balance scores, and Wilcoxon test was used to compare the mean values of other outcomes before and after CABG surgery. A level of $P<0.05$ was considered statistically significant.

Results: The results revealed a significant decrease in static and dynamic balance after CABG surgery ($P<0.001$). A significant reduction was also observed in the mean FRT scores in the postoperative period ($P<0.001$).

Conclusion: CABG surgery through the great saphenous vein influenced balance in patients with coronary artery disease.

Introduction

Cardiovascular disease is a primary cause of morbidity and mortality in different communities, accounting for more than 31% of all deaths worldwide [1]. The most common form of the disease is coronary artery disease (CAD). In the Iranian population, CAD accounts for nearly 50% of all deaths per year [2]. It is characterized by irregularly distributed lipid deposits in the intimal layers of medium and large coronary arteries [3]. Therefore, atherosclerotic plaques progressively narrow the arterial lumen and impair myocardial blood supply [2]. To date, various protocols such as pharmacological treatment, percutaneous coronary intervention (PCI), coronary artery bypass graft (CABG) surgery, and lifestyle modification have been used to treat atherosclerosis [4, 5]. When pharmacological treatments and PCI are not effective, CABG surgery is a feasible treatment option. Previous studies have found that compared to PCI, CABG surgery was associated with lower rates and risks of coronary heart disease mortality, myocardial infarction,

*Corresponding author: Sara Abolahrari-Shirazi, School of Rehabilitation Sciences, Shiraz University of Medical Sciences, Chamran Blvd., Abiverdi 1 Street, P.O. Box 71345-1733, Shiraz, Iran. **Tel:** +98 71 36265108; **Fax:** +98 71 36272495
Email: sa_ahrari@yahoo.com

and repeated revascularizations [6, 7]. Moreover, quality of life, physical performance, and social and emotional functioning were improved in patients who underwent revascularization [8-10]. CABG surgery, however, may be associated with several complications. For example, inactivity can reduce the physical ability to perform activities of daily living (ADL) [11]. Musculoskeletal impairments have been addressed in individuals enrolled in phase II cardiac rehabilitation [12-14]. In addition, chest pain, antigravity muscle exhaustion, inability to maintain proper alignment, forward head posture, and reduced craniovertebral angle were reported [11]. Patients with chronic pain at the saphenectomy site were found to have disturbed balance [13].

Balance and strength are two components of physical fitness. Postural balance is a complex motor skill that participates in dynamic body posture modifications to prevent falling and is an essential component for safe performance of ADL [15]. Balance disturbances and impaired lower extremity function may exist in patients with cardiac illnesses, and postural instability can have negative impacts on patients' care and quality of life [13, 16]. Balance impairments are also reportedly associated with increased risk of falling, the possibility of morbidity and mortality, and increased healthcare costs [17]. To the best of our knowledge, the effect of CABG surgery on balance control in patients with cardiovascular disease has remained unclear, and one study has described cardiac rehabilitation programs intended to improve balance in this population. Dynamic and functional balance have not previously been evaluated. As dynamic balance is very important in everyday life, the current study was designed to compare static, dynamic, and functional balance pre-to-post-CABG surgery among patients with CAD. It was hypothesized that static/dynamic and functional balance would differ pre- to post-CABG surgery. The findings may provide a basis for recommendations aimed at enhancing cardiac rehabilitation programs with emphasis on balance exercises for patients undergoing CABG surgery.

Methods

Study Design and Participants

This cross-sectional survey was conducted at Al-Zahra Heart Hospital in Shiraz between April and July 2017. The study protocol complied with the guidelines of the Declaration of Helsinki and was approved by the Ethics Committee of Shiraz University of Medical Sciences (IR.SUMS.REC.1396.195). The sample size was calculated based on the results of a previous similar study [18] and considering an alpha value of 0.05 and a beta level of 0.2. Accordingly, 87 patients with CAD aged 45–65 years were recruited through convenience sampling. Informed consent forms were signed by the patients before starting the study protocol. Patients were included if they had undergone CABG surgery via the great saphenous vein. Exclusion criteria were musculoskeletal disorders (fractures, deformities), history of lower extremity surgeries, history of cardiac surgeries, heart failure, inability to stand or walk independently, neurological disorders, leg length discrepancy, diabetes, and uncontrolled hypertension.

Static Balance Assessment

To assess static balance performance, the participants performed the Single Leg Stance Test (SLST), in which they were required to stand barefoot on their right or left leg (donor leg) and keep the contralateral leg in approximately 45 degrees of hip flexion and 90 degrees of knee flexion. They were also instructed to cross their arms over the chest. The assessor used a digital chronometer to measure the time patients were able to stand on a single limb. The test was stopped when the patient's legs touched each other, their non-stance leg touched the floor, or their arms moved from the starting position. This procedure was repeated three times with open eyes and three times with closed eyes. To avoid fatigue, a two-minute rest period was considered between the trials. The average of the three trials was calculated separately. This test is a stronger predictor of falls in older adults [19], and its reliability and validity have been established [20, 21].

Dynamic Balance Assessment

The Y-balance test was used to measure dynamic balance performance. This test has been demonstrated to provide reliable and valid clinical measurements within a variety of populations [22]. Participants were asked to stand barefoot on the donor leg at the central point of the Y figure and to reach as far as possible in anterior, posteromedial, and posterolateral directions with the tip of their toe in the non-stance limb and then return to the starting position. Three trials were carried out in each direction with 30-second rest periods. Three types of failure were considered in this test: when the patient was unable to maintain balance on the supporting foot, when the body weight was shifted to the reach foot during the test, and when the hands came off the hips. After the test, the lengths of both lower limbs were measured, and the recorded values were normalized to the individual's limb length.

The functional reach test (FRT) is widely used as a dynamic measure of balance in older individuals [23] and is a reliable measure of balance for clinical assessment of instability [24]. Participants were asked to stand with their dominant side adjacent to a wall and raise their arm to shoulder height. They were then asked to reach forward as far as possible while maintaining a fixed base of support. A tape measure was fixed horizontally to the wall, and maximum reach distance was recorded as the furthest point of the third metacarpophalangeal joint from the initial (standing) position. In other words, the maximum distance that the participants were able to reach forward from a standing static position was measured [25]. Three trials were carried out and the mean values were recorded. All clinical tests were performed during the week before the start of surgery and were repeated one month after that.

Statistical Analysis

All analyses were done using SPSS 25 software (IBM, Statistics, New York, NY, USA). Normality of data was verified using the single-sample Kolmogorov–Smirnov

test. To compare the pre-and post-CABG values, paired t-test and Wilcoxon signed rank test were used for the variables following normal distribution and those with non-normal distribution, respectively. A value of P<0.05 was considered as criterion for statistical significance.

Results

Participants' Characteristics

The sample consisted of 87 patients with CAD who had undergone CABG surgery (58 males and 29 females, mean age: 58.21±6.78 years, mean height: 167.71±9.72 cm, mean weight: 72.74±13.18 kg). All participants successfully completed the testing procedures.

Balance Performance

Because the data for different variables showed both normal and non-normal distributions, both parametric and nonparametric tests were employed for analysis. The Wilcoxon signed rank test was used for SLST and FRT, while the independent t-test was used for pre-post comparisons of Y- balance test scores.

The means, standard deviations, and pre-/post-CABG comparisons for static balance tests are presented in Table 1. The findings revealed significant differences in the SLST results in open-eye and closed-eye conditions in the pre-and post-CABG periods (P<0.001). The Y-balance and FRT scores are presented in Table 2. As the table depicts, the Y-balance composite score was significantly lower for both sides after CABG surgery (P<0.001). The mean score of FRT was also lower after CABG surgery (P<0.001) (Table 2).

Discussion

The study findings revealed significant changes in both static and dynamic balance among patients with CAD after CABG surgery through the great saphenous vein. Other outcomes reported in the research also reflected reductions in functional balance among these patients.

Postural control is critical to performing movements and functional activities [26]. From the theoretical view, balance is classified operationally into static and dynamic forms and depends on the combined organization of neurological and musculoskeletal systems [13]. Standing balance relies on the continuous multisensory integration and processing of visual, vestibular, somatosensory, and auditory information to generate motor commands required for standing [27]. Proprioceptive function has an important role in postural control and movement, because it designates motor commands before and during task execution. The proprioceptive system sends information to the central nervous system, which plays a major role in maintaining whole-body stability [28]. In CABG surgery, the great saphenous vein is the most commonly used conduit for revascularization [29]. In this surgery, an incision is made through the skin about 5 cm above the medial malleolus and is extended proximally [30]. According to previous reports, the majority of patients experience lower limb complications such as infection in the saphenous vein harvest site [31], wound dehiscence, hematoma, necrosis [30], pain, and numbness (tingling) related to the wound [32]. Chronic, moderate to severe pain after surgery was also mentioned as an important complication in these patients [33, 34]. Leg pain can alter the sensory inputs needed for postural control, which may be related to increased presynaptic inhibition in afferent muscles. Thus, reduced proprioception from the donor site may contribute to alterations in balance control [33]. The development of musculoskeletal dysfunction can also be attributed to median sternotomy during CABG surgery. Impairments of shoulder girdle and upper back function have been found due to the effect of sternal retraction [35, 36]. Thoracic kyphosis is not only a disfiguring effect of median sternotomy, but it may also play a critical role in balance disorders [37, 38]. Postural impairment and muscular imbalance can reduce activity, thereby contributing to limb weakening, poorer coordination patterns, and imbalance [37]. Another possible explanation for post-CABG balance deficits is physical deconditioning, which can last for

Table 1: Comparison of single leg stance time (SLST) pre-to-post coronary artery bypass grafting (CABG) surgery under different conditions

Variable	Condition	Pre-CABG	Post-CABG	P value
		Mean±SD	Mean±SD	
SLST time (RT side) (sec)	Eyes open	19.61±20.82	12.24±9.89	<0.001*
	Eyes closed	4.48±3.95	2.86±1.79	<0.001*
SLST time (LT side) (sec)	Eyes open	18.50±24.13	11.06±12.58	<0.001*
	Eyes closed	4.12±4.41	2.15±1.61	<0.001*

*P<0.05; CABG, coronary artery bypass grafting; SLST, single leg stance test. RT, right; LT, left.

Table 2: Comparison of dynamic balance pre-to-post coronary artery bypass grafting (CABG) surgery

Variable	Pre-CABG	Post-CABG	P value
	Mean±SD	Mean±SD	
Total Y- balance test score (cm) RT side	62.28±18.07	54.69±17.99	<0.001*
Total Y balance test score (cm) Lt side	59.73±17.84	52.21±17.51	<0.001*
FRT (cm)	33.69±8.60	31.81±8.75	<0.001*

P<0.05; CABG, coronary artery bypass grafting; FRT, functional reach test.

several weeks. Furthermore, cardiac surgery can worsen pulmonary function [39, 40], and respiratory muscle dysfunction and postoperative pulmonary complications may, in turn, influence functional capacity and balance [41, 42]. Additionally, postsurgical disability has been shown to be associated with cardiac disease [43]. Therefore, this disability may also contribute to poor balance control [44]. A diminished ability to maintain balance is associated with an increased risk of falling, bone fracture, joint dislocation, concussion, and even death [45]. A previous study showed that disability was a more frequent complication than death after CABG surgery [46]. The present results revealed a decrease in static/dynamic balance after CABG surgery. Standing on one leg, although a challenging situation, is a human life activity. The SLST is a simple test for measuring static balance performance, which can be done under altered visual conditions (e.g., with eyes open and eyes closed). The tests conducted with closed eyes may yield valuable information, because patients rely heavily on their visual sense to maintain balance [47]. Although the results of SLST in the current study were statistically significant, the measurement of this variable had no clinical significance due to the small effect size (ES=0.1- 0.2).

The Y-balance test is another reliable, easy, and inexpensive method to assess dynamic postural control deficits [48]. However, as a predictor of falling, dynamic balance tests are better than static measures [49]. Similarly, the effect size of Y-balance test was small and had no clinical significance (ES=0.2).

The FRT was developed to assess standing dynamic balance in anterior–posterior movements and to evaluate individual limits in stability [50]. This task involves displacing the body's center of pressure in the anterior direction by rotating around the ankle joints while maintaining hip extension [22]. A previous study demonstrated that the plantar flexion of the ankle joint motion was associated with FRT performance [25]. Moreover, most patients have reported sensory deficits such as anesthesia or hyperesthesia and pain in their sternums, ankles, and legs after CABG surgery [51]. Reduced FRT results appear to be associated with pain around the ankles and the donor site. Although the results of FRT were statistically significant in the present study, the measurement of this variable had no clinical significance due to the small effect size (0.2).

One advantage of the present research is its applicability in the healthcare system, because the results revealed valuable information about postural control complications in patients undergoing CABG surgery. However, one of the study limitations was some patients' unwillingness to cooperate. As another study limitation, the results may not be generalizable to patients older than 65 years.

Conclusion

The study findings indicated that CABG surgery via the great saphenous vein negatively affected balance among CAD patients. Therefore, balance disorder is a major problem which can lead to falling and increased morbidity and mortality in these patients.

Acknowledgment

The authors would like to thank Ms. A. Keivanshekouh at the Research Consultation Center (RCC) of Shiraz University of Medical Sciences for improving the use of English in the manuscript. The authors would also like to thank the participants who took part in this study.

Funding

This research was funded by the Vice-Chancellor for Research, Shiraz University of Medical Sciences.

Conflict of Interest: None declared.

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