J. Phys. Ther. Sci.
27: 1855–1859, 2015

Original Article

Effect of in-hospital physical activity on cardiovascular prognosis in lower extremity bypass for claudication

Tomohiro Matsuo, PT[1)]*, Taichi Sakaguchi, MD, PhD[2)], Atsuhisa Ishida, MD, PhD[2)], Satoshi Yuguchi, PT, PhD[1)], Kazuya Saito, PT, MSc[1)], Masaharu Nakajima, PT[1)], Takuya Ujikawa, PT[1)], Tomoyuki Morisawa, PT, MSc[3)], Genta Chikazawa, MD, PhD[2)], Tetsuya Takahashi, PT, PhD[4)]

[1)] *Department of Rehabilitation, The Sakakibara Heart Institute of Okayama: 2-5-1 Nakaicho, Kitaku, Okayamashi, Okayama 700-0804, Japan*
[2)] *Department of Cardiovascular Surgery, The Sakakibara Heart Institute of Okayama, Japan*
[3)] *Department of Physical Therapy, School of Rehabilitation, Hyogo University of Health Sciences, Japan*
[4)] *Department of Physical Therapy, School of Health Sciences, Tokyo University of Technology, Japan*

Abstract. [Purpose] This study aimed to evaluate the effect of in-hospital physical activity on patient prognosis after lower extremity bypass surgery for peripheral arterial disease. [Subjects and Methods] A total of 13 patients (16 limbs; 11 males and 2 females; mean age [standard deviation], 72.8 [5.9] years) who underwent lower extremity bypass surgery for Fontaine stage 2 peripheral arterial disease were included in this study and assigned to either an active group (n = 6) to perform increased physical activity after surgery or an inactive group (n = 7) to perform decreased physical activity after surgery. Daily in-hospital physical activity levels were measured continuously with a triaxial accelerometer. The occurrence of adverse cardiovascular events within a 2 year follow-up period was compared between groups. [Results] At discharge, the patients in the active group were able to walk more steps daily than those in the inactive group. The incidence of adverse events was 16.7% in the active group and 71.4% in the inactive group. [Conclusion] A higher in-hospital physical activity level was associated with a better long-term prognosis after lower extremity bypass surgery in patients with peripheral arterial disease.

Key words: Peripheral arterial disease, Lower extremity bypass surgery, Physical activity

(This article was submitted Jan. 5, 2015, and was accepted Mar. 7, 2015)

INTRODUCTION

The main purpose of a rehabilitation program after lower extremity bypass surgery in patients with peripheral arterial disease (PAD) is the early reacquisition of skills in activities of daily living (ADL) by improving walking ability. A multicenter study[1)] reported that patients who underwent uneventful lower extremity bypass surgery started walking on postoperative day (POD)2 and were discharged home on POD16.9. An aggressive postoperative rehabilitation is important to improve a patient's walking performance considering the recent trend of shortening the length of hospital stay. However, some patients show a very low physical activity (PA) level, spending most of their time in bed, despite the improvement in their walking ability by revascularization.

Patients with symptomatic PAD have a lower PA level than non-PAD patients because of their limited walking capacity[2–4)]. It has been shown that a low PA level is a significant risk factor for progression of PAD, loss of physical function, and occurrence of cardiovascular disease (CVD)[5, 6)]. Thus, rehabilitation programs should focus not only on improving walking ability but also on increasing daily PA levels to prevent future adverse cardiovascular events. However, in patients who have undergone lower extremity bypass surgery, the association between perioperative PA level and long-term prognosis has not been investigated.

This study aimed to evaluate preoperative-to-postoperative changes in PA levels of PAD patients who underwent lower extremity bypass surgery and to examine the effect of these changes with long-term clinical outcomes.

SUBJECTS AND METHODS

A total of 13 patients (16 limbs; 11 males and 2 females; Fontaine stage 2) who underwent lower extremity bypass surgery for PAD between February 2010 and November 2010 were included in this study. The mean age of the male participants was 73 years (range, 65–81 years). All patients

*Corresponding author. Tomohiro Matsuo (E-mail: tomohiro19860104@yahoo.co.jp)

were independent walkers. Patient characteristics are described in Table 1.

The PA level of the patients was measured objectively and continuously with a triaxial accelerometer (Active Style Pro. HJA-350IT, Omron Healthcare) attached to the patient's waist. Daily PA (metabolic equivalents [METs]-hours/day) was defined as the total amount of METs-hours, calculated using BI-LINK-analysis software (Omron Healthcare), which calculates the intensity of PA (represented by METs) as a 1-minute value. Measurement began at least 2 days prior to the surgery and continued until the day of discharge, except on the day of surgery.

Walking ability was evaluated by measuring the maximum walking distance (MWD) and via the walking impairment questionnaire (WIQ). The Self-Efficacy for Physical Activity (SEPA) test was also used for subjective estimation of self-efficacy. MWD was measured distance to walk without rest on a flat surface. WIQ and SEPA questionnaires were used to measure parameters preoperatively and at discharge, respectively. There were no target PA levels to attain, and the patients were not provided with any guidance by the medical staff to increase their PA level during hospitalization.

The rehabilitation program was initiated at POD1 and gradually advanced, unless there were reports of perioperative complications or subjective symptoms such as oppressive pain. Once independent walking was established, the patients visited the rehabilitation center and started a supervised exercise program, which consisted of a 60-minute session including a warm-up phase, 20 minutes of treadmill walking, and a cool-down phase. The exercise intensity was gradually increased according to the TASC II recommendation[7], with a maximum grade of 12% if patients achieved a walking speed of 2.4 km/h.

Based on the postoperative change in their PA levels, patients were classified into 2 groups: an active group (n = 6), who showed an increase in PA postsurgery, and an inactive group (n = 7), who showed a decrease in PA postsurgery. The MWD, WIQ, and SEPA scores were compared between groups. In addition, the occurrence of adverse events such as bypass graft occlusion, CVD events, and cardiovascular intervention for a new lesion was compared between the 2 groups.

This study was approved by the ethics committee of the Sakakibara Heart Institute of Okayama (approval no. 20120101), and all participants provided written informed consent. Differences in baseline patient characteristics were evaluated with 2-tailed t tests for continuous variables and $2 \times 2\ \chi^2$ tests for categorical variables. Paired t tests were used to compare parameters before and after bypass surgery. The occurrence of adverse events within 24 months after the surgery was evaluated using Kaplan-Meier curves, and the log-rank test was used to assess the association of in-hospital PA level with subsequent cardiovascular events. Differences were considered significant when $p < 0.05$.

RESULTS

There were no hospital deaths or major postoperative complications during the course of the study. The mean length of hospitalization after bypass surgery was 13.7 ± 3.9 days, and all patients were discharged home from the hospital without a transfer to a rehabilitation facility. There were no events of bypass occlusion identified during the hospitalization. The ankle-brachial pressure indexes were significantly improved from 0.53 ± 0.23 preoperatively to 0.90 ± 0.18 at discharge ($p < 0.001$). As a result, the walking ability of the patients improved significantly, with the MWD improving from 265.8 ± 173.6 m to 744.6 ± 440.5 m ($p < 0.001$) and the WIQ score improving from 120.1 ± 60.9 to 259.6 ± 87.0 ($p < 0.001$). The SEPA score showed improvement from 38.5 ± 17.6 to 50.1 ± 17.2 ($p < 0.05$). These results demonstrate that the walking performance and self-efficacy of these patients improved significantly with surgical revascularization.

In terms of PA level, the number of steps the patients were able to walk daily improved significantly, from 1,713.1 ± 1,261.5 steps preoperatively to 2,692.4 ± 1,967.1 steps at discharge ($p < 0.05$). However, the actual PA level (represented by a mean daily METs-hours) did not increase after surgery (23.0 ± 4.4 METs-hours/day preoperatively and 22.3 ± 4.3 METs-hours/day at discharge). These results suggest that the improved walking ability after lower extremity bypass surgery was not necessary associated with increased in-hospital PA level in some patients (Table 2).

To clarify the association between perioperative PA level and patient prognosis after bypass surgery, patients were classified into 2 groups based on the preoperative-to-postoperative change in PA levels as follows: an active group (n = 6), whose daily PA level (METs-hours/day) at discharge was higher than that at the preoperative level (rate of change, 117.5 ± 9.1%), and an inactive group (n = 7), whose daily PA level was lower (82.9 ± 11.8%) than that at the preoperative level. The baseline characteristics of the patients are shown

Table 1. Baseline characteristics of patients with peripheral arterial disease (n = 13)

Baseline characteristics	n (%)
Demographic factors	
Male	11 (84.6)
Mean age at study inclusion, mean (range) years	73 (65–81)
Body mass index, mean ± SD	22.7 ± 3.1
Medical history at bypass surgery	
Angina pectoris	5 (38.5)
Myocardial infarction	2 (15.3)
TIA and/or stroke	5 (38.5)
Ankle brachial pressure index	0.53 ± 0.23
Diabetes mellitus	8 (61.4)
Hypertension	13 (100)
Hyperlipidemia	10 (76.9)
Smoking	11 (84.6)
Trial bypass	
Aortobifemoral	1 (7.7)
Iliofemoral	2 (15.4)
Femoropopliteal (above the knee)	7 (53.8)
Femoropopliteal (below the knee)	2 (15.4)
Popliteal-popliteal (from above to below the knee)	1 (7.7)

TIA: transient ischemic attack

Table 2. Preoperative and postoperative results

	Preoperation	Postoperation
Ankle brachial pressure index	0.53 ± 0.23	0.90 ± 0.18**
Maximum walking distance (m)	265.8 ± 173.6	744.6 ± 440.5**
Walking impairment questionnaire	120.1 ± 60.9	259.6 ± 87.0**
Self-Efficacy for Physical Activity	38.5 ± 17.6	50.1 ± 17.2*
Daily walking steps (step)	1,713.1 ± 1,261.5	2,692.4 ± 1967.1*
PA (METs-hours/day)	23.0 ± 4.4	22.3 ± 4.3

*p<0.05, **p<0.01

Table 3. Characteristics of the active and inactive groups

	Active (n = 6)	Inactive (n = 7)
Baseline characteristics	n (%)	n (%)
Demographic factors		
Male	6 (100)	5 (71.4)
Age at study inclusion, mean (range) years	73 (67–81)	73 (65–80)
Medical history at bypass surgery		
Angina pectoris	3 (50)	2 (28.6)
Myocardial infarction	1 (16.7)	1 (14.3)
TIA and/or stroke	4 (66.7)	1 (14.3)
Diabetes mellitus	4 (66.7)	4 (57.1)
Hypertension	6 (100)	7 (100)
Hyperlipidemia	5 (83.3)	5 (71.4)
Smoking	6 (100)	5 (71.4)
Trial bypass		
Aortobifemoral	1 (16.7)	0 (0)
Iliofemoral	1 (16.7)	1 (14.3)
Femoropopliteal (above the knee)	3 (50)	4 (57.1)
Femoropopliteal (below the knee)	0 (0)	2 (28.6)
Popliteal-popliteal (from above to below the knee)	1 (16.7)	0 (0)
Ankle brachial pressure index		
Preoperation	0.50 ± 0.19	0.46 ± 0.22
Postoperation	0.88 ± 0.18	0.99 ± 0.13

TIA: transient ischemic attack

Table 4. Rate of preoperative-to-postoperative changes in walking ability and self-efficacy

	Active group	Inactive group
Maximum walking distance (m)	392.44±404.05	296.34±120.20
Walking impairment questionnaire	267.95±185.24	244.13±80.05
Self-Efficacy for Physical Activity	236.59±233.83	137.12±86.79

in Table 3. The PA level at discharge was significantly higher in the active group (25.1 ± 3.8 METs-hours/day) than in the inactive group (19.9 ± 3.2 METs-hours/day, $p < 0.05$). The number of steps that the patients were able to walk daily at discharge was also significantly higher in the active group (3,884.5 ± 1,783.0 steps) than in the inactive group (1,670.6 ± 1,565.3 steps, $p < 0.05$). Furthermore, in the active group, both values increased significantly after surgery ($p < 0.05$), whereas no significant improvements were seen in the inactive group. The WIQ score at discharge was significantly higher in the active group than in the inactive group (313.2 ± 43.3 and 213.7 ± 90.9, respectively; $p < 0.05$), whereas no significant differences were noted in the MWD or SEPA scores. There were no significant differences in the rate of preoperative-to-postoperative changes in the MWD, WIQ, and SEPA scores between groups (Table 4).

In terms of long-term outcomes (within 24 months after surgery), adverse cardiovascular events occurred in 16.7% of the patients in the active group (1 percutaneous transluminal angioplasty), whereas adverse cardiovascular events occurred in 71.4% of the patients in the inactive group (3 graft occlusions, 1 percutaneous coronary intervention, and 1 congestive heart failure; p = 0.08: Fig. 1).

DISCUSSION

In the present study, we evaluated the preoperative-to-postoperative changes in PA level of patients who underwent lower extremity bypass surgery and the effect of these changes on long-term clinical outcomes. The walking ability (based on MWD and WIQ scores) and self-efficacy (based on SEPA score) of the patients improved significantly after surgery. Lundgren et al.[8] reported that the walking ability of patients improved after surgical revascularization secondary to improvement in lower leg blood flow and ankle blood pressure. A randomized trial involving PAD patients with intermittent claudication showed that supervised exercise rehabilitation further improved walking ability after revascularization[8]. Thus, our aggressive rehabilitation program, including supervised exercise therapy, might have enhanced the effect of surgical revascularization. The self-efficacy of PAD patients has been demonstrated to be related to walking ability[9]. The improvement in SEPA scores in this study is attributable to the improvement in patients' walking ability after surgical revascularization.

However, despite an improved walking ability, PA levels did not improve postoperatively in approximately half of the patients. Sieminski et al.[4] compared the PA levels of patients with and without PAD by using an accelerometer and found that the PAD patients had significantly lower PA levels than the non-PAD patients (357 and 616 kcal/day, respectively). McDermott et al.[2] reported that a higher rate of PAD patients (15%) showed physical inactivity in low-intensity activities such as casual walking or strolling compared with non-PAD patients (5%), suggesting that the low PA level in PAD patients was attributable to the inactivity of the relatively low-intensity activities. Furthermore, PAD patients are less likely to develop regular exercise habits compared with non-PAD individuals[2–4]. In this study, improved walking capacity with supervised exercise did not result in an improvement in total PA in the inactive group, probably because the patients continued to be inactive even after revascularization and, as a consequence, their PA level did not increase outside the rehabilitation center.

Despite the similarities in the baseline characteristics and walking ability of the patients in the 2 groups, late adverse cardiovascular events occurred in 71.4% of patients in the inactive group within 24 months after surgery (graft occlusion, 42.9%; percutaneous coronary intervention for progress of coronary artery lesion, 14.3%; rehospitalization for congestive heart failure, 14.3%), whereas the incidence of CVD in the active group was only 16.7%. Considering the fact that physical inactivity is a risk factor for progression of arteriosclerosis, the patients who did not show improvement in in-hospital PA levels even after revascularization may be more likely to experience late adverse cardiovascular events because they may not change their sedentary lifestyle despite the improvement in their walking ability.

Generally, PA is considered to be effective for controlling risk factors like diabetes mellitus[10, 11]. Furthermore, several studies have demonstrated the relationship between physical inactivity and adverse cardiovascular events. Depressive symptoms in PAD patients are associated with adverse events, and this association is partially explained by physical inactivity in these patients, who exercise only a few times in a month[12]. Another study showed the association between PA level and inflammatory biomarkers, which are risk factors for adverse cardiovascular events[13]. In addition, Garg et al.[6] reported that PAD patients with higher daily PA levels have lower rates of mortality and adverse cardiovascular events than those with lower PA levels. In contrast, low-intensity physical activities such as recreational activities have been shown to decrease the risk of adverse cardiovascular events, which are strongly related to mortality in PAD patients[14].

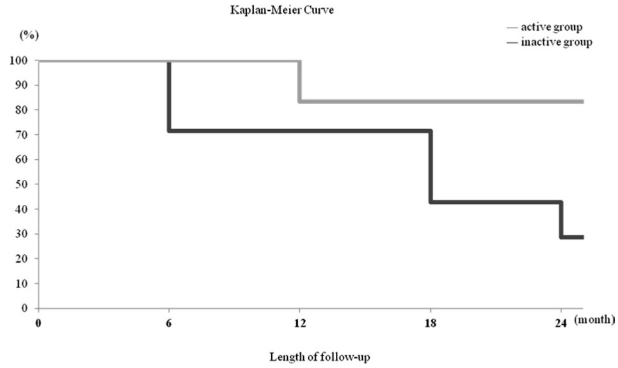

Fig. 1. Kaplan-Meier curve for freedom from adverse cardiovascular events

In conclusion, the higher level of in-hospital PA after lower extremity bypass surgery was associated with a better long-term prognosis in our study. Post-bypass surgery rehabilitation programs should aim at improving the daily PA level and walking ability of PAD patients for the prevention of CVD.

This study evaluated the PA of patients only during their hospitalization. It is unknown whether patients who showed a high PA level during hospitalization continue to be active after discharge. Therefore, a long-term assessment of PA in the home setting is necessary for a more precise analysis of the association between perioperative PA and patient prognosis after lower extremity bypass surgery for PAD. Furthermore, the number of patients in this study was small and the follow-up period was relatively short. In the future, a clinical trial may be needed to determine whether interventions that increase in-hospital PA levels reduce the occurrence of long-term adverse cardiovascular events in patients with PAD.

ACKNOWLEDGEMENT

This work was supported by JSPS KAKENHI Grant Number 22592469.

REFERENCES

1) Morisawa T, Oura K, Obata K, et al.: Fact-finding about rehabilitation after the lower limbs bypass. Jpn Assoc Card Rehabil, 2012, 17: 124–128.
2) McDermott MM, Liu K, O'Brien E, et al.: Measuring physical activity in peripheral arterial disease: a comparison of two physical activity questionnaires with an accelerometer. Angiology, 2000, 51: 91–100. [Medline] [CrossRef]
3) McDermott MM, Liu K, Greenland P, et al.: Functional decline in peripheral arterial disease: associations with the ankle brachial index and leg symptoms. JAMA, 2004, 292: 453–461. [Medline] [CrossRef]
4) Sieminski DJ, Gardner AW: The relationship between free-living daily physical activity and the severity of peripheral arterial occlusive disease. Vasc Med, 1997, 2: 286–291. [Medline]
5) McDermott MM, Liu K, Ferrucci L, et al.: Physical performance in peripheral arterial disease: a slower rate of decline in patients who walk more. Ann Intern Med, 2006, 144: 10–20. [Medline] [CrossRef]
6) Garg PK, Tian L, Criqui MH, et al.: Physical activity during daily life and mortality in patients with peripheral arterial disease. Circulation, 2006, 114: 242–248. [Medline] [CrossRef]
7) Norgren L, Hiatt WR, Dormandy JA, et al. TASC II Working Group: Inter-Society Consensus for the Management of Peripheral Arterial Disease (TASC II). Eur J Vasc Endovasc Surg, 2007, 33: S1–S75. [Medline] [CrossRef]
8) Lundgren F, Dahllöf AG, Lundholm K, et al.: Intermittent claudication—surgical reconstruction or physical training? A prospective randomized trial of treatment efficiency. Ann Surg, 1989, 209: 346–355. [Medline] [CrossRef]
9) Collins TC, Lunos S, Ahluwalia JS: Self-efficacy is associated with walking ability in persons with diabetes mellitus and peripheral arterial disease. Vasc Med, 2010, 15: 189–195. [Medline] [CrossRef]
10) Murano I, Asakawa Y, Mizukami M, et al.: Factors increasing physical activity levels in diabetes mellitus: a survey of patients after an inpatient diabetes education program. J Phys Ther Sci, 2014, 26: 695–699. [Medline] [CrossRef]
11) Maeda N, Murakami M, Takahashi K, et al.: Correlations between pedometric measurement in daily physical activity and cardiorespiratory fitness in patients with type 2 diabetes mellitus. J Phys Ther Sci, 2004, 16: 39–42. [CrossRef]
12) Grenon SM, Hiramoto J, Smolderen KG, et al.: Association between depression and peripheral artery disease: insights from the heart and soul study. J Am Heart Assoc, 2012, 1: e002667. [Medline] [CrossRef]
13) Craft LL, Guralnik JM, Ferrucci L, et al.: Physical activity during daily life and circulating biomarker levels in patients with peripheral arterial disease. Am J Cardiol, 2008, 102: 1263–1268. [Medline] [CrossRef]
14) Wilson AM, Sadrzadeh-Rafie AH, Myers J, et al.: Low lifetime recreational activity is a risk factor for peripheral arterial disease. J Vasc Surg, 2011, 54: 427–432, 432.e1–432.e4. [Medline] [CrossRef]