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Original Article

Rehabilitation progress after lower-extremity bypass surgery in patients with peripheral arterial disease with different occlusive lesions

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Abstract. [Purpose] To examine the differences in rehabilitation progress after lower-extremity bypass surgery for peripheral arterial disease (PAD) depending on the occlusive lesions. [Participants and Methods] This was a retrospective study. We included 50 patients (61 limbs; 38 males and 12 females; mean age, 73 years) who underwent lower-extremity bypass surgery for Fontaine stage 2–3 PAD. The patients were assigned to the aortoiliac (A-I) group (n=23), femoropopliteal (F-P) group (n=18), and below-knee group (n=9). We evaluated the postoperative rehabilitation progress and length of hospital stay of these groups. [Results] The postoperative ankle-brachial pressure index (ABI) of the A-I group was significantly lower than that of the F-P group, although there were no differences before surgery. The progress of rehabilitation and the length of hospitalization showed no significant differences among the three groups. The postoperative date of independent walking was significantly later in the presence of complications than in the absence of complications. [Conclusion] The progress of rehabilitation after lower-extremity bypass surgery did not differ depending on the occlusive lesions, and patients may acquire independent walking ability in approximately 5 days in the absence of postoperative complications.
Key words: Peripheral arterial disease, Lower-extremity bypass surgery, Rehabilitation progress

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INTRODUCTION

Surgical revascularization in patients with peripheral arterial disease (PAD) has a positive impact on the quality of life and walking parameters affected by claudication[1, 2]. Furthermore, in patients with critical limb ischemia (CLI), surgery is performed to minimize tissue loss, completely heal wounds, and preserve the foot function[3]. There are various characteristics of invasive therapy for occlusive lesions. The surgical options for aortoiliac (A-I) occlusive disease include direct aortic reconstructions (aortofemoral bypass, A-I bypass), which are the most durable methods but also have considerable morbidity and mortality[4]. In patients with an unsuitable anatomy or those deemed to be at a high risk for direct aortic surgery, or both, extra-anatomic bypasses (axillary-femoral, iliac-iliac, iliac-femoral, and femoral-femoral bypasses), which are less morbid but also less durable alternatives, can be selected[4]. Invasive therapy for occlusive lesions of the F-P segment, which is usually performed after a supervised exercise trial[5], provides better durability, decreases the need for reintervention, and is well tolerated with a low rate of complications[4]. Lesions of the crural and foot arteries may cause severe calf claudication,

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and the symptoms can involve the foot.

Notably, structured rehabilitation is recommended for patients with PAD, and the basic component of rehabilitation is supervised exercise therapy[3]. Furthermore, a randomized trial involving PAD patients with intermittent claudication showed that supervised exercise rehabilitation further improved walking ability after revascularization[6]. Although this is one of the primary care practices for intermittent claudication, there are no guidelines on mobilization and exercise therapy after bypass surgery. An aggressive postoperative rehabilitation is important to improve the walking ability of patients, considering the recent trend of shorter hospital stay durations. A multicenter study[7] reported that patients who underwent uneventful lower-extremity bypass surgery started walking on postoperative day (POD) 2.0 and were discharged home on POD 16.9. However, there have been no reports about the differences of postoperative mobilization in patients with occlusive lesions at different sites although there are various characteristics of bypass surgery for different occlusive lesions. This study aimed to investigate the differences in the progress of mobilization after lower-extremity bypass surgery for PAD depending on the occlusive lesions and the factors of delayed rehabilitation.

PARTICIPANTS AND METHODS

This was a retrospective study examining the medical records of patients. We included in this study a total of 50 patients (61 limbs; 38 males and 12 females) with PAD (Fontaine stage from 2 to 3) who underwent scheduled lower-extremity bypass surgery for PAD at the Sakakibara Heart Institute of Okayama between October 2007 and July 2011. The mean age of the participants was 73 years (range, 49–93 years). All patients were independent walkers. The exclusion criteria were hospital death or the development of bypass graft occlusion during hospitalization. Postoperative complications were defined as cardiovascular events, wound infection, anemia, and organ infection.

According to the occlusive or inflow lesions, the patients were classified into the following 3 groups: A-I group (n=23), F-P group (n=18), and below-knee (BK) group (n=9). A-I group included in-line aortic surgery (aorto-bifemoral bypass) and extra-anatomic reconstructions (axillary-bifemoral, iliofemoral, or femorofemoral bypass). The F-P group was only F-P (above-knee) bypass for the infrainguinal disease. Conversely, the BK group involved bypasses crossing or below the knee joint (F-P [BK], femorotibial).

The rehabilitation program was initiated on POD 1 and was gradually advanced, unless there were reports of perioperative complications or subjective symptoms such as oppressive pain and active bleeding. Once independent walking was established, the patients visited the rehabilitation center and started a supervised exercise program, which consisted of a 60-min session including a warm-up phase, 20-min treadmill walking or cycle ergometer exercise, and a cool-down phase. The exercise intensity was gradually increased according to the TASC II recommendations[8] and the guidelines for rehabilitation in patients with cadiovascular disease [9].

This study was approved by the ethics committee of the Sakakibara Heart Institute of Okayama (approval no. 20120101), and informed consent was obtained in the form of opt-out on the website of the institution. Differences in baseline patient characteristics were evaluated using 2-tailed t-tests for continuous variables and 2 × 2 χ^2 tests for categorical variables. Analysis of variance and Kruskal-Wallis tests followed by post-hoc multiple comparison tests (Tukey test) were used to compare the ankle-brachial pressure index (ABI), progress of rehabilitation, and length of hospital stay after bypass surgery. Mann-Whitney U test was used to examine the differences in the rehabilitation progress between patients with and without postoperative complications. All analyses were performed using StatMate software (version 4.01; ATMS Institute Inc., Japan). The differences were considered significant at $p<0.05$.

RESULTS

The patients' characteristics are described in Table 1. The mean length of hospitalization after bypass surgery was 18.9 ± 6.2 days, and all patients were discharged home from the hospital without being transferred to a rehabilitation facility. No hospital deaths or events of bypass occlusion during hospitalization were identified. The ABI significantly improved from 0.54 ± 0.13 preoperatively to 0.91 ± 0.20 at discharge ($p<0.001$).

The baseline characteristics of the patients in each group are shown in Table 2. The postoperative ABI of the A-I group was significantly lower than that of the F-P group ($p=0.03$), although there were no differences in the ABI before surgery.

No differences were observed in the progress of rehabilitation among the 3 groups (Table 3). The POD of first sitting on the edge of the bed was 1.8 ± 0.9, and the POD of first walking was 2.5 ± 1.1. Similarly, no significant differences were found in the POD of acquiring independent walking in the ward and starting supervised exercise in a rehabilitation center. Moreover, the length of hospital stay was 18.9 ± 6.2 days, and all groups showed no differences in the length of hospitalization. The rate of postoperative complications also showed no differences among the 3 groups. However, when patients with and without postoperative complications were compared (Table 4), the POD of acquired independent walking after surgery was significantly later in the complicated group than in the uncomplicated group ($p=0.03$).

Table 1. Characteristics in peripheral arterial disease participants (n=50)

Baseline characteristics	n (%)
Demographic factors	
Male	38 (76.0)
Mean age at study inclusion (years)	73
Height (cm)	157.4 ± 10.3
Weight (kg)	53.2 ± 8.5
Body mass index (kg/m^2)	21.5 ± 3.4
Medical history at bypass surgery	
Diabetes mellitus	25 (50.0)
Hypertension	30 (60.0)
Dyslipidemia	23 (46.0)
Angina pectoris	22 (44.0)
Myocardial infarction	10 (20.0)
post CABG	5 (10.0)
TIA and/or stroke	6 (12.0)
post LEBS	3 (6.0)
Abdominal aortic aneurysm	3 (6.0)
Chronic heart failure	5 (10.0)
COPD	6 (12.0)
Chronic kidney disease	12 (24.0)
Hemodialysis	7 (14.0)
Rheumatoid arthritis	3 (6.0)
Trial bypass	
Aorto-Iliac lesion	
Aorto-bi Femoral	3 (6.0)
Axillary-bi Femoral	2 (4.0)
Ilio-Iliac	1 (2.0)
Ilio-Femoral	10 (20.0)
Femoro-Femoral	7 (14.0)
Femoro-Popliteal lesion	
Femoro-Popliteal (AK)	18 (36.0)
Below Knee lesion	
Femoro-Popliteal (BK)	2 (4.0)
Femoro-Popliteal (BK)-Post tibialis	1 (2.0)
Popliteal-Popliteal (AK-BK)	1 (2.0)
Popliteal (AK)-Post tibialis	2 (4.0)
Superficial femoro-Post tibialis	1 (2.0)
Popliteal (BK)-Post tibialis	2 (4.0)
Ankle brachial pressure index	
pre operation	0.54 ± 0.13
post operation	0.91 ± 0.20

Data are presented as the mean ± standard deviation. TIA: transient ischemic attack; CABG: coronary artery bypass grafting; LEBS: lower extremity bypass surgery; COPD: chronic obstructive pulmonary disease; AK: above knee; BK: below knee.

DISCUSSION

In the present study, we evaluated the progress of rehabilitation in patients who underwent lower-extremity bypass surgery and the differences in the progress depending on various occlusive lesions.

First, although the ABI significantly improved in all groups, the ABI after bypass surgery was significantly lower in the A-I group than in the F-P group. Aortobifemoral bypass is considered the gold standard of repair with a high patency

Table 2. Characteristics of each group

	A-I (n=23)	F-P (n=18)	BK (n=9)	p value
Baseline characteristics	n (%)	n (%)	n (%)	
Demographic factors				
Male	17 (73.9)	15 (83.3)	6 (66.7)	0.60
Mean age (years)	75	74	69	0.23
Body mass index (kg/m^2)	21.3 ± 4.0	21.3 ± 2.8	22.7 ± 2.8	0.59
Medical history at bypass surgery				
Diabetes mellitus	10 (43.5)	11 (61.1)	4 (44.4)	0.50
Hypertension	14 (60.9)	10 (55.6)	6 (66.7)	0.85
Dyslipidemia	10 (43.5)	7 (38.9)	6 (66.7)	0.37
Angina pectoris	11 (47.8)	8 (44.4)	3 (33.3)	0.76
Myocardial infarction	3 (13.0)	6 (33.3)	1 (11.1)	0.21
post CABG	3 (13.0)	2 (11.1)	0 (0)	0.53
TIA and/or stroke	1 (4.3)	3 (16.7)	2 (22.2)	0.28
post LEBS	1 (4.3)	0 (0)	2 (22.2)	0.07
Abdominal aortic aneurysm	1 (4.3)	2 (11.1)	0 (0)	0.47
Chronic heart failure	2 (8.7)	3 (16.7)	0 (0)	0.38
COPD	3 (13.0)	1 (5.6)	2 (22.2)	0.44
Chronic kidney disease	4 (17.4)	5 (27.8)	3 (33.3)	0.57
Hemodialysis	2 (8.7)	2 (11.1)	3 (33.3)	0.18
Rheumatoid arthritis	2 (8.7)	1 (5.6)	0 (0)	0.64
Ankle brachial pressure index				
pre operation	0.53 ± 0.15	0.51 ± 0.12	0.59 ± 0.15	0.44
post operation	0.85 ± 0.21*	1.00 ± 0.14*	0.92 ± 0.13	0.03
Surgical information				
Surgical time (min)	208.2 ± 69.6	267.6 ± 105.1	281.9 ± 73.0	0.04
Bleeding (mL)	903.0 ± 782.0	561.8 ± 298.2	553.3 ± 684.6	0.36
Postoperative complications	5 (21.7)	2 (11.1)	1 (11.1)	0.59
Symptomatic angina pectoris	1			
Congestive heart failure		1		
Steal syndrome	1			
Infected wound	1			
Anemia	1		1	
Acute cholecystitis	1	1		

Data are presented as the mean ± standard deviation. Asterisk denotes significant difference (p<0.05). TIA: transient ischemic attack; CABG: coronary artery bypass grafting; LEBS: lower extremity bypass surgery; COPD: chronic obstructive pulmonary disease.

rate[10]; however, this bypass surgery also has high mortality and morbidity because of the invasiveness of the procedure, which requires opening the abdomen[11]. Conversely, extra-anatomic bypasses such as axillary-bifemoral and femorofemoral bypasses were reported to be less morbid alternatives but also less durable than anatomical reconstructions[4]. Similarly, the hemodynamic performance of axillary-bifemoral bypass was much lower than that of aortobifemoral bypass[12]. Furthermore, steal syndromes can occur after iliofemoral or femorofemoral grafting because of the unmasking of a previously unrecognized disease in the donor arterial segment[13]. Steal syndrome occurred in 1 patient in the A-I group who underwent iliofemoral bypass surgery. The fact that 20 of the 23 patients with A-I occlusive diseases underwent extra-anatomic reconstruction (87%) might explain why the A-I group did not obtain a dramatic improvement in postoperative ABI.

Second, the progress of postoperative mobilization was similar among the 3 groups. The POD of first sitting on the edge of the bed was 1.8, and the POD of first walking was 2.5. The acute-phase rehabilitation in this study was a similar to another report[7]. Because there are few reports on rehabilitation after lower-extremity bypass surgery, it was unclear whether or not this rehabilitation progress is the general course. Nevertheless, it is obvious that early reacquisition of independent walking ability after revascularization is important to shorten the length of hospital stay. We have reported that a higher level of in-hospital physical activity after lower-extremity bypass surgery is associated with a decrease in readmission rates[14], and a lower level of physical activity after endovascular treatment is associated with a higher cardiovascular event rate within

Table 3. Progress of rehabilitation

	A-I (n=23)	F-P (n=18)	BK (n=9)	p value
First sitting, POD	1.9 ± 0.8	1.9 ± 0.8	1.6 ± 1.3	0.58
First walking, POD	2.5 ± 1.0	2.6 ± 1.1	2.6 ± 1.3	0.92
Independent walking at ward, POD	5.9 ± 3.6	5.7 ± 1.6	6.1 ± 3.2	0.63
First supervised exercise, POD	7.0 ± 3.4	7.5 ± 1.8	9.3 ± 5.1	0.13
Length of stay in the hospital, POD	18.8 ± 6.7	19.2 ± 6.0	19.3 ± 6.0	0.97

POD: post operative day.

Table 4. Comparison of progress of rehabilitation depending on occurrences postoperative complications

	Uncomplicated (n=42)	Complicated (n=8)	p value
First sitting, POD	1.7 ± 0.7	2.5 ± 1.4	0.16
First walking, POD	2.5 ± 1.0	3.0 ± 1.3	0.29
Independent walking at ward, POD	5.0 ± 1.6*	9.5 ± 4.5*	0.03
First supervised exercise, POD	6.9 ± 2.2	11.3 ± 5.4	0.06
Length of stay in the hospital, POD	18.3 ± 6.2	22.1 ± 5.5	0.11

POD: post operative day. Asterisk denotes significant difference ($p<0.05$).

the first 3 months after revascularization[15]. Furthermore, several studies have demonstrated that patients with PAD with not only claudication but also critical limb ischemia have a lower physical activity level than non-PAD patients because of their limited walking capacity[16, 17], and the relationship between physical inactivity and adverse cardiovascular events and mortality has been previously reported[18]. Therefore, increasing the amount of physical activity through early reacquisition of independent walking could be also important.

Finally, the POD of independent walking after reconstruction was significantly delayed in patients with postoperative complications, such as symptomatic angina pectoris, than in patients without adverse events. In addition, the complicated group tended to have prolonged hospital stay. The factors associated with a significantly longer postoperative hospital of stay included preexisting coronary artery disease, preoperative anemia, elevated preoperative serum creatinine level, and presence of any postoperative complication[19]. Similarly, Aziz et al.[20] reported that 11% of patients who underwent lower-extremity bypass surgery were transferred from other institution, such as an acute care hospital, a nursing home or an intermediate care institution, and an outside emergency department. This review also indicated that several factors, including the need for an emergency surgery, wound infection, and age >85 years, increased the risk of interfacility transfer. Thus, the delayed progress of rehabilitation and prolonged hospitalization after lower-extremity bypass surgery in patients with postoperative complications suggest that these patients may require more long-term rehabilitation than patients without complications.

This study had some limitations. First, this study included a relatively small study population. Future studies with a higher number of participants may provide more evidence and clarify the relationship between the difference in the progress of postoperative rehabilitation and different occlusive lesions. Second, this study was performed at a single facility. Our results should be interpreted considering the differences in cohorts and cardiac rehabilitation programs. Finally, the physical function parameters (e.g., muscle strength and maximum walking distance) of patients were not examined in this study. Thus, we could not fully identify the reason for the delay in mobilization after revascularization and discharge.

In conclusion, patients with PAD with different occlusive or inflow lesions showed no difference in the progress of postoperative rehabilitation. Independent walking may be acquired approximately 5 days after lower-extremity bypass surgery in the absence of major adverse events.

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Conflict of interest

None.

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