J. Phys. Ther. Sci. 31: 629–632, 2019

The Journal of Physical Therapy Science

Original Article

Predictive factors for ambulatory state in critical limb ischemia patients at discharge

Shinsuke Imaoka, RPT, MS[1, 3)*], Koji Sato, OTR[1)], Masahide Hurukawa, MD, PhD[2)], Toshio Higashi, OTR, PhD[3)]

[1)] *Department of Rehabilitation, Oita Oka Hospital: 3-7-1 Sakamoto, Nagasaki, Nagasaki 852-8523, Japan*
[2)] *Department of Plastic Surgery, Oita Oka Hospital, Japan*
[3)] *Unit of Rehabilitation Sciences, Nagasaki University Graduate School of Biomedical Sciences, Japan*

Abstract. [Purpose] In patients with critical limb ischemia, the ambulatory state often has a lasting impact on recovery and wound healing. The aim of this study was to examine the predictive factors connected with the ambulatory state in wounds with critical limb ischemia. [Participants and Methods] This study included 125 inpatients with critical limb ischemia, who underwent physical therapy between January 2015 and December 2018. We retrospectively studied factors from the participant's medical records and comparisons were made between the ambulatory and non-ambulatory groups. Next, we analyzed the differences between factors using multiple logistic regression analysis. [Results] The factors associated with the ambulatory state in patients with critical limb ischemia, as determined by multiple logistic regression analysis, were knee extension muscle strength, off-loading the foot duration, and the presence or absence of heart disease. [Conclusion] Shortening off-loading the foot period and intensive rehabilitation at an early stage after amputation need to be prioritized to maintain the quality of life and ambulatory status of patients with wounds in critical limb ischemia.

Key words: Ambulatory state, Critical limb ischemia, Rehabilitation

(This article was submitted Mar. 22, 2019, and was accepted May 5, 2019)

INTRODUCTION

Critical limb ischemia (CLI) is a clinical syndrome of ischemic pain at rest or tissue loss (non-healing ulcers or gangrene), which are related to peripheral artery disease[1)]. CLI patients with rest pain and wound are likely to lose the ability to walk and adequately perform activities of daily living (ADL). The TASCII (Trans-Atlantic Inter-Society Consensus II) reports a major amputation rate as high as 40% at 6 months and a mortality rate of 20–25% in the first year after presentation[2)]. At 5 years, the all-cause mortality rate of 70% exceeds that of colorectal cancer, breast cancer, stroke, and coronary artery disease[3, 4)].

Patients with CLI are typically elderly and have a high prevalence of multiple severe comorbidities including diabetes and cardiovascular or cerebrovascular disease, as well as histories of hypertension, renal insufficiency, and transient ischemic attacks[5)].

Overall long-term outcome and survival in CLI patients result from complex interactions between age, chronic infection, nutritional status, and ambulatory status[6–11)]. In recent years, limb salvage has become more frequent to maintain the quality of life (QOL) and ambulatory status. Rehabilitation care is increasingly performed after limb salvage to prevent complications and maintain limb function. However, to the best of our knowledge, little research has been conducted on the ambulatory status of patients with CLI. Therefore, this study aimed to examine the predictive factors connected with the ambulatory state in wounds with CLI.

*Corresponding author. Shinsuke Imaoka (E-mail: ptssinnsukeimaoka@yahoo.co.jp)

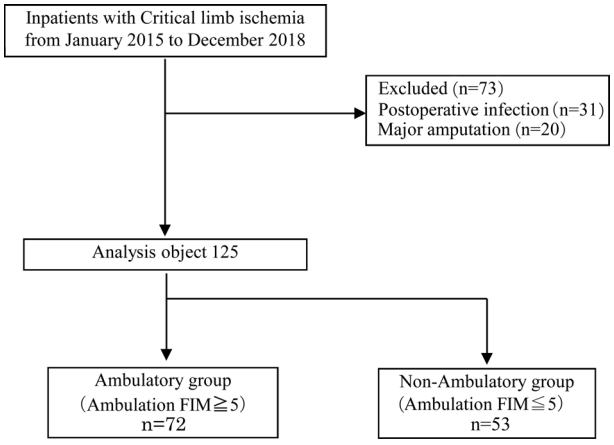

Fig. 1. Selection process of target patients.

PARTICIPANTS AND METHODS

This study included 198 patients with CLI, who had undergone revascularization and minor amputation followed by physical therapy between January 2015 and December 2018.

We excluded patients with (1) infections after revascularization and minor amputation, (2) major amputations (below knee and above knee), (3) discharge due to death or other systemic complications, (4) use of a wheelchair for mobility before hospitalization.

After the exclusion criteria were applied, 73 inpatients were excluded, and 125 were selected as participants (Fig. 1).

We retrospectively evaluated the factors available from the medical records. The factors were age, gender, body mass index (BMI), amputation region (Toe, Ray, Transmetatarsal, Lisfranc), off-loading the foot period, pre-operative knee extension muscle strength, lower limb blood flow, comorbidities (hypertension, hyperlipidemia, diabetes, heart disease, cerebrovascular disease, chronic obstructive pulmonary disease, hemodialysis), pre-operative laboratory parameters (serum albumin, C-reactive protein, white blood cells), and functional independence measure (FIM) ambulation at discharge.

Regarding the lower limb muscle strength, the maximum voluntary isokinetic knee extension muscle strength was measured using a hand-held dynamometer (μ-tasF-1, ANIMA, Japan).

For knee extensor strength measurements, patients were asked to sit on a chair with the knee flexed at 90 degrees and to push against the dynamometer pad as much as possible for 5 seconds. Isokinetic knee extensor strength was measured 2 times on each side, and the highest value for the right and left legs was used as the knee extensor muscle strength.

In addition, skin perfusion pressure as the blood flow of the lower limb artery was evaluated by using a Laser Doppler (SensiLase PAD4000, KanekaMedix, Osaka, Japan) at the time of the first outpatient visit.

The ambulation status was evaluated using the movement parameter of the FIM. Patients with a score of 6 FIM were classified into the Ambulatory group and those with a score of 5 or lower were classified into the Non-Ambulatory group.

This study was approved by the Ethical Committee of Oita Oka Hospital (approval number: B0018).

The information of only those patients who had consented comprehensively for the study was analyzed. Furthermore, the database used in this study was anonymized in a linkable fashion, and only the researchers could access the identification numbers.

To analyze the factors influencing the ambulatory state of CLI, the χ^2 test and the Mann-Whitney U test were performed. Logistic regression analysis (Stepwise method) was conducted with the item showing a significant difference between the two groups as the independent variable, and with the ambulatory state of CLI as the dependent variable. In choosing the independent variable, after considering multicollinearity, the internal correlation between each variable was confirmed, and the variable was deleted when the correlation coefficient was 0.7 or more. Finally, the odds ratio of the items left in the regression model, the 95% confidence interval, and the discriminant predictive value of the whole model were calculated. For statistical analysis, IBM SPSS statistics version 22 (IBM, Armonk, NY, USA) was used and p values less than 0.05 were considered significant.

RESULTS

The 125 patients were divided into two groups: Ambulatory (n=72, 57.6%) and Non-Ambulatory (n=53, 42.7%). There were significant differences between the groups with respect to the amputation region, off-loading the foot period, knee extension muscle strength, serum albumin levels, and presence or absence of heart disease (Table 1).

Table 1. Patient clinical characteristics

Variables	All (n=125)	Ambulatory group (n=72)	Non-Ambulatory group (n=53)	p value
Age (years)	73.2 ± 18.5	72.5 ± 9.7	74.3 ± 10.7	0.36
Male (%)	72 (57.6)	41 (56.9)	31 (58.4)	0.26
BMI (kg/m^2)	23.3 ± 7.7	24.1 ± 4.6	22.8 ± 5.9	0.31
Amputation region (Toe/Ray/TMA/Lisfranc)	51/38/25/11	33/18/15/6	18/20/10/5	0.04
Off-loading the foot period (days)	15.0 ± 9.8	11.7 ± 4.5	15.7 ± 10.5	0.02
Knee extension muscle strength (kgf)	24.3 ± 14.5	28.4 ± 19.1	22.6 ± 9.7	0.01
FIM ambulation	5.5 ± 1.7	6.1 ± 0.9	4.0 ± 3.2	0.02
Comorbidities				
Hypertension	62 (49.6)	35 (48.6)	27 (50.9)	0.55
Hyperlipidemia	42 (33.6)	24 (33.3)	18 (33.9)	0.29
Diabetes	56 (44.8)	31 (43.0)	25 (47.1)	0.38
Heart disease	36 (28.8)	15 (20.8)	21 (39.6)	0.02
Cerebrovascular disease	5 (4.2)	3 (4.1)	2 (3.7)	0.73
COPD	4 (3.2)	2 (2.7)	2 (3.7)	0.85
Hemodialysis	36 (28.8)	21 (29.1)	15 (28.3)	0.42
Laboratory parameters				
Serum albumin (g/dL)	3.4 ± 1.8	3.9 ± 1.4	3.1 ± 1.2	0.04
CRP (mg/dL)	0.6 ± 1.2	0.5 ± 1.1	0.5 ± 1.3	0.51
WBC (10^3/μL)	7496 ± 1986	6991 ± 1861	7269 ± 1497	0.08
Lower limb blood flow				
SPP (mmHg)	38.0 ± 24.0	39.0 ± 15.0	34.0 ± 18.0	0.18
ABI	0.5 ± 0.2	0.4 ± 0.2	0.5 ± 0.3	0.32

Values are shown as the mean ± SD or n (%).
BMI: body mass index; FIM: Functional Independence Measure; Off-loading the foot period: Number of days from amputation to loading start; TMA: Transmetatarsal amputation; COPD: chronic obstructive pulmonary disease; CRP: C-reactive protein; WBC: white blood cell; SPP: skin perfusion pressure; ABI: ankle brachial pressure index.
Gender, Amputation region, Comorbidities: χ^2 test, Other items: Mann-Whitney test.

Table 2. Multivariate logistic regression analyses for determinants of ambulatory state

	OR	95% CI		p value
Knee extension muscle strength	2.56	1.82	6.23	<0.05
Off-loading the foot period	0.82	0.62	0.93	<0.05
Heart disease	0.79	0.56	0.89	<0.01

OR: Odds Ratio; CI: Confidence interval.
Model χ^2 test p<0.01, Hosmer-Lemeshow p=0.94.
Predictive value of the predicted value and the measured value was 75.6%.

After logistic regression analysis, knee extension muscle strength, off-loading the foot period, and the presence or absence of heart disease were selected as the factors influencing the ambulatory state. The Hosmer-Lemeshow test results were compatible with p=0.94, and the discriminant predictive value of the predicted value and the measured value was 75.6% (Table 2).

DISCUSSION

Our study revealed that knee extension muscle strength, off-loading the foot period, and the presence or absence of heart disease were associated with ambulatory status in wound with CLI patients. Sakaki et al.[12] reported that ambulation status was associated with the prognosis of the knee extensor muscles. Additionally, Mäkitie et al.[13] reported that biopsy of the quadriceps and gastrocnemius muscle showed myodegeneration and myopathy.

CLI patients are projected to have decreased skeletal muscle function associated with chronic lower limb ischemia.

In this study, the Ambulatory group showed significantly higher knee extension strength. In the Ambulatory group, off-loading the foot period was 11.7 ± 4.5 days, which was shorter than that seen in the Non-Ambulatory group. Patients with

CLI need off-loading during the treatment of a wound to reduce the burden on the wounded area. Nehler et al.[14] reported that CLI patients were likely to show a significantly low value of the lower limb extension muscle strength during wound treatment. Therapy is therefore often needed to maintain physical function during off-loading the foot period.

It is reported that 51.6% of CLI patients have cardiac disease complications[6] and exercise intolerance[15]. Additionally, the relationship between heart disease and ambulatory state reportedly decreases the patient's maximum continuous walking distance[16] and walking speed[17]. Among the patients of the study, the proportion of heart disease combined was 20.8% and 39.6% in the Ambulatory and Non-Ambulatory group, respectively. We therefore determined that the presence of heart disease was likely to cause a decline in physical activity, leading to reduced ADL and circulatory dynamics before admission.

This study aims to contribute to the body of knowledge regarding appropriate goals of rehabilitation and the prediction of ambulatory state in CLI patients.

This study has several limitations. First, our results were obtained in a single facility. Similar findings need to be confirmed in other facilities for generalizability. Second, the influences of the rehabilitation program on the patients' ambulatory abilities were not sufficiently examined in this study. Therefore, future prospective investigations that include a larger number of patients are required to clarify the influence of CLI on the ambulatory state.

Conflicts of interest

All authors declare that there is no conflict of interest.

REFERENCES

1) Hirsch AT, Haskal ZJ, Hertzer NR, et al. American Association for Vascular Surgery Society for Vascular Surgery Society for Cardiovascular Angiography and Interventions Society for Vascular Medicine and Biology Society of Interventional Radiology ACC/AHA Task Force on Practice Guidelines American Association of Cardiovascular and Pulmonary Rehabilitation National Heart, Lung, and Blood Institute Society for Vascular Nursing TransAtlantic Inter-Society Consensus Vascular Disease Foundation: ACC/AHA 2005 guidelines for the management of patients with peripheral arterial disease (lower extremity, renal, mesenteric, and abdominal aortic): executive summary a collaborative report from the American Association for Vascular Surgery/Society for Vascular Surgery, Society for Cardiovascular Angiography and Interventions, Society for Vascular Medicine and Biology, Society of Interventional Radiology, and the ACC/AHA Task Force on Practice Guidelines (Writing Committee to Develop Guidelines for the Management of Patients With Peripheral Arterial Disease) endorsed by the American Association of Cardiovascular and Pulmonary Rehabilitation; National Heart, Lung, and Blood Institute; Society for Vascular Nursing; TransAtlantic Inter-Society Consensus; and Vascular Disease Foundation. J Am Coll Cardiol, 2006, 47: 1239–1312. [Medline] [CrossRef]
2) Norgren L, Hiatt WR, Dormandy JA, et al. TASC II Working Group: Inter-society consensus for the management of peripheral arterial disease (TASC II). J Vasc Surg, 2007, 45: S5–S67. [Medline] [CrossRef]
3) Hunt D, Young P, Simes J, et al.: Benefits of pravastatin on cardiovascular events and mortality in older patients with coronary heart disease are equal to or exceed those seen in younger patients: results from the LIPID trial. Ann Intern Med, 2001, 134: 931–940. [Medline] [CrossRef]
4) Ljungman C, Holmberg L, Bergqvist D, et al.: Amputation risk and survival after embolectomy for acute arterial ischaemia. Time trends in a defined Swedish population. Eur J Vasc Endovasc Surg, 1996, 11: 176–182. [Medline] [CrossRef]
5) Tsetis D, Belli AM: The role of infrapopliteal angioplasty. Br J Radiol, 2004, 77: 1007–1015. [Medline] [CrossRef]
6) Cavender MA, Steg PG, Smith SC Jr, et al. REACH Registry Investigators: Impact of diabetes mellitus on hospitalization for heart failure, cardiovascular events, and death: outcomes at 4 years from the reduction of atherothrombosis for continued health (REACH) registry. Circulation, 2015, 132: 923–931. [Medline] [CrossRef]
7) Flu HC, Lardenoye JH, Veen EJ, et al.: Functional status as a prognostic factor for primary revascularization for critical limb ischemia. J Vasc Surg, 2010, 51: 360–71.e1. [Medline] [CrossRef]
8) Kumakura H, Kanai H, Aizaki M, et al.: The influence of the obesity paradox and chronic kidney disease on long-term survival in a Japanese cohort with peripheral arterial disease. J Vasc Surg, 2010, 52: 110–117. [Medline] [CrossRef]
9) Logar CM, Pappas LM, Ramkumar N, et al.: Surgical revascularization versus amputation for peripheral vascular disease in dialysis patients: a cohort study. BMC Nephrol, 2005, 6: 3. [Medline] [CrossRef]
10) Stenvinkel P, Heimbürger O, Paultre F, et al.: Strong association between malnutrition, inflammation, and atherosclerosis in chronic renal failure. Kidney Int, 1999, 55: 1899–1911. [Medline] [CrossRef]
11) Iida O, Soga Y, Yamauchi Y, et al.: Clinical efficacy of endovascular therapy for patients with critical limb ischemia attributable to pure isolated infrapopliteal lesions. J Vasc Surg, 2013, 57: 974–981.e1. [Medline] [CrossRef]
12) Sakaki S, Takahashi T, Matsumoto J, et al.: Characteristics of physical activity in patients with critical limb ischemia. J Phys Ther Sci, 2016, 28: 3454–3457. [Medline] [CrossRef]
13) Mäkitie J, Teräväinen H: Histochemical changes in striated muscle in patients with intermittent claudication. Arch Pathol Lab Med, 1977, 101: 658–663. [Medline]
14) Nehler MR, Hiatt WR, Taylor LM Jr: Is revascularization and limb salvage always the best treatment for critical limb ischemia? J Vasc Surg, 2003, 37: 704–708. [Medline] [CrossRef]
15) Nakamura Y, Kunii H, Yoshihisa A, et al.: Impact of peripheral artery disease on prognosis in hospitalized heart failure patients. Circ J, 2015, 79: 785–793. [Medline] [CrossRef]
16) Bittner V, Weiner DH, Yusuf S, et al. SOLVD Investigators: Prediction of mortality and morbidity with a 6-minute walk test in patients with left ventricular dysfunction. JAMA, 1993, 270: 1702–1707. [Medline] [CrossRef]
17) Pepera GK, Sandercock GR, Sloan R, et al.: Influence of step length on 6-minute walk test performance in patients with chronic heart failure. Physiotherapy, 2012, 98: 325–329. [Medline] [CrossRef]