Effects of Early Physical Therapist-supervised Walking on Clinical Outcomes after Liver Resection: Propensity Score Matching Analysis

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ABSTRACT. Objective: The study aimed to demonstrate the significance of early postoperative physical therapy interventions on clinical outcomes by determining the influence of the distance walked under the supervision of a physical therapist in the early postoperative period after liver cancer. **Methods:** All consecutive patients who underwent surgery for liver cancer between April 2018 and March 2020 were eligible for enrollment in the study. The total walking distance during physical therapy till the third postoperative day was examined. The clinical outcomes comprised duration of postoperative hospital stay, time to independent walking, and occurrence of postoperative complications. For data analysis, the patients were divided into two groups: those who walked more than the median total distance (the long-distance group) and those who walked less than the median distance (the short-distance group). We used propensity score matching to match the background characteristics between the groups. **Results:** Of the 65 patients who were eligible, 14 patients were included in the two groups each, after matching. The long-distance walking group had a significantly shorter hospital stay (9.0 days vs. 11.0 days, $p=0.008$) and a shorter time to independent walking (3.5 days vs. 7.5 days, $p=0.019$) than the short-distance walking group. There were no significant differences in postoperative complications between the two groups (7.1% vs. 42.8%, $p=0.08$). **Conclusion:** In the early postoperative period after liver cancer surgery, increasing the walking distance under the supervision of a physical therapist is important for improving clinical outcomes. Further prospective studies are needed to confirm the findings of this study.

Key words: Early postoperative physical therapy, Longer walking distances, Postoperative hospital stay, Liver cancer

(Phys Ther Res 00: 00-00, 0000)

In recent years, the concept of enhanced recovery after surgery (ERAS)¹⁾ has become widespread, especially in postoperative patients. It is effective in reducing hospital stay and postoperative complications and aids in the recovery of gastrointestinal function²⁻⁴⁾ through appropriate management before and after surgery. The early mobilization of

patients after gastrointestinal surgery has been reported to be effective in reducing hospital stays and preventing complications^{5,6)}. It has recently been reported that early mobilization within 24 hours after partial hepatectomy positively affects the pain score and aids the recovery of gastrointestinal function⁷⁾, making early mobilization essential.

While there are many papers on early postoperative mobilization⁵⁻⁷⁾, few have examined early postoperative activity. It has been reported that the duration of ‘standing time’ in the first three days after abdominal surgery is related to the length of hospital stay⁸⁾. It is important to maintain physical activity in the early postoperative period. It has also been reported that the presence or absence of perioperative physical therapy influences the extent of activity

Received: March 19, 2021

Accepted: June 8, 2021

Advance Publication by J-STAGE: September 3, 2021

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doi: 10.1298/ptr.E10107

until the third postoperative day⁹⁾, and the role of physical therapists in ensuring the same in the early postoperative period is significant. In contrast, it was reported that additional walking with volunteer staff during the stable period after abdominal surgery did not affect hospital stay or complications¹⁰⁾. This suggests that increasing the frequency of walking during hospitalization alone may not be sufficient to improve clinical outcomes. However, the walking with the volunteer staff of college students started after the postoperative risks had been reduced. There is no study about increasing the walking distance during the early postoperative period under the supervision of a physical therapist when the risk is considered to be higher. Demonstrating the impact of physiotherapist-supervised ambulation on clinical outcomes in the early postoperative period after hepatic tumor resection is also important for planning physiotherapy programs.

Therefore, the purpose of the present study was to examine if the distance walked under the supervision of a physical therapist in the early postoperative period after partial hepatectomy for hepatocellular carcinoma could affect the duration of hospital stay, time to independent walking, and occurrence of postoperative complications.

Method

Eligibility

All consecutive patients who underwent hepatectomy for the diagnosis of primary hepatocellular carcinoma at our hospital between April 2018 and March 2020 were considered eligible for enrollment. The exclusion criteria comprised death during hospitalization and missing data. This study was conducted in accordance with the Declaration of Helsinki, with due care taken to protect the patients. It was approved by the Ethics Committee of Aso Iizuka Hospital (Approval No. R19172). Patients were granted the option to opt-out of the study.

Physical therapy program

Physical therapy was initiated according to the attending physician's prescription. The criteria for discontinuation included the "Anderson's criteria¹¹⁾" and "obvious deterioration of respiration or circulatory dynamics from the previous day". The physical therapy program conducted until the third postoperative day consisted of walking, coughing, deep breathing, pain-free standing exercises, and patient education. The interventions were carried out twice a day (in the morning and afternoon) for 20-40 minutes, until the third day after surgery. From the fourth day onwards, the physical therapy program included exercise therapy in the rehabilitation room where the patient could walk 300 meters. Exercise therapy included aerobic exercises, such as bicycle ergometer and treadmill walking, and resistance training. The interventions were performed every day, five

to six times a week for 40-60 minutes.

Measurement items

The following items were extracted retrospectively from medical records. Walking distance was the primary factor, that was defined as the total distance walked during physical therapy until the third postoperative day. Walking distance was measured by the number of laps made around the 30, 100, and 110-meter circuits in the ward. The primary outcome of this study was the duration of postoperative hospital stay. The secondary outcomes were time to independent walking and occurrence of postoperative complications. Background factors included age, sex, body mass index (BMI), geriatric nutritional risk index (GNRI), Charlson Comorbidity Index (CCI), hepatocellular carcinoma stage, surgical procedure (laparoscopic or laparotomy) and intraoperative blood loss. The postoperative items measured comprised the duration of urinary catheterization, the deterioration in activities of daily living (ADL), whether the patient was transferred to a hospital for rehabilitation, and the presence of pain from postoperative days 1 to 7.

Postoperative complications

The Clavien-Dindo classification^{12,13)} was used to measure the postoperative complications. Postoperative complications were defined as grade II or higher in the Clavien-Dindo classification based on previous studies¹⁴⁾. In addition, the presence or absence of the following: atelectasis due to pleural effusion within one week after surgery, delirium diagnosed by a psychiatrist, lower extremity thrombus, internal carotid artery thrombus, portal vein thrombus, bile leak, ileus, pseudomembranous enteritis, liver failure, and postoperative hemorrhage were noted during the postoperative period until discharge and were extracted from the medical records.

Measurement of ADLs

The Katz Index¹⁵⁾ is a highly reliable and valid assessment tool of ADL ability¹⁶⁻¹⁸⁾. The definition of deterioration in ADL ability¹⁹⁾ was a decrease of 1 point or more between the preoperative period and the time of discharge from the hospital.

Measurement of pain

The numeric rating scale (NRS) is a reliable and valid assessment of postoperative pain^{20,21)}. In this study, the NRS scores were categorized into three categories according to the National Comprehensive Cancer Network guidelines²²⁾: 0-3 points for mild, 4-6 points for moderate, and 7-10 points for severe.

Statistical analysis

For statistical analysis, patients were divided into two groups based on the association of the walking distance: a

Fig. 1. Study flow chart in this study

long-distance walking group and short-distance walking group. Regarding the walking distance, we divided the patients into two groups using the median walking distance because there was no previous study with reports or results that could be used to divide them into two groups. For the continuous variables in each measurement item, the unpaired t-test was used for those with normality, and the Wilcoxon rank sum test was used for those without normality. Categorical variables were assessed using the χ^2 test.

To examine the effect of walking distance on the outcome, we calculated the probability of walking distance after adjusting for confounders. We matched long-distance walkers and short-distance walkers using the approximate probability approach, and we compared the two groups based on the outcomes using the propensity score method. The variables used to calculate the propensity score were age, sex, GNRI, CCI, intraoperative blood loss, and surgical procedure, which could affect walking distance and outcome. The optimal range of matching (caliper) was set to $\pm 20\%$ of the standard deviation for the propensity score, which is the standard value. After matching, the two groups were compared using the χ^2 test for categorical variables and the Wilcoxon rank sum test for continuous variables. The statistical analysis software used was Stata Statistical Software (Release 15. College Station, TX: StataCorp LLC), and the significance level was set at 5%.

Results

Background characteristics

Of the 70 patients who met the eligibility criteria, 65 patients were included in the analysis, four patients were excluded because they had some missing data and one pa-

tient died during hospitalization (Fig. 1). The median age (interquartile range) was 72.0 (69.0-78.0) years, and 45 patients (69%) were male. The median walking distance was 530 m. Thirty patients in the long-distance walking group and 35 patients in the short-distance walking group walked a total of 530 m, and the balance was adjusted, 14 and 14 patients in the long-distance and short-distance walking groups, respectively, were matched.

On comparing the background factors between the two groups before propensity score matching, the long-distance walking group had a significantly higher percentage of patients who underwent laparoscopic surgery ($p=0.007$) and had a less intraoperative blood loss ($p=0.024$), shorter operation time ($p=0.04$), and shorter anesthesia time ($p=0.008$). After propensity score matching, there was no significant difference between the groups, and the balance was adjusted (Table 1).

Comparison of outcomes

The median duration of postoperative hospital stay in the long-distance walking group was 9.0 days, while that in the short-distance walking group was 11.0 days ($p=0.008$). The median time taken to walk independently was 3.5 days in the long-distance walking group and 7.5 days in the short-distance walking group ($p=0.019$). Regarding postoperative complications, the percentage of complications classified as grade II or higher as per the Clavien-Dindo classification were inclined to be higher in the short-distance walking group (42.8%) when compared to the long-distance walking group (7.1%) ($p=0.077$) (Table 2).

Postoperative factors

There were no items that showed significant differ-

Table 1. Patient characteristics before and after propensity score matching

	All patients n=65			Propensity-matched patients n=28		
	Long-distance walking (n=30)	Short-distance walking (n=35)	p-value	Long-distance walking (n=14)	Short-distance walking (n=14)	p-value
Total gait distance, m	940.0 [726.3, 1187.5]	390.0 [270.0, 442.5]	<0.001	940.0 [728.8, 1175.0]	340.00 [272.5, 436.3]	<0.001
Age, year	72.0 [69.3, 76.8]	72.0 [69.0, 79.0]	0.490	73.0 [66.0, 76.8]	72.5 [71.0, 77.8]	0.490
Sex, male	22 (73.3)	23 (65.7)	0.595	9 (64.3)	10 (71.4)	1
BMI, kg/m ²	24.0 [20.5, 25.8]	23.0 [21.0, 24.0]	0.133	24.0 [20.0, 25.0]	23.0 [19.8, 23.8]	0.200
GNRI	114.0 [110.0, 118.0]	111.0 [105.5, 113.5]	0.087	112.0 [103.0, 117.5]	106.5 [103.3, 112.0]	0.311
CCI, <3	23 (76.7)	32 (91.4)	0.167	14 (100.0)	12 (85.7)	0.481
Cancer stage			0.655			0.870
I	11 (36.7)	9 (25.7)		6 (42.9)	6 (42.9)	
II	15 (50.0)	19 (54.3)		7 (50.0)	5 (35.7)	
III	4 (13.3)	5 (14.3)		1 (7.1)	2 (14.3)	
IV	0 (0.0)	2 (5.7)		0 (0.0)	1 (7.1)	
Laparoscopy	15 (50.0)	6 (17.1)	0.007	5 (35.7)	3 (21.4)	0.678
Blood loss, ml	102.5 [50.0, 259.0]	250.0 [127.0, 465.0]	0.024	150.0 [51.5, 259.0]	240.0 [156.0, 380.0]	0.370
Operative time, min	184.50 [150.00, 234.50]	248.00 [211.50, 305.00]	0.004	212.50 [162.50, 238.25]	235.00 [209.50, 302.25]	0.148
Anesthesia time, min	278.50 [218.75, 320.75]	328.00 [288.00, 378.00]	0.008	302.50 [240.75, 331.50]	317.50 [278.75, 385.25]	0.26

BMI, body mass index; GNRI, geriatric nutritional risk index; CCI, Charlson Comorbidity Index.

n (%), median [25, 75%]

Table 2. The differences of hospital stay, the time to independent walking, and complications between long and short distance groups.

	All patients n=65			Propensity-matched patients n=28		
	Long-distance walking (n=30)	Short-distance walking (n=35)	p-value	Long-distance walking (n=14)	Short-distance walking (n=14)	p-value
Postoperative hospital stay, days	9.0 [8.0, 10.0]	11.0 [9.0, 13.0]	<0.001	9.0 [8.0, 9.8]	11.0 [9.0, 14.5]	0.008
The time to independent walking, day	4.0 [3.0, 5.0]	4.0 [4.0, 10.0]	0.013	3.5 [3.0, 4.8]	7.5 [4.0, 10.0]	0.019
The Clavien-Dindo Classification, ≥II	7 (23.3)	15 (42.9)	0.12	1 (7.1)	6 (42.8)	0.077

n (%), median [25, 75%]

ences in postoperative factors after matching (Table 3).

Discussion

This study showed that the distance walked by patients under the supervision of a physiotherapist during the early postoperative period after partial hepatectomy for hepatocellular carcinoma affected the duration of hospitalization. Furthermore, it influenced how quickly they could walk in-

dependently.

Association with the hospital stay

Long-distance walking under physiotherapist supervision in the early postoperative period after partial hepatectomy affected the length of hospital stays. Browning et al.⁸⁾ stated that the duration of standing in the early postoperative period was an important indicator for the length of hospital stay after upper abdominal surgery. The outcomes

Table 3. The differences of the duration of urinary catheterization, ADLs deterioration, hospital transfer, and types of complications and pain between long and short distance groups.

			All patients, n=65			Propensity-matched patients, n=28		
			Long-distance walking (n=30)	Short-distance walking (n=35)	p-value	Long-distance walking (n=14)	Short-distance walking (n=14)	p-value
The duration of urinary catheterization, day			3.0 [2.0, 3.0]	3.0 [3.0, 4.0]	0.002	3.0 [2.0, 4.0]	3.5 [3.0, 4.0]	0.084
ADLs deterioration	yes		3 (10.0)	8 (22.9)	0.201	2 (14.3)	5 (35.7)	0.685
Hospital transfer	yes		1 (3.3)	2 (5.7)	1	0 (0.0)	2 (14.3)	0.481
Types of complications	Atelectasis	yes	9 (30.0)	16 (45.7)	0.213	5 (35.7)	7 (50.0)	0.704
	Delirium	yes	1 (3.3)	4 (11.4)	0.363	1 (7.1)	3 (21.4)	0.596
	Lower extremity thrombus	yes	1 (3.3)	3 (8.6)	0.618	0 (0.0)	2 (14.3)	0.481
	Internal carotid artery thrombosis	yes	1 (3.3)	2 (5.7)	1	0 (0.0)	1 (7.1)	1
	Portal vein thrombosis	yes	4 (13.3)	6 (17.1)	0.742	1 (7.1)	1 (7.1)	1
	Bile leak	yes	0 (0.0)	0 (0.0)		0 (0.0)	0 (0.0)	
	Ileus	yes	1 (3.3)	1 (2.9)	1	0 (0.0)	1 (7.1)	1
	Enteritis	yes	2 (6.7)	0 (0.0)	0.209	0 (0.0)	0 (0.0)	
	Liver failure	yes	0 (0.0)	0 (0.0)		0 (0.0)	0 (0.0)	
	Postoperative hemorrhage	yes	0 (0.0)	2 (5.7)	0.495	0 (0.0)	0 (0.0)	
NRS	Day1	mild	20 (66.7)	24 (68.6)	1	9 (64.3)	10 (71.4)	1
		moderate	4 (13.3)	5 (14.3)		4 (28.6)	3 (21.4)	
		severe	6 (20.0)	6 (17.1)		1 (7.1)	1 (7.1)	
	Day2	mild	19 (63.3)	20 (57.1)	0.076	9 (64.3)	10 (71.4)	1
		moderate	6 (20.0)	14 (40.0)		4 (28.6)	4 (28.6)	
		severe	5 (16.7)	1 (2.9)		1 (7.1)	0 (0.0)	
	Day3	mild	19 (63.3)	23 (65.7)	0.549	8 (57.1)	9 (64.3)	1
		moderate	8 (26.7)	11 (31.4)		6 (42.9)	5 (35.7)	
		severe	3 (10.0)	1 (2.9)		0 (0.0)	0 (0.0)	
	Day4	mild	23 (76.7)	25 (71.4)	0.299	11 (78.6)	10 (71.4)	1
		moderate	4 (13.3)	9 (25.7)		3 (21.4)	4 (28.6)	
		severe	3 (10.0)	1 (2.9)		0 (0.0)	0 (0.0)	
	Day5	mild	23 (76.7)	28 (80.0)	0.904	11 (78.6)	11 (78.6)	1
		moderate	4 (13.3)	5 (14.3)		3 (21.4)	3 (21.4)	
		severe	3 (10.0)	2 (5.7)		0 (0.0)	0 (0.0)	
	Day6	mild	24 (80.0)	26 (74.3)	0.69	12 (85.7)	9 (64.3)	0.472
		moderate	2 (6.7)	5 (14.3)		1 (7.1)	3 (21.4)	
		severe	4 (13.3)	4 (11.4)		1 (7.1)	2 (14.3)	
	Day7	mild	26 (86.7)	29 (82.9)	0.222	13 (92.9)	11 (78.6)	0.596
		moderate	1 (3.3)	5 (14.3)		1 (7.1)	3 (21.4)	
		severe	3 (10.0)	1 (2.9)		0 (0.0)	0 (0.0)	

ADL, Activities of daily living; NRS, The numeric rating scale
n (%), median [25, 75%]

were similar to those in the present study, in which the factor under consideration was a longer walking distance under the supervision of a physical therapist. Hussey et al.²³⁾ reported that in postoperative patients with esophageal can-

cer, 96% of the day is spent in a sitting or supine position until the fifth day after surgery. The early postoperative period after hepatic resection is also long, and it is likely that patients do not stand or walk except during physical ther-

apy. In the early postoperative period after hepatocellular carcinoma surgery, it is imperative to provide an environment in which patients can stand and walk under the supervision of a physical therapist to improve their physical activity.

Association with independent walking

Long-distance walking under the supervision of a physical therapist in the early postoperative period after hepatocellular carcinoma surgery affected the time taken to walk independently. de Almeida *et al.*²⁴⁾ reported that the implementation of a discharge program that included early walking under the supervision of a physical therapist after abdominal tumor surgery was related to early recovery of physical function. Comparable results were obtained in the present study when the defined factor was a longer walking distance under the supervision of a physical therapist in the early postoperative period. Therefore, walking practice in the early postoperative period could be important in early discharge programs. Additionally, it has been reported that pain²⁵⁾ and postoperative complications^{25,26)} affect the recovery of postoperative physical function. In this study, there was no significant difference in pain or postoperative complications between the two groups. However, the long-distance walking group tended to have fewer postoperative complications, which may have influenced the recovery in physical function. These results suggest that active walking practice in the early postoperative period may prevent postoperative complications and shorten the time to independent walking after surgery.

Association with postoperative complications

The long-distance walking group had a lower rate of postoperative complications than the short-distance walking group, but the difference was not significant. Ni *et al.*³⁾ reported that early mobilization after hepatocellular carcinoma surgery did not show a significant reduction in complications, but there was a lower rate of pleural effusion and lower extremity thrombus. In this study, the long-distance walking group tended to have a lower rate of postoperative complications like lower extremity thrombus, atelectasis due to pleural effusion, and delirium, although the difference was not significant as well. Extending the walking distance in the early postoperative period after hepatic resection may be effective against some postoperative complications.

There are three important limitations of the present study. First, the sample size was small, and there were not enough events to adjust for confounders in the multivariate analysis²⁷⁾. Therefore, the propensity score method was used for the analysis. It has been reported that when adjusted for the same variables, the results of both the propensity score and classical multivariate analysis are approximately the same²⁸⁾. Therefore, in this study, we believe that the con-

founding factors were sufficiently accounted for despite a small sample size and fewer number of events. Second, because we collected information from medical records in a retrospective study, we were unable to obtain adequate items for measurement. Due to ethical issues, it was difficult to conduct an interventional study with a control group in which the walking distance is shortened. Therefore, it is necessary to examine the other unmeasured items prospectively in the future. Third, since this study was not a prospective interventional trial, the walking distance could have been shorter due to various factors, such as risk management and judgement of the therapist. In a retrospective study, it was difficult to identify factors that led to a reduction in the walking distance. Therefore, the investigation of the causes for shorter walking distances requires prospective studies and is a topic for future research.

Conclusion

This is the first study to demonstrate that a longer walking distance under the supervision of a physiotherapist in the early postoperative period after partial hepatectomy could affect the length of hospital stays and the time to independent walking. In the early postoperative period after partial hepatectomy surgery, it is important to extend the walking distance under the supervision of a physical therapist in an appropriate environment to improve the clinical outcomes. Further prospective studies with larger number of patients are needed to confirm this result.

Acknowledgments: We would like to extend our appreciation to the clinical research team members: Mr. Itsuki Oka, Ms. Takako Nakazono, Mr. Ryohei Oda, Mr. Kazuki Yamauchi, Ms. Kumi Kusaba, Ms. Shinobu Ichibagase, and Mr. Shintaro Inoue, for their immense support while conducting this study.

Conflict of Interest: The authors declare no conflicts of interest associated with this manuscript.

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