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ORIGINAL ARTICLE

Factors associated with short-term changes in physical function after gastrointestinal surgery: A preliminary study of the effect of exercise therapy

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Abstract

［Objective］ The association of changes in physical function at 1 and 2 weeks after gastrointestinal surgery with postoperative conditions and surgical factors was surveyed to investigate intervention methods and the need for postoperative rehabilitation.

［Methods］ The subjects were 28 patients who had undergone surgery for digestive cancer. Knee extensor muscle strength, grip strength, SPPB (balance test, 4-meter walking time, and 5-sit-to-stand time), and 6-minute walking distance were measured about 1 and 2 weeks after surgery for evaluation of physical function. Canonical correlation analysis was performed with physical function factors as dependent variables and preoperative and surgical data as independent variables.

［Results］ Physical function improved over 2 weeks. The 4-meter walking time and 5-sit-to-stand test were correlated with preoperative %FVC, days of postperative rehabilitation, and presence or absence of postoperative complications ($p<0.01$).

［Conclusion］ Preoperative physical condition may affect postoperative functional improvement.

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Key words: gastrointestinal cancer; postoperative; physical function; Complications.

Introduction

The prevalence of cancer is increasing yearly in Japan, and this is leading to an era of "coexistence with cancer"[1]. Many patients suffer from digestive organ-related cancers, such as stomach and colorectal cancer. Surgical resection is used as first choice treatment for many solid cancers, such as those in the stomach and large intestine, that are diagnosed in the early stage, with expectation of a complete cure[2]. Therefore, there is a need to improve physical activity postoperatively for patients who will ultimately return to regular life as cancer survivors.

The target of cancer rehabilitation is for the patient to return to their daily life and society as early as possible. Physical therapy is mainly used to improve physical function, but a clear intervention effect is not always observed. To return to a normal life after surgery, recovery of physical function is needed, and improvement of physical activity while still under surgical stress may be an important factor in postoperative rehabilitation. Insufficient improvement of physical function has frequently been found after discharge following gastrointestinal surgery in Japan[3-5]. Moreover, although the efficacy of exercise therapy after cancer treatment has been shown in a systematic review, a need to investigate the content and load was also indicated[6].

Increased inflammation due to elevated protein

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catabolism caused by surgical stress is also a concern. About one week is required for restart of protein synthesis[7], and amino acid levels decrease to the lowest level at the 3rd day and normalize at around the 14th day postoperatively, as factors related to wound healing after surgery for esophageal cancer[8]. Thus, strengthening of exercise therapy should be started at about 1 week after surgery. However, the period for postoperative rehabilitation is limited to the time to discharge at about 2 weeks after surgery. Thus, in the current study, physical function at 1 to 2 weeks after surgery and related preoperative and surgical factors were examined, as a preliminary study of the effect of postoperative rehabilitation on improvement of physical function.

Subjects and Methods

1. Subjects

The subjects were patients who underwent gastrointestinal surgery for cancer between October 2015 and April 2016 at the institution of the first author. Acceptance criteria were agreed, and inspection and measurement were possible. Exclusion criteria were those with had dementia, can not get informed consent, and difficulty in rehabilitation due to severe complications. A total of 100 surgeries for digestive cancer were performed in this period, and rehabilitation was prescribed in 87 cases. Twelve patients with limited physical activity that was difficult to measure and with difficulty in follow-up due to cognitive decline and severe complications, and 47 patients in whom tests and measurement could not be performed on the specified days were excluded, leaving 28 patients in the analysis. The age and physical characteristics of these subjects are shown in Table 1. Complications influenced the physical activity in 2 patients due to use of a walker, but these patients were able to walk independently for a short distance. The study was performed after approval by the Ethics Committee of National Hospital Organization Kanmon Medical Center, and consent was obtained from the subjects.

2. Methods

1) Evaluation of physical function

Severe stress is induced after surgery for digestive cancer and muscle weakness occurs due to postoperative protein catabolism[8]. Thus, in evaluation of physical function, (1) knee extension muscle strength (KEMS) was measured as an index of instantaneous lower limb muscle strength, (2) grip strength was measured as an index of gross and instantaneous upper limb muscle strength, and (3) 6-minute walking distance (6MWD) served as an index of aerobic exercise ability and was measured in consideration of inhibition of cardiorespiratory function due to a severe stress-induced increase in inflammation. In addition, the Short Physical Performance Battery (SPPB)[10], which has established reliability in elderly people, was used to evaluate lower limb function[9]. The SPPB includes (4) a test of balance function based on retention of the tandem position, (5) 4-meter walking time (4MWT), reflecting the instantaneous short-distance walking ability, and (6) a 5-sit-to-stand test (SS-5) of complex lower limb muscle strength, including muscular endurance. Each evaluation was performed at 1 and 2 weeks after surgery by 5 physical therapists and an occupational therapist in patients for whom they were responsible. All of the following measurements were performed in all subjects.

(1) KEMS: The test was performed using a hand-held dynamometer (μ-Tas F-1, Anima Co.) using the method reported by Kato et al.[11] The trunk remained in a vertical sitting position with both lower limbs dropped, and the distal crus on the measurement side was fixed with a band. From this leg position, the patient performed

Table 1. Descriptive statistics for resaerch item

Characteristic	Measurements	
Sex (n)	Men	14
	Women	14
Age (y)	71.8 (11.7)	[48 - 87]
Weight (kg)	57.1 (12.9)	[37.0 - 92.0]
Height (cm)	159.2 (10.3)	[143.0 - 183.0]
BMII (kg/m^2)	22.3 (3.1)	[14.5 - 27.5]
Physical surface area (m^2)	1.7 (0.5)	[1.2 - 4.0]
Comorbidity presence for Cancer (n)	Yes	5
	No	23
Comorbidity presence for Cardiovascular disease (n)	Yes	5
	No	23
Comorbidity presence for Cerebrovascular disease (n)	Yes	2
	No	23
Comorbidity presence for Orthopedic disease (n)	Yes	5
	No	23
Comorbidity presence for Internal medicine disease (n)	Yes	20
	No	8
Cancer site (n)	Stomach	14
	Colon	11
	Liver	3
Cancer stage (n)	I	10
	II	7
	III	5
	IV	6
Preoperative %VC (%)	109.1 (16.0)	[78.6 - 137.3]
Preoperative %FVC (%)	105.0 (24.3)	[11.0 - 138.8]
Preoperative $FEV_{1.0\%}$ (%)	73.9 (5.2)	[60.1 - 86.1]
Preoperative ALB (g/dl)	4.0 (0.6)	[2.0 - 4.9]
Preoperative TLC (mm^3)	1585.7 (601.7)	[600.0 - 3000.0]
Preoperative CRP (mg/dl)	0.3 (0.5)	[0.02 - 2.47]
Operative procedure (n)	Laparotomy	9
	Laparoscopic	19
Blood loss (ml)	114.6 (134.2)	[2.0 - 600.0]
Operation time (minutes)	226.5 (74.1)	[115.0 - 406.0]
Postoperative complication (n)	Yes	4
	No	24
Postoperative ingestion start days (day)	4.0 (1.6)	[1.0 - 8.0]
Postoperative exercise start days (day)	1.2 (0.4)	[1.0 - 2.0]
Postoperative exercise implementation days (day)	9.9 (4.5)	[4.0 - 22.0]
Length of stay (day)	15.9 (6.3)	[8.0 - 29.0]

Results are presented as mean (SD) [minimum - maximum] or number of participants.

knee extension of about 3 s with maximum effort. The mean (N) of two measurements performed at an interval of ≥30 s was used in analysis after being standardized to Nm/kg by multiplying by crural length (m) and dividing by body weight (kg).

(2) Grip strength: Strength of the dominant hand for grasping at about the grip width was measured using the method of Ohtsuka et al.[12]. Test were performed in the sitting position at an interval of ≥2 min, and the maximum of the twice measurements was used for analysis.

(3) 6MWD: The protocol used was that prepared by the American Thoracic Society[13]. For the walking path, a level indoor 200-m outer path in a ward of the hospital was used, and the walking distance was measured once by the tester using distance measuring instrument.

(4) Balance test: Standing with closed legs and open eyes for <10 and 10 s were scored as 0 and 1, respectively. One point was added when the semi-tandem position could be maintained for 10 s, and another 1 and 2 points were added when the tandem position could be maintained for 3-9.99 and 10 s, respectively, to give a total possible score of 4. Each measurement was performed once.

(5) 4MWT: Starting from a standing position, the time to walk at 4m distance for maximum speed was measured. The use of a cane and walker was allowed. The time at normal walking speed was measured twice and the shorter time was used.

(6) SS-5: The sheet height was set at 40 cm. Patients crossed their arms in front of their chest and performed 5 sit-to-stand movements with maximum effort. The time required was measured. The test was performed twice with an interval of ≥1 min.

2) Preoperative and surgical data

The following information was extracted from medical records for use in analysis:

(1) Basic information: Sex, age, height, and body weight on admission, BMI and body surface area[14] calculated from height and body weight.

(2) Comorbidity: The presence or absence of each comorbidity was investigated in medical records. The disease and pathology were classified into a history of cancer, circulatory disease, cerebrovascular disease, orthopedic disease, and other internal diseases. Cancer cases were placed in one category regardless of the presence or absence of surgery; circulatory disease included myocardial infarction, angina, and heart failure; cerebrovascular disease included cerebral infarction and cerebral hemorrhage; orthopedic disease included osteoarthritis of the knee and fracture; and other internal diseases included hypertension, diabetes, and metabolic disease.

(3) Cancer type: Liver, stomach, large intestine, and rectal cancers in stages I-VI were surveyed. The cancers were all primary and did not include metastatic tumors.

(4) Laboratory date: Respiratory function and blood test values measured in the clinical laboratory of our hospital or those in preoperative measurements closest to the day of surgery were used. For respiratory function tests, %vital capacity (%VC), %forced vital capacity (%FVC), and forced expiratory volume % in 1 second ($FEV_{1.0\%}$) were used. In blood tests, the albumin level (Alb), total lymphocyte count (TLC), and C-reactive protein (CRP) level were examined.

(5) Surgery and postoperative course: Surgery was classified into laparotomic and laparoscopic procedures, and intraoperative blood loss and operative time were recorded. The day of initiation of postoperative rehabilitation, number of days with postoperative rehabilitation, the day of initiation of oral ingestion, and length of hospital stay after surgery were examined.

3) Protocol for postoperative rehabilitation (Table. 2)

In the postoperative course at the institution of the first author, analgesia by epidural pain relief and intravenous administration is performed and ambulation is initiated on the day following surgery. The time to initiation of oral ingestion starts at 2nd-4th day after surgery depending on the surgical site. Drinking of water may be permitted earlier, as appropriate. Postoperative rehabilitation is performed by a physical therapist and occupational therapist one-on-one for each patient for one period of about 20 min/day on 5-7 days/week. In the postoperative rehabilitation program, ambulation and walking exercise start on the day following surgery and the continuous walking distance increases in stages over 5 days. For patients with postoperative respiratory dysfunction, respiratory rehabilitation is performed, including time-to-time posture

Table 2. postoperative rehabilitation protocol

○ time schedule
  P.O.1day ; indoor and corridor (about 50m)
  until P.O.5day ; walking (continuous walking distance 400m or more)
    light resistance training, respiratory exercise
  after P.O.6day ; resistance training, ergometer
    ADL exercise
  continue until descharge (P.O.10～14day)

○ exercise therapy
  aerobic exercise
    type ; ergometer
    strength ; set target heart rate for karvonen formula
      within borg scale 13
    time ; 20～40 minites
  resistance training
    type ; weight and weight load training
    strength ; about 15RM (repetitotion maximum)
    part ; lower extremity ; knee extention・hip flexion・hip abduction・hip extention
        calf raise・squat
      upper extremity ; elbow flexion・shoulder abduction・shoulder elevation
      trunk ; abdominal muscle exercise・bridging

management and practice of sputum excretion and cough. Lower limb muscle training, such as strengthening of the knee extensor and hip flexor muscles and half squat, starts from the 3rd day after surgery depending on the condition of each patient. From the 5th day after surgery, aerobic exercise such as use of an bicycle ergometer is performed, with the contents adjusted for each patient based on their condition. At about 2 weeks after surgery, the patient is discharged after practice and guidance for activities of daily living. This protocol was prepared to ensure uniform content in postoperative rehabilitation before initiation of this study.

4) Statistical analysis

The difference in each physical function item between 1 and 2 weeks after surgery was compared by paired t-test for normally distributed data and by Wilcoxon signed-rank test for data without a normal distribution. To investigate the association between physical function items at 1 and 2 weeks after surgery and preoperative and surgical data, canonical correlation analysis was used. The analysis was divided into 1 week and 2 weeks after surgery. The dependent variables were analyzed as physical function items and the independent variables as preoperative and surgical data.

Furthermore, canonical correlation analysis was used to examine factors related to the change in physical function assessment from 1 week after surgery to 2 weeks after surgery. The dependent variables were analyzed as changes in physical function items and the independent variables as preoperative and surgical data.

Canonical correlation analysis is a multivariate analysis equivalent to regression analysis with two or more response and independent variables that allows analysis of the influence of multiple independent variables on multiple response variables. This approach was used as an exploratory analysis because of the small number of subjects and mixed confounding factors. R2.8.1 was used for statistical analysis, with a significance level of 5% in all analyses.

Results

The length of hospital stay after surgery was ≥20 days in 6 subjects, including 3 of the 4

Table 3. Comparison of physical function at the time of evaluation

	postoperative 1 week (po1w)	postoperative 2 week (po2w)	Change value	po1w vs po2w	effect size r
KEMS (Nm/kg)	0.844 (0.7)	0.987 (0.6)	0.144 (0.3)	$p<0.01^{\dagger}$	0.499
Grip strength (kg)	24.5 (10.1)	24.2 (10.1)	−0.3 (2.5)	$p=0.52$	0.125
6MWD (m)	307.2 (116.2)	374.3 (119.0)	67.1 (48.9)	$p<0.01$	0.813
Balance test (point)	3.5 (1.2)	3.6 (1.0)	0.1 (0.6)	$p=0.41^{\dagger}$	0.202
4MWT (sec)	5.5 (5.8)	4.2 (3.2)	−1.2 (2.8)	$p<0.01^{\dagger}$	0.757
SS-5 (sec)	12.4 (7.2)	9.6 (4.0)	−2.8 (4.4)	$p<0.01^{\dagger}$	0.629

Results are presented as mean (SD) † ; Wilcoxon signed-rank test

subjects who developed a postoperative complication. The course proceeded along the protocol in all other subjects. Descriptive statistics for preoperative and surgical data are shown in Table 1. The cancer was located in the stomach, large intestine, and rectum in many cases, and in the liver in 3 cases; and varied from stage I early cancer to stage IV terminal cancer. In preoperative respiratory function tests, %VC was <80% in 1 patient and FEV1.0% was <70% in 4, but all patients were judged to be able to undergo surgery. In preoperative blood tests, Alb was <3.9 g/dL in 7 patients and <2.0 g/dL in one; and CRP was >0.5 mg/dL in 3 patients. All other values were within the normal ranges. In evaluation of physical function changes from 1 to 2 weeks after surgery, significant improvements were found for KEMS, 6MWD, 4MWT, and SS-5 ($p<0.01$) (Table 3).

In canonical correlation analysis of the association of physical function items with preoperative and surgical data at 1 week after surgery, the correlation was significant up to the second canonical correlation ($p<0.01$) (Table 4). In the dependent variable of the first canonical variable, the coefficient was large in the order of grip strength, KEMS, and the independent variable was related to sex and BMI. In the dependent variable of the second canonical variable, the coefficient was large in the order of 4MWT, SS-5, and the independent variable was related to %FVC and number of days with postoperative rehabilitation, and presence or absence of postoperative complications.

For the association of physical function factors at 2 weeks after surgery and preoperative and surgical data, only the first canonical correlation was significant ($p<0.01$) (Table 5). For the dependent variable of the first canonical variable, the coefficient was large in the order of grip strength, 6MWD, and KEMS, and the independent variable was related to sex and BMI. In the dependent variable of the second canonical variable, the coefficient was large in the order of 4MWT, balance test, SS-5, 6MWD. It was related with the presence of comorbidities and postoperative complications.

In analysis of the relationship of changes in physical function factors from 1 to 2 weeks after surgery with preoperative and surgical data, the first and second canonical correlations were significant ($p<0.01$ and $p<0.05$, respectively) (Table 6). The dependent variable of the first canonical variable had a 4MWT and SS-5, and the independent variable was related to %FVC, number of days with perioperative rehabilitation, and postoperative complications. The dependent variable of the second canonical correlation had a balance test and 6MWD, which was related to the presence or absence of cancer disease and cerebrovascular disease in the independent variables.

Table 4. Relationship between physical function evaluation for po1w and preoperative and surgical data

Dependent variable	1st Canonical Variates	Dependent variable	2nd Canonical Variates
Grip strength	−0.794	4MWT	0.840
KEMS	−0.386	SS-5	0.420
Balance test	0.276	6MWD	−0.358
6MWD	−0.259	Grip strength	−0.354
4MWT	−0.186	Balance test	−0.279
SS-5	−0.134	KEMS	−0.200

Independent variable	1st Canonical Variates	Independent variable	2nd Canonical Variates
Sex	0.817	Preoperative %FVC	−0.666
BMI	−0.591	exercise implementation days	0.433
Blood loss	−0.349	complication	0.429
Operation time	−0.326	Cardiovascular disease	0.381
Preoperative ALB	−0.291	Cancer	−0.352
Preoperative %FVC	0.232	Operation time	0.287
Cardiovascular disease	−0.223	Age	0.232
ingestion start days	0.154	Internal medicine disease	0.186
Cancer	−0.148	Preoperative ALB	−0.150
Orthopedic disease	0.145	BMI	−0.097
Cerebrovascular disease	0.130	ingestion start days	−0.088
exercise implementation days	−0.112	Cerebrovascular disease	−0.083
Internal medicine disease	0.094	Sex	0.082
Cancer stage	0.071	Cancer stage	−0.071
Operative procedure	0.052	Blood loss	0.030
complication	0.039	Orthopedic disease	0.023
Age	0.008	Operative procedure	0.018
Canonical correlation coefficient	0.992 ($p<0.01$)	Canonical correlation coefficient	0.967 ($p<0.01$)

Discussion

The purpose of this study was to clarify the improvement of postoperative physical function and influencing factors. Physical function was improved 2 weeks after surgery, which was related to preoperative physical status and comorbidity. Discuss by dividing into physical function and influencing factor.

1) Change of physical function

In the evaluation results at 1 and 2 weeks after surgery, improvement was noted in KEMS, 6MWD, 4MWT, and SS-5, but not in the grip strength or balance test. Based on several reports[4, 15, 16], It has been reported that a period of 4 to 8 weeks is required for sufficient postoperative physical function improvement. However, improvement can be obtained even in a short period of 2 weeks after the surgery, and it is thought that this is due to the fact that early mobilization are becoming habitual. Early mobilization involves rehabilitation. As a biological reaction, when muscles are broken down by surgical invasion and amino acids are released, protein catabolism is promoted[17]. Promotion of catabolism due to postoperative surgical stress reaches a maximum about 48 hours after surgery[17] and then there is a change toward amino acid synthesis[8]. Therefore, physical function at 1 week after surgery is likely to be influenced by the large reduction of skeletal muscle and difficulty with activities. At 1 week after surgery, the biological reaction turns to protein synthesis

Table 5. Relationship between physical function evaluation for po2w and preoperative and surgical data

Dependent variable	1st Canonical Variates	Dependent variable	2nd Canonical Variates
Grip strength	−0.927	4MWT	−0.920
6MWD	−0.621	Balance test	0.666
KEMS	−0.558	SS-5	−0.530
4MWT	0.312	6MWD	0.481
SS-5	0.180	KEMS	0.235
Balance test	0.006	Grip strength	0.097

Independent variable	1st Canonical Variates	Independent variable	2nd Canonical Variates
Sex	0.799	Preoperative %FVC	0.786
BMI	−0.453	exercise implementation days	−0.592
Preoperative ALB	−0.387	Cardiovascular disease	−0.471
Cerebrovascular disease	0.252	complication	−0.427
Blood loss	−0.215	Age	−0.397
Age	0.197	Sex	0.288
complication	0.188	Operation time	−0.283
Operation time	−0.159	BMI	−0.240
exercise implementation days	0.154	Orthopedic disease	0.171
Cancer	−0.145	ingestion start days	0.167
Internal medicine disease	0.144	Preoperative ALB	0.153
ingestion start days	0.134	Blood loss	−0.147
Preoperative %FVC	−0.126	Internal medicine disease	−0.104
Cancer stage	0.124	Cerebrovascular disease	0.088
Orthopedic disease	0.089	Cancer	0.061
Cardiovascular disease	−0.054	Cancer stage	−0.061
Operative procedure	−0.052	Operative procedure	0.041
Canonical correlation coefficient	0.987 ($p<0.01$)	Canonical correlation coefficient	0.941 ($p=0.10$)

and physical function improves. Therefore, I propose in addition to the early mobilization, it is important to increase the activity 1 week after surgery.

2) Relationship between physical function, preoperative and surgical data

Factors associated with physical function at 1 and 2 weeks after surgery were also investigated. In the first canonical correlation analysis, the elements of physique and strength exerted influence on physical function at 1 and 2 weeks after surgery. It porpose sex differences. Interesting results were obtained with the second canonical correlation. In the second canonical correlation analysis, physical function were associated with pre- and postoperative conditions at 1 and 2 weeks after surgery. Postoperative complication is likely to extend the length of hospital stay and suppress physical activity[18, 19]. Thus, although the days with postoperative rehabilitation increased, physical function declines when a postoperative complication develops. Postoperative complications are likely to occur due to a decrease in physique and physical function[20]. In this study, the fact that respiratory function declined and having cardiovascular disease was also agree with this.

We investigated factors associated with changes in physical function from 1 to 2 weeks after surgery. In terms of change of physical function, the first canonical correlation was influenced by respiratory function and postoperative complications. Among physical functions, 4MWT

Table 6. Change for physical function evaluation for po1w and preoperative and surgical data

Dependent variable	1st Canonical Variates	Dependent variable	2nd Canonical Variates
4MWT	−0.911	Balance test	−0.696
SS-5	−0.393	6MWD	0.372
6MWD	−0.359	KEMS	−0.226
Grip strength	−0.299	SS-5	0.225
KEMS	−0.229	4MWT	−0.115
Balance test	0.184	Grip strength	0.004

Independent variable	1st Canonical Variates	Independent variable	2nd Canonical Variates
Preoperative %FVC	−0.833	Cancer	−0.412
exercise implementation days	0.635	Cerebrovascular disease	−0.404
complication	0.434	Cardiovascular disease	0.334
Cardiovascular disease	0.374	Age	−0.304
Age	0.342	complication	0.307
Operation time	0.267	Preoperative ALB	0.260
Preoperative ALB	−0.169	BMI	−0.229
Internal medicine disease	0.121	Sex	−0.222
Cancer	−0.096	Blood loss	−0.178
BMI	0.093	Internal medicine disease	−0.167
Cerebrovascular disease	0.089	ingestion start days	−0.158
Blood loss	0.077	Operative procedure	0.141
Sex	−0.062	exercise implementation days	−0.096
Orthopedic disease	−0.045	Preoperative %FVC	0.036
Cancer stage	0.022	Orthopedic disease	0.021
Operative procedure	0.020	Operation time	−0.009
ingestion start days	−0.013	Cancer stage	0.001
Canonical correlation coefficient	0.979 (p<0.01)	Canonical correlation coefficient	0.971 (p<0.05)

and SS-5, which showed instantaneous muscle strength, were extracted. In the second canonical correlation analysis, changes in the balance test and 6MWD were influenced by the presence or absence of cancer disease and cerebrovascular and circulatory disease, that the preoperative disease status influences improvement of physical function after surgery. There is an association that preoperative comorbidity reduces activity, which may affect postoperative complications. Therefore, for patients whose physical condition is not sufficient before surgery, increasing physical activity will lead to prevention of complications[20, 21] and improvement of postoperative physical function.

Improvement after surgery is difficult in clinical practice in patients with reduced activity before surgery. This study confirmed this association and identified other important factors associated with postoperative physical function. One such factor, the length of hospital stay, has shortened after gastrointestinal surgery and there may be less opportunity for continued postoperative rehabilitation at outpatient clinics. Therefore, there is a need to investigate the influence of short-term postoperative rehabilitation on long-term physical function and QOL after surgery.

Limitations

The limitations of the study include the absence of evaluation of preoperative physical function and the long-term course, and the lack of investigation of the effect of postoperative rehabilitation because the study was performed to investigate the associated factors. It is also necessary to consider that the selection bias could not be excluded because there were only 28 subjects who could be surveyed out of 100 subjects. In addition, the findings may differ when the number of cases increases or inclusion criteria are changed because the multivariate analysis included many factors. A further study is required to examine the effects of these limitations.

Conclusion

Short-term postoperative changes in physical function were evaluated after postoperative rehabilitation and associations with preoperative and surgical factors were investigated. Regarding physical function, a significant improvement was noted in 6MWD, KEMS, and 4MWT from 1 to 2 weeks after surgery. Factors directly related to the physical condition, such as %FVC and postoperative complications, and preoperative factors such as complications are involved in changes in physical function. Based on the results of this study, we plan to evaluate the influence of preoperative conditions and the content of postoperative rehabilitation on physical function.

Conflict of Interest Statement

There are no conflicts of interest to declare.

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