



Original Article

## Impact of sarcopenia on the progress of cardiac rehabilitation and discharge destination after cardiovascular surgery

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**Abstract.** [Purpose] To investigate the factors that affect the progress of cardiac rehabilitation, length of stay in the hospital, and discharge destination after cardiovascular surgery. [Participants and Methods] This was a prospective observational study. Sixty-seven patients scheduled to undergo open-heart surgery were included in the study. We evaluated physical and psychiatric functions pre- and post-surgery. Sarcopenia was defined as a short physical performance battery score of <9.5. [Results] Sarcopenia was a significant factor of delay of the day of the first rehabilitation, independence in 100-m walking, and exercise training at the rehabilitation gym. Comparisons between pre- and post-surgery were performed in the sarcopenia group. No significant decreases in physical and psychiatric functions were found. The discharge transfer rate was significantly different between the sarcopenia and non-sarcopenia groups. Sarcopenia and the decline in balance score significantly correlated with discharge transfer. [Conclusion] Cardiac rehabilitation can achieve recovery of physical and psychiatric functions even in patients with sarcopenia; however, the discharge transfer rate among the patients with sarcopenia was high. Improving balance ability may result in early home discharge.

**Key words:** Cardiovascular surgery, Sarcopenia, Discharge destination

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### INTRODUCTION

Cardiovascular surgery aims to improve the survival and quality of life (QoL) of patients, and to develop surgical technique and administrations that enable safe and effective procedures despite the aging population of Japan<sup>1, 2)</sup>. Physical function may decrease immediately after surgery, especially in elderly patients. Cardiac rehabilitation is needed to prevent or improve the expected problems as it is recommended to start early mobilization, with consideration for the hemodynamics<sup>3)</sup>. With the aging society, there are many reports related to the impact of frailty. Patients with frailty preoperatively have delayed progress of rehabilitation, decreased rate of independent walking, delayed home discharge, increased length of stay (LOS) in the hospital, and increased rate of mortality after cardiovascular surgery<sup>4, 5)</sup>. It is clear that frailty induces various clinical problems; however, the concept of frailty is comprehensive, making the identification of the cause of clinical problems

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difficult. Sarcopenia, as a physical dysfunction, psychiatric dysfunction, and malnutrition may be the main problems related to frailty and aging. Decreasing walking speed, one of the symptoms of sarcopenia, is an independent predictor of adverse outcomes after cardiovascular surgery, with each 0.1-m/s decrease conferring an 11% relative increase in mortality<sup>6</sup>. One report suggested that the presence of depression prior to the operation may affect postoperative recovery after coronary artery bypass grafting surgery (CABG)<sup>7</sup>. Arai et al. reported that preoperative Geriatric Nutritional Risk Index (GNRI), as a nutritional status, was one of the independent predictors for the progression of postoperative cardiac rehabilitation in patients undergoing cardiovascular surgery<sup>8</sup>. However, multiple factors were not analyzed in the same study, and outcomes were different. A commonly important outcome is survival, but the LOS in the hospital is also an important outcome in Japan because the average LOS in Japanese acute hospitals is two to three times longer than that in the major G7 countries<sup>9</sup>. Naturally, there are patients who need long-term hospitalization to continue treatment, including patients who are critically-ill and those with post-surgical complications. Therefore, patients with successful progress should have a short LOS in acute hospitals and aim for early home discharge.

We hypothesized that clearing the causes of delay in the progress of cardiac rehabilitation, the increase in LOS, and the need for discharge transfer may help with clinical strategies to achieve early hospital discharge. The purpose of this study was to investigate factors affecting the progress of cardiac rehabilitation, LOS in the hospital, and the discharge destination by analyzing important factors of physical function, psychiatric function, and nutritional status in patients who were scheduled to undergo cardiovascular surgery.

## PARTICIPANTS AND METHODS

A prospective observational study was conducted comprising patients who were scheduled to undergo cardiovascular surgery, and were admitted to the Nagasaki University Hospital from December 2015 to August 2016.

Participants were able to ambulate independently, and able to the activities of daily living (ADL). The method of cardiovascular surgery was open heart surgery. The exclusion criteria were those under 20 years old, and those with cognitive dysfunction as making answering self-question reports impossible (e.g. dementia). This study was approved by the Human Ethics Review Committee of Nagasaki University Hospital (approval number 15122112, approval date 4 December 2015). All participants submitted written informed consent.

Information on the patients was collected through their medical records. Primary outcome is discharge destination, whether to leave the hospital at home or transfer to another medical facility after surgery. Diabetes was defined as HbA1c >6.5%<sup>10</sup>. Kidney disease was defined as an estimated glomerular filtration rate of <60 mL/min/1.73 m<sup>2</sup>, calculated using the Modification of Diet in Renal Disease formula<sup>11</sup>. Anemia was defined according to the World Health Organization criteria (hemoglobin <13 g/dL in men and <12 g/dL in women)<sup>12</sup>. For the progress of cardiac rehabilitation, independence in 100 m walking and first exercise training at the rehabilitation gym was extracted on the post-operative day (POD) of first rehabilitation.

The criteria of cardiac rehabilitation progress followed the evidence-based expert consensus for early rehabilitation in the intensive care unit, and the guidelines for rehabilitation in patients with cardiovascular disease<sup>13, 14</sup>. As the original criteria of that progress, the place of cardiac rehabilitation was shifted to the rehabilitation gym for the group rehabilitation if patients could walk 200 m, which was the distance around the ward. The group rehabilitation involved warm-up, stretching, resistance training, aerobic exercise, and cool-down for 40 to 60 minutes, and the exercise intensity was adjusted individually.

Physical functions, such as grip force (GF), isometric quadriceps force (QF), and short physical performance battery (SPPB), were evaluated at pre- and post-surgery. GF was assessed on the dominant hand using a dynamometer (T.K.K.5401; Takei-Kiki-Kogyo Corporation, Niigata, Japan) in a standing position with the elbow extended, and the arms fixed to the body<sup>15</sup>. The highest value (kg) of three attempts was recorded. QF was evaluated as the peak force developed during a maximal isometric knee extension maneuver using a hand-held dynamometer with a fixing belt ( $\mu$ -Tas F-1; Anima Corporation, Tokyo, Japan), with a standard protocol<sup>16</sup>. It was tested on the dominant side, in a sitting position with the hip and knee joint flexed at approximately 90°. The highest value among at least three maneuvers was recorded and expressed in kilograms. The SPPB comprised three tests including a balance test, a 4 m walking test, and five times sit-to-stand (5STS) test. Each performance measured was assigned a categorical score, ranging from 0 (inability to complete) to 4 (best performance possible), and the sum of the scores was 0 to 12. SPPB was employed to measure the physical function<sup>17</sup>. The cut-off point of SPPB score for determining sarcopenia was 9/10<sup>18</sup>.

Psychiatric function was evaluated by the hospital anxiety and depression scale (HADS) at pre- and post-surgery. HADS consisted of anxiety and depression subscales, with each subscale assessed by seven questions and scored from 0 (not at all) to 3 (most of the time, very often). The total score for each HADS subscale was 21, and the total HADS score was 42<sup>19</sup>.

Nutritional status was evaluated as GNRI, which was calculated as follows:  $14.89 \times \text{serum albumin (g/dL)} + 41.7 \times \text{body mass index}/22$  and malnutrition was defined GNRI <92<sup>20</sup>.

Spearman's rank correlation coefficient was used to analyze the relationships between the day of cardiac rehabilitation, LOS in the hospital, discharge destination, and variables. The categorical variables were converted to 1 if it corresponded to a variable, and to 0 if it did not correspond. Multivariate linear regression analysis was used to determine the independent determinants associated with the day of cardiac rehabilitation, LOS in the hospital, among the factors that had p value less

than 0.05 on Spearman's rank correlation coefficient, and adjusted age and gender. The variables of factors (sarcopenia at pre-surgery and SPPB total score at pre-surgery, 4 m walking score at pre-surgery, 5STS score at pre-surgery, GF at pre-surgery, and QF at pre-surgery) correlated significantly ( $|r|>0.7$ ,  $p<0.001$ ). We selected sarcopenia and GF at pre-surgery as physical functions to avoid multicollinearity. Comparison within each group was analyzed by Wilcoxon signed-rank test. Comparison between the two groups was analyzed by Fisher's exact test for categorical variables and Wilcoxon rank test for continuous variables. All analyses were performed using JMP14<sup>®</sup> software Version 14.3.0 (SAS Institute Inc., Cary, NC, USA). The level of significance was  $p<0.05$  for all analysis.

## RESULTS

The baseline characteristics of the patients are shown in Table 1. The number (percentage) of patients in each cardiovascular disease to be operated on was as follows: valvular disease, 53 (79.1); ischemic heart disease, 18 (26.9); and aortic disease, 3 (4.5). The number of surgeries was as follows: valve replacement or repair, 45 (67.2); CABG including off-pump, 13 (19.4); aorta replacement or repair, 1 (1.5); and combined surgery (e.g. CABG + valve replacement, aorta and valve repair), 8 (11.9).

In physical functions at pre-surgery, the median [interquartile range] SPPB total score was 12 [10 to 12]. More than half of the patients had a score of 12 (full score). Similarly, each subscale had an SPPB score of 4 (full score) for more than half of the patients. The physical function of many patients was normal, while the number of patients who were classified to be with sarcopenia was 13 (19.4). All physical functions in the sarcopenia group were significantly lower than in the non-sarcopenia group. In psychiatric functions at pre-surgery, each median HADS score was normal, but the number of patients who were classified as "most of the time" or "very often" in anxiety and depression were 20 (32.3) and 17 (27.4), respectively. There was no significant difference in each HADS score between the sarcopenia group and the non-sarcopenia group. In nutritional status, almost all patients had a normal score. The number of patients who were classified to be with malnutrition was only 4 (6.0). There was no significant difference in GNRI between the sarcopenia group and the non-sarcopenia group.

Surgical findings and progress at the intensive care unit were generally good. One patient in the non-sarcopenia group needed intra-aortic balloon pumping, but all patients could be extubated within 24 hours.

The median POD of first rehabilitation was one and there was no significant difference between the two groups. However, the POD of independence in 100 walking and first exercise at rehabilitation gym were significantly more delayed in the sarcopenia group than in the non-sarcopenia group. The median LOS in the hospital was 18, and there was no significant difference in the LOS in the hospital between the sarcopenia group and the non-sarcopenia group. Correlations between the progress of cardiac rehabilitation, LOS in the hospital, and variables are shown in Table 2. Results on multivariable linear analysis by extracting factors with significant correlation are shown in Table 3. Sarcopenia was a significant factor to the POD of first rehabilitation ( $\beta=0.20$ ;  $p=0.013$ ), independence in 100 walking ( $\beta=0.89$ ;  $p=0.003$ ), and first exercise at rehabilitation gym ( $\beta=1.93$ ;  $p=0.003$ ), but was not a significant factor to the LOS in the hospital.

Comparison of physical functions, psychiatric functions, and discharge destination between the sarcopenia group and the non-sarcopenia group at pre- and post-surgery are shown Table 4. In the sarcopenia group, all physical and psychiatric functions were not significantly different. An increasing trend was seen in the 4 m walking score ( $p=0.068$ ) and 5STS score ( $p=0.088$ ), and a decreasing trend was seen in the balance score ( $p=0.068$ ). The LOS in the hospital between the two groups was not significantly different. However, there was a significant difference ( $p=0.006$ ) in the discharge destination. Analysis of correlations between the discharge transfer and variables are shown Table 5. In the analysis, sarcopenia ( $r=0.361$ ;  $p=0.003$ ),  $\Delta$ SPPB balance score ( $r=-0.275$ ;  $p=0.024$ ), and kidney disease ( $r=0.377$ ;  $p=0.001$ ) were found to be significant factors.

## DISCUSSION

We analyzed factors, such as sarcopenia, psychiatric dysfunction, and malnutrition, that affect the cardiac rehabilitation at the same model. First, sarcopenia was the factor with the most effect, which delayed the progress of cardiac rehabilitation and increased the discharge transfer. Second, physical functions in the sarcopenia group were recovered to the same functions at pre-surgery after cardiac rehabilitation. Third, the amount of decreased balance ability at pre- and post-surgery was correlated with increased rate of discharge transfer.

A total of 13 patients (19.4%) were classified to be with sarcopenia, and their characteristics included old age and low physical functions. The sarcopenia group in this study was consistent with the general prevalence and characteristics of sarcopenia<sup>21</sup>. The acute phase progress of this study was good, as all patients were extubated within 24 hours, and almost all patients could start the first rehabilitation at POD1. The progress of cardiac rehabilitation was similar to any reports and general course<sup>22, 23</sup>. In the sarcopenia group, the POD of first rehabilitation, independence in 100 m walking, and first exercise at rehabilitation gym was significantly more delayed than in the non-sarcopenia group. Similar to our results, Yaguchi et al. reported that the median POD of independence in walking after cardiovascular surgery was 4.0 in patients with SPPB score of 10–12, and 4.5 in patients with SPPB score of 7–9, and that the value in the latter group was significantly higher because of post-surgical complications<sup>24</sup>. We could not confirm if post-surgical complications affected the delay of the cardiac rehabilitation, because that was not part of the investigation of this study. In our previous study in the same facility about the effect of complications after cardiovascular surgery on the progress of cardiac rehabilitation, we reported that the

**Table 1.** Characteristics

	Total (n=67)	Non-sarcopenia (n=54)	Sarcopenia (n=13)	p value
Age (years)	72.0 [62.0 to 76.0]	66.0 [60.0 to 74.3]	77.0 [74.0 to 81.0]	<0.001
Male	39 (58.2)	35 (64.8)	4 (30.8)	0.032
Height (cm)	161.5 [152.6 to 166.7]	161.9 [155.4 to 167.8]	153.1 [145.8 to 164.1]	0.059
Weight (kg)	58.0 [50.9 to 65.9]	59.3 [51.7 to 65.9]	55.8 [44.2 to 64.0]	0.154
BMI (kg/m <sup>2</sup> ), median [IQR]	22.34 [20.74 to 24.78]	22.56 [20.81 to 24.18]	22.34 [20.20 to 26.36]	0.757
Cardiovascular disease of surgery				
Valvular disease	53 (79.1)	43 (79.6)	10 (76.9)	1.000
Ischemic heart disease	18 (26.9)	14 (25.9)	5 (38.5)	0.494
Aortic disease	3 (4.5)	3 (5.6)	0	1.000
Comorbidity				
Hypertension	42 (62.7)	32 (59.3)	10 (76.9)	0.342
Diabetes	18 (26.9)	13 (24.1)	5 (38.5)	0.312
Dyslipidemia	24 (35.8)	17 (31.5)	7 (53.8)	0.197
Kidney disease	15 (22.4)	9 (16.7)	6 (46.2)	0.057
Anemia	23 (34.3)	17 (31.5)	6 (46.2)	0.344
Physical functions				
Grip force (kg)	25.0 [17.0 to 35.4]	28.6 [21.0 to 37.7]	16.0 [13.5 to 21.3]	<0.001
Isometric quadriceps force (kg)	24.5 [17.0 to 32.4]	26.9 [18.7 to 37.3]	15.6 [11.8 to 22.3]	0.001
SPPB total score	12.0 [10.0 to 12.0]	12.0 [11.0 to 12.0]	9.0 [7.0 to 9.0]	<0.001
Balance score	4.0 [4.0 to 4.0]	4.0 [4.0 to 4.0]	4.0 [3.5 to 4.0]	0.021
4 m walking score	4.0 [3.0 to 4.0]	4.0 [4.0 to 4.0]	2.0 [2.0 to 3.0]	<0.001
5 sit-to-stand score	4.0 [3.0 to 4.0]	4.0 [4.0 to 4.0]	3.0 [2.0 to 4.0]	<0.001
Psychiatric functions				
HADS-total score	11 [7.0 to 15.0]	11.0 [7.0 to 15.0]	9.0 [6.5 to 16.5]	0.729
Anxiety score	5.5 [3.0 to 9.0]	5.0 [3.0 to 9.0]	6.0 [2.0 to 9.5]	0.993
Depression score	6.0 [3.0 to 8.3]	6.0 [4.0 to 9.0]	5.0 [2.0 to 8.0]	0.455
Nutritional status				
GNRI	103.6 [98.8 to 110.8]	104.7 [99.1 to 110.6]	101.6 [95.3 to 111.1]	0.533
Type of surgery				
Valve replacement/repair	45 (67.2)	37 (68.5)	8 (61.5)	0.745
CABG	13 (19.4)	10 (18.5)	3 (23.1)	0.706
Aorta replacement/repair	1 (1.5)	1 (1.9)	0	1.000
Combined operation	8 (11.9)	6 (11.1)	2 (15.4)	0.647
Surgical time (min)	282 [247 to 265]	289 [247 to 370]	261 [229 to 330]	0.241
Pump time (min)	162 [119 to 195]	163 [123 to 204]	126 [101 to 177]	0.075
Aorta clamp time (min)	93 [69 to 133]	98 [70 to 134]	77 [63 to 103]	0.051
Extubation within 24 hours	67 (100)	54 (100)	13 (100)	1.000
Progress of cardiac rehabilitation				
First rehabilitation (POD)	1.0 [1.0 to 1.0]	1.0 [1.0 to 1.0]	1.0 [1.0 to 1.5]	0.051
Independence in 100 m walking (POD)	4.0 [3.0 to 4.0]	4.0 [3.0 to 4.0]	4.0 [4.0 to 7.5]	0.002
First exercise at rehabilitation gym (POD)	6.0 [5.0 to 7.0]	6.0 [5.0 to 6.3]	11.0 [6.0 to 17.0]	<0.001
Length of stay in the hospital (POD)	18.0 [15.0 to 22.0]	18.0 [15.0 to 22.5]	19.0 [14.5 to 22.5]	0.787
Discharge destination (home)	48 (71.6)	43 (79.6)	5 (38.5)	0.006

Data are presented as median [interquartile range], or n (%). BMI: body mass index; GNRI: geriatric nutritional risk index; SPPB: short physical performance battery; HADS: hospital anxiety and depression scale; CABG: coronary artery bypass grafting; POD: post-operative day.

post-surgical pulmonary complication was an independent predictor of the delay in 200 m walking in each cardiovascular surgery, and that progress was delayed as the number of post-surgical complications increased<sup>25</sup>). In this study, post-surgical complications may be related to the progress of cardiac rehabilitation.

The change of physical functions between pre- and post-surgery were not different in the sarcopenia group. These results

**Table 2.** Correlations between the progress of cardiac rehabilitation, length of stay, and variables

	First rehabilitation (POD)		Independence in 100 m walking (POD)		Exercise training at rehabilitation gym (POD)		Length of stay in hospital (POD)	
	r	p value	r	p value	r	p value	r	p value
Age (years)	-0.008	0.946	0.300	0.014	0.373	0.002	0.024	0.848
Male	-0.118	0.341	-0.233	0.058	-0.261	0.033	-0.002	0.985
BMI (kg/m <sup>2</sup> )	0.041	0.743	0.098	0.432	0.182	0.140	0.105	0.396
Comorbidity								
Hypertension	-0.149	0.230	0.199	0.107	0.174	0.158	0.227	0.064
Diabetes	0.101	0.418	0.104	0.402	-0.037	0.768	0.003	0.983
Dyslipidemia	0.156	0.208	0.157	0.204	0.094	0.450	0.207	0.093
Kidney disease	-0.100	0.435	0.414	<0.001	0.424	<0.001	0.269	0.028
Anemia	-0.221	0.073	0.181	0.144	0.250	0.042	0.155	0.211
Physical functions								
Sarcopenia	0.241	0.049	0.383	0.001	0.428	<0.001	-0.033	0.789
Grip force (kg)	-0.185	0.135	-0.403	<0.001	-0.457	<0.001	-0.142	0.251
Isometric quadriceps force (kg)	-0.125	0.313	-0.351	0.004	-0.334	0.006	-0.208	0.091
SPPB total score	-0.160	0.196	-0.454	<0.001	-0.393	0.001	-0.042	0.737
Balance score	-0.120	0.334	-0.196	0.112	-0.156	0.207	-0.082	0.510
4m walking score	-0.223	0.070	-0.430	<0.001	-0.376	0.002	-0.047	0.705
5 sit-to-stand score	-0.108	0.386	-0.402	<0.001	-0.389	0.001	-0.027	0.831
Psychiatric functions								
HADS-total score	-0.055	0.672	-0.103	0.427	-0.050	0.698	0.155	0.230
Anxiety score	-0.021	0.872	-0.248	0.052	-0.121	0.350	0.060	0.645
Depression score	0.062	0.634	0.068	0.599	0.014	0.915	0.253	0.047
Nutritional status								
GNRI	0.109	0.389	-0.077	0.542	-0.040	0.753	-0.172	0.171
Type of operation								
CABG	0.031	0.802	-0.008	0.948	-0.099	0.427	-0.082	0.508
Valve replacement/repair	0.026	0.833	-0.133	0.283	-0.030	0.812	-0.194	0.116
Aorta replacement/repair	-0.023	0.856	0.040	0.750	-0.001	0.958	0.153	0.216
Combined operation	-0.068	0.587	0.188	0.128	0.166	0.180	0.324	0.008
Operation time (min)	0.101	0.416	0.099	0.425	-0.035	0.780	0.188	0.127
Pump time (min)	0.322	0.015	-0.051	0.706	-0.129	0.340	0.003	0.984
Aorta clamp time (min)	0.228	0.086	-0.133	0.319	-0.176	0.187	-0.073	0.586

POD: post-operative day; BMI: body mass index; GNRI: geriatric nutritional risk index; SPPB: short physical performance battery; HADS: hospital anxiety and depression scale; CABG: coronary artery bypass grafting.

meant that cardiac rehabilitation at post-surgery, in this study, had general effect, however, the progress of cardiac rehabilitation was delayed. It was clear that the independent factor to the progress of cardiac rehabilitation was sarcopenia, not psychiatric dysfunction or malnutrition, and the effects of sarcopenia increased as the cardiac rehabilitation progressed by multivariable linear regression. Drudi et al. reported that the pre-surgery exercise training may improve clinical outcomes, physical functions, and the QoL in patients undergoing cardiovascular surgery<sup>26</sup>). However, the Japanese insurance system apply only to post-surgical rehabilitation, and not to pre-surgical rehabilitation. Performing enough interventions in improving sarcopenia for patients scheduled for cardiovascular surgery is difficult in Japan. Waite et al. reported that providing a home-based pre-surgical rehabilitation for frail patients undergoing cardiovascular surgery may be able to improve physical functions and reduce the LOS in the hospital<sup>27</sup>). To improve sarcopenia at pre-surgery, it seems realistic to instruct patients to perform unsupervised exercise at home.

Sarcopenia had no significant effect on the LOS in the hospital, but the higher rate of discharge transfer was observed in the sarcopenia group than in the non-sarcopenia group. Therefore, the cumulative LOS in the hospital may still be longer in the sarcopenia group. Considering the economic aspects, such as reduction of medical expenses, and improving the home discharge rate, can be a social contribution. This is considered to be an important outcome, especially in Japan, where the LOS in the hospital is long. In the analysis of correlation between discharge transfer and variables, in addition to sarcopenia, the balance score was also significantly associated. In the comparison of SPPB score between pre-surgery and post-surgery,

**Table 3.** Multivariate linear regression analysis of the progress of cardiac rehabilitation

	First rehabilitation (POD)		Independence in 100m walking (POD)		First exercise at rehabilitation gym (POD)		Length of stay in hospital (POD)	
	$\beta$ [95%CI]	p value	$\beta$ [95%CI]	p value	$\beta$ [95%CI]	p value	$\beta$ [95%CI]	p value
Sarcopenia	0.19 [0.03 to 0.34]	0.018	0.91 [0.24 to 1.59]	0.003	2.02 [0.73 to 3.31]	0.003	-0.75 [-3.12 to 1.62]	0.528
Grip force, per 1 kg			-0.01 [-0.08 to 0.06]	0.788	-0.01 [-0.14 to 0.13]	0.927		
HADS-depression score, per 1 point							0.45 [-0.10 to 1.00]	0.104
Kidney disease			0.46 [-0.17 to 1.09]	0.151	2.24 [1.00 to 3.48]	0.001		
Anemia					0.12 [-0.95 to 1.19]	0.823		
Pump time, per 1 min	0.01 [0.00 to 0.01]	0.002						
Combined operation							4.09 [1.46 to 6.72]	0.003

Adjusted for age and gender in all models.

These models had a coefficient of multivariate determination,  $R^2$  of 0.22, 0.23, 0.41, 0.20, respectively.

POD: post-operative day; HADS: hospital anxiety and depression scale.

**Table 4.** Comparison of physical functions and psychiatric functions between at pre- and post-surgery

	Non-sarcopenia			Sarcopenia		
	pre	post	p value	pre	post	p value
Physical functions						
Grip force (kg)	30.1 ± 1.6	26.9 ± 1.5	<0.001	18.7 ± 1.7	17.5 ± 1.5	0.660
Isometric quadriceps force (kg)	29.5 ± 1.9	28.8 ± 1.8	0.504	17.5 ± 2.0	17.9 ± 2.3	0.872
SPPB total score	11.6 ± 0.1	11.8 ± 0.1	0.166	8.2 ± 0.3	8.8 ± 0.6	0.321
Balance score	3.9 ± 0.0	4.0 ± 0.0	0.159	3.8 ± 0.1	3.2 ± 0.3	0.068
4 m walking score	3.9 ± 0.1	3.9 ± 0.1	0.811	2.2 ± 0.2	2.8 ± 0.2	0.068
5 sit-to-stand score	3.8 ± 0.1	3.9 ± 0.0	0.057	2.2 ± 0.2	2.8 ± 0.3	0.088
Psychiatric functions						
HADS total score	11.9 ± 0.8	11.6 ± 0.9	0.435	11.3 ± 1.7	10.4 ± 1.6	0.720
Anxiety score	5.9 ± 0.6	5.1 ± 0.5	0.200	6.1 ± 1.2	4.4 ± 0.8	0.142
Depression score	6.0 ± 0.5	6.6 ± 0.6	0.565	5.2 ± 0.9	6.0 ± 1.1	0.363

Data are presented as mean ± standard error.

SPPB, short physical performance battery; HADS, hospital anxiety and depression scale.

there was decreasing trend only in the balance score. Actually, the exercise training to improve the balance ability included only 30 seconds of one-leg standing in our cardiac rehabilitation program. The balance ability was the consistent predictor for the onset of difficulty in performing basic ADLs<sup>28</sup>). While a decline in walking speed after cardiovascular surgery induced delay of the day of ambulating independently, it did not affect the LOS in the hospital<sup>29</sup>). Although the basic impairment and disability were recovered at discharge, the cardiac rehabilitation program may need to include training on improving the balance ability, according to individual physical performance needed to resume life at home.

Like sarcopenia, kidney disease was also an outcome-affected factor in this study. Kidney disease has been reported to worsen many outcomes, such as prolonged LOS in the ICU and the hospital, delayed independence in 100 m walking, and increased mortality, because of high incidence of composite cardiovascular events and difficulty in medical administration, such as fluid balance<sup>23, 30-32</sup>). To achieve early home discharge, not only cardiac rehabilitation, but also the strict kidney management at post-surgery, are important.

This cohort included patients with physical and psychiatric dysfunction, however, there were only four patients with malnutrition. The indications for surgery should be considered while accounting for various risks, such as excluding patients with malnutrition. One of the selection criteria in this study was scheduled surgery. The number of patients with malnutrition



**Table 5.** Correlations between the discharge of transfer and variables

	r	p value
<b>At baseline</b>		
Age (years)	0.201	0.102
Male	-0.071	0.567
BMI (kg/m <sup>2</sup> )	0.051	0.680
Comorbidity		
Hypertension	0.212	0.086
Diabetes	0.216	0.079
Dyslipidemia	0.083	0.507
Kidney disease	0.377	0.001
Anemia	0.173	0.162
Physical functions		
Sarcopenia	0.361	0.003
Grip force (kg)	-0.099	0.424
Isometric quadriceps force (kg)	-0.075	0.545
SPPB total score	-0.224	0.068
Balance score	-0.194	0.116
4 m walking score	0.207	0.093
5 sit-to-stand score	0.235	0.056
Psychiatric functions		
HADS-total score	-0.097	0.452
Anxiety score	-0.124	0.338
Depression score	-0.027	0.833
Nutritional status		
GNRI	-0.013	0.921
Type of operation		
Valve replacement/repair	0.017	0.892
CABG	0.026	0.833
Aorta replacement/repair	-0.077	0.533
Combined operation	-0.027	0.826
Operation time (min)	-0.018	0.885
Pump time (min)	-0.062	0.648
Aorta clamp time (min)	-0.019	0.886
<b>Amount of change at pre- and post-surgery (<math>\Delta</math>)</b>		
Physical functions		
$\Delta$ Grip force (kg)	-0.007	0.956
$\Delta$ Isometric quadriceps force (kg)	0.015	0.907
$\Delta$ SPPB total score	-0.183	0.138
$\Delta$ Balance score	-0.275	0.024
$\Delta$ 4 m walking score	-0.162	0.192
$\Delta$ 5 sit-to-stand score	0.091	0.462
Psychiatric functions		
$\Delta$ HADS-Anxiety score	0.123	0.295
$\Delta$ HADS-Depression score	0.090	0.468
$\Delta$ HADS-total score	0.128	0.303

Discharge destination as a categorical variable was converted follow as: discharge home=0, discharge transfer=1.  $\Delta$ value was calculated “the value at post-surgery” – “the value at pre-surgery”.

POD: post-operative day; BMI: body mass index; GNRI: geriatric nutritional risk index; SPPB: short physical performance battery; HADS: hospital anxiety and depression scale; CABG: coronary artery bypass grafting.

may have increased if emergency surgery cases, who had inadequate preoperative screening was included. Arai et al. reported that malnutrition was associated with the progress of cardiac rehabilitation after cardiovascular surgery in the cohort of 36.3% patients with malnutrition<sup>8</sup>). This report differed in patient's characteristics compared to this study. Our findings about malnutrition did not assert that malnutrition had no effect on outcomes after cardiovascular surgery. At least, GNRI had no effect on outcomes after cardiovascular surgery in the cohort of patients with normal nutritional status.

There are some limitations in this study. First, this study involved a relatively small study population. Furthermore, the multivariable logistic analysis could not be adapted. Increasing the subjects to show more evidence is recommended in a future study. Second, this study was performed at a single facility. Previous reports, including this study, reported slightly different cohorts and cardiac rehabilitation programs. There may be differences in the outcomes. It seemed necessary to consider the differences of cohort and cardiac rehabilitation program in the interpretation of our results. Third, we did not evaluate post-surgical complications. Therefore, we could not fully consider the reason for the delay of cardiac rehabilitation and discharge destination. Fourth, there was a significantly difference in age between the two groups. Although this is the results of considering the effect of age in multivariate analysis, it cannot be ruled out that the aging characteristics of the sarcopenia group may effect the results.

In conclusion, among the various reports of factors that affect post-surgical outcomes, it was suggested that sarcopenia, not psychiatric dysfunction or malnutrition, was an independent factor in the delay of the progress of cardiac rehabilitation. Therefore, patients with sarcopenia have a high rate of the discharge transfer, and the decline in the balance score of SPPB was shown to be significantly associated to the discharge destination.

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There are none.

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